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BULGARIAN NATIONAL BANK

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на Българската народна банка

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Financial Cycle in the Bulgarian Economy and Its Interaction with the Business Cycle

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February 2019

Abstract: This study proposes an estimate of the phases of the financial cycle in the Bulgarian economy using a variety of financial and macroeconomic indicators and investigates its interaction with the business cycle. For assessing the financial cycle in Bulgaria two alternative approaches are applied. The first one is based on the use of the band-pass filter and the principal component analysis. The second one relies on a structural unobserved components model. According to both methods the length of the financial cycle is estimated in the range of 11–12 years, which fits well within the widely accepted in the academic literature range of 8 to 30 years. At the same time the business cycle is found to exceed the generally assumed maximal length of 8 years. The results from both approaches indicate, that the financial cycle in Bulgaria is to a large extent synchronised with the business cycle. Another finding of our research is that in 2017 the Bulgarian economy is entering an initial phase of cyclical risk accumulation.

Резюме: Изследването представя оценка на фазите на финансовия цикъл в българската икономика чрез използването на различни финансови и макроикономически показатели и изучава неговото взаимодействие с бизнес цикъла. За оценяване на финансовия цикъл в България са използвани два алтернативни подхода. Първият се базира на използването на лентов филтър и на метода на главните компоненти. Вторият се базира на структурен модел с ненаблюдаеми компоненти. При прилагането и на двата метода дължината на финансовия цикъл се оценява в диапазона до 11–12 години, което съответства на широко приетия в научната литература диапазон от 8 до 30 години. Същевременно според изследването бизнес цикълът надхвърля общоприетата максимална дължина от 8 години. Резултатите от прилагането на двата подхода показват, че финансовият цикъл в България е до голяма степен синхронизиран с бизнес цикъла. Друг извод на нашето изследване е, че през 2017 г. българската икономика навлиза в начална фаза на натрупване на цикличен риск.

JEL classifications: C14, C32, E32, E44
Keywords: financial cycles, business cycles, band-pass filter, principal component analysis, unobserved components model

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1. Introduction

The macroeconomic profession has experienced a renewed interest in the study of financial cycles. Both policy makers and academics were caught off guard by the global financial crisis of 2008–2009, which was highly unexpected and whose consequences were severe. Since then, governments and central banks around the world have agreed on the urgency to develop financial cycle measures that go beyond standard credit-to-GDP ratios in order to secure a more comprehensive understanding of the forces that govern the financial side of the economy, and its interaction with the real cycle. These considerations have also informed the purpose and direction of the following paper.

The study of the financial cycle and the way it interacts with the business cycle is crucial for taking informed decisions when applying the macroprudential policy instruments of the central bank. The financial cycle arises from the self-reinforcing interaction between the financial constraints of economic agents and the change in their risk perceptions and risk tolerance (Borio, 2014b). As a result of this interaction, financial markets undergo periods of ups and downs. Taking macroprudential measures in a timely manner is important for limiting the cyclical systemic risk accumulation in the financial system and the adverse impact of its unwinding on economic growth. The activation of such measures is essential for the "building up of buffers during financial booms, so as to draw them down during busts, which would make the system more resilient and better able to withstand the bust" (Borio, 2014a).

The set of macroprudential supervision instruments is expected to be effective in limiting the cyclical accumulation of risk in the financial system. Regulation (EU) No 575/2013 and Directive 2013/36/EU envisage the counter-cyclical capital buffer as one of the instruments to limit the cyclical accumulation of risk in the financial system. The deviation of the credit-to-GDP ratio from its long-term trend is the main indicator envisaged in ESRB Recommendation (ESRB, 2014) for the assessment of the financial cycle. Nevertheless, ESRB recommends the use of a set of additional indicators which may complement the credit-to-GDP gap for signalling the build-up of cyclical systemic risk in the financial system and support the process of macroprudential decision-making.

Two possible alternative approaches for assessing the financial cycle prevail in the academic literature. The first one is based on the assumption that the length of the financial cycle is within predefined ranges, most often between 8 and 30 years, and this assumption is used to derive an estimate of the financial cycle and study its dynamics and characteristics (Drehmann, Borio and Tsatsaronis, 2012; Borio, 2014b). Within this approach, univariate frequency filters like

the HP filter (Hodrick and Prescott, 1997) and band-pass filter (Christiano and Fitzgerald, 2003) are used to derive trend and cycle information from the time series. Another method used within the first approach is the turning point analysis (Harding and Pagan, 2002), (Claessens, Kose and Terrones, 2012) based on the identification of turning points in the time series using a predefined algorithm to identify these points.

Within the second approach no ex ante constraints are imposed on the length of the financial cycle. An example of such an approach is an unobserved components model (Rünstler and Vlekke, 2016), based on the estimation of a system of equations that characterise the individual cyclical and trend components of a set of observable variables. The advantage of using this type of models is that their built-in design allows for greater flexibility in the decomposition of the time series without imposing limits on the length of the financial cycle. Other similar methods include the so-called wavelet transform (Kunovac, Mandler and Scharnagl, 2018), which represents a series both in the frequency and time domain at the same time. These methods allow exploring the synchronisation and coherence of the cycles over several time series.

The aim of this study is to assess the phases of the financial cycle in the Bulgarian economy using a variety of financial and macroeconomic indicators. Two specific methods belonging to the two alternative approaches are applied. The first one is based on the use of the band-pass filter and the principal component analysis to extract the cyclical components of the individual series and then to combine them into a single measure of the financial cycle. When applying this method we assume that the length of the financial cycle ranges between 8 and 30 years. The second method relies on a structural unobserved components model and does not impose any restrictions on the length of the cycle, rather it allows this length to be estimated freely within the model. As far as we know, this is the first attempt to estimate the financial cycle in Bulgaria.

The results from the first approach suggest that the best performing financial cycle measure includes a wide set of indicators covering not only the credit-to-GDP ratio, but also credit growth, house prices growth, private sector debt burden, interest rate spreads, current account deficit, and indicators for the sustainability of the banking system. Its length, based on available data, is estimated at around 12 years, making it more of a midterm phenomenon. When compared with an estimate of the business cycle in Bulgaria, derived using a production function approach, the selected measure of the financial cycle shows a considerable degree of synchronisation with the output gap at 59%. Another finding of the first approach is that according to the selected

measure of the financial cycle, in 2017 the economy is entering an initial phase of cyclical risk accumulation.

The findings of the second approach reveal that the length of the cyclical components of the real credit and house prices series, used as proxy variables for the financial cycle, fits into the commonly used in the literature range of 8 to 30 years. In contrast, the length of the real GDP cycle is above the widely assumed upper limit frequency for the business cycle of 8 years. This study furthermore investigates the interrelations among the cyclical components of the included series. We find that the business cycle leads both the credit and the house prices ones, is well synchronised with the latter and less so with the former.

The paper is organised as follows. In Section 2 we review the literature on the methods used to estimate the financial cycles. In Section 3 we present the estimate of the financial cycle based on the use of the band-pass filter and the principal component analysis. Section 4 discusses the results from a multivariate structural state space model (STSM). Section 5 concludes the paper.

2. Literature Review

Developments during the global financial crisis of 2008–2009 and its aftermath revealed once again that volatility in the financial side of the economy can affect real activity in deep and lasting ways. This has urged policy-makers and academics to focus their efforts on understanding the financial cycle and its relationship to the business cycle (BC), especially with respect to the correct design and implementation of macroprudential tools. In particular, increasing importance has been placed on grasping the dynamics of systemic risk and developing early warning signals to detect it, as well as exploring whether distinct components of the financial cycle interact to aggravate or dampen imbalances. With a measure of the financial cycle at hand, the goal of research is to assess how it interacts with the business cycle.

Although the term "financial cycle" has been used in the macroeconomic literature for decades, there is yet no clear definition of the phenomenon. However, the majority of researchers adopt the formulation of Borio (2014b) as "the self-reinforcing interaction between risk perceptions and risk tolerance on the one hand and financial constraints of the other that, as experience indicates, can lead to serious episodes of financial distress and macro dislocations." Although a commonly accepted model for measuring the financial cycle does not exist, most scholars agree on several results, which have come to be viewed

as stylised facts. Thus, the financial cycle is a medium-term process and is longer than business cycles, the latter lasting up to 8 years. Drehmann, Borio and Tsatsaronis (2012) demonstrate that peaks in financial cycles coincide with banking crises or strains, and that the amplitude and frequency of financial cycles are regime-dependent, where financial liberalisation, short-term inflation targeting monetary policy and supply side-developments since the 1980s have almost doubled the length while increasing the amplitude of the financial cycle.

Before more elaborate measures of the financial cycle were introduced, credit-to-GDP was a widely-used measure of the phenomenon, originating from the ideas of Minsky (1970) and Kindelberger and Manias (1978) that credit booms sow the seeds of financial crises, and the ratio has been shown to be a good indicator of the expansion/contraction phase of financial systems (Borgy, Clerc and Renne, 2009; Drehmann et al., 2010). Defining a credit boom as a period in which the ratio of credit to GDP grows faster than the suggested by its HP trend, Dell'Ariccia et al. (2014) show that one-third of credit booms are followed by financial crises and three-fifths by economic underperformance. Furthermore, Borio and Lowe (2002) demonstrate that simple deviations of the ratio from its long-run trend can identify banking crises with a good lead of 2 to 4 quarters, and that inclusion of asset price deviations can serve as proxies for the likelihood and size of the expected reversal. The credit-to-GDP ratio does not require complex data which renders it suitable for cross-country analysis, and it is still germane to macro-financial analysis as a first-pass indicator.

Despite its historical footing and ongoing relevance, the credit-to-GDP suffers from a number of drawbacks. Orphanides and Norden (2002) note that data revisions could lead real-time reliance on the indicator to over- or underestimate the extent of credit expansion, and that the frequent omission of intra-financial lending from the measure is liable to underestimate increased fragility of the system in periods of stress. Because of this, and the fact that credit-to-GDP is slow to decline when crises hit Borio and Zhu (2012), the ratio may be an inadequate guide to the implementation of countercyclical buffers. Lastly, for the purpose of supervising debt levels, leverage indicators such as household credit-to-income and non-financial corporations credit-to-profits could be more useful in assessing the financial health of economic agents (Drehmann, Borio and Tsatsaronis, 2011).

With a view to these weaknesses of the credit-to-GDP indicator, recent studies have developed more elaborate measures of the financial cycle. One category consists of financial condition indices (FCI), which seek to measure the extent to which financial conditions are tight or easy, employing this as a proxy for

the level of stress in the financial system. An underlying assumption of the FCI approach is the importance of non-neoclassical credit channels due to the existence of asymmetric information, which necessitates the inclusion of asset prices as proxies for collateral. For example, Guichard, Haugh and Turner (2009) construct an OECD FCI by supplementing a monetary conditions index which already includes long and short rates, and the real exchange rate with financial sector indicators such as credit availability, corporate bond spreads and household wealth. While these authors determine the weight of each constituent parameter in the index by the sensitivity of activity to the respective parameter, other possibilities for assigning weights have also been tested.[1] Similar FCI's have been constructed in Hooper, Slok and Dobridge (2010), D'Antonio (2008) and Dudley and Hatzius (2000). The advantage of using FCI's is that, with the inclusion of asset prices it can capture the external finance premium, and thus the credit channel of monetary policy to the real economy (Bernanke and Gertler, 1995). Nevertheless, this method remains a goal-oriented one. By placing a disproportionate emphasis on monetary variables in forming the FCI, it tends to neglect the build-up of sectoral, specifically banking, fragilities.

To address such criticism of FCI's, financial stress indicators (FSI) attempt to aggregate into a single index sector- and segment-specific indicators, and make this index appropriate for real-time analysis and policy-making. Thus, Cardarelli, Elekdag and Lall use 7 parameters that describe 3 sub-groups – banking sector, securities and foreign exchange markets. The FSI is constructed by taking the variance-weighted average of the constituent parameters, and a Hodrick-Prescott filter is applied to the FSI. When the cyclical component of the FSI exceeds its HP-implied trend, the authors define the episode as one of financial stress. Hollo, Kremer and Lo Duca (2012) create a composite index of financial stress (CISS) out of 15 variables (5 sectors with 3 parameters each), and they innovate in aggregating using portfolio theory, whereby weights reflect time-varying cross-correlation. This allows more importance to be placed on scenarios where stress affects several markets at one and the same time. Overall, FSI's are an advance in understanding the inherent cycle of the financial system, and they make significant inroads in capturing the interaction of its constituent parts. However, there still exist areas where the methodology could be improved. For example, it remains unclear what the criteria are that define which sectors will be covered by the FSI, and, subsequently, in pinning

[1] Weights could alternatively be determined from structural models (Goodhart and Hofmann, 2002), reduced-form models (Gauthier, Graham and Liu, 2004), or time-varying weights from Kalman filters (Swiston, 2008).

down which variables best characterise a given sector. More generally, FSI's, together with FCI's, are indirect ways of characterizing the financial cycle, because these methods focus on how financial conditions are transmitted in financial markets via prices.

Direct ways of describing the cycle attempt to extract the long-run component from one or more series that are assumed to contain enough financial cycle-specific information. One hallmark approach known as turning point analysis (Harding and Pagan, 2002) consists of the application of an algorithm to one or more time series in order to identify peaks and troughs, where the algorithm includes rules about the duration and alternation of booms and busts. Claessens, Kose and Terrones (2012) applies a multivariate version of the algorithm, based on Harding and Pagan (2006), to expose the cycle in credit, property and house prices, and they find long duration of the cycle together with high synchronicity between credit and house prices. An appealing feature here is that the researcher can produce a cycle inherent to all underlying variables, which makes the methodology a more genuinely bottom-up one.

The other direct approach to measuring the financial cycle relates to the use of frequency-based filters, the band-pass filter being the prominent representative. It is a two-sided moving average filter which isolates cyclical components in the time series (Christiano and Fitzgerald, 2003). As frequency-based filters allow for the comparable transformations of multiple series, while their additive property makes it straightforward to stack the filtered series into a single estimate, they can be viewed as combining the main advantages of the other methods described previously. Drehmann, Borio and Tsatsaronis deploy a band-pass filter with a frequency of 8 to 30 years, chosen to account for the mid-term nature of financial cycles, to credit, asset and equity prices, and then they aggregate the filtered components into a single time series via averaging. They show that credit and asset prices are important for characterising the financial cycle, while equity prices do not carry significant information. Stremmel (2015) commend a similar approach in a cross-EU study, the novelty in their research being the inclusion of banking sector developments such as funding-to-total assets, net income-to-total assets and loans-to-total assets, but they find that such parameters do not contribute to the "best-fitted"[2] financial cycle. In choosing which specification of the financial cycle to report as final, both Drehmann, Borio and Tsatsaronis (2012) and Stremmel (2015)

[2] The "best-fitted" indicator of financial cycle is determined with the area under the receiver operating curve (AUROC) which allows to judge the model's adequacy and the goodness of fit (Stremmel, 2015).

apply a concordance index, which is a measure of the synchronicity between the underlying bandpass-implied series and the resulting financial cycle indicator.

Finally, wavelet analysis integrates time and frequency decomposition, thus bringing together features of turning point dating and band-pass filters while imposing less prior restrictions[3]. Thus, wavelet analysis does not presuppose any cycle length or frequency but allows to account for variation of these parameters over time and across series. This makes the method particularly beneficial in the cross-country euro area analysis by Scharnagl and Mandler (2016) which concludes that loans to non-financial corporations exhibit strong co-movement since 1980, while the inter-country synchronicity of loans to households has increased with the introduction of the EMU.

Prior to the new wave of research on financial cycles, the academic literature's focus was on uncovering the mechanisms through which financial imbalances translated to the real economy. The importance of leverage and financial frictions comprised the central themes of this scholarly agenda, which showed that ease of access to external financing could amplify wealth and substitution effects and thus carry over to the real economy (Bernanke, Gertler and Gilchrist, 1999; Kiyotaki and Moore, 1997)[4]. Ten years after the global financial crisis of 2008–2009, interest in the interplay between finance and business cycles is stronger than ever, and this is motivated by two goals. The first is to understand what it is about the underlying structure of financial developments that may aggravate a downturn of the real cycle. The second is to explore the extent of synchronisation of the two cycles – whether their amplitudes and durations match or diverge and what the feedback effects are between them, in order to improve the implementation of macroprudential policy.

A straightforward avenue for approaching these problems is comparing and analysing financial and business cycles that come about as a result of detrending procedures (HP filter, band-pass filter, turning point analysis, *etc.*), where a number of variables – usually credit, property and equity prices, are used separately to proxy different aspects of the financial cycle. The significant body of papers that has adopted this methodology has agreed on a set of findings

[3] Wavelet analysis is a form of spectral analysis which decomposes a time series into a set of cycles with/matched to specific periods and estimates the contribution of these cycles to the variation of the series.

[4] Drehmann and Juselius (2015) argue that aggregate debt service is just as important in propagating shocks from the financial to the real side of the economy. In particular, they show that both leverage and debt service relationships have to be in equilibrium in order for credit and asset prices to be at their long-run sustainable level.

about the interaction of financial and real cycles around peaks and troughs[5]. Thus, it has been found that recessions associated with housing and equity price busts are long and more severe than those without such disruptions, while recoveries associated with rapid growth in credit and property prices are stronger. Also, sustained growth in house prices prior to an economic downturn is associated with increased duration of the recession, while growth in equity prices before a recession is inconsequential to the length or depth of the downturn. Last but not least, credit growth does not impact the duration or amplitude of a recession but it can foster a recovery (Claessens, Kose and Terrones, 2012; Comunale, 2017; Reinhart and Rogoff, 2009).

As useful as such studies have been in laying down the foundations for future research, there are two major issues with their general approach. Firstly, one cannot reach conclusions about a single financial cycle, as cyclical components of different variables are used interchangeably to proxy aspects of the financial cycle. Secondly, the framework does not shed light on the interaction of both cycles throughout their past developments, but only highlights correlations around peaks and troughs.

Building on the agreement that financial cycles do have a bearing on macroeconomic aggregates, Hubrich and Tetlow (2015) attempt to quantify the effects in a Bayesian Markov-switching VAR model (BMS-VAR) of the US economy[6]. The paper reveals that shocks to the financial cycle do impact consumption, yet the magnitude is episodic in nature – the linkage between financial and business cycles is characterized by non-linearities, whereby financial conditions impact real activity more heavily during periods of financial turmoil. The researchers also establish that conventional monetary policy is ineffective during crisis periods. Nevertheless, such embedding of real variables and financial cycle indicators suffers from the general purpose of the set-up used. In the case of Hubrich and Tetlow (2015), the BMS-VAR model is employed for the assessment of monetary policy transmission, and the FSI is heavily skewed to capturing the movement of financial prices, rather than aggregates. Its results may therefore be interpreted as portraying how the effect of financial market conditions influence the workings of monetary policy on a given macroeconomic aggregate.

[5] Other studies focus on the international synchronicity cycles. Many papers discuss the cross-country correlation of business cycles, mostly finding increased coherence in Europe since the introduction of the EMU (Gayer, 2007; Gächter, Riedl and Ritzberger-Grünwald, 2013; Belke, Domnick and Gros, 2016; Mink, Jacobs and Haan, 2011; De Haan, Inklaar and Jong-A-Pin, 2008; Samarina, Zhang and Bezemer, 2017). Regarding financial developments, Samarina, Zhang and Bezemer (2017) points out that after the introduction of the EMU, international coherence of credit cycles has diminished.

[6] This strand of the literature also includes the works of Ng (2011) and Dees (2016).

It has become clear that a major challenge in grasping the interplay between financial and business cycles is that most analyses start from a position where the two estimates are different by construction[7], which limits the analysis to periods where their peaks or troughs overlap but convey little information about the rest of the co-movement of their dynamics (Rünstler and Vlekke, 2016). To overcome this drawback, a final class of papers attempts to estimate the two cycles in a multivariate framework (Rünstler and Vlekke, 2016; Bulligan et al., 2017). The advantage of this approach is twofold: first, no prior restrictions are placed on the duration of financial and business cycles, thus allowing the model to select the most appropriate parameters; and second, the multivariate framework allows the measurement of cycles to take into account how one cycle influences the other, and *vice versa*. The results of the multivariate estimation are compared to those from univariate models and the difference is interpreted as the inter-cycle impact. Thus, Rünstler and Vlekke (2016), using credit and house prices as components of the financial cycle for six OECD countries, observe that compared to the baseline univariate scenario, joint estimation of financial and business cycles result in longer, by 1 to 5 years, business cycles and shorter, by 1 to 4 years, financial cycles, taking this as evidence that the latter acts to lengthen the former, while the business cycle effects a shortening on the financial cycle. Further, the credit cycle tend to lag the business cycle, while the house price cycle moves roughly contemporaneously with the latter.

The foregoing has shown that scholarly work has gone a long way in understanding the financial cycle. With the credit-to-GDP ratio widely regarded as insufficient for a holistic grasp of the phenomenon, direct and indirect ways of gauging it have emerged, each with their advantages and drawbacks. In line with the theoretical and computational developments described in this literature overview, the ensuing study adopts two separate approaches to measuring the financial cycle, building on the respective strengths of each of them. The selection of these methods is underscored by the view that the two represent comprehensive tools with mutually reinforcing properties. The first relies on the band-pass filter and is based on the widespread assumption that the financial cycle spans within the 8 to 32 years frequency bands. The cyclical components of the financial series derived using the band-pass filter are then aggregated into a single measure by means of principle component analysis. The second part of the paper deploys a multivariate state space model where the goal of this exercise is twofold. On one hand, by employing the property of such models that they are not restricted by prior assumptions regarding the

[7] In the case of detrending and filtering methods, the real cycle is assumed to span 8–32 quarters, while for the financial the duration is much longer – 32–120.

length of the cycle, the purpose is to test the assumptions of the band-pass filter approach. On the other hand, given the inherent advantage of such joint estimation methods that allows the identification of leads and lags, the state space model will attempt to make the first steps in uncovering the interplay between the financial and business cycles in Bulgaria.

3. Financial Cycle Estimates

Following the academic literature on financial cycles and also taking into account the Recommendations of the ESRB (2014) on the indicators that may complement the credit-to-GDP gap for signalling the build-up of cyclical systemic risk in the financial system, as well as the availability of information for the Bulgarian economy, we base the assessment of the financial cycle on aggregation of the cyclical component information of the following set of indicators:

1) Measures of credit developments and private sector debt burden. Excessive growth of lending to firms and households and, respectively, high private sector indebtedness create risks of inability to repay the debt obligations in the downside phase of the business cycle.

2) Measures of potential overvaluation of property prices. Rapid growth in property prices is one of the factors considered in the literature to accompany and accelerate the onset of most financial crisis. During the expansion phase of the financial cycle cheap financing can push demand and prices above a sustainable level, which can stimulate further credit expansion.

3) Measures of external imbalances. High and persistent current account deficits are usually associated with an excessive accumulation of external debt and overheating of the economy.

4) Interest rate spreads. In the upside phase of the business cycle, the favourable macroeconomic environment, the positive attitude of economic agents and growing income and profits contribute to a reduction in risk perceptions, resulting in declining interest rate spreads. At the same time, the reduced risk assessment can stimulate the financing of more risky projects, which can turn out to be unprofitable in the downside phase of the cycle, generating losses for creditors.

Measures of the strength of banks' balance sheets. The low level of capital adequacy and the high ratio of loans to attracted deposits reduce the ability of banks to respond to shocks.

The indicators used to obtain a measure of the financial cycle are displayed in Table 1. All data are quarterly and cover the period 1999 Q1–2017 Q4.

Table 1: **Indicators Used to Obtain a Measure of the Financial Cycle in Bulgaria**

Groups of indicators	Indicators	Notation	Source
Measures of credit developments and private sector debt burden	Credit to NFC-to-GDP (domestic credit+external debt*)	CR_GDP_NFC	BNB: Monetary statistics, Gross external debt; NSI
	Credit to households-to-GDP	CR_GDP_H	BNB: Monetary statistics NSI
	Credit to NFC (annual growth rate)	CR_NFC_Y	BNB: Monetary statistics
	Credit to households (annual growth rate)	CR_H_Y	BNB: Monetary statistics
Measures of potential overvaluation of property prices	House price index (annual growth rate)	HPI_Y	NSI
Measures of external imbalances	Current account balance-to-GDP	CA_GDP	BNB: Balance of payments NSI
Interest rate spreads	Spread between interest rates on new loans to NFC and 3-month EURIBOR	LIRC_EUR	BNB: Interest rate statistics; ECB
	Spread between interest rates on new loans to households and 3-month EURIBOR	LIRH_EUR	BNB: Interest rate statistics; ECB
Measures of the strength of banks' balance sheets	Capital-to-asset ratio (leverage)	C_A	BNB: Banking supervision
	Bank profits to total assets	P_A	BNB: Banking supervision
	Loan-to-deposit ratio	L_D	BNB: Banking supervision

* External debt includes the items "Other sectors" and "Direct investment: inter-company lending" from the Gross external debt statistics.

Concerning the indicators measuring credit developments and private sector debt burden we assume that the main source of financing for households is the bank credit. At the same time enterprises in Bulgaria rely not only on bank lending, but also on external financing from parent companies. For that reason concerning enterprises we adopt a broader definition of credit, which includes bank credit, foreign direct investment and external debt. The reason for compiling two different variables (separately for the non-financial corporations sector and for the household sector) is to make it easier to distinguish between sectoral tendencies and tendencies at the whole-economy level. Further we take into consideration the annual growth rates of bank credit to NFC and households to account for different pattern of credit developments from that of GDP. Naturally, during the expansion phase of the business cycle credit growth accelerates as the optimistic expectations of economic agents stimulate credit demand for financing consumption and investment. From the supply side, banks are also more prone to lend even to riskier clients. However, during the

contraction phase of the business cycle it is possible that GDP growth turns negative, while credit growth remains subdued, but still positive due to the long term nature of some of the credit contracts.

All indicators used to obtain an estimate of the financial cycle are normalised to ensure comparability of their units, which is a standard approach in the literature on financial cycles. The normalisation procedure for each time series consists of extracting the mean from each observation and dividing the result by the standard deviation. In addition to being normalised, some of the indicators are multiplied by a coefficient of -1 so that an increase of the respective variable indicates accumulation of risk and a decline is indicative for materialisation or reduction of risk. This is the case with the current account balance as a ratio to GDP. It is multiplied by a coefficient of -1, so that when this ratio increases it means that the deficit (not the surplus) on the current account increases as a percent of GDP and this indicates accumulation of risk in the financial system. Similarly we treat interest rate spreads and the capital-to-asset ratio. This implies that accumulation of risk occurs when interest rate spreads decrease and when the capital of banks in relation to their assets declines. Interest rate spreads decline in the upside phase of the business cycle when risks are accumulating.[8] At the same time the reduction of capital relative to banks assets poses risks to the ability of banks to deal with shocks.

After the normalisation procedure a standard technique is applied to extract the cyclical components of the series, namely the band-pass filter. Band-pass filters are two-sided moving average filters designed to isolate and extract cycles with certain lengths in the series. The frequency band of the filter, which defines the upper and lower boundary of the cycle lengths are set in advance.

There is a common view in the academic literature, based on a wide range of evidence, that in contrast to the business cycle which is a short-term process (with duration of 8 to 32 quarters), the financial cycle is more of a mid-term length (32 to 120 quarters).[9] Following the literature, we use band-pass filter with a frequency of 32 to 120 quarters for the individual indicators we have chosen to analyse, in order to obtain an aggregate measure of the financial cycle. When filtering the series we also take into account whether they are stationary or integrated of order 1.[10] The individual band-pass filtered series are displayed in Figure 1. Due to the normalisation of the indicators, generally

[8] See Figure 7 in Appendix A.

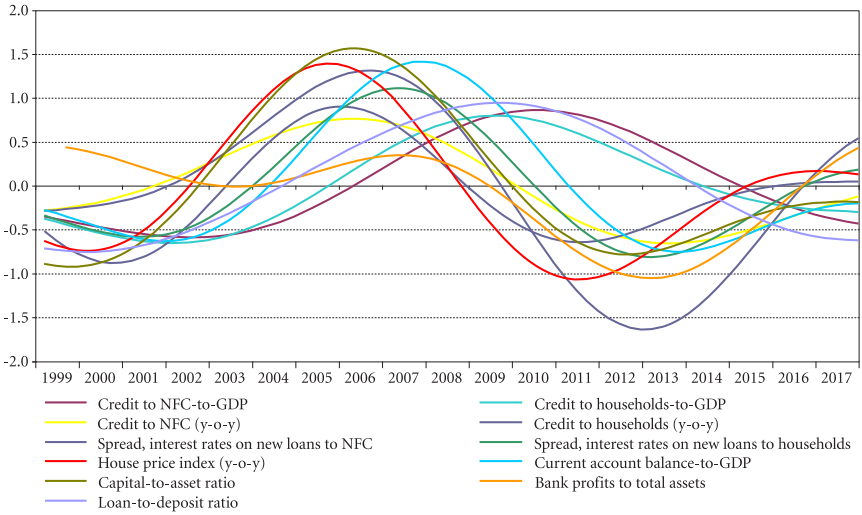
[9] Drehmann, Borio and Tsatsaronis (2012); Aikman, Haldane and Nelson (2015).

[10] Unit root tests are presented in Table 10 in Appendix A.

the crossing of the null axis can be interpreted as a boundary between the phases of risk accumulation and risk materialisation.

Based on the cyclical movements of individual indicators it can be concluded that recently an accumulation of risks is observed in respect to growing house prices, declining interest rate spreads, rising bank profits and acceleration of lending to households. According to the cyclical components of both ratios of credit-to-GDP, the annual growth of lending to NFC, the current account balance and the ratios of capital to assets and loans to deposits in 2017 the Bulgarian economy is still in the phase of risk materialisation.

Figure 1: **Cyclical Movements of Individual Indicators**



Once we have extracted the cyclical components of the selected series, we employ a principal component analysis in order to obtain an aggregate measure of the financial cycle. Basically, the principal component analysis is designed to extract the common components of the series under consideration. It is a statistical procedure that transforms a number of (possibly) correlated variables into a set of uncorrelated variables called principal components. The principal components are linear combinations of the original variables weighted by their contribution to explaining the variance. The number of the extracted principal components is equal to the smaller of the number of original variables or the number of observations minus one. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

In order to extract the common components of the selected indicators, which are supposed to characterise the financial cycle in Bulgaria, these indicators need to be grouped in a certain way. For this purpose, nine sets of indicators have been compiled, and from each of these sets the first principal component is being derived. The first principal component is of major interest for the analysis, as it explains the most of the variation in each group. The first set of indicators (FC1) includes only the two ratios of credit to GDP – credit to non-financial corporations as a ratio to GDP (including both domestic and external financing) and credit to households as a ratio to GDP. The argument for that being that the credit-to-GDP gap has a long history in being used as a core indicator to measure cyclical movements in the financial system. In the second group (FC2) the annual growth of credit to NFC and households are added to both ratios of credit to GDP to account for different patterns in lending and real activity (Schularick and Taylor, 2012; Jordá, Schularick and Taylor, 2013). In the third group (FC3) we add interest rate spreads to account for funding conditions and risk premium (Giese et al., 2014; Plasil et al., 2015; English, 2002). As a next variable we incorporate property prices, which are commonly used in the literature on financial cycles to take account of risk perceptions (FC4) (Borio, 2014b; Drehmann, Borio and Tsatsaronis, 2012; Claessens, Kose and Terrones, 2012; Dees, 2016). The inclusion of the current account balance as a ratio to GDP in FC5 aims at accounting for external imbalances (Giese et al., 2014; Plasil et al., 2015; Comunale, Hessel et al., 2014). Although not widely used in the literature on financial cycles, bank balance sheets indicators are included in the last four groups (FC6 to FC9), with the last (FC9) being limited to them (Giese et al., 2014; Stremmel, 2015). Table 2 gives information on the way the indicators have been grouped.

Table 2: **Potential Measures of the Financial Cycle**

Financial cycle measure	Bandpassed variables included (cyclical components)
FC1	CR_GDP_NFC, CR_GDP_H
FC2	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y
FC3	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR
FC4	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y
FC5	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP
FC6	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A
FC7	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A, P_A
FC8	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A, P_A, L_D
FC9	C_A, P_A, L_D

Table 3 displays the results of the principal component analysis of the nine potential measures of the financial cycle. In each group the first principal component (PCA1) is considered.

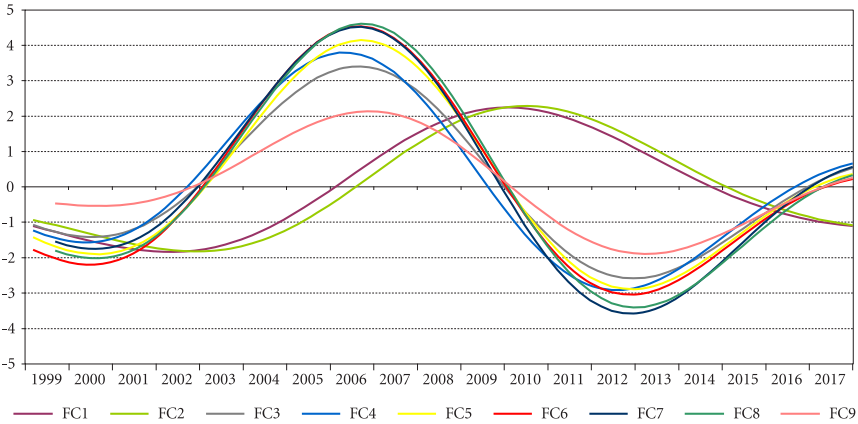
Table 3: **Results of the Principal Component Analysis**

		FC1	FC2	FC3	FC4	FC5	FC6	FC7	FC8	FC9
	PCA1	0.98	0.49	0.58	0.62	0.62	0.66	0.64	0.58	0.51
Loadings	CR_GDP_NFC	0.71	0.71	-0.06	-0.11	-0.02	-0.01	-0.06	-0.03	
	CR_GDP_H	0.71	0.68	0.08	0.01	0.10	0.09	0.05	0.08	
	CR_NFC_Y		-0.15	0.51	0.45	0.42	0.38	0.37	0.37	
	CR_H_Y		-0.08	0.47	0.44	0.40	0.37	0.35	0.34	
	LIRC_EUR			0.51	0.46	0.42	0.38	0.38	0.37	
	LIRH_EUR			0.51	0.43	0.43	0.39	0.37	0.38	
	HPI_Y				0.45	0.39	0.36	0.35	0.34	
	CA_GDP					0.38	0.34	0.32	0.33	
	C_A						0.40	0.38	0.38	0.75
	P_A							0.28	0.27	0.64
	L_D								0.13	0.17

The first row in Table 3 shows how much of the variance in each group of indicators is explained by the first principal component. In the case of the first potential measure of the financial cycle (FC1), where only the two ratios of credit to GDP are included, not surprisingly PCA1 explains about 98% of the variance. Such a result can be expected when the number of variables in the group is small and when the variables share common dynamics. In the special case of only one variable, the PCA1 would be 100%. When adding complementary indicators to the credit-to-GDP gap, the variance explained by the first principal component expectedly declines. The comparison between the potential measures of the financial leads to the conclusion that, apart from FC1, most of the data variation explained by the first principal component is present in the sixth group FC6 (66%). However, although it is important how much of the variance PCA1 accounts for, the size and the sign of the loadings on the different indicators in each group should also be taken into consideration. By construction the signs of all loadings should be positive. This is the case, because all indicators are so constructed, that an increase in each indicator is associated with the accumulation of risk in the financial system and respectively a decrease in the indicator is associated with materialisation or reduction of risk. The negative sign in front of the ratio of credit to NFC to GDP in most of the potential measures of the financial cycle can be explained by the relatively different dynamics of this indicator in comparison with the rest of the variables. Even if the sign in front of the ratio of credit to NFC to GDP is negative, its loading is the smallest in FC6. Apart from this variable, all other indicators in the sixth group (FC6) have the expected sign and with the

exception of the ratio of credit to households to GDP display very close weights. FC6 has also the advantage of containing indicators from all groups defined earlier – *Measures of credit developments and private sector debt burden, Interest rate spreads, Measures of potential overvaluation of property prices, Measures of external imbalances and Measures of the strength of banks' balance sheets*. This suggests that they could be more informative about cyclical fluctuations in the financial system than just the credit-to-GDP ratio. Graphical illustration of the nine potential measures of the financial cycle is displayed in Figure 2.

Figure 2: **Potential Measures of the Financial Cycle in Bulgaria**



The graphical representation is not sufficient to draw a definitive conclusion about the most appropriate measure of the financial cycle. However, when using only the credit-to-GDP gap (which is represented by FC1), it can be concluded that the peak of the financial cycle occurred at the end of 2009. Extending the range of observed variables leads to different conclusions, namely that the peak of the financial cycle occurred earlier than the fourth quarter of 2009 and that in 2017 the Bulgarian economy was not any more in the phase of risk materialisation, but in an initial phase of risk accumulation. The gradual inclusion of complementary indicators, beyond the credit-to-GDP gap, results in a left-hand shift of the aggregate estimate of the financial cycle and increase in volatility. Table 4 presents the volatility (measured by the standard deviation), the peak and the through of the financial cycle according to the nine potential measures.

Table 4: **Volatility, Peaks and Troughs of the Potential Measures of the Financial Cycle in Bulgaria**

	FC1	FC2	FC3	FC4	FC5	FC6	FC7	FC8	FC9
Volatility	1.41	1.41	1.88	2.09	2.24	2.44	2.54	2.55	1.24
Trough (MIN)	-1.84	-1.82	-2.59	-2.91	-2.89	-3.04	-3.59	-3.41	-1.95
Timing	2002 Q1	2002 Q4	2012 Q4	2012 Q2	2012 Q4	2012 Q4	2012 Q4	2012 Q4	2012 Q4
Peak (MAX)	2.24	2.29	3.40	3.79	4.14	4.54	4.55	4.63	2.18
Timing	2009 Q4	2010 Q2	2006 Q3	2006 Q1	2006 Q3	2006 Q3	2006 Q3	2006 Q3	2006 Q4

According to financial cycle measures FC1 and FC2, which include the credit-to-GDP ratios and credit growth rates, the peak of the cycle occurred between 2009Q4 and 2010Q2. At the same time the trough of the cycle was between 2002Q1 and 2002Q4. The inclusion of interest rate spreads and the house price index in the aggregate measure of the financial cycle (FC4) leads to a significant backward shift of the peak to 2006Q1. According to the potential measures of the financial cycle from FC5 to FC8, the peak cycle estimate coincides – 2006Q3. The same applies for the trough of the cycle, which is concentrated in 2012Q4. Even when only banks' balance sheets indicators are taken into account, the conclusions do not change significantly, with the peak and trough of the cycle close to those indicated by aggregate measures FC5 to FC8.

A statistical approach, which can be employed to evaluate the various measures of the financial cycle and to help deciding on the most appropriate one, is the so called concordance index. It is a bi-variate index of synchronisation, developed by Harding and Pagan (2002). Basically, the concordance index enables to study the synchronicity or co-movement between the different ingredients of a financial cycle measure and the aggregate measure itself.[11] The concordance index measures the time periods in which two series are in the same phase (expansion or contraction) relative to all periods. If both series are in the same phase all of the time, the concordance index would be 100%, respectively if both series are in the opposite phase all of the time, the index would be 0%.

"We propose that co-movement be measured by the degree of concordance between the specific cycle for y_{jt} and the reference cycle (based on (say) the variable y_{rt}), and that this be quantified by the fraction of time both series are simultaneously in the same state of expansion $(S_t = 1)$ or contraction $(S_t = 0)$" (Harding and Pagan, 2002).

$$I_{jr} = n^{-1}\left[\sum S_{jt}S_{rt} + (1 - S_{jt})(1 - S_{rt})\right] \quad (1)$$

[11] The concordance index is also used by Stremmel (2015) to assess different measures of the financial cycle.

Following Stremmel (2015), we calculate the concordance between the different indicators included in each financial cycle measure and the aggregate measure itself. We first calculate the concordance between each indicator in a group and the aggregate measure and then take the average. The results are displayed in Table 5.

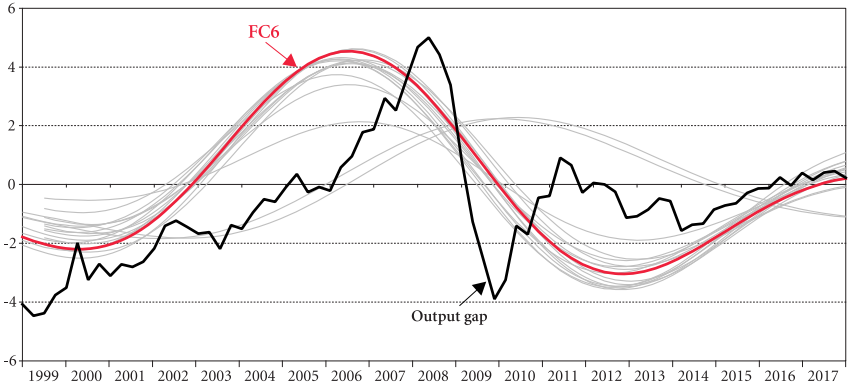
Table 5: **Concordance Index**

Financial cycle measure	Bandpassed variables included (cyclical components)	Concordance index
FC1	CR_GDP_NFC, CR_GDP_H	97%
FC2	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y	64%
FC3	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR	74%
FC4	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y	73%
FC5	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP	76%
FC6	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A	78%
FC7	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A, P_A	78%
FC8	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A, P_A, L_D	76%
FC9	C_A, P_A, L_D	74%

The degree of concordance between both credit-to-GDP ratios and the aggregate measure FC1 is 97%. This result can be explained by the fact that both indicators included in the first group, share common dynamics in the period under consideration. With the addition of other indicators, in order to obtain financial cycle measures FC2, FC3, FC4, *etc*. the degree of concordance between the individual indicators and the aggregate measure declines. This is the case until FC5 is reached, where the concordance index starts growing again and reaches its highest value in potential measures FC6 and FC7 – 78%. This indicates that the separate indicators included in FC6 and FC7 and the aggregate measure of the financial cycle extracted from them co-move in 78% of the time. The results indicate that with the exception of financial cycle measure FC1, which is derived only from the credit-to-GDP ratios, it can be assumed that the appropriate choice for a measure of the financial cycle would be FC6 or FC7 where the evaluation takes into account a wider set of indicators. The fact that a wider spectrum of variables indicates a simultaneous expansion or contraction of the cycle, should be more informative for macroprudential policy decisions than relying only on the credit-to-GDP gap. Overall, these results are consistent with the results obtained from the principal component analysis. Besides FC6 and FC7, in general, all measures from FC5 to FC9 display very close estimates of the degree of concordance between the different indicators included in the respective group and the aggregate measure of the financial cycle derived from them. In order to examine the robustness of the results obtained, we tested all possible combinations of the selected indicators in the respective aggregate

measures, with indicators measuring credit developments and house prices included in all. Figure 3 shows the selected aggregate measure of the financial cycle – FC6 against the background of all possible alternatives. Except the first two potential measures, FC1 and FC2, which include only the credit-to-GDP ratios and the growth of credit to NFC and households, all other alternative measures exhibit similar dynamics and differ only in respect to their amplitude. The calculated concordance indexes between the different indicators in each possible combination and the aggregate measures derived from them do not change the current conclusions, with financial measures FC6 and FC7 remaining with the highest concordance index of 78% (see Table 11 in Appendix A).

Figure 3: **Output Gap, Financial Cycle Measure FC6 and Alternatives**



Note: The grey lines show all possible alternatives to the selected potential measure of the financial cycle in Bulgaria (FC6), derived by combining the selected indicators.

As a next step in the analysis the selected aggregate measure of the financial cycle FC6 is compared to an estimated business cycle for Bulgaria, using production function approach[12], in order to examine the synchronicity between them. The dynamics of both cycles is presented in Figure 3.

The graphical investigation of the dynamics of the selected measure of the financial cycle and the output gap leads to the conclusion that both cycles are generally well synchronised. Following the major financial crisis of 1996–1997 and the introduction of the currency board in Bulgaria, in the period 1999–2002 the economy still operated below its optimal production capacity. The negative output gap corresponded to high unemployment and high inflation, which was partly a legacy from the hyper-inflationary period in the end of the 90s. At the same time, this period was characterised by

[12] See Appendix B for the estimation of the output gap.

moderate credit growth, low credit-to-GDP ratio, comparatively high interest rate spreads between Bulgarian and European interest rates and low banking sector profits. The average annual growth of the house price index was close to 0%. These developments explain the dynamics of the selected measure of the financial cycle, which in this period indicated, that the Bulgarian economy was in the phase of risk materialisation. It is important to mention that in this period there were also structural factors which affected the banking system developments in Bulgaria. They were related to the high share of state-owned banks, which were stocked with non-performing loans and cautious in new credit disbursement. Meanwhile, bank privatisation was an important factor which started the gradual process of restructuring of the banking sector in Bulgaria.

From 2003 onwards the ongoing process of structural reforms and privatisation of many domestic banks by foreign financial institutions contributed to the deepening of financial intermediation in the country. Parent banks provided capital, liquidity and know-how to their subsidiary banks and their branches in Bulgaria, intending to boost their market share in the region where return on capital was very high. These processes prompted a strong competition among banks and contributed to a gradual acceleration of credit growth. In this period the demand for loans was also high, stimulated by domestic and external factors.[13] High expected return on investment and positive income convergence expectations related to the process of gradual transition to a market economy, as well the favourable domestic macroeconomic environment and the global upswing in the business cycle stimulated consumption, investment and FDI inflows. Growing income and profits on the other hand contributed to an increase in attracted funds in the banking system. Funding their lending activity through residents' deposits and funds from parent credit institutions, the banks in Bulgaria expanded their operations, contributing to further acceleration of credit growth. The period from 2003 to 2007 was characterised by declining spreads between lending interest rates in Bulgaria and the 3-month EURIBOR reflecting the reduction in risk perceptions. High credit growth pushed up banks' profits and among other factors contributed to an increase in house prices. In the period under consideration the current account deficit was widening as a percent of GDP due to the high level of investment in the economy as well as the high domestic demand (in particular investment demand boosted by FDI) which resulted in import growth exceeding that of exports.

[13] For more details about demand and supply factors affecting the growth of credit to the private sector see (Karamisheva, 2016).

In accordance with these developments the selected measure of the financial cycle indicates that in this period the economy was in the phase of risk accumulation, with the peak occurring in the third quarter of 2006, earlier than the peak of the business cycle. A possible explanation for the turning of the financial cycle earlier than the business cycle could be the introduction of a number of counter-cyclical measures by the Bulgarian National Bank in 2005 and 2006[14] aimed at moderation and stabilisation of the rate of private sector credit growth to levels sustainable for the medium run and not threatening the financial stability. It could be stated that these administrative measures were effective in constraining the growth of lending to households and non-financial corporations, and even in restraining the growth of house prices and thus in reducing the accumulation of risk in the financial system (see Figure 8 and Figure 9 in Appendix A).

It should be taken into account that the potential aggregate measures of the financial cycle are extracted from the cyclical components of a set of indicators, each of them peaking at different point in time. In Figure l it is evident that the cyclical components of the annual growth of credit to households and NFC, as well as of house prices peak earlier than the rest of the indicators and the inclusion of these three variables in the aggregate measure leads to a left-hand shift of the entire measure.

The positive output gap peaked in the second quarter of 2008 and with the spreading of the effects of the global financial crisis started its downward phase turning negative in the second quarter of 2009 and reaching its trough at the end of 2009. Following the developments in the real sector, the financial cycle entered the phase of risk materialisation in the end of 2009, when the business cycle was at its trough and this phase continued till the beginning of 2017. According to the selected measure of the financial cycle, in 2017 the economy is entering an initial phase of risk accumulation.

A notion for the degree of synchronisation between the selected financial cycle measure and the output gap can be gained through the computation of the respective concordance index between the two cycles. Table 6 exhibits the concordance between FC6 and the output gap. For comparison we also display the respective concordance indexes between the output gap and the remaining potential measures of the financial cycle.

[14] For detailed information on the counter-cyclical measures of the BNB see BNB Annual Reports 2005–2006.

Table 6: **Concordance between the Potential Measures of the Financial Cycle and the Output Gap**

Financial cycle measure	Concordance with the output gap
FC1	43%
FC2	44%
FC3	59%
FC4	53%
FC5	60%
FC6	59%
FC7	59%
FC8	60%
FC9	61%

According to Table 6, financial cycle measures FC5 to FC9 display the highest degree of synchronisation with the business cycle. According to the concordance index, the selected measure FC6 and the output gap are in the same phase 59% of the time. By way of comparison, financial cycle measure FC1, which takes into account only the credit-to-GDP gap co-moves with the business cycle in only 43% of the time.

With the aim of getting a notion of the length of both cycles a turning point analysis is applied. Generally, the length of a cycle is measured from peak to peak (respectively from trough to trough). Table 7 displays the minimal values of the respective measures of the financial cycle and the business cycle as well as their timing when we split the data set into two subsets, namely from 1999 to 2007 and from 2008 to 2017. Concerning the maximal values, the data set does not need to be split into subsets, as both the business cycle and the measures of the financial cycle reached only one peak in the period under consideration. According to Table 7 the selected measure of the financial cycle (FC6) displays two local minima – the first one in 2000Q2 and the second one in 2012Q4, which indicates that the length of the cycle is estimated at around 12 years. At the same time the business cycle reached one trough in 1999Q2 and a second one in 2009Q4, meaning that its length is estimated at approximately 10 years, longer than the generally assumed in the academic literature maximum for the business cycle frequency of 8 years.

Table 7: **Peaks and Troughs of the Business Cycle and the Potential Measures of the Financial Cycle**

	Output gap	FC1	FC2	FC3	FC4	FC5	FC6	FC7	FC8	FC9
1999–2007										
Trough (MIN)	-4.47	-1.84	-1.82	-1.41	-1.57	-1.90	-2.20	-1.78	-2.04	-0.53
Timing	1999 Q2	2002 Q1	2002 Q4	2000 Q2	2000 Q2	2000 Q3	2000 Q2	2000 Q3	2000 Q3	2001 Q1
2008–2017										
Trough (MIN)	-3.90	-1.11	-1.08	-2.59	-2.91	-2.89	-3.04	-3.59	-3.41	-1.95
Timing	2009 Q4	2017 Q4	2017 Q4	2012 Q4	2012 Q2	2012 Q4	2012 Q4	2012 Q4	2012 Q4	2012 Q4
1999–2017										
Peak (MAX)	5.00	2.24	2.29	3.40	3.79	4.14	4.54	4.55	4.63	2.18
Timing	2008 Q2	2009 Q4	2010 Q2	2006 Q3	2006 Q1	2006 Q3	2006 Q3	2006 Q3	2006 Q3	2006 Q4

4. Structural State Space Model

The derivation of a financial cycle presented in Section 3 rests on a set of assumptions about the cycle attributes which, albeit considered standard in the literature, are still subject to some degree of uncertainty. In an attempt to capture the values of these cyclical features, in this section we offer an estimate of the financial cycle based on a structural unobserved components model. The multivariate model was first introduced by Harvey et al. (1997) and decomposes a series into latent trend and stochastic cycle components. It was then expanded by Rünstler (2004) by introducing phase shifts among the cyclical components in the multivariate case and recently further built on by Rünstler and Vlekke (2016) by adding an additional autoregressive root within the stochastic cycle specification. The model belongs to the family of the so-called "parametrized" decompositions, the name stemming from the fact that the parameters characterizing the latent components of the series are not a priori defined but are rather derived within the model framework itself. This specification allows for a greater degree of flexibility in modeling the unobservables as the filter is tailored to the series specifically and further on provides an estimate of the inherent for the latent components features such as cycle length, persistence, or trend growth rate for example. The final decomposition of the observable series obtained from the model can then serve as a validation for the restrictions imposed on the band-pass filter employed in Section 3 to derive the financial cycle component, namely the frequency bands containing the cycle length.

The model can either decompose a single series to its respective latent components by fitting each one of them to a parametrized equation, or can

provide the aforementioned decomposition for a group of series in which case estimation is performed jointly for all. The latter builds on the former and integrates information contained within all series by allowing the model to select the optimal level of correlation among the cyclical components and the innovations of the latent components across series. The difference between the final decomposition reached by employing the univariate and the multivariate specifications reveals about the degree to which the observable series affect one another either through inter-cycle impact or through shocks correlation.

In a univariate structure, the one proposed originally by Harvey (1989), the series is decomposed into a stochastic trend (τ_t), a stochastic cycle component (ψ_t), and a white noise term (ϵ_t):

$$y_t = \tau_t + \psi_t + \epsilon_t, \qquad \epsilon_t \sim NID(0, \sigma_\epsilon^2) \tag{2}$$

The stochastic trend component is assumed to follow the flexible local linear trend specification and is defined as:

$$\tau_{t+1} = \tau_t + \beta_t + \xi_t, \qquad \xi_t \sim NID(0, \sigma_\xi^2) \tag{3}$$

$$\beta_{t+1} = \beta_t + \zeta_t, \qquad \zeta_t \sim NID(0, \sigma_\zeta^2) \tag{4}$$

where β_t is the trend's slope and equals the underlying long-term growth of the series which varies with the innovation term ζ_t. The cyclical component ψ_t is defined as a bivariate $\mathrm{AR}(1)$ process where:

$$(1-\phi L)\left(I_2 - \rho \begin{bmatrix} cos\lambda & sin\lambda \\ -sin\lambda & cos\lambda \end{bmatrix} L\right) \begin{bmatrix} \psi_t \\ \psi_t^* \end{bmatrix} = \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix}, \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix} \sim NID\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_\kappa^2 & 0 \\ 0 & \sigma_\kappa^2 \end{bmatrix} \right) \tag{5}$$

The stochastic cycle is parametrized in terms of its persistence ρ which under the assumption of being less than one ensures the stationary property of the cyclical component. The additional autoregressive root ϕ allows for the extended persistence of the cyclical component expected in financial series as suggested by previous research. The cycle's frequency is measured by $0 < \lambda < \pi$, its spectral density peaks at λ, and its length equals $\frac{2\pi}{\lambda}$.[15]

In the multivariate case, we consider the Nx1 vector of observed time series $y_t' = (y_{1,t},...,y_{n,t})'$ with t ranging from 1 to T. The model decomposes the series into their latent components: an Nx1 vector of stochastic trend components τ_t, Nx1 vector of cyclical components x_t^C, and an Nx1 vector of irregular components ϵ_t, such as:

$$\boldsymbol{y_t} = \boldsymbol{\tau_t} + \boldsymbol{x_t^C} + \boldsymbol{\epsilon_t}, \qquad \boldsymbol{\epsilon_t} \sim NID(0, \sigma_\epsilon^2) \tag{6}$$

[15] $\frac{2\pi}{4\lambda}$ in annual term.

All trend components are modelled within the local linear trend framework and both trend and slope innovations may be correlated across the N series where Σ_ξ and Σ_ζ are the NxN covariance matrices. Each cyclical component x_t^C is modelled as a linear combination of the stochastic cycle components of all series, as defined by equation 5, with loadings expressed in the A and A^* matrices:

$$x_t^C = \left[A, A^*\right] \begin{bmatrix} \boldsymbol{\psi_t} \\ \boldsymbol{\psi_t^*} \end{bmatrix} \tag{7}$$

This specification[16] allows the cyclical component of each series to load on stochastic cycles with different parameters and therefore dynamics, and to account for phase shifts between the cyclical components (Rünstler, 2004). Correlations across the innovation terms of the cyclical components of the series are allowed as well and defined in the NxN covariance matrix Σ_κ.

To estimate the financial and business cycle by capturing their correlation without imposing prior ad hoc constraints on the parameters characterizing them, we use the unobserved components model in its multivariate specification. The observable variables are then real GDP, real credit[17], and real house prices[18], and the estimation is performed using maximum likelihood by employing the Kalman filter.

In theory, a wide set of financial variables should be included in order to extract the cyclical component they all share, an estimation approach we have already applied in Section 3. Within the state space framework however, we include the real bank credit and the real house price index as representative for the financial cycle variables and the real GDP as an indicator of the business cycle. This selection follows other similar studies and is motivated by a handful of reasons. There is an already existing in the literature notion that credit can be used as a proxy for leverage and furthermore the credit-to-GDP ratio is at present included in financial regulatory frameworks. The real house price index is widely assumed to measure the availability of collateral within the economy and withal to serve as a proxy for asset prices.

[16] Certain identifying restrictions are imposed on the *A* and *A** matrices, namely $a_{ij} < 0$ for all $i < j$ and $a_{ij}^* < 0$ for all $i \leq j$.

[17] Credit is measured by the index of notional stocks of loans (non-MFIs excluding general government sector) calculated by the European Central Bank. The index of notional stocks adjusts for reclassifications, other revaluations, exchange rate variations and any other changes which do not arise from transactions. Within the state space framework this definition is preferred as some of the information which is contained within the credit stock series, but is not significant for the structural decomposition, is already pre-filtered.

[18] All three series (GDP, credit, and house prices) are deflated using GDP deflator.

Estimation is performed over the 2000–2017 period and all observable series enter the model in logarithms. The measurement equations are defined as in equation 6 and the latent variables are characterized within the framework described in equations 6, 3, 4, and 5. The structure of the presented model is slightly altered by imposing similar cycle restrictions on real credit and real house prices assuming that both series share the same inherent cyclical dynamics. This entails that the features of two cycle components (length and persistence) are set to be equal but no other restrictions are imposed concerning their value. The shared between the two series cyclical component can then economically be interpreted as a financial cycle estimate and the joint estimate of its parameters present an estimate of a financial cycle length and persistence respectively. Correlation among slope innovations across the series in the estimate of the model is allowed, and all trends are modelled within the integrated random walk specification.[19] The values of all model parameters were estimated within the model framework.

The difference between the estimated parameters based on the univariate and the multivariate approach serves to illustrate how the additional information contained within the multivariate framework alters the final estimate, or in other words, the degree to which each individual series' decomposition impacts the decomposition of the other two series (see Table 8). The cyclical component of the real GDP series, which is defined as the deviation of real GDP from its trend level excluding all other shocks[20], can be said to represent an estimate of the real business cycle in the economy. The length of the business cycle, extracted solely from the GDP series, is estimated to be about four years.[21] When adding supplementary information, the business cycle appears more volatile and with lower frequency, with length close to 11 years. Intuitively this entails that information contained in the real credit and house prices series does have an impact on our understanding of the state of the real economy by both prolonging the real business cycle and by making its peaks and troughs more severe.

The estimate of the cyclical attributes of real credit based on the univariate approach results in a cycle length of close to five years, but however the cycle is prolonged when estimated within the multivariate framework. The relatively short length of the cyclical component of real credit likely has a twofold explanation: the rather short sample period over which estimation is performed

[19] The standard deviations of the trend innovations were estimated to be insignificant and close to zero, and for ease of further computation calibrated to zero.

[20] These shocks include the measurement error and trend innovations.

[21] It is widely accepted in the literature that the business cycle length is between 2 and 8 years.

and the introduction of credit ceilings (BNB, 2005) by the Bulgarian National Bank in April, 2005, which the model attributes to a cyclical innovation.

The univariate decomposition of the real house prices series suggests a cycle length of fourteen yeas, but when impacted by real GDP and real credit the cycle oscillates at a higher frequency and spans over an eleven year period.

The multivariate model indicates the existence of two stochastic cycle components: one characterized with higher frequency and length of about five years, and the other by a lower frequency with length of more than 14 years (see Table 8). These two stochastic cycles then load with different weights on the cyclical components of the three individual series, and in doing so prolong the real GDP and credit cycle, but at the same time shorten the house prices one. Additional information on the interplay between the cyclical components of the series can be inferred from Table 9. The model suggests high degree of coherence between the house prices and real GDP cycles, the latter leading the former, reflecting the impact of real output on both demand and supply factors underlying house prices growth. House prices and credit cycles appear to be less coherent with each other and phase estimate indicates that the latter lags the former, a likely result considering house prices drive the demand for credit. Credit and GDP show the least amount of coherence and credit cycle appears to lag the business one.

Table 8: **Main Parameters Estimate**

	Univariate estimate		Multivariate estimate		
	Cyclical component		Cyclical component	Stochastic cycle	
	length (in years)		length (in years)		length (in years)
Real GDP	4		11	*SC I*	4.47
Credit	5		10	*SC II*	14.79
House prices	14		11		
	Standard deviation		Standard deviation		
	Cyclical component	Slope (error term)	Cyclical component		Slope (error term)
Real GDP	0.3	0.1	1.5		0.03
Credit	2	0.4	4.7		0.2
House prices	9.6	0.3	9.1		0.2

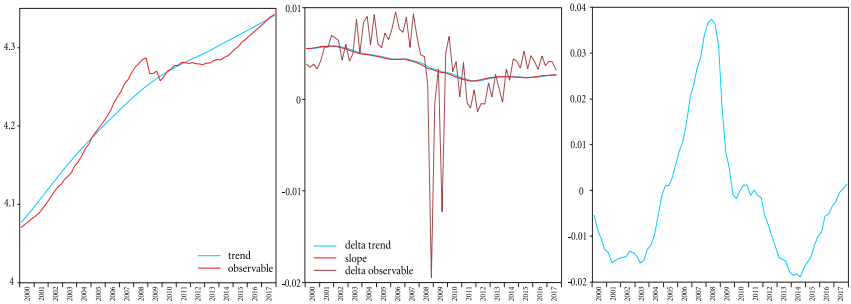
Table 9: **Phase Shifts and Coherence**

	Phase (years)			
Coherence (average)		GDP	Credit	House prices
	GDP		0.691	0.676
	Credit	0.634		-0.198
	House prices	0.949	0.826	

The upper-right half of the table shows by how much each series leads the others in years. It should be noted that if the value is positive, *series row* leads *series column*, whereas if the value is negative, then *series column* leads *series row*. The bottom-left half of the Table shows the coherence of each set of series on average for the whole estimation period.

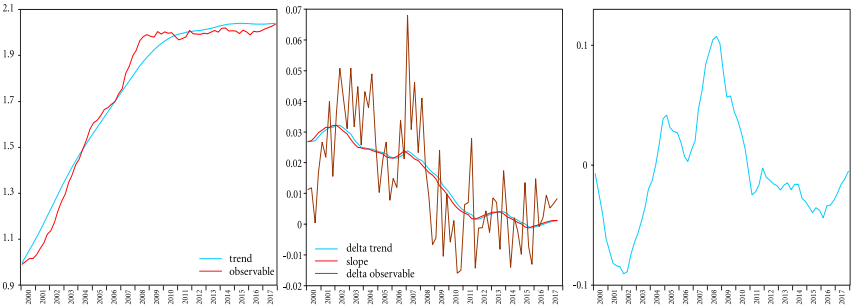
The tailored filter based on the multivariate structural unobserved components framework further provides a detailed breakdown of the series to their latent components, as illustrated in Figures 4, 5 and 6. The break-down of real GDP, as presented by Figure 4a and Figure 4b, indicates a smooth long-run growth of the series with no remaining leftover cyclical residue. The slope estimate is slowly decreasing over the sample period, likely reflecting converging processes happening in the early 2000s, and remains fairly constant in recent years. The closure of output gap at the end of the sample period signals that the economy is currently operating at its optimal level. Real credit series decomposition provides a smooth slope of the trend component decreasing with time, which long-term growth is anchored at 0 in the last year of the sample. The model then attributes credit growth in 2017 to cyclical fluctuations rather than a structural changes and in turn the cyclical component presented in Figure 5c, while still remaining below the zero bound, indicates the building up of some financial distress. In decomposing the house prices series to its latent components within the multivariate framework, the model attributes most of the volatility of the series to cyclical movements rather than inherent long-term trend. Respectively, the slope term is smooth and stable throughout the entire estimated period (see Figure 6b). The derived cycle, as illustrated in Figure 6c, appears to be volatile and with large amplitude, and in recent years to be in a phase of expansion. In the last quarters of the sample its value turns positive, which in turn suggests that house prices are currently at a level above their equilibrium one.

Figure 4: **Real GDP Multivariate Decomposition (log)**



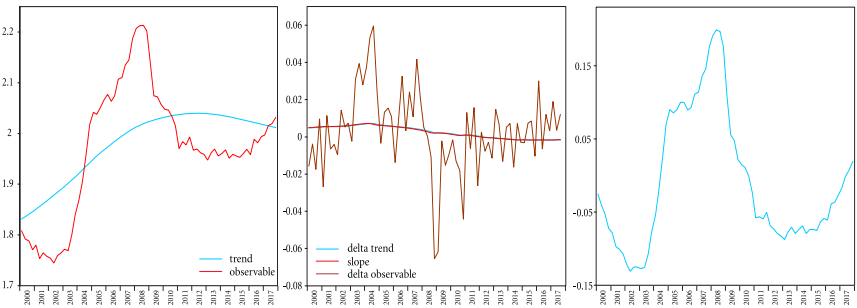
(a) Real GDP and trend decomposition (b) Slope, trend, and real data (c) Cyclical Component

Figure 5: **Real Credit Multivariate Decomposition (log)**



(a) Real GDP and trend decomposition (b) Slope, trend, and real data (c) Cyclical component

Figure 6: **Real House Prices Multivariate Decomposition (log)**



(a) Real GDP and trend decomposition (b) Slope, trend, and real data (c) Cyclical component

The decomposition derived from the multivariate approach enhances our understanding of the economic activity measured using the real GDP, real

credit, and real house prices series. Within the state space framework, the model optimally distributes volatility between measurement errors and the latent components driving the movement of the observable series. Providing an assessment of the financial cycle *per se* is beyond the scope of the model, but nonetheless it casts a light on the inherently unobservable features of the series included measuring financial activities. Furthermore, it indicates the existence of both a high and a low frequency cycles, the two of which combined with the respective innovation shocks, explain the movement of the cyclical components of the series included in the framework. The estimated length of the real GDP cycle of 10.7 years spans beyond the commonly predefined in the literature range of 2–8 years used to extract the business cycle which sets the ground for further research on the topic. The credit and house prices cycles length however fits well within the a priori set constraint of 32 to 120 quarters concerning the financial cycle length widely accepted in the literature and respectively used in Section 3 of this paper to derive a more broad measure of a financial cycle.

5. Concluding Remarks

In this study we present an estimate of the financial cycle in the Bulgarian economy derived using two different statistical filtering methods commonly employed in the literature. The measure of the financial cycle provided in Section 3 relies on the information contained within a wide set of indicators covering credit, house prices growth, private sector debt burden, interest rate spreads, current account deficit, and indicators for the sustainability of the banking system. This estimate shows that in 2017 we observe an initial phase of accumulation of cyclical risk in the economy. The assessment of the phases of the financial cycle in Bulgaria through the aggregation of a broad selection of indicators serves to identify the appropriate moments for the build-up or release of buffers in the financial system. The proper timing of the aforementioned in turn will make the system more robust and flexible to shocks. In theory a shortcoming to this method is the presupposed length of the cycle assumed when applying the band-pass filter. However we show that the assumption holds true by estimating the length within an unobserved components framework.

We find that the length of the cyclical components of the real credit and house prices series, used as proxy variables for the financial cycle in the model, falls well within the widely accepted in the literature range of 8 to 30 years. In contrast, the length of the real GDP cycle is above the generally assumed maximum for the business cycle frequency of 8 years. This assessment sheds light on the interplay between financial variables and real economic activity.

It shows that within a multivariate framework estimation, the real GDP and credit cycles appear prolonged and more volatile, whereas the real house prices cycle seems to be at a higher frequency and with lower amplitude. The study furthermore hints at what feedback effects are at play among the cyclical components, showing that the real GDP cycle leads both the credit and the house prices ones, while at the same time the former lags the latter. Disentangling the complex relationship between macroeconomic aggregates and financial indicators both benefits our estimates of the current phases of the business and financial cycles, and can provide a deeper understanding of the effects of macroprudential policy on economic activity.

Limitations of the state space approach can be found in both the rather constrained selection of financial variables included, and the lack of nominal, Phillips curve type of block in the model. These possible extensions, and a more thorough study of the features of the business cycle within a multivariate framework including financial variables, we leave for further research.

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Appendix A

Figure 7: **Spreads between Interest Rates on New Loans to Households and NFC with the 3-month EURIBOR and the Output Gap**

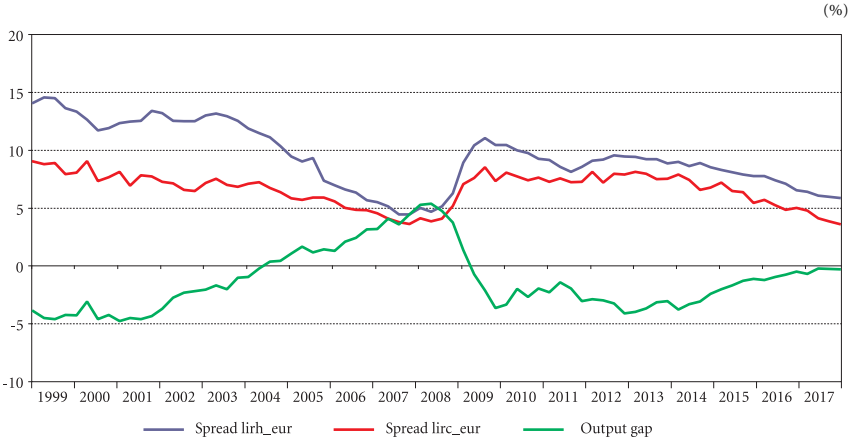


Table 10: **Unit Root Tests**

H0: Variable has a unit root	ADF Test t-Statistic			
Variables	Level	First difference	Second difference	Degree of integration
CR_GDP_NFC	-1.68	-2.40	-15.94***	I(2)
CR_GDP_H	-1.78	-2.09	-13.31***	I(2)
CR_NFC_Y	-1.99	-5.75***		I(1)
CR_H_Y	-1.58	-5.65***		I(1)
CA_GDP	-1.94	-3.28**		I(1)
HPI_Y	-3.74***			I(0)
LIRC_EUR	-1.55	-9.74***		I(1)
LIRH_EUR	-2.04	-5.25***		I(1)
C_A	-2.45	-3.93***		I(1)
P_A	-2.22	-7.23***		I(1)
L_D	-1.73	-2.57*		I(1)

H0: Variable has a unit root	Phillips Perron Test Adj. t-Statistic		
Variables	Level	First difference	Degree of integration
CR_GDP_NFC	-1.74	-4.60***	I(1)
CR_GDP_H	-1.59	-3.17**	I(1)
CR_NFC_Y	-2.10	-11.97***	I(1)
CR_H_Y	-4.98***		I(0)
CA_GDP	-1.34	-4.82***	I(1)
HPI_Y	-2.19	-3.90***	I(1)
LIRC_EUR	-1.62	-9.67***	I(1)
LIRH_EUR	-1.63	-5.25***	I(1)
C_A	-1.69	-9.39***	I(1)
P_A	-1.95	-8.61***	I(1)
L_D	95	-8.30***	I(1)

Table 11: **Concordance Indexes**

Financial cycle measure	Bandpassed variables included (cyclical components)	Concordance index
	CR_GDP_NFC, CR_GDP_H	97%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y	64%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR	74%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y	73%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP	76%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, C_A	77%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, P_A	75%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, L_D	72%
FC6	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A	78%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, P_A	76%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, L_D	75%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, C_A, P_A	77%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, C_A, L_D	74%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, P_A, L_D	73%
FC7	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A, P_A	78%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A, L_D	76%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, P_A, L_D	75%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, C_A, P_A, L_D	75%
	CR_GDP_NFC, CR_GDP_H, CR_NFC_Y, CR_H_Y, LIRC_EUR, LIRH_EUR, HPI_Y, CA_GDP, C_A, P_A, L_D	76%
	C_A, P_A, L_D	74%

Figure 8: **Annual Growth of Credit to NFC and Households**

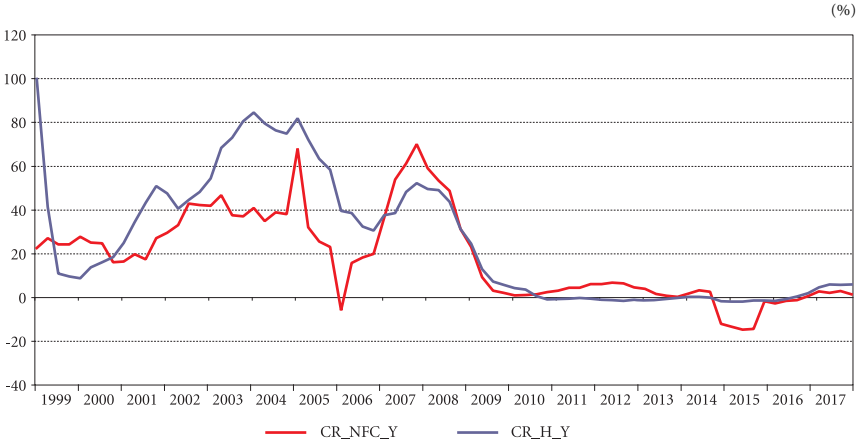
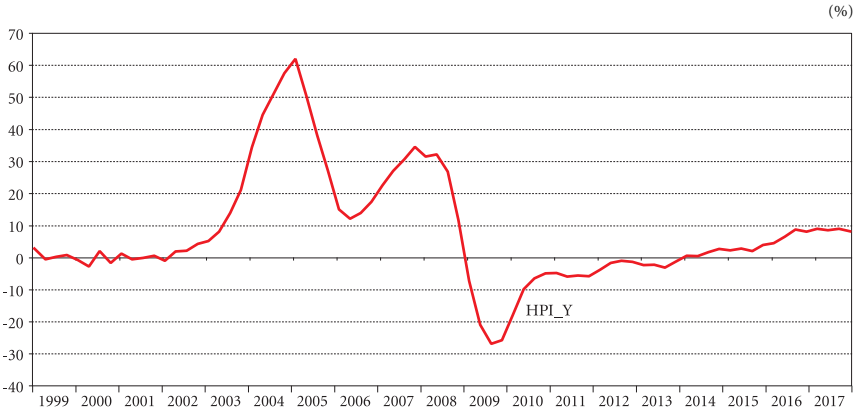


Figure 9: **Annual Growth of House Prices**



Appendix B

Business cycles have garnered the attention of both economists and policy-makers for centuries and a great number of studies has attempted to establish a theoretical and empirical characterization of the phenomenon. The term in recent years has been widely accepted to refer to the inherent fluctuation of aggregate economic activity (Mitchell, 1927). Assuming potential output growth to be the sustainable level of aggregate supply an economy can achieve without straining its resources and factors of production, the business cycle then represents the cyclical "force" that pushes an economy away from its potential and towards phases of growth and prosperity, but also decline in output and depression. The business cycle, when defined as the aggregate estimate of slack or strain remaining in the economy,[22] is then in its nature unobservable and relates to the deviation of a series from its trend. Research on the topic spans over time and over ideas, and a wide range of methods has been proposed to extract an estimate of the business cycle. Deriving such a measure is of particular interest to central banks, as it both indicates how volatile economic activity is, and represents a key tool in assessing and forecasting inflationary pressures. Here we present two estimates of the output gap currently at use at the Bulgarian National Bank, one based on a theoretical production function set-up, and the other on a statistical filtering approach, namely a multivariate unobserved components model.

The growth accounting estimate is based on a Cobb-Douglas production function and follows the general approach suggested in Tsalinski (2007) but applies minor modifications. The Cobb-Douglas function takes as resource input capital, labor, and total factor productivity, has constant returns to scale, and is defined within the following framework:

$$Y = TFP * K^{\alpha} * L^{\beta} \tag{B.1}$$

The output elasticities of capital and labor are assumed to be $\alpha = 0.4$ and $\beta = 0.6$, ensuring that $\alpha + \beta = 1$. The Bulgarian National Statistics Institute provides no measure of capital stock in the economy, hence an estimate of capital employing the perpetual inventory method is used instead. Labor input is based on the growth rate of working age population, labour force participation rate, unemployment rate and hours worked per employee, and TFP is in turn defined as the Solow residual. Further the trend components

[22] Also referred to as the *output gap*.

of all series are extracted using the Hodrick-Prescott filter[23]. Potential output is then derived by using the trend components as factors of production in equation B.1. With a measure of potential output at hand, the output gap is defined as the difference between what is produced within the economy, and what could be produced without straining or underusing resources. Main drawback of this estimate is the univariate filter employed to isolate the cyclical component of each series entering the production function. The use of HP-filter is also associated with end-point bias as the estimate provided by it is very sensitive to new observations. Be that as it may, this approach has the benefit of offering a contributions breakdown of both potential growth and output gap which in turn provides an intuitive economic interpretation of the estimates derived.

The second model we present is a state space model employing the Kalman filter, as presented in Kasabov et al. (2017). The model is set within the unobserved components framework, and assumes that each observable variable included can be represented in terms of its latent gap and trend components. The observable series entering the model are real GDP, inflation, and unemployment. The real output block broadly represents a local linear trend model in which the observable GDP equals the sum of its gap and trend components. The former and the latter are both defined as an AR(1) process, and the trend moves with its long-term growth which in turn is anchored by an exogenously set steady state value. Inflation dynamics is modelled based on the Phillips curve which relates the inflation gap to the output one, and the unemployment block incorporates Okun's Law. All equations defining both the latent and the observable components are then cast into state space form and estimated simultaneously employing Bayesian methods.[24] The multivariate setup of the model provides a business cycle measure, the estimation of which includes information about the relationship among the trend and cyclical components of all series within the model system.

[23] In extracting the trend component, lamda has been set to 1600, as is commonly accepted in the literature when quarterly data is filtered.

[24] For more information on model setup, parameters calibration, and estimation techniques, see Kasabov et al. (2017).

Figure 10: **Output Gap Estimates**

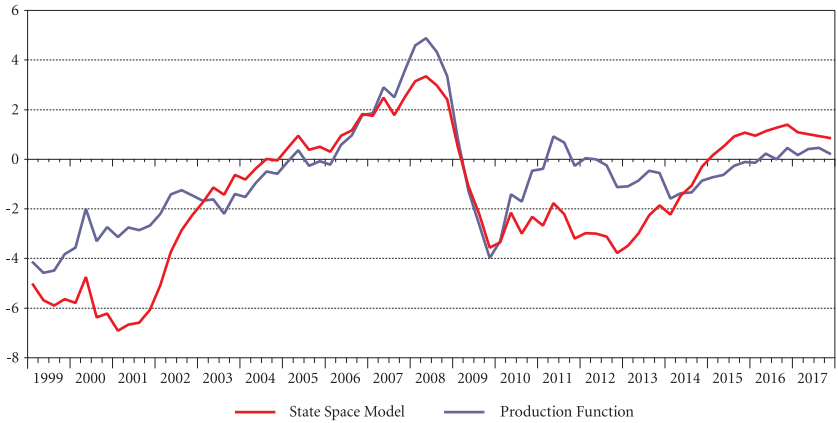


Figure 10 provides an overview of the two measures of the business cycles derived using the methods described above. The gap based on the growth accounting method appears to be less volatile and while both models suggest some build-up of slack in the economy in the early 2000s, the state space approach results in a deeper trough of the business cycle. As the state space filter is multivariate in its nature, this can likely be explained by the persistent high unemployment throughout that period. Both estimates peak in 2008, and the production function based one indicates a higher degree of overheating. In recent years, both measures are above the zero level, pointing to production above the optimal for the Bulgarian economy level and consequently straining of the resources available.

Both methods used here to derive a business cycle estimate suffer from their respective shortcomings. The one based on the unobserved components model, albeit applying a tailored to the series filter set in a multivariate framework, remains sensitive to both the design of the model and the priors used in the Bayesian estimate. The production function approach indeed is subject to the critique to the filter it employs as described in Hamilton (2017), but however offers certain benefits over the state space model. It provides an estimate easily comparable to other countries' measures as this approach is widely used by other institutions as well, further on is build upon a solid theoretical background, and offers a contributions break-down of the business cycle.

DP/114/March 2019

Labour Market Functioning and Matching Efficiency in Bulgaria over the Period 2004–2017: Qualification and Regional Aspects

Ventsislav Ivanov, Desislava Paskaleva, Andrey Vassilev

March 2019

Abstract: The paper tries to assess the extent of mismatch between the supply of labour and the demand for labour in Bulgaria during the period 2004–2017, using both descriptive and econometric approaches. We construct various descriptive indicators and estimate the change in efficiency of the labour market across fields of education and regions in Bulgaria on the basis of Employment Agency data. Our analysis points to the fact that after 2015 labour market efficiency has shown signs of deterioration in a number of educational fields. In addition, there are significant differences in efficiency dynamics between the northern and southern parts of the country. We comment on the probable factors responsible for the decline in efficiency at the end of the sample period and discuss possible policy responses.

Резюме: Изследването прави опит да оцени степента на дисбаланс между предлагането и търсенето на труд в България през периода 2004–2017 г., като се използват едновременно два подхода: дескриптивен (описателен) и иконометричен. Конструират се различни описателни показатели и се оценяват измененията в ефективността на пазара на труда по области на образование и по региони в България въз основа на данни от Агенцията по заетостта. Нашият анализ свидетелства, че след 2015 г. се наблюдават признаци на влошаване на ефективността на трудовия пазар в различни области на образование. Освен това са налице значителни разлики по отношение на динамиката на ефективността на пазара на труда в северните и в южните части на страната. Разглеждат се вероятните причини и фактори, довели до понижаването на ефективността в края на анализирания период, и се обсъждат варианти за корективни мерки на политиката.

JEL classifications: J22, J23, J24, J63, J64
Keywords: labour market mismatches, matching efficiency

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1. Introduction

The match between labour demand and supply is crucial for the level of unemployment in the short term and for the dynamics of potential output in the long term. The slow decline of unemployment in the EU and the US following the global financial crisis of 2008–2009[25] has raised concerns about a key ingredient in the matching process – labour market efficiency. The labour market situation in Bulgaria is no exception. With the economy recovering in the period following the global crisis (the post-crisis period), unemployment in Bulgaria began to decline starting in 2014 as a result of both rising employment and a decline in the workforce due to negative demographic processes. The improvement of economic activity over the same period has helped to reveal a significant number of vacancies, of which many remain unfilled despite the fall in unemployment. These developments raise the question whether there is a mismatch between labour supply and demand.

While it is customary to refer generically to "labour market mismatch", it should be noted that labour market mismatches are of different types – they can be cyclical, frictional, and structural – and correspondingly have different causes. In a cyclical upswing, labour demand is on the rise and employers face difficulties in recruiting, while in times of recession the negative effects are passed on to job seekers. Frictional unemployment and vacancies are permanent in nature: it takes some time for the exact match between labour supply and demand to materialise. The recruitment process can be prolonged by an insufficient number of job applicants, or there can be too many applicants due to job search intensity. Reservation wages and income replacement also impact these developments. Mismatches may also be of structural nature, *e.g.* if the qualification level of job-seekers does not coincide with that demanded by employers. Moreover, the different types of mismatches between labour demand and supply can also interact with each other. For example, a structural source of unemployment, such as inadequate educational level and profile of the labour force, may further prolong the frictional unemployment period due to a mismatch between demanded and offered skills. Similarly, recruitment problems of cyclical nature may exacerbate structural labour market mismatches.

This paper tries to evaluate if there is a mismatch between labour demand and supply in Bulgaria, as measured by the change in matching efficiency,

[25] Throughout the text we refer to this period as "the global financial crisis" or "the global crisis" for brevity. The years before 2008 are referred to as "pre-crisis period" and the years after 2009 – as "post-crisis period".

and quantify the degree of mismatch. Using monthly data collected by the Bulgarian Employment Agency for the number of unemployed, vacancies and other variables over the period 2004–2017[26], we study matching efficiency across fields of education and regions. (In what follows we sometimes use the term "efficiency" instead of "change in efficiency" for brevity, when no confusion can arise.) We conclude that in about two-thirds of the observed fields of education there has been some reduction in efficiency at the end of the period covered by our analysis. Moreover, there are also differences in efficiency dynamics between the northern and southern parts of the country. Another finding is that, contrary to prevalent empirical results for other economies, the efficiency of the labour market in Bulgaria does not seem to be procyclical.

The match between labour demand and supply, and specifically the degree of labour market efficiency, can be evaluated using data on the flows and stocks of unemployed, workers and number of vacancies. Depending on the researcher's preferences, this evaluation can be more descriptive and theory-agnostic, or it can be based on a specific theoretical framework. In this paper we employ both approaches. First, using standard assessment methods such as the Beveridge curve, labour market tightness, job-finding and job-separation rates, we present a descriptive analysis of the state of the Bulgarian labour market. Second, we estimate matching efficiency by adapting econometric approaches implemented in the literature to data on Bulgaria.

The remainder of the paper is structured as follows. In section 2 we discuss the main ideas behind the matching function and we take a look at the theoretical foundations of the matching function. Section 3 describes the data used. Section 4 analyses a number of indicators characterising the state of the Bulgarian labour market across fields of education and regions. In section 5 we develop an econometric approach based on matching functions by first presenting the methodology of the approach and then discussing our estimates of matching efficiency. Section 6 concludes and discusses implications for economic policy.

2. Literature Review

There are two main types of empirical approaches in the literature to study the matching between demand and supply on the labour market. Descriptive approaches tackle the question by examining the dynamics of core labour market data and their derivatives. Econometric approaches employ formal

[26] The 2004–2017 period was chosen due to the lack of detailed monthly data for earlier periods.

statistical methods based on theoretical assumptions to evaluate and extract information about the underlying labour market processes.

2.1. Descriptive Approaches

Labour market mismatch is traditionally measured through various descriptive approaches. Blanchard et al. (1989) argue that shifts of the so-called Beveridge curve (the theoretical negative relationship between vacancies and unemployment) or fluctuations of job-finding rate are indicative of changes in matching between demand and supply on the labour market and are commonly discussed in papers on the subject, *e.g.* Arpaia, Kiss, and Turrini (2014), Davis, Faberman, and Haltiwanger (2012), Veracierto (2011). Below we discuss several commonly used indicators which can help us to explore the extent and direction of labour market mismatch in different regions and in fields of education, namely the Beveridge curve, labour market tightness, job-finding and job-separation rates.

In general, stylized facts suggest that unemployment is high during recessions and job vacancies are numerous during economic expansions (see, *e.g.* Arpaia, Kiss, and Turrini (2014)). The negative relationship between the number of unemployed and vacancies is represented by the Beveridge curve.

Another important indicator in determining the balance between the demand for, and the supply of, labour throughout different stages of the business cycle,

is labour market tightness, defined as the ratio of vacancies to unemployed. The vacancy-to-unemployment ratio[27] (or v/u) is regarded as an important indicator of tightness in most matching models, as it aims to measure the ease with which unemployed people and vacancies reach a successful match. Indeed, Pissarides (2000) makes a the comprehensive survey of matching models and argues that the vacancy-to-unemployment ratio is an appropriate measure of the tightness of the labour market.

Additionally, Hobijn and Sahin (2007) calculate the job-finding rate as the part of unemployed persons that flow out of unemployment and the job-separation rate as the part of workers who leave their jobs. These rates can be interpreted as the probabilities of finding or losing a job, respectively. Changes in job-finding and job-separation rates can be decomposed to structural (changes in the composition of labour demand and supply or by changes in institutions

[27] One should take into account, though, that in the case of constructing this indicator using data from the Bulgarian Employment Agency, the data for unemployment is more representative than that for vacancies, since the incentives of unemployed workers to register at the agency are stronger than firms' incentives to post their vacancies there, especially in the case of private firms.

or policies) and cyclical components, contributing to the overall variations of unemployment. A cyclical pattern is particularly observed for the job-finding rates, which increase if the labour market is tight (there are a lot of vacancies per unemployed) and it is rather easy for job-seekers to find a job, see Shimer (2005). Moreover, in upturns (downturns) the share of long-term unemployed tends to fall (rise), leading to higher (lower) job-finding rates on average. In contrast, the job-separation rate is not characterised by cyclical volatility. The explanation of this stylised fact is that the job-separation rate is affected by two factors working in opposite directions over the cycle, *i.e.* the number of persons who leave their jobs voluntarily and those who are fired move in the opposite direction in the course of the economic cycle. However, Arpaia, Kiss, and Turrini (2014) argue that in the presence of a large negative demand shock, the job-separation rate tends to register sudden increases.

In this paper we focus on the following indicators: Beveridge curve, labour market tightness, job-finding and job-separation rates.

2.2. Econometric Approaches

A commonly used method in econometric studies on the evaluation of labour market mismatch is the estimation of labour market efficiency, which typically rests upon the matching model of Mortensen and Pissarides (1994). This approach assumes that the new matches can be modelled by a simple production function that relates the flow of new hires to the stock of unemployed and vacancies, where the term that corresponds to total factor productivity is interpreted as matching efficiency. The matching function is a tool that "partially captures a complex reality with workers looking for the right job and firms looking for the right worker" (Blanchard et al. (1989)). Unemployed workers and posted vacancies determine the total number of new matches that are formed according to the following matching function:

$$m_t = A_t U_t^{\alpha} V_t^{1-\alpha} \tag{1}$$

where m_t represent the number of new hires, U_t the number of unemployed, V_t the number of vacancies, α is the elasticity of new hires with respect to the stock of unemployed persons (see below for an alternative interpretation) and A_t is matching efficiency[28].

Equation (1) can be rewritten in intensive form by defining the job-finding rate $jf_t = \frac{m_t}{U_t}$, *i.e.* the ratio of new hires to the stock of unemployed, and aggregate

[28] The Cobb-Douglas form of the matching function is used in almost all macroeconomic models with search and matching frictions (*e.g.*, Pissarides (2000)).

labour market tightness $\theta_t = \frac{V_t}{U_t}$, *i.e.* the ratio of vacancies to the unemployed. Then we have

$$jf_t = A_t \theta_t^{1-\alpha}, \tag{2}$$

where $1-\alpha$ is the elasticity of the job-finding rate with respect to labour market tightness.

To operationalise this framework, one needs to decide whether to model only transition between employment and unemployment, or there is a third possible state that captures exiting the labour force altogether. Generally research on the subject allows for two labour market states (employment and unemployment) and assume that the matching model is always at its steady state, which are also the assumptions that we have adopted in this paper. As an example, Barlevy (2011) allows for two labour market states, takes the separation rate to be constant, and assumes that the model is always at its long-run steady state.[29] Barnichon and Figura (2011) try to incorporate a third labour market state (non-participation) and permit the transition rates between the three labour market states to vary over time. However, similar to Barlevy (2011), Barnichon and Figura (2011) assume that the model is always at its steady state. Veracierto (2011), on the other hand, has no such constraints and tests different specifications with two and three labour market states with a constant and different values of the separation rate. Some authors (*e.g.* Shimer (2005) and Hall (2005)) argue that fluctuations in separation rate contribute little to overall changes in unemployment and can be ignored or assumed to be constant, but others, such as Fujita and Ramey (2009) and Sahin et al. (2011), show that the separation rate appears to be considerably cyclically sensitive, and find the separation rate makes an important but still comparatively small contribution to the overall variation in unemployment. Shimer (2005) argues that a rise in hiring leads to higher expected wages for new workers and eliminates the incentives for posting new vacancies. As a result, equilibrium occurs and fluctuations in labour market efficiency should not have a big impact on the unemployment and vacancies rates. The latter is theoretically consistent, but it does not take into account structural changes that affect demand and supply, such as new professions and work-flow automation.

The approaches described above can be reduced to two major models. The first one is proposed by Barnichon and Figura (2011) (variation with two labour market states), which is based on Mortensen and Pissarides (1994). The authors use the residuals from a regression of the job-finding rate on labour

[29] A steady state can be interpreted as the total matches, vacancies and unemployment that the economy will converge to in the long-run (Veracierto (2011)).

market tightness as a proxy for matching efficiency, similarly to obtaining an estimate of total factor productivity as the Solow residual in empirical growth theory. They model the flow of hires with a standard Cobb-Douglas matching function with constant returns to scale, therefore they express the matching function as follows:

$$\ln jf_t = (1-\alpha)\ln\theta_t + E_T(\ln m_{0t}) + \mu_t, \tag{3}$$

with E_T denoting the average over the estimation period, so that $E_T(\ln m_{0t})$ denotes the intercept of the regression, and denoting the error term. Note that according to this notation, the term $E_T(\ln m_{0t})$ is the counterpart of A_t as used in equations (1) and (2) in the case when A_t is constant.

The second way to measure the matching efficiency is proposed by Veracierto (2011). He uses a simple version of the Mortensen and Pissarides model with a variety of different specifications to measure mismatch and evaluate its consequences during the post-2007 recession period in US. He assumes that there are two types of agents: firms and workers. Each firm has one job available, which can either be filled or vacant. Workers can be in either of two states: employed or unemployed. Employed workers get separated from their current jobs with probability λ_t. The difference with the other approach is that Veracierto (2011) estimates matching efficiency directly by re-writing the matching function in a suitable manner. First, the evolution of unemployment over time is described by the following equation:

$$U_{t+1} = U_t - M_t + (1 - U_t)\lambda_t,$$

where, as before, U_t is the total number of unemployed persons in period t and M_t is the number of new matches in period t. Thus, $U_t - M_t$ is the part of the pool of currently unemployed persons that do not find a job, and $(1 - U_t)\lambda_t$ the number of workers losing their jobs in period t.

Assuming a constant separation rate λ, in equilibrium the matching function can be represented in the following way:

$$A_t = \left[\frac{\lambda_t}{U_t} - \lambda_t\right]\left(\frac{U_t}{V_t}\right)^{1-\alpha}$$

with A_t, α and V_t defined previously.

In our estimation of labour market efficiency we decided to exploit the first approach, as implemented in Barnichon and Figura (2011), since it can naturally be extended to capture both transitions into and out of unemployment, and transitions to employment in different regions or fields of education.

Other studies which explore the matching efficiency for Bulgaria include Petkov (2011) and Arpaia, Kiss, and Turrini (2014). Petkov (2011) estimates the matching function by applying a panel regression approach for the period 2004–2011, using the regional dimension of Employment Agency data. Arpaia, Kiss, and Turrini (2014) investigate the matching efficiency for the period 2000–2013 for a number of European countries, including Bulgaria. The authors provide estimates of the matching efficiency on a country level by following the approach of Veracierto (2011) and calculate additionally a skill, sectoral and regional mismatch indicator for each country.

Our paper adds to the rest of the literature by including in the exploration a more recent time period – from 2004 to 2017, as well as by using not only the regional dimension of the Employment Agency data, but also by taking into account its variations by fields of education in the panel regression estimation of the matching function. Moreover, the paper provides an estimate of the changes of the matching efficiency over time for each of the regions and fields of education separately. This approach aims to enhance the discussion of the structural shifts in labour demand and its effects on labour supply shortages.

3. Data

Our analysis is based on monthly Employment Agency data for the number of registered unemployed persons and vacancies[30] by regions and by fields of education[31] (see Figure 1). The sample covers the period January 2004 to December 2017. The data also contains information about newly registered unemployed and job starters[32] at the same disaggregation level, as well as age structure of unemployed which would allow us to study the demographic changes during the period. For the purpose of descriptive analysis we use data aggregated to annual frequency, while we use monthly seasonally adjusted data for estimating the matching efficiency.[33] Unemployed and job vacancies in different fields of education and regions are scaled by the total labour force in the respective age group to present the Beveridge curve. In terms of degree of education, it should be noted that not all the unemployed in the group of specialists have tertiary education: some of them have only professional qualification in a given field. This is the case for fields of education

[30] Vacancies declared during the month.

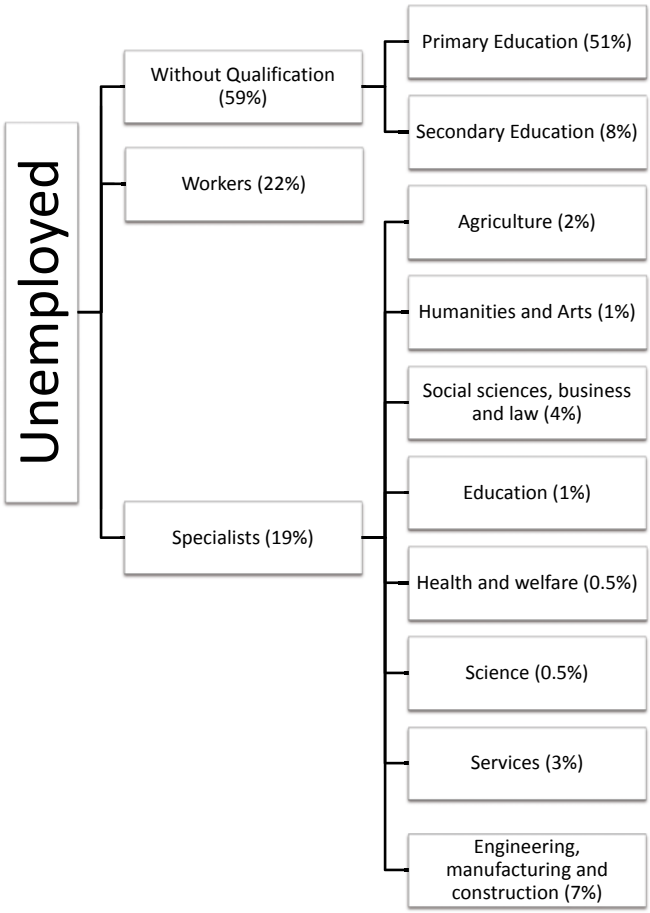
[31] These are stated by unemployed persons and correspond to the international classification of the fields of education FOET 1999.

[32] Unemployed persons starting job during the month.

[33] Seasonally adjusted with Oxmetrics and R package seasonal.

"Agriculture" and "Engineering, manufacturing and construction", where only around one-fourth of the unemployed have tertiary education, while in the other fields they are predominantly university graduates. As a rule, most people with low education seek employment through the Employment Agency, with the proportion of people with primary education accounting for over half of the total number of unemployed.

Figure 1: **Structure of the Pool of Unemployed Persons**



Unemployed persons as a percent of total unemployed, average for the period 2004–2017.

A limitation of the analysis is that available fields of education can not be directly linked to other data sources (*e.g.* National Accounts) to verify the obtained results. Another data constraint is associated with the vacancy series: while figures on registered unemployed are administrative statistics and are comprehensive, those on job vacancies posted to the Employment Agency are only a fraction of all vacancies posted in the economy since private firms are likely to recruit not only through the Employment Agency. However, in the descriptive analysis we are focusing on the dynamics of the indicators and the availability of more representative data on job vacancies most likely would have an impact only on the level of indicators rather than on their dynamics. Another shortcoming of the data is that each field of education covers a number of professions that cannot be individually examined to discover what specifically affects the respective field. For example, the field "Engineering, manufacturing and construction" contains a number of categories[34], with certain categories being specific to either manufacturing or construction, yet the level of aggregation of our dataset prevents us from distinguishing between them.

As a general note on our dataset, the number of unemployed persons and the vacancies have been decreasing simultaneously for the period 2004–2008, which seems to contradict theoretical expectations. There are several possible reasons (that most likely interact with each other) which can explain these developments. First, according to National accounts data, the sectors of "Construction" and "Wholesale and retail trade, transport, accommodation and food service activities" accounted for the major part of the employment growth during the pre-crisis period. These are sectors that typically use less educated staff, which was in abundant supply between 2004 and 2008. Therefore, it is likely that companies did not have to post job vacancies at the Employment Agency. Another reason for the atypical behaviour of vacancies in the upturn is that with the onset of global crisis, the level of unemployment started to rise and the government initiated many subsidized employment schemes, which may have incentivised entrepreneurs to post vacancies.

[34] These categories are: Chemical and process; Environmental protection technology; Electricity and energy; Electronics and automation; Mechanics and metal work; Motor vehicles, ships and aircraft; Manufacturing and processing of the following: Food processing, Materials (wood, paper, plastic, glass), Materials (wood, paper, plastic, glass); Mining and extraction; Architecture and town planning; Building and civil engineering; Broad programmes involving narrow field.

4. Descriptive Results

As already indicated in the previous section, the actual pattern of the selected indicators in general is not always in line with theoretical expectations. In this section we will briefly describe the theoretical dynamics of each indicator during recessions or economic upturns, and we will provide possible explanations for deviations of the actual behaviour from the theoretical framework.

The negative relationship between vacancies and unemployment presented by the Beveridge curve allows us to determine the cyclical state of the labour market. When economic activity slows down, there is a downward movement along the curve: firms open less vacancies and the number of unemployed rises. During a recovery upward movement along the curve is observed: firms increase vacancies and the number of unemployed starts to decline, typically with some lag. The position of the curve with respect to the axes indicates the degree of efficiency: the closer the curve is to the axes, the fewer unemployed there will be for the same number of vacancies, reflecting higher efficiency. So, an inward shift of the Beveridge curve is an indication of increasing efficiency. When the Beveridge curve shifts outward (away from the axes), this is interpreted as a sign of decreasing efficiency in the labour market caused by structural reasons, since unemployment and vacancies rise simultaneously.

Labour market tightness, or the ratio of vacancies to unemployed, measures how many unemployed are competing for a vacancy. Theoretically, the indicator should increase during an expansion part of the cycle because there are more vacancies and fewer unemployed than in a downturn.

The job-finding rate tends to increase during economic upturns since the number of vacancies increases and the number of unemployed begins to decline.

The interpretation of the job-separation rate is less clear-cut because people quit jobs during an economic expansion too, but there are big spikes in the indicator associated with large-scale lay-offs. However, we can use the job-separation rate together with movement along the Beveridge curve to determine the beginning of a recession.

Utilising the structure of the available dataset, we define job-finding and job-separation rates more precisely than in the literature review, so the job-finding rate is the ratio between newly hired and the total number of unemployed and job- separation rate as the ratio between newly registered unemployed and

the total number of unemployed persons by educational fields and regions. In combination with the labour market tightness indicator, the higher the job-finding rate for a given labour market tightness, the more efficient the matching process. The investigation of job-finding and job-separation rates is an indirect approach to assessing Beveridge curve shifts.

In order to better understand the labour market processes, we use data on the age structure of the unemployed. In the analysis of age structures by fields of education, we use the percentage change in the number of unemployed persons in 2017 compared to 2008, when the unemployment coefficients are relatively comparable. Also, in order to simplify the analysis, we have divided the unemployed into persons up to the age of 39 and over 40 years of age.

4.1. Results across Fields of Education

For a number of fields of education the vacancy-unemployment relationship appears to follow the typical counter-clockwise looping movements that ensue from labour demand shocks. According to the Beveridge curve shape for the total economy (see Figure 2), in the period 2004–2008, the unemployed decreased, along with the decrease in vacancies (the shortcoming in the data mentioned above).

For the economy as a whole, as well as by fields of education, we observe an improvement in labour demand and supply matching between 2004 and 2008. During the global crisis period, the curve shifted its course, which is related to the destruction of jobs and the increase in unemployment. The severity of the recession and the sluggish recovery that followed led to lacklustre job creation and low vacancy rates in most fields of education. In the post-crisis period the Beveridge curve started to move in the theoretically predicted direction (with the increase in vacancies, unemployment began to decline), most notably after 2013–2014.

Labour market tightness was respectively high during 2006–2008 and especially in 2016–2017, when demand for labour was high and supply was limited.

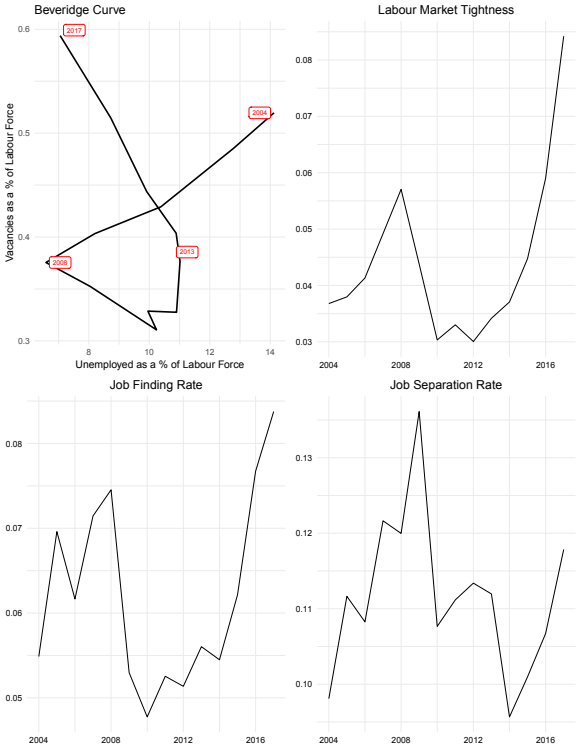
The dynamics of the job-finding rate are similar to the one of labour market tightness, with the highest values observed in periods of high demand and strong positive GDP growth.

The job-separation rate recorded its highest value in 2009 in the midst of the global crisis, indicating massive layoffs. In 2012 there was another spike, probably induced by the sovereign debt crisis in Europe. Towards the end of the period analysed (2004–2017) labour market tightness was high mainly due

to the higher contribution of the primary and secondary education groups. The job-finding rate was also at its highest in 2017, a stylised fact which was observed in all fields of education.

The share of unemployed over the age of 55 in the total number of unemployed persons has more than doubled, almost entirely at the expense of the unemployed up to 29 years of age. A similar trend is also observed in Labour Force Survey data, which implies that because of a decrease in the young population due to demographic factors, its participation in the labour market is declining. At the same time, people over the age of 55 tend to increase their participation in the labour market, partially related to the gradual increase of the retirement age.

Figure 2: **Total for the Economy**



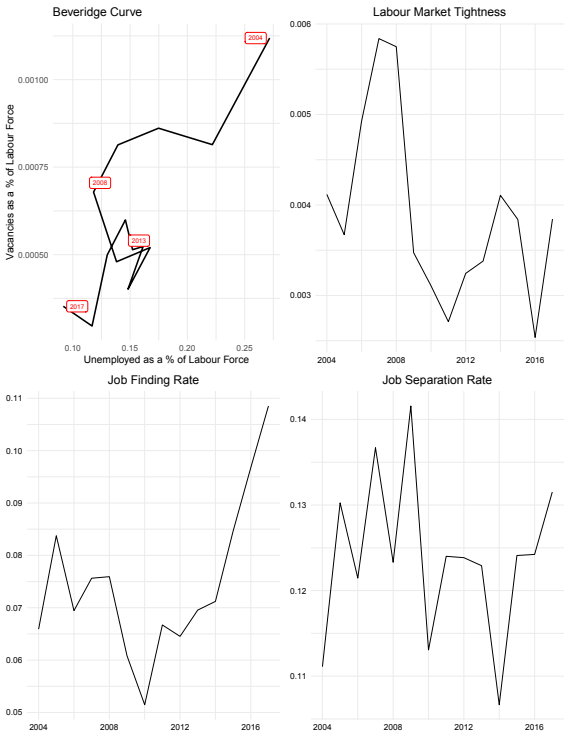
Source: Employment Agency, own calculations.

In conclusion, in 2017 according to the Beveridge curve the labour market was less efficient compared to 2008 because, for a similar level of unemployment, there was a larger number of unfilled vacancies. However, the latest data point on the curve moved upward and inward, and the job-finding rate was historically high, signalling improved efficiency.

4.1.1. Specialists with Education in "Agriculture"

In this field of education the Beveridge curve (see Figure 3) shows declining demand and supply of labour for the whole period, which can be related to the shrinking share of this sector in the economy. The unemployment rate declined over the whole period and the Beveridge curve moved inward, yet due to sector-specific factors, supply and demand declined throughout the period. Some of these sector-specific factors limiting supply and demand for

Figure 3: **Agriculture**



Source: Employment Agency, own calculations.

labour include consolidation of farms, labour mechanization and labour force outflow from the rural areas[35] that have resulted in a decrease in the share of agriculture in employment. This is a protracted process that started in the early 1990s, linked to increased external and internal migration. Another trend is the more intensive cultivation of crops requiring mechanized processing[36], which reduces the need for human labour. Labour market tightness experienced its highest values in 2007–2008, while after that period there were less unemployed per one vacancy. The lower labour supply in the post-crisis period, mainly because of the reduction of persons over 40 years of age, and the rising labour demand toward the end of the examined period determine the dynamics of the job-finding rate. In the observed period there were three peaks of the job-separation rate – in 2005, 2007 and 2009, probably linked to the factors outlined above. The end of the period is characterised by a more noticeable improvement in the indicators, with the job-finding rate starting to grow rapidly, the job-separation rate standing at relatively low levels and labour market tightness being comparatively low. This indicates increased efficiency in this field in comparison to the pre-crisis period.

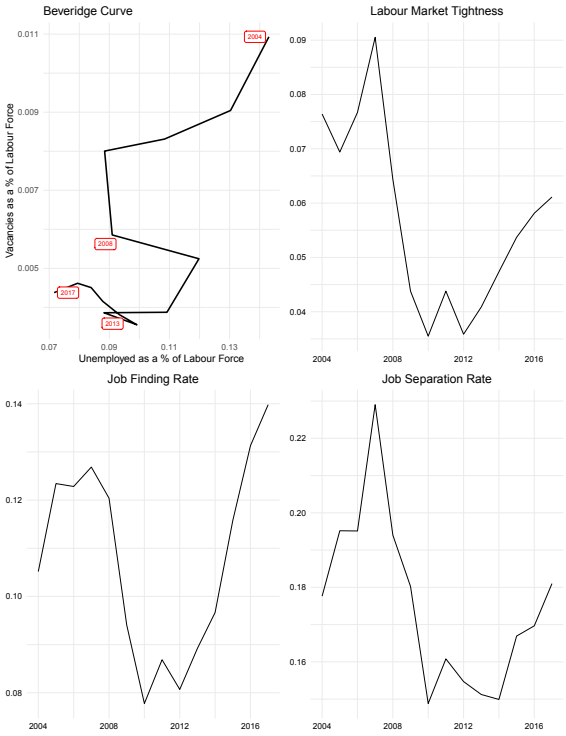
4.1.2. Specialists with Education in "Humanities and Arts"

Until 2012 the dynamics of the Beveridge curve in this field (see Figure 4) were similar to that in "Agriculture", with simultaneous decreases in unemployed persons and vacancies, followed by an upward correction in vacancies after 2012. Labour market tightness reached its maximum in 2007 and declined afterwards due to a reduction in vacancies. In 2012, a more sustainable recovery of supply-demand matching in this field of education began, with the job-finding rate starting to grow and the job-separation rate stabilising at comparatively low levels. This sector seems to be performing well toward the end of 2017 compared to the previous years, as there were still low levels of labour market tightness and the job-finding rate stood at a historically high level, implying that efficiency in this field was relatively high. Also, the Beveridge curve began to move in a theoretically-consistent manner, with vacancies rising and unemployment declining.

[35] Source: Population statistics of the NSI.

[36] Source: Farm Structure Survey of the Ministry of Agriculture, Food and Forestry.

Figure 4: **Humanities and Arts**

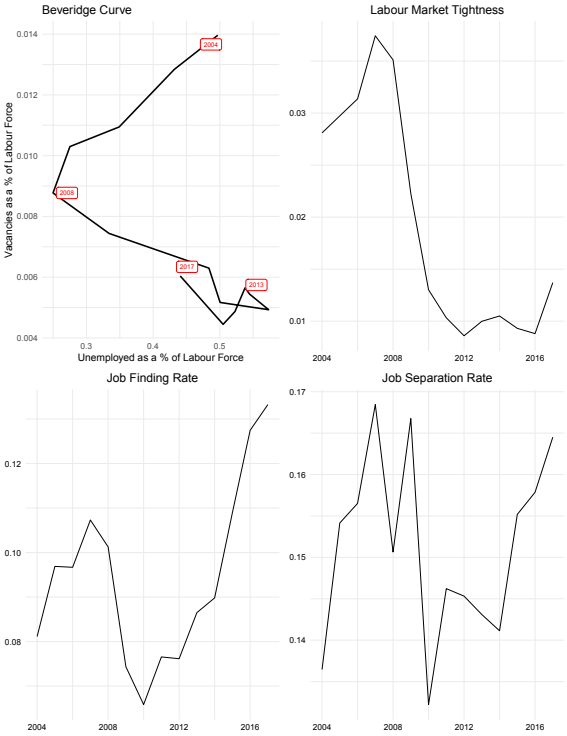


Source: Employment Agency, own calculations.

4.1.3. Specialists with Education in "Social Sciences, Business and Law"

Over the pre-crisis period the Beveridge curve for this field of education (see Figure 5) was similar to that for the economy as a whole. With the onset of the global crisis the Beveridge curve took a downward course, indicating large-scale job destruction and rising unemployment. Labour market tightness was high in 2007–2008 and declined afterwards. However, the underlying factor was not lower labour supply. In the post-crisis period, demand (measured by the number of vacancies) was decreasing, while there was an increase in labour supply – in 2017 compared to 2008, the number of unemployed up to 39 years of age was nearly 140 percent higher and for those over the age of 40 there was a modest increase. The excess supply was due to the large flows of graduates for this fields of education: for the whole period the share of graduates in this

Figure 5: **Social Sciences, Business and Law**

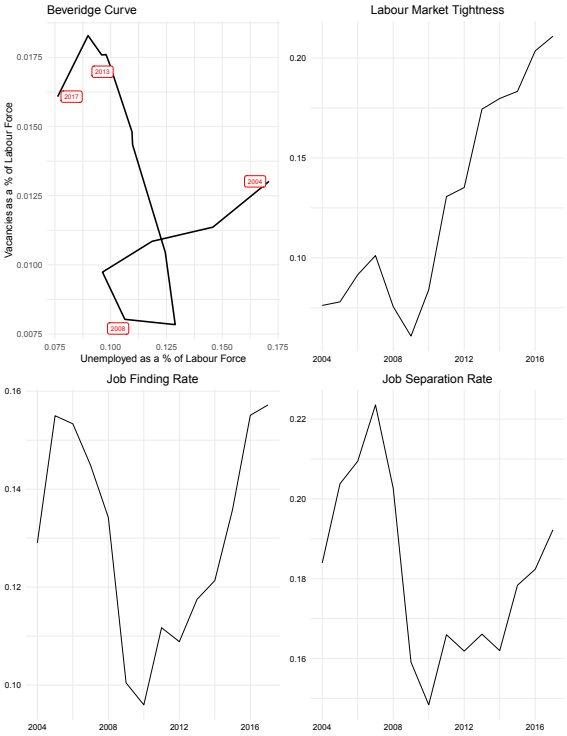


Source: Employment Agency, own calculations.

field in total graduates was more than 40 percent.[37] The job-finding rate was high in 2016–2017, coinciding with a high job-separation rate, which indicates substantial turnover in this field of education. After 2013, despite the high levels of the job-finding rate, there was a minor improvement with supply still exceeding demand[38] and the job-separation rate being close to its pre-crisis levels. Towards the end of the studied period the position of the Beveridge curve and the level of labour market tightness suggest that this area of education is still recovering and that future demand can be satisfied. Efficiency seems to have improved somewhat compared to the first years of the post-crisis period.

[37] Source: Students by educational qualification degree and narrow field of education of the NSI.
[38] Given the shares of unemployed and vacancies to the total unemployed and vacancies.

Figure 6: **Education**



Source: Employment Agency, own calculations.

4.1.4. Specialists with Education in "Education"

According to the Beveridge curve the rise of unemployment in this field of education began in 2007 (see Figure 6), but due to the importance of the sector and its public funding, the curve moved inward relatively quickly in 2010. After that, job vacancies started to grow very fast without having a substantial impact on unemployment, most likely due to the limited labour supply. The main reason for the constrained supply seems to be the ageing of staff[39] (over 50 percent of teachers are 50 years old or over) and the low number of new entrants in the system. After 2011, this field of education experienced high values of labour market tightness due both to higher labour demand and lower supply. According to the age structure of the unemployed, labour supply

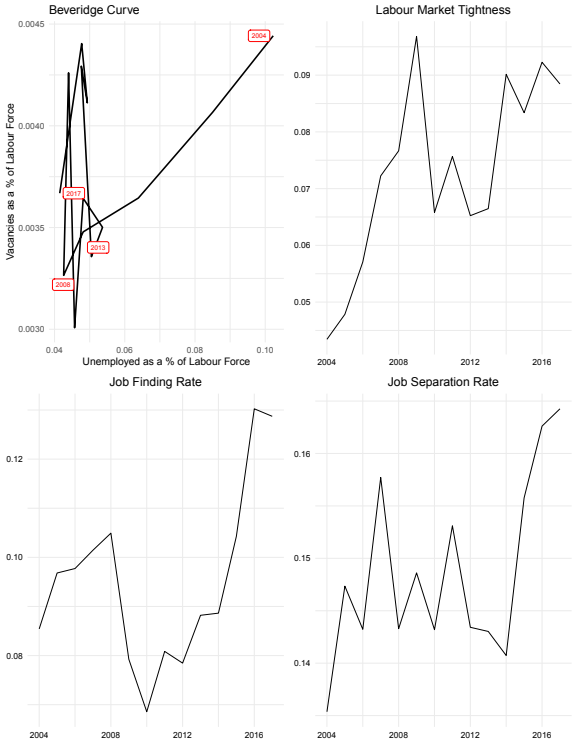
[39] Source: Teaching staff in general schools by age, NSI.

decreased on average by about 30 percent both in the age group up to 39 and for those over 40 years of age. Despite the earlier shift of the Beveridge curve and the fast increase of vacancies, the job-finding rate reached its pre-crisis levels only recently. The job-separation rate moved in line with the Beveridge curve, with a spike in 2007. Toward the end of the period analysed this indicator stood at intermediate levels. The implications for labour market efficiency are not definitive, as the Beveridge curve moved inward and upward, indicating rising efficiency, while at the same time there was insufficient supply according to the labour market tightness indicator.

4.1.5. Specialists with Education in "Health and Welfare"

Over the period 2004–2007, the Beveridge curve in this field of education (see Figure 7) moved down and to the left, indicating a gradual filling of vacancies and a drop in unemployment. After 2008 there was a large fluctuation in

Figure 7: **Health and Welfare**



Source: Employment Agency, own calculations.

vacancies and a slight increase in unemployment. The much lower increase in unemployment compared to other fields of education even over the global crisis period reveals the inelastic demand for healthcare professionals. Starting in 2004 the labour market tightness in this field was on the rise, indicating insufficient labour supply, with a slight decrease between 2010 and 2014. According to the age structure of unemployed, in 2017 compared to 2008 the number of unemployed up to the age of 39 increased by 44 percent, while those over 40 years of age decreased by 25 percent. Despite the decrease, the number of persons in the second group was higher.

By 2017 job-finding and job-separation rates had reached historically high levels, suggesting high turnover in this field of education. Most likely this is due to the growing share of private healthcare spending.[40] Additionally, it is likely that the establishment of a large number of private hospitals has contributed to the expanded pool of job opportunities for the healthcare professionals.

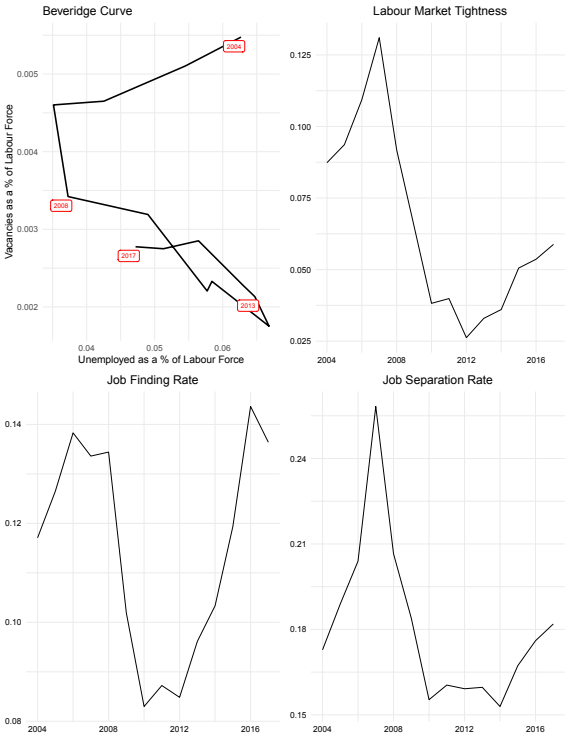
The relatively larger discrepancy between the shares of unemployed and vacancies as a percent of the total in the "Education" and "Health and welfare" fields compared to the other specializations may be due to the fact that these sectors have large public sector participation. The respective institutions (schools and hospitals) are obliged to post vacancies at the Employment Agency, while in the private sector this is optional and the decision to do so is usually related to applying for various subsidized employment schemes.

4.1.6. Specialists with Education in "Science"

As evident from the Beveridge curve, unemployment started to increase in 2007 (see Figure 8) and moved inward in 2012. The labour market tightness indicator suggests that there was enough labour supply in post-crisis period (mainly due to the increase in the number of unemployed up to the age of 39), with the indicator posting a rise only recently. The job-finding rate increased in upturns similarly to other fields of education, and stood at a high level in 2017. The peak of the job-separation rate in 2007 is in line with the dynamics of the Beveridge curve. Toward the end of the sample the job-separation rate stood at comparatively low levels. Given the higher unemployment rate and the lower level of vacancies, over the post-crisis period labour market efficiency appears lower than in the pre-crisis period.

[40] Source: System of Health Accounts, NSI.

Figure 8: **Science**



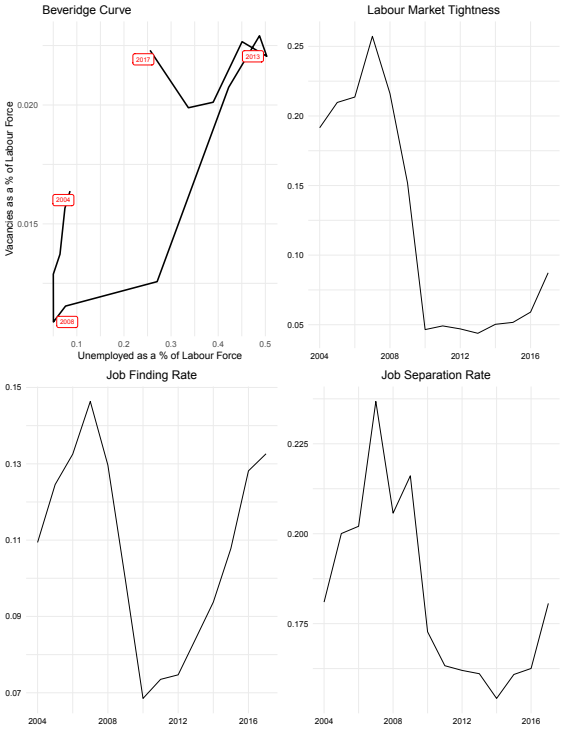
Source: Employment Agency, own calculations.

4.1.7. Specialists with Education in "Services"

Services is the field of education affected relatively strongly by the global crisis, with the Beveridge curve shifting outwards in 2009 (see Figure 9). This is the only field of education where unemployment and vacancies increased simultaneously (leading to outward movement of the points of the curve) in the wake of the global crisis, which is indicative of declining efficiency, probably caused by mismatch of a structural nature. In 2007 the labour market tightness was at historically high levels, reflecting the reduced supply. After that there was a large decrease in the indicator, given the higher vacancy rate and the large increase in supply both for people under 39 and for those over 40 years of age. In the last years of the period 2004–2017 the job-finding and job-separation rates give indications that this field of education was still recovering and the

unemployment rate was substantially above its 2008 levels. Given the level of vacancies, this points to an existing mismatch and low efficiency.

Figure 9: **Services**

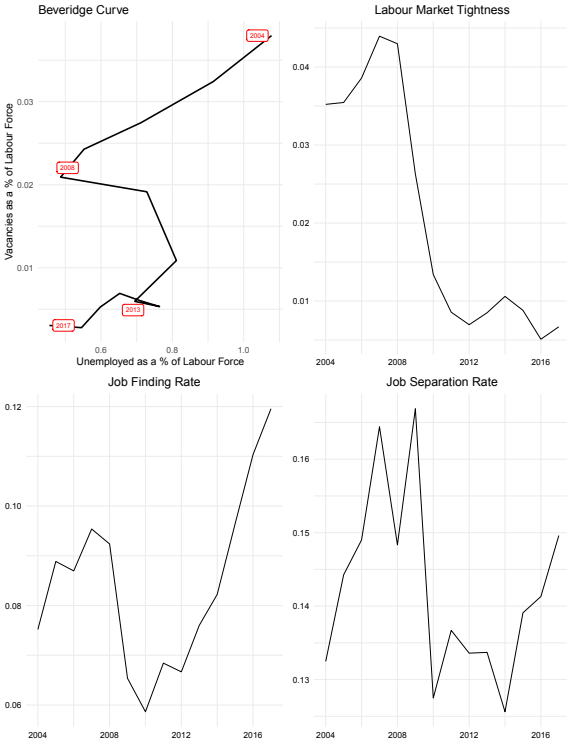


Source: Employment Agency, own calculations.

4.1.8. Specialists with Education in "Engineering, Manufacturing and Construction"

Unemployed and vacancies for this educational field declined simultaneously over almost the entire period, with the Beveridge curve sloping upwards (see Figure 10). The global crisis period was an exception to this pattern, and there was another temporary outward shift in 2012, probably caused by the sovereign-debt crisis in Europe. With the onset of global crisis and the concomitant contraction in construction activity, the demand for construction specialists dropped, which is a possible explanation for the declining vacancy rate in the post-crisis period. Tightness experienced a big drop in the post-crisis period and stood at relatively low levels toward the end of 2017. The dynamics of the job-finding rate after

Figure 10: **Engineering, Manufacturing and Construction**



Source: Employment Agency, own calculations.

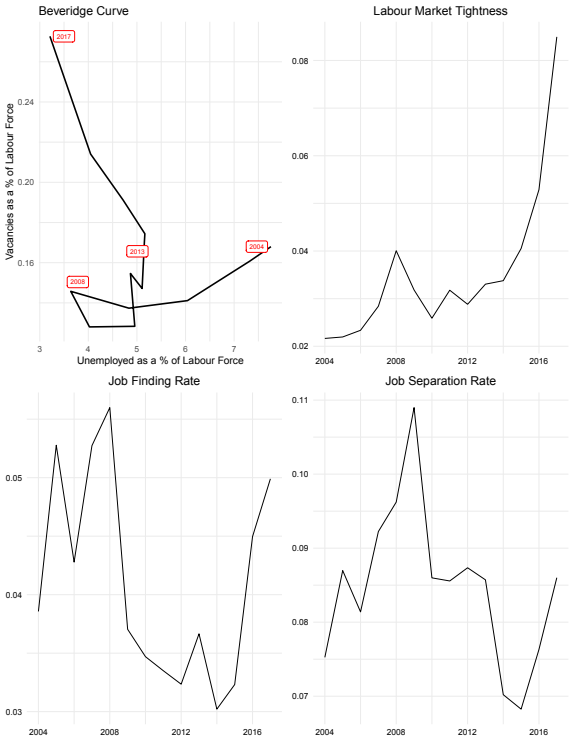
2015 imply a higher probability of finding a job for unemployed persons with such specialization, while the job-separation rate stood at moderate levels. As far as the age structure of the unemployed is concerned, in the post-crisis period, the unemployed up to the age of 39 were increasing, and those over the age of 40 were on the decrease. The lower levels of vacancies indicate depressed labour demand. Despite that, the unemployment rate and labour market tightness were low, indicating high efficiency in this sector.

4.1.9. Persons without Educational Qualification Having Primary Education

The group of people with primary or lower education occupies the largest share among job-seekers registered at the Employment Agency. One possible explanation is that these people are experiencing greater difficulty finding a job and need an intermediary in this effort. There was no substantial rise in

unemployment for this group after 2008 according to the Beveridge curve (see Figure 11). The reasons for this could be the general decline in the number of persons with basic and lower education, and their transition to higher qualification groups, as well as the bigger propensity of these individuals to leave the workforce. Age data confirms the above statement, with the unemployed up to 39 years of age declining by 24 percent in 2017 compared to 2008. Between 2010 and 2015 vacancies rose without any response in unemployment, indicating declining efficiency in this period. Toward the end of the 2017 the labour market tightness indicator for this field of education stood at its highest values, which can be interpreted as evidence of emerging labour shortages, which may have forced entrepreneurs to recruit less educated workers. The job-finding rate was consistent with the tightness indicator and started to recover after 2015. Firms laid off workers with primary education more intensively only in 2009 and toward the end of the period the indicator

Figure 11: **Primary Education**



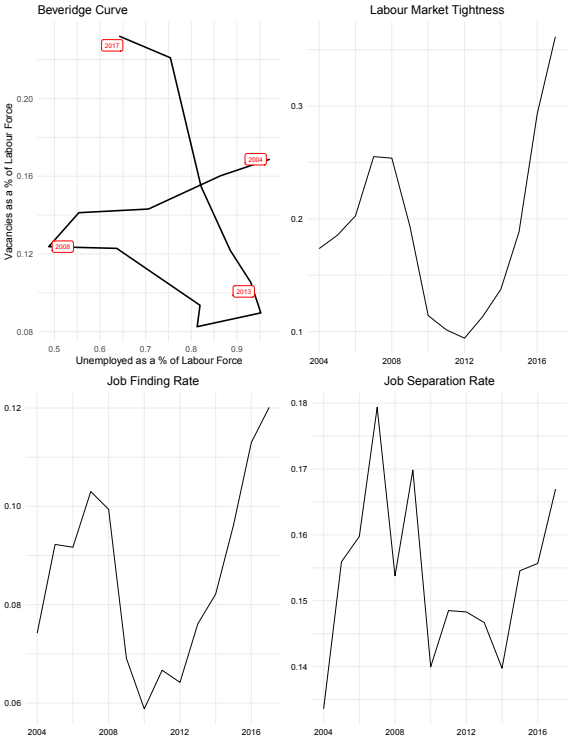
Source: Employment Agency, own calculations.

was at low levels. After 2015, unemployment is declining with job-finding rate going up, which we interpret as rising efficiency.

4.1.10. Persons without Educational Qualification Having Secondary Education

This group was strongly affected by the global crisis. The Beveridge curve shifted its movement in 2009 and moved downward until 2012 (see Figure 12). With the increase of demand in the post-crisis period, labour market tightness began to increase, reaching the highest values in 2016–2017. The recovery of efficiency started in 2012 with an increase in the job-finding rate and the number of vacancies, yet labour demand increased more than supply and the unemployment-vacancy points on the Beveridge curve began moving inward and up, *i.e.* there was a slight decrease in unemployment accompanied by a

Figure 12: **Secondary Education**



Source: Employment Agency, own calculations.

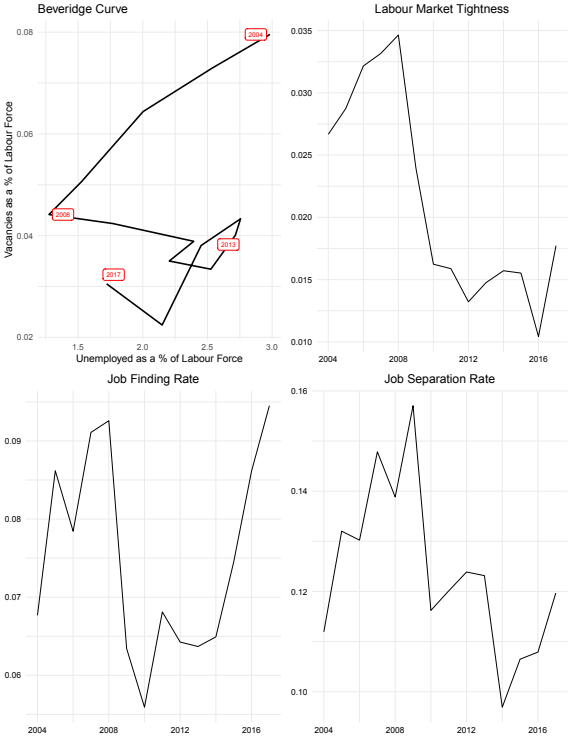
sharp increase in vacancies. The job-separation rate reached its peak in 2007, accompanied by another one in 2009. Similar levels were recorded toward the end of the period under investigation. In 2017 compared to 2007 the number of unemployed persons with secondary education increased by 24 percent, probably as a result of a general increase in the educational level of the population and, in particular, of those with primary education. The position of the Beveridge curve with respect to the axes suggests that in this group the labour market has become less efficient, with a higher unemployment rate despite the larger demand.

4.1.11. Persons without Educational Qualification Having Workers' Professions

Persons with workers professions constitute the second largest subgroup in the unemployment pool after primary education. The Beveridge curve moved downward in pre-crisis period for this educational field, with 2009 being the turning point (see Figure 13). A process of recovery started in 2015 with the Beveridge curve reversing direction, yet a rise in vacancies was only observed in 2017. Labour market tightness was relatively high in the pre-crisis period but with falling demand after 2009 it rapidly decreased. The dynamics of the job-finding rate were similar to those for the primary education field, with the exception that it reached its maximum in 2017. The job-separation rate peaked in 2009, but stood at relatively low levels in the post-crisis period. In 2017, compared to 2008, there was an increase in the number of unemployed over the age of 40, while those up to the age of 39 remained almost unchanged, which can be interpreted as evidence of ageing in this group. Labour market efficiency in 2017 appears higher than pre-crisis period, reflecting almost the same unemployment rate as in 2007 and lower vacancy rate.

As a recapitulatory comment on the descriptive analysis by fields of education, the global financial crisis affected the different sectors across the board, but specific factors also had an impact. Labour market tightness peaked around 2008 for almost all fields of education, while post-crisis developments were more diverse and additional indicators suggest some heterogeneity of labour market outcomes across educational fields. During the 2015–2017 period there was declining efficiency in some fields of education, despite the increase in economic activity.

Figure 13: **Workers' Professions**



Source: Employment Agency, own calculations.

4.2. Results by Administrative Regions

The indicators used to describe the regional dynamics of unemployment and vacancies during the period 2004–2017 are almost the same as in the previous section, with the exception of the job-separation rate, which cannot be calculated due to data unavailability.

During the period 2004–2008, all regions experienced a drop in unemployment, with the shift of the Beveridge curve observed in 2009 (see Figure 14). In 2017 the unemployment rate was higher than its pre-crisis levels in seven regions, including Blagoevgrad, Burgas, Sliven, Sofia, Varna, Vidin and Vratsa. Demand, as measured by the number of vacancies, decreased more noticeably in 2017 compared to 2008 in the following regions: Razgrad, Vratsa and Vidin;

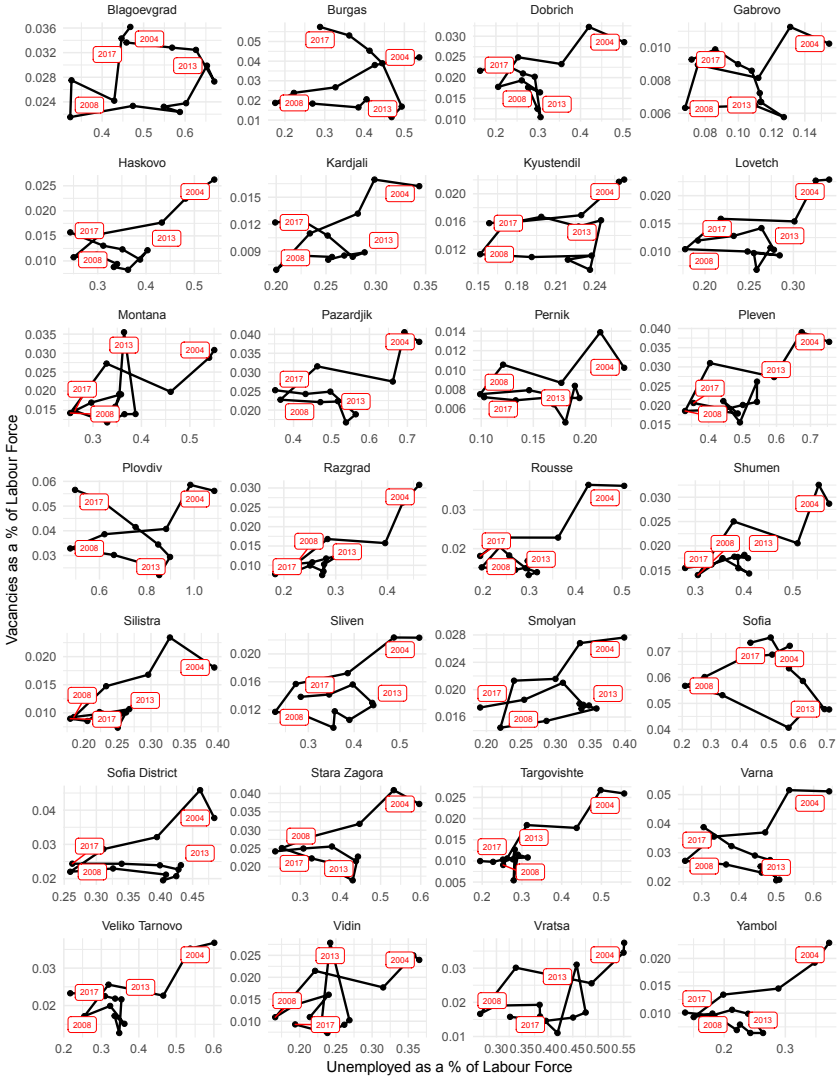
in the latter two regions, unemployment was higher compared to 2008, which likely reflects labour demand problems in these regions.

Labour market tightness was rising during the 2004–2007 and 2013–2017 periods for almost all regions (see Figure 15). Administrative regions that did not reach the 2007–2008 levels of tightness by 2017 are located mostly in northern parts of the country (more noticeably in north-east and north-west), with the exception of Pernik, Sliven and Sofia, where tightness is also low. Labour market tightness is the lowest in the regions with the highest unemployment rates in the north-west and north-east part of the country.

The job-finding rate typically follows the dynamics of labour market tightness and this is the case for almost all regions (see Figure 16). In 2017 the job-finding rate recorded the maximum value for the period analysed in all regions of the country excluding Montana, Ruse, Shumen, Sofia, Vidin and Vratsa. This is consistent with the outcome for the tightness indicator, except for Ruse, where tightness was high in this period. Measured by the job-finding rate, the recovery started at the earliest in 2012 for the following regions: Gabrovo, Kyustendil, Plovdiv, Razgrad, Sofia, Sofia District, Stara Zagora, Targovishte, Varna and Veliko Tarnovo. In 2013, the job-finding rate in the regions of Burgas, Dobrich, Kardzhali, Lovech, Pazardzhik, Pernik, Ruse, Shumen, Silistra, Sliven, Smolyan and Yambol also responded, and in 2014 Haskovo and Pleven followed suit. The other four regions – Blagoevgrad, Montana, Vidin and Vratsa – underwent a rise and a sharp fall in the indicator over the period 2012–2014, probably linked to more extensive temporary employment schemes in these regions.

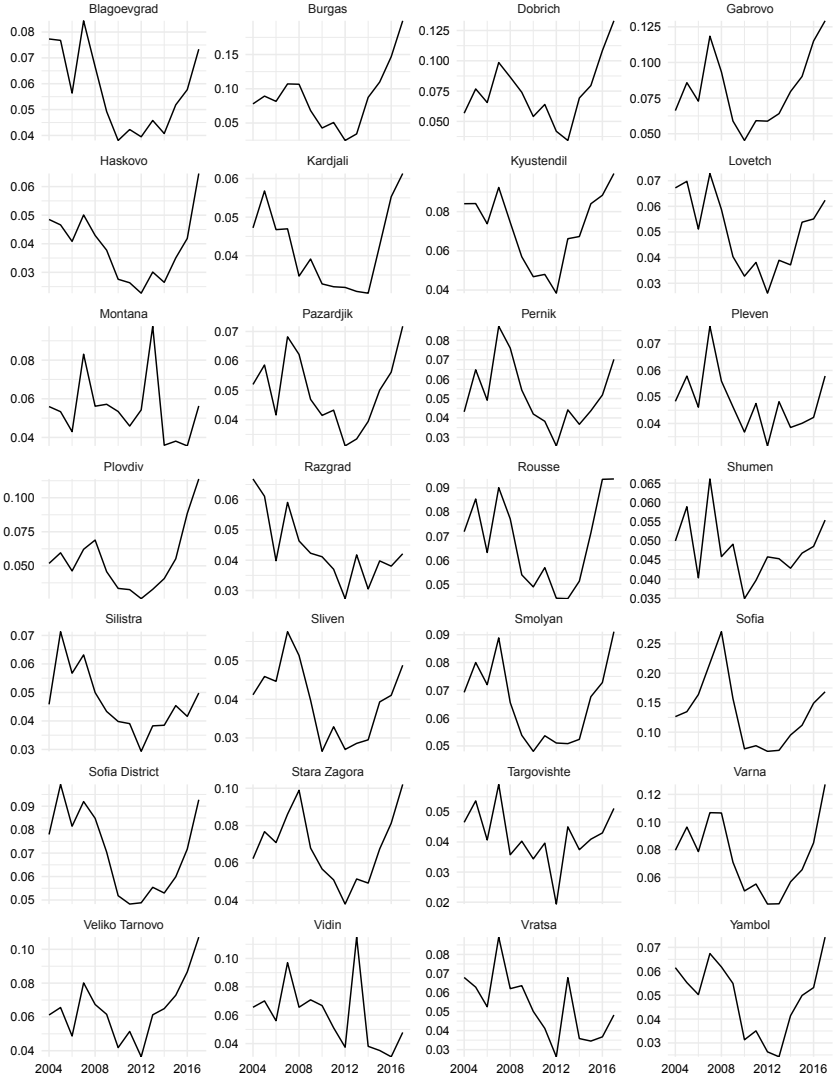
The implications of these facts for labour market efficiency are mixed, since regions with both higher levels of unemployment and job vacancies are expected to have, in principle, lower labour market efficiency in comparison to the pre-crisis period. Yet, for the big regional centres (Sofia, Burgas, Varna) this higher unemployment rate is due to the increased supply through the whole period, a direct consequence of substantial internal migration. For other regions (Vidin, Vratsa), where supply shrank, the higher level of unemployment is probably entrenched due to structural factors and may require specific policy actions in order to be resolved.

Figure 14: **Beveridge Curve – Unemployed and Vacancies as a Percent of Labour Force by Regions**



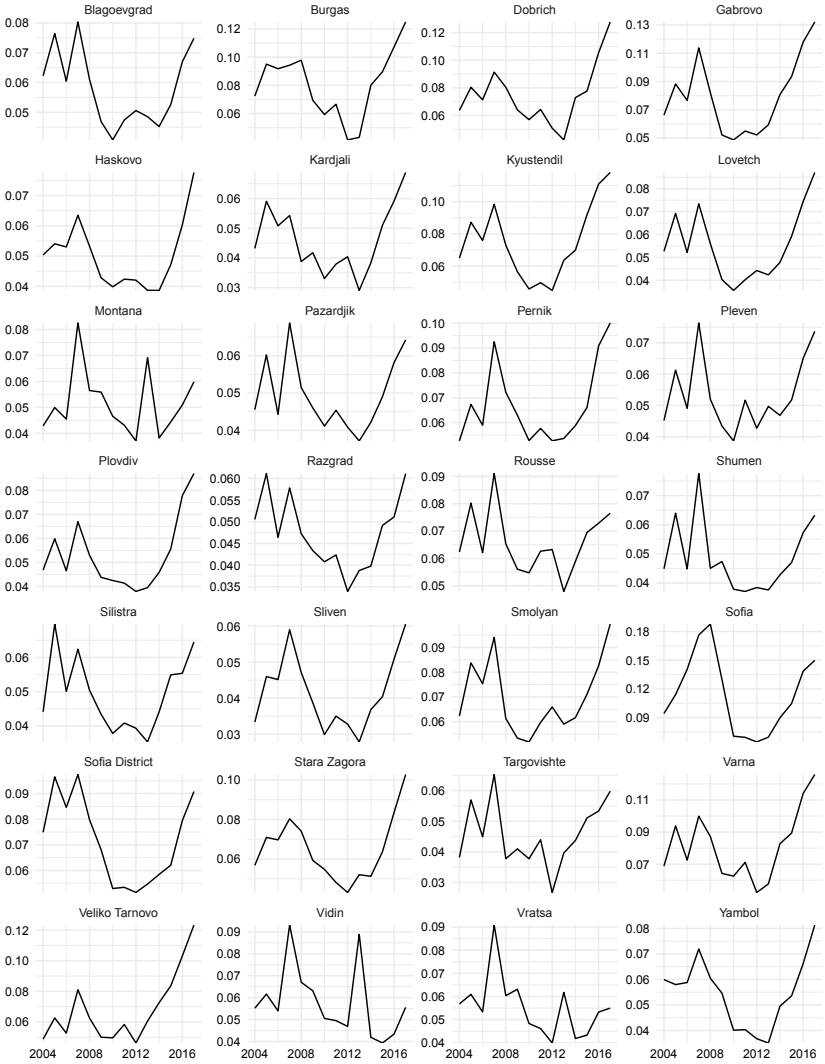
Source: Employment Agency, own calculations.

Figure 15: **Labour Market Tightness – Ratio of Vacancies to Unemployed by Regions**



Source: Employment Agency, own calculations.

Figure 16: **Job Finding Rate – Ratio of Job Starts to Unemployed (End of Period) by Regions**



Source: Employment Agency, own calculations.

5. Econometric Results

5.1. Methodology

5.1.1. General Notes

Our approach to assessing the degree of labour market efficiency for the Bulgarian economy exploits the matching function as given by equation (1) and estimates it in a panel model framework. The matching function framework is a prominent approach to modelling labour market efficiency and constitutes a natural first step in studying these issues. Moreover, the available data is conducive to the application of this approach to the analysis of the Bulgarian labour market. The particular implementation works with a modification of equation (1) that was proposed by Barnichon and Figura (2011). The modification seeks to relax the assumption that transitions between employment and unemployment occur only *within* regions or fields of education that is implicit in the standard matching function approach. In cases where granular data on transitions between various forms of employment are unavailable, Barnichon and Figura (2011) suggest to use the specification

$$jf_{it} = m_i \theta_{it}^{\zeta} \theta_t^{1-\zeta}, \tag{4}$$

where the subscript i denotes the units (regions or fields of education) and the overall tightness θ_t serves as a proxy for transitions between sectors (*i.e.* finding employment in a different field of education or region). The term m_i can be treated as a slightly generalised version of the intercept $E_T(\ln m_{0t})$ in equation (3).

Taking logs in equation (4), we can estimate it and use the residuals as a measure of the sectoral deviations of matching efficiency around the respective long-run level. Going along this route effectively means that one focuses on the dynamics of efficiency for a specified sector without attempting comparisons of the level of efficiency across units (fields of education or regions in our case). As a consequence, while we report the estimated intercepts for the random effects models that are presented below, we do not attach any special significance to these values and treat them merely as inputs for the computation of the matching efficiency deviations from the long-run mean. However, in the discussion of the econometric analysis results we still use the term "efficiency" as a shortcut in order to avoid cumbersome references to the deviations of efficiency from its long-run level.

The above approach should not be treated as a strictly econometric one, since it entails working with a fixed theoretical structure and therefore loses some

of the flexibility associated with a purely statistical approach to estimating the association between the job-finding rate and tightness indicators. At the same time, it is necessary to test and modify accordingly those aspects of the estimation procedure that are not affected by the constraints of the chosen theoretical framework. We outline the main steps of this approach in the following paragraphs. The results reported relate to equation (4), transformed in logarithmic form. Note that, since the coefficients for sectoral tightness and overall tightness are constrained to sum to one, the coefficient for overall tightness can be treated as derivable from that for sectoral tightness, Thus, we can equivalently estimate a transformed version of the logged equation (4), for which ζ is the coefficient multiplying the difference of the logarithms of sectoral and overall tightness. As this approach constitutes a technical detail of the implementation and does not have substantive implications, we retain the use of the terms "sectoral tightness" and "regional tightness" in all tables reporting the estimation results below.

Since our main approach follows the theoretical structure prescribed by (4) and therefore enforces a constraint of the constant returns to scale type, it is legitimate to ask to what extent the latter constraint impacts the results. To address this question, the appendix presents the results from testing and estimating an unconstrained version of equation (4), *i.e.* $jf_{it} = m_i \theta_{it}^{\zeta_1} \theta_t^{\zeta_2}$. Overall, these results provide some evidence in favour of a decreasing-returns-to-scale specification of the matching function. The different methods (including the constrained versions of the model with either individual or time effects) also exhibit sensitivity of the sectoral tightness estimates with respect to the specification and the chosen estimation routine. Additionally, testing for autocorrelation in the residuals gives positive indications of autocorrelation, which can be anticipated in view of the monthly frequency of the sample data. Taken together, these findings suggest that in future research consideration needs to be given to the trade-off between adherence to an established theoretical framework versus exploiting a more data-driven but potentially less interpretable approach. The present work follows the first route, which can be interpreted as imposing a theory prior on the econometric analysis.

Our current approach takes the following steps to check the validity of the procedures employed and determine the details of the estimation method. First, we conduct a poolability test in order to establish whether using a panel estimation method holds any advantages over pooling the data and estimating an ordinary regression. Second, we test the appropriateness of including individual, time or two-way effects. Third, we run a Hausman test to determine whether to use a fixed-effect or random-effect estimation procedure. Following

that, we estimate the respective equations and extract the residuals to be used as a measure of efficiency variation.

The above steps were applied separately to the data by fields of education and by regions. The next subsection reports the details for the two tracks of the analysis.

5.1.2. Testing and Estimation Results for the Fields of Education Breakdown

The results of the poolability test for the fields of education data are presented in Table 3 in the appendix. Based on the test we can reject the null hypothesis of identical coefficients at the 0.1% level, which implies that we can proceed with estimation in a panel data framework.

Tables 4, 5 and 6 in the appendix report the results of testing for individual, time and two-way effects. For our model there is evidence supporting the three types of effects. We can thus take the two-way effects as the main specification, with individual and time effects used for comparison purposes.

To determine whether to estimate a fixed-effect or a random-effect model, we run a Hausman test. The results, presented in Table 7 in the appendix, indicate that random effects estimation is the appropriate route to take.

Based on the above testing framework, we estimate a two-way effect model based on equation (4). The results are provided in Table 1.

Table 1: **Restricted Matching Function Regression, Fields of Education Data, Two-way Effects**

	Dependent variable:
	Job-finding rate
Sectoral tightness	0.032^{***}
	(0.005)
Constant	-2.431^{***}
	(0.097)
Observations	1,848
R^2	0.018
Adjusted R^2	0.018
F Statistic	34.686^{***} (df = 1; 1846)
Note:	*p<0.1; **p<0.05; ***p<0.01

For comparison, in the appendix we present the results from estimating an individual effects model in Table 8 and those for a time effects model in Table 9.

5.1.3. Testing and Estimation Results for the Regional Breakdown

In parallel to the approach employed for the fields of education breakdown, we present the results of the poolability test for the regional data in Table 10 in the appendix. The null hypothesis of identical coefficients can be rejected at the 0.1% level, therefore estimation in a panel data framework is legitimate.

Tables 11, 12 and 13 in the appendix report the results of testing for individual, time and two-way effects. Again, evidence supporting the three types of effects is found, mirroring results for the fields of education case. Correspondingly, we take the two-way effects as the main specification and report the individual and time effects cases for comparison.

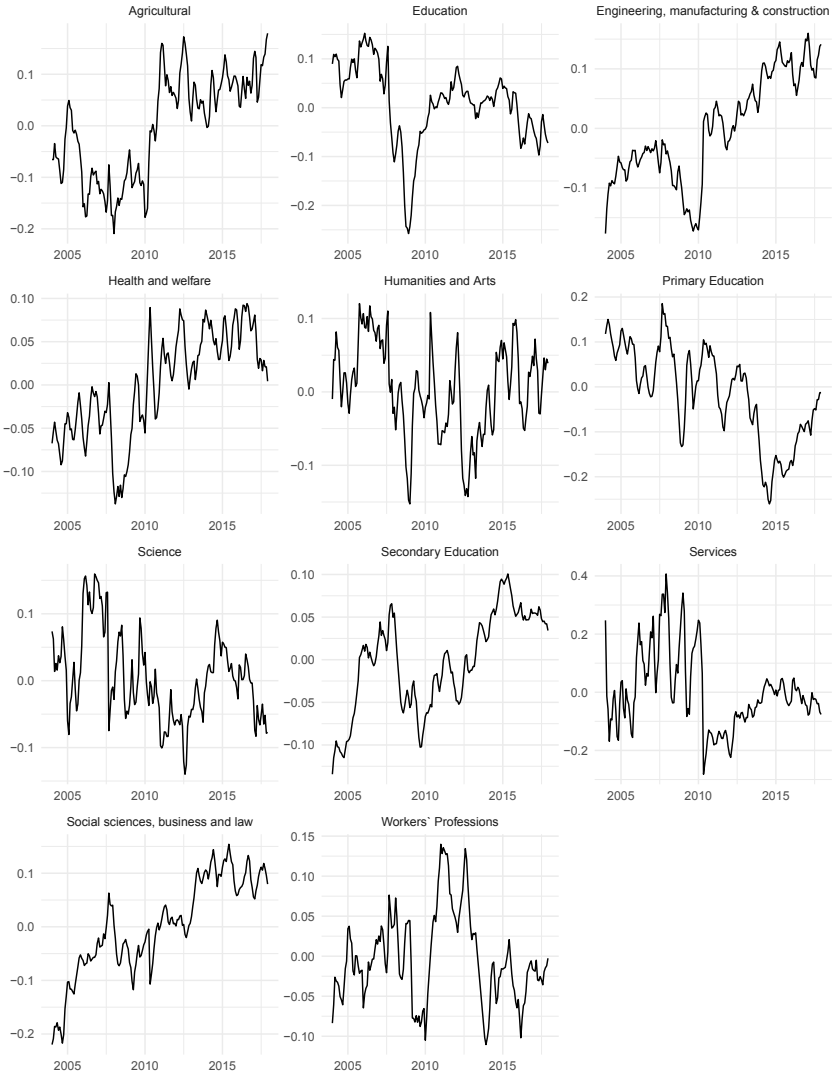
The results of the Hausman test are reported in Table 14 in the appendix. They indicate that employing fixed effects estimation is appropriate.

At the estimation step, we estimate the two-way effect model and report the results in Table 2. This compares with the results from estimating an individual effects model as shown in Table 15 and those for a time effects model, which are provided in Table 16, both presented in the appendix.

5.2. Estimated Changes in Labour Market Matching Efficiency across Fields of Education

The dynamics of labour market matching efficiency vary across fields of education (see Figure 17). The most significant improvement in comparison to the pre-2008 period was recorded in the following fields of education: "Agriculture", "Social science, business and law" and "Engineering, manufacturing and construction". Conversely, other fields, such as "Science", "Primary Education" and "Services", experienced a decline in efficiency.

Figure 17: **Labour Market Efficiency Dynamics by Field of Education**



Source: Own calculations.

Table 2: **Restricted Matching Function Regression, Regional Data, Two-way Effects**

	Dependent variable:
	Job-finding rate
Regional tightness	0.055***
	(0.004)
Observations	4,676
R^2	0.032
Adjusted R^2	−0.010
F Statistic	147.172*** (df = 1; 4481)
Note:	*p<0.1; **p<0.05; ***p<0.01

The rising efficiency in "Agriculture" is related to both lower demand and lower supply of labour, which is a direct consequence of the sector-specific factors discussed in Section 4. The increase in supply for "Social science, business and law" from 2000 onwards has matched the rising demand over past years. The improved efficiency in the field of education "Engineering, manufacturing and construction" is associated with a reduction in the large labour supply observed before 2008 and the higher job-finding rate after 2012.

In the field of education "Science" the efficiency started to recover from 2013 up to 2015. After 2015 the efficiency in this field declined again. This can be related to the rising demand for specialists with education in sectors such as computer science and communications, and the relatively slow response of supply.

Efficiency in the "Health and welfare" increased moderately for almost the entire period under investigation. A possible explanation for this development is provided by rising private expenditures in the healthcare system over the entire period. However, anecdotal evidence points to labour shortages in healthcare, even though according to healthcare data[41] the number of physicians per 100 people in 2017 is higher compared to 10 years earlier.

A recovery in the efficiency of group "Primary Education" started in 2015, reinforced by the favourable economic situation and the increasing external and domestic demand. Active labour market policies have also played a significant role because they were targeted at vulnerable groups in the labour market.

[41] Source: Population per physician and per dentist by statistical zones, statistical regions and districts of the NSI.

Notably, in the 2015–2017 period labour market efficiency seems to have declined somewhat in two thirds of the observed fields of education.

5.3. Estimated Changes in Labour Market Matching Efficiency across Regions

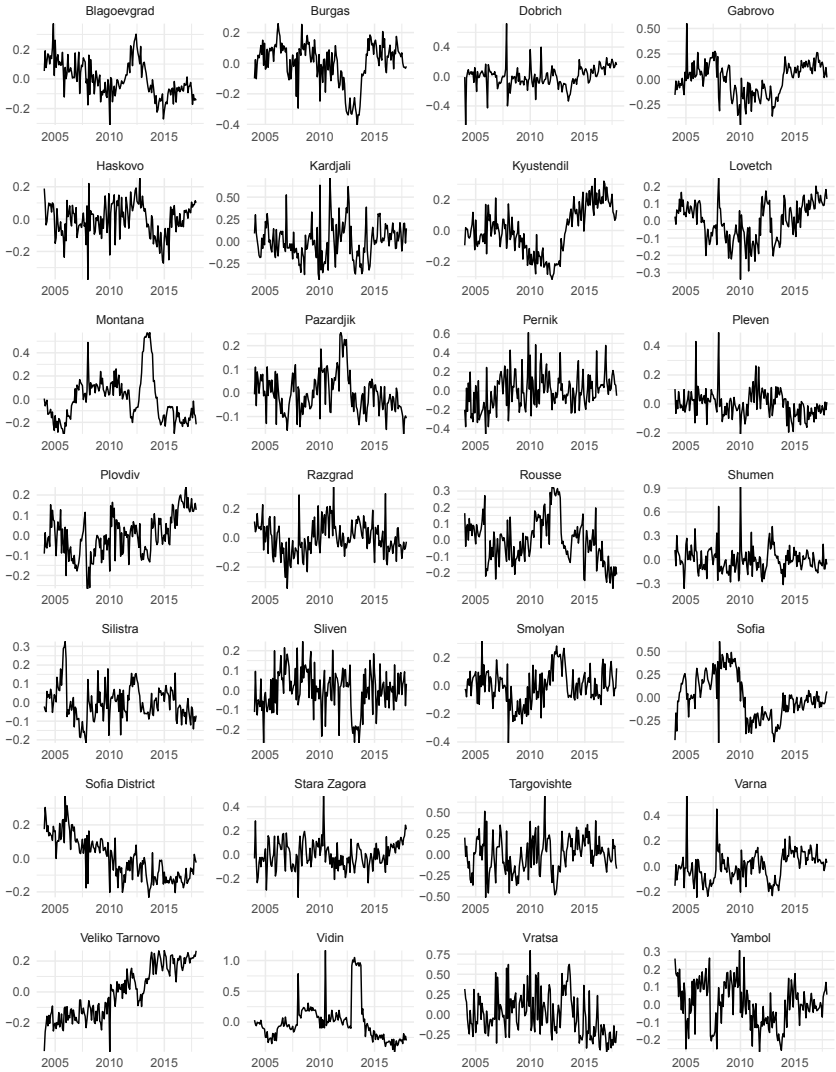
Our estimates reveal mixed dynamics of matching efficiency across regions (see Figure 18), confirming the conjectures in the descriptive analysis. The decline in labour market efficiency started in late 2007 and early 2008, with a slow recovery initiated in 2010. This efficiency recovery was subsequently halted by the sovereign debt crisis in Europe. In some regions the pickup in efficiency seems to have been postponed by one to two years, *e.g.* Sofia, Sofia District, Stara Zagora, Sliven, Vidin, Pernik and Haskovo. According to the labour market efficiency dynamics the global crisis continued around 16 quarters on average, while in the east part of the country about 20 quarters.

There emerge two groups of regions according to the difference in matching efficiency levels before and after 2008. There were substantial post-crisis improvements in some regions such as Veliko Tarnovo, Kyustendil, Plovdiv, Lovetch and Dobrich, where labour market efficiency increased compared to the levels before 2008. In other regions, such as Montana, Pazardjik, Ruse, Sofia, Sofia District, Vidin and Vratsa, efficiency was lower than its pre-crisis levels. As a whole, in the post-crisis period labour market efficiency declined to a greater extent in the northern part of the country compared to the south, probably due to internal migration to the larger regional centres offering more job opportunities.

It should be noted that some regions – Blagoevgrad, Ruse, Lovech, Montana, Pazardzhik, Silistra, Smolyan, Veliko Tarnovo, Vidin and Yambol – experienced a second decline in efficiency around 2010–2013. In these regions there was also a relatively large decline in the working age population.

The recovery of efficiency picked up pace in early 2014, with the indicator reaching its highest values in 2015, followed by a stabilization and a slight decline in 2017. We conjecture that this decline can be attributed to the negative demographic developments and, specifically, the high rates of external migration in the period immediately after the global crisis of predominantly young Bulgarians. While ageing and low birth rates are a global process observed in richer and highly educated societies, high levels of external emigration are usually seen in low-income countries with comparatively easy external labour mobility, and both processes are ongoing in Bulgaria.

Figure 18: **Labour Market Efficiency Dynamics by Regions**



Source: Own calculations.

5.4. Cyclically-adjusted Measures of Matching Efficiency

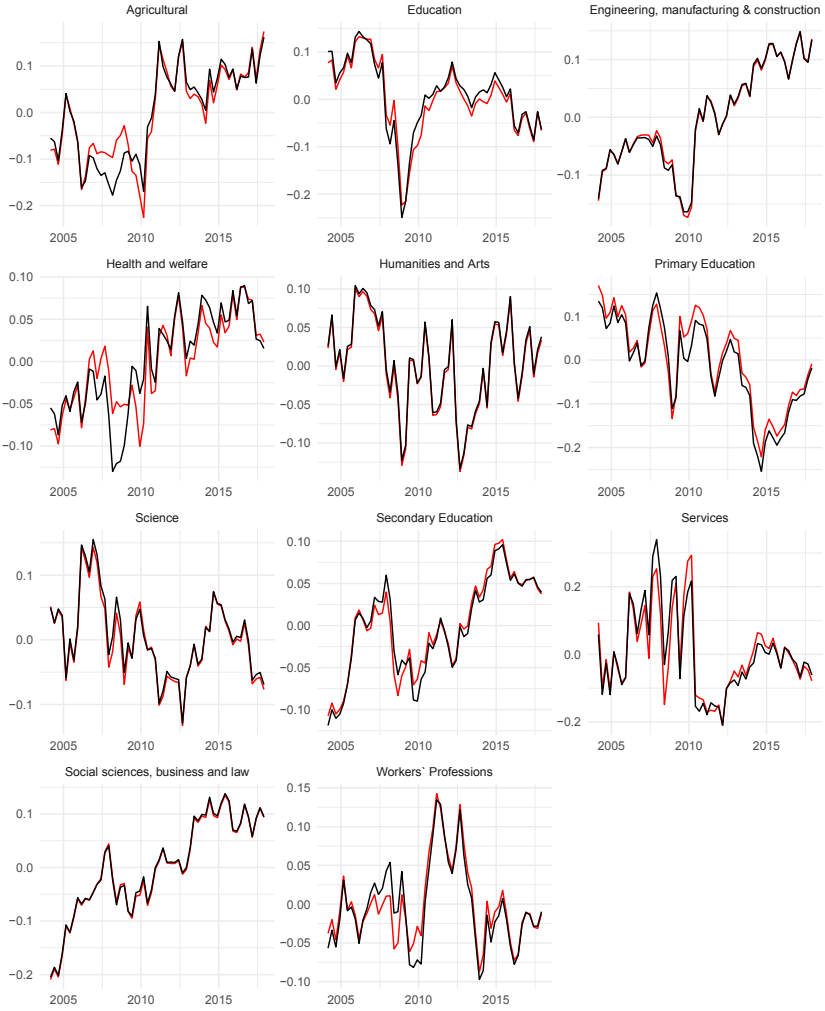
The literature on matching efficiency identifies the existence of procyclical variation of the efficiency measures constructed in the above described manner (see Barnichon and Figura 2015 for a recent example). This implies that one could incorrectly attribute changes induced by the cyclical position of the economy to structural changes in the labour market. One strategy to disentangle cyclical from structural variation of our efficiency measure would be to regress it on an appropriately chosen output gap estimate and check whether the residuals from the secondary regression deviate substantially from the originally constructed efficiency measure.

In what follows we implement the above strategy by regressing each estimate of labour market efficiency by field of education or region on an output gap series constructed by using a production function approach. More precisely, the output gap is the difference between actual and potential output, where potential output is obtained by means of a fixed-share production function combining total factor productivity, capital and labour. Capital is constructed using a perpetual inventory method and the inputs to the production functions are the trend components resulting from applying the Hodrick-Prescott filter to the respective series.

The cyclically-adjusted labour market matching efficiency, as measured by the residuals of the regression of the (original) efficiency on the output gap, is presented on Figure 19 for the case of the fields of education breakdown and on Figure 20 for the regional breakdown. The results indicate that explicit adjustment for the cyclical position of the economy marginally affects the original efficiency estimates. While some variation inevitably exists for the different units analysed, it appears that the original measures of labour market efficiency exhibit a limited degree of procyclicality.

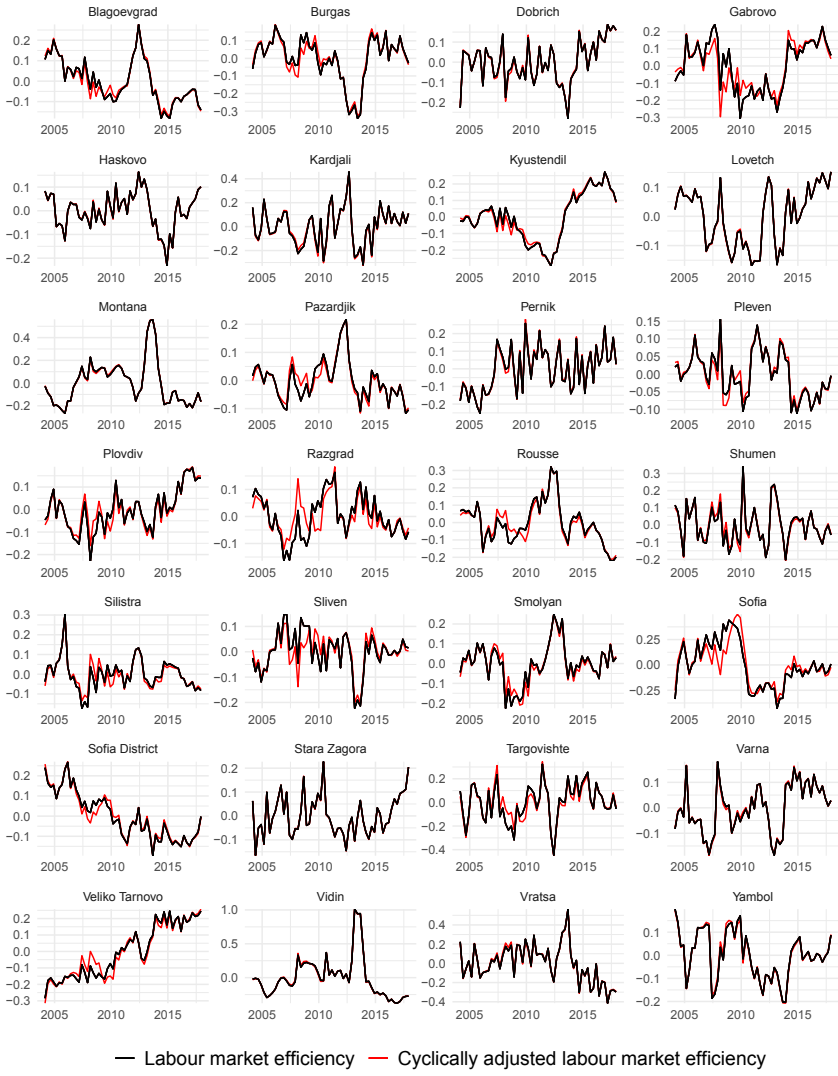
As a sanity check on the results, we can note that where there exist more substantial deviations of cyclically-adjusted efficiency from the unadjusted ones, the differences correspond to narrative evidence of the development of the Bulgarian economy over the sample period. At the same time, a limitation of the analysis stems from the fact that an aggregate output gap measure is applied to sector- or region-specific efficiency estimates. However, as a full-fledged decomposition of economic activity and potential output developments by regions or fields of education is infeasible due to data constraints, the current approach remains the most accessible mode of adjustment.

Figure 19: **Cyclically-adjusted Labour Market Efficiency Dynamics by Field of Education**



Source: Own calculations.

Figure 20: **Cyclically-adjusted Labour Market Efficiency Dynamics by Regions**



Source: Own calculations.

A possible explanation of the relatively low degree of procyclicality of the estimated labour market efficiency is that labour market adjustment over the business cycle in Bulgaria was taking place predominantly on the extensive margin. This would imply that the tightness measures embedded in the matching function formulation already contain substantive information about cyclical developments in the Bulgarian economy, which lowers the explanatory power of the output gap measure.

6. Conclusion

Our analysis of labour market developments and the application of complementary approaches to measuring labour market efficiency point to several conclusions about the functioning of the Bulgarian labour market over the period 2004–2017.

Matching efficiency dynamics have been heterogeneous across fields of education and regions. While the global crisis clearly impacted efficiency, changes in efficiency over time exhibit a small degree of procyclicality. The period 2015–2017 is characterised by increased demand for labour, with evidence of lagging supply response in some regions and fields of education. While these processes are predominantly reflected in the behaviour of labour market tightness, there are indications of spillovers to matching efficiency, which has shown signs of deterioration towards the end of the period analysed. Additionally, there are regional differences in efficiency between the southern and northern parts of the country. Both descriptive and econometric analysis show that in general the northern parts of the country are more vulnerable to demand shocks, and there labour supply exceeds demand.

There are several possible factors that can explain these developments. First, demographic factors constrain the supply of labour. As pointed out in section 4, population dynamics in Bulgaria weigh heavily on the labour market, with persons under the age of 30 declining at the expense of those over the age of 55. This is the combined result of lower birth rates after 1990 and increased external labour migration in recent decades.

Second, and following up on the first factor, as a small open economy and an EU member state, Bulgaria is highly integrated with the European economy and dependent on developments there. As a result, labour market conditions in Bulgaria are both directly and indirectly affected by fluctuations in economic activity in the EU. Moreover, since Bulgaria joined the EU in 2007, member states have gradually phased out labour market constraints for Bulgarian

citizens, with the last restrictions being lifted in 2014. According to the data on the migration of the OECD, the total inflows of Bulgarian citizens to EU Member States are three times greater for the period 2007–2015 compared to the period 2000–2006[42]. This process affects both the quantity and the quality of labour supply in Bulgaria, and may be reflected in matching efficiency dynamics.

Third, excess supply in some fields of educations, such as "Social sciences, business and law" and "Services", leads to higher unemployment rates within these groups in the absence of sufficient demand and may also have adverse impact on matching efficiency.

Analogously, uneven labour demand across regions worsens the functioning of the labour market and exacerbates matching efficiency. As discussed earlier, regions in the northern part of the country experience higher levels of unemployment and worse labour market indicators. This in turn is reflected in matching efficiency outcomes. A likely reason for that is the concentration of economic activity in large regional centres located mainly in the south and across the Black Sea, which attracts labour resources.

Finally, and on a more speculative note, factors such as digitalization, fast changes in consumer preferences, the emergence of new types of jobs and the demand for novel skills that can not be developed quickly under the current educational system also affect the Bulgarian labour market to some extent and may be manifested in lower efficiency outcomes.

It is noteworthy that there are indications of untapped potential labour supply outside the labour force: fields of education such as "Primary education" and "Secondary education" have relatively high labour market tightness while the Labour Force Survey of the NSI indicates that there are enough people with such qualification outside the labour force. Theoretically, as labour demand increases, the participation rate tends to rise, so these shortages should be filled by the natural functioning of the labour market. At the same time, the fact that a large share of the unemployment pool is concentrated in these sectors flags the potential existence of skills and qualification mismatches, which may require additional policy measures to help align the characteristics of this labour supply pool to demand requirements.

Furthermore, some of the narrow fields of specialization such as education and healthcare that exhibit relatively high tightness are amenable to direct government interventions because of the large share of public sector

[42] For more information see International Migration Database of the OECD.

employment there. In a near term perspective, such interventions can take the form of monetary compensation to activate discouraged persons with appropriate skills or various forms of qualification and training, while safeguarding fiscal stability and observing spending efficiency considerations. More generally, appropriate active labour market policies can have a broader impact that covers a more diverse set of educational fields or regions. Over a longer time horizon, efforts to align the output of the educational system to labour market requirements should facilitate labour market matching and increase efficiency.

The present work can naturally be extended in a couple of directions. We make the assumption that there are only two states of the labour market, the unemployed and the employed, but in reality this is not the case. Future work may aim to include also the people outside the labour force in the calculation of the labour market efficiency. Another development may be to introduce adjustments that enhance the comparability between the data of the Employment Agency and the national accounts, which, for example, can assist the assessment of the impact of wage developments on labour market efficiency.

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A. Selected Results from the Restricted Versions of the Testing and Estimation Procedure for the Fields of Education and Regional Data

Table 3: **Poolability Test (restricted version, null hypothesis: identical coefficients)**

	Model 1
F statistic	45.60***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 4: **Lagrange Multiplier Test – Individual Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	265.85***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 5: **Lagrange Multiplier Test – Time Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	18.68***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 6: **Lagrange Multiplier Test – Two-way Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	201.19***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 7: **Hausman Test for Fixed vs. Random Effects**

	Model 1
χ^2 statistic	0.70

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 8: **Restricted Matching Function Regression, Fields of Education Data, Individual Effects**

	Dependent variable:
	Job-finding rate
Sectoral tightness	−0.003
	(0.011)
Constant	−2.442***
	(0.096)
Observations	1,848
R^2	0.00003
Adjusted R^2	−0.001
F Statistic	0.054 (df = 1; 1846)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 9: **Restricted Matching Function Regression, Fields of Education Data, Time Effects**

	Dependent variable:
	Job-finding rate
Sectoral tightness	0.068***
	(0.007)
Constant	−2.419***
	(0.014)
Observations	1,848
R^2	0.055
Adjusted R^2	0.054
F Statistic	106.417*** (df = 1; 1846)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 10: **Poolability Test (Restricted Version, Null Hypothesis: Coefficients)**

	Model 1
F statistic	15.56***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 11: **Lagrange Multiplier Test – Individual Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	213.70***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 12: **Lagrange Multiplier Test – Time Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	103.90***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 13: **Lagrange Multiplier Test –Two-way Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	224.57***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 14: **Hausman Test for Fixed vs. Random Effects**

	Model 1
χ^2 statistic	8.76**

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 15: **Restricted Matching Function Regression, Regional Data, Individual Effects**

	Dependent variable:
	Job-finding rate
Regional tightness	0.038***
	(0.008)
Observations	4,676
R^2	0.005
Adjusted R^2	−0.001
F Statistic	24.896*** (df = 1; 4647)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 16: **Restricted Matching Function Regression, Regional Data, Time Effects**

	Dependent variable:
	Job-finding rate
Regional tightness	0.138^{***}
	(0.006)
Observations	4,676
R^2	0.104
Adjusted R^2	0.071
F Statistic	523.935^{***} (df = 1; 4508)
Note:	*p<0.1; **p<0.05; ***p<0.01

B. Unrestricted Versions of the Testing and Estimation Procedure for the Fields of Education and Regional Data

An unrestricted version of the testing and estimation procedure for the fields of education data is provided in Tables 17–23. This mirrors the structure presented in subsection 5.1.2. As the testing framework did not find evidence of time effects, the counterpart of Table 9 is not provided here.

Tables 24–29 present the unrestricted version of the testing and estimation procedure for the regional data that was outlined in subsection 5.1.3. The estimation of the overall tightness coefficient is unavailable for the case of time and two-way effects under fixed effects (within) estimation and the corresponding tables are not provided here. The estimated regional tightness coefficients for those two cases are respectively 0.14 and 0.05.

Table 17: **Poolability Test (Unrestricted Version, Null Hypothesis: Identical Coefficients)**

	Model 1
F statistic	26.08***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 18: **Lagrange Multiplier Test – Two-way Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	241.24***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 19: **Lagrange Multiplier Test – Individual Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	345.52***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 20: **Lagrange Multiplier Test – Time Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	-4.35

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 21: **Hausman Test for Fixed vs. Random Effects**

	Model 1
χ^2 statistic	0.38

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 22: **Unrestricted Matching Function Regression, Fields of Education Data, Individual Effects**

	Dependent variable:
	Job-finding rate
Sectoral tightness	0.015**
	(0.006)
Overall tightness	0.868***
	(0.014)
Constant	0.051
	(0.103)
Observations	1,848
R^2	0.718
Adjusted R^2	0.717
F Statistic	2,343.540*** (df = 2; 1845)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 23: **Unrestricted Matching Function Regression, Fields of Education Data, Two-way Effects**

	Dependent variable:
	Job-finding rate
Sectoral tightness	0.030***
	(0.005)
Overall tightness	0.855***
	(0.027)
Constant	0.059
	(0.123)
Observations	1,848
R^2	0.376
Adjusted R^2	0.376
F Statistic	556.627*** (df = 2; 1845)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 24: **Poolability Test (Unrestricted Version, Null Hypothesis: Identical Coefficients)**

	Model 1
F statistic	13.20***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 25: **Lagrange Multiplier Test – Two-way Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	229.40***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 26: **Lagrange Multiplier Test – Individual Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	233.84***

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 27: **Lagrange Multiplier Test – Time Effects (Honda) for Balanced Panels**

	Model 1
LM statistic	90.58***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 28: **Hausman Test For Fixed vs. Random Effects**

	Model 1
χ^2 statistic	9.46**

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 29: **Unrestricted Matching Function Regression, Regional Data, Individual Effects**

	Dependent variable:
	Job-finding rate
Regional tightness	0.035***
	(0.007)
Overall tightness	0.152***
	(0.010)
Observations	4,676
R^2	0.137
Adjusted R^2	0.131
F Statistic	367.691*** (df = 2; 4646)
Note:	*p<0.1; **p<0.05; ***p<0.01

DP/115/July 2019

Transmission of ECB's Monetary Policy in Bulgaria: Insights from a Large Macro-econometric Model

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Abstract: The aim of this paper is to examine the transmission channels of European Central Bank's (ECB) monetary policy in Bulgaria, taking into consideration the structural aspects of the Bulgarian economy, including its strong trade and financial integration in the EU at the background of free movement of capital; the conditions of the currency board regime and the prevalence of euro area (EA) based banks on the domestic financial market. The elaborated structural features determine the sizable influence of the ECB's monetary policy on the Bulgarian economy. The large macro-econometric forecasting model of the BNB has been applied to derive a simulation scenario. The special case of a tightening of the ECB's monetary policy is studied by modelling a combination of simultaneous shocks: an increase of the euro area short- and long-term interest rates, an appreciation of the euro against the US dollar and a decline in economic activity in the euro area.

Our results suggest that the effects through the foreign trade channel play a dominant role in explaining the contraction of domestic output relative to the baseline level following a tightening of the ECB's monetary policy. Investment is the GDP component with the strongest reaction to monetary policy tightening. The Bulgarian labour market adjusts to the ECB's contractionary monetary policy through declines in both employment and wages. The downward adjustment of prices compared to the baseline level is relatively weak and we find that throughout the simulation horizon the reaction of real variables is more pronounced than the reaction of prices.

Резюме: Целта на настоящото изследване е да проучи каналите за предаване на политиката на Европейската централна банка (ЕЦБ) в България, включително нейната силна търговска и финансова интеграция в Европейския съюз (ЕС) на фона на свободното движение на капитали; условията при режима на паричен съвет и преобладаването на местния финансов пазар на базирани в еврозоната банки. Сложните структурни характеристики предопределят значителното влияние на паричната политика на ЕЦБ върху българската икономика. С цел извличане на симулационен сценарий е приложен големият макроиконометричен прогностичен модел на БНБ. Особеният случай на затягане на паричната политика на ЕЦБ е изследван посредством моделиране на комбинация от едновременни шокове: увеличение на краткo- и дългосрочните лихвени проценти в еврозоната, поскъпване на еврото спрямо долара на САЩ и спад на икономическата активност в еврозоната.

Резултатите показват, че за обясняване свиването на вътрешното производство спрямо базисното ниво след затягането на паричната политика на ЕЦБ главна роля играят ефектите чрез канала на външната търговия. А инвестициите са този компонент на БВП, който реагира най-силно спрямо затягането на паричната политика. Пазарът на труда в България се приспособява към твърдата парична политика на ЕЦБ чрез едновременно съкращаване на заетостта и заплатите. В сравнение с базисното равнище приспособяването чрез снижаване на цените е сравнително слабо и ние смятаме, че в рамките на хоризонта на прогнозата реакцията на реалните променливи е по-видима, отколкото реакцията на цените.

Keywords: Monetary policy transmission, Macro-econometric models, Currency board

1. Introduction

The specifics of the monetary regime in Bulgaria and the country's trade and financial integration with the euro area (EA) determine the high relevance of ECB's monetary policy changes for the domestic economy. Understanding of the specific channels of European Central Bank's (ECB) monetary policy transmission is fundamental for analysing domestic economic developments from historical and forward-looking perspective as well as for assessing the impact of policy changes. Knowledge on the transmission of the monetary conditions in the euro area to the Bulgarian economy has been an important input for policy discussions over recent years and is becoming increasingly relevant for policy analysis in the context of Bulgaria's preparation to join the Exchange Rate Mechanism (ERM II) and eventually the EA. In addition to that, the favourable economic developments in the EA in recent years are a prerequisite for the withdrawal of the ECB's monetary policy accommodation. This makes the transition to policy normalisation in the euro area and its effect on the Bulgarian economy an important topic for investigation. The contraction of EA output and prices, resulting from a tightening of the ECB's monetary policy, is expected to have sizeable negative effects on Bulgaria's foreign trade (trade spill-over channel) given that the euro area is by far the country's largest trading partner. Moreover, under the currency board arrangement a monetary policy induced appreciation of the anchor currency, the euro, will be directly transferred to Bulgaria's export and import prices, which in turn will affect real volumes of foreign trade (the exchange rate channel), adding up to the effect of the trade spill-over channel. The irrevocably fixed exchange

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rate of the lev with respect to the euro and the very limited instruments that the national authorities have at hand to influence monetary policy conditions under the currency board arrangement suggest that domestic monetary conditions are largely determined by the monetary environment in the EA. An additional prerequisite for a strong pass-through of interest rate change from EA to domestic financial markets is the dominant role of EA-owned banks in the Bulgarian banking sector. Furthermore, as external borrowing and FDI flows from parent companies in the EA constitute a significant source for non-bank debt financing of domestic companies, it could be expected that the cost and availability of non-bank financing for a large share of the domestic companies will also be influenced by monetary conditions in the EA.

In order to fully account for these structural characteristics of the domestic economy and their respective role in hampering or facilitating the specific channels of the transmission of the ECB's monetary policy to the Bulgarian economy we have opted out for an analytical framework that would allow the inclusion of numerous interrelations between foreign and domestic variables. The current analysis is based on simulations with the BNB's macro-econometric model (BNBQPM), which is the Bank's main toolkit for forecasting and simulation purposes. Despite being subject to the Lucas critique, large-scale econometric models still represent a useful tool for combining detailed econometric estimates related to the functioning of the individual channels and stages of transmission especially in view of the inconclusive results for Bulgaria based on VAR models (see for example Elbourne and de Haan (2006), Minea and Rault (2009), Potjagailo (2016), Moder (2017), Bluwstein et al. (2016) and Horvath and Voslarova (2017)).

This paper contributes to the existing literature by identifying the channels through which the ECB's monetary policy is transmitted to the monetary conditions in Bulgaria. Moreover, it establishes the relative importance of each of these channels based on simulations with the BNBQPM. The macroeconomic simulation exercise includes a simultaneous increase in the EA short-term and long-term interest rates, an appreciation of the euro against the US dollar and a decline in the economic activity in the EA induced by tightening of ECB's monetary policy (simulated in a multi-country framework)[43]. The combination of these shocks forms a scenario of a monetary policy tightening by the ECB.

[43] The expected change in external demand for Bulgarian goods and services (based on the weight of the euro area in Bulgaria's external trade) is simulated with a modelling package developed by the ECB, called Stress-Test Elasticities toolbox (STEs). In line with the design of the STE toolbox (latest version as from 2018, for more information on the toolbox see (ECB, 2013)) the change in the ECB's policy rate is simulated by the change in the 3-month EURIBOR. The same proxy for the tightening of ECB's monetary policy is used throughout the paper.

Our results suggest that the foreign trade spill-over channel plays a dominant role in explaining the contraction of domestic output compared to our baseline following a tightening in the ECB's monetary policy. Real exports decline as a result of the simulated lower foreign demand, which then triggers a decline in domestic output with relatively fast negative second-round effects on the labour market, investment, consumption and prices. The contractionary effect from higher interest rates and lower asset prices as a result of higher market interest rates in the EA takes more time to materialise and begins to weigh on the real GDP a year and a half after the introduction of the shocks. Investment is the GDP component with the strongest response to monetary policy tightening. Throughout the simulation horizon, the reaction of real variables is more pronounced than the reaction of prices.

The paper is organised as follows: the next section reviews the most relevant monetary policy transmission channels for a country with a currency board regime from both theoretical and empirical point of view. Section 3 discusses the structural aspects of the Bulgarian economy that have implications for the transmission of ECB's monetary policy. Section 4 provides details on the macro-econometric model used for the empirical assessment of the transmission of the ECB's monetary policy to the Bulgarian economy with a focus on the individual transmission channels at work. Model simulations are provided in Section 5 and Section 6 concludes and suggests avenues for future work.

2. Literature Review

The monetary transmission mechanism (MTM) can be broadly defined as the mechanism through which monetary conditions affect economic activity and prices. Monetary conditions are typically determined by the national central bank's monetary policy actions, but spill-over effects from global and main trading partners' monetary policy conditions have become increasingly relevant. In countries with currency board arrangements, such as Bulgaria, there is no policy-induced change in interest rates or the money supply and the monetary environment is determined to a large extent by the monetary policy of the anchoring country. Given the high trade and financial sector integration, capital and labour mobility in the EU, we might expect significant interactions between domestic and foreign economic developments.

2.1. Channels of the Monetary Transmission Mechanism

A standard way to analyse the monetary transmission mechanism is by considering the individual channels through which monetary policy changes are transmitted

to the real economy and prices. In line with the literature on international transmission of monetary policy, the transmission of ECB's monetary policy to the domestic economy takes place through two main channels: **foreign trade channel and financial channel** (Canova, 2005 and Potjagailo, 2016).

The **trade channel** is the first main channel of international monetary transmission. It operates mainly through changes in net exports and its functioning can be analysed in a standard Mundell-Fleming model. Following a monetary policy tightening in the center economy, output and prices in this economy will decline and will have a contractionary impact on foreign demand for the periphery countries. The resulting negative impact on domestic output and prices is supposed to be larger for the periphery countries with fixed exchange rates as there will be no domestic currency depreciation to offset the negative impact of lower foreign demand (Potjagailo, 2016). Countries with fixed exchange rates to the center country's currency will be affected by the functioning of the exchange rate channel in the center country – upon an interest rate increase the currency of the center country is expected to appreciate against all other currencies. As a result, net exports in both the center economy and periphery countries with fixed exchange rates will contract as the goods and services they produce will become less competitive relative to third countries.

Further in the paper, we will analyse the functioning of the trade channel of international monetary transmission by decomposing the spill-over effects on the Bulgarian economy stemming from changes in EA output and prices (trade spill over channel) and from changes in the value of the euro against other currencies (exchange rate channel)[44]. These two channels reinforce each other as they both lead to a contraction in domestic output and prices following a monetary policy tightening in the EA. While a precondition for the functioning of these channels is naturally the effectiveness of the monetary transmission mechanism within the EA, relevant factors specific to the Bulgarian economy are its trade openness, the structure of trade, the share of imported goods, participation in the global value chains and size of the residents' net foreign non-euro liabilities (Kapuscinski et al., 2016).

The second main channel of international monetary policy transmission, **the financial channel**, operates through the impact of monetary policy changes

[44] Please note, that in this paper the exchange rate channel is defined in terms of the movements between the currency of a periphery country with a fixed exchange rate to the center country and the currencies of third countries, while other authors (Canova, 2015 and Takáts and Vela, 2014) use the term to define the effects stemming from bilateral changes in the exchange rate between the periphery and the center country. In the latter definition, the exchange rate channel works in the opposite direction of the trade spill-over channel.

in the center country on financial conditions in the periphery country. Spillovers to various financial indicators in the periphery countries can be defined as different channels of transmission within the financial channel (see for example Bluwstein and Canova (2016), Takas and Vela (2014) and Rey (2016) for alternative classifications). This paper will focus primarily on the interest rate channel, the asset price channel and the credit channel in line with the traditional classification of the monetary transmission channels (Mishkin, 1995), while acknowledging the effects through risk perceptions, uncertainty and expectations might play a very important role in international transmission of monetary policy (Bluwstein and Canova (2016), Rey (2016)).

Due to enhanced financial integration and prevalence of foreign bank ownership, domestic market interest rates will follow closely the dynamics of EA money market interest rates (interest rate channel). Moreover, when the exchange rate in the periphery economy is fixed to the center economy's currency, the uncovered interest rate parity would imply a complete and simultaneous pass-through with regard to domestic money market rates considering that the country risk premium remains unchanged. Deposit and lending rates in the center and periphery countries are also expected to co-move if there are close ties between the banking sectors of the two countries. Stock prices and other asset prices in the periphery country are also expected to react to monetary policy changes in the center country (asset price channel). Last but not least, the functioning of the credit channel is justified by the presence of financial frictions (Boivin et al., 2010) as the increase of domestic interest rates will have negative effects on bank's capital and balance sheets and at the same time it will undermine borrowers' creditworthiness, resulting in lower credit supply. The credit channel would typically enhance the role of the traditional interest rate channel. While the credit channel has been analysed mostly in a closed economy perspective, it might be equally relevant in the international transmission of monetary policy (Rey (2016) and Bech et al. (2018)). The importance of the credit channel is expected to be stronger when the bank lending is the major financing source for domestic economic agents (Kapuscinski et al., 2016).

While the interest rate, credit and asset price channels are usually seen as the main channels of international transmission of conventional monetary policy, with the extensive use of non-standard monetary policy measures in the aftermath of the global financial crisis, a number of additional transmission channels have been identified (Altavilla et al., 2017). Credit easing measures, which are designed to reduce marginal costs, are important for the functioning of a cost relief channel, while quantitative easing measures are expected to activate a portfolio rebalancing channel. Moreover, non-standard measures

give rise to a signalling channel, which functions through the signal central banks give on their intentions to keep interest rates low in the future. Somewhat related to the signalling channel is the confidence channel as defined by Bluwstein and Canova (2016) which operates through spill-overs to uncertainty and financial risk perceptions.

The functioning of all of the above mentioned channels of transmission of international monetary policy changes will ultimately have an impact on real activity and prices in the periphery economy. As already mentioned, the trade channel will affect net exports mainly *via* the trade spill-over and the exchange rate channel. Following a change in domestic financial conditions, investment is affected through the change in the user cost of capital (direct interest rate channel) and the change in the firms' stock prices (asset price channel) through the so-called Tobin's q ratio. Based on the Tobin's q relation between the market value of capital and the replacement cost of capital, an increase in domestic interest rates will result in lower share prices as demand for shares will decline and eventually this would lead to lower investment. Consumption is also affected by interest rate changes through both the direct interest channel and the asset price channel. On the one hand, changes in interest rates trigger intertemporal substitution effects and induce changes in the slope of the consumption profile as could be seen from the standard Euler consumption optimization equation. On the other hand, short-term interest rates have an impact on the prices of shares, real estate and other assets, held by households. When interest rates increase, asset prices fall and affect negatively consumption through the decline in households' wealth. The negative effects from the functioning of the interest rate and asset price channels on consumption and investment will be intensified by the functioning of the credit channel through lower availability of bank credit.

2.2. Relevant Empirical Studies

Empirical research on the functioning of the monetary transmission mechanism is vast. Various approaches have been employed, depending on whether the focus is on all aspects of the transmission mechanism or on individual channels and stages of transmission. This study relates more closely to two streams of empirical literature: studies on the monetary transmission mechanism in large-scale macro-econometric models and studies on individual channels of the transmission mechanism in Bulgaria. While structural vector autoregressive models and New Keynesian DSGE models have been widely used for empirical analysis of the overall monetary transmission mechanism, they are left beyond the focus of this analysis.

2.2.1. Large-scale Macro-econometric Models

Large-scale macro-econometric models have until recently been extensively used by central banks in the EU and worldwide for monetary policy transmission mechanism analysis. Short-run dynamics in these models is predominantly data-driven, while the long-run dynamics is assumed to converge to a theoretical long-run steady state. This would require the estimation of long-run (co-integrating) relationships first, followed by an estimation of the dynamic equations in error-correcting form. Expectations in these models play only a partial role as price and wage formation are typically backward-looking and depend only on their lagged values. Berben, Locarno, Morgan, and Valles (2004) report that less than half of the models used in the ECB and EA countries have some forward-looking features and Mayes (2004) acknowledges that the expectations channel is not given enough emphasis in the macro-econometric models for the three Baltic countries.

In a comparative study of the MTM in 12 large-scale macro-econometric models, used by central banks, Smets (1995) finds that "the exchange rate and the cost of capital are the most important channels of transmission, with the exchange rate channel being more important in more open economies". Simulations with the EA Wide Model (McAdam and Morgan, 2001) find evidence for a dominant role of the investment-based channel in the EA as a whole. Fagan, Henry, and Mestre (2005) confirm the importance of the investment channel and find that the exchange rate channel contributes to around one third of the decline in output through its negative effects on net trade and consumption (Fagan et al., 2005).

Simulations with macro-econometric models have also been applied to study the MTM in other currency board countries (see Vetlov (2003) for Lithiania, Kattai (2005) for Estonia and Mayes (2004) for a comparative study on the three Baltic states). The latter study summarises the common features of the macro-econometric models for the Baltic countries: owing to the specifics of the exchange rate regime short-term interest rates are modelled through uncovered interest parity with an adjustment for a downward trending risk premium (exogenous or dependent on forward rates), while money supply is modelled as a function of transactions demand and foreign inflows. The structure of the models suggests a relatively small role for the credit and bank lending channels, which to a certain extent is justified by the high degree of firms' foreign ownership and the important role of FDI flows for the availability of funding at the industry level. Despite the structural differences between the three models, in all of them the role of the interest rate channel in the MTM was found to be stronger as

compared to the exchange rate channel. Similarly to the results from the EA Wide Model, in the case of Lithuania and Latvia investment is the aggregate demand's component mostly affected by changes in the monetary conditions, while in Estonia there is a stronger impact on consumption.

2.2.2. Studies on the Individual Transmission Channels in Bulgaria

Empirical studies on the foreign trade channel for Bulgaria are focussed exclusively on the functioning of an exchange rate channel. The results from earlier cross-country studies including Bulgaria (Ganev et al., 2002) are largely influenced by the inclusion of data before the introduction of the currency board and therefore are not comparable with the current study's results. Later on, Beirne and Bijsterbosch (2011) employ a multivariate co-integration approach (VECM) and find conclusive evidence that the exchange rate pass-through to domestic prices is stronger in Bulgaria and the Baltic countries as compared to the Central and Eastern European countries with flexible exchange rates. The BNB (2015a) used a Bayesian vector autoregression model to assess the effects from changes in the nominal effective exchange rate on output and prices in Bulgaria and found that consumer prices increase by 0.1 percent on impact after a one-percent depreciation of the nominal effective exchange rate, while the reaction of GDP materialises only with a lag and is maximised after approximately one year (0.2 per cent).

The transmission of ECB's monetary policy through the financial channel is analysed in a number of empirical studies. Earlier studies offer in many cases inconclusive results. The studies reviewed by Ganev et al. (2002) support the existence of a credit transmission channel in Bulgaria and provide evidence for a regime switch after the currency board establishment, while Elbourne and de Haan (2006) find little evidence of any link between financial structure indicators and monetary policy. In a VAR framework, Minea and Rault (2009) find that domestic interest rates and monetary aggregates react to the ECB interest rate shock with a substantial lag, while output and prices' responses are not significant.

More recently, Mihaylov (2016) uses symmetric and asymmetric error-correction models to study the effect of money market conditions in the EA on lending interest rates in Bulgaria depending on the sector of the borrower, the currency denomination and the maturity of loans. The analysis shows a complete pass-through from EA market interest rates to all domestic lending rates in the long-term. The short-run pass-through is not complete (at 58 per cent) and statistically significant only for corporate lending rates. There is no evidence for asymmetric reaction of domestic interest rates when money

market conditions in the EA are expansionary or contractionary. Recent cross-country studies have also analysed the spill-over effects from EA to domestic monetary conditions (including the impact of the unconventional monetary policy) on non-euro area countries, including Bulgaria. While Potjagailo (2016) finds a complete and immediate pass through from EA short-term rates (with and without accounting for the impact on UMP) to short-term money market rates in Bulgaria, Moder (2017) does not find statistically significant reactions of domestic interest rates to changes in the foreign monetary conditions.

Credit growth dynamics is analysed in Peshev (2015), Karamisheva (2016) and Mihaylov (2017). The studies identify various relevant supply-side factors (such as bank-specific interest rate spreads between lending and deposit rates, the share of bad and restructured loans, bank ownership and so on). Karamisheva (2016) finds demand factors to be relatively more important, while Mihaylov (2017) finds a strong correlation between supply and demand for credit through an estimated credit market disequilibrium model for the period 2000–2016. The author identifies three distinct periods, in which the supply of credit was estimated to be lower than the demand (in the wake of the financial crisis, during the period 2011–2013 and more recently, in 2015–2016), but attributed the shortage of credit supply to various temporary factors.

On the transmission of domestic interest rate changes to asset prices (proxied by house prices) there is a recent study by Kotseva and Yanchev (2017). The authors model house prices in a VECM framework that simulates the dynamic interplay between prices and demand for housing and find that the interest rate on new housing loans is an important determinant of house prices together with external demand (proxied by FDI in real estate) and the dynamics of domestic GDP *per* capita.

The second stage of transmission of ECB's monetary policy to domestic prices and output has also been analysed in a number of studies. Vladova and Yanchev (2015) find evidence for a two-way relationship between money supply and prices in Bulgaria over the period 1998–2012, with the causality in the direction prices → money demand → money supply being justified by the endogeneity of money supply in a currency board framework. More recently, Ivanov et al. (2018) analyse the determinants of business investment dynamics in Bulgaria. The authors employ a BVAR model estimated over the period 2000–2017 and find that changes in real long-term corporate lending rates have a significant impact on investment, even though it materialises with a lag. Foreign demand, uncertainty and FDI flows seem to be of higher importance in the historical decomposition of investment dynamics, thus suggesting a strong role for trade channel, firms' balance sheet channel and expectations channel.

3. Structural Aspects of the Bulgarian Economy

The theoretical grounds delineating the possible channels through which the monetary policy is transmitted to the real economy and to price dynamics can be used as a starting point in the analysis of transmission mechanism in an individual country. Depending on the specific structural features of the economy, however, the strength of a given theoretically defined transmission channel and the lag in transmission can vary across countries. To identify the possible important channels of monetary policy transmission in Bulgaria we first outline a number of fundamental structural aspects of the economy which provide a focal point of the analysis and preliminary assessment of the potential strength of a channel in the transmission process.

3.1. Small Open Economy Highly Integrated in the Single EU Market

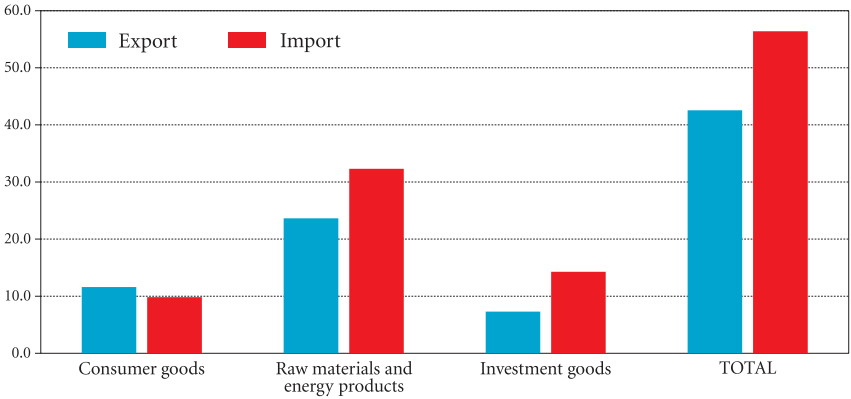
Foreign trade has always played a vital role for the economic development of Bulgaria. The ratio of foreign trade to GDP fluctuated at around 100 per cent for 1995–2017. The dependence of the country's economic progress on imported natural resources like minerals and fuels pre-determines the relatively high share of imports in foreign trade and in turn the crucial role of exports for supplying the economy with the required foreign currency. Imports of basic resources represent more than half of total imports of goods (in some years going up to and above 70 per cent) while the trade deficit in the group of raw materials and energy commodities has usually been the main reason for the overall trade deficit.

In recent years another import group gained prominence – *i.e.* investment goods. Since 2005 (two years before Bulgaria's accession to the EU) the import of investment goods accelerated, linked to and financed by the rising inflow of foreign capital (mainly from EA countries). The trade deficit in investment goods contributed markedly to the overall trade deficit.

The integration of Bulgaria in the Single EU Market has secured both stability in foreign trade flows and rising participation rate in EA dominated global value chains. Moreover, the free movement of capital within the EU and the capital transfers from the EU Structural Funds support a rising inflow of foreign capital in Bulgaria, which typically covers the trade deficit more than 100 per cent. Due to Bulgaria's tight links to the EU, the economy is highly sensitive to the cyclical fluctuations of the EU and more specifically of the EA.

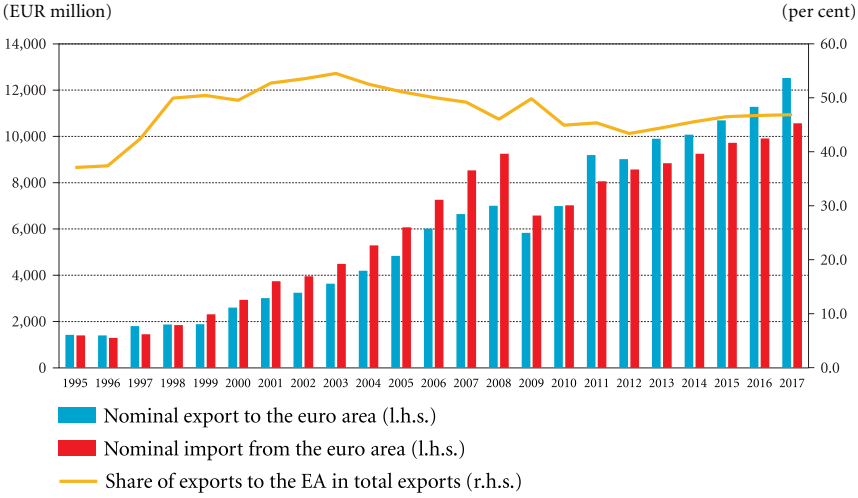
Figure 1: **Annual Average Exports and Imports in 1999–2017**

(total and by commodity groups, per cent of GDP)



Source: the BNB.

Figure 2: **Foreign Trade of Bulgaria with the EA**



Source: the BNB.

The openness of the Bulgarian economy and its tight economic relations with the EU and the EA in particular suggests that the foreign trade and financial flows channel may have an important role in transmitting the ECB's monetary

policy[45] to the Bulgarian economy via changes in demand and cost of funding in the EA.

3.2. The Currency Board with a Fixed to the Euro Exchange Rate

It has been a topic of intensive research and debate in the academic literature whether a floating exchange rate can support better export performance in small and open developing countries.[46] There is a trade-off, well studied in the academic literature, between frequent and/or sizable exchange rate adjustments aimed by the national authorities at counteracting negative international environment changes and the target of maintaining macroeconomic stability. The trade-off is normally resolved in favour of macroeconomic stability.[47]

According to the estimations presented in research papers focused on Bulgaria (Barber and Vassilev (2003), Stoevsky (2009), BNB (2009)) the elasticities of exports and imports to foreign and domestic demand respectively are much higher than the export and import elasticities to the real exchange rate. The interpretation of the size and interrelation of these elasticities is that, other things equal, a depreciation of the national currency can be ineffective for improving the overall trade balance or the export performance in case of a deterioration in foreign demand.

Going back to the early 1990s Bulgaria opted for a floating exchange rate and full-fledged monetary policy. At the background of the expansionary fiscal policy of that time the overall macroeconomic policy proved unsuccessful[48] and drove the economy into a deep economic and banking crisis in 1996 – the beginning of 1997.

[45] The key interest rates for the euro area set by the ECB Governing Council are: 1) the interest rate on the main refinancing operations (MROs), which normally provides the bulk of liquidity to the banking system. The Eurosystem may execute its tenders in the form of fixed rate or variable rate tenders; 2) the rate on the deposit facility, which banks may use to make overnight deposits with the Eurosystem; 3) the rate on the marginal lending facility, which offers overnight credit to banks from the Eurosystem.

[46] According to the Marshall-Lerner condition a depreciation of the national currency can improve the trade balance only if the sum of the absolute values of the price elasticities of demand for exports and imports is above 1.

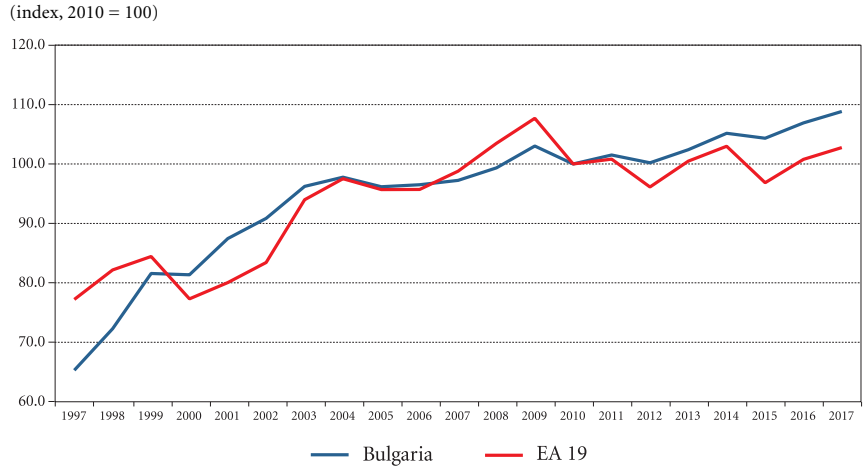
[47] Although this issue has not found an ultimate agreement in economic literature, the arguments in favour of stable exchange rates are provided in the seminal work of Calvo and Reinhart (2000).

[48] There are many publications describing the stop and go transition reforms in Bulgaria till 1997 and the overall macroeconomic instability of the economy.

To resolve the accumulated imbalances and stabilise the economy in July 1997, a currency board arrangement was introduced with a fixed exchange rate to the German mark (later to the euro at the same exchange rate as the German mark was fixed to the euro) and a stringent rule of money issue. According to the rule, the central bank, upon demand, exchanges lev for euro and euro for lev at the fixed by the BNB law exchange rate. The operation of the currency board was and continues to be safeguarded by prudent fiscal policy and structural reforms.

While the lev is fixed to the euro, it fluctuates to all other currencies in a similar way as the euro: the nominal effective exchange rate of the lev moves closely to the dynamics of the nominal effective exchange rate of the euro.

Figure 3: **Nominal Effective Exchange Rate of the Lev and the Euro (*vis-à-vis* the Currencies of 42 Countries)**



Note: The NEER or the "trade-weighted currency index", tracks changes in the value of a given country's currency relative to the currencies of its principal trading partners. It is calculated as a weighted average of the bilateral exchange rates with those currencies. On the graph the NEER is calculated against the currencies of 42 countries, namely: EU28 + Australia, Canada, Japan, Mexico, New Zealand, Norway, Switzerland, Turkey, USA, Brazil, China, Hong Kong, Korea, Russia. The difference in the dynamics of the presented indices is mainly due to the different weights of the 42 countries in each specific index. An increase in the index would be interpreted as an appreciation of the particular currency against those of the selected 42 trading partners.

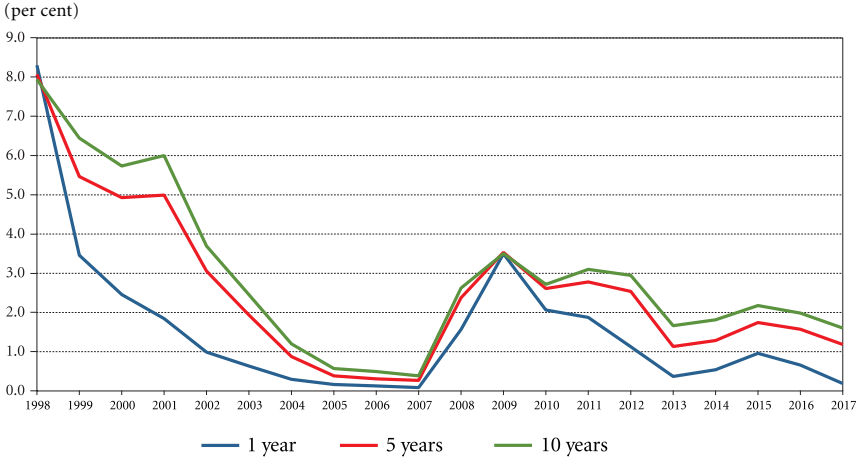
Source: European Commission, Price and Cost Competitiveness Data Section.

The ECB's monetary policy, while targeting the inflation rate, may have an impact on the free floating euro exchange rate, depending on the degree of synchronisation or diversion between the ECB's policy and other central banks'

monetary policy. In this respect the ECB's monetary policy changes may affect the Bulgarian economy through the nominal effective exchange rate channel and its impact on the relative import/export prices.

With the introduction of the currency board the risk premium for Bulgaria has decreased significantly, which facilitated the transmission of the ECB's monetary policy to the Bulgarian economy. However, differences in monetary conditions between Bulgaria and the EA may arise due to a risk-premium that varies over time in line with market participants' assessment of economic fundamentals in Bulgaria and in the EA (see Figure 4).

Figure 4: **CDS Rates for Bulgaria**



Source: JP Morgan.

As the fixed exchange rate of the lev eliminates the exchange rate risk to the euro, the currency board facilitates trade integration with EU member states and the participation of the country in the global value chains (UNCTAD, 2013). In addition, with the free movement of capital, which is an indispensable attribute of the EU, the process of deepening financial interlinkages between Bulgaria and the EA, is made more efficient by the currency board.

The currency board accelerates the transmission of the monetary policy in the EA to the monetary conditions in Bulgaria through the foreign trade and financial channels. As far as the nominal effective exchange rate of the lev co-moves with the nominal effective exchange rate of the euro the exchange rate channel is also open to facilitating the transmission.

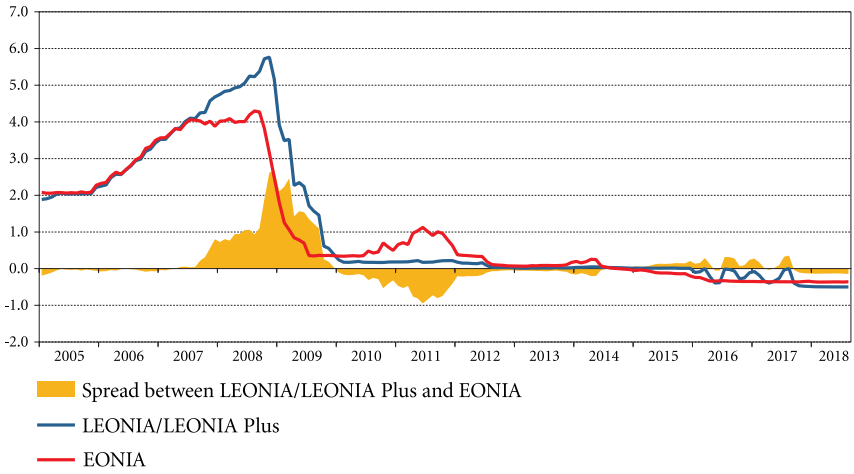
3.3. Prevalence of EA Banks in the Financial Sector

After the introduction of the currency board in 1997 the authorities initiated procedures for privatisation of state-owned banks. Most of the banks on sale became property of international banking groups established in the EA. The subsidiaries of EA based parent banks represent around 60 per cent of total bank assets in 2017.

Though the banks in Bulgaria have no direct access to the ECB financing facilities, the EA banks' subsidiaries, operating in the country, can borrow funds from their parent banks at rates close to the corresponding ECB's policy or at EA money market interest rates. The currency board guarantees the fixed exchange rate of conversion of euro to levs and levs to euro at any time on demand which can explain the co-movement between the overnight money interest rate in levs in Bulgaria and the overnight EA money market.

Figure 5: **LEONIA and EONIA**

(per cent, percentage points)



Note: With effect from 1 July 2017, LEONIA Plus index replaces LEONIA. LEONIA Plus monthly values are calculated as an arithmetic average for those days when overnight unsecured lending transactions are concluded in the interbank market in levs. For more information about the calculation of LEONIA Plus, see http://www.bnb.bg/PressOffice/POPressReleases/POPRDate/PR_20170316_EN

Sources: the BNB, the ECB.

One of the key principles of the currency board in Bulgaria is that the central bank does not refinance banks. Only in the case of a threat for a systemic banking crisis the central bank may provide the facility of a lender of last

resort but at very stringent requirements to the borrower. Consequently banks manage their liquidity carefully and maintain additional buffers to safeguard their solvency while on its side the central bank assigns a higher level of liquidity and supervisory requirements and standards for the banks, operating in Bulgaria. Higher requirements for banks in Bulgaria increase the costs of funding which may cause the existence of positive interest rate spreads *vis-à-vis* similar products of the EA banking sector.

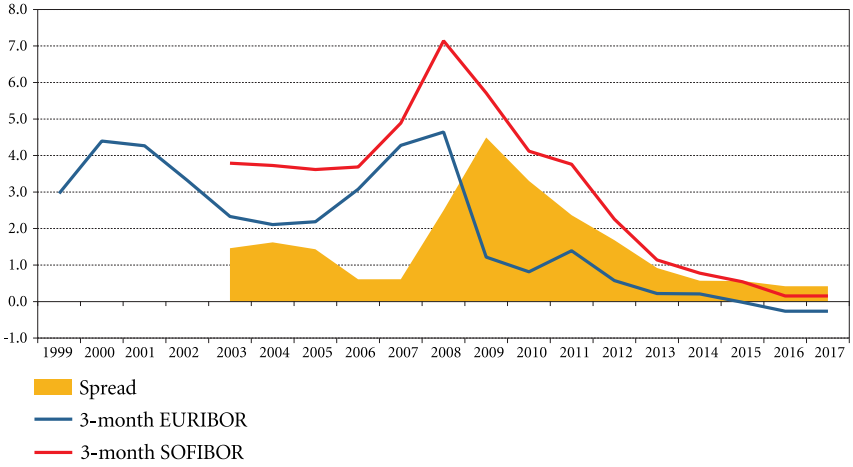
A clear cut example of a higher requirement is the level of the minimum required reserves. In Bulgaria the effective implicit minimum required reserve rate has averaged 9.4 per cent in the period September 2017 – August 2018[49] while for the EA banks the rate is 1.0 per cent (lowered by the ECB from 2 per cent since 2012). Moreover, two of the five capital buffers as defined in Directive 2013/36/ EU – the capital conservation buffer and the systemic risk buffer, are set at their maximum so that the minimum capital adequacy ratio for banks in Bulgaria is 13.5 per cent compared to 8 per cent in general.

Based on the elaborated higher requirements and standards to the banking sector of Bulgaria, positive spreads may characterise money market interest rates of higher maturities, as well as deposit and lending rates. In addition, the perception of risk, which may fluctuate over time depending on the expectations about economic developments and policy changes in Bulgaria, may augment the positive interest rate spreads for longer term financial instruments.

[49] According to Article 3 of the new BNB Ordinance No 21 on the Minimum Required Reserves Maintained with the Bulgarian National Bank by Banks, effective as of 4 January 2016, the rate of minimum required reserves on funds attracted from residents remains at 10 per cent of the deposit base, from non-residents 5 per cent and from the state and local government budgets 0 per cent. Those rates of the minimum required reserves were introduced as of 1 January 2009.

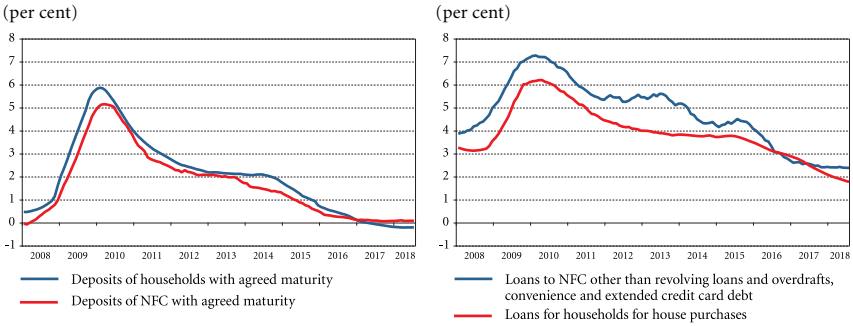
Figure 6: **Spread between EURIBOR and SOFIBOR**

(per cent, percentage points)



Sources: the BNB, the ECB.

Figure 7: **Spread between Deposit and Lending Rates**

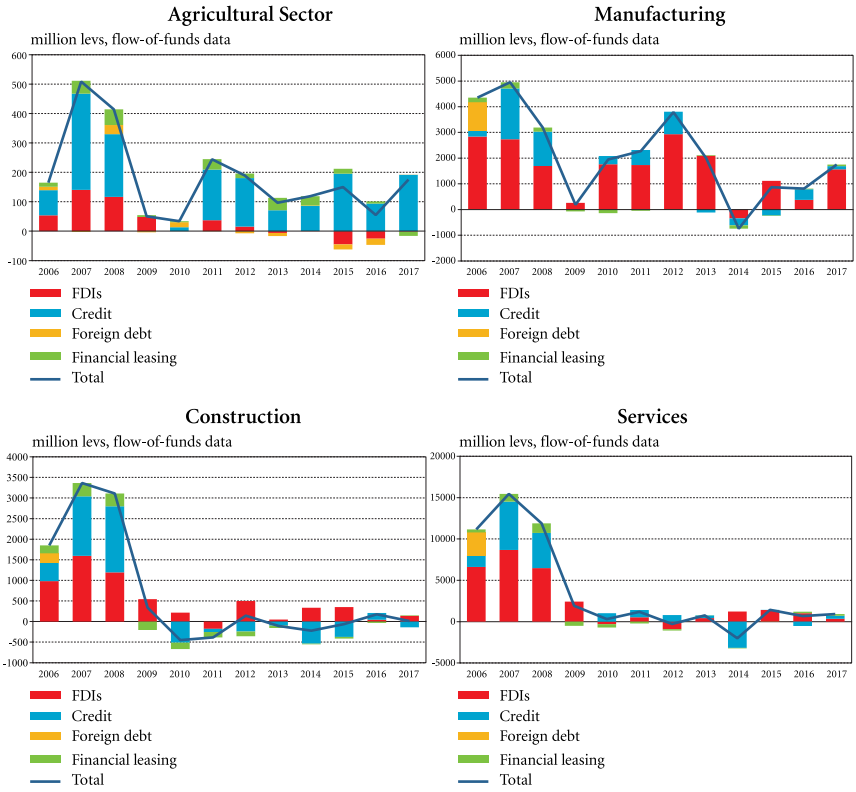


Sources: the BNB, the ECB.

The level of the deposit interest rates in Bulgaria are set by the individual banks in a rather competitive environment and depending on the abundancy or scarcity of domestic financial resources, which comprise the bulk of banking sector attracted funds. Bank lending rates for households and corporations are usually calculated by adding a mark-up over a certain money market index, such as the EURIBOR (Mihailov, 2014) or recently adding a mark-up over a selected by the individual banks deposit interest rate. Companies in Bulgaria usually recourse to their gross operating surplus, which occupies the biggest

share in their overall financing[50]. In respect to borrowed funds the structure of financing differs by sectors. According to data, agriculture resorts mainly to domestic bank credits while the share of external financing (FDI and debt) dominates in manufacturing, construction and services (excluding financial intermediation services and public services), related to the share of foreign ownership in those sectors.

Figure 8: **Sources of Financing**



Note: Due to data limitations FDI flows are compiled following BPM 5 methodology for the period prior to 2014 and BPM 6 methodology thereafter. Credit flows are compiled following NCEA-2003 classification of economic activity prior to 2009 and CEA-2008 classification thereafter.

Source: the BNB.

[50] The level of the operating surplus by sectors and the structure of borrowed funds of companies are presented in each issue of the BNB quarterly publication "Economic Review".

Despite the more stringent macro- and microprudential requirements and hence higher costs of banking in Bulgaria, the subsidiaries of EA based parent banks can act as transmitters of the ECB's monetary policy to the monetary conditions in Bulgaria, although the transmission may be only partial depending on the actual circumstances. The financial inflows from the EA – foreign direct investments or external debt, which are not channelled through the domestic banks, but may affect their interest rates, also transmit the monetary conditions in the EA to Bulgaria. All those financial flows bring into being the interest rate channel of transmission of the ECB's monetary policy to the Bulgarian economy.

3.4. Instruments of the Bulgarian Central Bank to Influence the Monetary Conditions in the Country

Under the currency board, the BNB does not set a policy interest rate and does not conduct open market operations. Consequently, it does not avail of the standard monetary policy instruments to change the monetary conditions in the country. But the central bank may use the minimum required reserves to directly influence the liquidity in the economy and within the existing regulatory limits it may apply also macroprudential and microprudential tools to similar effect.

The regulation of the minimum reserve requirements that banks hold at the BNB represents the main instrument through which the central bank can affect the monetary conditions in the country and either accelerate the transmission of the ECB's monetary policy or slow it down. For example, during the economic boom between 2004 and 2007, a series of regulatory changes were adopted by the BNB, one of which was the increase of the minimum reserve requirement rate from 8 per cent to 12 per cent and the imposition of additional reserve requirements on banks that violate an administratively determined credit growth rate[51]. After the global liquidity squeeze that followed the Lehman Brothers bankruptcy in September 2008 the BNB undertook a series of measures to enhance the disposable liquidity of banks, one of the measures being the reduction of the minimum reserve requirement rate.

After the ECB introduced a negative interest rate on its deposit facility in June 2014, the banks operating in Bulgaria started to hoard excess reserves on their accounts with the BNB, the interest rate on these accounts being zero. To cope with this excess accumulation of liquid funds which was costly for the central

[51] For details of the BNB measures undertaken in the period 2005–2007 see the BNB Annual Reports for those years.

bank, at the end of 2015 the BNB Governing Council adopted a new Ordinance No 21 on the Minimum Required Reserves maintained by Banks which entered into force on 4 January 2016. The main new provisions in the latter are the introduction of a definition for banks' excess reserves with the BNB and the application of the ECB deposit facility interest rate on the excess reserves when this interest rate is negative[52]. The BNB continued to apply a zero interest rate on excess reserves where the ECB deposit facility rate is positive or zero. As regards the minimum required reserves, the BNB retained its policy of not incurring interest.[53]

An important feature of the currency board in Bulgaria is the coverage of all monetary liabilities of the central bank by foreign reserves apart from reserve money (banknotes and coins in circulation and banks' deposits with the central bank). This wider coverage of monetary liabilities allows for the accumulation of buffers, which through changes in the minimum reserve requirements (set by the BNB), or through the fiscal policy measures, could be used to mitigate the effects of external shocks on Bulgaria's balance of payments flows and the economy as a whole.

3.5. A Summary of the Transmission Channels of the ECB's Monetary Policy to the Monetary Conditions in Bulgaria

The elaborated specific features of the economy have important implications for the transmission of the ECB's monetary policy to the Bulgarian economy. Due to the openness of the economy, its strong trade and financial links with the EA, we may expect that the trade and financial channels are very important. Apart from the impact on the demand for Bulgarian goods and services in the EA, the ECB's monetary policy, by advancing changes in the effective exchange rate of the euro, reflects on the nominal effective rate of the lev and hence influences the relative export and import prices in extra-EA trade of Bulgaria.

Through the financial channel and the prevalence in the Bulgarian banking sector of subsidiaries of EA based banks the ECB's monetary policy has a comparatively rapid effect on the domestic short-term money market rates. In terms of the funds attracted from parent banks, the ECB's monetary policy transmission works through their cost of funding which depends partially on money market rates in the EA. Then it has a secondary effect through bank

[52] This was later changed in October 2017. The BNB introduced an extra minus 20 basis points on top of the ECB deposit facility interest rate, with which bank's excess reserves held at the BNB are charged.

[53] For details of the BNB policy see the BNB Annual Report for 2015, 2016 and 2017.

assets, affecting lending interest rates, excess reserves and foreign assets of banks. Fluctuation of asset prices in Bulgaria (represented in this paper by house prices) has been determined in the past by the inflow of capital (foreign demand) and the growing income *per* capita (domestic demand). The free capital movement in the EU contributed for the important share of EU residents' demand for housing in Bulgaria.

In summary, given the close economic and financial integration of Bulgaria in the EU, the currency board with the exchange rate fixed to the euro and the prevalence of subsidiaries of EA-based banks, it should be expected that the ECB's monetary policy is transmitted to the Bulgarian economy by the following channels: foreign trade channel, nominal effective exchange rate of the Bulgarian lev and relative export/import prices, asset price channel and last but not the least through the interest rate channel.

4. Channels of Monetary Policy Transmission in the BNB Quarterly Projection Model (BNBQPM)

4.1. Short Overview of the BNBQPM

The transmission channels of the ECB's monetary policy to the economy of Bulgaria are examined within the large quarterly projection macro-econometric model of the Bulgarian National Bank (BNBQPM) which is the main macro-econometric tool used for forecasting and simulation purposes. The model is estimated on quarterly data and covers the main sectors of the economy and the existing interlinkages between them. The functioning of each sector of the economy is modelled in an error-correction framework. As such the model structure is based on the idea that the dynamics of a variable can be explained by the interaction of short-term factors capturing transitory phenomena and long-term ones capturing structural information, as embodied in a standard error-correction model. Some equations defining the short-term variation of each series include as an explanatory variable a lag term of the dependent variable as well[54], with the aim of this being a twofold one. First, there is strong economic reasoning supporting the lag term structure of some variables with a widely popular example of this being sticky prices and adaptive inflation expectations generating persistence in the HICP series. Second, including the lagged dependent variable as an explanatory one is used as a

[54] Within the BNBQPM, these equations are the ones defining the unemployment benefits, the HICP and its components, the bank deposits, the total and household credit, and all deposit interest rates.

means to ensure that there is no residual autocorrelation if some existed in the initial specification of the equation.

In line with standard practices, the BNBQPM takes a certain number of predefined variables as inputs and makes assumptions about certain characteristics of the future economic and political environment. The assumptions and exogenous variables used are related mainly to the development of the external environment, including ECB's monetary policy decisions. The projected paths of selected variables describing the world economy are based on forecasts prepared by international institutions (ECB, EC, IMF, World Bank, OECD) or represent technical assumptions.

Conceptually, the BNBQPM can be viewed as consisting of six interacting blocks (real sector block, external sector block, price developments block, labour market block, monetary sector block and fiscal sector block), each producing forecasts for a key set of variables describing in a comprehensive way the Bulgarian economy. The separation of the model into these blocks is merely a notional device to delineate typical areas of analytical interest and is not indicative of the structural independence of the blocks. The structure of the BNBQPM with the main interrelations and propagation channels in the model could be found in BNB (2015b).

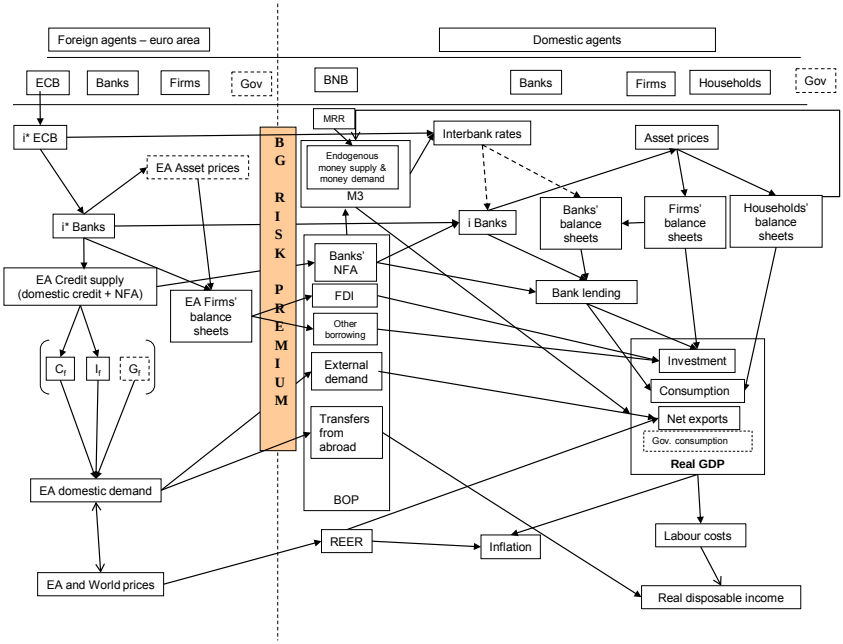
The rest of this section provides more information on the transmission channels of the ECB's monetary policy within the BNBQPM. The basic scheme of transmission from ECB's policy interest rates to economic activity and inflation is depicted in Figure 9. Once the policy rate is set by the ECB, the corresponding changes in the USD/EUR exchange rate[55] and the EA interest rates are transmitted to both the EA countries and Bulgaria. The ECB's monetary policy decision then has an impact on prices and imported volumes (through its effects on domestic demand) of all EA countries. These effects are in turn transmitted to the Bulgarian economy via changes in the country's foreign demand and competitors' prices on the export side[56]. The BNBQPM captures the following channels through which the shocks are transmitted

[55] In the paper the USD/EUR exchange rate is defined as how many U.S. dollars are needed to purchase one euro. Therefore an increase in the USD/EUR exchange rate should be interpreted as appreciation of the euro against the US dollar.

[56] Competitors' prices on the export side are calculated as a double-weighted average of the export deflators of Bulgaria's competitors. In the first stage of the weighting scheme, the competitors' prices faced by Bulgarian firms in their individual export markets are calculated as a weighted average of competitors' export prices, with the weights reflecting the importance of each competitor with regards to the imports of that individual country. In the second stage, the competitors' prices faced by Bulgarian firms in each of its export markets are weighted according to the share of each market in Bulgaria's total exports, and aggregated. Competitors' prices on the import side are calculated following a similar approach. Further details can be found in Hubrich and Karlsson (2010).

to the economy: (1) the foreign trade channel (comprising the trade spill-over channel and the exchange rate channel; (2) financial markets channel (comprising the interest rate, credit and the asset price channel). Due to model limitations, the expectations channel of monetary policy transmission is not accounted for.

Figure 9: **Primary Transmission Channels and Spill-over Effects from the ECB's Monetary Policy**



Note: Fiscal policy is assumed to remain unchanged in both the EA and the domestic economy following an ECB monetary policy shock as displayed by the dotted boxes in the diagram. The same notation is applied to EA asset prices, which are not explicitly accounted for in the simulations.

The importance of these channels and the way in which they are modelled in the BNBQPM reflect the operation of the currency board, the high openness of the economy and the foreign-bank dominated financial system. In the BNBQPM the 3-month EURIBOR is used as a reference rate for the European money market response to the ECB's monetary policy change. Although the money market rate is not set by the ECB, it responds to the ECB's monetary policy changes (both in the standard and the non-standard measures) (Lenza, Pill and Reichlin, 2010). In the sections that follow the channels, covered by the

BNBQPM, are explained in more detail, starting from the one contributing the most to the overall change in real GDP – the trade spill-over channel.[57]

4.2. Transmission through the Foreign Trade Channel

In the context of foreign trade, changes in the ECB's policy rate are passed onto Bulgarian net exports through trade spill-over effects (mainly through the change in EA demand) and effects stemming from changes in the exchange rate.

4.2.1. Trade Spill-over Channel

Assuming that changes in the ECB's policy affect the economic activity of the EA, an increase in the main policy rate is expected to have a negative impact on the external demand for Bulgarian goods and services. This direct transmission can be attributed to the fact that the EA is the main trading partner of the country (in 2017 approximately 47 per cent of total exports of goods from Bulgaria are for countries from the EA) and to Bulgaria's high integration in global value chains (Ivanova and Ivanov, 2017). Apart from the direct demand transmission, the trade spill-over channel also includes a price effect. This price effect takes into account that a change in the ECB's policy rate would eventually affect the price level in the EA by altering the EA's domestic demand (despite that in this channel we assume no change in the effective exchange rate). As a result a policy rate increase is likely to lower export prices in the EA countries, which in turn will put pressure on Bulgaria's export price competitiveness provided that Bulgarian exporters do not adjust their export prices accordingly.

Within the BNBQPM the trade spill-over channel will mainly have an effect on real exports of Bulgarian goods. Real imports will react only to the extent to which domestic demand in Bulgaria changes as a result of the tightening of the ECB's monetary policy.

Real exports of goods are modelled as a function of external demand, price and non-price competitiveness[58]. External demand in the BNBQPM is taken as an exogenous variable and measures the real weighted imports of Bulgaria's main trading partners. The price competitiveness term represents a ratio of the export prices (export deflator) and a weighted average of the export prices

[57] In this paper we use the BNBQPM version as of June 2018.

[58] The non-price competitiveness term accounts for the unobserved driver of exports growth beyond external demand and price competitiveness.

of Bulgaria's competitors (exogenous to the model)[59]. Full transmission from a change in the external demand to the real export of goods from Bulgaria is assumed in line with Laxton et al. (1998) and Fagan et al. (2005). Therefore, a one percent decrease in the external demand for Bulgarian export as a result of an increase in the ECB's policy rate would transfer directly into a one percent decrease in export volumes. Given the estimated short-run and long-run equations for real export of goods from Bulgaria, we observe strongest transmission from changes in the ECB's monetary policy through the external demand component, whereas the effect through price competitiveness is of secondary importance. The error-correction term suggests a relatively fast adjustment back to equilibrium (from two to three quarters).

4.2.2. Exchange Rate Channel

Apart from the trade spill-over channel, the ECB's policy rate change will also affect Bulgaria's foreign trade via an exchange rate channel. When the ECB hikes its policy rate, return on EA assets is expected to increase compared to foreign assets and as a result the euro will appreciate in effective terms against other currencies (Bovin, 2010)[60]. Assuming similar price developments in Bulgaria and the EA, an appreciation of the euro against the US dollar will have a negative effect on the competitiveness of Bulgarian exports to countries outside the EA (given that their currencies do not appreciate in accordance with the euro). At the same time, as imports become cheaper, imported volumes in Bulgaria will increase and this could have a negative impact on consumption of domestically produced goods and services.

In technical terms, a change in the USD/EUR exchange rate, induced by a change in the ECB's policy rate, is reflected in several steps in the BNBQPM. Initially, we see the effect on export and import prices for Bulgaria, which depends on the characteristics of Bulgaria's foreign trade (product structure, geographical market orientation, currency invoicing). As these characteristics differ between exported and imported flows, we could expect that the terms of trade (measured as the ratio between the export deflator and the import deflator) will change as a result of an exchange rate shock.

The export and import deflators are modelled in the BNBQPM both in the short-run and in the long-run as a combination of domestic prices and external

[59] An increase in this price competitiveness term suggests that Bulgarian export prices grow at a higher rate compared to competitors' prices which would imply lower price competitiveness of Bulgarian exporters.

[60] Changes in the euro area nominal effective exchange rate historically follow closely the movements of the bilateral USD/EUR exchange rate (see BNB (2015a)).

prices. Domestic prices are proxied by the GDP deflator, while external prices both on the import and export side represent a weighted average of prices in euro of five major commodity groups traded on international markets (oil, metals, food, agricultural raw materials and others). The estimation of the external prices on the export and import side takes into account the characteristics of Bulgarian exports and imports respectively (product structure, geographical market orientation, currency invoicing[61]). Given this construction changes in the USD/EUR exchange rate impact external prices on the export and import side only to the extent to which trade is invoiced in currencies other than the euro. Considering the fact the share of Bulgarian trade with non-EU countries invoiced in currencies other than the euro is higher in imports than in exports, one would expect that an appreciation of the euro against the US dollar will lead to an improvement in the terms of trade for Bulgaria, assuming no change in domestic prices and in the price of inputs.

The relative importance of external and domestic prices for determining the dynamics of the export and import deflators is comparable as suggested by the estimated coefficients. Moreover, the error-correction term suggests that after a shock is introduced, both deflators return to their long-run equilibrium in approximately four quarters.

Movements in the USD/EUR exchange rate will be passed onto the exported volumes of Bulgarian goods via the price competitiveness term in the BNBQPM (both through the change in the export deflator and through the impact on export prices of Bulgaria's competitors). Additionally, appreciation of the EUR against the US dollar will lower EA's domestic demand which in turn will reduce Bulgarian exports.

Imported volumes to Bulgaria are modelled as dependent on demand for imported goods and a relative prices term (a ratio of the import deflator and the GDP deflator) in the BNBQPM. Therefore, it is the relative prices term through which changes in the exchange rate will be mainly transmitted to the real import of goods (via the import deflator and to a lesser extent via second-round effects on the GDP deflator). Moreover, lower exports as a result of the

[61] We introduce the assumption that all trade transactions of Bulgaria with EU countries are invoiced in euro. Regarding the transactions with countries outside of the EU, the currency composition is estimated based on Eurostat data about the invoicing currency structure of export and import transactions of Bulgaria. Data suggests that the most commonly used currency for transactions between Bulgaria and non-EU countries is US dollars.

introduced appreciation of the euro will affect negatively Bulgarian import volumes.[62]

4.3. Transmission through the Financial Markets Channel

4.3.1. Interest Rate Pass-through

Through the interest rate channel, monetary policy decisions of the ECB affect real economic activity in Bulgaria by changing key domestic interest rates, thus influencing consumption, saving and investment decisions of households and firms. First, changes in key ECB interest rates influence the costs of interbank borrowing on the money market in Bulgaria, to which banks subsequently react by adjusting their deposit interest rates. At the same time, the changes in the cost of bank financing influence the interest rates on loans provided by banks. Interest rates on deposits and loans then enter the decision making process of economic agents and affect key macroeconomic variables, such as the amount of credit extended to the private sector, consumption and investment in the economy.

a. Money market rates[63]

Section 3 outlined the main characteristics of the currency board arrangement in Bulgaria and pointed out that domestic money market developments in the country are expected to follow closely those in the EA. Against the observed tight historical co-movement between domestic and EA money market rates, the former have been modelled in BNBQPM as a linear combination of the contemporaneous 3-month EURIBOR and a country-specific short-term risk premium. This specification would imply a complete and simultaneous pass-through of the ECB's policy changes to domestic money market rates considering that risks perceptions remain unchanged.

b. Deposit rates

The transmission of the ECB's monetary policy changes to the domestic money market subsequently feeds into deposit rates of commercial banks. Deposit rates[64] are modelled in an error-correction framework as dependent positively on the spread between three-month money market rates in Bulgaria and the

[62] Due to the import content of exports, that is incorporated in the demand for imported goods component.

[63] The money market rate used in this simulation exercise is the 3-month SOFIBOR. The calculation and publication of the SOFIBOR index was discontinued by the BNB in July 2018 (for more information see BNB press release from 16 March 2017).

[64] In the BNBQPM term deposit interest rates for the private non-bank sector are modelled.

EA and negatively on the ratio of bank deposits to bank loans. The purpose of including the money market spread in the deposit rates equation is to account for the country-specific risk premium relative to the EA market rate. The deposit-to-loans ratio is included to capture liquidity and availability of loanable funds in the banking system, and is expected to be inversely related to the deposit interest rate[65].

The short- and long-run equations for deposit interest rates in the BNBQPM point to a higher sensitivity of deposit interest rates to changes in the deposit-to-loans ratio, compared to changes in the money market spread. This may be explained by the significant share of resident deposits in banking sector attracted funds, particularly after the global financial and economic crisis when households increased their savings rate. The estimated error-correction term coefficient suggests that equilibrium is restored within 7 quarters. In the short-run, deposit interest rates exhibit moderate persistence. Under the assumption of unchanged country-specific risk premium, as done in the simulations, the transmission of the ECB's monetary policy changes to deposit interest rates is an indirect one in the model and depends entirely on the adjustment of deposit and credit aggregates.

c. Lending interest rates

Lending rates for households and non-financial corporations are modelled separately in the BNBQPM. This breakdown allows for a more accurate evaluation of the monetary policy transmission mechanism as the pass-through to corporate and consumer lending rates could differ considerably[66]. The specifications used for modelling these two types of lending rates capture effects associated with the cost of funds, borrower's risk profile, banks' balance sheet considerations and macroeconomic risks.

i. Lending rates for non-financial corporations

The interest rates on loans to non-financial corporations are modelled in an error-correction framework as a function of the three-month EURIBOR, the deposit interest rate, real exports and banks' non-performing loans to non-financial corporations. Deposit interest rates and the three-month EURIBOR approximate domestic and external financing costs, respectively. The inclusion of exports as explanatory variable for corporate lending rates aims to capture changes in borrower-inherent risk related to export-oriented companies. As

[65] The deposit-to-loans ratio employs bank-held private deposits and loans issued to the private sector.

[66] The rates are weighted across all maturity segments. Household lending rates are aggregated across overdraft, consumption, house purchase and other loans subcomponents.

real exports increase, export-oriented firms are likely to be able to repay more easily their loans and become more profitable and less cash-constrained, and as a result firm-specific credit risk in these companies is reduced. Furthermore, increasing exports indicate positive external environment developments which contributes to reducing banks' assessment of overall macroeconomic risks in the economy. The inclusion of non-performing loans of non-financial corporations reflects potential lower lending capacity of banks when non-performing loans are increasing, pushing banks to provide higher lending rates to firms.

In the long-run equation, the pass-through from changes in the three-month EURIBOR to domestic corporate lending rates is relatively strong. Probably due to the much higher weight of domestic liabilities in bank's balance sheets, the lending rate for non-financial corporations is estimated to be slightly more sensitive to the change in domestic financing costs compared to the EURIBOR. Changes in real exports and firms' non-performing loans have a less pronounced impact on corporate lending rates. The estimated value for the error-correction coefficient indicates that adjustment to equilibrium occurs in approximately two quarters. According to the short-run econometric specification, corporate lending rate dynamics is driven predominantly by changes in EA money market rates and to a lower extent by changes in the cost of domestic financing. In the short-run equation, corporate lending rate is also more sensitive to changes in exports as compared to changes in non-performing loans.

ii. Lending rates for households

Household lending rates are modelled in an error-correction framework that includes the Bulgaria – EA money market spread[67], the deposit interest rate for households[68], the residential property price[69] index and the average monthly wage in nominal terms. Again, deposit rates are meant to reflect cost-of-funds pricing effects, while the money market spread reveals information about the country-specific risk premium. Changes in EA monetary policy would transmit through their impact on domestic deposit rates, and possibly, via the risk premium if the spread between local money and EA market rates widens. Under the assumption of unchanged country-specific risk premium,

[67] Attempts to include the 3-month EURIBOR, as in the case for lending rates for NFC, revealed counterintuitive coefficient estimates, which is why the spread between 3-month money market rate in Bulgaria and the 3-month EURIBOR was chosen in the BNBQPM.

[68] The deposit interest rate for households is modelled in the BNBQPM in a similar way to the term deposit interest rate for the private non-bank sector.

[69] Residential property prices and house prices are used interchangeably in the text.

the transmission of the ECB's monetary policy changes to the lending rate for households in Bulgaria will take place indirectly through their impact on the dynamics of the deposit interest rate for households, as well as through the effect of the ECB's monetary policy changes on house prices and the labour market in the country.

The inclusion of house prices and wages serves a couple of purposes. House prices capture loan-specific collateral in the case of mortgage and consumption loans, respectively. Wages could be used as an additional proxy for borrowers' risk profile, lower wages implying higher risk on the loan repayment schedule; while house prices capture both collateral constraints and bank balance sheet effects. Lower house prices decrease the value of collateral and make it more difficult for borrowers to negotiate loans, resulting in a higher lending interest rate for households. Furthermore, lower residential property prices lead to a deterioration in the asset position of banks, given the significant amount of property posted as collateral in the banking system.

In the long-run equation, the estimated impact of changes to deposit rates for households is stronger as compared to money market spread changes. Furthermore, household lending rates appear to be slightly more sensitive to changes in house prices than they are to changes in the average monthly wage. The estimated error-correction term coefficient implies a return to equilibrium in a little more than two quarters. In the short-run, household lending rates are less sensitive to changes in deposit interest rates than they are to changes in the money market spread. The estimated importance of wages becomes less relevant in the short-run compared to the long-run equation, while changes in house prices are almost equally important in the short and the long-run.

4.3.2. Asset Prices

Changes in interest rates affect the prices of various types of assets and these changes in the market value of assets affect the decision-making process of households. The asset price channel in the BNBQPM is related to the impact of interest rates on house prices and accounts for the existence of substitution effects between savings, in the form of deposits, and investment in real estate. The direct effect of interest rates on house prices comes through its influence upon the amount that prospective house buyers can borrow from financial institutions. A more indirect effect of the ECB's monetary policy on domestic house prices comes through its influence on the income of households, which is another determinant of housing affordability and demand for housing.

A key determinant of house prices is domestic demand for housing, which is a function of the average housing loan level. Housing loan level is assumed to be a function of the amount that can be borrowed from a financial institution based on current disposable income and the existing mortgage interest rate. The typical amount lent out by financial institutions to their customers is based on the present value of an annuity, where the annuity is some fraction of current disposable income, which is used for mortgage repayment and is discounted at the current mortgage interest rate for a horizon equal to the term of the mortgage. Thus, according to the financial literature the amount which can be borrowed is proportional to the household disposable income and inversely related to the mortgage interest rate.

Therefore, an upward shift in income or downward movements in the interest rate yields an increase in the average amount of mortgage credit available from banks. In turn, mortgage credit influences house prices. This reasoning is closely related to the notion of a housing affordability index frequently used in assessments of housing market developments and has been embodied in the BNBQPM.

Following the approach proposed by Kotseva and Yanchev (2017), house prices in the BNBQPM have been modelled within a VECM framework that simulates the dynamic interplay between prices and demand for housing. On the demand side, we distinguish between external demand (proxied by FDI in real estate[70]) and domestic demand for housing. Domestic demand is approximated by an indicator based on GDP *per* capita and the current interest rate on new housing loans.

The short-run equation for house prices suggests that the adjustment to the long-run level takes approximately 5 quarters. The model structure and the magnitude of the estimated coefficients suggest that house prices in the short-run are driven mostly by their adjustment to the long-run equilibrium level. Prior to the global financial and economic crisis, large FDI inflows in real estate activities was another factor that played a key role for the dynamics of house prices in the short-run.

[70] We use FDI in Real estate, renting and business activities as a percentage of GDP.

4.3.3. Deposit and Credit Aggregates

a. Credit to households[71]

Credit aggregates are modelled as a mixture of demand- and supply-side factors: consumption/gross fixed capital formation (respectively in the equations for credit to households and credit to non-financial corporations), a price component, and an interest rate component.

More specifically, loans to households are modelled as being influenced, first, by real consumption, which reflects both a greater demand for credit as consumption goes up and increasing disposable income which allows this consumption and subsequently facilitates credit availability. Furthermore, HICP is added to account for the price component of credit, as the aggregate modelled is a nominal quantity and theory predicts that rising prices would stimulate credit demand. Lastly, the net interest spread (the spread between lending interest rate and deposit interest rate) for households is included to capture lending conditions for households and borrowers' specific credit risks. The intuition for including the spread, rather than only the lending rate for households is that changes in the lending rate alone might not be representative of how loose or tight credit conditions are relative to the overall financial conditions in the country. A widening net interest rate spread signifies less favourable borrowing conditions due to increased credit risks, thus exerting a negative influence on household credit. As evidenced by the relatively low value of the error-correction term coefficient in the econometric specification, speed of adjustment to the long-run level is slow, taking on average about 9 quarters.

b. Credit to non-financial corporations

Credit to non-financial corporations is modelled as a function of gross fixed capital formation, the HICP and the net interest rate spread defined as the difference between lending rates to non-financial corporations and long-term German bonds yields. The spread is used as a proxy for domestic entrepreneurial credit risk. Hence, a widening of the spread should affect adversely credit developments for firms. The inclusion of real gross fixed capital formation is meant to capture rising firm activity and a related pick-up of the demand for loans.

Estimation in an error-correction framework over the historical period shows that developments in credit to corporations are more sensitive to changes in

[71] The credit to households aggregate excludes loans extended under the National programme for energy efficiency of multi-family residential buildings.

investment prospects and prices than they are to changes in the interest spread in both the long- and the short-run equation. The adjustment to equilibrium takes less than three quarters. In the short-run investment developments seem to have a higher impact on corporate credit, while price and interest spread developments lose much of their explanatory power.

c. Deposit aggregates

The deposit aggregate captured in the model encompasses deposits by the private non-bank sector. Similarly to the stock of credit, in its specification it depends on real and price components as well as an interest rate spread. Specifically, aggregate private deposits are modelled as a function of real private consumption, private consumption deflator and the spread between deposit interest rates for the private sector and the 3-month SOFIBOR. Aggregate deposits are expected to depend positively on real private consumption. The spread captures the relative attractiveness of deposits to savers, compared to the overall financial conditions in the economy and should also be positively related to the dynamics of deposits. Thus, if deposit rates are relatively higher than the benchmark money market interest rate, economic agents would be more willing to increase deposit savings.

In the long-run equation, the econometric specification shows that deposits react stronger to changes in the deposit rate-SOFIBOR spread than to changes in private consumption and price components. In the short-run, the error-correction term suggests adjustment to long-run steady state in just slightly above 3 quarters. Overall, these results incline us to anticipate more pronounced effects from the interest rate spread in the long-run, while the short-run deposit aggregate developments are expected to be dominated by real private consumption and equilibrating factors.

4.3.4. Long-term Government Bond Yields and Impact on Government Debt Interest Expenditure

The long-term yield in the BNBQPM is the long-term interest rate for convergence assessment purposes (LTIR)[72]. LTIR is modelled in an error-correction form. In the long-run, domestic long-term yields are expected to co-move with the German long-term government bond yields, which are

[72] The LTIR is defined by the provisions of Article 140 of the Treaty establishing the European Community and Article 4 of The Protocol on the Convergence Criteria. The calculation of the LTIR for Bulgaria is based on secondary market transactions of central government bonds issued in national currency with maturity close to 10 years. LTIR data is available in daily and monthly frequency since 2003. More details on the data complication are available in http://www.bnb.bg/bnbweb/groups/public/documents/bnb_download/st_m_instr_ltir_en.pdf

standardly used to represent risk-free rates. To account for local money market conditions, the spread between the 3-month SOFIBOR and the 3-month EURIBOR is also included in both the long- and short-term equations. Non-performing loans (NPLs), as an indicator of risks in the financial system, are also found to be positively related to long-term interest rates in the short- and the long-term. Moreover, as a large share of the Bulgarian government bonds is held by domestic financial institutions, the demand for government bonds is expected to decline if banks' financial resources and profitability are negatively impacted by higher NPLs.

The estimated coefficients in the long-run equation suggest a complete pass-through of changes in the German yields. In addition, the Bulgarian long-term interest rate reacts strongly to changes in the short-term money market spread. The estimated coefficients in the short-run equation point to a relatively weak reaction to changes in the German long-term rate. As indicated by the estimated error-correction term coefficient, the adjustment towards the long-run equilibrium is relatively fast (around three quarters). In the short-term, long-term interest rates show a relatively low persistency and are also less sensitive to changes in the short-term money market spread and NPLs as compared to the long-run relationship.

Changes in LTIR have an impact on 1) government interest payments; and 2) external debt, particularly that of "other sectors"[73]. Due to the long-term structure of government debt[74], government interest payments are modelled as a function of LTIR. However, it should be noted that sensitivity of interest payment to changes in the LTIR is expected to be relatively low as interest payments on the predominant part of existing government debt are fixed and the share of government debt to be rolled over each year in the simulation period is around 1 per cent of GDP.

4.3.5. External Debt Financing and Flows Related to the Primary Income of the BOP

In the BNBQPM, the external debt of Bulgaria is obtained by summing up the external debt of the government, the banking sector, the FDI-related external debt and the external debt of other sectors. An ECB's monetary policy tightening will affect external debt mainly via the long-term interest differential between Bulgaria and the EA as well as the debt service burden. The

[73] External debt excluding government gross external debt, direct investment-related debt and foreign liabilities of the banking sector.

[74] The average residual maturity of government debt in 2016 is 7.8 years.

more the interest rate differential goes up, the more external debt is expected to increase, induced by the higher return on Bulgarian external debt. Increased interest rates will make it more difficult for economic agents to service their debt which will have implications for the overall stock of debt.

The increase in EA interest rates will also increase the burden of debt servicing which would affect the current account through the primary income balance. The primary income balance in Bulgaria has been negative since 2006, reflecting the high stock of foreign investments in the country and the related to it significant payments of interest on investments to non-residents. In the BNBQPM the primary income balance is modelled in a single-equation framework and includes the stock of gross external debt, gross operating surplus and 3-month EURIBOR as determinants. Gross external debt and 3-month EURIBOR are included in the equation for income paid to non-residents as to account for that portion of primary income that is related to interest payments on external debt. When ECB tightens its monetary policy we could expect that the debt servicing burden for Bulgaria will increase, leading to higher primary income outflows. Gross operating surplus should be positively related to primary income outflows since increasing firms' profitability leads to increases in payment outflows (dividends paid to non-residents' on their foreign direct investments in Bulgaria).

4.4. Impact on Domestic Demand and Prices

This section focuses on how changes in the stance of the ECB's monetary policy feed through the various transmission channels to domestic demand and prices. Movements in the user cost of capital are a key determinant of domestic demand, whether it is investment goods, residential housing, or consumer durables. Consumption and investment decisions of economic agents are further affected by substitution effects between consumption, savings and investment as well as by movements in asset prices (house prices) via wealth effects and the corresponding impact on the value of collateral.

Standard applications of the life-cycle hypothesis of saving and consumption indicate that consumption spending is determined by the lifetime resources of consumers. In line with this reasoning in the BNBQPM private consumption[75] in the long-run is modelled by a number of factors, reflecting the financial resources of households allocated for consumption. In particular, in the long-run household's real private consumption is modelled as a function of

[75] In the BNBQPM model we work with private consumption, excluding imputed rent for dwelling services.

bank credit to households[76] and a proxy for permanent income. Bank credit to households accounts for the impact of supply-side factors on households' credit (credit channel). Permanent income is approximated by the level of real disposable income[77], the capital stock and real house prices[78]. The variables about the capital stock and the housing price level capture the impact of the households' wealth on consumption. The use of house prices in real terms suggests that households will tend to increase their spending only in case that house prices grow at a faster pace than consumer prices.

In the spirit of large-scale macro-econometric models, the equation for private consumption is in an error-correction form, thus allowing for short-run variations of consumption from the expected long-run equilibrium path of consumer spending. One source of such short-run variations arises from possible substitution effects between current consumption and savings in the form of deposits. While the amount of bank credit to households accounts for the effects of credit constraints on households' consumption behaviour in the long-run equation, the nominal interest rate on household deposits is included in the short-run equation to account for the impact of monetary conditions on the households' saving rate. In the short-run households decide between consumption and savings on the basis of the interest rates on deposits.

The long-run equation for private consumption implies that the variation of the disposable income leads to higher changes in consumption than the rest of the equation's components' dynamics. The adjustment to the long-run path of consumption is estimated to be relatively slow and to take approximately 6 quarters. The model structure and the magnitude of the estimated coefficients suggest that the error-correction term (*i.e.* adjustment to the long-run path) and wealth effects (proxied by the change of relative housing prices) account for most of the dynamics of household consumption in the short-run period. Changes in real disposable income and nominal interest rates on household deposits also affect consumption spending in the short-run, though to a lesser degree.

[76] The variable for bank credit to households refers to banks' claims on households and NPISHs, deflated by the HICP.

[77] Real disposable income is calculated as the sum of nominal components of compensation of employees, net government social transfers, net income and current transfers from abroad deflated with the private consumption deflator.

[78] Real house prices measure the changes in the transaction prices of dwellings purchased by households adjusted for the impact of consumer prices. In the BNBQPM we use the deflated house price index which is the ratio between the house price index (HPI) and the national accounts deflator for private final consumption expenditure.

According to the above setup, a tightening of the monetary policy in the EA in the form of higher short-term interest rates will have a direct negative impact on private consumption through the resulting limited availability of bank credit. Moreover, higher interest rates raise the discount rate applied to the income and service flows associated with homes, lowering their prices. The resulting decrease in total wealth will then dampen household consumption and aggregate demand. In the short-run, the increase in interest rates on household deposits will lower further consumption as it encourages consumers to save.

In the BNBQPM real private gross fixed capital formation is modelled within an error-correction form. The ECB's monetary policy affects investment activity in Bulgaria most directly through the change in the user cost of capital (direct interest rate channel), which in the BNBQPM is approximated by the nominal interest rate on corporate loans[79]. In the long-run private investment is modelled as a function of potential sources of financing like the real gross operating surplus (GOS)[80], the stock of foreign direct investments in Bulgaria (measured by their ratio to total capital stock), the stock of external debt[81] and the monetary conditions that determine the availability of bank credit, namely lending interest rates on corporate loans. An additional risk premium, approximated by the difference between the lending rate to corporations and the long-term risk-free German rate is added to the user cost of capital in the simulation period. In addition to the above variables, we also include in the co-integration relationship the level of house prices (deflated by the GDP deflator) in order to capture possible balance sheet effects on firms and households. In the case of firms, increasing house prices which are a proxy for asset prices indicate an increase in the net worth of firms that could be used for collateral. Higher net worth and collateral values imply lower costs of financing and thus more investment. Regarding households, increasing house prices are associated with an easier access to mortgage credit (through the higher value of the collateral) and thus stronger demand for houses.

In addition to the error-correction term, changes in investment in the short-run are modelled as a function of changes in gross operating surplus, corporate lending interest rates and house prices. The short-run equation suggests that

[79] We use corporate lending rates on new loans weighted by the relevant volumes for all maturities and currencies. Most of the new corporate loans tend to be with medium- to long-term maturity.

[80] The real gross operating surplus (obtained as a quotient of nominal gross operating surplus and the GDP deflator) is a proxy for firms' profits and its increase is expected to have a positive impact on investment.

[81] We use the stock of external debt other than FDI and external debt of financial institutions.

the adjustment to the long-run level takes approximately 4 quarters. Regarding the importance of the identified factors for investment, the magnitudes of the coefficients suggest that the variation of gross fixed capital formation in the short-run is determined mostly by the adjustment of investment to the long-run path and by changes in gross operating surplus, followed by changes in asset prices and interest rates on corporate loans.

According to the above setup, a tightening of the ECB's monetary policy in the form of higher short-term interest rates will discourage directly private investment in Bulgaria through the bank lending channel and the balance sheet channel. Higher lending rates and more difficult access to bank financing (due to lower asset prices and the associated lower collateral value) will constrain firms' demand for bank credit, discouraging private gross fixed capital formation. ECB's monetary policy transmits indirectly to domestic investment activity through its impact on foreign trade (trade spill-over effects). Higher ECB policy rates will dampen the external demand for Bulgarian exports (see section 4.2), which will lead to a decrease in economic activity, profits (gross operating surplus) and hence the demand for investment.

In the BNBQPM inflation is measured by the Harmonized Index of Consumer Prices (HICP)[82]. The HICP is modelled as a weighted average of four components: core inflation (services and non-energy industrial goods prices), food prices, energy prices (excluding administered prices) and administered prices. The ECB's monetary policy is transmitted to consumer prices through the trade channel and through its impact on domestic demand. Changes in the ECB's policy rates induce changes in the USD/EUR exchange rate and import prices of food and energy products, which are then passed through along the supply chain to consumer prices.

According to the model structure, import prices have a direct impact on domestic energy and food prices but they also influence core inflation through firms' production costs. In the long-run equation the modelling of core inflation is based on the concept of cost-push inflation. According to this setup, explanatory variables are the costs of production, namely unit labour costs and external prices on the import side. In the short-run the price level of core components is also influenced by demand-side factors (measured by private consumption) and inertia (lagged value of core inflation[83]). Clearly, a

[82] HICP is used to construct other price indices in the BNBQPM, such as the private consumption deflator equation. Core prices are also used to construct the government consumption deflator and gross fixed capital formation deflator.

[83] The lagged value of core inflation is a proxy for adaptive inflation expectations.

contractionary monetary policy of the ECB in the form of higher short-term interest rates will lower core inflation through the appreciation of the euro against the US dollar (foreign trade channel through changes in the exchange rate). Furthermore, as tighter monetary conditions in the EA are transmitted to domestic interest rates, they will discourage private consumption and decrease production costs of domestically produced goods and services (through wage decreases). Lower demand and production costs are associated with lower core inflation.

In the long-run the food and energy price indices are modelled to follow the path of import prices of food and oil products, respectively. Unit labour costs are also included in order to account for domestic cost factors along the supply chain. The short-run equation for food prices represents the adjustment of food prices to their long-run equilibrium level. The short-run equation with an error-correction term includes as explanatory variables lagged food inflation and dummy variables to account for specific harvesting conditions in the past. The short-run specification of the energy price equation determines the quarterly rate of change of energy prices conditional on: the deviation of energy prices from the long-run equilibrium level, lagged inflation and import prices of oil products. A contractionary monetary policy of the ECB in the form of higher short-term interest rates will lead to similar effects as in the case of core prices, with differences stemming from the degree of the exchange rate pass-through.

5. Model Simulations[84]

5.1. Design of the Simulations

In the design of the simulation we employ a two-step approach. First off, we select the exogenous to the BNBQPM variables through which the change in the ECB's monetary policy will be transmitted (as described in section 4.1.) and estimate the magnitude of the respective exogenous shocks. As a second step we introduce these exogenous shocks to the BNBQPM in order to quantify the impact of the ECB's monetary policy change on the domestic economy. Overall, we identify and apply four shocks to the BNBQPM that would correspond to a scenario of a monetary policy tightening by the ECB: namely, these are changes compared to the baseline in the EA short- and long-term interest rates, in the nominal effective exchange rate (proxied by the USD/EUR exchange rate), and

[84] All changes in the macroeconomic variables discussed in this section as a result of ECB monetary policy tightening represent percentage deviation from baseline levels.

in the trade spill-over (represented by a combined change in external demand and competitors' prices on the export side).

The shock in EA short-term rates is defined as a temporary increase of the 3-month EURIBOR by 100 basis points as implemented in similar policy experiments for the EA and the Baltics (see for example Smets (1995), van Els et al. (2001), McAdam and Morgan (2001), Vetlov (2004) and Kattai (2005)[85]. In the aforementioned studies, the shock is implemented as an eight-quarter level shift of the EURIBOR by 100 basis points. In similar fashion we apply an increase of the same size for the first four quarters, but however assume gradual convergence towards baseline values for the consequent eight quarters of the simulation.

Following van Els et al. (2001) and Fagan et al. (2005) long-term interest rates are expected to react to the monetary shock in line with the expectations hypothesis and are assumed to initially increase by 20 basis points compared to the baseline before gradually returning to baseline values in the course of two years. While acknowledging that this assumption is subject to the Lucas critique and does not incorporate any changes in the term structure of interest rates induced by the widely used by the ECB over the last decade unconventional monetary policies, we still believe that the current design of the simulation is informative for analysing the role of individual channels of transmission.

To simulate the appreciation of the euro against other currencies as a result of higher interest rates, we follow McAdam and Morgan (2001). The authors rely on a modified uncovered interest parity to simulate the expected appreciation of the euro after a monetary shock with the Area Wide Model (AWM). During the first year of the simulation the euro appreciates against all currencies that are not fixed to the euro by 0.88 per cent, while in the second year it returns to slightly below baseline values (-0.05 per cent). This response of the exchange rate to changes in the short-term interest rates is somewhat weaker than what would be expected under the standard uncovered interest rate parity condition (see Els et al. (2001) and Fagan et al. (2005)). The applied modification is motivated by the increasingly high correlation between interest rate policies across the world and especially in Europe.

[85] In some of these studies it is acknowledged that the assumption for exogenous movement of short-term interest rate is not very realistic as in reality short-term rate are endogenously determined on the basis of a Taylor rule type of relationship. The assumption for truly exogenous shocks in short-term interest rates, long-term interest rates and the exchange rate is also imbedded in the STE tool. Given our reliance on the STE tool for assessing the induced-by-monetary-policy change in foreign demand and competitors prices relevant for Bulgaria, we are left with no other option but to follow the same approach.

The assumed changes in short- and long-term interest rates in the EA compared to the baseline as well as the exchange rate are then used in simulations with the STE toolbox[86] to arrive at the combined change in foreign demand and competitors' prices, relevant for the Bulgarian economy. As a result of the introduced tightening of the monetary conditions in the EA, trade spill-over effects have a contractionary impact on the Bulgarian economy as both foreign demand for Bulgarian goods and services and competitors' prices decrease relative to the baseline[87].

In all simulations with the BNBQPM, we assume unchanged domestic fiscal policy. Nominal government spending (with the notable exclusion of social payments) and non-tax revenues remain at their baseline levels. The expected worsening of the budget balance compared to the baseline as a result of both lower tax revenues and higher interest and social payments is financed through the fiscal reserve, while the level of government debt remains unchanged and the debt ratio is only affected through the denominator. The monetary policy instrumentarium, available to a central bank, is constrained in Bulgaria given the currency board arrangement. Possible measures at the disposal of the Bulgarian National Bank, including changes in the minimum reserves ratio, and the macroprudential policy tools are assumed to remain unchanged throughout the simulation horizon as well.

The change in the ECB's monetary policy is expected to affect the user cost of capital to an extent exceeding the simulated impact on corporate lending rates due to an assumed increase of the non-bank financing costs. This stronger reaction of the user cost of capital in the BNBQPM is introduced by allowing changes in the spread between the lending rate to corporations and the long-term risk-free German government bond yield rates[88] to affect firms' investment decision making in the long-run. The elasticity of private investment to changes in the spread is assumed to be equal in amount to

[86] The STE platform combines National Central Banks' models into a multi-country EU-wide simulation tool, which allows simulating exogenous shocks (to real economic variables and some financial asset prices) to derive responses for a wide range of endogenous model variables covering each of the 28 EU countries.

[87] The assumption that developments in the home economy do not influence developments in the euro area is also standard in VAR-based studies on the monetary transmission mechanism in Baltic countries (see for example Stakenas, J., & Stasiukynaite, R. (2016). Monetary policy transmission: the case of Lithuania. Baltic Journal of Economics, 17(1), 1. and Errit, G., & Uuskula, L. (2014). Euro area monetary policy transmission in Estonia. Baltic Journal of Economics, 14 (1–2), 55–77.

[88] For the purposes of the simulation in the scenario of a monetary tightening by the ECB, the 10-year German government bond yield rates are assumed to react in the same way as the shock in the 10-year EA government bond yield rates – namely, an initial increase by 20 basis points, followed by a gradual return to baseline values in the course of two years.

the historically observed elasticity of private investment to domestic lending interest rate. This stems from the presumption that this elasticity coefficient captures changes in investment with respect to risk as the latter is a component of the interest rate. It has to be noted that the change of the risk premium depends adversely on the assumed response of long-term rates in the EA and Germany. The weaker the assumed pass-through to long-term rates in the EA, the stronger will be the increase of domestic entrepreneurial risk premium.

Table 1. **Calibration of the Simultaneous Shocks to EA Short- and Long-term Interest Rates, Competitors' Prices, Foreign Demand and the USD/EUR Exchange Rate**

	Year I	Year II	Year III	Year I				Year II				Year III			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
EURIBOR (percentage points)	1.00	0.69	0.19	1.00	1.00	1.00	1.00	0.88	0.75	0.63	0.50	0.38	0.25	0.13	0.00
USD/EURO (per cent)	0.88	0.30	0.00	0.88	0.88	0.88	0.88	0.65	0.42	0.18	-0.05	0.00	0.00	0.00	0.00
Trade spillover *via*:															
(1) Foreign demand (per cent)	-0.09	-0.24	-0.22	-0.02	-0.06	-0.11	-0.16	-0.20	-0.24	-0.26	-0.27	-0.27	-0.25	-0.21	-0.17
(2) Competitors' export prices (per cent)	-0.10	-0.11	-0.09	-0.07	-0.10	-0.12	-0.13	-0.13	-0.11	-0.10	-0.08	-0.08	-0.09	-0.09	-0.09
EA 10Y BONDS (percentage points)	0.18	0.10	0.02	0.20	0.19	0.17	0.16	0.14	0.11	0.09	0.06	0.05	0.03	0.02	0.00

5.2. Simulated Impact on the Domestic Economy

As previously discussed, in order to study the reactions of domestic output and prices after a monetary policy change in the EA, we simulate simultaneous changes to EA short- and long-term interest rates, trade spill-overs and the USD/EUR exchange rate.[89] A short overview of the cumulative responses of selected key macroeconomic variables to the scenario of the ECB's monetary policy tightening is presented in Table 2.

Overall, real GDP's deviation from the baseline level equals -0.16 per cent at the end of the simulation horizon. The monetary conditions tightening causes consumers and firms to reduce their spending, while at the same time exports of goods and services contract mainly due to the reduced external demand. Consequently imports of goods and services remain at levels below baseline, following the observed decline in all domestic demand components, as well as exports. The assumed EURIBOR hike is fully transmitted to the domestic money market rate, and partly to the lending rate for households. Subsequently other domestic interest rates follow, which in turn, and against the background

[89] The appendix includes detailed tables with the responses of the key macroeconomic variables in the BNBQPM to each of the abovementioned shocks, with the size of the individual shocks normalised to 1 per cent.

Table 2. **Simulation Results**

*Percentage deviations from baseline**	Year I	Year II	Year III	Year I				Year II				Year III			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
Real output															
GDP	-0.07	-0.23	-0.20	-0.02	-0.05	-0.08	-0.13	-0.19	-0.23	-0.25	-0.25	-0.24	-0.22	-0.19	-0.16
Private consumption	-0.02	-0.15	-0.19	0.00	-0.01	-0.02	-0.05	-0.09	-0.14	-0.17	-0.19	-0.20	-0.20	-0.18	-0.16
Investment	-0.19	-1.29	-0.89	-0.01	-0.09	-0.25	-0.41	-0.93	-1.48	-1.43	-1.35	-1.19	-1.00	-0.80	-0.58
Exports (goods and services)	-0.09	-0.25	-0.24	-0.02	-0.06	-0.11	-0.16	-0.21	-0.24	-0.27	-0.28	-0.27	-0.26	-0.23	-0.19
Imports (goods and services)	-0.06	-0.40	-0.36	0.00	-0.03	-0.08	-0.14	-0.28	-0.42	-0.44	-0.45	-0.43	-0.39	-0.33	-0.27
Price developments															
HICP	-0.04	-0.06	-0.06	-0.02	-0.03	-0.04	-0.05	-0.06	-0.07	-0.07	-0.06	-0.06	-0.06	-0.06	-0.05
Export deflator	-0.06	-0.06	-0.04	-0.05	-0.06	-0.07	-0.07	-0.07	-0.07	-0.06	-0.04	-0.04	-0.04	-0.03	-0.03
ULC	-0.03	-0.08	-0.06	-0.01	-0.02	-0.03	-0.05	-0.07	-0.09	-0.08	-0.08	-0.07	-0.06	-0.05	-0.04
Labour market															
Employment	-0.01	-0.04	-0.04	0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.05	-0.05	-0.05	-0.04	-0.04	-0.03
Unemployment rate	0.01	0.04	0.04	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.05	0.05	0.04	0.04	0.03
External developments (per cent of GDP)															
Balance on goods and services	0.00	0.11	0.08	0.00	0.00	0.00	0.01	0.07	0.13	0.13	0.12	0.10	0.09	0.07	0.05
Current account plus capital account	-0.29	-0.07	0.03	-0.30	-0.29	-0.28	-0.28	-0.18	-0.07	-0.04	-0.01	0.01	0.03	0.04	0.06
Fiscal developments (per cent of GDP)															
Government primary budget balance	0.00	-0.02	-0.03	0.00	0.00	0.00	0.00	0.00	-0.01	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
Interest spending	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Financial market and asset price developments															
Money market rate	1.00	0.69	0.19	1.00	1.00	1.00	1.00	0.87	0.75	0.63	0.50	0.38	0.25	0.13	0.00
Lending rate to non-financial corporations	0.51	0.54	0.27	0.39	0.49	0.55	0.60	0.59	0.57	0.52	0.47	0.40	0.32	0.23	0.14
Lending rate to households	0.03	0.12	0.13	0.00	0.01	0.03	0.06	0.09	0.12	0.13	0.14	0.14	0.14	0.12	0.11
Long-term interest rate	0.14	0.16	0.06	0.00	0.13	0.20	0.21	0.20	0.18	0.15	0.12	0.09	0.07	0.05	0.04
House price index	-0.07	-0.47	-0.61	0.00	-0.02	-0.07	-0.17	-0.29	-0.42	-0.54	-0.61	-0.65	-0.65	-0.61	-0.55
Credit to non-government sector	-0.91	-1.41	-1.03	-0.15	-0.40	-0.66	-0.91	-1.09	-1.23	-1.36	-1.41	-1.40	-1.32	-1.20	-1.03

* The real output and price developments variables, employment, house price index and credit to non-government sector are all expressed as a percentage deviation from baseline. The remaining variables represent an absolute difference from baseline.

of decreasing aggregate demand, leads to a drop of both asset prices and credit to the non-government sector compared to the baseline level. Price and labor developments, granted being at levels under their baseline values at the end of the simulation horizon, show relatively weak elasticity to the ECB's monetary policy changes. The path of the impacts of all variables considered points to a smooth decay of the policy change effect. Whereas the variables do not return to their respective baseline levels within the simulation horizon, the gradual decrease of the contractionary effect still signals that the ECB's policy change should have only a temporary effect on the economy.

Apart from the summarised results in Table 2, the paper also discusses in more details the extent to which the transmission of the ECB's monetary policy change on certain macroeconomic variables for Bulgaria is caused by trade spill-overs, changes in the exchange rate or changes in the EA's interest rates. To that aim the analysis decomposes the cumulative impulse responses of the selected variables into the contributions of the outlined exogenous shocks that represent the ECB's monetary policy tightening scenario. The lines in the graphs below correspond to the impulse reactions in the simulation with a simultaneous change in all exogenous variables[90], while the bars represent the contribution of each of the exogenous assumptions to the overall change in the respective variable as compared to the baseline[91]. In order to estimate the contribution of each exogenous shock, we run four consecutive simulations, each time adding up a new shock to the ones already introduced. The first simulation incorporates only the short-term EA interest rate. We then introduce an additional shock each round and the difference in the results between the current and the previous round's cumulative response represents the contribution of the newly introduced shock. Apart from the short-term interest rate the other shocks that appear in the simulation are trade spill-over (combined effect on external demand and competitors' prices on the export side), the USD/EUR exchange rate and EA long-term interest rates.

We first discuss one of the channels where the transmission of the ECB's monetary policy tightening is observed to be most direct and significant for the overall change in the Bulgarian economic activity, namely the foreign trade channel. The rapid response of real exports and thereafter domestic output to changes in economic developments in the EA can be explained by Bulgaria's high degree of trade openness and integration in global value chains (Ivanova

[90] This approach is considered to be superior to simply adding the responses from four different simulations with only one assumption changing at a time.

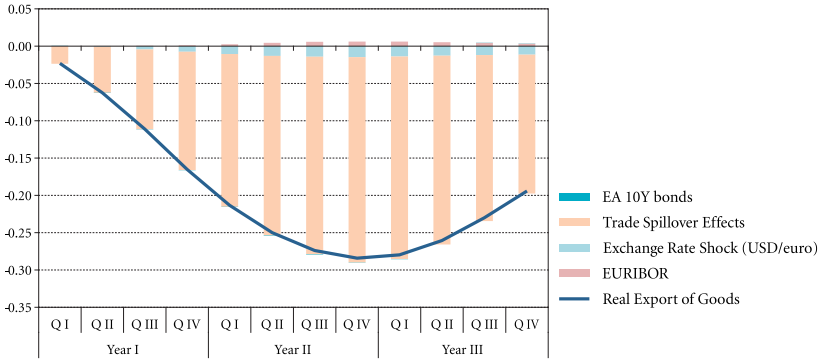
[91] Please note that the change in foreign demand and competitors' prices are combined in one simulation, named "trade spill-over effects".

and Ivanov, 2017). Lower exports compared to the assumed in the baseline, as a result of the ECB's monetary policy tightening, will in turn trigger second-round effects such as lower companies' profits, labour demand and wages. The respective decline in gross operating surplus and disposable income will likely result in a decline in private investment and consumption, leading to a contraction of real GDP, which is partially offset by the induced contraction in real imports.

5.2.1. Impact from the Functioning of the Foreign Trade Channel

The foreign trade channel is dominated mainly by the impact on exports of goods, which represents the GDP component to contract most significantly compared to its baseline level in the first quarter of the simulation (-0.03 per cent). This is due to the immediate and combined negative impact from the trade spill-over effect and the exchange rate effect which result in lower foreign demand and deteriorating price competitiveness. The decline of exports as a result of the simulated scenario relative to baseline is maximised in the last two quarters of the second year (-0.28 per cent). Given the design of the simulation, the impulse response function of real exports is expectedly humped-shaped. At the end of the three-year simulation horizon, exports remain 0.19 per cent below their baseline level. Throughout the simulation horizon, the impact of contractionary trade spill-over effects explains most of the decline in exports, while the contribution of the negative effects stemming from the appreciation of the USD/EUR exchange rate is significantly less pronounced. The interest rate channel has an insignificant role for the simulated reaction of real exports.

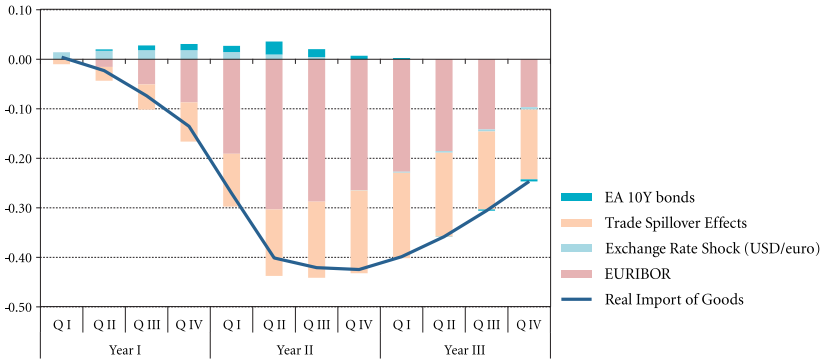
Figure 10: **Response of Real Exports of Goods***



* Deviations from baseline in per cent, percentage points.

As a result of the ECB's monetary policy tightening, real imports are expected to adjust downwards relative to the baseline. The maximum decline of imports of goods (0.42 per cent deviation from the baseline path) is reached a year and a half after the beginning of the simulation. The main channel through which the transmission flows is the induced change in Bulgaria's domestic demand components and exports. Due to its highest import content, investment is more important in determining import dynamics, compared to exports and consumption.[92] The negative impacts stemming from both the interest rate and the trade spill-over channel follow a gradually increasing and then decaying path, the former reaching its maximum negative contribution in the sixth quarter of the simulation, and the latter in the beginning of the last year. The contractionary interest rate induced effect however fades away at a faster pace compared to the trade spill-over one, and in turn over the last two quarters reduced exports appear to be the main dampening factor to imports. The negative effect on real imports compared to the baseline as a result of the ECB's monetary policy tightening is partly offset by the positive contribution of relative prices of imported to domestically produced products – as the exchange rate appreciates in effective terms, imports become cheaper which stimulates an increase in imported volumes. However, after the first seven quarters of the simulation the decline in domestic prices relative to their baseline levels is more substantial than the decline in import prices (due to the slowdown of the domestic economy) which contributes to the observed decline in imports.

Figure 11: **Response of Imports of Goods***



* Deviations from baseline in per cent, percentage points.

[92] Changes in the Bulgarian domestic demand components as a result of the ECB's monetary policy tightening are explained in details in section 5.2.3.

The tightening of the ECB's monetary policy and the following appreciation of the euro against the US dollar results in relatively small declines in both the export and import deflators in the first two years of the simulation. The highest decline in the export and import prices relative to the baseline is reached four quarters after the beginning of the simulation at -0.07 per cent and -0.1 per cent, respectively. As expected, the terms of trade improve due to the appreciation of the euro against the US dollar as the decline of the import deflator is somewhat larger as compared to the reaction of the export deflator.

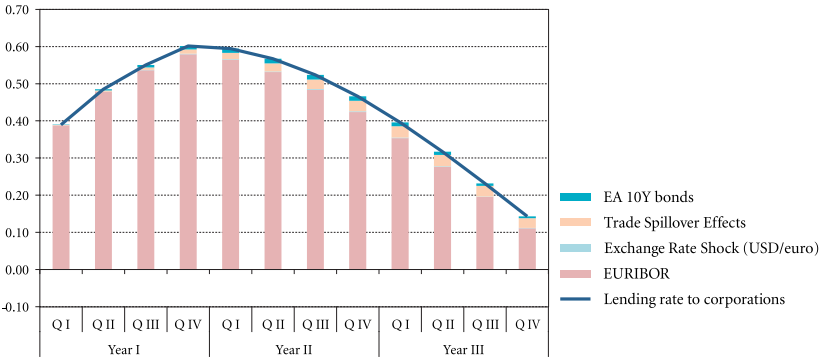
Having discussed the reaction of the real and price components of the foreign trade variables, we can analyse the resulting effect on the balance of goods and services. As a result of the simulation, this balance in ratio to GDP deteriorates marginally relative to the baseline scenario only in the first year of the simulation as the speed of decline of nominal exports is somewhat higher than that of imports. For the rest of the projection horizon, however, the decline of real imports exceeds that of real exports and the balance increases as compared to the baseline. The maximum improvement in the overall balance of goods and services is reached in the second year of the simulation (0.13 per cent of GDP). The improvement in the balance as per cent of GDP after the first year is driven almost entirely by the change in the real volumes of exports and imports.

5.2.2. Impact from the Functioning of the Financial Channel

Changes in the 3-month EURIBOR affect directly domestic money market rates and lending rates for corporations, while the channel of transmission to deposit rates is less direct and is triggered mainly by changes in the loan-to-deposit ratio. Following the increase of deposit interest rates compared to the baseline, the reduced value of real-estate type of collateral and the subsequent decline of wage earnings, lending rates for households also increase. Last but not least, the adjustment of long-term government bonds yields is driven mainly by the simulated increase of long-term rates in the EA.

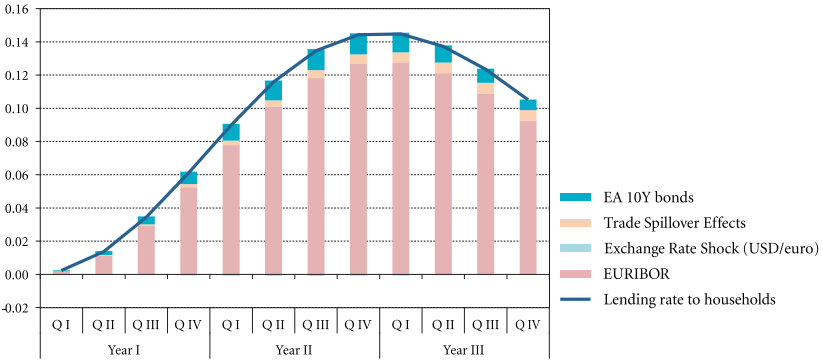
The speed and the degree of adjustment of the different interest rates modelled in BNBQPM, however, vary significantly. Domestic money markets rate increases relative to the baseline with the same amount as the induced hike in the EURIBOR, a result of the assumed full pass-through from the latter to the former. The rise in short-term interest rates in the EA is transmitted relatively quickly to lending interest rates for non-financial enterprises in Bulgaria as well. The maximum increase as compared to baseline (60 basis points) is reached in the fourth and fifth quarter after the beginning of the simulation.

Figure 12: **Response of Lending Rates to Corporations***



* Deviations from baseline in per cent, percentage points.

Figure 13: **Response of Lending Rates to Households***



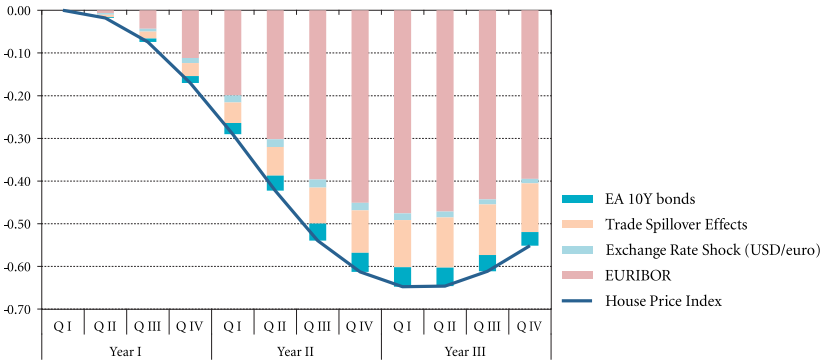
* Deviations from baseline in per cent, percentage points.

The pass-through to deposit rates is weaker (24 basis points at maximum) and is reached a year and a half after the beginning of the simulation. The reaction of lending rates for households is even less pronounced with the maximum increase of 15 basis points relative to the baseline observed almost two years after the initial monetary policy change in the EA. Under the assumption of unchanged short-term country-specific risk premium, the main driver of the simulated increase of domestic long-term government bonds yields is the simulated increase of risk-free German government bonds. The impact of second-round effects from deteriorating loan quality following the increase of lending interest rates and the contraction of domestic output is more

limited. As compared to baseline the maximum increase of long-term rates by 21 basis points is reached relatively fast – already in the fourth quarter after the beginning of the simulation.

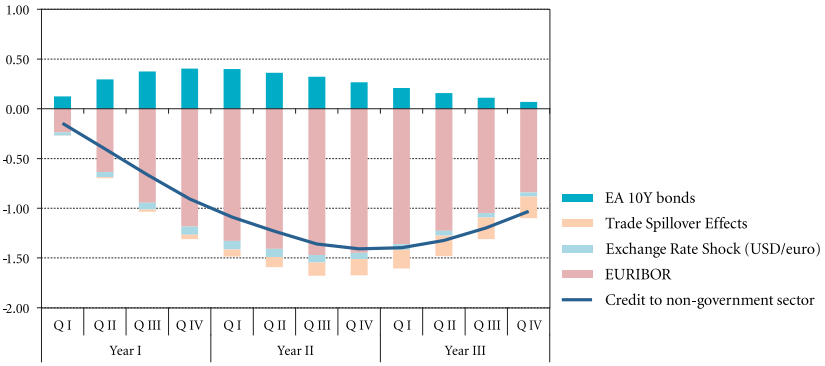
Following largely the increase of domestic interest rates, house prices decline, but their response is somewhat delayed and the maximum decline of -0.65 per cent from the baseline level is reached only in the beginning of the third year of the simulation. Due to the dependence of house prices on GDP *per* capita, they are also negatively affected by the reaction of output to the contractionary trade spill-over impact.

Figure 14: **Response of House Prices***



* Deviations from baseline in per cent, percentage points.

Figure 15: **Response of Private Sector Credit***



* Deviations from baseline in per cent, percentage points.

As expected, total bank lending to the private sector declines following the simulated monetary policy change in the EA. The maximum decline of credit (by 1.4 per cent as compared to the baseline level) is observed at the end of the second year of the simulation. This observed fall of credit relative to the baseline is almost entirely due to the decrease of lending to non-financial corporations, whereas lending to households falls slightly below baseline values only in the last couple of quarters. In contrast to household lending, corporate lending declines significantly as compared to baseline, reaching its trough eight quarters after the beginning of the simulation, and the negative effect gradually begins to fade away afterwards. The initial drop in non-financial corporations' credit is largely driven by the widening spread between corporate lending rates and the risk-free German long-term rates[93]. The hike in EA long-term rates has limited but positive impact on corporate lending. While counterintuitive, this can be explained by the design of the simulation exercise[94]. While the interest rate spread remains the main dampening factor on credit growth, second-round effects stemming from lower private investment and prices have some negative impact as well.

5.2.3. Response of Domestic Demand and the Labour Market

In line with economic theory and with the majority of empirical studies, private investment in our simulation is the domestic demand component that is most negatively affected by the ECB contractionary monetary policy. The combined effects of higher user cost of capital, higher risk premium, lower bank credit and lower value of the collateral (as proxied by house prices), which result from the increase of short-term rates in the EA, have a dominant role for the decline of private investment compared to its baseline level. The contraction of investment reaches its maximum a year and a half after the beginning of the simulation (-1.5 per cent). In terms of the contribution of each shock to the overall change in investment around 70 per cent of the decline is attributable to the shock in EA short-term rate. The trade spill-over effects together with

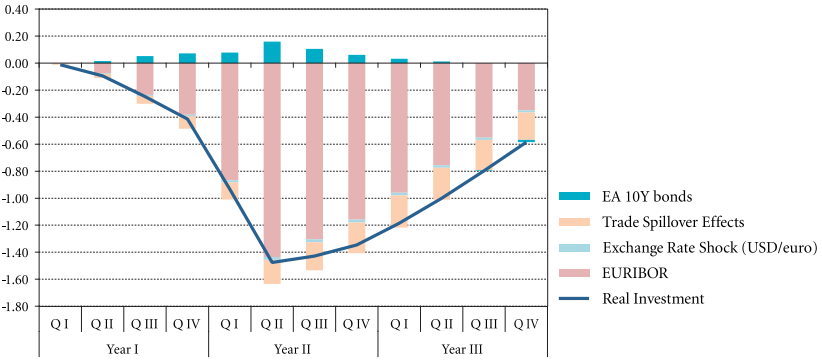
[93] This can be explained with our assumption for the reaction of the German 10-year government bond yields. In the simulation we set the reaction of the German 10-year government bond yields to be equal to that of the EA 10-year government bond yields – namely, an initial increase by 20 basis points, followed by a gradual return to baseline values in the course of two years. At the same time corporate lending rates react stronger to the ECB's monetary policy tightening, leading to a widening of the spread.

[94] In order to calculate contributions to overall deviation from baseline, shocks are introduced to the BNBQPM one by one. Holding all else constant and assuming no changes in the EURIBOR, a hike in the EA long-term rates leads to an overall increase of lending due to the narrowing of the spread between corporate lending rates and the risk-free German long-term rates. Once the EURIBOR shock is introduced however the spread widens instead and affects lending negatively, due to the strong pass-through of EA short-term rates to domestic corporate lending rates.

the exchange rate change also weigh negatively on investment, albeit to a much lower extent.

The hike in German long-term rates compared to the baseline, as a result of the increase in the EA long-term rates in the simulation, outweighs the initial increase of domestic long-term rates and leads to a decrease of foreign external debt[95]. Consequently this has a rather limited but positive impact on private investment due to the estimated in the model negative elasticity of investment to changes in external debt. Similarly to the effect on credit for non-financial corporations, the shock in EA long-term rates impacts positively investment through the narrowing spread between corporate lending rates in Bulgaria and Germany's long-term interest rates.

Figure 16: **Response of Real Investment***



* Deviations from baseline in per cent, percentage points.

Note: The Figure depicts the response of overall real investment activity, which is driven entirely by private investment dynamics as government investment is assumed to remain unchanged in the simulation.

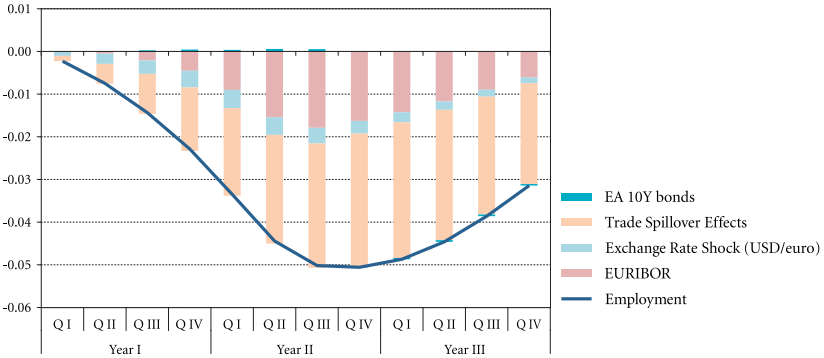
Lower real exports and lower investment, as a result of the monetary policy tightening, lead to a decrease in aggregate demand in the economy relative to the baseline. Consequently this dampens business activity and constrains firms' demand for labour. The trade spill-over shock, transmitted to labour demand through its impact on real output, has a dominant role in explaining the downward adjustment in employment. The decline, triggered solely by the change in money market rates in the EA is less prominent and materializes with a one-year lag. The maximum decline of employment as compared to the baseline level is reached mid-simulation period (-0.05 per cent as compared to

[95] See section 4.3.5. for more details on the transmission channel.

baseline). The decrease of employment is less pronounced than the drop of real output, and in consequence labour productivity decreases as well.

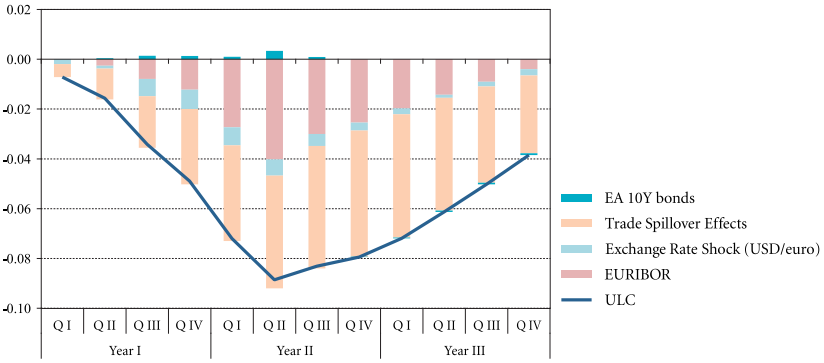
As both demand for goods and services and productivity decline relative to the baseline, firms are pushed to adjust to the monetary policy changes by decreasing wages. The decline of unit labour costs is largely explained by the trade spill-over effects, while the impact of the interest rate channel becomes more visible only in the second and third year of the simulation. The maximum decline of unit labour cost is reached in the sixth quarter of the simulation and comes up to 0.09 per cent as compared to baseline.

Figure 17: **Response of Employment***



* Deviations from baseline in per cent, percentage points.

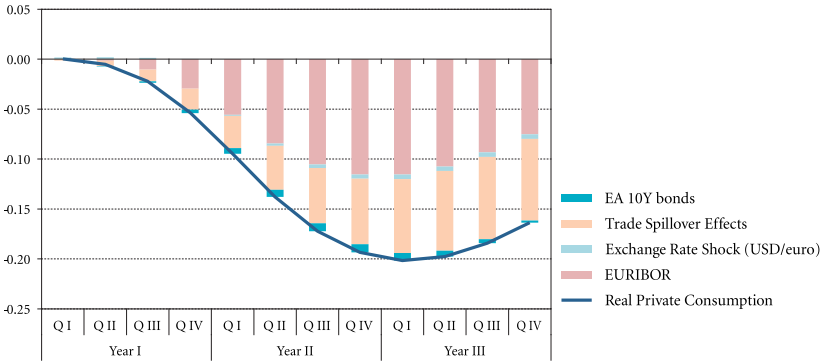
Figure 18: **Response of Unit Labour Costs***



* Deviations from baseline in per cent, percentage points.

The decline of both employment and wages compared to their levels in the baseline translate into a downward adjustment of disposable income. This decrease in financing available to households, against the background of also declining house prices, tighter lending conditions and eventually lower household wealth constrain household spending and consequently private consumption declines relative to the baseline. In the simulation exercise the maximum decline of consumption (by 0.20 per cent as compared to the baseline level) is reached in the beginning of the third year, with the interest rate (EURIBOR) channel having the most pronounced negative impact. At the end of the simulation horizon the contractionary effect on consumption begins to gradually fade away, albeit consumption still remaining at a level around 0.16 per cent lower than what the baseline scenario suggests.

Figure 19: **Response of Real Private Consumption***



* Deviations from baseline in per cent, percentage points.

5.2.4. External Debt Financing and Current Account Developments

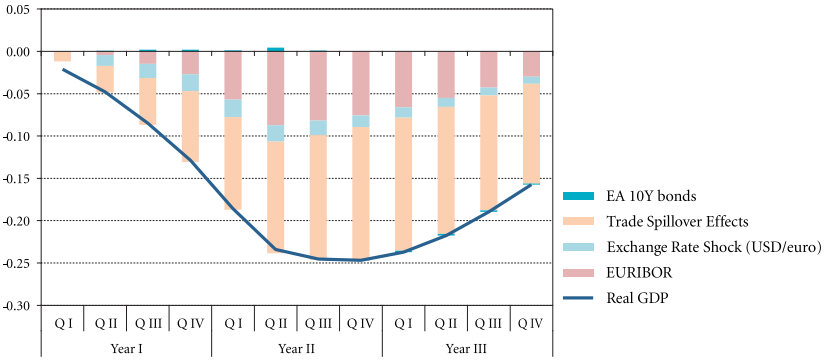
As a result of the changes in the flows on the external sector of the Bulgarian economy, the current account balance deteriorates as per cent of GDP in the simulation scenario. The main components of the current account that are affected by the change in the ECB's monetary policy are the trade balance and the primary income balance. The simulated deterioration of the primary income deficit dominates over the improvement of the trade balance in the first ten quarters of the simulation and the current account decreases as per cent of GDP compared to the baseline. The maximum decline of the current account is reached in the first quarter of the simulation (-0.3 percentage points of GDP).

The increase in external debt service payments as a result of the increased 3-month EURIBOR leads to higher primary income deficit, despite the offsetting, yet weaker, effect of reduced firms' profitability (proxied in the simulation by the gross operating surplus). The increase in the primary income deficit relative to the baseline as per cent of GDP is maximised in the fourth quarter of the simulation, reaching 0.3 per cent of GDP.

5.2.5. Response of Aggregate Output and Prices

The reaction of real GDP is aggregated across the simulated response of all expenditure components. Following the ECB's monetary policy change real GDP contracts compared to the baseline level with maximum decline of 0.25 per cent as reached in the seventh quarter of the simulation exercise. As expected, given the openness of the economy and trade integration with EA countries, the foreign trade channel plays a dominant role in the response of real output to a change in ECB's monetary policy. The contractionary effect from higher interest rates and lower asset prices takes more time to materialise and begins to weigh on real GDP a year and a half after the beginning of the exercise. Based on the design of the simulation, the impact from the functioning of the exchange-rate channels fades away in the third year after ECB's monetary policy tightening.

Figure 20: **Response of Real GDP***

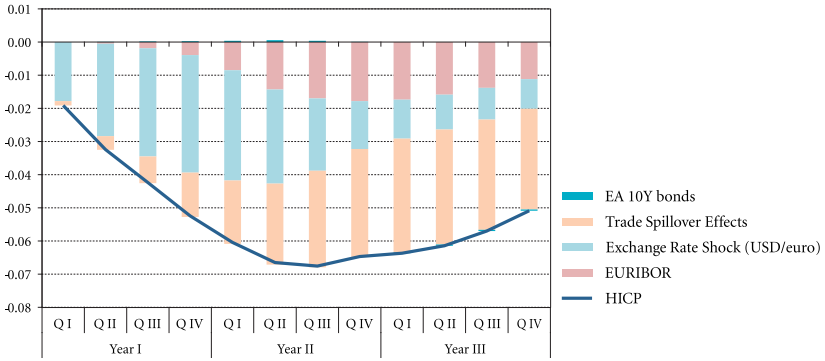


* Deviations from baseline in per cent, percentage points.

Following the ECB's monetary policy change, domestic prices adjust downwards as a result of the combined effects from declining import prices, unit labour costs, and consumer spending. The decline of the HICP core index is very similar to the reaction of import prices and unit labour cost (maximum

decline is 0.09 per cent as compared to baseline). At the same time, given the assumption than administrative prices do not react to the monetary policy change, the resulting decline in the HICP index is somewhat weaker, reaching a maximum of 0.07 per cent in the sixth quarter from the beginning of the simulation. The reaction of prices is quite persistent and HICP is 0.05 per cent lower relative to baseline at the end of the simulation horizon.

Figure 21: **Response of HICP***



* Deviations from baseline in per cent, percentage points.

6. Conclusion

With the expected normalisation of monetary policy in the EA, discussions on the possible spill-over effects on small, open economies with strong trade and financial ties to the EA, such as Bulgaria, are highly relevant.

The study examines the transmission of a tightening in ECB's monetary policy to the Bulgarian economy through the lens of a large macro-econometric model that allows for the inclusion of numerous interrelations between foreign and domestic variables. The scenario of a tightening in ECB's monetary policy in the BNBQPM is represented by a combination of shocks to the EA short- and long-term interest rates, an appreciation of the euro against the US dollar and a decline in economic activity in the EA. We identify two broad channels of transmission as particularly important for Bulgaria, given the structural characteristics of the country – namely, the foreign trade and the financial channel.

Our results suggest that the foreign trade channel plays a dominant role in explaining the contraction of domestic output following a tightening of

ECB's monetary policy. This is expected given the high trade openness of the economy and its high trade and financial integration with EA countries. The contractionary effect from higher interest rates and lower asset prices takes more time to materialise and begins to weigh on real GDP a year and a half after the beginning of the simulation exercise.

Following the ECB's monetary policy tightening real GDP contracts, with maximum decline of 0.25 per cent as compared to the baseline level, reached in the seventh quarter of the simulation exercise. Investment is the GDP component with the strongest reaction to monetary policy tightening. The contraction of investment reaches its maximum a year and a half after the beginning of the simulation (-1.5 per cent), with around 70 per cent of this decline attributable to the interest and asset price channel. Exports of goods also react strongly and decline by -0.28 per cent, with the peak of the decline occurring only two quarters after the introduction of the shocks, suggesting a quick transmission. The Bulgarian labour market adjusts to ECB's contractionary monetary policy through declines in both employment and wages. The decline in unit labour costs is somewhat faster and slightly more pronounced as compared to that in employment.

The downward adjustment of prices is relatively weak, reaching a maximum of 0.07 percentage points in six quarters. The maximum decline of house prices (0.8 percentage points) is reached at the beginning of the third year and is largely driven by increasing interest rates. Overall, throughout the simulation horizon, the reaction of real variables is more pronounced than the reaction of prices.

The main limitations of the study are related to short-comings of the chosen econometric approach, used to examine the channels of transmission of ECB's monetary policy on the Bulgarian economy. Expectations in our setup play only a partial role as price and wage formation are backward-looking. As such we see addressing this short-coming as a potential area for future research on the topic. Another interesting topic that can also be explored in future work is how the relative importance of the identified channels of transmission has evolved over time, taking into account the structural and cyclical changes that the economy has gone through.

Table 3. **Foreign Demand Shock**

*Percentage deviations from baseline**	Year I	Year II	Year III	Year I				Year II				Year III			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
Real output															
GDP	-0.52	-0.57	-0.59	-0.49	-0.51	-0.53	-0.54	-0.55	-0.57	-0.57	-0.58	-0.59	-0.59	-0.60	-0.60
Private consumption	-0.14	-0.28	-0.36	-0.05	-0.13	-0.18	-0.21	-0.24	-0.27	-0.30	-0.32	-0.33	-0.35	-0.36	-0.37
Investment	-0.59	-0.91	-0.94	-0.43	-0.58	-0.64	-0.70	-0.78	-0.94	-0.96	-0.96	-0.95	-0.94	-0.93	-0.93
Exports (goods and services)	-0.95	-0.96	-0.96	-0.95	-0.95	-0.95	-0.96	-0.96	-0.96	-0.96	-0.96	-0.96	-0.96	-0.97	-0.97
Imports (goods and services)	-0.51	-0.67	-0.72	-0.42	-0.50	-0.55	-0.59	-0.62	-0.67	-0.69	-0.70	-0.71	-0.72	-0.72	-0.73
Price developments															
HICP	-0.09	-0.13	-0.13	-0.05	-0.08	-0.10	-0.11	-0.12	-0.12	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13
Export deflator	-0.07	-0.10	-0.10	-0.04	-0.07	-0.08	-0.09	-0.09	-0.10	-0.10	-0.10	-0.10	-0.10	-0.11	-0.11
ULC	-0.17	-0.18	-0.18	-0.22	-0.16	-0.16	-0.16	-0.17	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.19
Labour market															
Employment	-0.10	-0.11	-0.11	-0.05	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11
Unemployment rate	0.09	0.11	0.11	0.05	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.10
External developments (per cent of GDP)															
Balance on goods and services	-0.32	-0.23	-0.21	-0.37	-0.33	-0.30	-0.28	-0.26	-0.23	-0.22	-0.22	-0.21	-0.21	-0.20	-0.20
Current account plus capital account	-0.31	-0.22	-0.20	-0.36	-0.32	-0.29	-0.27	-0.25	-0.22	-0.22	-0.21	-0.20	-0.20	-0.20	-0.20
Fiscal developments (per cent of GDP)															
Government primary budget balance	0.00	-0.01	-0.02	0.01	0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02
Interest spending	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Financial market and asset price developments															
Money market rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to non-financial corporations	0.08	0.11	0.11	0.04	0.07	0.09	0.11	0.11	0.11	0.12	0.12	0.11	0.11	0.11	0.11
Lending rate to households	0.01	0.02	0.03	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
Long-term interest rate	0.03	0.06	0.05	0.00	0.02	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05
House price index	-0.21	-0.41	-0.48	0.00	-0.23	-0.30	-0.33	-0.37	-0.40	-0.42	-0.44	-0.46	-0.47	-0.48	-0.49
Credit to non-government sector	-0.54	-0.84	-0.94	-0.09	-0.25	-0.40	-0.54	-0.64	-0.71	-0.79	-0.84	-0.88	-0.90	-0.92	-0.94

* The real output and price developments variables, employment, house price index and credit to non-government sector are all expressed as a percentage deviation from baseline. The remaining variables represent an absolute difference from baseline.

The shock is defined as a sustained decline in foreign demand by 1 per cent.

Table 4. **Change in Competitors' Prices**

*Percentage deviations from baseline**	Year I	Year II	Year III	Year I				Year II				Year III			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
Real output															
GDP	-0.11	-0.18	-0.20	-0.05	-0.10	-0.13	-0.16	-0.17	-0.18	-0.19	-0.20	-0.20	-0.20	-0.21	-0.21
Private consumption	-0.03	-0.08	-0.11	-0.01	-0.02	-0.03	-0.05	-0.06	-0.08	-0.09	-0.10	-0.10	-0.11	-0.12	-0.12
Investment	-0.11	-0.26	-0.31	-0.04	-0.10	-0.14	-0.18	-0.21	-0.26	-0.28	-0.29	-0.30	-0.31	-0.31	-0.31
Exports (goods and services)	-0.17	-0.27	-0.28	-0.07	-0.16	-0.21	-0.24	-0.26	-0.27	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28
Imports (goods and services)	-0.08	-0.16	-0.19	-0.02	-0.06	-0.10	-0.12	-0.14	-0.16	-0.17	-0.17	-0.18	-0.19	-0.19	-0.19
Price developments															
HICP	-0.02	-0.04	-0.05	-0.01	-0.02	-0.03	-0.03	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
Export deflator	-0.08	-0.08	-0.07	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.07	-0.07	-0.07	-0.07
ULC	-0.03	-0.03	-0.03	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
Labour market															
Employment	-0.02	-0.04	-0.04	-0.01	-0.02	-0.03	-0.03	-0.03	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04
Unemployment rate	0.02	0.03	0.04	0.00	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04
External developments (per cent of GDP)															
Balance on goods and services	-0.05	-0.05	-0.03	-0.03	-0.05	-0.06	-0.06	-0.06	-0.05	-0.04	-0.04	-0.04	-0.03	-0.03	-0.03
Current account plus capital account	-0.05	-0.04	-0.03	-0.03	-0.05	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04	-0.03	-0.03	-0.03	-0.02
Fiscal developments (per cent of GDP)															
Government primary budget balance	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Interest spending	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Financial market and asset price developments															
Money market rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to non-financial corporations	0.01	0.03	0.04	0.00	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Lending rate to households	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Long-term interest rate	0.00	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
House price index	-0.04	-0.13	-0.18	0.00	-0.03	-0.05	-0.08	-0.11	-0.13	-0.14	-0.16	-0.17	-0.18	-0.19	-0.19
Credit to non-government sector	-0.12	-0.26	-0.32	-0.01	-0.04	-0.08	-0.12	-0.16	-0.20	-0.23	-0.26	-0.28	-0.30	-0.31	-0.32

* The real output and price developments variables, employment, house price index and credit to non-government sector are all expressed as a percentage deviation from baseline. The remaining variables represent an absolute difference from baseline.

The shock is defined as a sustained decline in competitors' prices by 1 per cent.

Table 5. **Change in USD/EUR Exchange Rate**

*Percentage deviations from baseline**	Year I	Year II	Year III	Year I				Year II				Year III			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
Real output															
GDP	-0.27	-0.41	-0.45	-0.15	-0.25	-0.31	-0.36	-0.39	-0.41	-0.43	-0.44	-0.45	-0.45	-0.46	-0.46
Private consumption	-0.01	-0.08	-0.13	0.01	0.00	-0.02	-0.04	-0.06	-0.08	-0.09	-0.10	-0.11	-0.12	-0.13	-0.14
Investment	-0.20	-0.46	-0.54	-0.07	-0.18	-0.24	-0.30	-0.36	-0.46	-0.50	-0.52	-0.53	-0.54	-0.55	-0.55
Exports (goods and services)	-0.23	-0.36	-0.36	-0.10	-0.22	-0.29	-0.32	-0.34	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36
Imports (goods and services)	0.05	-0.01	-0.02	0.08	0.06	0.03	0.01	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03
Price developments															
HICP	-0.32	-0.46	-0.53	-0.20	-0.31	-0.37	-0.40	-0.43	-0.46	-0.48	-0.49	-0.51	-0.53	-0.54	-0.55
Export deflator	-0.58	-0.62	-0.64	-0.55	-0.56	-0.60	-0.61	-0.62	-0.62	-0.62	-0.63	-0.64	-0.64	-0.64	-0.64
ULC	-0.07	-0.10	-0.10	-0.04	-0.04	-0.10	-0.11	-0.10	-0.10	-0.09	-0.10	-0.10	-0.10	-0.10	-0.11
Labour market															
Employment	-0.05	-0.08	-0.09	-0.02	-0.04	-0.06	-0.07	-0.08	-0.08	-0.08	-0.09	-0.09	-0.09	-0.09	-0.09
Unemployment rate	0.05	0.08	0.08	0.02	0.04	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
External developments (per cent of GDP)															
Balance on goods and services	0.03	0.08	0.13	0.04	0.03	0.02	0.04	0.06	0.08	0.10	0.10	0.11	0.12	0.13	0.14
Current account plus capital account	0.04	0.09	0.13	0.04	0.03	0.03	0.05	0.06	0.09	0.10	0.11	0.12	0.13	0.13	0.14
Fiscal developments (per cent of GDP)															
Government primary budget balance	0.00	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.01	0.01
Interest spending	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Financial market and asset price developments															
Money market rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to non-financial corporations	0.02	0.05	0.05	0.00	0.01	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Lending rate to households	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Long-term interest rate	0.02	0.06	0.06	0.00	0.01	0.02	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
House price index	-0.10	-0.31	-0.40	0.00	-0.07	-0.13	-0.20	-0.26	-0.30	-0.33	-0.36	-0.38	-0.40	-0.41	-0.42
Credit to non-government sector	-1.00	-1.51	-1.79	-0.32	-0.60	-0.82	-1.00	-1.16	-1.29	-1.41	-1.51	-1.60	-1.67	-1.74	-1.79

* The real output and price developments variables, employment, house price index and credit to non-government sector are all expressed as a percentage deviation from baseline. The remaining variables represent an absolute difference from baseline.

The shock is defined as a sustained appreciation of the euro against the US dollar by 10 per cent.

Table 6. **Sustained Increase in Short-term EA Interest Rates**

*Percentage deviations from baseline**	Year I	Year II	Year III	Year I				Year II				Year III			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
Real output															
GDP	-0.01	-0.08	-0.08	0.00	0.00	-0.01	-0.03	-0.06	-0.09	-0.09	-0.09	-0.09	-0.09	-0.08	-0.08
Private consumption	-0.01	-0.09	-0.13	0.00	0.00	-0.01	-0.03	-0.06	-0.09	-0.11	-0.12	-0.13	-0.13	-0.13	-0.13
Investment	-0.17	-1.33	-1.29	0.00	-0.07	-0.23	-0.38	-0.87	-1.55	-1.49	-1.43	-1.37	-1.31	-1.26	-1.21
Exports (goods and services)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Imports (goods and services)	-0.04	-0.30	-0.32	0.00	-0.02	-0.05	-0.09	-0.19	-0.33	-0.34	-0.34	-0.33	-0.32	-0.31	-0.30
Price developments															
HICP	0.00	-0.02	-0.02	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
Export deflator	0.00	-0.02	-0.02	0.00	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
ULC	-0.01	-0.03	-0.03	0.00	0.00	-0.01	-0.01	-0.03	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
Labour market															
Employment	0.00	-0.02	-0.02	0.00	0.00	0.00	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
Unemployment rate	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01
External developments (per cent of GDP)															
Balance on goods and services	0.03	0.21	0.22	0.00	0.01	0.03	0.06	0.13	0.23	0.23	0.23	0.23	0.23	0.22	0.21
Current account plus capital account	-0.26	-0.07	-0.04	-0.30	-0.27	-0.25	-0.23	-0.15	-0.04	-0.04	-0.04	-0.04	-0.03	-0.04	-0.05
Fiscal developments (per cent of GDP)															
Government primary budget balance	0.00	-0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.01	-0.02	-0.02	-0.03	-0.03	-0.03	-0.03
Interest spending	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Financial market and asset price developments															
Money market rate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lending rate to non-financial corporations	0.50	0.65	0.68	0.39	0.48	0.54	0.58	0.61	0.64	0.66	0.67	0.68	0.68	0.68	0.68
Lending rate to households	0.02	0.11	0.16	0.00	0.01	0.03	0.05	0.08	0.10	0.12	0.14	0.15	0.16	0.16	0.16
Long-term interest rate	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
House price index	-0.04	-0.35	-0.56	0.00	-0.01	-0.04	-0.11	-0.20	-0.30	-0.40	-0.47	-0.52	-0.56	-0.58	-0.59
Credit to non-government sector	-1.18	-1.82	-2.04	-0.24	-0.64	-0.94	-1.18	-1.36	-1.51	-1.69	-1.82	-1.91	-1.97	-2.02	-2.04

* The real output and price developments variables, employment, house price index and credit to non-government sector are all expressed as a percentage deviation from baseline. The remaining variables represent an absolute difference from baseline.

The shock is defined as a sustained increase of 3-month EURIBOR by 100 basis points.

Table 7. **Increase in Long-term Interest Rates in the EA**

*Percentage deviations from baseline**	Year I	Year II	Year III	Year I				Year II				Year III			
				Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV
Real output															
GDP	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.04	0.03	0.02	0.01	0.01	0.01	0.01
Private consumption	-0.01	-0.04	-0.05	0.00	0.00	-0.01	-0.02	-0.03	-0.04	-0.04	-0.05	-0.05	-0.05	-0.04	-0.04
Investment	0.16	0.93	0.68	0.00	0.04	0.23	0.36	0.42	1.30	1.09	0.92	0.80	0.70	0.64	0.59
Exports (goods and services)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Imports (goods and services)	0.03	0.16	0.11	0.00	0.01	0.04	0.06	0.07	0.23	0.19	0.16	0.14	0.12	0.11	0.10
Price developments															
HICP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Export deflator	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00
ULC	0.00	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.01	0.01
Labour market															
Employment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Unemployment rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
External developments (per cent of GDP)															
Balance on goods and services	-0.02	-0.11	-0.08	0.00	0.00	-0.03	-0.04	-0.05	-0.15	-0.13	-0.11	-0.10	-0.08	-0.08	-0.07
Current account plus capital account	-0.02	-0.11	-0.08	0.00	0.00	-0.03	-0.04	-0.05	-0.15	-0.13	-0.11	-0.10	-0.08	-0.08	-0.07
Fiscal developments (per cent of GDP)															
Government primary budget balance	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Interest spending	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Financial market and asset price developments															
Money market rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lending rate to non-financial corporations	0.03	0.08	0.09	0.00	0.02	0.03	0.05	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Lending rate to households	0.02	0.07	0.09	0.00	0.01	0.03	0.04	0.06	0.07	0.08	0.09	0.09	0.10	0.10	0.10
Long-term interest rate	0.70	1.09	1.04	0.00	0.66	1.01	1.13	1.14	1.10	1.07	1.05	1.04	1.04	1.04	1.05
House price index	-0.03	-0.21	-0.33	0.00	-0.01	-0.04	-0.09	-0.14	-0.20	-0.23	-0.27	-0.31	-0.33	-0.35	-0.35
Credit to non-government sector	2.38	2.78	2.81	0.62	1.55	2.08	2.38	2.56	2.61	2.73	2.78	2.81	2.81	2.81	2.81

* The real output and price developments variables, employment, house price index and credit to non-government sector are all expressed as a percentage deviation from baseline. The remaining variables represent an absolute difference from baseline.

The shock is defined as a sustained increase of 10-year government bond yields in Germany and the EA by 100 basis points.

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