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MAINTAINING PRICE STABILITY IN MONTENEGRO THROUGH GOVERNANCE OF EXTERNAL AND INTERNAL FACTORS OF INFLATION

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ODRŽAVANJE STABILNOSTI CIJENA U CRNOJ GORI KROZ UPRAVLJANJE SPOLJNIM I UNUTRAŠNJIM FAKTORIMA INFLACIJE

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PREFACE

Inflation is one of the central and foundational macroeconomic indicators, and it is in-depth examined by both macroprudential policymakers and macroeconomic researchers. Government authorities have a great interest in reliable inflation forecasts. Forecasting inflation is challenging research. A significant number of researchers have estimated and forecasted the time-series properties of inflation. The general agreement from these studious examinations is that the fundamental trend and volatility of inflation have altered significantly over time; however, there is still no consensus on the best way to forecast inflation dynamics. Inflation forecasts that are free from errors are essential for other agents in the economy. Economic agents will decide about wages and prices based on inflation expectations formed and relied on accurate inflation forecasts.

On the other hand, the dependency level of a small and open economy, such as Montenegro, and the dynamics of its macroeconomic indicators, have gone through significant development changes over recent decades. Some of these changes are featured in the regaining of Montenegro's independence, while others tend to be attributed to the European Union's economic and political orientation. These significant changes brought a substantial reduction in the volatility of the macroeconomic environment in Montenegro: inflation is a key indicator. Hence, the government and macroprudential policymakers of Montenegro have taken the duty and obligation to design sounder macroeconomic policies, intending to stabilize and anchor inflation. The European Commission explicitly reports the convergence criteria where the price-performance must be sustainable and average inflation not more than 1.5 percentage points above the rate of the three best performing Member States.

This dissertation employs a wide range of econometric models, each carrying robust time series, and estimates and evaluates their forecasting performance across time and models. Various studies have conducted forecast comparisons on one particular model. However, we focus on aggregating key external and internal factors of inflation and performing forecast combination puzzles of the same event: no single "best" model exists. Regardless of the existence of many highly sophisticated combination methods, forecast accuracy is the best when merely averaging is applied across the set of models. We employ equal and

relative performance weights (inverse MSE weights) approach. It is the first time that a combined prediction has been obtained for the economy of Montenegro, suggesting high – dimensional dynamic models.

Ceteris paribus, our main objective is to reveal external and internal inflation determinants in Montenegro. We explain a significantly broader and deeper knowledge gap: first, theoretical specification, based on which empirical examinations of inflation determinants are investigated, combining theory and empirical analysis, still is not prevailing; second, we identify recursively three structural VAR models and combine them with an equal and inverse MSE weighting approach. This approach has not been applied in previous research to Montenegrin inflation data.

This dissertation's empirical findings are published in the scientific journal "Engineering Economics" (SSCI) titled *Forecasting Inflation: A Combination Approach.*

PREDGOVOR

Inflacija je jedan od centralnih odnosno osnovnih makroekonomskih pokazatelja koji se temeljno ispituje od strane kreatora makroprudencijalne politike i makroekonomskih istraživača. Vlada je veoma zainteresovana za pouzdane prognoze inflacije. Prognoza inflacije je izazovno istraživanje. Značajan broj istraživača procijenio je i predvidio svojstva vremenskih serija inflacije. Opšta saglasnost ovih studioznih ispitivanja je da se osnovni trend i volatilnost inflacije tokom vremena znatno mijenjaju; međutim, još uvijek ne postoji konsenzus o najboljem načinu predviđanja dinamike inflacije. Prognoze inflacije bez grešaka od značaja su i za ostale subjekte u ekonomiji. Ekonomski akteri će donijeti svoje odluke o platama i cijenama na osnovu inflacionih očekivanja koje se formiraju i oslanjaju na tačnost prognoze inflacije.

Sa druge strane, nivo zavisnosti jedne male i otvorene ekonomije, poput Crne Gore, kao i dinamika njenih makroekonomskih indikatora, prošli su kroz značajne razvojne promjene poslednjih decenija. Neke od ovih promjena se ogledaju u obnovi nezavisnosti Crne Gore, dok se druge pripisuju ekonomskoj i političkoj orijentaciji ka Evropskoj uniji. Ove velike promjene donijele su značajno smanjenje volatilnosti makroekonomskog okruženja u Crnoj Gori: inflacija je ključni pokazatelj. Dakle, Vlada i makroprudencijalni kreatori politike Crne Gore preuzeli su dužnost i obavezu da kreiraju jasne makroekonomske politike sa namjerom da stabilizuju i učvrste inflaciju. Evropska komisija eksplicitno izvještava o kriterijumima konvergencije u kojima performanse cijena moraju biti održive i prosječna stopa inflacije ne viša od 1,5 procentnih poena iznad stope inflacije tri države članice sa najboljim rezultatima.

Ova disertacija koristi širok spektar ekonometrijskih modela, od kojih svaki nosi robustne vremenske serije, i procenjuje i ocijenjuje njihove prognozne performanse kroz vrijeme i modele. Različite studije su vršile poređenja predviđanja na jednom određenom modelu. Međutim, ova disertacija fokusira se na objedinjavanje ključnih internih i eksternih faktora inflacije i izvođenje kombinacije predviđanja za isti događaj: budući da nema pojedinačno "najboljeg" modela. Bez obzira na postojanje mnogih visoko rafiniranih kombinacionih metoda, tačnost predviđanja je često najbolja kada se primijenjuje jednostavno prosiječno korišćenje na svim modelima. Mi koristimo pristup jednakih i

relativnih težina performansi (inverzni MSE). Ovo je prvi put da je za ekonomiju Crne Gore dobijeno kombinovano predviđanje, sugerišući višedimenzionalne dinamičke modele.

Ceteris paribus, naš glavni cilj je otkrivanje eksternih i internih determinanti inflacije u Crnoj Gori. Otkrivamo značajno širi jaz znanja: prvo, teorijska specifikacija, na osnovu koje se analiziraju empirijski determinante inflacije, koja kombinuje teoriju i empirijsku analizu, još uvijek nije opšteprihvaćena; drugo, izvođenjem identifikujemo tri strukturna VAR modela i kombinujemo ih sa jednakim i inverznim MSE pristupom ponderisanja. Ovaj pristup u dosadašnjim istraživanjima nije primijenjen na podatke o inflaciji u Crnoj Gori.

Empirijska istraživanja ove disertacije objavljena su u naučnom časopisu „Engineering Economics“ (SSCI), pod nazivom *Forecasting Inflation: A Combination Approach* (Predviđanje inflacije: kombinovani pristup).

ABSTRACT

The determinants of inflation are an essential question that macroeconomic policymakers in Montenegro have faced continually over the past decade, especially since 2002, following the euro's adoption as Montenegro's formal currency. This doctoral dissertation aims to theoretically and analytically research and then examine and forecast Montenegrin's inflation determinants empirically, using the forecast combination approach: from January 2006 to December 2016. Out-of-sample 12-month horizon forecasting is performed from January 2017 to December 2017.

The central research problem is that given the struggle macroprudential policymakers have had to define proper criteria to identify and diagnose the onset of inflation indicators, we felt compelled to identify an approach and methodology that the government of Montenegro can use in maintaining price stability within the accession process towards the European Union. We research three individual-predictor SVAR models to forecast inflation.

Combining three VAR and three Bayesian VAR (BVAR) models, we disclose four more VAR RMSEs: (i) two VAR equal and inverse MSE weights, and (ii) two more BVAR RMSEs. We find predicting sustainable performances: average inflation not higher than 1.5 p.p. above the three best performing Member states' average rate. The standard VAR combination performs the best forecasting for the quarter I and II of 2017, while the BVAR combination shows the best forecasting performance for quarters III and IV of 2017.

Our results allow the policymakers of Montenegro to understand the factors involved in identifying the onset of inflation dynamics and inflation expectations better and develop more effective state regulations and measures. In so doing, the findings advance and recommend the methodological tools needed, combining forecasts, to more efficiently combat the challenges of maintaining price stability by macroprudential policymakers in Montenegro.

Keywords: macroeconometric forecasting, inflation; BVAR combinations, Montenegro

Scientific area: Macroeconomics

Scientific field: Applied econometrics

REZIME

Determinante inflacije su kritično pitanje sa kojim su se makroekonomske politike u Crnoj Gori suočavale kontinuirano tokom protekle decenije, a posebno od 2002. godine, nakon usvajanja eura kao zvanične valute Crne Gore. Cilj ove doktorske disertacije je da se teorijski i analitički, a zatim i empirijski istraže i predvide determinante crnogorske inflacije, koristeći pristup kombinacija prognoza, od januara 2006. do decembra 2016. godine i van-uzorka 12-mjesečno predviđanje horizonta od januara 2017. do decembra 2017. godine.

S obzirom na veliki napor kreatora politika da definišu odgovarajuće kriterijume za dijagnostikovanje nastanka inflacionih indikatora, osjećali smo se obaveznim da, kao glavni problem istraživanja, identifikujemo pristup i metodologiju koje Vlada Crne Gore može koristiti za održavanje stabilnosti cijena, a u okviru procesa pristupanja Evropskoj uniji. Istražujemo tri individualna-prediktora SVAR modela da bismo prognozirali inflaciju.

Kombinujući navedena tri VAR i tri Bayesian VAR (BVAR) modela, otkrivamo još četri RMSE-a: (i) dvije VAR jednake i inverzne MSE težine, i (ii) još dva BVAR RMSE-a. Oni pokazuju performanse prognoziranja koja su održiva: prosječna inflacija ne viša od 1,5 p.p. iznad prosječne stope tri države članice sa najboljim performansama. Standardna VAR kombinacija daje najbolje predviđanje za I i II kvartal 2017. godine, dok Bayesian VAR kombinacija pokazuje najbolje performanse predviđanja za III i IV kvartal za 2017.

Naši rezultati omogućavaju kreatorima politika Crne Gore da bolje razumiju faktore koji su uključeni u prepoznavanje dinamike inflacije i inflacionih očekivanja i razviju efikasnije regualtivu i mjere. Na navedeni način, ovo istraživanje unaprjeđuje i preporučuje potrebne metodološke alate, kombinujući prognoze, kako bi se kreatori markoprudencijalnih politika u Crnoj Gori efikasnije borili sa izazovima održavanja stabilnosti cijena.

Ključne riječi: makroekonomsko prognoziranje, inflacija, BVAR kombinacije, Crna Gora

Naučna oblast: Makroekonomija

Uža naučna oblast: Primijenjena ekonometrija

LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike information criterion
AR	Autoregression
ARMA	Autoregressive moving average
ARIMA	Autoregressive integrated moving average
BAT	Best available technology
BLUE	Best, linear, unbiased estimates
C^2	Law of conservation of energy
CBCG	Central Bank of Montenegro
CPI	Consumer price index
CR	Croatia
DF	Dickey-Fuller
DGP	Data generating process
E	Energy
EC	European Commission
EGDI	Electronic Government Development Index
EGOV	Electronic Government
EMDC	Emerging markets and developing countries
EMU	Europen Monetary Union
EPI	Export Potential indicator
ERP	Economic Reform Programme
EU	European Union
G2B	Government to businesses
G2C	Government to citizens
GARCH	Generalized autoregressive conditional heteroscedasticity
GDP	Gross domestic product
GHG	Greenhouse gas
HCI	Human capital index
HHI	Herfindahl - Hirschmann index
HPP	Hydropower plant
IMF	International Monetary Fund
IS-LM-PC	Investment-savings, liquidity preference-money supply, and Phillips curve
ITC	International trade center (ITC)
KAP	Aluminum Plant Podgorica
KPSS	Kwiatkowski, Phillips, Schmidt and Shin
LM	Lagrange Multiplier
LME	London Metal Exchange market
M	Markups
M	Law of conservation of mass
M2	Broad money
MA	Moving average
ME	Montenegro
MSE	Mean squared error
NSSD	National strategy for sustainable development
OLS	Ordinary least squares
OSI	Online service index
PACF	Partial autocorrelation function
PDI	Product diversification indicator
PP	Phillips - Perron
PS	Product space
RCA	Revealed competitive advantage
RMSE	Root mean squared error
SBC	Schwarz Bayesian criterion
SE	Standard error
SI	Slovenia

SR	Serbia	ULC	Unit labor cost
SVAR	Structural vector autoregression	UN	United Nations
		UP	Untapped potential
T^2	Technological development speed	US	United States
		USD	United States dollar
TII	Telecommunication infrastructure index	VAR	Vector autoregression
		VECM	Vector error correction mechanism
TPP	Thermal power plant		
U1	Forecast accuracy	WTO	World trade organization
U2	Forecast quality		

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1. Introduction

The price volatility is one of the significant sources of concern of contemporary economic systems since the 1970s. The issue is of a more serious and complex nature in countries where inflation is known as "imported inflation," making domestic policies to control inflation ineffective. Similarly, in Montenegro, the domestic price level seems to be predominantly "imported" based on the impact of external inflation factors. Moreover, the shadow economy's size is associated with a higher inflation rate, public debt, and unemployment, hence becoming a crucial problem to mitigate the inflation level, especially in developing countries. Remembering all the multifaceted nature and complexity of inflation factors, within other policies and instruments, composite factors, as estimation of the level of economic freedom and progress of the electronic government services (or e-government), can contribute to controlling at least that part of the inflation, which is based on the impact of internal factors.

Inflation is the critical question that macroeconomic policymakers in Montenegro have faced continuously over the past three decades, particularly since 2002, following the adoption of the euro as Montenegro's official currency[1]. Montenegrin authorities, in exceptional circumstances, adopted the euro as its official currency, which is entirely distinct from euro area membership and its Maastricht criteria of the accession (the convergence criteria). Montenegro started formal negotiations with the EU in June 2012[23].

A large number of factors influence the maintenance of price stability in Montenegro, and the focus of this research will be the study of key (selected) external and internal factors

[1] Fabris, N., "The monetary policy framework of the central bank of Montenegro: is financial stability a feasible central bank goal?", in book 'The Challenge of Economic Rebalancing in Europe', Edward Elgar, 2015, 222-233.

[2] Djurovic, G., "Potential of the EU pre-accession assistance in financing of local economic and infrastructure development: experiences of Montenegro in MFF 2007–2013." In: Conference proceedings, Local Economic and Infrastructure Development of SEE in the Context of EU. *Academy of Sciences and Arts of Bosnia and Herzegovina*, Sarajevo, September 2013, 318–321.

[3] Djurovic, G., and B. Bulatovic., "Proposal for the EU CAP compliant agricultural budgeting model in Montenegro," *Agricultural Economics*, 2014, 60(10), 479-487.

of inflation, with a focus on governing these instruments in the meantime. Furthermore, the focus of research attention will be on the analysis of factors such as selected imported or exported products that affect the price stability in the country, as well as the movement of key macroeconomic indicators such as GDP growth and employment, and the efficiency of public administration and its intermediate but significant impact on the level of the informal sector and the quality of economic governance in the country.

An essential factor determining the country's price stability is the price of energy, the constant oil price fluctuations on the international market. Oil is a worldwide commodity traded globally. Since oil is a profoundly requested product from huge economies and with a limited supply, oil prices are extraordinarily impacted by a few economic, financial, and geopolitical factors. These factors significantly impact the equilibrium of oil products, increasing oil prices. Large price fluctuations disrupt the market: consequently, having a non-negligible impact on the Montenegrin inflation, economy. In the Energy Balance of Montenegro, out of the total final energy consumption, oil and gas account for 36% and 37% in 2018 and 2019, respectively. The most significant oil and oil derivatives consumption is expected to take place in the transport sector, about 70% of total consumption, followed by the industry sector. The share of the agriculture, trade, and household sectors in oil and gas consumption is at a much lower level. Given that there is no production of petroleum products or gas in Montenegro, the Montenegrin market's total quantities are imported. In other words, oil and gas consumption is a significant imported category, which derives from the Energy Balance and significantly affects the country's overall trade balance[4].

The Aluminum Plant Podgorica (KAP) is a significant representative of the non-ferrous metals industry in Montenegro. The products of the KAP are sold in US dollars at the London Metal Exchange. Till 2006, KAP covered 60%-80% of the overall commodities exports of Montenegro in different periods. Consequently, the London Metal Exchange (LME) stock price disparities and changes in the external demand caused by the global

[4] Energetski bilans za 2020 .godinu ("Sl.list CG", br. 76/19). Energy Balance, Official Gazette of Montenegro, no. 76/19.

economic and financial crisis, from 2006 to 2014, covered 36% of commodities exports on average. In case KAP would work in its full capacity (which is expected following the dynamic flow of projected investments, especially after 2020), it will reach the production of about 120,000 tons of aluminum annually, fulfilling environmental standards by applying the best available technologies (BAT), which would lead to a reduction in GHG emissions[5] to the target level, as well as the inclusion of some semi-products in their offer. With adequate investment, it is estimated that aluminum and all its components could restore the leading position in Montenegrin industrial exports and thus be one of the critical factors for governing imported inflation. In line with the above, the fluctuation of aluminum shares' prices on LME will remain one of the key factors that will affect the level of inflation in Montenegro.

In addition to the above mentioned, the shadow economy is one of the internal inflation factors to be considered in Montenegro. The shadow economy reduces Government revenues and, in this way, forces it to find new, additional budget revenues. An effective response to the informal sector of the economy is to increase public administration work efficiency, particularly by strengthening e-government and providing various public services to citizens and businesses, and reducing administrative barriers. The European Union categorized 20 basic *e*-services as a set of key *e*Government services, and today in Montenegro, there are as many as 564 electronic services provided by more than 50 institutions. As these services increase efficiency, it is reasonable to expect that by further strengthening electronic services, citizens will be more satisfied with the offered *e*-services, the economy will be more efficient, the growth of Montenegrin GDP will achieve better dynamics, and therefore, the control of price stability in Montenegro will be tighter.

[5] Djurovic, G., J. Cetkovic, V. Djurovic, N. Jablan., "Paris Agreement and Montenegro's INDC: assessing the environmental, social and economic impacts of selected investment," *Polish Journal of Environmental Studies*, 2018, 27(3), 1019-1032.

1.1. Objectives and hypothesis

Montenegro is a transitional economy, with the euro as unilaterally introduced currency, well advanced in the EU accession talks[6]. Montenegro represents an illustrative example of a small euroized economy with aluminum as the main industrial export product with the potential for significant export growth (currently 40% of total commodity export with perspective to reach 60-70% in the medium term), where the domestic price level seems to be "imported" through aluminum stock price. Hence, *the objective of the thesis* studies the effects, *inter alia*, oil prices, aluminum stock price, unemployment, GDP, economic freedom, e-Government, capital stock, human capital, employment, exchange rate, broad money (M2), wages, and productivity index on inflation in Montenegro for the period from 2006:1 to 2017:12. Moreover, econometrically, the model will analyze external and internal factors determining the level of inflation in Montenegro, such as the dynamic movements of oil prices and the direction of GDP as a synthetic indicator of the dynamics of our economy. The results will be obtained using the recursive and non-recursive structural vector autoregression (SVAR) identification, Bayesian VAR, average and inverse MSE combinations, and panel econometric analysis providing empirical evidence of relations between internal and external factors of inflation, i.e., the impact of variables to inflation in Montenegro. This research is essential for policymakers in transitional economies and central banking authorities in economic policy planning, with a particular focus on maintaining price stability.

Bearing in mind all of the above, one of the *key research questions* in this thesis is the analysis and determination of the optimal inflation rate, in fact, the analysis of the determinants that influence the achievement and maintenance of price stability in the country. Moreover, the next research question is analyzing *the main factors of inflation in Montenegro* and what *instruments* policymakers need to govern the inflation. Since

[6] Zugic, R. and Fabris N., "Framework for Preserving Financial Stability in Montenegro," Journal of Central Banking Theory and Practice, 2014, 3(1), 27 – 41.

prices are not arbitrary figures but reveal how markets value things marginally, it is one of the most principal and significant economic ideas[7].

Critical research assumptions and hypotheses made to draw out and test its logical and empirical results are structured as follows:

H1: *Achieving and maintaining price stability* in Montenegro, as one of the goals of the central monetary authority in the country (and its instruments) on its path to the European Union and the European Monetary Union, is significantly contributed by the measurement of the impact of critical factors that determine the level of inflation in the country.

> It is important to emphasize that this is one of main Montenegro's goals in fulfilling the criterion of being a functioning market economy, which is precisely defined in the set of closing benchmarks for the EU negotiation chapter 17, European and monetary union (opened on June 26, 2018). Montenegro is also obliged to adopt the required constitutional change to ensure that the primary objective of price stability is defined in accordance with Articles 127(1) and 282(2) of the Treaty on the Functioning of the European Union.

H2: Factors of inflation in the area of external demand crucial to maintaining price stability in the country, such as the Montenegrin economy and in the proposed model, are the price of energy and aluminum prices. In other words, the changes in the price of oil in the international market, expressed by the level of energy prices on the domestic market, as one of the key inputs for economic activities in the country, significantly determine the level of inflation. Montenegro's forward-looking and knowing the oil markets allows estimating the oil supply distribution, considering worldwide geographical and political events, and thus its consequences. Simultaneously, the price of aluminum affects the Montenegrin economy, which is also a stock market product. The

[7] Varian, H.R., *Intermediate Microeconomics: A Modern Approach, 9th ed.* New York: W. W. Norton & Company, 2014.

more advancement of technological sophistication of KAP and its product diversification of aluminum (as the principal industrial export growth engine) – the greater assistance to policymakers to stabilize the trade balance, debt/GDP ratio, productivity growth, unemployment reduction, output gap, and consequently, limit external shocks to inflation in Montenegro, fixing price disparities and qualifying for the membership into the EU/EMU. In other words, this research will be focused on the measurement of the impact of oil prices and aluminum export growth on the average inflation rate in Montenegro.

H3: Strengthening of the measures and state administration policies towards the development of *e*-services contributes to more efficient and efficient provision of public services, which affects GDP, productivity growth, unemployment, production gap and therefore stabilizes internal inflation shocks in Montenegro. Namely, one of the internal factors determining the inflation rate in Montenegro, in this survey, will be the level of developed *e*-services, included in the VAR and Bayesian VAR models, such as the EGDI index. Another critical factor in the VAR and BVAR models will be economic freedom since it is fundamental to what is regarded as economic progress. By testing the hypothesis in the models, the correlation between the selected variables will be evaluated.

1.2. Methods and research plan

The main impacting factors of the inflation rate in Montenegro could be categorized as internal and external. Internal shocks predominantly come from the volume of public revenues collected, especially indirect taxes generated through trade on food and food processing products, alcohol, tobacco, and accommodation services. The external shocks come mostly from pass-through increases in oil prices and aluminum LME prices.

We examine three individual-predictive recursive and non-recursive structural vector autoregressive (SVAR) and Bayesian VAR models to investigate and forecast inflation determinants of Montenegro. We continue employing the average and inverse MSE combinations approach, and the data are examined from January 2006 to December 2016. Additionally, out-of-sample 12-month horizon forecasting is performed from January 2017 to December 2017. Model 1 examines external determinants. Model 2 examines the internal determinants of inflation. Model 3 relates to demand-pull and cost-push

variables. Combining the above three forecasts, using an equal and inverse MSE weighting approach, we disclose four more RMSEs: two VAR equal and inverse MSE weights and two Bayesian VAR equal and inverse MSE weights. Besides, we use impulse responses to trace the effects of structural shocks on the endogenous variables and forecast error variance decomposition of shocks to variables.

Moreover, we use the panel vector error correction model (VECM) approach to forecast inflation dynamics and inflation expectations in Montenegro, Serbia, Croatia, and Slovenia from January 2006 to December 2015 out-of-sample 24-month horizon forecasting from January 2016 to December 2017. The objective of the panel cointegration approach is not only to compare two subgroups: i) Montenegro (ME) and Serbia (SR) as candidate countries for the EU membership and ii) Croatia (CR) and Slovenia (SI), already in EU, but to highlight the Montenegrin case. We employ alternative forecasting scenarios since the Central Bank of Montenegro wants to hypothetically have a forward-looking forecasting reaction of inflation in different sensitive scenarios, such as an increase in the oil price (external innovations) and economic freedom index-internal innovations.

The oil price and aluminum LME price variables are used as the core factors in Montenegro to measure its economy's strength to absorb the external shocks, especially considering the aluminum as the primary potential productivity growth engine based on the revealed competitive advantage. The aluminum LME price and oil price variables are related to GDP, unemployment rate, and inflation. These factors will be included in model 1, using the recursive and non-recursive SVAR identification and Bayesian VAR analysis to measure the controlling strength of external shocks into inflation in Montenegro.

The economic freedom and *e*-government development index[8] (EGDI) will be used as critical internal factors contributing to anchor inflation in model 2. Human capital, telecommunication infrastructure, and online services are the three components that build

[8] United Nations, E-Government Knowledgebase, *https://publicadministration.un.org*, accessed, March 13, 2020.

the EGDI. Per capita growth rate, in the long run, settles down to the speed of technological change. Model 2 will include capital stock, human capital, employment, GDP, and inflation as well.

Other variables, such as GDP, unemployment rate, nominal exchange rate, wages, industrial production growth, and money in circulation (broad money M2, the estimate of CBCG), are also included in another model, model 3. These variables incorporate both demand-pull and cost-push ingredients, starting from a balance between aggregate demand and aggregate supply.

The recursive and non-recursive SVAR identification, Bayesian VAR, panel data analysis, and forecast combination puzzles of inflation will be applied, using an equal and inverse MSE weights approach. The variables in this research study are oil price, aluminum price, GDP, unemployment rate, exchange rate, industrial productivity growth, wages and money in circulation (broad money M2), economic freedom, EGDI, capital stock, human capital, employment, and inflation. The monthly data are observed from January 1, 2006, to December 31, 2017.

The following equations represent the three models estimated:

$$\pi_t = \beta_0 + \beta_1 \log(Oil)_t + \beta_2 \log(Alu)_t + \beta_3 Un_t + \beta_4 GDP\_GAP_t + u_t \quad (1)$$

$$\pi_t = \beta_0 + \beta_1 \log(EF)_t + \beta_2 \log(EDGI)_t + \beta_3 CStock_t + \beta_4 \log(H)_t + \beta_5 Emp_t + \beta_6 GDP\_GAP_t + u_t \quad (2)$$

$$\pi_t = \beta_0 + \beta_1 \log(EX)_t + \beta_2 \log(M2)_t + \beta_3 \log(W)_t + \beta_4 Prod_t + u_t \quad (3)$$

Some of the variables were found in the Montenegrin national publications while some in the international ones. The variables of inflation (*Inf)* and unemployment *(Un)* are collected from tradingeconomics.com[9]. The *GDP* variable time series is collected from statista.com[10]. The exchange rate variable time series (*Exch)* is obtained from oanda.com[11], while aluminum price time series (*Alu)* and oil price (*Oil)* are collected from

[9] Trading Economics , *https://tradingeconomics.com/*, accessed, October 17, 2019.

[10] Statista , *https://www.statista.com/*, accessed, October 17, 2019.

[11] Oanda , *https://www.oanda.com/rw-en/*, accessed, October 17, 2019.

indexmundi.com[12]. The broad Money *M2* is collected from the CBCG[13]. The EGDI time series is drawn from UN eGov surveys[14]. The economic freedom (*EcoFree*) variable is collected from the Heritage Foundation[15]. Capital stock (investments/GDP) variable comes from data.worldbank.org[16] and employment (*Employ*) from Fred economic data[17]. Human capital (*HumCap*), wages (*W*), and industrial productivity (*IndG*) growth time series are collected from monstat.org[18].

In addition to the above mentioned, the following research methods will be used: descriptive method, historical method, comparative analysis, case studies, content analysis, statistical (econometric) method, and combination methods. Regarding additional quantitative research methods, the Product Space Metrics methodology will also be applied.

1.3. Scientific contribution

Since the primary objective of the monetary policy of Montenegro, on its path towards the EU and the European Monetary Union, should be *achieving and maintaining price stability*, (which is one of the key criteria for closing chapter 17, Economic and Monetary Policy), the above could be enhanced by the study, i.e., by measuring internal and external variables that determine the level of inflation in Montenegro. The research on maintaining price stability by governing the external and internal factors of inflation will contribute to

[12] Index Mundi , *https://www.indexmundi.com/*, accessed, October 17, 2019.

[13] Central Bank of Montenegro, *https://www.cbcg.me/*, accessed, October 17, 2019.

[14] United Nations, E-Government Knowledgebase, *https://publicadministration.un.org*, accessed, March 13, 2020.

[15] The Heritage Foundation, *https://www.heritage.org*, accessed, October 31, 2019.

[16] World Bank Open Data, *https://data.worldbank.org/*, accessed, October 31, 2019.

[17] Fred Economic Data, *https://fred.stlouisfed.org/*, accessed, October 31, 2019.

[18] Monstat, *https://www.monstat.me*, accessed, October 25, 2019.

an in-depth understanding of the complexity of the economic governance mechanism. The research center is price stability.

Montenegro is obliged to gradually harmonize its economic and monetary policy with the EU and Eurozone. Research like this one is essential for scientists and the business community to understand the final phase of the accession process and key changes in the decision-making process within the economic governance mechanism (supranational economic policy coordination mechanism of the EU Member States).

Applying the above-mentioned scientific research methods, we will analyze and measure the impact of the variables on Montenegro's inflation level in current and alternative sensitivity scenarios. The analysis will consequently help macroprudential policymakers stabilize the trade balance, reduce debt/GDP ratio, enhance productivity growth, lower unemployment, run-down output gap, and govern external and internal shocks to inflation in Montenegro. At the same time, with this research, the necessary conditions that Montenegro achieves through effective economic policy implementation will be analyzed, and these are the conditions that qualify Montenegro for future membership in the EU, i.e., to the European Monetary Union.

Summarizing, our findings help policymakers understand in-depth the factors involved in detecting the commencement of inflation dynamics and its expectations in Montenegro better and set forth more effective government regulations. In so doing, this research enhances and suggests the approach and methodology needed to fight the worries of many macroprudential policymakers in Montenegro, especially the Central Bank of Montenegro.

2. Governance of External and Internal Factors of Inflation

Macroeconomic stabilization and structural reforms follow the transition of the Western Balkans and their convergence towards the European Union. Macroeconomic stabilization implies external and internal macroeconomic equilibrium, whereby the internal macroeconomic equilibrium mirrors, among other things, a low and stable inflation rate. Besides, structural reforms inevitably carry with themselves waves of layoffs and affect the unemployment rate. Since Montenegro is at the threshold of entering the EU, we are motivated to theoretically and empirically examine and predict external and internal inflation determinants in Montenegro.

Many factors influence the maintenance of price stability in Montenegro, and the focus of this research will be the study of key (selected) external and internal factors of inflation, with a focus on governing these instruments in the meantime. Furthermore, the research attention will analyze factors such as selected imported or exported products that affect the country's price stability. The movement of key macroeconomic indicators such as GDP growth, employment, public administration efficiency, and its intermediate but significant impact on the informal sector's level and the quality of economic governance in the country will have an in-depth analysis.

The objective is to reveal the internal and external determinant factors of inflation in the specified period and forecast the inflation dynamics, using VAR, Bayesian VAR, and combination puzzle approach. To achieve that objective, we estimate recursively and non-recursively three structural VAR and three BVAR identified inflation models to develop a complementary toolset to forecast inflation[19][20].

[19] Mejía, J. D. Ch., and C. Ch. Morales., "Forecasting Inflation by Bayesian Techniques," *Banco Central De Costa Rica, Economic Research Department,* 2015.

[20] Lindholm, U., M. Mossfeldt., and P. Stockhammar., "Forecasting inflation in Sweden," *Economia Politica,* 2020, 37, 39–68.

Montenegro gave up the independent monetary policy and adopted a unilateral and official euroization in 2002[21]. Historically, Montenegro used foreign currencies mostly[22]. A monetary union in Europe is a vital intermediate move toward political union[2324]. Countries with "good" institutions display *fear of floating*: they float less than announced[25]. A type of government with the most substantial incentive to give up its currency is a small country with high inflation history[26]. Montenegro, since independence, decided *de jure* and *de facto* toward building and strengthening the core institutions. A government's decision to enhance institutions depends on the conflict of institutions and the government's goodwill[272829303132]. Based on an IMF empirical analysis, de jure and de facto exchange rate regime classifications for 146 EMDCs over 1980–2010 (Emerging Markets and Developing Countries), they find that inflation is

[21] Djurovic, G., *The European Union and Montenegro: The Accession Process.* Podgorica: EU Info centar, 2017.

[22] Fabris, N., "The History of Money in Montenegro from 1906–1918," Conference *The Economic Causes and Consequences of the First World War, Belgrade University, Faculty of Economics,* 2014.

[23] Alesina, A., and V. Grilli., The European Central Bank: Reshaping Monetary Policy in Europe. National Bureau of Economic Research, Working Paper 7927, 2000.

[24] Djurovic, G., "Montenegro's Strategic Priorities on the Path of Euro-Atlantic Integration," *Political Science,* 2009, 93-112.

[25] Alesina, A., and A. Wagner., "Choosing (and Reneging on) Exchange Rate Regimes," *Journal of the European Economic Association,* 2006, 4(4), 770-799.

[26] Alesina, A., and R. J. Barro., "Currency Unions," *The Quarterly Journal of Economics,* 2002, 117(2), 409-36.

[27] Galli, A., G. Djurovic., L. Hanscom., and J. Knezevic., "Think globally, act locally: Implementing the sustainable development goals in Montenegro," *Environmental Science & Policy*, 2018, 84, 159-169.

[28] Jaksic, M., and A. Prascevic., *Makroekonomija: analiza i politika*. Beograd: Čugura, 2014.

[29] Acemoglu, D., and J. A. Robinson., *Economic Origins of Dictatorship and Democracy*. Cambridge, UK: Cambridge University Press, 2005.

[30] Acemoglu, D., S. Naidu, P. Restrepo, and J. A. Robinson., Democracy, Redistribution and Inequality. National Bureau of Economic Research Working Paper 19746, 2013.

[31] Acemoglu, D., *Introduction to Modern Economic Growth*, New Jersey: Princeton University Press, 2009.

[32] Djurovic, G., M. Bigovic., and N. Milovic., "Support for Further Enlargement of the EU: Statistical Analysis of Regional Differences," *Journal of Balkan and Near Eastern Studies,* 2017, 19(3), 243-258.

indeed lower — especially in emerging markets — by some 4%[33][34][35][36]. Meanwhile, Reinhart and Rogoff (2003) find the opposite when an official categorization is a form of the peg; roughly half the time, their classification reveals the real underlying monetary regime to be radically different, often a variant of float[37]. Euroized countries should have a very low pass-through inflation as their currencies are anchored to that of their principal trade partner[38]. On the other hand, Fabris and Acimovic (2010) propose a two-nominal-anchor regime: inflation and the exchange rate[39].

[33] Ghosh, A. R., M. S. Qureshi, and Ch. G. Tsangarides., "On the Value of Words: Inflation and Fixed Exchange Rate Regimes," *IMF Economic Review,* 2014, 62(2), 261-287.

[34] Giavazzi, F., and M. Pagano., "The Advantage of Tying One's Hands: EMS Discipline and Central Bank Credibility," *European Economic Review,* 1988, 32(5), 1055-1075.

[35] Hashem, E. A., "Inflation Targeting in Emerging Economies and its Applicability to the Egyptian Economy," *Arab Journal of Administration,* 2015, 36(2), 421-436.

[36] Hossain, A. A., "Monetary Policy for Maintaining Low, Stable Inflation in Malaysia," *The Journal of Developing Areas*, 2017, 51(2), 381-404.

[37] Reinhart, C., and K. Rogoff.' "The Modern History of Exchange Rate Arrangements: A reinterpretation," *Quarterly Journal of Economics,* 2003, 119(1), 1-48.

[38] Del Cristo, L.M.M., and Gómez-Puig, M., "Pass-through in Dollarized Countries: Should Ecuador Abandon the U.S. Dollar, Universitat de Barcelona," *Research Institute of Applied Economics Working Paper,* No.2012/16, 2012.

[39] Fabris, N., and S. Acimovic., "Exchange Rate Policy in Serbia," *South East European Issues:Transit Stud Rev*, 2010, 17, 170-180.

Investigating and determining empirical inflation determinants is vital. Determining inflation factors in well-advanced and transitional countries has been a research topic of many empirical and theoretical studies[40][41][42][43][44][45].

Researches that investigate Montenegrin inflation are narrow, and the examined works highlight that only the SVAR models would accurately predict inflation in Montenegro[46][47]. Lipovina – Bozovic et al. (2015) highlighted that ARIMA forecasting models could not appropriately predict inflation since many external factors influence Montenegro's price movement. Mitrovic – Mijatovic and Ivanovic (2017) highlight that Montenegrin openness increased house prices. In the meantime, openness brought more money, and external shocks have a positive impact on inflation. International Monetary Fund, Montenegro-Article IV Consultation, (2018) reports that a 2 p.p. VAT and excise increase adds 1 p.p. to inflation on average[48].

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[40]Golinelli, R., and R. Orsi., "Modeling Inflation in EU Accession Countries: The Case of the Czech Republic, Hungary, and Poland," *Ezoneplus, Working Paper,* 2011, No.9.

[41]Egert, B., "Real Convergence, Price Level Convergence, and Inflation Differentials in Europe," *CESifo Working Paper*, 2007, No. 2127.

[42]Blanchard, O., G. Dell'Ariccia, and P. Mauro., "Rethinking Macroeconomic Policy," *Journal of Money, Credit and Banking,* 2010, 42(1), 199-215.

[43]Koop, G., and D. Korobilis., "Forecasting inflation using dynamic model averaging," *International Economic Review*, 2012, 530(3), 867–886.

[44]Apostolov, M., and D. Josevski., "Aggregate Demand–Inflation Adjustment Model Applied to Southeast European Economies," *Journal of Central Banking Theory and Practice*, 2016, 5(1), 141-157.

[45]Obradovic, S., S. Sapic, S. Furtula, and N. Lojanica., "Linkage between Inflation and Economic Growth in Serbia: An ARDL Bounds Testing Approach," *Inzinerine Ekonomika-Engineering Economics,* 2017, 28(4): 401-410.

[46]Lipovina-Bozovic, M., J. Cerovic, and S. Vujosevic., "Forecasting inflation in Montenegro using univariate time series models," *BEH – Business and Economic Horizons*, 2015, 11, 51-63.

[47]Mitrovic-Mijatovic, M., and M. Ivanovic., "Inflation in a Fully-Euroised Economy: Could Inflation Differentials Threaten Competitiveness?," *Journal of Central Banking Theory and Practice*, 2017, 2, 101-124.

[48]International Monetary Fund, (IMF)., "Montenegro: 2018 Article IV Consultation," *IMF Country Report*, 2018, No 18/121, Washington, D.

Having only a few research papers that examine Montenegrin inflation, we have examined and investigated a broad number of empirical studies on inflation determinants. Different methodological approaches and indicators are suggested to explore and forecast inflation determinants. Cecchetti et al. (2000), among other factors, emphasize the economy's impulse response innovations to inflation[49]. Using a panel VAR approach, Dées and Güntner (2016) untwist the role of unit labor costs and profit margins as the essential determinants of price dynamics across euro area countries[50].

On the other hand, Yi and Choi (2005) examined 207 countries from 1991-2007 and found: an internet penetration rate increase of 1% decreases inflation from 0.04%-0.13%[51]. Czernich et al., (2011) examined OECD from 1996-2007 and found a positive and essential relationship between broadband nexus and growth[52].

Acemoglu (2009) argues that economic institutions *cause* dissimilarities in GDP[53]. The Heritage Foundation (2019) highlights that free societies drive people to work, create, and invest: being protected by the government.[54]" The nexus between economic freedom and the endogenous growth model have shown several studies[5556]. Using panel data

[49]Cecchetti, S.G., R. S. Chu, and Ch. Steindel., "The unreliability of inflation indicators," *Current Issues in Economics and Finance*, 2000, 6, 1-6.

[50]Dées, S., and J. Güntner., "Forecasting Inflation Across Euro Area Countries and Sectors: A Panel VAR Approach," *Journal of Forecasting*, 2016, 36, 431-453.

[51]Yi, M. H., and Ch. Choi., "The Effect of the Internet on Inflation: Panel Data Evidence," *Journal of Policy Modeling*, 2005, 27(7), 885-89.

[52]Czernich, N., O. Falck, T. Kretschmer, and L. Woessmann., "Broadband Infrastructure and Economic Growth," *The Economic Journal*, 2011, 121(552) 505-532.

[53]Acemoglu, D., *Introduction to Modern Economic Growth*. New Jersey: Princeton University Press, 2009.

[54]The Heritage Foundation, *https://www.heritage.org*, accessed, October 31, 2019.

[55]Berggren, N., "The Benefits of Economic Freedom: A Survey," *The Independent Review*, 2003, 8(2), 193-211.

[56]Gwartney, J. D., R. G. Holcombe, and R. A. Lawson., "Economic Freedom, Institutional Quality, and Cross-Country Differences in Income and Growth," *Cato Journal*, 2004, 24(3), 205-233.

econometrics, Cebula (2011) finds a positive relationship between EF and EGM[57]. Based on 19-panel transition economies, Hammermann and Flanagan (2007) highlight that greater liberalization would reduce higher inflation incentives [58].

The speed of technological progress speed (A^e) and the dynamics of expectations that workers form is essential upon the shaping of price expectations (P^e) as well[59]. New and innovative technological progress changes the market's structural contour, making old technology no longer used[60].

Broad money enters short-term inflation determinants[61]. Bobeica et al., (2019) conclude that demand shocks, through labor costs, are passed on to inflation more likely than supply shocks[62].

Kilian (2009), Wei et al., (2010), Peersman and Van Robays (2012), and Baumeister and Peersman (2013) is another coastline that examines the literature of time-varying effects

[57]Cebula, R.J., "Economic Growth, Ten Forms of Economic Freedom, and Political Stability," *Journal of Private Enterprise*, 2011, 26(2), 61:82.

[58]Hammermann, F., and M. Flanagan., "What Explains Persistent Inflation Differentials Across Transition Economies?," *Kiel Institute for the World Economy,* Working Paper 1373, 2007.

[59] Blanchard, O., *Macroeconomics, 7th ed.* Harlow, UK: Pearson, 2017.

[60] Aghion, Ph. And P. Howitt., *The Economics of Growth*. Cambridge, MA: MIT Press, 2008.

[61]Lissovolik, B., "Determinants of Inflation in a Transition Economy: The Case of Ukraine," *International Monetary Fund*, 2003, WP/03/126.

[62]Bobeica, E., M. Ciccarelli, and I. Vansteenkiste., "The link between labor cost and price inflation in the euro area," *European Central Bank,* 2019, WP 2235.

of oil price innovations on the inflation dynamics[63][64][65][66]. They conclude that the fundamentals of oil prices are important determinant factors of inflation. Choi et al., (2017) conclude that domestic inflation increases on average by 0.4% when global oil prices rise 10%. The results are similar between advanced and transitional countries[67].

To extend the range of instruments available for the Central Bank of Montenegro, we have developed a set of models that make it possible for us to have a complementary toolset to forecast inflation: i) external variables, ii) internal variables, and iii) demand-pull and cost-push variables.

2.1. Approach to the analysis of inflation

What is the optimal inflation rate in Montenegro? What determines the inflation equilibrium in Montenegro? What is the structure of inflation in Montenegro, and what instruments policymakers need to govern inflation? As long as prices are not unreasonable figures but reveal how people value things precisely, it is one of economics' most fundamental ideas[68].

In a competitive market, where each wage setter and firm are a small part of the market, real wage price-setting relation determines the market price and the unemployment rate.

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[63]Kilian, L., "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," *American Economic Review*, 2009, 99(3), 1053-1069.

[64] Wei, Y., Y. Wang., and D. Huang., "Forecasting crude oil market volatility: Further evidence using GARCH-class models," *Energy Economics*, 2010, 32(6), 1477-1484.

[65]Peersman, G., & Van Robays, I., Cross-country differences in the effects of oil shocks," *Energy Economics*, 2012, 34(5), 1532-1547.

[66]Baumeister, Ch., and G. Peersman., "Time-Varying Effects of Oil Supply Shocks on the US Economy," *American Economic Journal: Macroeconomics*, 2013, 5(4), 1-28.

[67]Choi, S., D. Furceri, P. Loungani, S. Mishra, and M. Poplawski-Ribeiro., "Oil Prices and Inflation Dynamics: Evidence from Advanced and Developing Economies," *International Monetary Fund*, 2017, WP/17/196.

[68] Varian, H.R., *Intermediate Microeconomics: A Modern Approach, 9th ed.* New York: W. W. Norton & Company, 2014.

In turn, wages are determined by the expected price level, unemployment rate, and positively correlated other factors. On the other hand, firms determine prices depending on wages and markups[69]. The expected inflation comprises of two variables: a constant $(1-\alpha)$ and a last year's inflation coefficient α.

$$\pi_t^e = (1-\alpha)\pi + \alpha\pi_{t-1} \quad (4)$$

At a constant inflation rate, firms and wage-setters' behavior is compatible, indicating a natural unemployment rate and output equal to potential. For output levels above potential, change in inflation increases. The positive change shows how the price and wage adjustment, in turn, affects production.

Euroization in Montenegro anchored expectations. Since independence, 2006, economic reforms have been undertaken, and economic growth emerged in the market. Demand increased and led to growth, shifting inflation, consumption, and foreign direct investments (FDI) up. Since the Montenegrin economy is predominantly oriented in imports, it is of significant interest to see whether inflation is determined by core inflation (long term) or external shocks[7071]. Dimitrijevic et al. (2016) emphasize that: (i) administrative products (medicines, flour, electricity, fixed telephony), (ii) agricultural products, and (iii) oil products should be excluded as potential group products from core inflation. Oscillation of the above three groups are innovations that determine structural breaks, long term fluctuations, and seasonal inconsistency of inflation in Montenegro.

The wave of FDI in 2007 and 2008 impacted, in 2012 and 2013, inflation by 37.2% and 129,4%, respectively, in the housing market in Montenegro[72]. In 2014, communication

[69] Blanchard, O., *Macroeconomics, 7th ed.* Harlow, UK: Pearson, 2017.

[70] Fabris, N., and I. Pejovic., *Ekonomija*. Savremena administracija: Beograd, 2015.

[71] Dimitrijević, B., N. Fabris, Lj. Vladušić, M. Radović, and M. Jadrić., *Economic Policy-Regional Aspects*. Belgrade: Čugura, 2016.

[72] Mijatovic-Mitrovic, M., and M. Ivanovic. Inflation in a Fully-Euroised Economy: Could Inflation Differentials Threaten Competitiveness? De Gruyter. *Journal of Central Banking Theory and Practice, 2017, 2, 101-124.*

Table 1: CPI structure percentage by categories

% to CPI	Av. 2011	Av. 2012	Av. 2013	Av. 2014	Av. 2015	Av. 2016	Av. 2017
FOOD AND NON-ALCOHOLIC BEVERAGES	42.0%	32.7%	-34.8%	-358.7%	84.3%	38.4%	24.6%
ALCOHOLIC BEVERAGES AND TOBACCO	22.4%	18.0%	110.5%	-84.2%	7.5%	3.5%	14.2%
CLOTHING AND FOOTWEAR	-4.9%	-0.8%	-7.4%	-17.6%	27.1%	-1.8%	8.8%
HOUSING, WATER, ELEC., GAS & OTHER FUELS	-4.9%	37.2%	129.4%	24.2%	25.2%	18.1%	10.5%
FURNISHINGS, HOUS. EQ. & MAINTENANCE	-1.2%	0.0%	-12.2%	92.4%	-1.8%	1.4%	-2.0%
HEALTH	17.0%	3.8%	24.3%	-209.8%	11.5%	2.0%	4.7%
TRANSPORT	28.7%	7.1%	-107.6%	303.6%	-69.3%	25.2%	31.7%
COMMUNICATION	0.8%	2.5%	-7.9%	265.7%	0.4%	-0.4%	0.4%
RECREATION AND CULTURE	-4.8%	1.5%	-31.9%	1.2%	5.7%	0.7%	-0.6%
EDUCATION	-0.2%	-0.1%	1.3%	-0.2%	0.0%	0.0%	0.0%
RESTAURANTS AND HOTELS	5.8%	4.0%	-1.0%	26.1%	5.2%	6.7%	9.1%
MISCELLANEOUS GOODS AND SER.	1.3%	0.0%	48.6%	44.6%	-1.4%	2.6%	2.7%

Source: Monstat, author's calculations, 2019.

and transport impacted inflation by 265.7% and 303.6%, respectively, which was counterbalanced by the negative shock of food and non-alcoholic beverages by -358.7%. Still, in 2016 and 2017: (i) import of food, tobacco and non-alcoholic beverages, (ii) housing, electricity and oil, (iii) and tourism industry and transport institute the cardinal impact on inflation in Montenegro. The CPI structure percentage by categories is represented in Table 1. The structure of Montenegrin inflation remains vulnerable to external shocks (imports of fuel especially), fiscal policy (excise tax on tobacco and accommodation services), and energy (tax and uncompetitive products), which harm Montenegro's economic stability and sustainable growth. Table 1 shows that in the pre-crisis period, food, alcoholic beverages and tobacco, and health and transport determined the inflation predominantly.

Table 2: The impact of predominant internal and external factors on inflation

Year	Internal impact	External impact
2017	Higher excise tax in Tobacco & Accom.	Pass-through of oil and food in the world market
2016	Tobacco and Accom. services	Deflation pass-through impact of oil and food
2015	Food & non-alc. beverages The deflationary impact of transport (decrease of the world oil market). An introductory tax of 7cents/lit for highway Bar-Bolare increased the oil price	The inflationary effect of food price Decrease of world market oil price, and stagnation of Electricity price
2014	Weak growth of available income	The deflationary trend of food prices and weak growth of effects income.
2013	Excise taxes on tobacco, VAT from 17% to 19%, deflationary of transport, electricity prices, medicine taxes, and accom. services	The decrease in the cost of oil/transport
2012	Electricity, the excise tax on tobacco, alcohol, soft drinks, and coffee, tax on electricity counters and SIM cards	Increase of world market price of oil
2011	Electricity, the excise tax on tobacco, alcohol, soft drinks and coffee, medecine taxes. Increase of Transport.	Pass-through increase of oil and food prices

Source: Economic Reform Programme for Montenegro, 2011-2018, pp. 17-26.

The output gap in Montenegro is below potential. Bogetic et al. (2013) highlight that Montenegro is not using the principal growth engine – *exports* – that has transformed many small countries, especially locations with significant geographical advantages. The ratio of exports-to-GDP averaged only 39% in Montenegro for 2007-2011, while in Slovenia 68%, Estonia 78%, and Malta 85%[73].

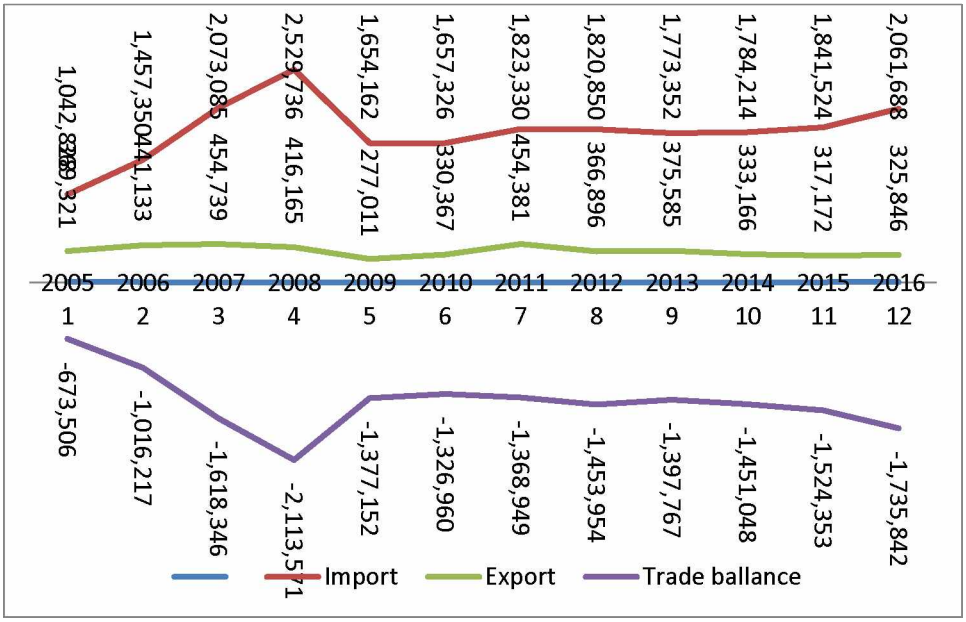


Figure 1: Import, export, and trade balance in Montenegro 2005-2016
Source: Monstat, author's calculations, 2019.

Montenegro runs a trade deficit since 2005, implying that it accumulates debt, vis-à-vis the rest of the world, paying interest rates steadily. Increases in foreign demand, which would improve the trade balance, is a proper path. An increase in domestic demand, especially since the independence of Montenegro, has mostly increased imports, resulting in the trade deficit. To contribute to removing or reducing these obstacles, the ERP 2018

[73] Edgardo, F., Small states, *Smart Solutions: Increasing Connectivity and Effectiveness of Public Services*, World Bank, Washington D.C., 2008.

designed the reform processes in each of the significant reform areas in line with the European Commission's Guidance[7475].

The planned growth of the economic activity, in the time frame 2017-2030, is based on the priority development projects in the field of (i) energy production (hydropower plant - HPP, small HPPs, wind power plants, photovoltaic power stations, TPP Pljevlja II (changed to the ecological revitalization of TPP I) and energy efficiency programs; (ii) transportation (highway and other projects); (iii) industry (especially metal industry); (iv) tourism (tourist complexes and hotels); (v) and agriculture[76].

Exports are a fundamental economic problem in Montenegro. As Figure 2 shows, there is a too high concentration in aluminum, iron, and steel. It shows that this category accounts for 50% of exports on average from 2005-2016. It is planned to invest in the aluminum industry (KAP), BAT technology of 50 million euros until 2030, reducing the GHG by 82.76% and diversifying aluminum products[77]. The technological sophistication of KAP would have multiplicative effects on the economic growth episodes. In 2013, Montenegro's technological export structure was mostly concentrated in semi-products 73.6%, primary products 16.3%, consumer goods 5.2%, capital equipment 4.7%, and high technology products 1.3%, implying low export sophistication, relatively little income potential[78].

[74] Djurovic, G., M. Muhadinovic, V. Djurovic,and M. M. Bojaj., "Agenda 2030: measuring progress in the Montenegro's national strategy for sustainable development," chapter 5 in the Book "Statistics, Growing data Sets and Growing Demand for Statistics," edited by Turkment Goksel, IntechOpen, UK, 2018.

[75] Galli A., G. Djurovic, L. Hanscom, and J. Knezevic., "Think Globally, Act Locally: implementing the Sustainable Development Goals in Montenegro," *Environmental Science and Policy*, 2018, 84, 159-169.

[76] Government of Montenegro, Economic Reform Programme for Montenegro, 2018-2020.

[77] Djurovic, G., M. Bojaj., and M. Muhadinovic., Greenhouse Gas Emissions and Sustainable Growth in Montenegro; A SVAR Approach," Research, Faculty of Economics, 2020.

[78] Halilbasic, M., S. Brkic., and V. Bosic., "Comparative Analysis of Export", *EA*, 2015, 48(1-2), 108-129.

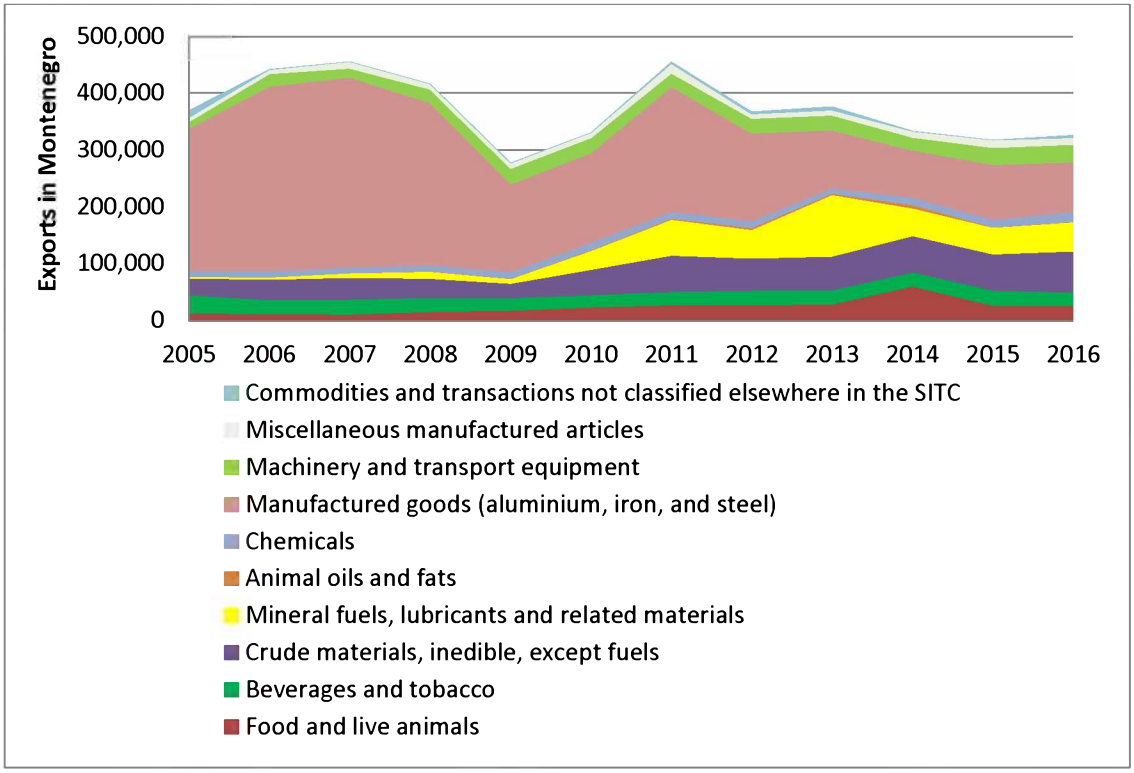


Figure 2: Montenegro export concentration 2005-2016
Source: author's calculations.

Halilbasic et al. 2015 highlight that the number of export products, greater than 100,000$ USD, for Montenegro ranges from 201-198, respectively, during 2006-2013. The Herfindahl - Hirschmann index of geographic export concentration (HHI) ranges from 0.24-0.16, indicating a low export basket dispersion. Bogetic et al. (2013) find that exported products for which Montenegro has revealed comparative advantage (RCA[79]>1) are sparse in the product space (PS) methodology and often located in the difficult-to-reach periphery of the PS. Three income potential groups are aluminum and iron, agriculture, and tourism. An increase in exports (mostly aluminum, iron, and steel) and its structural diversification helps stabilize the trade balance, debt/GDP, productivity growth, unemployment, output gap and consequently, limits external shocks to inflation in Montenegro, fixing price disparities and qualifying for the membership into European monetary union.

Since there are many factors, we estimate three structural VAR and three BVAR identified inflation models. The first model identifies the fundamental *external* and

[79] Revealed competitive advantage.

independent determinants of the supply shocks (oil and London Metal Exchange aluminum prices). The second model examines primary *internal* and independent determinants of inflation, focusing on economic freedom and e-government. Model 3 incorporates cost-push and demand-pull variables.

2.2. External determinants of inflation in Montenegro

It is vital for Montenegrin policymakers to examine and econometrically measure the external factors' impact on determining inflation. Thus, the Central Government of Montenegro is interested in seeing the dependency of inflation to changes in external factors. In the meantime, forecasting and causality are two other dimensions of high interest.

Oil prices play a prominent role in the build-up of persistent inflationary pressures in advanced and transitional countries. Oscillations in oil prices are worldwide phenomena. The impact of oil prices in emerging economies that are not financially stable and not strong to absorb external shocks is highly influential in determining these economies. The inflation rate is the first to get impacted by oil price changes. Consequently, fluctuation in inflation further leads to economic changes[80].

Several research papers have examined the impact of oil prices on inflation since oil is a direct production input. Hooker (2002) examined the relationship between inflation and oil prices from 1962-1980 and 1981-2000: the results showed that the impact of oil prices was noticed only in the first sample[81]. A great number of studies report a significant effect

[80] Kozaric, K., and N. Fabris., „Monetary Policy at Crises Time," *Journal of Central Banking Theory and Practice*, 2012, 1, 5- 25.

[81] Hooker, M., "Are oil price shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime," *Journal of Money, Credit and Banking*, 2002, 34(2), 540-561.

of oil prices on inflation[82][83][84]. Blanchard and Gali (2007) explain the strong relationship between oil prices and inflation in two episodes: (i) low growth and high unemployment before 1970, and (ii) high growth and low unemployment after 1980[85].

Table 3: Energy consumption in TJ energy units

Energy	2018	%	2019	%	2020	%
Electrical energy	12,492	20.13%	12,723	32.46%	13,015	30.88%
Biomass	8,317	13.40%	8,089	20.64%	8,409	19.95%
Coal	1,236	1.99%	1,289	3.29%	1,305	3.10%
Oil and gas	35,984	57.98%	13,053	33.31%	15,372	36.48%
Total	62065	100.00%	39192	100.00%	42141	100.00%

Source: Decision of Energy Balance of Montenegro for 2020.

Shocks coming from oil prices can be viewed from three factors: (i) the source of shocks, (ii) the pass-through transmission mechanism of oil shocks, and (iii) the structure of energy[86].

Table 3 shows energy consumption in terajoules (TJ) energy units of Montenegro. As seen from the table, oil consumption as an energy source is crucial for realizing planned economic and social activities in Montenegro. In 2018, oil was used 57.98% as an energy resource. Even though the percentage of oil consumption compared to the total energy sector is declining, oil usage increased from 330t, 347t, and 361t, respectively, from 2018-2020[87].

[82] Kiptui, M., "Oil price pass-through into inflation in Kenya," Kenya School of Monetary Studies Research Centre, 2009.

[83] Misati, R. N., E. M. Nyamongo, and I. Mwangi., "Commodity price shocks and inflation in a net oil-importing economy," *OPEC Energy Review*, 2013, 37(2), 125-148.

[84] Kargi, B., "The effects of oil prices on inflation and growth: time series analysis in Turkish economy for 1988:01 – 2013:04 period," MPRA paper, 2014, no. 55704.

[85] Blanchard, O. J. and J. Gali., "The macroeconomic effects of oil price shocks: why are the 2000s so different from the 1970s?," *National Bureau of Economic Research,* Working Paper, 2007, no. 13368.

[86] Lamazoshvili, B., "Effects of il price shocks on oil-importing developing economies: the case of Georgia and Armenia," *Economics Education and Research Consortium*, 2014, Working Paper no. E14/06.

[87] Government of Montenegro, 2020., *Decision of Energy Balance of Montenegro for 2020.*

The highway Bar-Boljare is expected to increase oil consumption usage, which is in the final stage of Section 1 construction. Thus, oil prices are an essential and dominant source of inflation, implying that supply-side and demand-side innovations originated by external oil shocks are a source of variations in output and inflation in Montenegro.

Figure 3: Empirical relationship between inflation and oil prices
Source: Author's calculations in EViews 11.

Let us start by looking at the empirical relationship between oil prices and inflation in Figure 3. The blue line represents inflation, while the orange line shows the seasonally adjusted logarithmic of oil. It is noticeable that up to the end of 2008, the variables were co-moving together. The gap has widened just around the global financial crisis. While the world oil market price was still increasing, the inflation in Montenegro was declining until the middle of 2010. After 2010, they comove closely together till the end of 2014. The relationship between the two variables seems to have changed in the middle of 2014.

Export potential is the primary productivity growth engine of Montenegro, based on the revealed competitive advantage [88]. Policy misalignment (through debt, low investments, and bank guarantees) of KAP caused the leading Montenegrin exporter to shadow. Bogetic et al. (2013) highlight that countries with ensured cheap energy, BAT technology, and the traditional background of merchandise exports of aluminum, according to Product

[88] Bogetić, Ž., I. Pejović, and I. Osorio Roddarte., „Expanding and Diversifying Montenegro's Exports: A Product Space Analysis," Journal of Central Banking Theory and Practice, 2013, 2, 19-34.

Space (PS) metrics methodology, could be large potential exporters with tourism and agricultural products. Aluminum application in cars, consumer goods, rail wagons, buses, aircraft, etc., has increased the demand for aluminum since aluminum is being used to reduce weight and fuel consumption.

International Trade Center (ITC), World Trade Organization (WTO), and the United Nations (UN) are joint agencies[89]. The UN has set global goals of sustainable development, and the mission of ITC is to nurture them. The Government of Montenegro nationalized the 2030 Agenda on Sustainable Development by adopting the National Strategy for Sustainable Development (NSSD) in 2016 and a corresponding Action Plan for its implementation[90]. Restructuring of the industrial sector in Montenegro, greening economy, and export promotion are parts of that process.

This section focuses on export potential and product diversification since central policymakers are interested in designing proper measures to maintain stable and low inflation. What are the top products, sectors, and targeted markets that could potentially increase the exports of Montenegro, and how will they impact inflation? To answer these questions, we will focus on developing two measurable indicators: export potential and product diversification. There exists a necessity to know what Montenegro exports and what its potential is. Many sources can cause the gap. One of them can be a lack of knowledge of Montenegrin exporting companies about market regulations in the targeted markets. Another reason might be identifying potential partners in the targeted markets. Also, the economic freedom of Montenegro might be an internal factor. There exists a comprehensive list that assists in creating the gap between actual and potential exports in Montenegro. Therefore, economic experts need to identify this gray area and find which products have the highest chance to succeed in the targeted markets. Thus, this is where the export potential estimation methodology gets into action. First, we will find which products Montenegro can export. Second, we will identify markets that can bring the best for Montenegro and bring great results. The potential export assessment methodology

[89] International Trade Centre (ITC), http://www.intracen.org/itc/about/, accessed, March 13, 2020.

[90] Djurovic, G., Muhadinovic, M., Djurovic, V., and Bojaj, M., "Agenda 2030: measuring progress in the Montenegro's national strategy for sustainable development," chapter 5 in the Book "Statistics, Growing data Sets and Growing Demand for Statistics," edited by Turkment Goksel, IntechOpen, UK, 2018.

points out profitable products, sectors, and target markets for trade development activities[91].

2.2.1. Export potential indicator

The first indicator that the methodology points out is Export Potential Indicator (EPI). Its purpose is to support already-established sectors and identify the products and industries that Montenegro has the highest potential to sell outside the country in specific target markets. Thus, EPI tries to find the products and sectors that Montenegro already succeeded in the past from the supply side. On the other hand, the indicator searches the countries on demand for such a product or sector with the best chance of success.

The second indicator we will use is the Product Diversification Indicator (PDI). It aims to identify new products for export diversification. For Montenegrin policymakers, it would be exciting to know what products can be diversified further to the already established export sectors. We put together the supply and demand and the market access condition of the targeted markets to estimate how targeted markets the new diversified products would have the best potential for export success. These products are not yet exported, but we predict the potential success in targeted markets.

EPI is composed of two sub-factors. The first one is the potential export value[92]. It measures the expected supply of a particular product from the exporter, the demand, and the exporter's accessibility. The second element of EPI is the difference between what is realized and what could have been realized. The margin is called the unrealized potential. Decreux and Spies (2016) show the following model:

$$e_{ijk} = \alpha_{ik}\beta_{ij}\gamma_{jk} \tag{5}$$

and e_{ijk} measures the exports of country *i*, product *k*, and market *j*. For example, this would correspond to the Montenegrin exports of a product. While parameter α_{ik}, in this panel data, would measure the performance of Montenegro in exporting the product, γ_{jk}

[91] Decreux, Y., and J. Spies., Export Potential Assessments, A methodology to identify export opportunities for developing countries, ITC, 2016.

[92] Ibid.

shows the demand of the country *(j)* for our product, and β_{ij} corresponds to market access conditions from Montenegro to the country. Panel data econometrics could not give the expected results[93], and therefore a different approach is given:

$$e_{ijk} = \alpha_{ik}\beta_{ij}e_{jk} = \frac{e_{ik}}{e_k}\frac{e_{ij}}{\Sigma_k(\frac{e_{ik}}{e_k}e_{jk})}e_{jk} \tag{6}$$

As Montenegro exports certain products, it reveals its sectors which make the country competitive, and this phenomenon in economics is known as Revealed Competitive Advantage (RCA), popularized by Balassa[94]:

$$XRCA = \frac{X_{ij}}{\Sigma_i X_{ij}} \Big/ \frac{\Sigma_i X_{ij}}{\Sigma_i \Sigma_j X_{ij}} \quad \& \quad \frac{X_{ij}}{X_i} \approx RCA_{ik} \cdot \frac{m_k}{m} \tag{7}$$

The ITC believes that a country's share of a product to its total exports can be written as its RCA times the percentage of the world demand (*DShare*). The ITC shares the following expression as the potential share of a product in a country's exports to a given market *j:*

$$\left[\frac{X_{ijk}}{X_{ij}}\right] = \frac{RCA_{ik}}{\Sigma_k\left(RCA_{ik}\cdot\frac{m_{jk}}{m_j}\right)} \cdot \frac{m_{jk}}{m_j} \tag{8}$$

Expression (7) changes from (8); in fact, that expression (8) considers the demand of a market (*MA*) instead of the demand for the wealth. Thus, at the RCA ratio, we see the portion of a product's supply and the demand for that product by a specific country. Moreover, the final EPI is as follows:

$$EPI_{ijk} = CA_{ik}\frac{Exp\ X_{ij}}{\sum_k CA_{ik}DShare_{jk}MA_{ijk}}DShare_{jk}MA_{ijk} \tag{9}$$

The first constituent on the right-hand side is the supply side. The supply side consists of RCA, RCA growth, X/M ratio, and global tariff conditions the export country faces. The second component is the demand indicator. The first part of the demand indicator deals with the proportion of a country's imports and the growth of that share. For example, this

[93] Egger, P., An Econometric View of the Estimation of Gravity Models and the Calculation of Trade Potentials, *World Economy*, 2002, 25(2), 297-312.

[94] Balassa, B., Trade Liberalization and Revealed Comparative Advantage, *The Manchester School*, 1965, 33, 99-123.

part would be the share of the country's imports from Montenegro and its growth. The second part of the demand would be the tariffs that the country applies to our products and the distance from Montenegro to the country.

2.3.2. The supply of Montenegrin products

It is of valuable interest for policymakers of Montenegro to know the ingredients of the supply side and quantitatively reach a conclusion about the basket of exports of Montenegro. The ITC shows several sub-indicators of the supply side:

$$CA_{ik} = RCA_{ik} \cdot \left(\frac{RCA_{ik}^{t_3 t_5}}{RCA_{ik}^{t-1 t_1}}\right)^{\delta} \cdot min\left(1, \frac{x_{ik}}{m_{ik}}\right) \cdot \left(\frac{1+av.tariff_k}{1+av.tariff_{ik}}\right)^{-\sigma_k} \quad (10)$$

By exporting products, Montenegro reveals its competitive products, the RCA. On the right-hand side, the first one, is RCA, where *i* stands for Montenegro (exporter) and *k* for aluminum (product). The next in line is the dynamic factor, the growth of RCA. It is followed by the trade surplus, $\frac{x_{ik}}{m_{ik}}$, and the global tariff disadvantages of Montenegro faced in the world market. The RCA of a product such as aluminum in Montenegro represents the share of aluminum in Montenegro's exports to the share of aluminum in world exports. In the meantime, it can be interpreted in another way as the share of KAP in the aluminum's exports to the share of Montenegro in world exports:

$$RCA_{ik} = \frac{\frac{KAP\ export}{Aluminum\ export}}{\frac{Export\ of\ Montenegro}{World\ export}}, \quad RCA_{ik} = \frac{\frac{KAP\ export}{Export\ of\ Montenegro}}{\frac{Export\ of\ Aluminum}{World\ export}}, \quad RCA_{ik} = \frac{0.2\%}{0.18\%} = 1{,}11 \quad (11)$$

From this viewpoint, we can see the share of KAP in aluminum exports to the share of exports of Montenegro in world exports. In case the share of exports of KAP in Montenegro's exports is higher than the share of aluminum in world exports, we reveal that Montenegro has a comparative advantage in exporting aluminum. For example, the illustrative example in expression (11) shows that Montenegro is specialized in aluminum.

RCA's growth is also remarkable to measure because we would like to know the RCA dynamics, how the share of aluminum in Montenegro's exports has evolved to the change of the share of aluminum in the world exports. The ITC has done some econometric work about RCAs' dynamics, and the empirical results indicate that there is a continual progress

of RCA. Based on the results, after five years of RCA growth, the growth discontinues its dynamics, but within five years, econometric work is reliable to predict the RCA growth range from 0.73% to 165%[95].

The third component of the supply side is the trade balance, export to import ratio of Montenegro. Why this component is included in the supply side of the expression. There are some products that, for example, Montenegro imports and re-exports the same to neighboring countries with almost no change at all and these products should not be considered in the expression whenever the imports are higher than exports. In this case, the RCA should be corrected, and usually, in recent years, the imports exceed exports in Montenegro. Thus, the RCA needs to be adjusted for cases when the export-to-import ratio is <1; otherwise, there is no need for correction. For example, if Montenegro imports bananas in value of 8.9 million euros and exports 8.3 million euros of bananas, then the ratio is $8.3/8.9 = 0.9325$, and the RCA should be multiplied in this case by 0.9325.

The last component of the supply side is the global tariff disadvantage. This part of the expression compares the average tariff applied by the world to Montenegro of aluminum with the world's average tariff to all-aluminum suppliers. In case the ratio is <1, then RCA has to be downgraded, and for ratio >1, RCA should be upgraded. Why? Consider Montenegro. In case Montenegro faces higher average global tariffs than the average world and manages to export aluminum successfully, this implies that in a market with better tariff conditions, the RCA of Montenegro for aluminum would score higher. Therefore, an upgrade is necessary to balance the market access conditions.

2.3.2. The demand for Montenegrin products

The demand for aluminum is a component of the EPI, and Montenegro needs to find out what is the demand for our products and who is in demand for them. The construction of the expression of the demand side of the EPI is as follows[96]:

[95] Egger, P., An Econometric View of the Estimation of Gravity Models and the Calculation of Trade Potentials, *World Economy*, 2002, 25(2), 297-312.

[96] Decreux, Y., and J. Spies., Export Potential Assessments, A methodology to identify export opportunities for developing countries, ITC, 2016.

$$DShare_{jk} \cdot MA_{ijk} = \frac{m_{jk}}{m_j} \cdot \left(\frac{Share\ in\ demand_{jk}^{t_3 t_5}}{Share\ in\ demand_{jk}^{t_{-1} t_1}} \right)^{\delta} \cdot \left(\frac{1+av.tariff_{jk}}{1+av.tariff_{ijk}} \right)^{\sigma_k} \cdot e^{-|av.log\ distance_{jk} - log\ distance_{ij}|} \quad (12)$$

The first component of expression (12) shows the share in market demand. For example, it shows the demand share of LME to the overall market demand for aluminum. It continues to show the growth of this share in demand over some period. For example, it would be interesting to know the growth rate of the share in demand of LME for 2008-2010 and 2012-2014. Thus, it compares the demand share in 2012-2014 to the demand share in 2008-2010 while accounting for the pass-through of growth rates between two periods of time (within a specified interval). In case it is >1, then we have an increase in demand share, and for <1, we have a reduction in demand share.

Next, we have an access indicator of the market, LME. This part of the expression shows the LME conditions of tariffs for Aluminum Plant Podgorica. This indicator compares the average tariff the LME applies to all-aluminum suppliers with the tariff the LME applies to Montenegro's exports of aluminum while accounting for the product's price sensitivity. In case the ratio is >1, then there is a tariff advantage for the Montenegrin market since the average tariff the LME applies to all suppliers of aluminum comparing to the tariff the LME applies to Montenegro is greater than >1. Thus, this would be advantageous for Montenegro; otherwise, it would be at a disadvantage compared to the other countries.

Finally, we have a distance factor that captures the logarithmic distance of LME to the logarithmic range of KAP. In case the suppliers of aluminum to LME are located further than Montenegro, then Montenegro is located ideally, and no correction of the demand share is needed. It depends on the nature of the product because importing milk and aluminum changes the demand share drastically.

2.3.2. The bilateral trade relations

The bilateral trade is based upon some expected trade between Montenegro and LME. The first component of expression (10) is the current, actual, easiness of trade x_{ij}. The growth rate of economic activities of the exporter and the importer to the growth rate of

the world is further considered as part of the expected bilateral trade of *i* and *j*, respectively KAP and LME:

$$Exp\ x_{ij} = x_{ij} \cdot \frac{\Delta GDP_i^{t_5 t_{10}} \Delta GDP_j^{t_5 t_{10}}}{\Delta GDP_w^{t_5 t_{10}}}, \quad Bilateral_{ij} = \frac{Exp\ x_{ij}}{\Sigma_k CA_{ik} \cdot DShare_{jk} MA_{ijk}} \tag{13}$$

In expression (13), we have the denominator that corrects complementarities in the trade structure between Montenegro and the United Kingdom. This part makes sure that easiness of business, for example, for aluminum between the two countries might be different for other products. Expression (13) helps us find the expected potential export value of aluminum from KAP to LME. The difference between actual and potential is unrealized or missed expected potential export value of aluminum between KAP and LME. The elaborate expression is as follows:

$$EPI_{ijk} = CA_{ik}\ Bilateral_{ij}\ DShare_{jk} MA_{ijk} \tag{14}$$

$$Degree\ of\ unused\ potential_{ijk} = 1 - \frac{min(x_{ijk}, EPI_{ijk})}{EPI_{ijk}} \tag{15}$$

Thus, expressions (14) and (15) give us an expected value of trade that could happen. The difference between the realized and the potential will provide us with the unrealized, which is essential to find the reasons and policies that should be considered to get to Montenegro's full potential realization. The EPI for exporting aluminum not only to LME but to a region would be.

$$EPI_{IJK} = \Sigma_{i \in I, j \in J, k \in K} EPI_{ijk} \tag{16}$$

$$Degree\ of\ unused\ potential_{IJK} = 1 - \frac{\Sigma_{i \in I, j \in J, k \in K}\ min(x_{ijk}, EPI_{ijk})}{\Sigma_{i \in I, j \in J, k \in K}\ EPI_{ijk}} \tag{17}$$

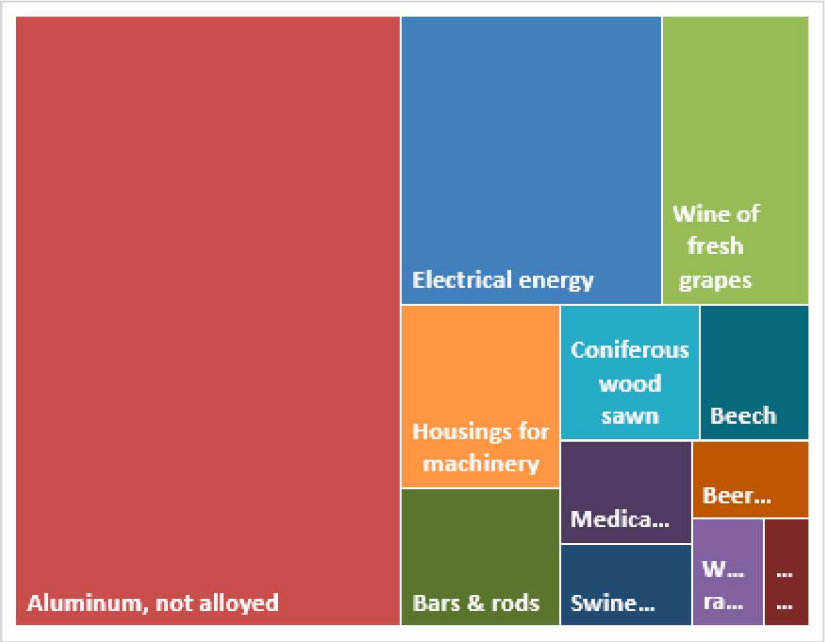
$$EPI_{ijk} = Exp.MShare_{ik}\ \frac{x_{ij}}{\sum_k MShare_{ik} Demand_{jk} MA_{ijk}} Exp.Demand_{jk} MA_{ijk} \tag{18}$$

The market share is based on the current market share, while the growth of the exporter is explained relative to the world exports, and global tariff conditions are added as previously:

$$Exp.MShare_{ik} = f\left(\frac{x_{ik}}{x_k}, (\Delta RCA_{ik}), \left(\frac{\Delta GDP_i}{\Delta GDP_w}\right), \frac{x}{m}\ ratio, global\ tariff\ conditions\right) \tag{19}$$

As far as the demand, we have total imports of a product, followed by the growth of the share and the importer's GDP growth. Tariff conditions remain unchanged from the previous representation:

$$Exp.Dem._{jk}\, MA_{ijk} = f\left(m_j, \left(\Delta DShare_{ijk}\right), \left(\Delta GDP_j\right), tariff\ con., dis.fac\right) \quad (20)$$



Graph 1: Export potential from Montenegro to the world
Source: ITC, author's simulations, 2020.

Graph 1 shows that aluminum not alloyed-unwrought, electrical energy, and wine of fresh grapes are the products with the most significant export potential from Montenegro to the World.

Despite the utmost efforts to carefully check and process data through this methodology, the Montenegrin economy and country experts' in-depth knowledge remains to be further examined. Whole raw hides follow it, then split raw hides & skins, coniferous wood, housing for machinery, swine meat, whole raw hides and skins of bovine, bars and rods of alloyed steel, medicaments containing antibiotics, beech sawn, and beer made from malt.

As we see from Table 4, the untapped potential (UP) of electrical energy in absolute terms is 91.4$ million. The supply capacity remains to be further developed, and the main demanders are Serbia, Bosnia and Hercegovina, and Hungary. The closest export links for electrical links are with Albania, while Italy remains the market with the highest demand potential for electrical energy.

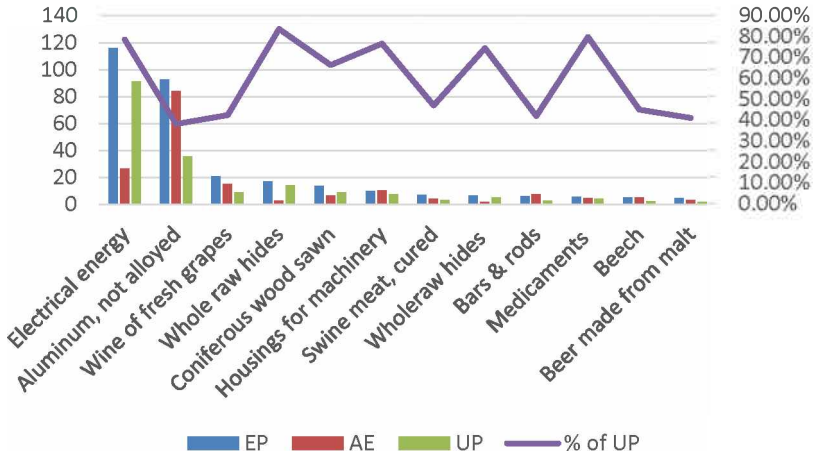
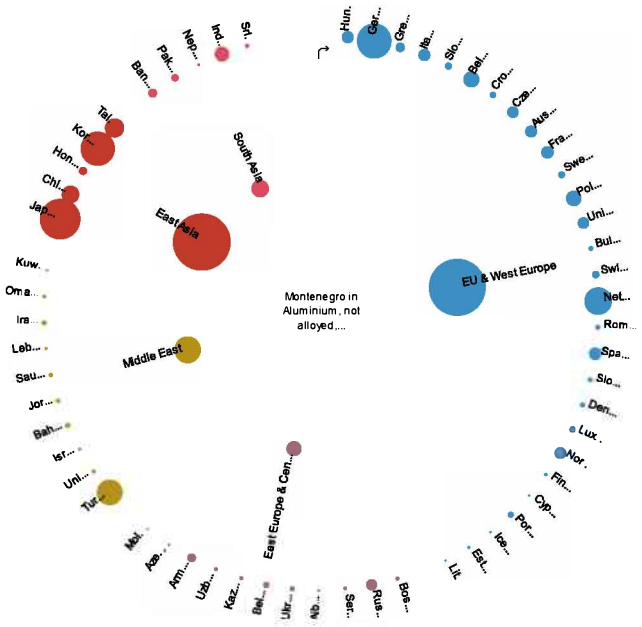


Figure 4: Montenegro export potential, actual export, and untapped potential
Source: Author's calculations.

Based on the expected calculations, Montenegro has an export potential of electrical energy towards Serbia of 39.5$ million, Bosnia and Herzegovina 13.1$, and Hungary 9.8$. We have included only 12 products in our representative study, Table 3, summing an untapped export potential of 186.9$ million.



Graph 2: Sub-regional export potential of aluminum for Montenegro
Source: ITC, author's simulations, 2020.

This unused export potential should be considered by policymakers to analyze further what can be done to improve the trade balance of Montenegro, hence better control inflation. On average, the percentage of unused potential reaches 59.78%, and it is

confirmed in Figure 4 as well that the UP (the purple line) is around 60%. East Europe and Asia's participation in the UP is 48.61% on average, while the unused export potential towards EU & West Europe reaches 77.70%. The percentage goes further for the Middle East, reaching 84.83% on average. We see, from Figure 4, that the highest EP products are the first couple of products. Aluminum is the product with the best combination of the supply and demand out of Montenegro's products. Thus, aluminum is a product that has the best production line to get offered to the world. In the meantime, the world is asking for aluminum. Germany is one of the most significant export potential destinations of aluminum for Montenegro (as seen from Graph 2), with an unused potential of 10.4$ million, followed by Turkey, with untapped potential for Montenegro of 4.9$ million. We can notice that from Graph 2, the sub-regions have an enormous potential to export aluminum for Montenegro.

EU & west Europe is the most significant regional potential, followed by East Europe and Central Asia. Montenegro has closest export links with Bosnia and Herzegovina, Albania, and Serbia. The Middle East could be further used with 4.9$ million. The total unused export potential of aluminum is 35.6$ million, as seen in Table 4. Towards Belgium remains an unused export potential of aluminum of 2.2$ million. The total export potential for EU & West Europe of aluminum, not alloyed-unwrought sums up to 19.6$ million. As seen from Table 4, fresh grapes wine has a tremendous unused potential to be exported to neighboring countries such as Serbia, Bosnia and Herzegovina, and the United Kingdom. It is East Europe & Central Asia with a possibility of 2.8$ million, and EU and West Europe of 5.7$ million.

Whole raw hides, split raw hides & skins of bovine or equine animals have an unused export potential of 14.4$ million. Just towards Serbia, there is an unused export potential worth 5 million dollars, Bosnia and Herzegovina 2.2, and Italy 4.8. the closest export links are with Bosnia & Herzegovina. Coniferous wood sawn sums a total of 9$ million of unused export potential toward the world, specifically 4.6$ million toward EU & West Europe, and 1.6$ with an untapped export potential toward East Europe & Central Asia. Housings for machinery also have a high export potential for Montenegro, totaling 7.6$ million, out of which 2.5 would be possible towards Hungary and 982,000$ to Germany.

Table 4: Export potential from Montenegro to the world

		World				*EE & Central Asia*				*EU & West Europe*				*Middle East*			
Prod. Code	**Product description**	**EP**	**AE**	**UP**	**% of UP**	**EP**	**AE**	**UP**	**% of UP**	**EP**	**AE**	**UP**	**% of UP**	**EP**	**AE**	**UP**	**% of UP**
271600	***Electrical energy***	116	26.7	91.4	78.79%	88.4	23.2	65.3	73.87%	25.7	3.5	24.2	94.16%	1.5	0	1.5	100.00%
760110	***Aluminum, not alloyed***	92.8	84.1	35.6	38.36%	15.1	20.1	4.2	27.81%	56.2	54.4	19.6	34.88%	14.5	9.6	4.9	33.79%
220421	***Wine of fresh grapes***	21.1	15.2	9	42.65%	13	12.2	2.8	21.54%	6.6	1	5.7	86.36%	0.06	0	0.06	100.00%
4101XX	***Whole raw hides***	17.2	2.8	14.4	83.72%	10.1	2.8	7.3	72.28%	6.2	0.05	6.2	100.00%	0.19	0	0.19	100.00%
4407Xa	***Coniferous wood sawn***	13.7	6.8	9.1	66.42%	6.1	6.6	1.6	26.23%	4.7	0.12	4.6	97.87%	0.64	0	0.62	97.14%
848330	***Housings for machinery***	9.9	10.4	7.6	76.77%	1.8	0.2	1.6	88.89%	6.7	7.6	4.8	71.64%	0.46	0	0.42	89.71%
21019	***Swine meat, cured***	7.2	3.9	3.4	47.22%	5.1	3.9	1.3	25.49%	2	0	2	100.00%	0	0	0	100.00%
410150	***Wholeraw hides***	6.7	1.7	5	74.63%	3.3	1.6	1.6	48.48%	2.9	0.11	2.8	96.55%	0.08	0	0.08	100.00%
722840	***Bars & rods***	6.4	7.8	2.7	42.19%	0.9804	0.16	0.82	83.67%	3.6	6.5	1.2	33.33%	1.2	1.2	0.03	2.22%
300420	***Medicaments***	5.5	4.9	4.4	80.00%	1.6	4	0.71	44.68%	3.1	0.92	2.9	93.55%	0.09	0	0.09	100.00%
440792	***Beech***	5.3	5.3	2.4	45.28%	1.7	1.3	0.65	37.99%	1.1	2.6	0.44	39.73%	0.14	0	0.13	95.07%
220300	***Beer made from malt***	4.6	3.3	1.9	41.30%	3.7	2.7	1.2	32.43%	0.7	0.46	0.59	84.27%	0.01	0	0.01	100.00%

Source: ITC, author's calculations, 2020.

In Figure 4, we can visually observe the gap between actual and unused export, potentially actualized. The purple line is close to the first two products, while for the rest of the products, the gap is rather broad.

2.2.2. Product diversification index in Montenegro

What other products could Montenegro produce? How many products Montenegro currently produces, or what is its export basket? This section will deal with potential products or rank of a new product in a given target market. Since we deal with potential futuristic products, we rank them based on the Product Space (PS) methodology, invented by Hidalgo et al. (2007)[97]. They studied the network of relatedness between products, or 'product space,' finding that higher-income products are densely connected, while lower-income products occupy a less connected periphery. Hidalgo et al. (2007) show that nations tend to move to items similar to those they are already specialized, allowing countries located in more connected parts of the product space to upgrade their export basket more quickly.

The demand and market access conditions variables will be calculated in the same manner as in the EPI. The supply-side changes from EPI, based on the PS methodology, establish connectivity between exported products by all countries worldwide. The identified potential products, based on PS, are filtered against the availability of natural resources in the countries under analysis. Furthermore, two filters are applied. The first filter identifies the relevant climatic zones to produce and export certain goods. In case the climatic zone is not available as a natural resource, the product(s) stops being analyzed further. The second filter deals with the status of a landlocked country. If a country is suggested to diversify into sea-related products, it is then taken off because no other landlocked country has successfully exported such products.

$$\left[\frac{x_{ijk}}{x_{ij}}\right] = \frac{RCA_{ik}}{\Sigma_k(RCA_{ik}\cdot\frac{m_{jk}}{m_j})} \cdot \frac{m_{jk}}{m_j} \tag{21}$$

[97] Hidalgo, C.A., B. Klinger, A.-L. Barabasi, and R. Hausmann., The Product Space Conditions the Development of Nations, Science, 2007, 317(5837), 482-487.

As far as the identification of the opportunities for diversification of new products, the linkage between the current export products to new potential products is analyzed. The linkage is the new supply measure to indicate supply capacities of Montenegro:

2.3.2. Product space methodology

This section will show the product space methodology on which we base our supply capacity measure in product diversification. Productive factors, such as capital, labor, human capital, and institutions, and on the other hand, the technological differences create externalities that further lead to accelerated growth.[98] Developed countries have shown that they have a continuum in production, advancing with a product slightly different or just a different one that moves countries forward. Countries that specialize in producing, for example, aluminum, such as Montenegro, have already invested in the broad sense in this industry and specialized in manufacturing aluminum. The underlying productive factors are relatively specific to producing aluminum. For example, making shoes would require a different set of environments. In common sense, providing an aluminum chocolate foil for a company from Switzerland might be more related between aluminum and aluminum foil then specializing in another product as making shoes for Gucci in France. We will study this pattern to show this relatedness and how countries diversify to a related or approximate good.

Each country has some predetermined dispositions that can potentially bring into existence some products. For example, Montenegro's capabilities to produce aluminum are different from Serbia, for a straightforward fact of natural resources. Thus, these capabilities refer to anything needed to export aluminum, such as the infrastructure, soil, climatic conditions, experts, specialists, human resources, legislation, institutions, chamber of commerce, and anything that the country possesses to export a given product. Coming back to our example of aluminum and aluminum foil for chocolates, it becomes common sense that if Montenegro specialized in exporting aluminum, the set of capabilities it possesses overlaps intensely with the onset of skills needed to export aluminum foil. Therefore, it already has many things to export and aluminum or other

[98] Klenow, P. J., and A. Rodriguez-Clare., Externalities and Growth, *National Bureau of Economic Research*, Working Paper 11009, 2004.

types of aluminum products. Thus, Montenegro is much more likely to diversify into aluminum chocolate foil or wheel's rim than into shoes, for example. So, from aluminum, Montenegro can start exporting aerospace, medical, transportation, automotive, and marine industries. It is more likely to continue to do that than to begin shipping manufactured shoes, fish, or other unrelated products to aluminum. So, we can say that Montenegro has a high density around aluminum and has already developed a comparative advantage in exporting aluminum.

Conditional probabilities measure density. Thus, conditional probabilities between each set of commodities estimate the probability to export product *k* with CA, knowing that product *l* is already exported with CA.

$$\varphi_{ikl} = P\left(\frac{CA'_{ik}}{CA'_{il}}\right), \quad \& \quad Density_{ik} = \frac{\Sigma_l CA'_{il}\varphi_{ikl}}{\Sigma_l \varphi_{ikl}} \tag{22}$$

Density measure puts together conditional probabilities. That is a weighted average of the CA. Thus, the density measures a country's supply capacities as the average approximation to a country's new potential export product.

Nevertheless, a country might be in very close proximity to a given good. The PS would suggest that the country has excellent ease of diversifying into this new product. Still, these exports might never happen in real life because a) it is not possible to physically export the good, because as we have noticed earlier it is based only on trade statistics and there might be specific problems related to trade statistics, b) insufficient demand, and c) severe market access conditions. Even though the supply capacity for a new potential export product and the demand for such products is high, it is not enough to realize this new product because of the low accessibility of market conditions. Thus, all components must be considered to implement a new potential diversified product to a target market.

2.3.2. Supply-side of the product diversification index

The supply side, the density, is the first component of the PDI. The density measures the average proximity of a product of Montenegro to a new export product. The average proximity shows the linkages between products based on how often they are jointly exported by countries, with corrected and RCA dynamic. We normalize the density measure because it has a different range than the comparative advantages used as the EPI

supply indicator. That is why we normalize the density measure to ensure that the scope of densities between the first and the diversified product is in conformity between the first and the last product in the EPI:

$$Density'_{ik} = Density_{ik}^{\frac{logCA_{ik_1} - logCA_{ik_N}}{log\ Density_{ik_1} - log\ Density_{ik_N}}} \quad (23)$$

to ensure that $\frac{Density'_{ik_1}}{Density'_{ik_N}} = \frac{CA_{ik_1}}{CA_{ik_N}}$ where1,…N are product ranks.

Even though the density measure for a feasible diversified product is passed through two filters, it is not enough unless we demand such a product and the market access conditions.

$$PDI_{ijk} = Density'_{ik} \cdot DShare_{jk} \cdot MA_{ijk} \cdot Bilateral_{ij} \quad (24)$$

In this case, instead of supply, we use densities that are not equivalent to CAs, and that is why we need to rescale these densities to ensure that the PDI reveals the capacity of the total export capacity and the aggregate demand of the product. The process is necessary because the PDI is initially computed for all products (exported and non-exported). Eventually, only new products or products with marginal export potential (< 200,000$ and < top 95% cumulative EPI share) are kept in the PDI. The scaling is done in two steps:

$$Density''_{ik} = Density'_{ik} \cdot \frac{\Sigma_{jk} Exp\ x_{ijk}}{\Sigma_{jk} PDI_{ijk}}, so\ that\ PDI'_i = Exp\ x_i \quad (25)$$

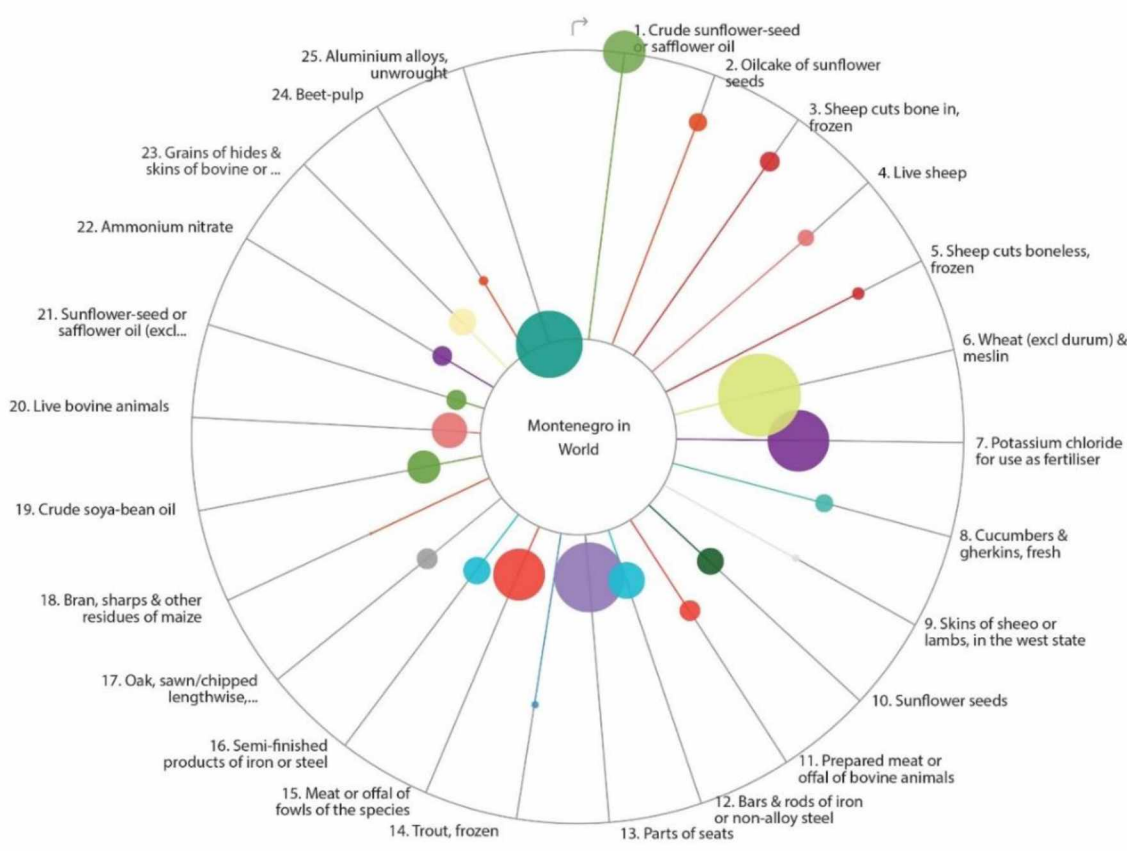
$$Density'''_{ik} = Density''_{ik} \cdot \frac{\Sigma_{jk} Exp\ x_{ijk}}{\Sigma_{jk} PDI'_{ijk}}, so\ that\ PDI''_k = Exp\ x_k \quad (26)$$

where x-exports, m-imports, i-exporter, j-market, k-product for diversification, and l-exported product. Equation (25) shows how we rescale our initial densities so that the total PDI of Montenegro would correspond to the total export capacity. Moreover, we rescale the densities so that the PDI corresponds to the aggregate demand, the projected demand for this product. Thus, the final PDI is calculated by the given current exports of this anticipated product into the GDP growth. Therefore, our final PDI ranks are assigned by an equation that uses these rescale densities combined with the demand side:

$$PDI''_{ijk} = Density'''_{ik} \cdot DShare_{jk} \cdot MA_{ijk} \cdot Bilateral_{ij} \quad (27)$$

The PDI as EPI is always computed at the final level of aggregation, so we calculate it by the exporting country, product, and target market. But from here, we can aggregate to identify, for instance, diversification opportunities in a particular region.

The total demand indicator in Graph 3 corresponds to the side of the bubble. The easiness to trade between country *i* and *j*, is represented by the width of the line in the analytical graph, and the length of the line shows the supply side (the growth and the expected growth of the exporter comparative to the world). Montenegro's best options for export diversification in the world are crude sunflower-seed or safflower oil, oilcake of sunflower seeds, and sheep cuts bone-in frozen, as it can be noticed in Graph 3 by the length of the line of the first three potential diversified products.



Graph 3: Product Diversification Rank of Montenegro to World
Source: ITC, author's calculations, 2020.

Montenegro finds crude sunflower-seed or safflower oil easiest to reach as the line length reaches the outer circle. Wheat and meslin seed (excl. durum) is the product that faces the most energetic demand potential globally, confirmed by the size of the light-green bubble. The world's import value in US dollars reaches 35.5$ billion. Bosnia and Herzegovina

imports 74$ million dollars of wheat and meslin, and the applied tariff to wheat & meslin from Montenegro is 0%. While Indonesia imports wheat & meslin 2.2$ billion, and the applied tariff from Montenegro is 2%.

Table 5: Product diversification rank of Montenegro

Pro code	Product description	Product's divers. potential rank in MNE				
		World	Europe	Asia	Americas	Pacific
151211	Crude sunflower-seed/oil	1	1	1	1	1
230630	Oilcake of sunflower seeds	2	2	2	8	28
20442	Sheep cuts bone in, frozen	3	4	3	2	7
10410	Live sheep	4	3	7	11	40
20443	Sheep cuts boneless, frozen	5	5	6	4	20
1001Xb	Wheat (excl durum) & meslin	6	6	5	7	5
310420	Potass chloride for use as fertil.	7	12	4	3	2
70700	Cucumbers & gherkins, fresh	8	7	8	5	
420510	Skins of sheep or lambs	9	8	14	22	
120600	Sunflower seeds	10	9	11	27	14
160250	Prepared meat	11	10	21	9	3
721420	Bars of iron or non-alloy st	12	11	23	10	10
940190	Parts of seats	13	13	13	6	6
30314	Trout frozen	14	15	12	16	30
160232	Meat or offal of fowls	15	14	19	21	9
720711	Semi-finished p. of iron or st.	16	28	9	36	45
440791	Oak, sawn/chipped lengthwise	17	17	15	14	11
230210	Bran, sharps & res. of maize	18	16	25	44	41
150710	Crude soya-bean oil	19	27	10	17	22
102	Live bovine animals	20	20	16	18	
151219	Sunflower-seed or sunfl. oil	21	19	22		21
310230	Ammonium nitrate	22	18	27	13	8
410411	Grains of hides & skins of bo.	23	21	18	25	47
230220	Beet-pulp	24	22	30	43	29
760120	Aluminum alloys, unwrought	25	24	29	26	23
2204XX	Wine of fresh grapes	28	25	49	23	15

Source: ITC, author's calculations, 2020.

Turkey also is in high demand for wheat, amounting to 886.1$ million, but the tariff is 65% from Montenegro for this product. Greece, Albania, and North Macedonia are in high demand, 192.1$, 43.5$, and 15.3$ million, respectively, for this product, and the applied tariff is 0%. The policymakers of Montenegro might consider this fact for further analysis.

As we can notice from Graph 3, aluminum is in high demand from the world (the green bubble, product number 25), but the readiness for potential export diversification from Montenegro is not high estimated by the length of the line. The total value that the world imports aluminum is 27.5$ billion (bn). Germany imports 3.7$ bn, and the applied tariffs are 0%, while the United States imports 4.4$ bn with the applied tariff of 1%. Great potential for the diversified aluminum alloys-unwrought is imports from Hungary, Serbia, and Slovenia with 385.8$ million, 41.6$ million, and 146.2$ million, respectively.

Potassium chloride for use as fertilizer faces quite strong demand potential in the world, confirmed by the size of the purple bubble (product number 7 in the above Graph), reaching 12.4$ billion, and the length of the line is half-way, meaning the potential of potassium chloride supply to diversify further the product is quite ready. China, Brazil, and Indonesia are in high demand importing for potassium chloride, amounting to 1.8$ bn, 2.1$ bn, and 734.7% million, respectively.

Product diversification rank of Montenegro to the world, Europe, Asia, America, and Pacific is shown in Table 5. Crude sunflower-seed or oil remains product number 1 ranked for all regions and the world, while the other products change ranks for different regions.

The EPI and PDI both consider the aluminum products as a potential that policymakers might take for further in-depth analysis. Thus, the question is: what if aluminum is processed further by Montenegro, and how it would impact its economy.

2.3. Internal determinants of inflation in Montenegro

The efficiency and effectiveness of monetary policy under the convergence criteria as the one proposed by the CBCG is based on appropriate forecasting performance and impulse responses (causality) of internal variables of inflation, assisting central policymakers in designing correct macroprudential actions.

Technological progress is a variable affecting shadow economies and, consequently, the labor market. Shadow economies induce developing countries to present a broader set of tax basket, increasing the prices set by firms and wage setters, thus higher inflation. In the meantime, the structural change of technological progress affects the labor market's

expectations and, consequently, inflation. Therefore, economic freedom is an essential variable in our further analysis and its impact on Montenegro's inflation.

The economic freedom, e-government development index[99] (EGDI), capital stock, human capital, employment, and GDP will be used as critical internal factors contributing to anchor inflation in model 2.

There are many different services that citizens and businesses seek from their governments, and it appears as though the number of functions available online grows annually. However, the most recent survey of those services deemed by the European Commission (EC), as the 20 basic services of e-government (eGov), had not been conducted since 2011.[100]

Table 6: 20 e*Gov* services for citizens and businesses

20 Basic e*Gov* services	
Services for Citizens	**Services for Businesses**
Income Taxes	Social Contribution for Employees
Job Search	Corporate Tax
Social Security Benefits	VAT
Personal Documents	Registration of a New Company
Car Registration	Submission of Data to the Statistical Office
Application for Building Permission	Custom Declaration
Declaration to the Police	Environment-related Permits
Public Libraries	Public Procurement
Birth and Marriage Certificates	
Enrollment in Higher Education	
Announcement of Moving	
Health-related Services	

Source: Blinn, 2014, pp. 2-3.

Therefore, it was the primary goal to assess the current status of these basic services provided via the web portal www.euprava.me in Montenegro, because it was stated in the 2010 action plan that: "Electronic administration portal is a tool for government

[99] United Nations, E-Government Knowledgebase, *https://publicadministration.un.org*, accessed, March 13, 2020.

[100] European Commission, Digitizing Public Services in Europe: Putting ambition into action, eBook, 28, 2011

institutions and represents a single point where electronic public services offered by state administration authorities can be found."[101]

2.3.1. E*Gov* benchmarking methodology

One of the most often encountered issues when utilizing a benchmarking study is developing the scoring criteria and determining each question's weighting.[102] The scoring metric of Blinn et al. (2008) was used to evaluate government to business (G2B) and government to citizens (G2C) services provided in Montenegro.

2.3.2. Rating Criteria

This section analyzes the 20 basic e*Gov* services across 17 criteria, sub-divided into four categories for investigation. Each measure was then assigned an associated weight depending on its perceived economic importance[103] (Appendix 1 at the end of the dissertation gives elaborate scoring criteria, categories, and weighting).

2.3.3. Maturity of e*Gov* services in Montenegro

West (2004) developed a four-stage maturity model of e*Gov* and included 1,813 United States (US) government web sites in 2000, and a follow-up study of 1,680 government web sites in 2001[104]. This maturity model can be graphically portrayed as in Figure 5 below.

Figure 5: E*Gov* maturity model
Source: Author's calculations.

[101] Montenegro, Montenegro Action Plan: Open Government Partnership, 2104.

[102] Blinn, N., F. Hogrebe, R. Lange, M. Nüttgens., "Benchmarking study on municipal portals: A Survey of G2B-Services in European capitals and large cities," Universität Hamburg, Arbeitsberichte zur Wirtschaftsinformatik, 2008, 4, 6.

[103] Appendix 1: Evaluation Criteria of e*Gov* services.

[104] West, D. M., "E-Government and the Transformation of Service Delivery and Citizen Attitudes," *Public Administration Review*, 2004, 64(1), 15–27.

In Figure 5, we see that a web portal is mainly used for posting information during the first stage of maturation. The "one-stop-shop" stage marks full online availability and is characterized by the user's ability to accomplish tasks at a single location. The fourth and final stage is "interactive democracy." Notifications are pushed to the user based upon personal timelines, and feedback forms are utilized to continue to tailor the site to suit the user's needs. According to Fath-Allah et al., (2014), in their study on e*Gov* maturity models, "many government agencies have mastered the first and second stage, while few government web sites have achieved the 3rd and 4th stage"[105].

2.3.3.1. E*Gov* portal of Montenegro

The Ministry for Information Society and Telecommunications has opened one world wide web page, www.euprava.me[106]. The web page clearly shows the »Individual«, »Business«, and »Public Administration« services and sub-services for each category.

2.3.3.2. Calculation of values per basic service

With a valid model in hand, the research evaluates the web portal utilizing the Mystery Shopper approach.[107] Each service represented a task the researcher needed to accomplish. The eGovernment web portal was utilized as if the researcher were an average user attempting to complete their assigned task. This exercise resulted in the assignment of points based on the above criteria to an evaluation matrix. These points were then multiplied by the weight factor to achieve the final score for each of the basic services. Following the calculation of individual scores, the average score for G2C and G2B services was calculated.

[105] Fath-Allah, A., L. Chikhi, R.E. Al-Qutaish, and A. Indri., "E-Government Maturity Models: A Comparative Study," *International Journal of Software Engineering & Applications*, 2014, 5(3), 71-91.

[106] Government of Montenegro, Ministry for Information Society and Telecommunications, 2019.

[107] Mystery Shopper note.

2.3.3.3. Maturity of G2C and G2B services in Montenegro

In Figure 6, it is noticed that G2C services in Montenegro are less mature than G2B. Furthermore, the distribution of G2C services is not equitable across the spectrum of services. The standard deviation among the group of G2C services is 21,53%. Clearly, this number is mostly affected by those areas which remain entirely undeveloped, such as the announcement of moving. While several services have achieved a degree of maturity that enables online activity, and it raises the question of why other services remain either significantly under-developed or completely undeveloped. It should be noted that there exist areas where scores reflect substantial investment on the part of the government to reach consumers. The more apparent regions are Income Taxes and Job Search.

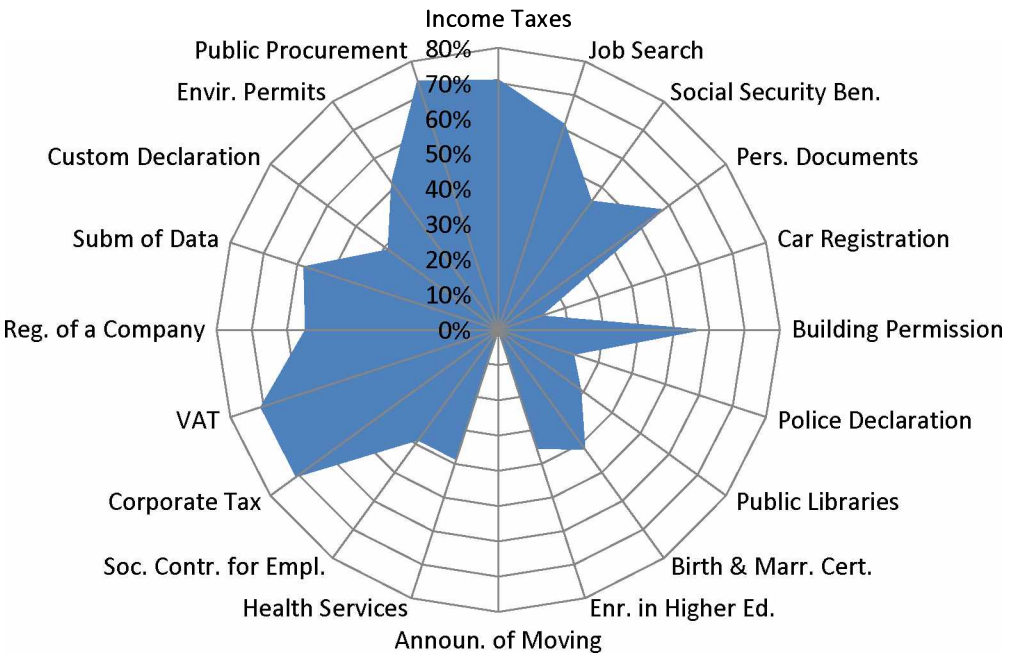


Figure 6: Maturity level of G2B and G2C e*Gov* services in Montenegro, 2017
Source: Author's calculations.

Looking at G2B services, we again see a wide disparity between the maturities of services. Despite the conspicuous absence of an undeveloped category, the standard deviation for the data is 20,29%. Once again, services exist, such as VAT and Corporate Taxes, which have achieved maturity levels that suggest full interaction and the ability to complete a transaction online. However, other services such as Social Contribution and

Customs Declarations make maturity levels that indicate they are still very much in the "read-only" phase. These facts might be taken elaborately into consideration by policymakers in relatedness with economic freedom, which will be one of the critical variables down the lines since economic freedom variable is measured based on 12 quantitative factors: a) Rule of Law (property rights, government integrity, judicial effectiveness), b) Government Size (government spending, tax burden, fiscal health), c) Regulatory Efficiency (business freedom, labor freedom, monetary freedom), and d) Open Markets (trade freedom, investment freedom, financial freedom)[108]. We will see the interconnectivity among e*Gov, economic freedom,* and *inflation* later. It is interesting to note that those areas where the service involves financial transactions appear to be most developed.

2.3.4. Comparison of G2C and G2B services in Montenegro

Observing the maturity of e*Gov* services within the confines of G2B and G2C, it is no imperative to compare the findings of the research regarding the sophistication of these categories of services against each other. The study indicated that G2C services have a 40% maturity level, while G2B services demonstrated a 65% maturity level. The maturity level shows apparent favoritism towards the development of G2B services. The analysis includes additional data from Djurickovic (2013) study for comparative purposes.[109] It is essential to emphasize that these studies were conducted utilizing different evaluation criteria and a different maturity model. The results should not be used to draw quantitative conclusions. Instead, these results are to be used to compare that regardless of the evaluation model utilized, the data still indicates that G2B and G2C services are in the same level of maturity and the difference in the maturity levels between G2B and G2C are relatively constant. However, this information runs contrary to the most recent United Nations eGovernment Survey 2018[110], where Montenegro is ranked 58th and with a high

[108] The Heritage Foundation, www.heritage.org, accessed, September 25, 2019.

[109] Djurickovic, T., "Analyis of EGovernment Services as a Tool for Measuring the Digital Development of Montenegro," *Facta Universitatis - Series: Economics and Organization,* 2013, 10(1), 65-76.

[110] United Nations Department of Economic and Social Affairs, United Nations E-Government Survey 2018 Survey, Accessed Sep 25, 2019, 33-34.

level of electronic government development index (EGDI). Further review of this same survey explicitly notes that the improvement in the EGDI of Montenegro primarily resulted from investments made in G2B services.[111] The difference between the results of the two findings can most likely be attributed to the difference in the evaluation criteria. While both the research of this study and the Djurickovic (2013) study focused on providing the 20 basic eGov services, the United Nations survey incorporates many additional criteria in evaluating e*Gov* maturity, including multiple approaches based on infrastructure. Legal production of goods and services are hidden from government authorities to avoid payment of taxes, social security contributions, minimum wages (safety standards), etc.

The EGDI is a weighted average on three most important dimensions of e-government, namely: a) online services scope and quality (Online Service Index, OSI), (2) telecommunication infrastructure development status (Telecommunication Infrastructure Index, TII), and (3) inherent human capital (Human Capital Index, HCI):

$$EGDI = \frac{1}{3}(OSI_{normalized} + TII_{notmalized} + HCI_{normalized}) \quad (28)$$

Productivity growth has not increased in line with the expectations of firms. The workers in Montenegro ask for larger wages (high expectations). Still, the producers cannot afford it (productivity growth not in line with workers' expectations), increasing unemployment, and as a result affecting inflation. Technological progress is neglected so far, and its structural economic change should be considered to forecast and govern inflation through economic shadows and equilibrium in the labor market.

2.3.2. Economic freedom

The Heritage Foundation (2019) measures economic freedom based on 12 quantitative and qualitative factors, grouped into four broad categories, or pillars, of economic freedom[112]:

1. **Rule of Law** (property rights, government integrity, judicial effectiveness)
2. **Government Size** (government spending, fiscal health, tax burden)

[111] Ibid.

[112] The Heritage Foundation, www.heritage.org, accessed, November 4, 2019.

3. **Regulatory Efficiency** (labor freedom, business freedom, monetary freedom)
4. **Open Markets** (investment freedom, trade freedom, financial freedom)

Protection of property rights, financial freedom, judicial effectiveness, fiscal health, and government spending remains the next institutional commitment step. Massive investments in infrastructure have created gaps in budgetary sustainability.

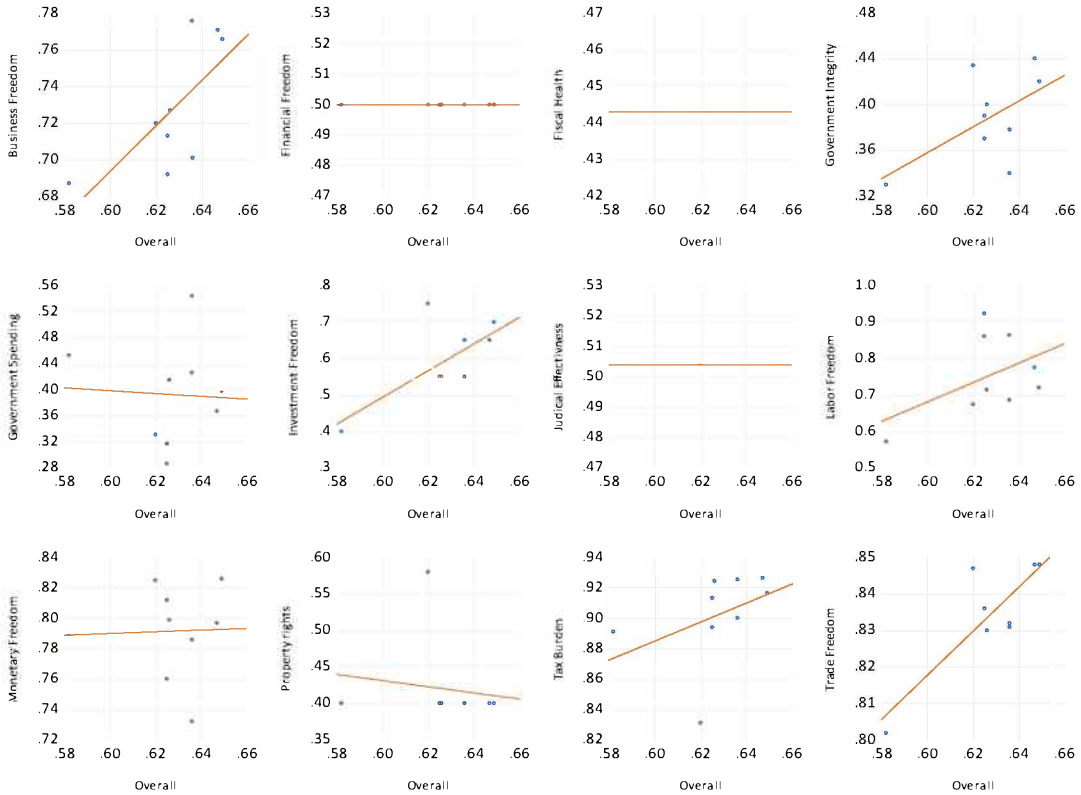


Figure 7: Twelve quantitative and qualitative factors of economic freedom, 2009-2017
Source: Author's calculations in EViews 11.

As we can observe from Figure 7, business freedom, government integrity, investment freedom, labor freedom, monetary freedom, tax burden, and trade freedom vs. overall economic freedom index have prospered since 2009. For instance, comparing business freedom vs. total economic freedom, significant progress can be observed.

Arnason (1999) says: "property rights are fundamental to what is generally regarded as economic progress, and with well-defined and enforced property rights surplus production becomes possible.[113]" The higher quality of the property rights are, the more

[113] Arnason, R., "Property Rights as a Means of Economic Organization," Conference Use of Property Rights in Fisheries Management, 1999.

effective and efficient the economy will be. In a globalized world, trade can be almost unimaginable without the well-defined property rights of transferable goods and services[114]. For example, buying online shares of KAP should be well-defined for and by the KAP. Without clearly stated policies, economic activity is very limited. A free market will generate full economic efficiency and optimal economic growth[115][116]. A free market without clearly defined property rights cannot function, making the property rights the core of a free market[117]. The characteristics of property rights are elaborated in Scott's article (1996), which presents the following four attributes of property rights[118][119][120]:

- **Exclusivity** – The right to utilize and a resource without interference.
- **Duration** – The length of time the owner can use the resource.
- **Security** – The strength of the entitlement.
- **Transferability** – The extent of the entitlement.

The combination of the characteristics of property rights is multidimensional[121]. The relation of security and duration might be high, e.g., 1, but the relationship between security and transferability might be lower than 1. Scott (1988) constructed an aggregate numerical measure of the quality of property rights[122]. In our case, it can help

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[114] Scott, A.D. *Introducing Property in Fisheries Management*. A paper submitted at FishRights99, Mini course. Fremantle, 1999.

[115] Debreu, G. *Theory of Value: An Axiomatic Analysis of Economic Equilibrium*. New Haven and London: Yale University Press, 1959.

[116]Varian, H.R., *Intermediate Microeconomics: A Modern Approach, 9th ed.* New York: W. W. Norton & Company, 2014.

[117] Uzawa, H. *Note on the Existence of an Equilibrium for a Competitive Economy*. Mimeographed, Department of Economics, Stanford University, 1956.

[118] Scott, A.D. The ITQ as a Property Right: Where it Came From, How it Works and Where it is Going. In B.L. Crowley (ed.) *Taking Ownership: Property Rights and Fisheries Management on the Atlantic Coast*. Atlantic Institute for Market Studies, Halifax, 1996.

[119] Daniel E. Lane, D. E., "Property rights and governance in Canadian fisheries," *Optimum, The Journal of Public Sector Management,* 1999, 29(1), 1-8.

[120] Barro, R. X. Sala-i-Martin. *Economic Growth*. New York: McGraw-Hill, 1995.

[121] Smith, A. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Edition by E. Cannan 1977. Chicago: University of Chicago Press, 1776.

[122] Scott, A.D. Conceptual Origins of Rights Based Fishing. In Neher et al. (eds.) *Rights Based Fishing*. Kluwer Academic Publishers, Dordrecht, 1988.

policymakers judge the economic efficiency of an institutional framework of Montenegro's activity. Scott (1988) came up with the following quality measure (Q):

$$Q \equiv (\prod_{i=1}^{N} x_i^{a_i}) \cdot (w_1 + \sum_{j=N+1}^{M} w_{2,j} \cdot x_j^{a_j}) \quad (29)$$

Let us say, for example, that the security property right characteristic score for Montenegro is 0.95, exclusivity 0.95, duration 0.9, and transferability scores 0.1. Weights are as following: $w_1 = 0.5$ *and* $w_2 = 0.5$. What's the Q:

$$Q \equiv S^{\alpha} \cdot E^{\beta} \cdot D^{\gamma} (w_1 + w_2 \cdot T^{\delta}) = 0.5130 \quad (30)$$

Even though the security, exclusivity, and duration score very high, the Q-value of the property rights scores only 51.3% of the 100% potential because of the low transferability.

2.3.6. Capital stock, human capital, and employment

Capital stock denotes the gross fixed capital formation (% of GDP). The gross fixed capital formation, linked to the FDI drive model of economic growth, summarizes the demand side's impacts. The tourism, house sales, banking sector, and structural reforms mirror large FDI inflows in Montenegro. The just mentioned factors boosted domestic demand and increased bank deposits.

Human capital time series comprises higher education employed, critical for keeping sustainable growth, while the employment to the labor force (vital for inclusive and sustainable development). In contrast, human capital and employment are related to effects on Montenegro's economy's supply side[123]. We consider employment and human capital on the supply side. On the other hand, we use capital stock to measure the demand side. Let's examine the human capital and employment/unemployment interconnectivity.

2.3.6.1. Unemployment and wage inequality in Montenegro

Technological progress is a potential cost of unemployment for workers with inadequate skills, while it represents potential progress for those with the right skills. It leads to the

[123] Fabris, N., "Impact of the Global Financial Crisis on the Labour Market and Citizens Social Status in Montenegro", in the book The Social Consequences of the Global Economic Crisis in South East Europe, London School of Economics, 2013, 131 – 143.

inequality of wages. Let's see what happened in Montenegro's market since 2012, since that's the only available data for different sectors relative to education.

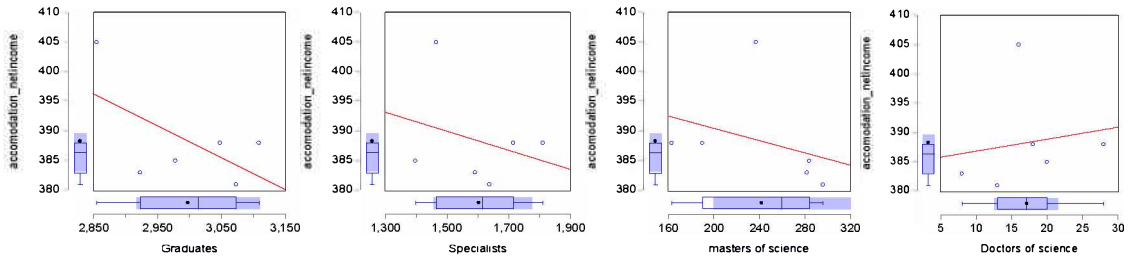

Figure 8: Accommodation and food services net income to graduates, specialists, masters, and doctors of science.
Source: Author's calculations in EViews 11.

Figure 8 shows the evolution of net income for different education levels from 2012 to 2017. Each of the regression lines shows the evolution of Accommodation and food service activities' net income for a given level of education: graduates, specialists, masters of science, and doctors of science. We can notice that the average net income without taxes and the accommodation and food service activities sector's contributions is around 385€ from 2012 to 2017. For the first three levels of education, the regression line shows a downward slope, while only doctors of science for this sector show an upward trend. The demand for graduates, specialists, Master of Science has steadily fallen over time for this sector, whereas doctors of science have seen their net income rise consistently.

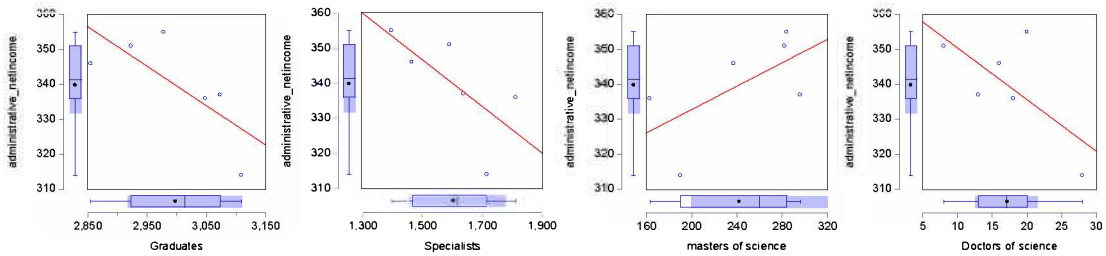

Figure 9: Administrative and support service activities net income to graduates, specialists, masters, and doctors of science.
Source: Author's calculations in EViews 11.

This specific sector's overall conclusion seems that Montenegro's demand relative to the education level is not upward. It implies that the sector of accommodation and food service activities does not have a high demand for education and that this sector is not related to net income inequality.

If we turn to Figure 9, the only master of science has seen their wages rise steadily. The number of graduates, students who finished faculty, increased slowly from 2012 to 2017, averaging to 3000 graduates, whereas their demand in the market shows a negative relation to net wages. The labor market was in demand for masters of science, and the demand was higher than the supply, thus increasing the net wages.

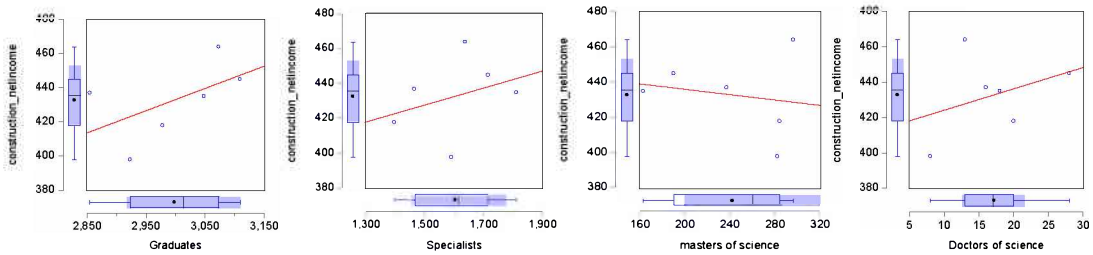

Figure 10: Construction net income to graduates, specialists, masters, and doctors of science.
Source: Author's calculations in EViews 11.

Net income for construction graduates, specialists, and Ph.D.'s increased smoothly, but for masters of science, we see a smooth decrease in Figure 10. The highest proportion of increase belongs to graduates since large governmental projects were going on in Montenegro since 2012.

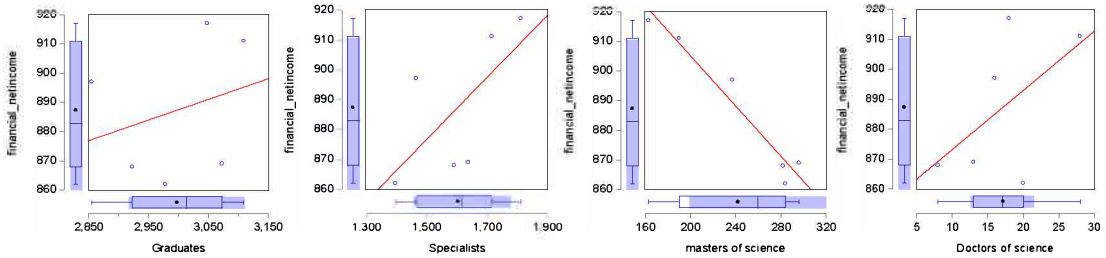

Figure 11: Financial and insurance net income to graduates, specialists, masters, and doctors of science.
Source: Author's calculations in EViews 11.

The financial and insurance sector has seen an increase for specialists and Ph.D.'s and a smooth increase for graduates, while masters of science show a decrease in net wages.

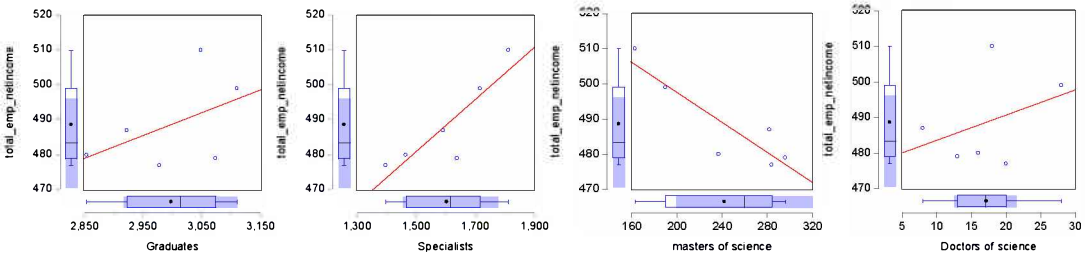

Figure 12: Total net income to graduates, specialists, masters, and doctors of science.
Source: Author's calculations in EViews 11.

A lot of banks and insurance companies entered into the market of Montenegro, increasing the demand for specialists and Ph.D.'s averaging from 860€ to 920€.

Figure 12 represents all sectors' total net income relative to graduates, specialists, masters, and PhDs. Only masters lack in the increase of demand in the labor market, signalizing the policymakers that this high-skilled group should be driven further in the market because the overall economy of Montenegro does not utilize their potential.

2.4. Demand-pull and cost-push ingredients of inflation

One of the models that analyzes inflation determinants in this research will incorporate aggregate demand and aggregate supply factors: exchange rate, broad money (M2), wages, and productivity index[124].

The nominal exchange rate of euro movements can influence Montenegro domestic prices through direct and indirect channels. In the direct channel, exchange rate movements can affect domestic prices through changes in the price of imported finished goods and imported inputs. In the indirect effect, the exchange rate depreciation affects the net exports, which in turn influences the domestic prices through the change in aggregate demand, putting upward pressure on domestic prices. For example, Ikechukwu Kelikume et al., (2017) find that in Nigeria, the effect of innovation to the exchange rate in 12-month dynamics is: a) increases price level by 50%, b) depreciation increases the price

[124] Bruno, M., *Crises, Stabilisation, and Economic Reform: Therapy by Consensus.* Oxford: Clarendon Press, 1993.

level by 41%, and c) appreciation impacts the price level by 14%[125]. Hooper and Lowery (1979) report that the various models they examined indicate that a 10% depreciation in the dollar, other things constant, produces a long-run increase in consumer prices in the order of 0.8% to 1.5%[126]. Whitt, Koch, and Rosensweig (1986) find that a 10% depreciation of the dollar produces a 1.6% increase in the price level after one year and a 4.6% increase after four years[127]. Real appreciation adversely affects exports[128129130131132].

The fiscal policy of Montenegro and productivity growth are highly related to unemployment and inflation. Labor productivity determines the relative prices: the generosity of unemployment and antitrust legislation, on the other hand, refers to real wages and, consequently, to unemployment and inflation[133]. Differences between output and potential output are related to the deviation of unemployment from its natural rate and inflation change. In an enlarged Europe, besides the catching-up process, the cyclical conditions and regulated prices are important determinants of the inflation rate[134].

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[125] Ikechukwu, K., F. Alabi, and A. Friday., "Nigeria Consumption Function – An Empirical Test of the Permanent Income Hypothesis," *Journal of Global Economics, Management and Business Research,* 2017, 9(1), 17-24.

[126] Hooper, P., and B. Lowrey., Impact of the dollar depreciation on the U.S. price level: an analytical survey of empirical estimates, Washington Board of Governors of the Federal Reserve System, International Finance Discussion Papers 128, 1979.

[127] Whitt, J. A., P. D. Koch and J. A. Rosensweig., "The dollar and Prices: An Empirical Analysis," *Economic Review,* 1986, 71, 4-18.

[128] Chen, R., G. M. Milesi-Ferretti, and T. Tressel., "External Imbalances in the Euro Area," *IMF Working Paper*, 2/236, 2012.

[129] Easterly, W., *National Policies and Economic Growth: A Reappraisal. In Handbook of Economic Growth, ed. P. Aghion and S. Durlauf.* Amsterdam: Elsevier, 1015– 56, 2005.

[130] Coudert, V., C. Couharde, and V. Mignon., "On Currency Misalignments within the Euro Area," *Review of International Economics*, 2013, 21(1), 35–48.

[131] Égert, B. and A. Morales-Zumaquero., Exchange rate regimes, foreign exchange volatility and export performance in Central and Eastern Europe: Just another blur project?, *BOFIT Discussion Papers*, No. 8., 2005.

[132] McKenzie, M. D., "The Impact of Exchange Rate Volatility in International Trade Flows," *Journal of Economic Surveys*, 1999, 13(1), 71-106.

[133] Blanchard, O., *Macroeconomics, 7th ed.* Harlow, UK: Pearson, 2017.

[134] Égert, B., Real Convergence, Price Level Convergence and Inflation Differentials in Europe, *CESIFO Working Paper*, No. 2127, 2007.

Imported inflation through food and oil prices, the internal excise tax on alcoholic beverages and tobacco, and accommodation services' costs impacted inflation the most in 2017[135].

Our research will use the deposits to private sector and demand deposits to measure broad money (M2), as defined by the IMF[136]. The money supply (M2) is an exogenous variable, in this case, being formed through capital and current account. Since Montenegro is an open economy, it can impact inflation. Low-interest rates change the money supply, affecting the consumers, investments, and aggregate demand: output. The implication is that it increases economic activity and inflation.

Moreover, we will use wages to measure their impact on inflation. First, if wages are more than productivity growth, they impact inflation: cost-push factor. Secondly, the purchasing power of clients affects aggregate demand through money expansion: demand-pull factor.

2.5. Maintaining price stability in Montenegro

Recently, there has been a direction by researchers to consider financial stability as a central bank target. At the time being, only the Central Bank of Montenegro has explicitly stated financial stability as its primary goal, while many central banks have financial stability as a secondary goal. Therefore, we can state that Montenegro is ranked as a leader in implementing modern monetary policy solutions.[137]

In 2010, Montenegro achieved the EU candidate status, and since June 2012, has been in the process of negotiations. In the final phase of the negotiations, Montenegro's present use of the euro will be addressed. From accession as a Member State, Montenegro will participate in the economic and monetary union with a derogation. Following an

[135] Government of Montenegro, Economic Reform Programme for Montenegro, 2018-2020.

[136] International Monetary Fund (IMF)., *Monetary and Financial Statistics Manual*, 2010.

[137] Zugic, R., and N. Fabris., "Financial Stability as the Goal of Central Banks," *Current issues of the Montenegrin economy*, 11-30.

evaluation of its fulfillment of the necessary conditions and the Council decision to this effect, Montenegro shall join the euro area[138].

According to the Maastricht convergence criteria requirements for entering the EU (European Commission, Convergence Report, 2018), the inflation rate must be stable and low as a prerequisite to joining. Article 87v of the Law of the Central Bank of Montenegro says:" The primary goal of the Central Bank of Montenegro is to maintain price stability, and that without prejudice to the achievement of the objective referred to paragraph 1 of Article 87v, the Central Bank shall support the general economic objectives policy of the European Union, to contribute to the achievement of the European Union objectives set out in Article 3 of the Treaty on European Union.[139]" By opening Chapter 17 – Economic and monetary policy negotiations, the European Union cautiously monitors the advancement and implementation following the *acquis* throughout the negotiating process[140]. The benchmark for the chapter is: Montenegro has embraced the required constitutional change. It has to ensure that the main objective of price stability is defined in compliance with: (i) Articles 127 (1) and (ii) Article 282 (2) of the Treaty on the Functioning of the European Union[141]. Montenegro has to fit its national legislation in line with the EU law to adopt the euro: meet price stability and ensure the country's economic convergence. Convergence criteria report that the government has to have a price-performance that is sustainable, and the average inflation rate should not be higher than 1.5% of the three best performing Member States[142]".

We find there is still sufficient room for inflation examination, even though inflation has been analyzed to a great extent. The CBCG used the autoregressive integrated moving

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[138]European Union, "General EU Position adopted by the Council," 2012, *AD 23/12, CONF-ME-2, 13-14*.

[139] Central Bank of Montenegro, "Law of the Central Bank of Montenegro," *Official Gazette of Montenegro*, 2017, No. 40/10, 46/10, 6/13, 70/17.

[140] European Commission, "Convergence Report. Institutional Paper 078," *European Economy,* 2018, ISSN 2443-8014.

[141]European Union, "Consolidated version of the Treaty on the functioning of the European Union," *Official Journal of the European Union,* 2012, C 326/47.

[142]European Commission, "Convergence Report. Institutional Paper 078," *European Economy,* 2018, ISSN 2443-8014.

average (ARIMA) model (2,1,2), in 2018, for forecasting inflation in Montenegro[143]. This dissertation's novelty uses a combined prediction (VAR and Bayesian VAR) for the Montenegrin economy. This study employs high – dimensional dynamic models. It examines time-series data from 2006:1 – 2017:12. It examines and compares the performance of different forecasting combination puzzles of inflation[144][145].

Since many factors affect Montenegro's inflationary pressures, we estimate recursively three VAR and three Bayesian VAR models. The Bayesian VAR models give a useful solution to the concerns of proliferation worries. Then, we combine the VARs and get two more RMSEs. We proceed to combine Bayesian VARs and get two more RMSEs. Moreover, we compare the combinations, using equal and MSE weights, and get the best RMSEs. In the meantime, we find causality among variables using impulse responses and variance decomposition. At the end of December 2017, the BVAR MSE combination inflation forecasting figures 2.661%, while the BVAR average combination inflation figures 2.822%. The average weights approach of standard VAR figures 1.537%, and the inverse of standard VAR MSE figures 1.516%. Standard VAR combination models, average and relative performance, show forecasting performances that are sustainable and fulfill the convergence criteria.

The average rate of three best performing Member states is 0.4 percentage points and, adding 1.5 percentage points, the reference is 1.9 p.p. Even though BVAR combination models, average and relative performance, end up way off compared to the convergence EU criteria, incorporation of these Bayesian combination models is significant for the CBCG[146]. The above results enable forecasters to address, evaluate, compare, and exploit the strength of using the high-dimensional dynamic composite forecast models.

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[143] Central Bank of Montenegro, "Price Stability Report," *Working Paper* 2018.

[144] Hendry, D. F., and M. P. Clements., "Pooling of Forecasts," *Econometrics Journal*, 2002, 5, 1-26.

[145] Jore, A.S., J. Mitchell., and S. P. Vahey., "Combining forecast densities from VARs with uncertain instabilities, "*Journal of Applied Econometrics*, 2010, 250(4), 621–634.

[146] Diebold, F. X. and P. Pauly., "The use of prior information in forecast combination," *International Journal of Forecasting*, 1990, 6, 503-508.

3. Data Methodology

The recursive and non-recursive SVAR identification, panel data analysis, and forecast combination puzzle of inflation will be applied, using an equal and inverse MSE weights approach. Georgiev et al., (2017)[147] highlight characteristically that tests for stochastic trends or persistence have been based on ordinary least squares (OLS) estimation, achieving optimal power properties under normality. Koutsoyiannis[148] (1997) marks out that OLS is one of the most commonly used methods in estimating relationships in econometric models, and it produces the best, linear, unbiased estimates (BLUE). This need stems from the fact that if data from a time series is non -stationary, the OLS regression performed on variables with unit root would be "spurious"[149] or "dubious." A series is stationary if: i) its mean and variance are constant over time, and ii) the value of covariance between the two time periods depends only on the distance or lag between the two periods and not the actual time, where the covariance is computed[150]. Several tests can be used to test stationarity [151]. Kovacic[152] (1995) accents that once the time series are identified as non-stationary series, they should be tested whether they are co-integrated. Moreover, Maddala and Kim[153] (1998) punctuate that the variables are co-integrated if they satisfy the condition that there are at least (k-1) co-integrating equations, i.e., stationary linear combinations of individually non-stationary variables. Several diagnostic tests have to be performed after the model is estimated so that all needed

[147] Georgiev, I., P.M.M. Rodrigues, and R.A.M. Taylor., "Unit Root Tests and Heavy-Tailed Innovations," *Journal of Time Series Analysis*, 2017, 38(5), 733-768.

[148] Koutsoyiannis, A., *Theory of Econometrics: Introductory to Exposition of Econometric Methods.* London: Macmillan Publishers, 1997.

[149] Granger, C.S.W.J. and P. Newbold., "Spurious Regression in Econometrics," *International Journal of Social Science,* 1974, 5(1), 111-120.

[150] Gujarati, D., *Basic Econometrics*. New York: The McGraw−Hill, 2004.

[151] Mladenovic, Z., and A. Nojkovic., *Primenjena analiza vremenskih serija.* Beograd: Ekonomski fakultet, CID, 2012.

[152] Kovacic, Z. J., *Analiza vremenskih serija*. Beograd: Ekonomski fakultet, 1995.

[153] Maddala, G. S., and I-M. Kim., *Unit Root, Cointegration, and Structural Change.* New York: Cambridge University Press, 1998.

corrections or even different estimators can be employed if necessary[154]. Many factors impact the internal and external shocks of inflation in Montenegro, and we will include variables with a significant impact on inflation in Montenegro.

First, we will analyze three different SVAR models:

a. *INF = LOGECOFREEDOM + LOGEGDI + CAPSTOCK + LOGHUMAN_CAPITAL + EMPLOYMENT*
b. *INF = LOGEXCH + LOGMLOGW + PROD_IND_GRWTH*
c. *INF = LOGOIL + LOGALEUR + UN + GDP_GAP*

We proceed with a combination puzzle of inflation, using equal and inverse MSE weights:

d. *1. LS INF C INF(-1) INF(-2) LOGECOFREEDOM_SA(-1) LOGECOFREEDOM_SA(-2) LOGEGDI(-1) LOGEGDI(-2) CAPSTOCK_SA(-1) CAPSTOCK_SA(-2) LOGHUMAN_CAPITAL_SA(-1) LOGHUMAN_CAPITAL_SA(-2) EMPLOYMENT_SA(-1) EMPLOYMENT_SA(-2) GDP_GAP(-1) GDP_GAP(-2) DUM2009 DUM2014*

2. LS INF C INF(-1) INF(-2) INF(-3) LOGEXCH(-1) LOGEXCH(-2) LOGEXCH(-3) LOGM(-1) LOGM(-2) LOGM(-3) LOGW(-1) LOGW(-2) LOGW(-3) PROD_IND_GRWTH(-1) PROD_IND_GRWTH(-2) PROD_IND_GRWTH(-3) DUM2008 DUM_2009M06 DUM_2011M03 DUM_2013M10

3. LS INF C INF(-1) INF(-2) INF(-3) LOGOIL_SA(-1) LOGOIL_SA(-2) LOGOIL_SA(-3) LOGALEUR_SA(-1) LOGALEUR_SA(-2) LOGALEUR_SA(-3) UN_SA(-1) UN_SA(-2) UN_SA(-3) GDP_GAP(-1) GDP_GAP(-2) GDP_GAP(-3) DUM_2009M06_AL DUM_2011M03_AL DUM_2013M07_AL DUM_2013M10_AL

The final step is panel data analysis of Montenegro, Serbia, Croatia and Slovenia:

e. *D(INF) = INF(-1) + CAPITAL_STOCK(-1) + EMPLOY(-1) + LOGEF(-1) + LOGEGDI(-1) + GDP(-1) + D(INF(-1)) + D(INF(-2)) + D(INF(-3)) + D(INF(-4)) + D(INF(-5)) + D(INF(-6)) + D(INF(-7)) + D(CAPITAL_STOCK(-1)) + D(CAPITAL_STOCK(-2)) + D(CAPITAL_STOCK(-3)) + D(CAPITAL_STOCK(-4)) + D(CAPITAL_STOCK(-5)) + D(CAPITAL_STOCK(-6)) + D(CAPITAL_STOCK(-7)) + D(EMPLOY(-1)) + D(EMPLOY(-2)) + D(EMPLOY(-3)) + D(EMPLOY(-4)) + D(EMPLOY(-5)) + D(EMPLOY(-6)) + D(EMPLOY(-7)) + D(LOGEF(-1)) + D(LOGEF(-2)) + D(LOGEF(-3)) + D(LOGEF(-4)) + D(LOGEF(-5)) + D(LOGEF(-6)) + D(LOGEF(-7)) + D(LOGEGDI(-1)) + D(LOGEGDI(-2)) + D(LOGEGDI(-3)) +*

[154] Jovicic, M., *Ekonometrijski metodi*. Beograd: CID, Ekonomski fakultet, 2002.

D(LOGEGDI(-4)) + D(LOGEGDI(-5)) + D(LOGEGDI(-6)) + D(LOGEGDI(-7)) + D(GDP(-1)) + D(GDP(-2)) + D(GDP(-3)) + D(GDP(-4)) + D(GDP(-5)) + D(GDP(-6)) + D(GDP(-7))

3.1. Empirical time series analysis

We will look at the time series and analyze them. Asteriou and Hall[155] (2007) point out that the starting point is to exploit the information we can get from a variable in the time series econometrics framework. Analyzing one variable at a time will give us a better understanding of the original time series properties. A systematized econometric knowledge will be used as a deductive way of understanding the time series's behavior. Moreover, intuition will be needed to compete for the scientific comprehension of the time series's behavior.

The time series are actual data used to analyze the general – stochastic – process of the facts drawn from a specific period. We can think of the stochastic process as a distribution of all possible outcomes that can occur over time[156]. As we move across time, we collect the data, and that constitutes observations. Each observation, for example Y_t, Y_{t+1}, Y_{t+2}, etc., has its probability density function, and it is usually represented as bell curves. As we move across time, for example, from $Y_t \dots Y_{t+k}$, what happens to the probability distribution function is very important. In case the probability distribution function changes over time, the time series is not stationary. The whole distribution does not change across time for a stationary process, but we will concentrate on the covariance-stationary process. A stochastic process $\{x_t$: t=1, 2, …$\}$ with a finite second moment $[E(x_t^2) < \propto]$ is **covariance-stationary** if: i) $E(x_t)$ is constant; ii) $Var(x_t)$ is constant, and iii) for any $t,\ h \geq 1, Cov(x_t, x_{t+h})$ depends on h and not on t[157]. The covariance is only dependent on the distance between two observations, and it is the distance that matters. The mean and variance are constant and time-independent. Therefore, at time t and time $t + h$, the mean and variance should hold constant:

[155] Asteriou, D., and S. G. Hall., *Applied econometrics, 3rd ed.* Basingstoke, United Kingdom: Palgrave MacMillan, 2015.

[156] International Monetary Fund (IMF), https://www.imf.org/en/Data, accessed, October 3, 2019.

[157] Wooldridge, J. M., *Introductory Econometrics: A Modern Approach*. Ohio: South-Western, 2013.

$$E(Y_t) = E(Y_{t+h}) = \mu; \quad Var(Y_t) = Var(Y_{t+h}), \quad Cov(Y_t, Y_{t+h}) = Cov(Y_z, Y_{z+h}) \quad (34)$$

Understanding the behavior of the variables will be of high importance for forecasting the variables.

3.1.1. Identification of covariance-stationarity of the time series

"You can observe a lot simply just by watching," says Lawrence Peter "Yogi" Berra[158]. The very first thing we will do is graph the data and observe their movement. Seeing the graphical behavior of the mean, variance, and covariance will familiarize us with the data and their potential breaks. In case the mean, variance, or covariance do not hold, the variable is nonstationary. From an economic perspective, if the deviation does not turn back to its long-run equilibrium, the variable is nonstationary. The equilibrium condition would get the variable to its mean in the long-run in case of stationarity (in case it diverges for a certain period). The variance of the time series depends on time. As time expands, the variance increases. If time series are nonstationary, the pattern of residual autocorrelations does not decay[159]. In stationarity cases, the trend of residual autocorrelations (the autoregressive - AR), moving average (MA), or autoregressive moving average (ARMA), models display a sharp cutoff in partial autocorrelation function (PACF) and the gradual decay in ACF. The right hint of non-stationarity would be a slow decay of ACF in the case of an AR model[160]. Nonstationary time series have a statistically detectable change over time – trend. The trend can be deterministic (a nonrandom function of time) and stochastic (random trend – random walk and random walk with a drift)[161]:

$$Y_t = \mu + \beta * t + u_t \quad (35)$$

[158] Lawrence Peter "Yogi" Berra (May 12, 1925 – September 22, 2015) was an American professional baseball catcher, who later took on the roles of manager and coach.

[159] Ouliaris, S., A. Pagan and J. Restrepo., *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation*. Institute for Capacity Development, 2018. E-book, available at https://www.eviews.com/StructVAR/structvar.html.

[160] Stock, J.H., and M. W. Watson., *Introduction to Econometrics, 4th ed.* Boston: Pearson, 2019.

[161] Greene, W. H., *Econometric Analysis*. Upper Saddle River, NJ: Pearson Prentice Hall, 2012.

$$Y_t = Y_{t-1} + u_t \quad (36)$$
$$Y_t = \mu + Y_{t-1} + u_t \quad (37)$$

In Equation 35, the deterministic trend is a function of a constant μ, a constant of time value β, and innovations u (assumed to be independently, identically distributed-white noise-iid). Equation 36 is a particular AR case with an autoregressive coefficient 1, so-called random walk, which varies over time. Besides, equation 37 has a drift added to equation 36, depending on both on its own lagged value Y_{t-1}.

In estimating a stationary model, such as ARMA, on a nonstationary variable, the consequences are that the distribution is non-normal, shocks do not die out, and test statistics are flawed (biasedness in coefficients will be present), and confidence intervals are not valid[162].

An AR(1) model can be represented as an MA(q)[163]:

$$Y_t = \beta_1 Y_{t-1} + u_t \quad (38)$$
$$Y_t = \beta_1(\beta_1 Y_{t-2} + u_{t-1} + u_t \quad (39)$$
$$Y_t = \beta_1^2(\beta_1 Y_{t-3} + u_{t-2}) + \beta_1 u_{t-1} + u_t \quad (40)$$
$$Y_t = \beta_1^t Y_0 + u_t + \beta_1 u_{t-1} + \beta_1^2 u_{t-2} + \beta_1^3 u_{t-3} + \ldots + \beta_1^{t-1} u_1 \quad (41)$$

Y_t is a function of innovations $u_t, u_{t-1}, u_{t-2}, u_{t-3}, \ldots, u_1$ and the impact of shocks will depend on the values of β_1. For values of $\beta_1 < 1$ the effect of shocks phases out, and the variable is stationary, while for values $\beta_1 = 1$ the impact of these innovations permanently do not diminish and have equal weight $Y_t = Y_0 + \sum_{i=0}^{t-1} u_{t-1}$. Therefore, the variable has a stochastic trend, summing up all shocks. Thus, the variance of the variable Y_t equals $t * \delta^2$, which is not constant but depends on time t. As a consequence of not diminishing the shocks, it makes the variable nonstationary. There is one more case when $\beta_1 > 1$, when the effects of shocks keep increasing, but this case in real life does not happen.

The rational roots theorem states that it has a polynomial with rational roots[164]. We keep looking at the factors of the constant, the leading coefficient, and all possibilities. Taking

[162] IMFx, Institute for Capacity Development, *Macroeconometric Forecasting*, 2018.

[163] Mladenovic, Z., and P. Petrovic., *Uvod u Ekonometriju*. Beograd: Ekonomski Fakultet, 2011.

[164] King, J. D., "Integer roots of polynomials," *Mathematical Gazette,* 2006, 90(519), 455-456.

all possible combinations of the elements of the constant dividing by the leading coefficient factors gives all possible rational roots of the polynomial[165]. A root is a number, and if we plug into the polynomial equation, it should equal zero at the end. We check one by one if there are any of the factors that would bring the polynomial to zero[166]. If we have the polynomial roots, we can factor them in the opposite sign and multiply all of it, giving us the original polynomial back. Therefore, having a factor (root) equaling the polynomial to zero, we say the time series is nonstationary[167].

In our case, we can test the hypothesis of non-stationarity by $\beta_1 = 1$, or equivalently take the differences $\Delta Y_t = \gamma Y_{t-1} + u_t$, where $\gamma = \beta - 1 = 0$. Therefore, we test for the significance of the coefficient γ, but we have to keep in mind that the t-test does not follow the standard distribution. The most successful tests of the unit-roots are the Dickey-Fuller test (DF) and the Augmented-Dickey-Fuller (ADF) test[168]. Adding a constant μ (intercept) and a constant and time trend, $\mu + \alpha * t$ (intercept and trend), we get an extended DF test[169]. In case the $\gamma = 0$, we have a non-stationary economic time series. On the opposite, the series is stationary. As the error term is not likely to be white noise, Dickey and Fuller extended their test procedure by suggesting an augmented version (augmented Dickey-Fuller ADF) of the test that includes additional lagged terms of the dependent variable to remove autocorrelation[170]:

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + u_t \quad (42)$$

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + u_t \quad (43)$$

[165] Barrs, Sh., J. Braselton and L. Braselton, "A Rational Root Theorem for Imaginary Roots," *The College Mathematics Journal*, 2003, 34(5), 380-382.

[166] De Pillis, L. G., "Determinants and polynomial root structure," *International Journal of Mathematical Education in Science and Technology*, 2005, 36(5), 469-481.

[167] Dickey, D., W. Bell, and R. Miller., "Unit Roots in Time Series Models: Tests and Implications," The American Statistician, 1986, 40(1), 12-26.

[168] Mladenovic, Z., and A. Nojkovic., *Primenjena analiza vremenskih serija.* Beograd: Ekonomski fakultet, CID, 2012.

[169] Guiley, D. K., and P. Schmidt., "Extended tabulations for Dickey-Fuller tests," *Economic Letters*, 1989, 31(4), 355-357.

[170] Asteriou, D., and S. G. Hall., *Applied econometrics, 3rd ed.* Basingstoke, United Kingdom: Palgrave MacMillan, 2015.

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \sum_{i=1}^{p} \beta_i \Delta Y_{t-1} + u_t \quad (44)$$

The same as with the simple DF test, the difference between the above three regressions is the intercept a_0 and intercept and trend $a_0 + a_2 t$.

As far as how many lags should be included in the ADF test, the Akaike[171] information criterion (AIC), Schwarz Bayesian criterion[172] (SBC), and general-to-specific criteria can be used. The null hypothesis for both tests, DF and ADF, is that $\gamma = 0$.

Because DF and ADF lack some qualities, we are going to use additional tests. For example, the DF and ADF have low power to reject in case of near unit roots, such as between the stationary process ($\beta_1 = 0.95$) and nonstationary process ($\beta_1 = 1$). The conclusion could be that the time series is nonstationary when the time series truly is stationary. Trend stationary processes can barely be distinguished by DF and ADF tests[173]. Peter C. B. Phillips and Pierre Perron[174] (1988) give a nonparametric approach concerning nuisance parameters and thereby allowing for an extensive class of weakly dependent and possibly heterogeneously distributed data: it is the AR(1) process $\Delta Y_t = \mu + \delta t + \omega Y_{t-1} + u_t$. It has an intercept μ, time trend δt, and coefficient ω considering for heteroscedasticity and serial correlation of u_t. It is also a unit root, testing for $\omega = 0$. Therefore, the PP test neutralizes the innovations u_t for any autocorrelation or heteroscedasticity.

Denis Kwiatkowski, Peter C.B. Phillips, Peter Schmidt, and Yongcheol Shin[175] (KPSS) suggest a null hypothesis test that an observable series is stationary around a deterministic

[171] Akaike, H., "A New Look at the Statistical Model Identification," *IEEE Transactions on Automatic Control*, 1974, 19, 716-723.

[172] Schwarz, G. E., "Estimating the dimension of a model," *Annals of Statistics*, 1978, 6(2), 461–464.

[173] Arltova, M., and D. Fedorova., "Selection of Unit Root Test on the Basis of Length of the Time Series and Value of AR(1)," Statistika - Statistics and Economics Journal, 2016, 96(3), 47-64.

[174] Phillips, P. C. B. and P. Perron., "Testing for a Unit Root in Time Series Regression," *Biometrika*, 1988, 5(2), 335-346.

[175] Kwiatkowski, D., P. C. B. Phillips, P. Schmidt, and Y. Shin., "Testing the null hypothesis of stationarity against the alternative of a unit root : How sure are we that economic time series have a unit root?," Journal of Econometrics, 1992, 54(1-3), 159-178.

trend: the series is represented as the sum of the deterministic trend, random walk, and stationary error. The test is a Lagrange Multiplier (LM)[176] test of the hypothesis that the random walk has zero variance. Kwiatkowski et al., (1992) assume to decompose the series into the sum of a deterministic trend, a random walk, and a stationary error:

$$Y_t = \vartheta t + r_t + u_t \tag{45}$$

Here r_t, is a random walk:

$$r_t = r_{t-1} + \varepsilon_t \tag{46}$$

where the ε_t, is iid $(0, \delta_u^2)$. The ϑt contains deterministic components, grouping the intercept and time trends. Whereas, the r_t denotes a random walk, and the hypothesis tests whether the variance equals zero, $\varepsilon_t = 0$. In case the $\varepsilon_t = 0$, then r_t is merely a constant because, with mean zero, there is no variance. Therefore, Y_t will have a trend and intercept, and it will be stationary since the innovations, ε_t, is white noise. The alternate hypothesis is that there is some variance in the disturbance term, in the r_t, making the Y_t nonstationary. A simple unified approach to testing in non-stationarity time series, again using the LM principle yielding test statistics, which also have Cramer-von Mises distributions under the null hypothesis, may be extended to multivariate models and models with structural breaks[177]. Bhargava (1986) continues that following Alok Bhargava[178] (1986), Seiji Nabeya and Katsuto Tanaka[179] (1990) and Peter Schmidt and Peter C. B. Phillips[180] (1992) and setting up the unit test of H_0: $\theta = 1$ against H_0: $\theta < 1$, a unified expression can be represented:

$$Y_t = \alpha + \beta t + \mu_t; \quad \mu_t = \theta \mu_{t-1} + \varphi_t, \qquad t = 1, \ldots, T, \tag{47}$$

---

[176] Silvey, S. D., "The Lagrangian Multiplier Test," *Annals of Mathematical Statistics*, 1959, 30, 389-407.

[177] Busetti, F., and A. Harvey., "Testing for the Presence of a Random Walk in Series with Structural Breaks," *Journal of Time Series Analysis*, 2001, 22(2), 127-150.

[178] Bhargava, A., "On the Theory of Testing for Unit Roots in Observed Time Series," Review of Economic Studies, 1986, 53(3), 369-384.

[179] Nabeya, S., and K. Tanaka., "Limiting power of unit-root tests in time-series regression," Journal of Econometrics, 1990, 46(3), 247-271.

[180] Schmidt, P., and P. C. B. Phillips., "LM Tests for a Unit Root in the Presence of Deterministic Trends," *Oxford Bulletin of Economics and Statistics*, 1992, 54(3), 257-287.

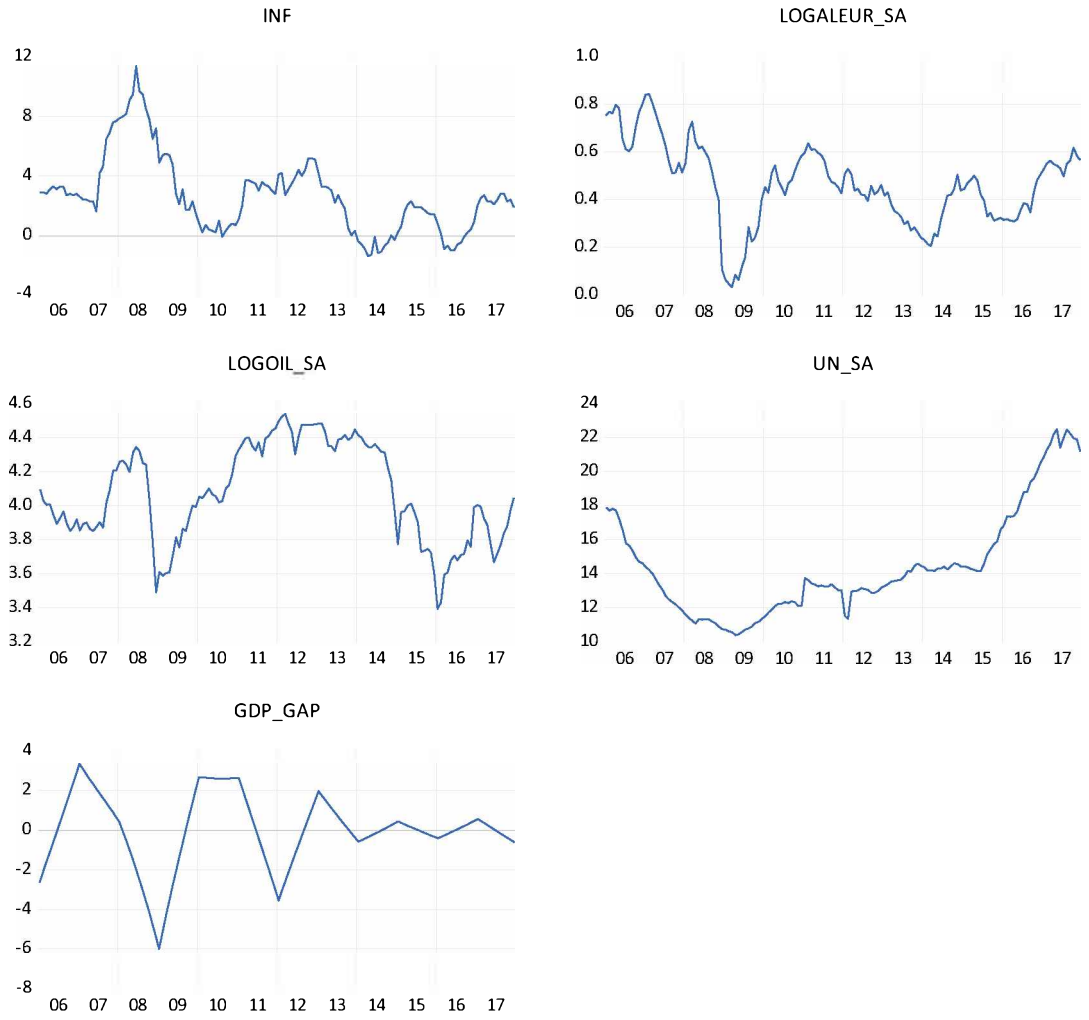


Figure 13: Inflation, aluminum, oil, GDP_GAP, and unemployment
Source: Author's calculations in EViews 11.

In case non-stationarity appears in Y_t, then it should come from μ_t. Therefore, we can test the autoregressive coefficient θ on μ_t. For $\theta = 1$, the time series is nonstationary and has a unit root. Otherwise, for $\theta < 1$, the time series does not have a unit root, and the polynomial does not equal zero. Behavior of the φ_t, in expression (47), will determine whether to use DF (in case φ_t is white noise) or ADF and PP (in case φ_t is $ARMA_{p,q}$) tests. In practice, the above approach is applied by EViews[181] testing for the autoregressive coefficient of the residual. Let us graph and observe the economic time series and try to assess stationarity or non-stationarity.

[181] Statistical Software System

Table 7: The summary of unit root and stationary tests

Unit Root & Stationarity Tests							
	H_0: Series has a unit root					H_0: Series is stationary	
Test	**ADF Tests**			**PP Tests**		**KPSS**	
Variables	None	I	I & t	I	I & t	I	I & t
Inflation							
Full sample	0.25	0.52	0.00	0.28	0.34	0.01<p<0.05	p > 0.10
Post crisis	0.22	0.07	0.05	0.39	0.49	0.01<p<0.05	0.01<p<0.05
GDP_gap							
Full sample	0.00	0.00	0.00	0.03	0.12	p > 0.10	p > 0.10
Post crisis	0.00	0.00	0.00	0.04	0.14	p > 0.10	p > 0.10
Logalu_sa							
Full sample	0.21	0.02	0.10	0.10	0.37	0.05<p<0.10	0.05<p<0.10
Post crisis	0.53	0.24	0.65	0.39	0.81	p > 0.10	p<0.01
Logoil_sa							
Full sample	0.65	0.04	0.43	0.27	0.58	p > 0.10	p<0.01
Post crisis	0.53	0.05	0.58	0.71	0.66	p<0.01	0.01<p<0.05
Unemployment							
Full sample	0.70	0.70	0.16	0.90	0.39	p < 0.01	p < 0.01
Post crisis	0.89	0.82	0.15	0.92	0.39	p < 0.01	p < 0.01

**Full sample: 2006:1-2017:12*
***Post-crisis sample: 2011:1-2017:12*

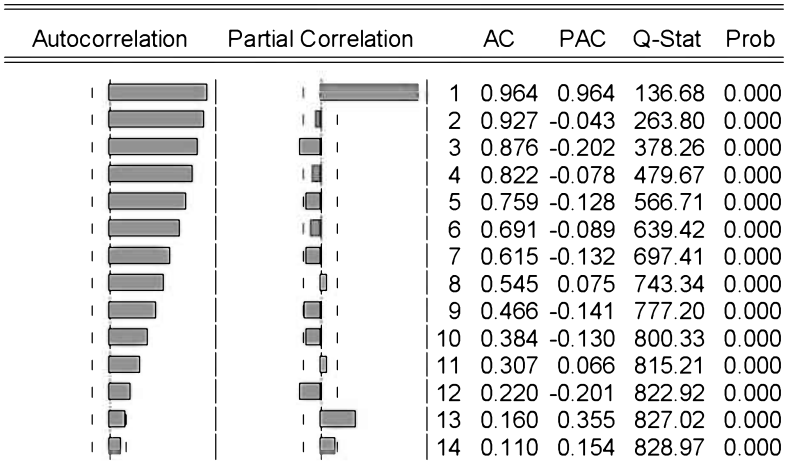
Source: Author's calculations in EViews 11.

We will use the *output gap* instead of the *output level* since it reduces the prize puzzle, and the coefficient is more likely to be constant[182]. The time series of inflation, aluminum, oil, GDP_GAP, and unemployment have sharp fluctuations, especially around 2008, corresponding to the global crisis. These intense steps can lead us to think that there might be a structural break. Not accounting for structural breaks would cause worse forecasting performance in terms of the mean forecast, incorrectly estimated confidence bounds, and forecast uncertainty[183]. The time series appear visually to be stationary except for these precipitous drops, and we are going to apply the unit root (ADF and PP) and KPSS tests. First, we will test the whole sample from January 2006 till December 2017, the post-crisis

[182] Giordani, P., "An Alternative Explanation of the Price Puzzle," Journal of Monetary Economics, 2004, 51, 1271-1296.
[183] De Gaetano, D., "Forecast Combinations for Structural Breaks in Volatility: Evidence from BRICS Countries," *Journal of Risk and Financial Management*, MDPI, Open Access Journal, 2018, 11(4), 1-13.

period from January 2011 to December 2017, except for unemployment from January 2012 to December 2017.

Observing Figure 14 and analyzing the test results will help us identify the study's time series' behavior. From the correlogram in Figure 14, we see from the autocorrelation (AC) column that shocks' impact diminishes quickly, reminding us that the time series of inflation is most probably stationary.



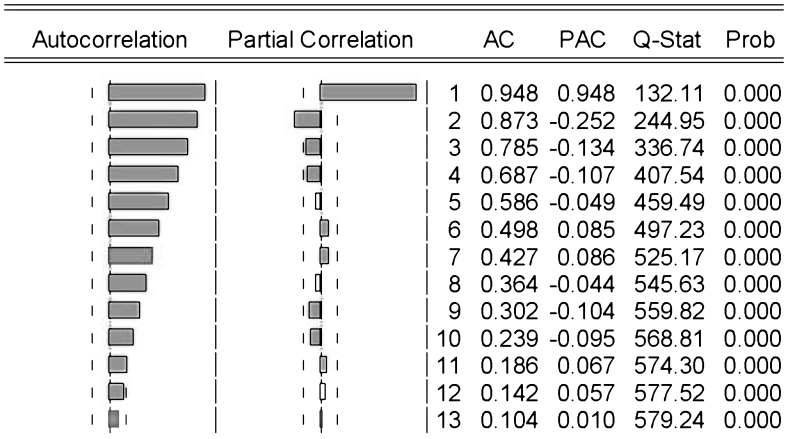
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.964	0.964	136.68	0.000
		2	0.927	-0.043	263.80	0.000
		3	0.876	-0.202	378.26	0.000
		4	0.822	-0.078	479.67	0.000
		5	0.759	-0.128	566.71	0.000
		6	0.691	-0.089	639.42	0.000
		7	0.615	-0.132	697.41	0.000
		8	0.545	0.075	743.34	0.000
		9	0.466	-0.141	777.20	0.000
		10	0.384	-0.130	800.33	0.000
		11	0.307	0.066	815.21	0.000
		12	0.220	-0.201	822.92	0.000
		13	0.160	0.355	827.02	0.000
		14	0.110	0.154	828.97	0.000

Figure 14: The correlogram of inflation
Source: Author's calculations in EViews 11.

Having specified the ADF test at 11 lags for the full sample, the inflation series becomes stationary, rejecting the null hypothesis of the unit root. Both trend and intercept are essential, having a *t*-statistic of -3.654 and 4.329, respectively. While the PP in the full sample fails to reject the unit root test, and KPSS rejects stationarity at the intercept, at 5% significance level, but fails to reject the null hypothesis of stationarity at intercept and trend because of having a statistic corresponding $p > 0.10$.

The ADF and KPSS test conclusion is that the series of inflation is stationary, while PP not stationary. The post-crisis period from January 2011 till December 2017 gives us pretty much the same results, except the KPSS at intercept and trend. In the case of KPSS, EViews 11 does not provide us the p value directly, but it provides us with test statistics, and we compare it with the three critical values at 1%, 5%, and 10%. The sample size and

correct specification is the key to testing for the unit-roots even though there is no guarantee that we may not end up with the wrong answer.[184]



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.948	0.948	132.11	0.000
		2	0.873	-0.252	244.95	0.000
		3	0.785	-0.134	336.74	0.000
		4	0.687	-0.107	407.54	0.000
		5	0.586	-0.049	459.49	0.000
		6	0.498	0.085	497.23	0.000
		7	0.427	0.086	525.17	0.000
		8	0.364	-0.044	545.63	0.000
		9	0.302	-0.104	559.82	0.000
		10	0.239	-0.095	568.81	0.000
		11	0.186	0.067	574.30	0.000
		12	0.142	0.057	577.52	0.000
		13	0.104	0.010	579.24	0.000

Figure 15: The correlogram of aluminum
Source: Author's calculations in EViews 11.

Having logged and adjusted the aluminum time series's seasonality, we will conduct the unit root and the stationarity tests. Observing Figure 15, the series has a constant mean (approx. 0.4) around which it oscillates except the period of crisis in 2008. Conducting the ADF unit root test, the series is stationary at the intercept, rejecting the null hypothesis of having a unit root. We can infer that the intercept is significant since it has a *t*-statistic of 2.985 (using Akaike Info Criterion) and $p = 0.003$. The trend statistic of $p = 0.630$ proves it as not significant. In the post-crisis sample, the KPSS test fails to reject the null hypothesis of stationarity having a value of 0.232 at the intercept, corresponding a $p > 0.10$.

At lag length 35 and intercept specification, the ADF test of oil time series rejects the null hypothesis of unit root, corresponding a $p = 0.044$. The KPSS test fails to reject the null hypothesis at intercept with a test statistic of 0.247, corresponding $p > 0.10$. At the intercept and lag length 22, the ADF has $p = 0.045$ for the post-crisis period, thus rejecting the unit root test of non-stationarity. The *t*-statistic for the constant has a probability of $p = 0.004$. The ADF and KPSS tests provide enough proof rejecting the

[184] Libanio, G. A. "Unit roots in macroeconomic time series: theory, implications, and evidence," Nova Economia, 2004, 15(3), 145-176.

unit root and failing to reject stationarity for the full sample. We can proceed and conclude that the series of oil is stationary.

As observed in Figure 16, all tests confirm stationarity and reject the null of unit root for the time series of the *output gap*. The specified ADF at 3 lags, intercept and trend specification, the time series of unemployment shows a $p = 0.105$. Conducting a post-crisis ADF test, a sub-sample from January 2011 till Jun 2015, at 1 lag and including intercept and trend, we get a *t*-statistic of -3.436 with $p = 0.0571$, thus rejecting the null of unit root at 10% significance.

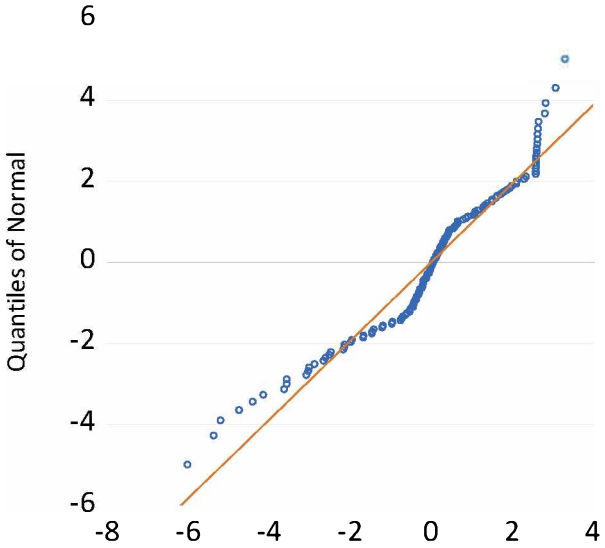


Figure 16: Quantile GDP_GAP
Source: Author's calculations in EViews 11.

The same is confirmed from the PP test resulting in $p = 0.071$ and significant trend and constant. The KPSS, specified at trend and intercept, fails to reject stationarity at 5% significance. The properties of the time series included in our study reject unit root and fail to reject stationarity.

3.1.2. Identifying structural breaks

As we can observe from the figures of ($alu\_sa_t, oil\_sa_t, inf_t, gdp\_gap_t, un\_sa_t$), there is a potential structural change, especially around the global crisis. Our economic time series behaved in a predictable, ordinary fashion in the post-crisis period, but very volatile during 2008 – 2009. In specifying a regression model, we assume that its assumptions

apply to all sample observations [185]. The hypothesis that we put here is whether the same regression model applies to the prior and post-crisis period. The world oil prices, aluminum, and inflation have not been stable over the whole sample from January 2006 till December 2017. Intercept or slope parameters may change by δ, and we notice abrupt changes in the setting parameters.

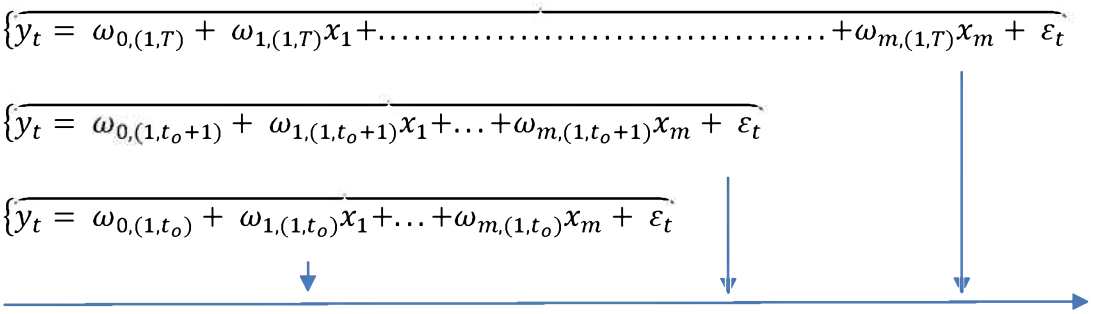
Instead of having the following inflation model:

$$\pi_t = F(X_t; \omega) + \varepsilon_t \qquad t = 1, \dots, T \tag{48}$$

We have an abrupt change in parameters:

$$\begin{aligned} &\pi_t = F(X_t; \omega_1) + \varepsilon_t \quad for \quad t = 1, \dots, \bar{t} \\ \text{and} \quad &\pi_t = F(X_t; \omega_2) + \varepsilon_t \quad for \quad t = \bar{t} + 1, \dots, T \end{aligned} \tag{49}$$

Misspecification and not accounting for structural breaks would lead us to wrong conclusions, and consequently, the Central Bank of Montenegro would not be correct with policy decisions. The critical question here is whether the inflation model's actual parameters in Montenegro have changed during the estimation period!



If we estimate coefficients recursively, in small sub-samples, and there is no break in true parameters, we do not have structural breaks. Therefore, we start by applying recursive estimation[186], expanding one more observation to the small sample. For each estimated sample, we get corresponding coefficients subsequently, as we expand the sample to time

[185] Greene, W. H., *Econometric Analysis*. Upper Saddle River, NJ: Pearson Prentice Hall, 2012.

[186] Bergman, N., "Recursive Bayesian Estimation: Navigation and Tracking Applications," 1999, *Linköping Studies in Science and Technology*. Dissertations No. 579.

T. We proceed with Chow (1960) test[187], which essentially breaks the sample into a restricted equation, allowing no breaks, and the unrestricted model with breaks:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \quad (50)$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} [\beta] + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \quad (51)$$

In case the SSR of different estimated equations fit the data well, then there is no structural break. The null assumption is that there is no break. Greene (2012) explains that the unrestricted least squares estimator is:

$$= (X'X)^{-1}X'y = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1'X_1 & 0 \\ 0 & X_2'X_2 \end{bmatrix}^{-1} \begin{bmatrix} X_1'y_1 \\ X_2'y_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} = \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} \quad (52)$$

continuing that the total sum of squared residuals from this regression will be the sum of the two residual sums of squares from the two separate regressions[188]:

$$e'e = e_1'e_1 + e_2'e_2 \quad (53)$$

$$e_r'e_r = e_{1r}'e_{1r} + e_{2r}'e_{2r} \quad (54)$$

Equation (54) represents the restricted regression of the residual sum of squares. Greene (2012) computes the F statistic as follows[189]:

$$F[n_2, n_1 - K] = \frac{(e_r'e_r - e_1'e_1)/n_2}{e_1'e_1/(n_1 - K)} \quad (55)$$

In case $e_r'e_r \ll e'e$, making the F statistic larger than the critical value, then the restricted model accounts for breaks, and the null hypothesis of no breaks is rejected. Another breakpoint test is the Quandt-Andrews test[190][191], where the sample is trimmed at the

[187] Chow, G. C., "Tests of Equality Between Sets of Coefficients in Two Linear Regressions," *Econometrica*, 1960, 28(3), 591-605.

[188] Spellman, F. R., and Nancy E. Whiting., *Handbook of Mathematics and Statistics for the Environment*. Boca Raton: Taylor & Francis Group, 2014.

[189] Greene, W. H., *Econometric Analysis*. Upper Saddle River, NJ: Pearson Prentice Hall, 2012.

[190] Quandt, R. E., "The estimation of the parameters of a linear regression system obeying two separate regimes," *Journal of the American Statistical Association*, 1958, 53, 873-880.

[191] Andrews, D. W. K., (1993) "Tests for parameter instability and structural change with unknown change point," *Econometrica*, 1993, 71, 395-397.

beginning and the end. As in the Chow test, we calculate F statistics sequentially. Quandt[192] (1958) finds that the switching point can be estimated most effectively by examining the appropriate likelihood function based on the F distribution, which is proposed for testing the hypothesis that no switch occurred against the single alternative of one switch.

Let's proceed to test for multiple breaks in intercept and coefficients using Bai-Perron[193] (2003) to test sequentially the hypothesis of L+1 vs. L determined breaks sequentially. The Quandt-Andrews test needs to be provided a sufficient number of observations after the break occurs; this is why we trim the estimation sample. For example, our break takes place in 2008m07, and we cannot detect it immediately. Instead, depending on a model specification and trimming parameters, we need several months after the break to pass and appear in our estimation sample. Such a scenario is difficult to avoid if we are entirely reliant on the statistical tests and do not use any prior information or judgment regarding a break. We may keep using a "broken" model (e.g., forecasting) for some time without realizing it is broken.

Comparing the forecasting performance of, for example, two models – one that accounts for a structural break and one that does not, clearly shows that the model that does not account for the break performs worse in terms of root mean squared errors (RMSE) than the one that accounts for the break, allowing to reduce the forecast bias substantially[194].

[192] Ibid.

[193] Bai, J., and P. Perron., "Critical values for multiple structural change tests," *The Econometrics Journal*, 2003, 6(1), 72-78.

[194] Casini, A., and P. Perron., "Structural Breaks in Time Series," Boston University - Department of Economics - Working Papers Series, 2018, WP2019-02.

3.1.3. Modeling dichotomous variables

If an observation belongs to a category or has an attribute, it can be represented by a binary value 0 or 1 as a useful device in a regression analysis[195]. A binary variable may represent significant strikes or policy happenings as 1 only for a specified period[196]. They are also known as indicator variables, as they will generally have a value of 1 to indicate if an observation belongs to a category and a 0 to note if not.

Table 8: Multivariate regression of inflation

Dependent Variable: INF
Method: Least Squares
Sample: 2006M01 2017M12
Included observations: 144

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGALEUR_SA	8.271636	1.003785	8.240446	0.0000
LOGOIL_SA	-0.161515	0.583851	-0.276637	0.7825
UN_SA	-0.385255	0.054475	-7.072198	0.0000
GDP_GAP	-0.779853	0.089415	-8.721705	0.0000
C	5.048492	2.704927	1.866406	0.0641

R-squared	0.518349	Mean dependent var	2.684028
Adjusted R-squared	0.504489	S.D. dependent var	2.586562
S.E. of regression	1.820747	Akaike info criterion	4.070476
Sum squared resid	460.8019	Schwarz criterion	4.173595
Log likelihood	-288.0743	Hannan-Quinn criter.	4.112378
F-statistic	37.39768	Durbin-Watson stat	0.185680
Prob(F-statistic)	0.000000		

Source: Author's calculations in EViews 11.

Binary variables are also called dummy variables since they are not real, and we create them to represent something else[197]. Therefore, quantifying qualitative information in a regression model is very important.

[195] Suits, D., "Use of Dummy Variables in Regression Equations," *Journal of the American Statistical Association,* 1957, *52*(280), 548-551.

[196] Gujarati, D., *Basic Econometrics*. New York: The McGraw−Hill, 2004.

[197] Asparoukhov, O. K., and A. Stam., "Mathematical programming formulations for two-group classification with binary variables," *Annals of Operations Research*, 1997, 74, 89-112.

Either it is shifted, or the underlying elasticities have moved around. From around the second half of 2014 onwards, the upward trend in inflation reflects the increase in food, alcoholic and non-alcoholic beverages and tobacco prices in Montenegro. After the crash in the United States' housing market in 2015, the economy recovered, and oil prices decreased. The direction we are following here is that the relationship between inflation and oil changed around 2008 and 2014, indicating that we need to consider bringing in multiple structural breaks around these periods.

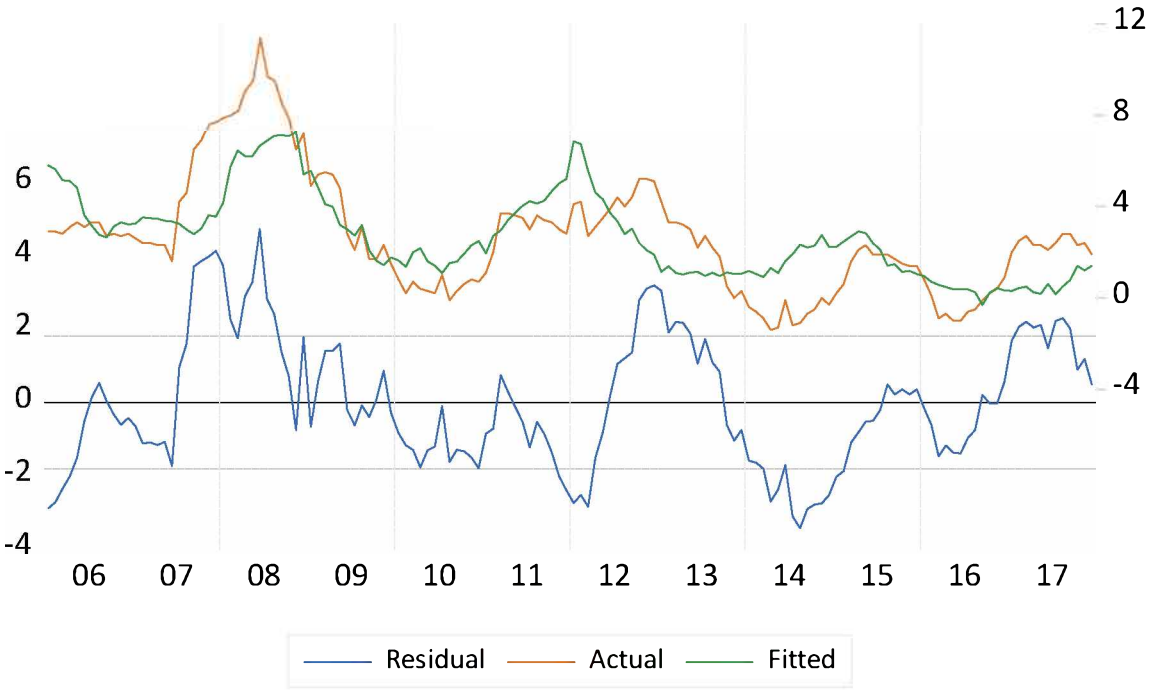


Figure 17: Actual, fitted, and residuals
Source: Author's calculations in EViews 11.

Confirming whether this is necessary, we are going to run a simple regression model between inflation, constant, and logarithmic oil prices, an elasticity expression. Including all variables inflation, oil, aluminum, unemployment, and GDP gap into a multivariate regression model, we get Table 8. The first notable thing is the R-squared (R^2)[198] of 51.83% but in the meantime low Durbin-Watson of 0.18 indicating positive autocorrelation. The autocorrelation is confirmed in Figure 17. Once again, the global financial crisis period shows positive residuals passing the upper border 2 and reaching

[198] Wooldridge, J. M., *Introductory econometrics: a modern approach*. Ohio: South-Western, 2009.

even the level of 4 and above. Around 2011, we notice negative residuals crossing the -2, and in 2013 soaring to around 3.

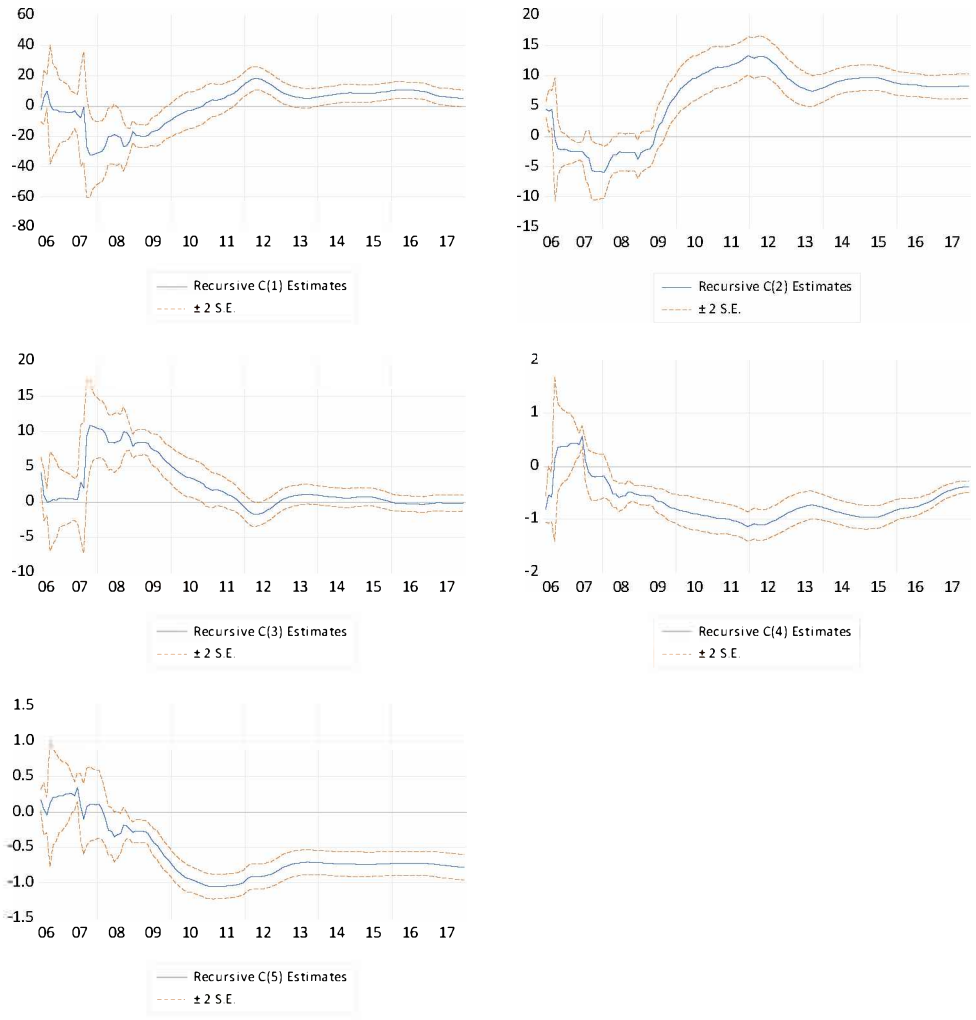


Figure 18: Recursive coefficient estimates of inflation
Source: Author's calculations in EViews 11

It can be explained from the increase in housing, water, electricity, gas, and other fuel category prices in Montenegro, impacting the inflation in 2012 by 37.2% and in 2013 by 129.4%. Also, alcoholic beverages and tobacco impacted inflation by 110, 5% in 2013. We see negative autocorrelation in 2014, which comes from a) communication with a shock of 265.7% into inflation, b) health category of -209.8% and c) furnishings - house equipment and maintenance of 92.4%. Food and non-alcoholic beverages impacted oscillations of inflation by 38.4% and 24.6% in 2016 and 2017, respectively. Figure 17 shows the positive autocorrelation.

Proceeding with the recursive ordering stability test, the results of Figure 18 put to consideration breaks in coefficients $c_1, c_2, c_3, c_4, and\ c_5$. Multiple breaks appear to be in each coefficient, confirmed by Bai-Perron multiple breakpoint test, as seen in Table 9. Intercept and slope coefficients propose breaks in June 2009, March 2011, October 2013, and March 2016. Quandt-Andrews breakpoint test suggests Jun 2009 as a breaking point.

Table 9: Multiple Bai-Perron test

Sequential F-statistic determined breaks: 4			
Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	29.88617	149.4308	18.23
1 vs. 2 *	26.67427	133.3713	19.91
2 vs. 3 *	9.725133	48.62566	20.99
3 vs. 4 *	9.194913	45.97456	21.71
4 vs. 5	0.000000	0.000000	22.37

** Significant at the 0.05 level.*

Break dates:

	Sequential	Repartition
1	2009M06	2008M11
2	2013M10	2011M03
3	2011M03	2014M01
4	2016M03	2016M03

Source: Author's calculations in EViews 11.

We need to consider the specifics of the above residuals described above to model dichotomous variables:

- Dum_2008m06 – takes account of the pre-crisis period.
- Dum_2009m06 – takes account of the global financial crisis. It has value 1 from June 2009 till February 2011.
- Dum_2011m03 – represents an increase in prices of alcoholic beverages and tobacco, and it has a value of 1 from March 2011 till May 2013.
- Dum_2013m07 – takes into account the increase of VAT from 17% to 19% in July 2013. It takes the value of 1 from July 2013 till September 2013.
- Dum_2013m10 – reflects an increase in prices of housing, water, electricity, gas, and other fuels. It takes the value of 1 from October 2013 till February 2016.
- Dum_2016m03 – accounts for the increase in prices of food & non-alcoholic beverages. It takes the value of 1 from March 2016 till December 2017.

The role of food prices and oil are very deterministic in inflation[199]. A large part of shifting in inflation appears to come from food, imported mostly and to some degree from domestic agricultural products, and products subject to high excise tax such as tobacco and oil. In the pre-crisis period, the economy was overheated due to increased foreign direct investments (FDI), impacting housing prices.

Table 10: Inflation model with dummy variables

Dependent Variable: INF
Sample: 2006M01 2017M12
Included observations: 144

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.177093	3.085924	1.353596	0.1781
LOGALEUR_SA	2.996166	1.330477	2.251948	0.0260
LOGOIL_SA	1.163165	0.692608	1.679398	0.0954
UN_SA	-0.416524	0.106706	-3.903482	0.0001
GDP_GAP	-0.398906	0.092200	-4.326546	0.0000
DUM_2009M06_AL	-3.376320	0.530496	-6.364458	0.0000
DUM_2011M03_AL	-1.745908	0.540293	-3.231409	0.0016
DUM_2013M07_AL	-1.917639	1.109249	-1.728773	0.0862
DUM_2013M10_AL	-3.439219	0.585772	-5.871263	0.0000
DUM_2016M03	-0.373596	0.917691	-0.407104	0.6846

R-squared	0.690179	Mean dependent var	2.684028
Adjusted R-squared	0.669371	S.D. dependent var	2.586562
S.E. of regression	1.487283	Akaike info criterion	3.698695
Sum squared resid	296.4095	Schwarz criterion	3.904932
Log likelihood	-256.3060	Hannan-Quinn criter.	3.782498
F-statistic	33.16759	Durbin-Watson stat	0.269650
Prob(F-statistic)	0.000000		

Source: Author's calculations in EViews 11.

Thus, the equilibrium of wage-setting and price-setting decreased the labor market's unemployment rate, corresponding to April 2009. The impact of increasing VAT, from 17% to 19%, pushed prices up, increasing the markups in the price-setting relation and lowering the employment rate: the markup is associated with the shadow economy.

[199] Mohanty, M. S., and M. Klau, "What determines inflation in emerging market economies?," BIS Papers chapters,in: Bank for International Settlements (ed.), Modelling aspects of the inflation process and the monetary transmission mechanism in emerging market countries, 2001, 8, 1-38.

Including the dummy variables in the inflation model, the R^2 increases significantly, and the F statistic remains stable. In the meantime, the Durbin – Watson statistic still is very low 0.27, indicating residual autocorrelation, which can and will be corrected by incorporating the lagged values. We never know the true slope β_i instead, we calculate the sample slopes b_i and make inferences about the β_i. We estimated four slope coefficients and five dichotomous variables. Each time we will make inferences about population slope values, we can never know what they are[200]. Our sample slope values will allow us to make inferences for the population values. Are our sample coefficients far away enough from zero that we can suggest that the population coefficients are nonzero[201]? And, how much variation is there on inflation in Montenegro? How much explaining is this model doing? The sum of squares $SS = \sum (x_i - \bar{x})^2$ calculates the whole deviation from the mean[202]. We subtract all observations from the mean and square, each getting the amount the variation in inflation[203]. The R^2 tells that 69.01% of the variation in inflation is being explained by x_i variables. Still, there are residuals of 30.99% going unexplained (keeping in mind that we did not incorporate the lagged values yet to fix the positive autocorrelation). Is this model with the above explanatory variables better than a model with 0 explanatory variables? The joint hypothesis is that all $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$[204]. If we can not reject this, then our model is useless. Reminding the statistics, if the p-value is less than the level of significance 5%, we reject the H_0. Even if we use a 1% level of significance, we will reject the null hypothesis. In our case, the F-statistic (33.167) is less than the critical value $(Prob\{F - statistic = 0.000\})$. It indicates that it is in the rejection region.

[200] Kim, J. H., and A. P. Robinson., "Interval-Based Hypothesis Testing and Its Applications to Economics and Finance," *Econometrics*, 2019, 7(21).

[201] Gauss, C. F., "Bestimmung der Genauigkeit der Beobachtungen," *Zeitschrift für Astronomie und Verwandte Wissenschaften*, 1816, 1, 187–197.

[202] Pearson, K., "On the dissection of asymmetrical frequency curves," *Philosophical Transactions of the Royal Society A.,* 1894, 185, 71–110.

[203] Ghahramani, S., *Fundamentals of Probability*, 2nd ed. New Jersey: Prentice Hall, 2000.

[204] Barreto, H., and F. M. Howland., *Introductory Econometrics: Using Monte Carlo Simulation with Microsoft Excel.* Cambridge, England: Cambridge University Press, 2010.

If we were to write the estimated regression equation, it would be like the one following equation 56. For example, its interpretation would be for every additional percentage of the aluminum price at the LME, the expected percentage of inflation increases by 2.996% on average, holding all other variables constant. The same logic of interpretation follows for the other variables.

$$\widehat{Inf} = 4.177 + 2.996 * LogAleur_sa + 1.163 * LogOil_sa - 0.398 * GDP_gap - 0.416 Un\_sa - 3.376 * Dum\_2009m06 - 1.745 * Dum\_2011m03 - 1.917 * Dum\_2013m03 - 3.439 * Dum\_2013m10 - 0.373 * Dum\_2016m03 \quad (56)$$

In addition to using the coefficients for interpretation, we can also predict inflation for a month. For example, for January 2011, the values of the model variables are logaleur_sa=0.5982, logoil_sa=4.3311, gdp_gap=2.6376, un_sa=13.7299, and dum_2009m06 is 1. Substituting the above values to the model, we get:

$$\widehat{Inf} = 4.177 + 2.996 * (0.5982) + 1.163 * (4.3311) - 0.398 * (2.6376) - 0.416 * (13.7299) - 3.376 * (1) = -2.7155 \quad (57)$$

The actual inflation, for January, is 1.1%, and the error is (1.1 – (-2.7155)) = + 3.81.

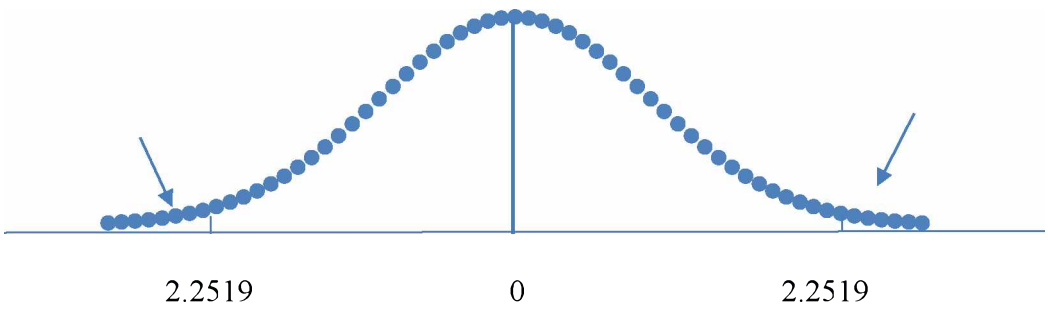


Figure 19: Theoretical t-distribution of logaleur_sa
Source: Author's simulations.

Standard deviation gives us a typical variation of a coefficient, average expected error term from the sample value[205]. Dividing the coefficient with the standard error, we get the *t*- statistic, and the higher the *t*-statistic[206] in magnitude, the more significant the

[205] Gurland, J., and T. Ram C. "A Simple Approximation for Unbiased Estimation of the Standard Deviation," *The American Statistician*, 1971, 25(4), 30–32.

[206] Gosset, W. S., "On the error of counting with haemacytometer," *Biometrika*, 1907, 5(3), 351–360.

variable is. We rarely or ever conduct inference in the constant term. The *p*-value will help us determine whether the coefficient is significant or not.

So, the $t_1 = 2.996166/1.330477 = 2.2519$ is the standardized coefficient, and the *p*-value indicates how extreme this coefficient is if indeed the population coefficient was zero. The initial hypothesis is that each of these coefficients at the population level is zero[207]. We start with the assumption that there is no effect of these variables into inflation, and on the other side, we get the sample values. The *p*-value tells us approximately how likely it is to be zero[208]. Let's have a look at a simple theoretical diagram in Figure 19. If the null hypothesis were zero, we would expect a *t*-statistic zero, but it could be any around zero due to the random selection. The *t*-distribution shows us the distribution of potential *t* value[209]. The standardized *t* value for the logarithmic value of seasonally adjusted aluminum expressed in euros is 2.2519, while the *p*-value tells us the value beyond the curves. The two-tailed areas equal to 0.026=2.6%. If the null hypothesis is $b_1 = 0$, the chance of getting a sample as extreme as we did, $b_1 = 2.9961$ is 2.6%. We are happy to infer that $b_1$is not zero, and more than 95% of b_1 is under the bell curve in Figure 19. In other words, the logarithmic value of aluminum is related to inflation in Montenegro. This methodology would apply to other variables in the model.

More examination should be done in the specification, but allowing structural breaks and including appropriate dichotomous variables solved some fundamental residual problems. Therefore, this is a reasonable starting point to develop a forecasting model.

3.2. Vector autoregressive model of inflation in Montenegro

Christopher Sims (1980) says: "Large-scale do perform useful forecasting and policy-analysis functions despite their incredible identification; the restrictions imposed in the usual style of identification are neither essential to constructing a model which can

[207] Johnson N. L., K. Samuel. N. Balakrishnan., Continuous Univariate Distributions, Volume 1, 2nd ed. United Kingdom: John Wiley & Sons, 1994.

[208] Lüroth, J., "Vergleichung von zwei Werten des wahrscheinlichen Fehlers," *Astron. Nachr.*, 1876, 87(14), 209–20.

[209] Helmert, F. R., "Über die Berechnung des wahrscheinlichen Fehlers aus einer endlichen Anzahl wahrer Beobachtungsfehler," *Z. Math. U. Physik*, 1875, 20, 300–3.

perform these functions nor innocuous; an alternative style of identification is available and practical."[210] Models being used from the 1960s, because the latter imposed many restrictions, were mostly not consistent with the notion that today's choices take into account the effect of tomorrow's utility by economic agents[211]. Sims (1980) continues arguing that the identification of the previous models is inappropriate and cannot be taken seriously, which became known as Sim's Critique[212]. Since then, VARs have been used for macroeconomic forecasting and policy analysis to investigate the sources of business-cycle fluctuations and provide a benchmark against which modern dynamic macroeconomic theories can be evaluated[213]. The VARs are linear time-series models designed to capture the joint dynamics of multiple time series[214].

Since no variable can be deemed as exogenous from forward-looking agents, all endogenous variables in the system are treated as a function of lagged values of all endogenous variables.[215] According to Sims, macroeconomic models could be designed without imposing strong restrictions and pretending to have a priori theory[216]. The VARs make theoretical identifying restrictions much more precise than models that were prevalent until the '60s[217]. The goal of the VARs is forecasting and policy projections[218].

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[210] Sims, C. A., "Macroeconomics and Reality," *Econometrica*, 1980, 48(4), 1–48.

[211] Pecican, E. St., Forecasting Based on Open VAR Model," *Romanian journal of economic forecasting*, 2010, 13(1), 59-69.

[212] Christiano, L. J., "Christopher A. Sims and Vector Autoregressions," *Scand. J. of Economics,* 2012, 114(4), 1082–1104.

[213] Del Negro, M. and F. Schorfheide., "Priors from Equilibrium Models for VARs," *International Economic Review* 2004, 45, 643–673.

[214] Del Negro, M. and F. Schorfheide., "Monetary Policy with Potentially Misspecified Models," *American Economic Review,* 2009, 99(4), 1415-1450.

[215] Sims, C. A., "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered," *American Economic Review,* 1980, 70(2), 250–257.

[216] Sims, C. A., "Are Forecasting Models Usable for Policy Analysis?," *Federal Reserve Bank of Minneapolis Quarterly Review,* 1986, 10 (1), 2–16.

[217] Sims, C. A., "Models and Their Uses," *American Journal of Agricultural Economics,* 1989, 71, 489–494.

[218] Stock, J. and M. Watson., "Vector Autoregressions," *Journal of Economic Perspectives*, 2001, 15, 101–115.

Forecasts obtained from VAR models are, in most cases, better than those obtained from the far more complex simultaneous equation models[219]. Asteriou and Hall (2016)[220] take two stationary simultaneous time series, y_t and x_t, affected by current and past values and respective white noise error terms u_{yt} and u_{xt}:

$$y_t = \beta_{10} - \beta_{12}x_t + \gamma_{11}y_{t-1} + \gamma_{12}x_{t-1} + u_{yt} \quad (58)$$
$$x_t = \beta_{20} - \beta_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}x_{t-1} + u_{xt} \quad (59)$$

Equations (58) and (59) have a contemporaneous impact on each other. The matrix algebra of the above two equations would look like:

$$\begin{bmatrix} 1 & \beta_{12} \\ \beta_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} \quad (60)$$

or:

$$\mathbf{A}\boldsymbol{z}_t = \boldsymbol{B}_0 + \boldsymbol{B}_1\boldsymbol{z}_{t-1} + \boldsymbol{u}_t \quad (61)$$

$$\mathrm{A} = \begin{bmatrix} 1 & \beta_{12} \\ \beta_{21} & 1 \end{bmatrix},\ \boldsymbol{z}_t = \begin{bmatrix} y_t \\ x_t \end{bmatrix},\ \boldsymbol{B}_0 = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix},\ \boldsymbol{B}_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix},\ \boldsymbol{z}_{t-1} = \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix}$$

$$\text{and } \boldsymbol{u}_t = \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} \quad (62)$$

Multiplying equation (61) by A^{-1} we get:

$$z_t = G_0 + G_1 z_{t-1} + e_t \quad (63)$$

following $G_0 = A^{-1}B_0$, $G_1 = A^{-1}B_1$, and $e_t = A^{-1}u_t$. G_0 is $(n * 1)$ vector of constants, G_1 is $(n * n)$ vector of coefficients, e_t is $(n * 1)$ vector of white noise[221] innovations. The rewritten VAR model looks as:

$$y_t = g_{10} + g_{11}y_{t-1} + g_{12}\,x_{t-1} + e_{1t} \quad (64)$$
$$x_t = g_{20} + g_{21}y_{t-1} + g_{22}\,x_{t-1} + e_{2t} \quad (65)$$

Equations (58) and (59) are structural VAR (SVAR), while (64) and (65) are reduced form VAR. Because we did not impose any restrictions and that residuals are not

[219] Brooks, C., *Introductory econometrics for finance*. Cambridge: Cambridge University Press, 2002.

[220] Asteriou, D., and S. G. Hall., *Applied econometrics, 3rd ed.* Basingstoke, United Kingdom: Palgrave MacMillan, 2015.

[221] The best-known generalized process is white noise, which can be thought of as a continuous time analogue to a sequence of independent and identically distributed observations.

orthogonal, equations (64) and (65) are reduced-form VAR[222]. Since $e_t = A^{-1}u_t$, errors e_{1t} and e_{2t}, in equations (64) and (65), are made up of two innovations u_{yt} and u_{xt}. White noise means that error terms are uncorrelated, so $E[e_t] = 0$ and finite variance[223]. An equation error term can be contemporaneously correlated with other equations' residuals but not correlated with their own lagged values and independent variables[224] (as in any specified regression). Therefore, the reduced-form innovations are not orthogonal, completely uncorrelated. The structure of the contemporaneous variance-covariance matrix is as follows:

$$E[e_t\ e_t'] = \begin{bmatrix} \delta_{e_1}^2 & \delta e_1 e_2 \\ \delta e_1 e_2 & \delta_{e_2}^2 \end{bmatrix} \tag{66}$$

where $\delta_{e_1}^2$ is the variance of the first variable, $\delta_{e_2}^2$ the variance of the second variable, and $\delta e_1 e_2$ denotes the contemporaneous covariance. For time t_0 and t_1 (not contemporaneous), however, the innovations need to be uncorrelated, and the variance-covariance matrix should be zero[225]:

$$E[e_{t_0}\ e_{t_1}'] = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \tag{67}$$

All equations have identical regressors, and estimates are consistent and efficient. The model we will estimate is parsimonious[226], meaning that we will include the lowest possible number of parameters in the VAR model because VARs are very parametrized[227].

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[222] Hamilton, J. D., *Time Series Analysis*. Princeton, New Jersey: Princeton University Press, 1994.

[223] Stein, M. L., *Interpolation of Spatial Data: Some Theory for Kriging. Springer Series in Statistics.* New York: Springer, 1999.

[224] Watson, M., "[Vector Autoregressions and Reality]: Comment," *Journal of Business and Economic Statistics*, 1987, 5, 451–453.

[225] Bernanke, B. and I. Mihov., "Measuring Monetary Policy," *Quarterly Journal of Economics,* 1998, 113, 869–902.

[226] Daganzo, C. F., V. V. Gayah, and E. J. Gonzales., "The potential of parsimonious models for understanding large scale transportation systems and answering big picture questions," EURO Journal on Transportation and Logistics, 2012, 1(1-2), 47-65.

[227] Blanchard, O. and R. Perotti, R., "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output," *Quarterly Journal of Economics,* 2002, 117, 1329–1368.

3.2.1. Estimation of the VAR model for the Montenegrin economy

Five variables will constitute our VAR model, as follows:

$$X_t = (alu\_sa_t, oil\_sa_t, inf_t, gdp\_gap_t, un\_sa_t, dum\_2009m06 - dum\_2011m03, dum\_2013m03, dum\_2013m10, dum\_2016m03) \quad (68)$$

The X_t is the vector, alu_t is the seasonally adjusted logarithmic aluminum price in euros, oil_t is the seasonally adjusted oil price in euros in logarithmic form, inf_t is the inflation expressed in percentage, gdp_gap_t[228] is the gap of gross domestic product, obtained by HP filtering log GDP, and un_t is the unemployment expressed in percentage and seasonally adjusted as well. As far as the dichotomous variables are described in the previous section. Key variables are oil and aluminum prices, which are included as exogenous variables to measure econometrically the impact of these shocks on inflation and the economy. Unemployment and gdp_gap will show the effect of corresponding shocks on other variables.

The sample period for the VAR will be starting from January 2006 till December 2017. Still, for estimation purposes, we will go from January 2006 till December 2015, and we will use the model to forecast inflation from January 2016 to December 2017. The onset will be our tool to assess whether our model can predict the actual inflation from 2016:01 onwards. The gdp_gap, inflation, and unemployment will capture the long-run path of inflation. At the same time, aluminum and oil prices, including dummy variables, will potentially explain the external short-run dynamic movements of inflation. Each column corresponds to one equation in the VAR. For example, the first equation is inflation, which is expressed as a function of its own 4 lags, the lags of *logaleur_sa, logoil_sa, gdp_gap, un_sa, constant,* and *dummy variables.* The process is applied to the other endogenous variables in the model. EViews calculates the coefficients, standard errors, and *t* statistics in brackets for each regressor. The coefficient of determination (R^2) is relatively high, but it is typical for VAR in levels[229]. We need to decide the number of lags that we want to use. Therefore, the specification issue is where we focus on in the

[228] Lipsey, R. G., K. A. Chrystal., *Economics, 11th ed.* Oxford, UK: Oxford University Press, 2007.

[229] Frost, J., *Regression Analysis: An Intuitive Guide for Using and Interpreting Linear Models*, ebook.

next paragraphs. Looking at the *t*-statistics of individual coefficients (in square brackets), it turns out that most coefficients are not statistically significant (one can use 2 as an approximate threshold for the 95% significance level). The phenomenon is also typical for VARs and should not cause concern. Usually, only the coefficients of the first own lag of each variable and maybe a few others are significant[230]. None of these results automatically implies that the VAR is good or bad, either from a statistical perspective or from an economic perspective[231]. More analysis needs to be done on checking the residuals' properties to find a statistically well-specified reduced form VAR[232]. Moreover, further investigation is also required to assess whether the VAR has meaningful implications from an economic perspective.

3.2.1.1. Stationarity of the VAR system

Establishing covariance-stationarity is vital in a VAR system[233]. It has important implications, such that the response to shocks gradually dies down, tending to zero in the long run. A vector process is said to be covariance-stationary if its first and second moments, $E[y_t]$ and respectively $E[y_t\, y'_{t-j}]$, are independent of the time *t*:[234]

$$y_t = c + \emptyset_1 y_{t-1} + \epsilon_t \quad (69)$$

$$y_{1t} = c_1 + \emptyset_{11}^{(1)} y_{1t-1} + \emptyset_{12}^{(1)} y_{2t-1} + \ldots + \emptyset_{1N}^{(1)} y_{Nt-1} + \epsilon_{1t} \quad (70)$$

$$y_t = c + \Phi_1[c + \Phi_1 y_{t-2} + \epsilon_{t-1}] + \epsilon_t \quad (71)$$

$$y_t = c + \Phi_1 c + \Phi_1^2 y_{t-2} + \epsilon_t + \Phi_1 \epsilon_{t-1} \quad (72)$$

$$y_t = \ldots \quad (73)$$

$$y_t = c + \Phi_1 c + \ldots + \Phi_1^{k-1} c + \Phi_1^k y_{t-k} + \epsilon_t + \Phi_1 \epsilon_{t-1} + \ldots + \Phi_1^{k-1} \epsilon_{t-k+1} \quad (74)$$

$$E[y_t] = \sum_{j=0}^{k-1} \Phi_1^j c + \Phi_1^k E[y_{t-k}] \quad (75)$$

[230] Blanchard, O. and D. Quah., "The Dynamic Effects of Aggregate Demand and Supply Disturbances," *American Economic Review,* 1989, 79 (4), 655–673.

[231] Chari, V. V., P. Kehoe, and E. McGrattan., "A Critique of Structural VARs Using Real Business Cycle Theory," Federal Reserve Bank of Minneapolis Working Paper 631.

[232] Luetkepohl, H., "Vector Autoregressive Models," EUI Working Paper ECO 2011/30.

[233] Pagan, A. R., and G. W. Schwert., "Testing for covariance stationarity in stock market data," *Economics Letters*, 1990, 33(2), 165-170.

[234] Rossi, E., and P. S. de Magistris., "Estimation of Long Memory in Integrated Variance," *Econometric Reviews*, 2014, 33(7), 785-814.

The value of this sum depends on the behavior of Φ_1^j as *j* increases. The expected value of the dependent variable does not depend on time. Moreover, the covariance of two expected values, let's say y_t and y_{t+j}, depends on the time lapsed *j*. In other words, a VAR system is stationary if the mean and variance of its variables are measurable and do not depend on time. If the VAR is stationary, all its components are stationary[235].

Rossi (2011) highlights that the VAR can be expressed in the following form[236]:

$$\left[I_N - \Phi_1 L - \ldots - \Phi_p L^p\right] y_t = c + \epsilon_t \quad (76)$$

$$\Phi(L) y_t = c + \epsilon_t \quad (77)$$

with

$$\Phi(L) = \left[I_N - \Phi_1 L - \ldots - \Phi_p L^p\right] \quad (78)$$

$\Phi(L)$ $(N\ x\ N)$ matrix polynomial in L. Where $y_{t-1} = Ly_t, y_{t-2} = L^2 y_t, etc,$ and I_N stands for the identity matrix. The polynomial in the lag operator, Φ of (L), must be invertible for the VAR to be stationary. Setting the polynomial to 0 and replacing the lag operator L by g, we get:

$$\left[I_N - \Phi_1 g - \ldots - \Phi_p z^p\right] \quad (79)$$

The characteristic polynomial is defined as:

$$\Phi(L) = \left[I_N - \Phi_1 g - \ldots - \Phi_p z^p\right] = 0 \quad (80)$$

Therefore, the VAR is stationary if all the *np* roots of the polynomial are outside the unit imaginary circle, greater than 1 in absolute value[237]. If one of the values, e.g., g = 1 or -1, then the VAR is integrated of higher-order, 1 or above[238]. We should notice that

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[235] Brooks, Ch., *Introductory Econometrics for Finance, 3rd ed.* Cambridge, United Kingdom: Cambridge University Press, 2014.

[236] Rossi, E., and P. S. de Magistris., "Indirect inference with time series observed with error," *Journal of Applied Econometrics*, 2018, 33, 874-89.

[237] Pankratz, A., *Forecasting with Dynamic Regression Models*. Hoboken, NJ: John Wiley & Sons, 1991.

[238] Glaister, S., *Mathematical Methods for Economists*, 3rd ed. Oxford, UK: Blackwell, Oxford, 1984.

EViews calculates the inverse roots of the characteristic polynomial ($\lambda = \frac{1}{g}$), for example, based on the equation:

$$\left[I_n\lambda^p - \Phi_1\lambda^{p-1} - \ldots - \Phi_p \right] = 0 \tag{81}$$

lying within the unit imaginary circle. Any mean zero covariance-stationary process y_t can be represented as a sum of all the past white noise shocks[239]:

$$y_t = \sum_{j=0}^{\infty} \theta_j \epsilon_{t-j} + \eta_t \tag{82}$$

and θ is the matrix of coefficients, describing the responses over time of each endogenous variable to the sequence of shocks ϵ_t.

3.2.1.2. Lag length specification of the VAR

The lag specification is crucial in a VAR system. The determination of the lag length is a critical element in the specification of VAR models[240]. Braun and Mittnik (1993) emphasize the inconsistency of a misspecification VAR model[241]. Lütkepohl (1993) indicates that overfitting causes an increase in the VAR's mean-squared forecast errors and that underfitting the lag length often generates autocorrelated errors[242]. Hafer and Sheehan (1987) find that the accuracy of forecasts from VAR models varies substantially for alternative lag lengths[243]. Overfitting is very problematic because, as we estimate many coefficients, it might, for example, just like in our case with a moderate range of data, be that the coefficients are quite poorly estimated. Meanwhile, we have to be careful

[239] Cochrane, J. H., *Time Series for Macroeconomics and Finance.* UK: Spring, 1997, 2005.

[240] Ozcicek, O., and D. McMillin., "Lag length selection in vector autoregressive models: symmetric and asymmetric lags," *Applied Economics*, 1999, 31(4), 517-524.

[241] Braun, P. A. and S. Mittnik., "Misspecifications in Vector Autoregressions and Their Effects on Impulse Responses and Variance Decompositions," *Journal of Econometrics*, 1993, 319-41.

[242] Lütkepohl, H., "Testing for causation between two variables in higher dimensional VAR models," *in* H. Schneeweis & K. F. Zimmermann (eds), *Studies in Applied Econometrics*, Physica, Heidelberg, pp. 75–91.

[243] Hafer, R. W., and R. G. Sheehan., "On the Sensitivity of VAR Forecasts to Alternative Lag Structures," Federal Reserve Bank of St. Louis Working Paper 1987-004A.

since this might lead us to omit important variables and consequently miss essential dynamics of Montenegro's inflation model. Thus, we have to find the golden middle.

In the process of selecting the appropriate number of lags in a VAR model, the Akaike information criterion (AIC), Schwarz information criterion (SC), and Hanna-Quinn information criterion (HQC) are employed in the following model[244]:

$$AIC(k) = ln\left|\widehat{\sum_k}\right| + \frac{2}{T} m^2 k \quad (83)$$

$$SC(k) = ln\left|\widehat{\sum_k}\right| + \frac{lnT}{T} m^2 k \quad (84)$$

$$HQC(k) = ln\left|\widehat{\sum_k}\right| + \frac{2ln(lnT)}{T} m^2 k \quad (85)$$

Hayashi (2000) highlights that the number of lags, minimizing the values of these criteria, can be assumed as the optimum, conditioned that the model is free of autocorrelation and that residuals are typically spread out[245]. Practitioner's advice (as a guide to assist in deciding for the optimum number of lags (variables) in a VAR), is to use 12 lags when working with monthly data and as a practical constraint $np < \frac{T}{3}$: T representing the sample size, n the number of variables, and p number of lags of the VAR.

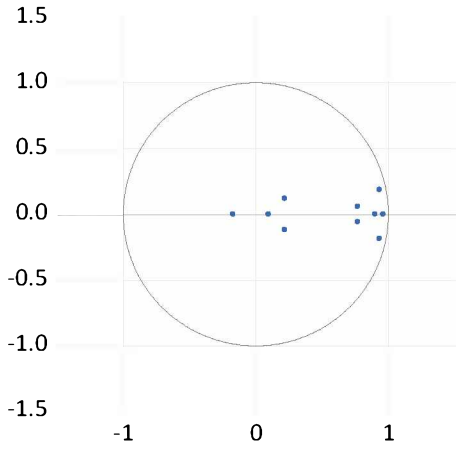


Figure 20: Inverse roots of AR characteristic polynomial
Source: Author's calculations in EViews 11.

[244] Hendry, D. F., *Dynamic Econometrics*. Oxford: Oxford University Press, 1995.

[245] Hayashi, F., *Econometrics*. Princeton: Princeton University Press, 2000.

Table 11: VAR lag order selection criteria

Endogenous variables: LOGOIL_SA LOGALEUR_SA UN_SA GDP_GAP INF
Exogenous variables: C DUM_2009M06_AL DUM_2011M03_AL DUM_2013M07_AL DUM_2013M10_AL
Sample: 2006M01 2015M12
Included observations: 108

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-374.4466	NA	0.001123	7.397160	8.018024	7.648898
1	181.1858	1008.370	6.08e-08	-2.429367	-1.187640	-1.925892
2	263.8264	142.3254	**2.10e-08***	-3.496786	**-1.634194***	**-2.741572***
3	289.2848	41.48773	2.11e-08	-3.505274	-1.021819	-2.498323
4	303.5246	21.88715	2.63e-08	-3.306012	-0.201693	-2.047323
5	318.3429	21.40423	3.28e-08	-3.117462	0.607720	-1.607036
6	344.8121	35.78236	3.35e-08	-3.144668	1.201378	-1.382505
7	358.1235	16.76251	4.43e-08	-2.928213	2.038697	-0.914311
8	391.0807	38.45012	4.16e-08	-3.075569	2.512204	-0.809930
9	412.5043	23.01050	4.97e-08	-3.009339	3.199298	-0.491962
10	454.8210	41.53302	4.16e-08	-3.330018	3.499483	-0.560904
11	483.1948	25.22121	4.70e-08	-3.392497	4.057867	-0.371645
12	563.8971	**64.26288***	2.12e-08	**-4.424020***	3.647209	-1.151430

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's calculations in EViews 11.

Our model has 144 monthly observations suggesting that the number of variables in the VAR should not be larger than 4; in fact, 3 in case we used 12 lags.

Let us see the behavior of the stationarity of our VAR (2) inflation model. As we can see in Figure 20, all the inverse roots of the characteristic polynomial lie within the unit circle, confirming the VAR model's stationarity. We have reached significant results: based on the stationarity tests assessed so far, we can infer the validity of impulse response standard

errors[246][247]. The largest inverse root of our VAR model's characteristic polynomial is 0.960867, accrediting our assessment of the stationarity of the VAR model.

Having included 12 lags in the lag exclusion test about deciding the maximum number of lags to be employed in our VAR (2) model, we get Table 11. For each of the criteria, an appropriate lag length is denoted by an asterisk (*). In our VAR (2) model, the FPE, SC, and HQ suggest 2 lags as the fitting lag length, while AIC and likelihood ratio (LR) select 12 lags. Consistency is missing between different criteria, which might indicate the right number of lags. The dispersion of the results is too broad, and some criteria are allowing for more dynamics in the system, while the others are not suggesting such a wide gap of dynamics. Nevertheless, we keep proceeding with 2 lags, like the appropriate lag length for our VAR (2) model. Thus, we re-estimate the model.

3.2.1.3. Residual diagnostic checks of the VAR model

We emphasized earlier that u_t (**residuals**) must not be correlated (**white noise**) for a stationary VAR to be correctly specified[248]. In case errors are autocorrelated $E\{\varepsilon_t'\varepsilon_{t-s}\} \neq 0$ for some s, the estimator $\widehat{\beta_1}$ is unbiased, $E\{\widehat{\beta_1}\} = \beta_1$(but not in case if we include a lagged dependent variable), but the estimator of the coefficient standard error is no longer consistently, resulting in an unreliable *t*-statistic[249].

Table 12: VAR (2) residual covariance matrix

	INF	LOGAL	LOGOIL	UN_SA	GDP_GAP
INF	0.4863	0.0029	0.0072	-0.0457	0.0148
LOGAL	0.0029	0.0022	0.0012	-0.0017	0.0005
LOGOIL	0.0072	0.0012	0.0049	-0.0011	-0.0002
UN	-0.0457	-0.0017	-0.0011	0.087	0.0044
GDP_GAP	0.0148	0.0005	-0.0002	0.0044	0.0277

[246] Lütkepohl, H., "Asymptotic distributions of impulse response functions and forecast error variance decompositions of vector autoregressive models," *Review of Economics and Statistics,* 72: 116–125.

[247] Lütkepohl, H., and D. S. Poskitt., "Estimating orthogonal impulse responses via vector autoregressive models," *Econometric Theory,* 1991, 7, 487–496.

[248] Granger, C. W. J., "Some properties of time series data and their use in econometric model specification," *Journal of Econometrics,* 1981, 16, 121–130.

[249] Poskitt, D. S., and Lütkepohl, H., "Consistent specification of cointegrated autoregressive moving average systems," *Discussion Paper 54*, SFB 373, Humboldt-Universität zu Berlin, 1995.

Source: Author's calculations in EViews 11.

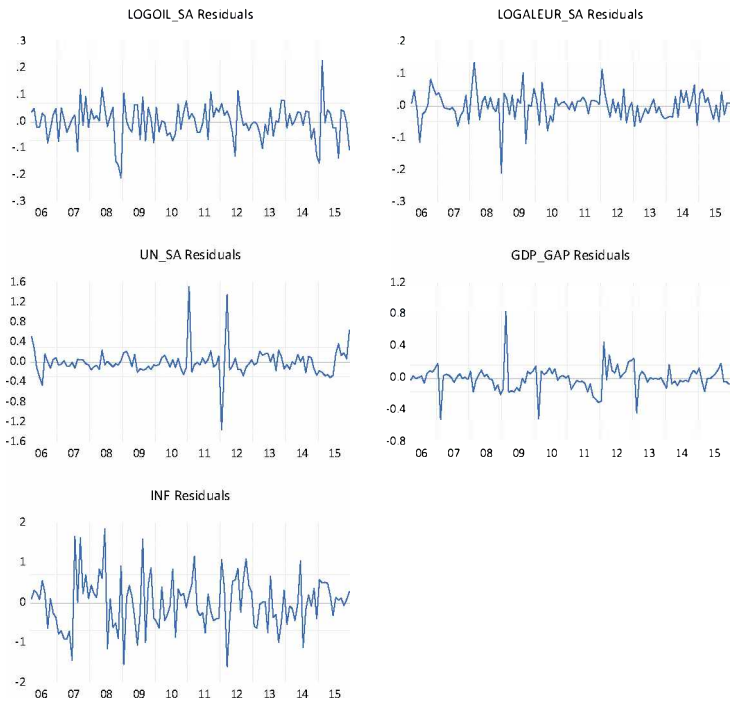


Figure 21: VAR (2) residuals
Source: Author's calculations in EViews 11.

Mean forecasting performance will worsen with the presence of autocorrelation of errors, and confidence bounds will be either too wide or too narrow[250].

Plotting the residuals in EViews 11, we get Figure 21. The first noticeable thing is that some residuals vary above and below the mean in specific periods, especially around the crisis episodes in 2008. The attributes inherent in and communicated by these residuals are valuable to us, and we have to keep them in mind since they produce specific effects[251]. Proceeding with the analysis, we get the covariance matrix of the residuals in Table 12. As long as the off diagonals are not zeros, there is autocorrelation among

[250] Box, G. E. P., and G. M. Jenkins., *Time Series Analysis: Forecasting and Control*, San Francisco: Holden-Day, 1976.

[251] Jarque, C. M., and A. K. Bera., "A test for normality of observations and regression residuals," *International Statistical Review,* 1987, 55, 163–172.

residuals[252]. Since we have not defined the shocks yet (which is the problematic issue, identifying the structural model), it is still expected to have errors correlated[253].

Exploring the properties of our VAR model's residuals, we get the correlogram of residuals of our VAR model, Figure 22.

Table 13: VAR residual serial correlation LM tests with 2 and 3 lags

	VAR with 2 lags		VAR with 3 lags	
Lags	LM-Stat	Prob	LM-Stat	Prob
1	34.08133	0.1062	21.59529	0.6590
2	**40.58314**	**0.0254**	21.72868	0.6514
3	18.75179	0.8089	27.85776	0.3144
4	18.15730	0.8356	18.23873	0.8321
5	26.71583	0.3702	26.35556	0.3888
6	22.76041	0.5916	18.15460	0.8358
7	34.42207	0.0992	35.18603	0.0849
8	26.38435	0.3873	34.28241	0.1020
9	19.58194	0.7684	16.74204	0.8909
10	20.38099	0.7266	26.95871	0.3580
11	25.48733	0.4353	16.67007	0.8934
12	69.78283	0.0000	53.05919	0.0009

Probs from chi-square with 25 df.

Source: Author's calculations in EViews 11.

Specified at 12 lags and with 2 standard error bounds, it shows the correlations of each variable with the others. For instance, in the first row, we see the autocorrelation of residuals among *inf* and the other variables, and so on. Looking at short term error correlations of the estimated VAR (2), practically at 1st lags, all the lines lie within the 2 standard error bounds suggesting no autocorrelation. Another back up to the suggestion of missing autocorrelation is non-noticeable continual wave sinusoidal. Continuing testing for residuals autocorrelation in our VAR model, we get Table 13.

[252] Del Negro, M., and F. Schorfheide., "Montetary Policy Analysis with Potentially Misspecified Models," *American Economic Review*, 99, 1415-1450.

[253] Den Haan, W. J., and Th. Drechsel., "Misspecification in Macroeconomics: Difficult but Not Impossible to deal with," Centre for Macroeconomics and London School of Economics and Political Science, 2019.

Based on the 95% significance level, the null hypothesis that there is no autocorrelation of residuals in our estimated VAR (2) model can be rejected with 2 lags, with p=2.54% for lag orders up to 2. But still, for orders up to 1, there is no indication based on the LM test that there is a correlation of errors. This finding suggests we should amend our VAR model with more lags, as indicated by AIC and LR. The estimated VAR (3) model with 3 lags suggests no autocorrelation based on the LM test, as seen in panel B of Table 13.

We choose to proceed with the VAR (3) model, as suggested by the LM test panel B in Table 13. The test indicates no autocorrelation of residuals for lag orders up to 11. The VAR (3) fitted to this data would have the form:

$$y_t = a_{11}^1 y_{t-1} + a_{12}^1 \pi_{t-1} + a_{13}^1 un_{t-1} + a_{14}^1 alu_{t-1} + a_{15}^1 oil_{t-1} + a_{11}^2 y_{t-2} + a_{12}^2 \pi_{t-2} + a_{13}^2 un_{t-2} + a_{14}^2 alu_{t-2} + a_{15}^2 oil_{t-2} + a_{11}^3 y_{t-3} + a_{12}^3 \pi_{t-3} + a_{13}^3 un_{t-3} + a_{14}^3 alu_{t-3} + a_{15}^3 oil_{t-3} + e_{1t} \quad (86)$$

$$\pi_t = a_{21}^1 y_{t-1} + a_{22}^1 \pi_{t-1} + a_{23}^1 un_{t-1} + a_{24}^1 alu_{t-1} + a_{25}^1 oil_{t-1} + a_{21}^2 y_{t-2} + a_{22}^2 \pi_{t-2} + a_{23}^2 un_{t-2} + a_{24}^2 alu_{t-2} + a_{25}^2 oil_{t-2} + a_{21}^3 y_{t-3} + a_{22}^3 \pi_{t-3} + a_{23}^3 un_{t-3} + a_{24}^3 alu_{t-3} + a_{25}^3 oil_{t-3} + e_{2t} \quad (87)$$

$$un_t = a_{31}^1 y_{t-1} + a_{32}^1 \pi_{t-1} + a_{33}^1 un_{t-1} + a_{34}^1 alu_{t-1} + a_{35}^1 oil_{t-1} + a_{31}^2 y_{t-2} + a_{32}^2 \pi_{t-2} + a_{33}^2 un_{t-2} + a_{34}^2 alu_{t-2} + a_{35}^2 oil_{t-2} + a_{31}^3 y_{t-3} + a_{32}^3 \pi_{t-3} + a_{33}^3 un_{t-3} + a_{34}^3 alu_{t-3} + a_{35}^3 oil_{t-3} + e_{3t} \quad (88)$$

$$alu_t = a_{41}^1 y_{t-1} + a_{42}^1 \pi_{t-1} + a_{43}^1 un_{t-1} + a_{44}^1 alu_{t-1} + a_{45}^1 oil_{t-1} + a_{41}^2 y_{t-2} + a_{42}^2 \pi_{t-2} + a_{43}^2 un_{t-2} + a_{44}^2 alu_{t-2} + a_{45}^2 oil_{t-2} + a_{41}^3 y_{t-3} + a_{42}^3 \pi_{t-3} + a_{43}^3 un_{t-3} + a_{44}^3 alu_{t-3} + a_{45}^3 oil_{t-3} + e_{4t} \quad (89)$$

$$oil_t = a_{51}^1 y_{t-1} + a_{52}^1 \pi_{t-1} + a_{53}^1 un_{t-1} + a_{54}^1 alu_{t-1} + a_{55}^1 oil_{t-1} + a_{51}^2 y_{t-2} + a_{52}^2 \pi_{t-2} + a_{53}^2 un_{t-2} + a_{54}^2 alu_{t-2} + a_{55}^2 oil_{t-2} + a_{51}^3 y_{t-3} + a_{52}^3 \pi_{t-3} + a_{53}^3 un_{t-3} + a_{54}^3 alu_{t-3} + a_{55}^3 oil_{t-3} + e_{5t} \quad (90)$$

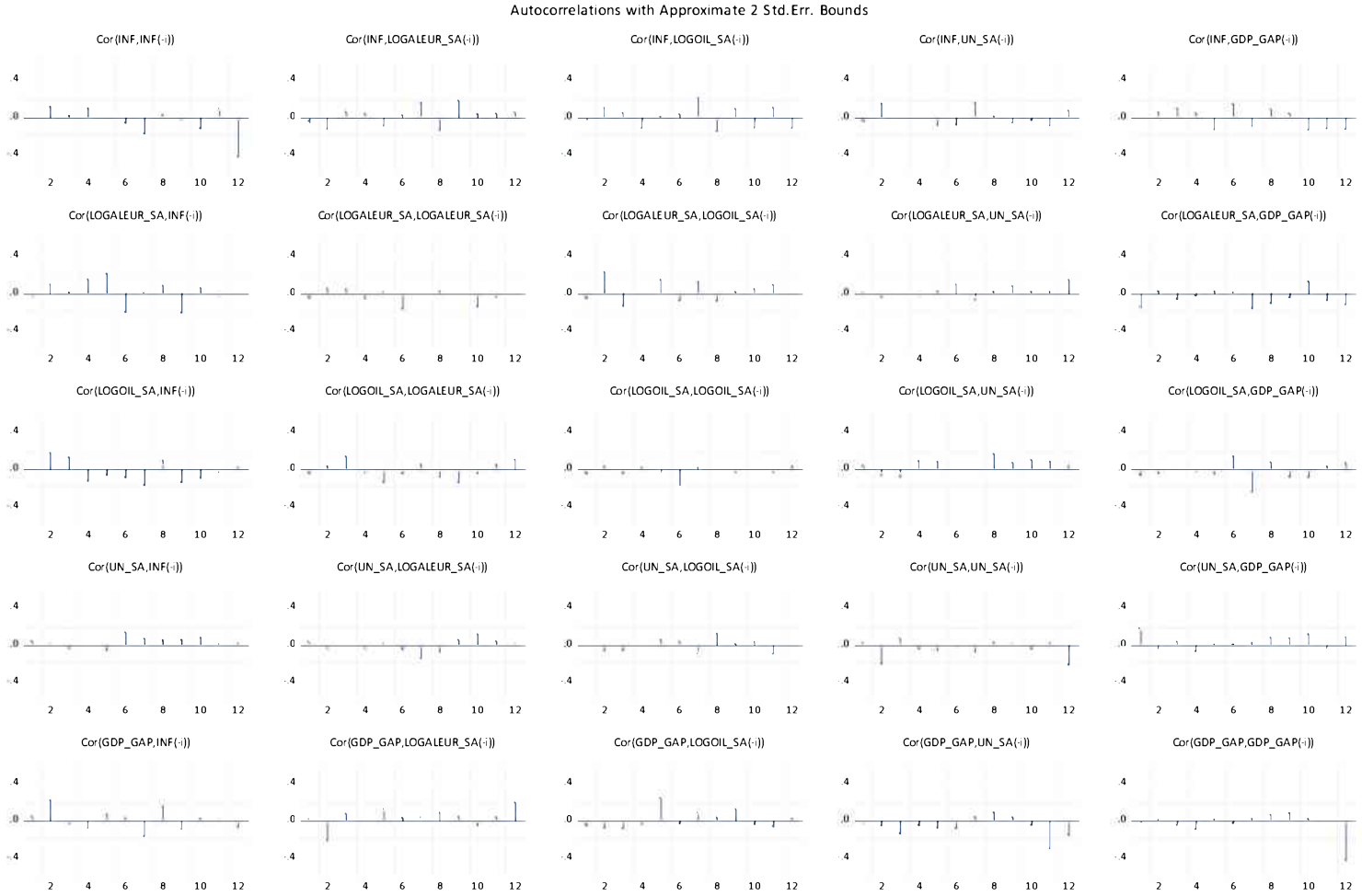


Figure 22: Correlogram specification-autocorrelations with 2 std.err. bounds
Source: Author's calculations in EViews 11.

Thus, from the New Keynesian perspective, we have chosen in the above model VAR (3) y_t, π_t, un_t, alu_t, and oil_t to analyze in-depth the above variables that might help macroprudential policymakers of Montenegro to understand better macroeconomic stabilization and outcomes by the government (using fiscal policy) and the central bank (using monetary policy).

3.2.1.4. VAR residual heteroscedasticity tests

The assumption of homoscedasticity states that the variance of the unobserved error, u, conditional on the explanatory variables, is constant[254]. Wooldridge (2013) explains that homoskedasticity fails whenever the variation of the unobserved factors change across different population segments, where the population segments are determined by the different values of the explanatory variables: if the errors are time-dependent, σ_t^2, then we deal with heteroscedasticity.

Let us consider a straightforward model of inflation in Montenegro with one lag to see heteroscedasticity's consequences in forecasting performance. For simplicity reasons, we will estimate a wrong model assuming the variance is constant. Still, in reality, it is heteroscedastic and a simple inflation model in Montenegro with generalized autoregressive conditional heteroscedasticity (GARCH) errors, which takes into account the time variance.

Table 14: One period ahead forecast assessment

Forecast evaluation

h=1	Correct (DGP) Model	Incorrect Model
RMSE	0.596938	0.607497
Bias	-0.106341	-0.105529
S.E.	0.616060	0.627461

**Forecasting period: 2017:2 2017:12*

Source: Author's calculations in EViews 11.

Moreover, we will compare the wrong and correct model in terms of forecasting performance. Based on the above results, we see RMSEs of the correct (0.5969) and incorrect model (0.6074) in one period ahead. The forecasting performances are not

[254] Wooldridge, J. M., *Introductory Econometrics: A Modern Approach*. Ohio: South-Western, 2013.

different a lot. While for the multiperiod ahead forecasting performance of our simple model, we can observe that the forecast standard error of the GARCH model is lower than the model that estimates the forecasting performance without considering the time variance dependency.

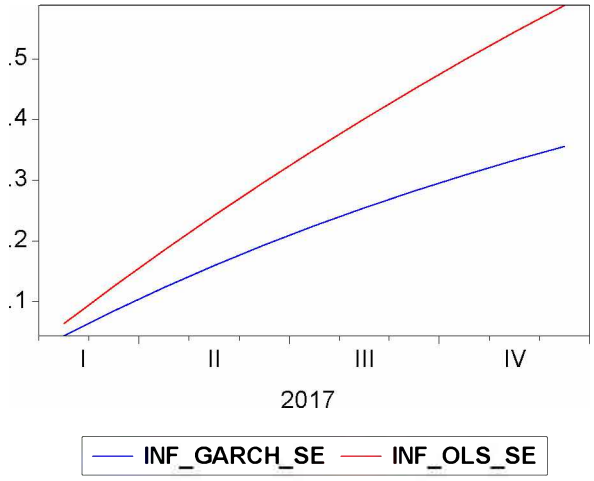


Figure 23: Multiperiod ahead forecasting performance of simple inflation model
Source: Author's calculations in EViews.

The estimates of confidence bounds in Figure 23 show that the model, which includes the GARCH errors, is more inclusive, tending to stabilize the interval of uncertainty. In contrast, the incorrect model tends to have confidence bounds to infinity, worsening forecasting performance uncertainty. The presence of heteroscedasticity does not impact the mean forecast[255]. Turning to our true VAR (3) model, there is one test that we will apply to test whether the residuals are heteroscedastic or not.

Table 15: VAR residual heteroscedasticity tests: no cross-terms

Chi-sq.	df	Prob.
628.3370	510	0.0003

Source: Author's calculations in EViews 11.

Since the p=0.0003, we can reject the null hypothesis of homoskedasticity. Heteroscedasticity does not affect model forecasting performance in terms of the mean forecast, as seen in Figure 24. However, if we decide to account for heteroscedasticity,

[255] Park, R.E., "Estimation with Heteroscedastic Error Terms," *Econometrica*, 1966, 34(4), 888.

we would need to reformulate our model as a system and use multivariate GARCH specification to model the variance-covariance matrix.

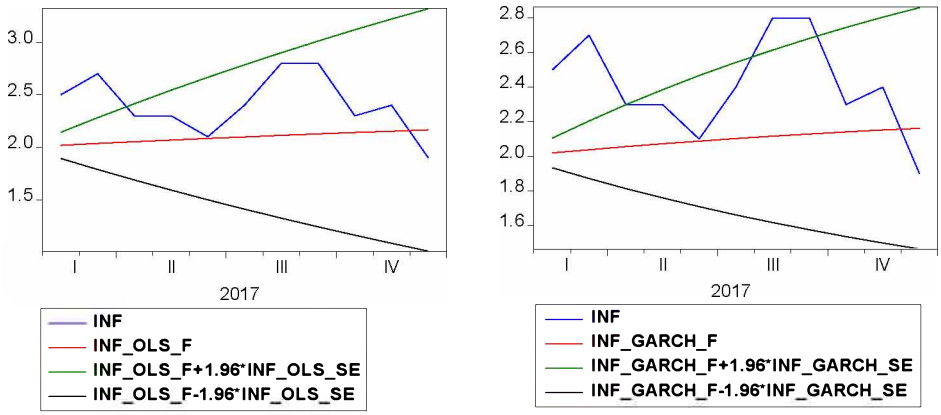


Figure 24: Mean forecast and 95% confidence intervals: Incorrect (OLS) vs. Correct (GARCH)

Source: Author's calculations in EViews 11.

3.2.1.5. VAR residual normality test

The presence of heteroscedasticity in our residuals from the previous findings may lead us to anticipate that there might be problems with the normality of residuals. Normality means no skewness, and expected residuals are not leptokurtic[256].

$$\widehat{\varepsilon_t} = y_t - \widehat{\beta_0} - \widehat{\beta_1} x_{1t} - \ldots - \widehat{\beta_k} x_{kt} \quad (91)$$

$$\hat{S} = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{\hat{\varepsilon_t}}{\hat{\sigma}}\right)^3 \quad \text{and} \quad \hat{K} = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{\hat{\varepsilon_t}}{\hat{\sigma}}\right)^4 \quad (92)$$

$$JB = \frac{T}{6}\left(\hat{S}^2 + \frac{(\hat{K}-3)^2}{4}\right) \quad (93)$$

No skewness means S is close to 0. No excess of kurtosis means – K is close to 3, leading Jarque- Berra test to 0. The skewness of *logaleur_sa* and *un_sa* seem to reject the normality hypothesis, and the kurtosis of *logaleur_sa*, *un_sa,* and *gdp_gap* as well. The joint statistic of the Jarque-Berra test is relatively high 966 with a *p*-value smaller than 5%; thus, we can reject the hypothesis that the residuals of our VAR model are normally distributed jointly. We notice an excess of K, but this is not the only cause. The skewness is also present.

[256] Thode, H. J., *Testing for normality*. New York: Marcel Dekker, 2002.

3.2.2. Forecasting performance of the estimated VAR (3) model

So far, we assigned, in the above cases, some numbers to the forecast performance, such as RMSE, Bias, and SE. To understand where they come from and how to interpret these statistics, we need to elaborate on these statistics to evaluate our estimated VAR model's forecasting performance. As seen previously, we estimated the model using the data from 2006:1 till 2015:12, while the remaining data from 2016:1 till 2017:12 will be used to evaluate out-of-sample forecast performance. We can never know the future, but we can use different econometric strategies and analyze the performance afterward. For example, we can never know if tomorrow the sun will rise, but we can use the past to forecast, inductively, that tomorrow the sun will rise in the morning. Our uncertainty forecast performance will be very low because we know with high certainty the time interval, the sun will rise in Montenegro. Another question here that raises is if we would like to see the temperature when the sun rises tomorrow in Montenegro. If we are close to the actual performance, then our forecast performance will be unbiased[257]. The time of rewriting this dissertation is November 2020, and to make good forecasting for the temperature when the sun rises in Montenegro, one needs to repeat often forecasting from the same model to draw sound reasonable conclusions. To make proper forecasting performance evaluation, we need to make daily forecasts for each day of March and then assess and evaluate the forecasting performance.

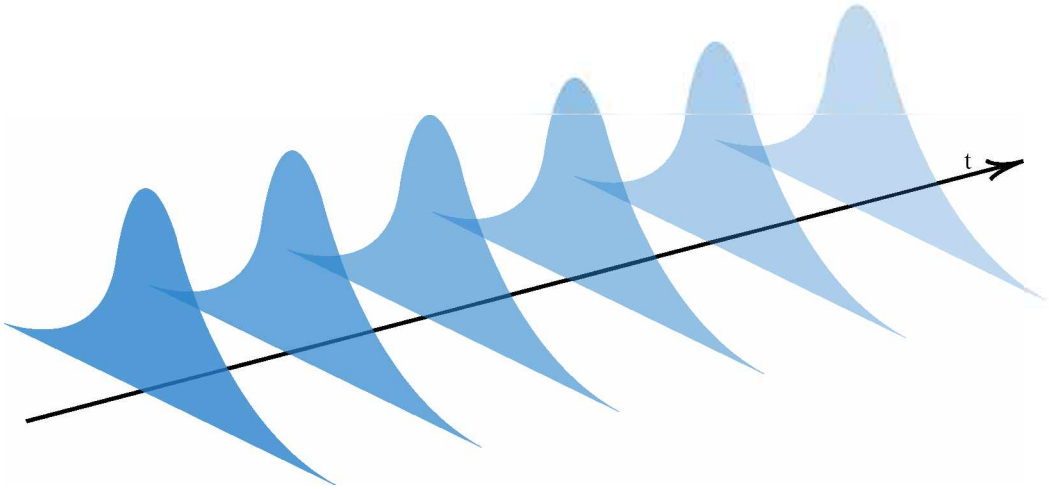
Each of our time series in the VAR model has a probability distribution, a random process. This randomness makes the prediction closely impossible to fit the actual outcome. We can assess the actual outcome and calculate the outcome number ratio to the total number of possible outcomes as a result of study and analysis. All our variables have a probability density function as long as they have an underlying data generating process (DGP)[258]. There can be different types of density functions, so econometricians do not deal with density functions but with models. The meaning of linearity is straight forward: a one-

[257] Dées, S. and J. Güntner., "Forecasting Inflation Across Euro Area Countries and Sectors: A Panel VAR Approach," *Journal of Forecasting*, 2016, 36, 431-453.

[258] Çınlar, E., *Probability and stochastics*. New York: Springer, 2011.

unit increase in variable *x*, $E\{y|x\}$, changes the conditional mean (the expected value) of *y* by β_1[259]. The distribution of *y* is centered about $E(y|x)$, as shown in Graph 4.

$$E(y|x) = \beta_0 + \beta_1 X + \varepsilon_t \quad (94)$$



Graph 4: Normal probability distribution

Source: Author's simulations.

The conditional means are used more frequently for modeling than density functions. The latter is more burdensome in terms of data. Even if we know all the proper variables that should be included to estimate the inflation in Montenegro, the errors should be white noise, meaning 0 mean, which in practice is not the case. The conditional mean and the error term determine the performance of the forecast to actual data[260]. The difference between the real data (actual) and the forecast is attributed to the distribution of true error terms. To the best of our knowledge capabilities, we cannot know the distribution of true error terms. As we expand the sample to infinity hypothetically, our best guess (even if we know all the required variables to estimate the inflation in Montenegro) is that the forecast errors are 0.

Each of the explanatory variables in our VAR model has its parameters, coefficients. These variables might probably have their explanatory variables within an equation,

[259] Draper N. R., and H. Smith., *Applied Regression Analysis, 3rd ed.* Wiley Series in Probability and Statistics. Hoboken, NJ: John Wiley & Sons, 1998.

[260] Tofallis, Ch., "A better measure of relative prediction accuracy for model selection and model estimation," *Journal of the Operational Research Society,* 2015, 66, 1352–1362.

including the error term. This phenomenon deduces to conclude that each of the variables increases the probability of uncertainty and widens the confidence interval in forecasting performance. In our case study, not only do we not know precisely the variables that should be included in the VAR in absolute terms, but there is time series for Montenegro that we cannot collect, such as real effective exchange rate, etc. Therefore, it is expected that the missing data will increase the uncertainty in our model[261]. The estimation of coefficients is based on random variables contributing to forecast error and uncertainty. Another source of forecast uncertainty is structural breaks[262]. Even though we included a fitting number of dummy variables, we proved that there are some areas left that could not be covered absolutely, increasing forecast uncertainty. Since the consumer price index (CPI) for Montenegro is available only from 2010, this increases forecast uncertainty due to not being able to manipulate with adequate ratios in the labor market, such as unit labor cost (ULC). Since labor productivity is not available, it is not possible to get to the ULC. So, we do not tempt to calculate ULC, but instead, we include unemployment coming due to price-setting and wage-setting relations. Because the random error is the difference between the actual value, y_t, and the estimation (the conditional mean), $\beta_0 + \beta_1 X$, the uncertainty is present in forecast error. Moreover, the unknown coefficients add to the forecast error together with the functional form. To conclude, there are many forecast uncertainty sources in our model that contribute to the forecast error. It is impossible to make a perfect prediction of inflation, and even if we do, we would be lucky.

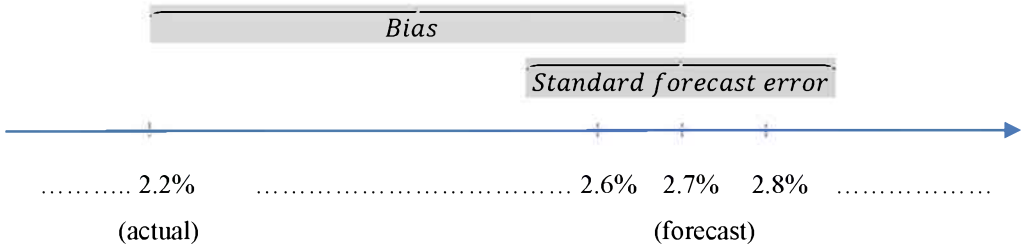
However, we need to quantify the forecast uncertainty of inflation. There is a set of econometric measures we will refer to evaluate our forecast performance. A forecast test can be computed to test that the model's structure has not been changed, but also the forecast quality of the model can be examined with measures of accuracy[263]. Bias is the first quantitative measure we will use, and it measures the difference between the actual results and the forecast. For example, if our true inflation rate is 2.2% and the forecasting

[261] Little, R., and R. Donald., *Statistical Analysis with Missing Data*. Hoboken: John Wiley & Sons, 2014.

[262] Tian, J., and Anderson, H. M., "Forecasting Under Structural Break Uncertainty," *International Journal of Forecasting*, 2014, 30(1), 161-175.

[263] Vogelvang, E., *Econometrics: Theory and Applications with EViews. Instructor's Manual*. Harlow, England: FT Prentice Hall (Pearson Education), 2005.

outcome is 2.7%, the difference of 0.5% is the bias as we can see in Graph 5. Standard forecast error measures the forecasting bands. If we say that, for example, the variance is narrow, varying from 2.6 – 2.8%, then the interval of error is not extensive, and the variation is acceptable.



Graph 5: Bias and variance in forecasting outcome
Source: Author's simulations.

If the error variance were from 2.5% to 2.9%, the forecast error variance would be broader, lowering accuracy. As we can notice it from Graph 5, the bias and variance overlap. A combination of the two gives us the third measure, mean squared forecast error[264] (MSFE). We will see down the lines that the MSE mathematically assumes both sides of the forecast symmetrically, and we must be careful in this case because we deal with inflation. The negative side of inflation means deflation, which is not symmetrical. In a large number of cases, it is more costly for a country than inflation. The most frequently used estimator for σ^2 is:[265]

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1} \quad (95)$$

$$Var[s^2] = \frac{2\sigma^4}{n-1} = MSE(s^2|\sigma^2) \quad (96)$$

Later, we will see when we perform the forecasting strategies that RMSE is very sensitive to data that jump out of its mean. For calculating the bias, it uses the average difference between the actual and the forecasting outcome. The calculation is seen in the other

[264] Wackerly, D., W. Mendenhall and R. L. Scheaffer., *Mathematical Statistics with Applications, 7th ed.* Belmont, CA, USA: Thomson Higher Education, 2008.

[265] Cho, E., and M. J. Cho., "Variance of Sample Variance with Replacement," *International Journal of Pure and Applied Mathematics,* 2009, 52(1), 43–47.

forecast evaluation statistics. However, EViews 11 uses root mean squared error (RMSE), the mean absolute error (MAE), and Theil's U statistics[266]:

$$RMSE = \sqrt{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}\left(Y_t - \widehat{Y_{f,t}}\right)^2} \quad (97)$$

$$MAE = \frac{1}{n_1}\sum_{t=n+1}^{n+n_1}\left|Y_t - \widehat{Y_{f,t}}\right| \quad (98)$$

$$U = \sqrt{\frac{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}(Y_t - \widehat{Y_{f,t}})^2}{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}Y_t^2}} \quad (99)$$

We do not see Bias, MSE, SE, mean percentage error (MPE), and Theil's U2 statistics in EViews. They might be treasured to draw correct conclusions about the meaning that stands behind the economic variables. The RMSE is particularly vulnerable to atypical calculations, but MAE is not susceptible to the outliers[267]. After we calculate our forecasting statistics, we need to compare it to a benchmark model. An ideal model that econometricians use is the *naïve* model or the so-called random walk model[268]. It assumes the variable will remain the same as the last period. If our model statistics are worse than that of the naïve model, it is a signal that our model forecast accuracy is poor. Besides, there is a tradeoff between the number of parameters and forecast accuracy. EViews adds two more statistics:

$$MAPE = \frac{1}{n_1}\sum_{t=n+1}^{n+n_1}\left|\frac{Y_t - \widehat{Y_{f,t}}}{Y_t}\right| \quad (100)$$

$$THEIL\ U1 = \frac{\sqrt{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}(Y_t - \widehat{Y_{f,t}})^2}}{\sqrt{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}Y_t^2} + \sqrt{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}\hat{Y}_{f,t}^2}} \quad (101)$$

We need to emphasize one thing here when calculating the MAPE in case of inflation in Montenegro. The MAPE forecast evaluation statistic can't be calculated in case the inflation is expressed as a percentage. Usually, the lower the error, the better the model,

[266] EViews, http://www.eviews.com/help/helpintro.html#page/content/series-Forecast_Evaluation.html, accessed, October 18, 2019.

[267] Kim, E., and B. H. S. Kim., *Quantitative Regional Economic and Environmental Analysis for Sustainability in Korea.* Singapore: Springer Nature, 2016.

[268] Clements, M. P., and D. F. Hendry., "Forecasting economic processes," *International Journal of Forecasting*, 1998, 14, 111–131.

considering all other facts and logical representation. The U1 statistic has the RMSE as the numerator, normalized by the actual and forecasted series' dispersion. The statistic of U1 lies between 0 and 1, 1 being the worst. There can be cases where U1 is smaller than its benchmark model but does not mean that it is better, making it not useful. In economic policy and forecast, Theil proposes the following formulae as a measure of forecast accuracy[269]:

$$THEIL\ U2\ = \frac{\sqrt{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}\left(\frac{Y_t - \widehat{Y_{f,t}}}{Y_{t-1}}\right)^2}}{\sqrt{\frac{1}{n_1}\sum_{t=n+1}^{n+n_1}\left(\frac{Y_t - Y_{t-1}}{Y_{t-1}}\right)^2}} \tag{102}$$

The U1 measures the forecast accuracy while the U2 measures the forecast quality. It compares the forecast to a naïve forecast, which is not reported by the EViews: it is a ratio of RMSEs. The smaller U2, the better forecast model, meaning the forecast method applied, is accepted since it beats the most straightforward no-change extrapolation of the naïve model. In the case of the U2=0, it means a perfect forecast. It can be shown that[270]:

$$MSE\ =\ SE^2 + Bias^2 \tag{103}$$

$$SE^2 = \left(s_y - s_{\hat{y}}\right)^2 + 2(1-r)s_y s_{\hat{y}} \tag{104}$$

where s_y denotes the standard deviation of actual data, $s_{\hat{y}}$ denotes the standard deviation of forecasted time series, and r is the correlation coefficient between actual and forecasted series. This break down is essential to be able to track the reason if MSE is high. From the above, we can get the bias proportion ($Bias^2/MSE$) telling us the distance of the mean forecast to the actual data mean. While the variance proportion ($\left(s_y - s_{\hat{y}}\right)^2/MSE$)) tells us how far the forecasted variance is from the original series variance. The ($2(1-r)s_y s_{\hat{y}}/MSE$), in equation (104), measures the covariance proportion. A right prediction has a small bias, and variance proportion with most of the error is concentrated

[269] Bliemel, F., "Theil's Forecast Accuracy Coefficient: A Clarification," *Journal of Marketing Research*, 1973, 10(4), 444-446.

[270] DeGroot, M. H., *Probability and Statistics, 2nd ed.* Boston, United States: Addison-Wesley, 1980.

in the covariance proportion, all summing to 1[271]. The above ratios are very valuable since they show us the measures and error concentration. The dispersion between bias and variance proportion can be crucial in determining the forecast's accuracy and structure for policy analysis since it pinpoints straight forward to the error. For example, if we find that a large proportion is concentrated in bias, it signals the gap between the forecast and the actual series. EViews uses observations from *1* to *T* to estimate a model and from *T+1* to *T+k* to evaluate forecast performance. For each period *T+1* till *T+k*, we get forecasts, and EViews averages these statistics, not letting us know precisely the prediction for each horizon. Based on average predictions, we can't evaluate the short-run or long-run performance of our VAR (3) model. To be more precise, we need measurements for each forecasting horizon to assess the performance. As long as the environment changes over time and economic stability cannot be guaranteed, we need different strategies to help us have measurements for different horizons. Two mechanisms to evaluate prediction horizons are rolling and expanding strategies[272]. The rolling window keeps rolling using a fixed size. The expanding approach expands the sample size. In case the forecast parameters change at some point during the sample, these strategies should capture the instability through RMSE, Bias, or SE. The time series is split into two subsamples.

Table 16: Rolling window forecast for $\widehat{inf}_t = \beta_0 + inf_{t-1} + \varepsilon_t$

HORIZON	h=1	h=2	h=3	h=4	h=5	h=6	h=7	h=8
Bias	-0.023	-0.019	-0.031	-0.055	-0.097	-0.121	-0.118	-0.112
MSE	0.680	1.369	2.060	2.970	4.064	5.310	6.325	6.991
RMSE	0.825	1.170	1.435	1.723	2.016	2.304	2.515	2.644
SE	0.825	1.170	1.435	1.722	2.014	2.301	2.512	2.642
MAE	0.625	0.901	1.161	1.405	1.703	1.908	2.106	2.267
MAPE	0.630	0.774	1.008	1.165	1.571	1.816	2.087	2.486

Source: Author's calculations in EViews 11.

The first is from *1* to *T,* and *h*-step ahead forecasts are made till *T+k* enabling forecasting errors. The starting sample is then either expanded or rolled forward by an increase, and

[271] Sharma, N. K., and M. Bicchal., "The properties of inflation expectations: Evidence for India," *EconomiA*, 2018, 19(1), 74-89.

[272] Levy, H., Levy, M. S. Solomon., *Microscopic simulation of financial markets: From investor behavior to market phenomena*. Orlando: Academic Press, 2000.

the sample is re-estimated until we reach the point of not being able to make more forecasts[273].

The approach brings us real error measurements of *h*-step ahead predictions[274]. These two strategies are not embedded in EViews. In Tables 15 and 16, we regress inflation on its first lag, applying *rolling* and *expanding* strategies to show the forecasting performance of an 8-step ahead forecast for 50 repeating samples. As the time horizon expands from 1 to 8, we notice that the error forecast performance of Bias, MSE, RMSE, SE, MAE, and MAPE gets worse. It is to be expected that the prediction accuracy will worsen since we are exposed to higher uncertainty in time. At some point, the conditional mean of this simple regression will stabilize. The second thing we notice is that rolling strategy has higher errors than expanding strategy, especially RMSE. The RMSE for the expanding strategy is 0.787, for h=1, while the rolling technique is 0.825. The expanding window uses more observations than the rolling or fixed window strategy, leading to a higher forecasting precision.

Table 17: Expanding window forecast for $\widehat{inf}_t = \beta_0 + inf_{t-1} + \varepsilon_t$

HORIZON	h=1	h=2	h=3	h=4	h=5	h=6	h=7	h=8
Bias	-0.131	-0.210	-0.298	-0.391	-0.496	-0.578	-0.627	-0.669
MSE	0.619	1.152	1.610	2.215	2.962	3.865	4.572	5.006
RMSE	0.787	1.073	1.269	1.488	1.721	1.966	2.138	2.237
SE	0.776	1.053	1.233	1.436	1.648	1.879	2.044	2.135
MAE	0.583	0.808	1.007	1.177	1.385	1.583	1.728	1.842
MAPE	0.596	0.680	0.874	1.009	1.384	1.625	1.870	2.252

Source: Author's calculations in EViews 11.

[273] Pesaran, M. H., and A. Timmermann., "Market Timing and Return Prediction under Model Instability," *Economic & Social Research Council*, 2002, Discussion Paper 412.

[274] Hyndman, R.J., and G, Athanasopoulos., *Forecasting: principles and practice*, *2nd ed.* Melbourne, Australia: OTexts, 2018.

3.2.2.1. Evolution of confidence interval – fan charts

To make a graphical representation of the evolution of confidence interval throughout the forecasting period, we will use a technique used by England's bank in their monthly inflation report – fan charts (Bank of England 2018). In a simple AR(1) model:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \varepsilon_t \qquad \varepsilon_{t\sim i.i.d.(0,\sigma^2)} \tag{105}$$

the forecast for one period ahead conditional on data up to t is:

$$\hat{y}_{t+1} = \beta_0 + \beta_1 y_t \tag{106}$$

and the forecasting error is: $FE_1 = \hat{y}_{t+1} - y_{t-1} = \varepsilon_{t+1}$ and variance of forecast error $Var(FE_1) = \sigma^2$. The confidence bounds at 2 standard errors, corresponding to a 95% confidence interval (1.s.e. corresponds $\approx$ 60% confidence interval), is $\beta_0 + \beta_1 y_t \pm 1.96\sigma$. As we proceed with forecasting periods ahead, the FE and $Var(FE_1)$ will get more significant than for one period ahead. It is expected to proceed into a more profound uncertainty of time, but the forecast error and its variance will stabilize after some periods. Therefore, the confidence bounds will expand as we move from period to the next. Usually, errors are not normally distributed, and we deal with bootstrapped errors, leading to an asymmetrical fan chart.

3.2.3. Forecasting the VAR model

Now, we turn to our VAR model moving ahead, describing the dynamic behavior of economic variables included in the model and forecasting. We will proceed with our VAR model for policy analysis and structural inference. One of our VAR model's primary objectives is predicting, and it has common characteristics as a univariate AR model. Zivot and Wang (2006) emphasize: "forecasting future values of a matrix Y_t when the Π parameters are assumed to be known, and there are no deterministic terms or exogenous variables, the best linear forecaster, in terms of minimum mean squared error (MSE), of Y_{t+1} or one-step forecast" is[275]:

[275] Zivot, E. and J. Wang., "Vector Autoregressive Models for Multivariate Time Series. In: Modelling Financial Time Series with S-PLUS," *Springer Science*, 2006, 385-429.

$$Y_{(T+1|T)} = c + \Pi_1 Y_T + \ldots + \Pi_p Y_{T-p+1} \quad (107)$$

and predictions for longer horizons *h* (*h*-step forecasts) are obtained using the *chain-rule of forecasting* as:

$$Y_{(T+h|T)} = c + \Pi_1 Y_{(T+h-1|T)} + \ldots + \Pi_p Y_{(T+h-p|T)} \quad (108)$$

Zivot and Wang (2006) proceed with providing the *h*-step forecast error, which may be expressed as[276]:

$$Y_{T+h} - Y_{(T+h|T)} = \sum_{s=0}^{h-1} \Psi_s \varepsilon_{T+h-s} \quad (109)$$

where the matrices Ψ_s are determined by recursive substitution[277]:

$$\Psi_s = \sum_{j=1}^{p-1} \Psi_{s-j} \Pi_j \quad (110)$$

with $\Psi_0 = I_n$ and $\Pi_j = 0$ for $j>p$.

Before continuing further, we need to mention that there are two ways of doing forecasting. The first is within the sample, which cuts the sample into two parts. The first part of the sample is used to make an estimation. The second part of the data that hasn't been included in the regression is employed for forecasting. The second option is to use all the data available and do out-of-sample forecasting. To make a forecast, we can employ known values or forecasted ones. Using the known values for prediction is *static* forecasting. We go back to the original data, ignore the previous forecast, and use actual value to generate the next prediction. This technique ignores any forecasting errors. In case we proceed using the forecasted values from regression, then it is *dynamic* forecasting. Here, if we continue to keep using the predicted values, we allow forecasted errors to increment. Under *fit* forecasting, it becomes relevant when we have more than

[276] Shephard, N., "Statistical Aspects of ARCH and Stochastic Volatility," in Cox D. R., D. V. Hinkley and O. E. Barndorff-Nielsen (eds), Time Series Models: *In Econometrics, Finance and Other Fields*. London: Chapman & Hall, 1996.

[277] Waggoner, D. F., and T. Zha., "Conditional Forecasts in Dynamic Multivariate Models," *Review of Economics and Statistics*, 1999, 81(4), 639-651.

one equation in a model, where each equation is treated individually without any interaction when generating a forecast.

Now, let us return to our preferred specification VAR (3) model. We can proceed with the equation object to do the *dynamic* and *static* forecasting, but it is limited, and we will use the model simulator.

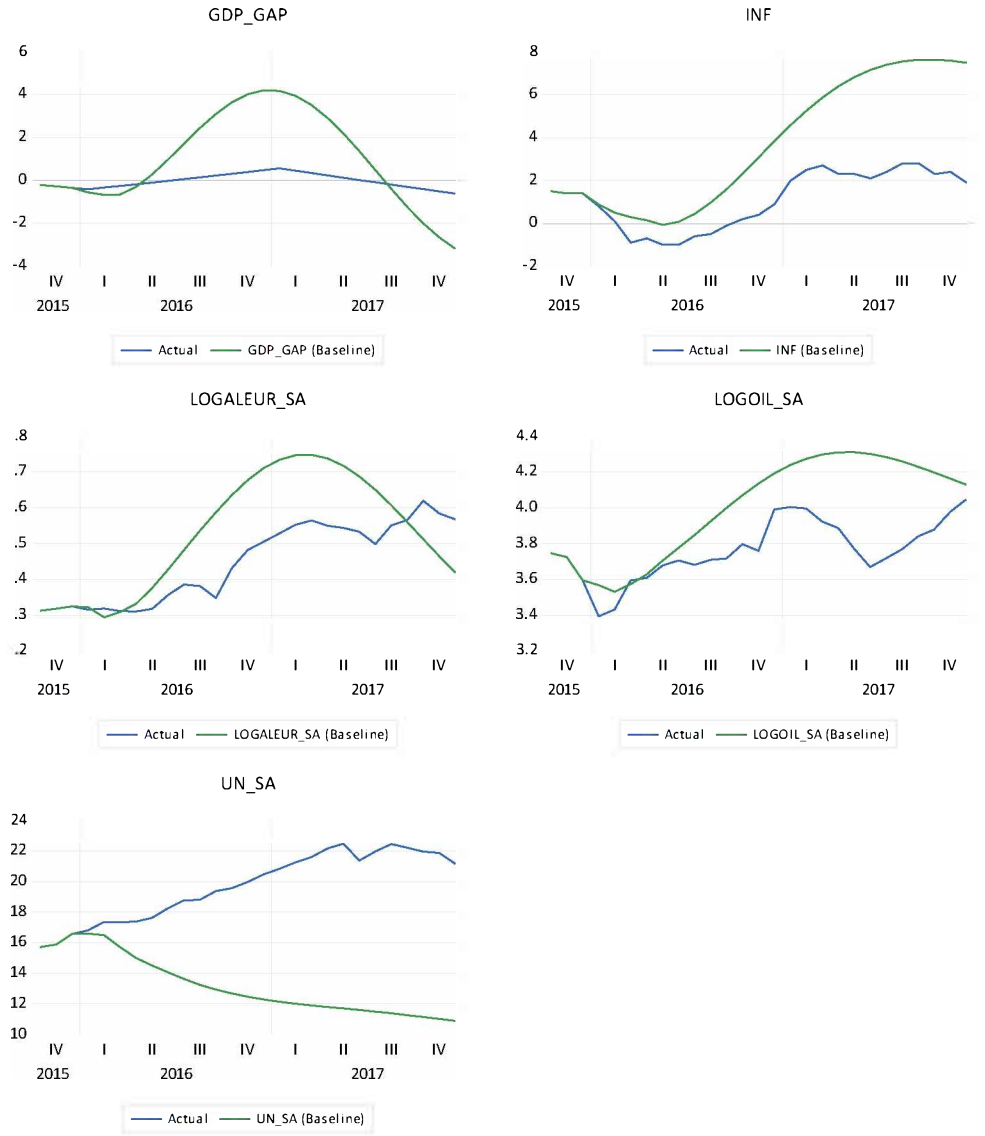


Figure 25: Dynamic solution – deterministic simulation
Source: Author's calculations in EViews 11.

There are two types of simulation processes. One is a *deterministic simulation*. We obtain only one value for the solution, which does not respond to shocks (yielding a single forecast rather than a distribution of possible values). It estimates under the current set of assumptions, without any innovations introduced, called the *baseline*.

We can add an alternative scenario where we change the premises of the forecast. For example, we might shock unemployment or aluminum by a 15% increase then see what happens to the forecast. The model object, or the solver, is a generalized forecasting mechanism. The model is solved for the forecast period of January 2016 till December 2017 for all endogenous variables.

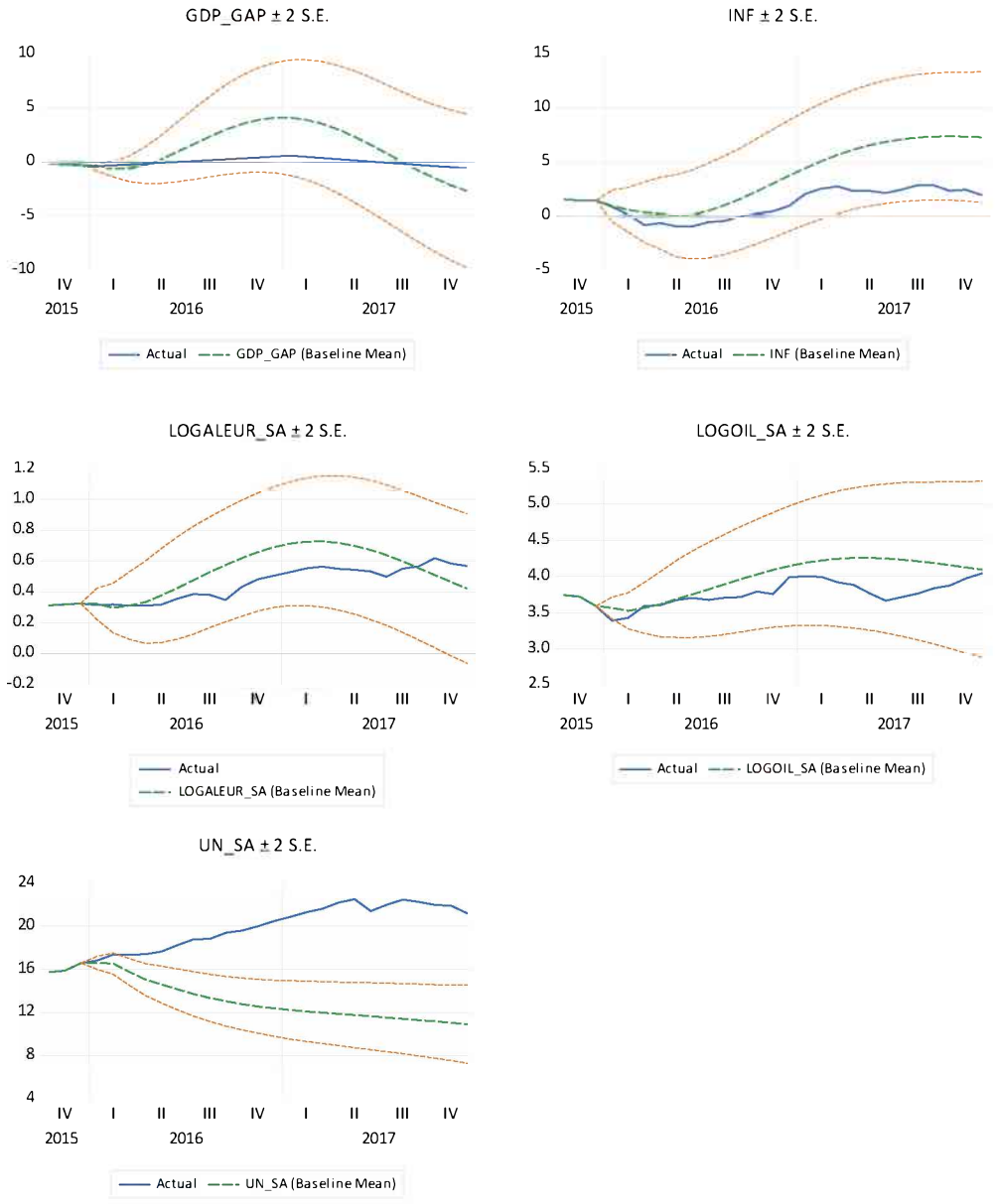


Figure 26: Dynamic solution – stochastic simulation
Source: Author's calculations in EViews 11.

Therefore, we now have one more baseline variable helping us to analyze the actual and forecasted values. Under dynamic solution – deterministic simulation, Figure 25 plots the actual values of all endogenous series and forecasts in light green. The first and imposing

thing that we can notice is that, even under the dynamic solution of the VAR model, inflation, aluminum, and oil have a right prediction, while gdp_gap and unemployment in the first quarter are doing well. Still, after that, the horizon of uncertainty expands. They start to deteriorate over time quite significantly. The model is not able to forecast unemployment, particularly.

A key consideration is that it should have the price-setting and wage-setting equations that determine Montenegro's natural unemployment rate. We have a dynamic solution, which uses only the endogenous variables' actual values before the forecast sample when producing the forecast. It uses the forecasted lagged values of the endogenous variables to solve forward for the forecast period; it deteriorates over time. It is not surprising that the forecast performance deteriorates at unemployment over time as well. While this initial forecast is deterministic, it assumes that our stochastic equations would hold "determined" over the period predicted. Because of random disturbances and estimated coefficients, the deterministic simulation ignores the fact that these relationships do not hold exactly. We should account for these uncertainty sources by using stochastic simulations. As seen in Figure 26, confidence bands are plotted in red. The first eye-catching thing is that the GDP gap, inflation, oil, and aluminum are within the confidence bands, taking into account the coefficient uncertainty, increased repetitions to 10,000, and bootstrap innovation generation.

Figure 27 is the stochastic simulation for the static solution model simulator for the period 2016m01 till 2017m12. To view the forecast with confidence bands, we propose to make a graphical representation. What can be noticed from Figure 27? The static solution performs better than the dynamic solution, both in terms of the fit and smaller standard error bounds. It comes as a result of de facto one period ahead forecast. It uses actual instead of forecasted lagged values over the forecast period. The whole picture has taken a better perspective with one period ahead forecast instead of a multi-period ahead forecast (dynamic).

To have a better view of the differences between simulation scenarios and solution types, we created Figure 28. What can be noticed? We can observe from Figure 28 that the stochastic-static model predicts way better the actual inflation than stochastic-dynamic because it uses the actual lagged values to forecast one-step ahead. The stochastic-

dynamic uses lagged forecasted values to forecast one-step ahead, accumulating errors and creating a gap widening deeper for each forecasted period ahead. The blue line represents the actual inflation, the black line shows the stochastic-static model's predicted values, and the smooth dark green line displays the stochastic-dynamic model. Until the middle of the second quarter of 2017, both models comove with actual inflation, and after that period, the gap starts to widen. But still, by the end of 2017, the confidence bands normalize and stabilize, as shown previously in the theoretical section of forecasting.

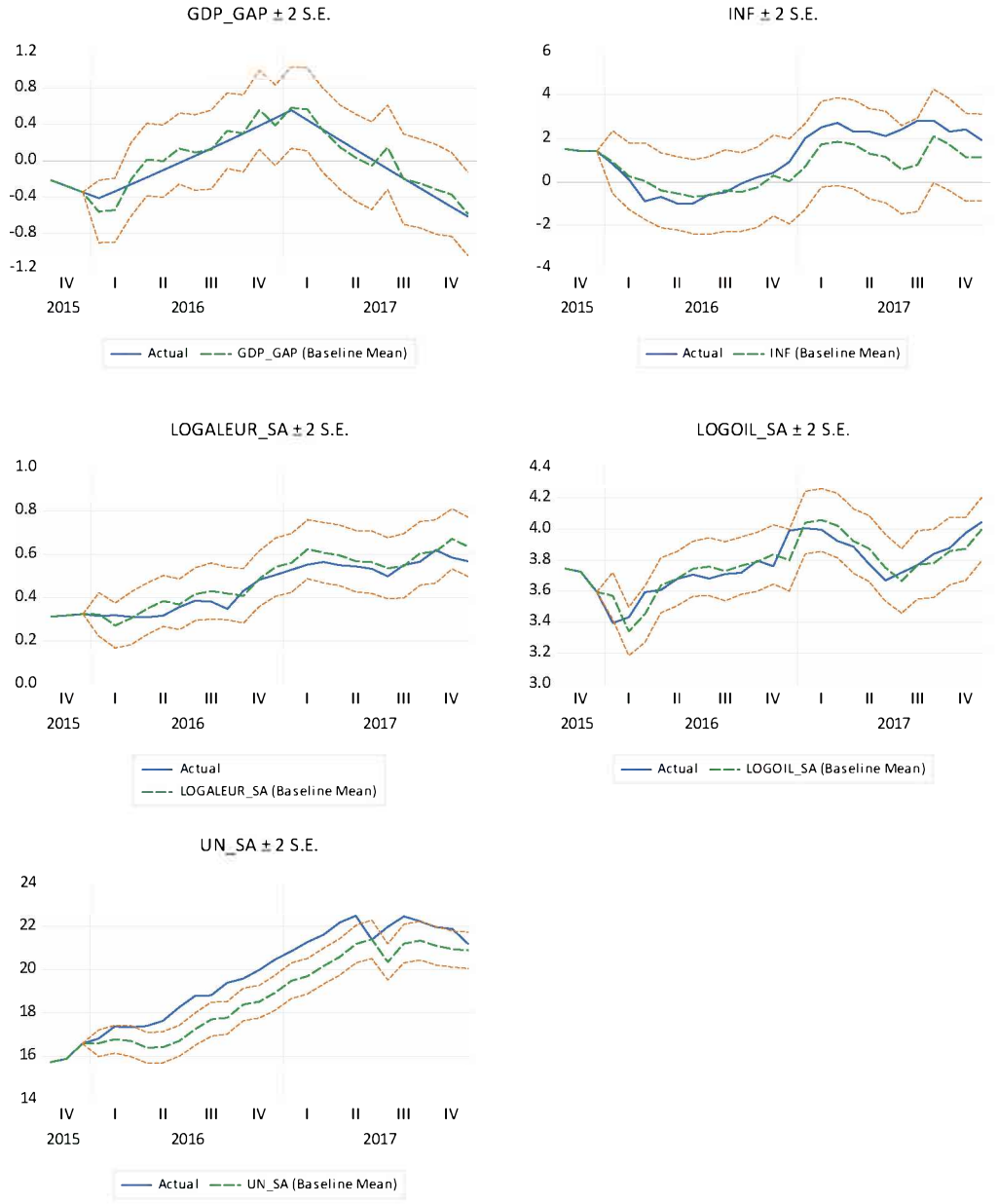


Figure 27: Static solution – stochastic simulation
Source: Author's calculations in EViews 11.

Figure 28 has included bootstrapped errors and coefficient uncertainty. In EViews, innovation generation controls how the errors are generated or re-sampled. It gives us the option of doing normal random numbers, in which case it draws from the normal distribution with mean zero and a particular variance one can set.

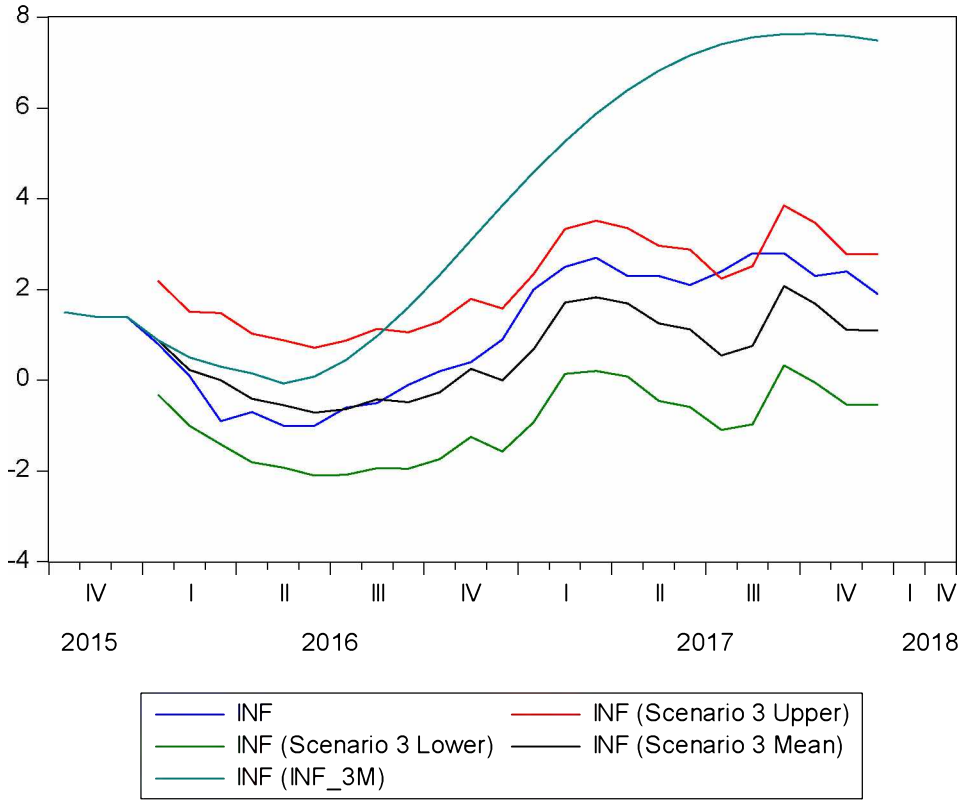


Figure 28: Stochastic-static and stochastic-dynamic of actual and forecasted values
Source: Author's calculations in EViews 11.

3.3. Alternative scenarios

The CBCG and the Ministry of Finance would be interested to hypothetically see the reaction of inflation in different scenarios, such as an increase in the price of oil, aluminum, or growth of gdp_gap into inflation. Why?

Even though this is not the determinate solution to the model, at this stage, we are interested in seeing the results of alternative forecasting scenarios. Let us observe how inflation changes when we change one of our variables' assumptions by some amount. We have created an alternative scenario solution to assess the increase of unemployment shock to inflation in Montenegro. The alternative scenario starts altering data from January 2016 till December 2017. Hypothetically, we increase unemployment from 1

point to 3.3, corresponding from 6.03% to 30.30%. In Figure 29, we compare the new alternative scenario in green, the baseline scenario in red, and the historical data in blue. Notice that unemployment is higher than before, as have specified it, and inflation is closer to the actual data.

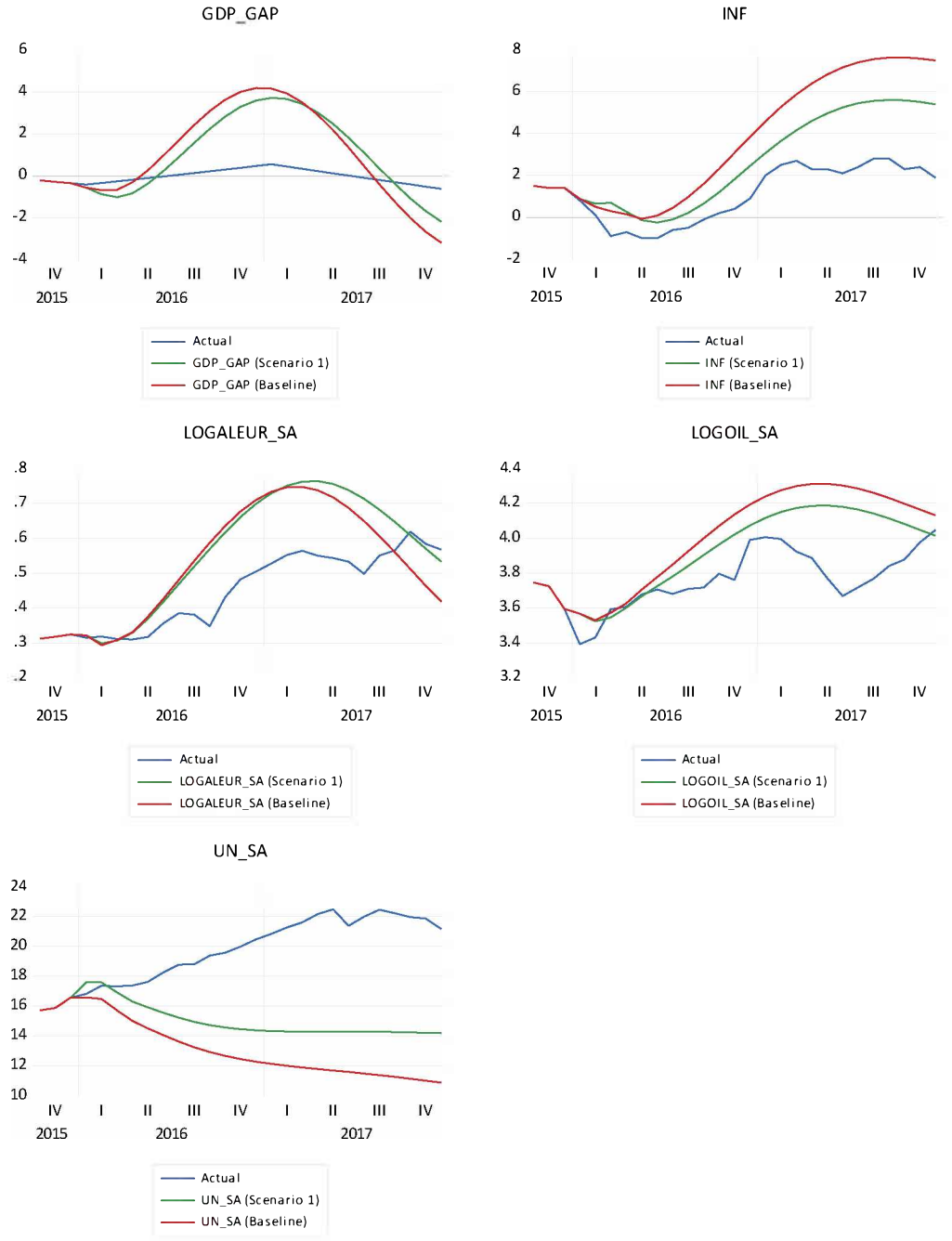


Figure 29: Deterministic – dynamic alternative scenario of unemployment increase
Source: Author's calculations in EViews 11.

One of the many reasons for higher unemployment might be, for example, higher unemployment benefits, as was the case in 2017 with early pensioned women with three

children. People who have more income are less interested in searching for a job, directly increasing wages and unemployment. The other factors that might affect the unemployment equilibrium are the shadow economy, letting firms have a higher potential impact on the market, and increasing prices. Furthermore, this means that the real wages paid by firms would decrease, consequently increasing unemployment. The facts in Figure 29 are consistent with the economic theory and real data, but it still does not say anything about causality. Usually, the VAR coefficient interpretation is not an easy process because there is no theoretical concept in economics that interprets them. It is recommended to move one step ahead and estimate impulse responses, giving us the causality.

Higher unemployment, meaning that the actual unemployment is higher than the natural rate, the output is below potential, and the output is negative[278]:

$$Y - Y_n = -L(u - u_n) \tag{111}$$

In our case, as unemployment increased in an alternative scenario, the output gap in the alternative scene, in the green line, is below the baseline line in red for the whole year of 2016. After the first quarter of 2017, the output gap gets higher. Once more, this does not show the causality of the relationship between inflation and unemployment. We need to move to impulse responses, which shows the response of inflation, the VAR's dependent variable, to shocks in the errors.

As a potential external factor, we have embedded an alternative scenario of the oil price increase. The reasons for such an increase are different, and it is beyond the scope of this study. In 2008, the global financial crisis led to a drop in demand and decreased oil prices. The Organization of Petroleum Exporting Countries (OPEC)[279], in the 1970s, controlled the oil industry and increased oil prices, while in 2000, China increased the oil demand. As a result, oil prices increased[280]. Causes for price increase might be many in the future,

[278] Ball, L., D. Leigh, and P. Loungani., "Okun's Law: Fit at 50?," *IMF Working Paper*, 2013, WP/13/10.

[279] The Organization of the Petroleum Exporting Countries (OPEC), *https://www.opec.org/opec_web/en/about_us/24.htm,* accessed, October 22, 2019.

[280] Baffes, J., M. A. Kose, F. Ohnsorge, and M. Stocker., "The Great Plunge in Oil Prices: Causes, Consequences, and Policy Responses," *World Bank Group, Policy Research Note*, /15/01, 2015.

as oil is the primary energy source for production. The logical question is: What would be the impact of an increase in oil price on the Montenegrin economy?

$$ULC = \frac{Wages}{Labour\ Productivity} \tag{112}$$

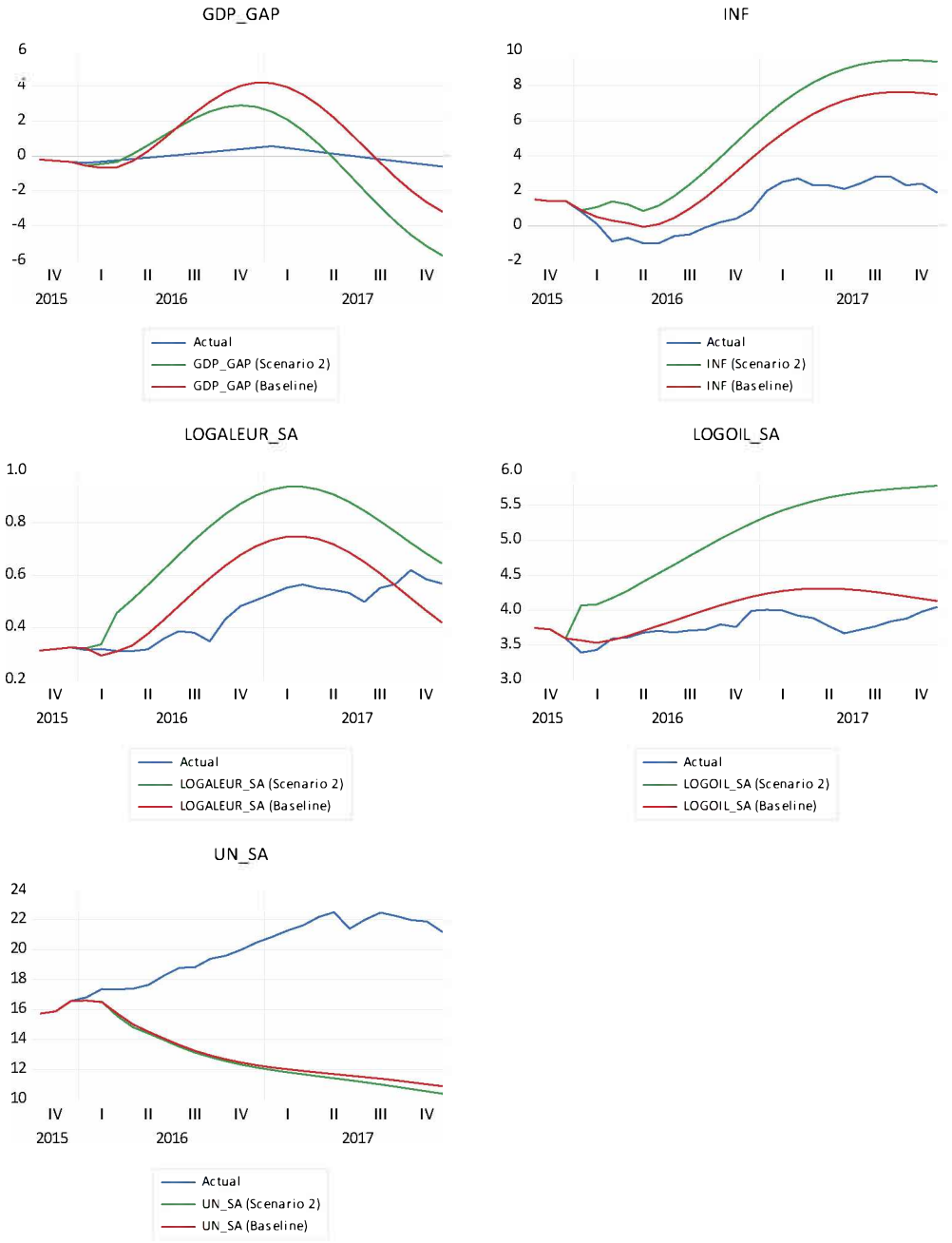
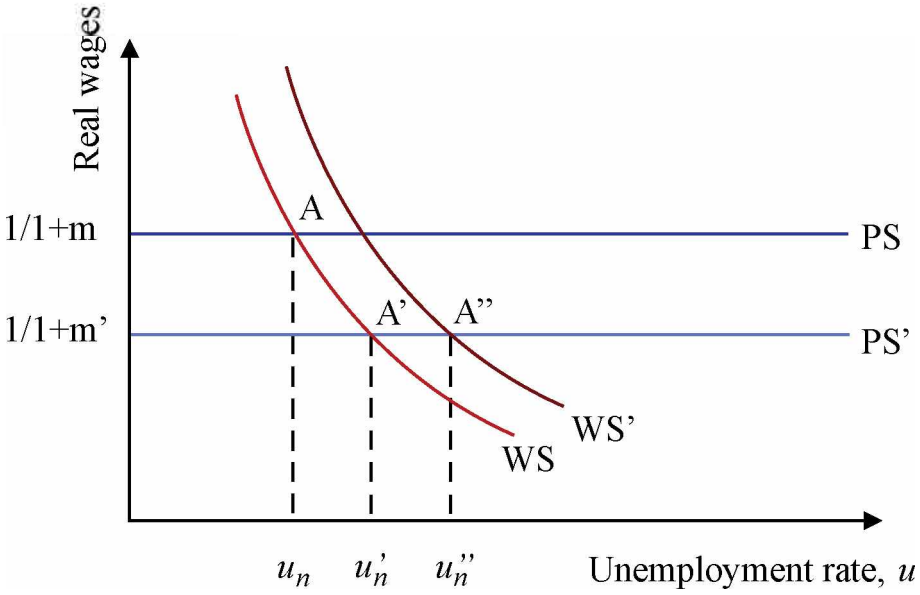


Figure 30: Deterministic – dynamic alternative scenario of oil price increase
Source: Author's calculations in EWiews 11.

A better way would have been as if we had the productivity price index and then see the effect of such an increase in the productivity price set by Montenegro's companies. The

result comes as a lack of time series of ULC as a determinant of unemployment rather than wages. The labor productivity at the time of writing is not available for Montenegro. Therefore, we consider the labor market equilibrium as the effect of the price-setting set by firms and wage-setting set by wage setters, which is unemployment[281]. The impact of oil price is multidimensional in Montenegro. It affects the production, consumers, government, investors, Tax Administration of Montenegro (TAM) through excise and taxes. The innovation of an increase in oil prices might come endogenously from fiscal policies due to fiscal consolidation. We can observe this from the side of firms that set prices on the relation with unemployment. The increase in oil prices increases production cost, pushing companies to raise rates to keep in an existing profit margin. The alternative scenario starts altering data from January 2016 till December 2017. Hypothetically, we increase oil prices from 0.5 points to 1.65, corresponding from 14.01% to 40.0%. As Figure 30 demonstrates, in the case of oil price increases, consumers do not have the same real value of money anymore.



Graph 6: Increase in oil price and unemployment
Source: Author's simulations.

Their real wages decrease, leading to a rise in unemployment because workers must accept this reality. GDP gap would decrease three-four months, and inflation would

[281] Blanchard, O., *Macroeconomics, 7th ed.* Harlow, UK: Pearson, 2017.

increase. In case we would like to characterize the behavior of unemployment, GDP gap, and inflation, it would be great to show their interconnectivity in a graphical format.

When confronted with a macroeconomic question about a shock or a policy, the income-spending, monetary - policy, and Phillips curve (IS-LM-PC) is a typical model to start the analysis and implications[282]. The horizontal line, PS, in Graph 6, represents the price-setting relation:

$$\frac{W}{P} = \frac{1}{1+m} \tag{113}$$

An increase in oil prices (markup m) pushes firms to increase prices, and consequently, real wages decrease. Suppose that the Ministry of Finance of Montenegro increases excise tax in oil prices, driving the market to increase its prices to maintain the marginal profit. The nominal wage we get paid does not change, but the power of our money in the market has changed since we can't buy the same consumption basket we could have purchased prior to the change. The higher the excise tax, the lower our real wages. The scheme is the interpretation of economic movement from PS to PS'. The simplifying assumption that labor returns are constant in production makes the PS line flat, but if the returns were decreasing, we would have a downward sloping curve. The opposite happened, for example, when the Government of Montenegro pensioned women with three kids in 2017. It increased the WS in Graph 6, moving the economy along the PS', shifting from WS to WS' – A", increasing the natural rate of unemployment. In case we analyze from a different perspective, labor market, we get labor supply and labor demand.

Having not in control the market of wages, it brings to scene a situation of a competitive market[283]. In this case, no cartels control the market, but everyone in the labor market participates individually, determining the market price, equilibrium[284]. Equilibrium means that all labor force in the market selects freely. For any other wage different from

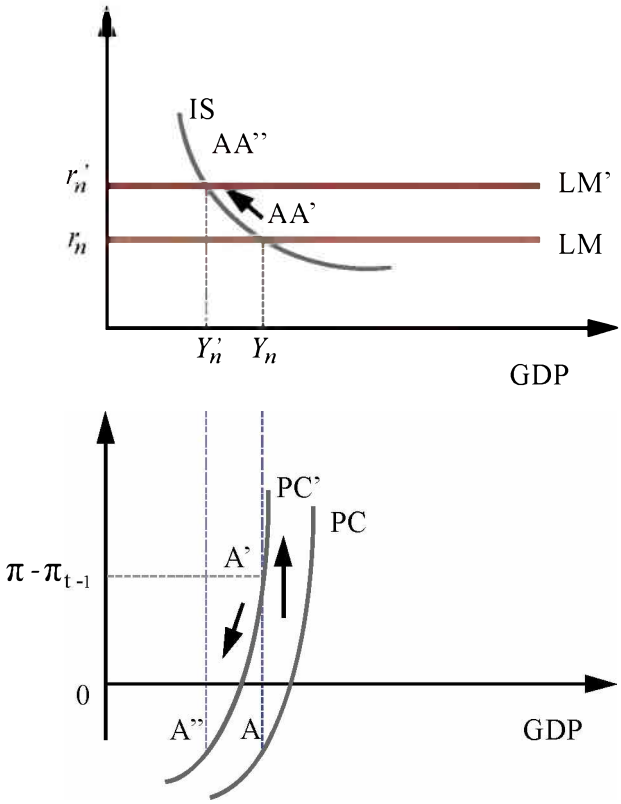
[282] Ibid.

[283] Leonard, J., "Wage Expectations in the Labor Market: Survey Evidence on Rationality," *Review of Economics and Statistics,* 1982, 64, 157–161.

[284] Staiger, D. O., J. Spetz, and C. S. Phibbs., "Is There Monopsony in the Labor Market? Evidence from a Natural Experiment," *Journal of Labor Economics,* 2010, 28, 211–236.

the equilibrium, some labor force would alter their behavior. It can't keep continuing for a long time because workers in the market are motivated to change their behavior.

The compatibility of the labor supply and demand is the optimal point. For wages that are lower than the equilibrium, firms' demand is higher than the workforce willing to offer work. It implies a labor force ready to offer work at a higher wage to the firms demanding the labor force. The dynamics will end up to the point where demand and supply are equal. For wages higher than the optimum, companies are unwilling to pay, driving down to the equilibrium. The competitive market will be at equilibrium only when the labor force equals the supply force.



Graph 7: IS-LM-PC equilibrium
Source: Author's simulations.

Increase of oil price, because excise tax, for instance, shifts the PS to PS' lowering the real wage from (W/P) to (W/P)' (because firms must pay a higher excise tax and thus reducing wages) pushing an increase in unemployment. Having assumed the proportion of units produced to the number of workers involved, then output decreases.

Let us start from the optimum point A in Graph 7, where the market is in equilibrium. Hypothetically, having decided with fiscal consolidation policy and increasing the excise tax, the output gap decreases to Y_n', leading firms to increase their prices, causing inflation to increase from *PC* to *PC'*[285]. It moves the economy from *A* to *A'*. It is the turn of the CBCG to increase the interest rate to slow down the heating of inflation, driving the economy to *A"*. The dynamic mechanism of decreasing output correlated with increasing inflation is known as *stagflation*[286]. When the output is shrinking, inflation keeps growing until the CBCG intervenes with economic policies and turns the equilibrium in the medium run.

Most probably, the Government of Montenegro, in this case, would have placed the fiscal policy into action, shifting the IS curve to the left through many budgetary mechanisms. In this case, the oil producers, for example, in the Middle East, would have a higher demand for their goods since they have more income, profiting from the price increase. Consequently, this would be reflected in less market demand for the European Union and Montenegro. The role of expectations explains the margin of inflation in the 1970s and 2000 in the United States. In case changes in the oil price (excise tax or stock market) in Montenegro are not associated with changes in inflation expectations, then they will remain constant, and the Government of Montenegro will have a much easier job. Is it to be expected that inflation expectations will remain constant? What determines inflation expectations? Suppose people have a strong belief in the stability of the macroeconomic environment. In that case, it is to be expected that they believe that the Government is making the right move to benefit Montenegro's future. But suppose some agents are motivating and promoting instability, especially in a small country in transition. In that case, expectations might change, and potential investors might expect inflation to continue increasing[287]. Prospects of a lower inflation rate in the future and stable expanding growth shifts the demand up to increasing spending and output. Thus, although a straight impact of excise tax on unemployment, production, and inflation is limited,

[285] Dornbusch, R., S. Fischer and C. Kearney., *Macroeconomics*. Sydney: The Mc-Graw-Hill Companies, Inc., 1996.

[286] Gokal, V., and S. Hanif., "Relationship between inflation and economic growth," *Reserve Bank of Fiji, Working Paper,* 2004/04.

[287] Todaro, M.P. Economic Development. New York: Addison Wesley Longman, Inc., 2000.

changes in expectations are to be taken seriously by the policymakers of Montenegro, especially in front of accessing the European Union. Political stability plays an important role, as well.

The effects of macroeconomic policies depend fundamentally on its impact on expectations. Therefore, if the inflation expectations remain unchanged because of higher excise tax and citizens believe this is for their current and future benefit, the effects of such an increase will be much limited in inflation and output growth[288]. In opposite, it could get the country into e deep recession. If expectations play such an important role, the logical question is whether macroeconomists can bring forward any valuable forecasting about the future. The answer is *yes*. People form their expectations based on the era of information and knowledge, starting from the internet to brokers, news, banks, and other agents in the market worldwide[289]. Thus, these futuristic expectations are very logical, so-called *rational expectations*.

Let us turn back to Figure 30. We notice that unemployment in this scenario is expected to be lower than predicted by the baseline, making us think that unemployment equilibrium might be affected by some other factors. The aluminum price changes drastically, which is expected since its production depends on the energy of oil. The GDP gap stays close to the baseline for three quarters of 2016, and after that starts to decline as explained previously. Inflation systematically follows the dynamic vibes of the benchmark, increasing as expected. By the second quarter of 2017, it stabilizes and starts to decline following the decline of the GDP gap, which signifies that the citizens' expectations remained constant, and the Government of Montenegro anchored its expectations. We can stipulate here that the unemployment curve might be very steep, inelastic to changes in the price-setting curve to oil changes, even though we should include adequate time series as mentioned previously that are related to unemployment. Nevertheless, we might think that unemployment insurance and employment protection

[288] Bank for International Settlements., *Inflation mechanisms, expectations and monetary policy*. Monetary and Economic Department, Papers No 89, 2016.

[289] Giacomini, R., "Economic theory and forecasting: lessons from the literature", *Econometrics Journal*, 2015, 18, C22–C41.

are two potential variables associated with wages and unemployment elasticity. It remains to be further examined in other researches.

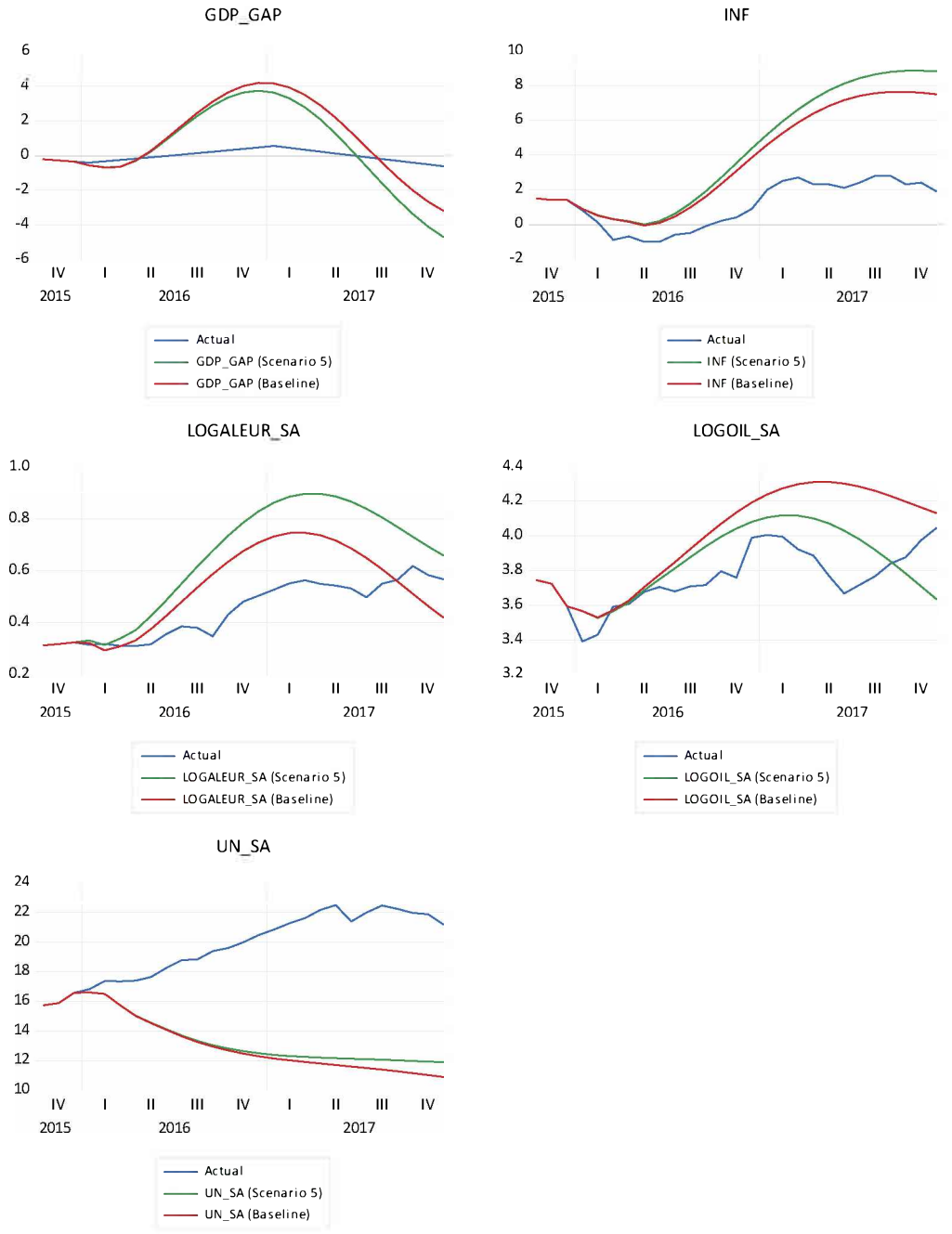


Figure 31: Deterministic – dynamic alternative scenario of aluminum LME price
Source: Author's calculations in EViews 11.

It would be interesting to see one of the last alternative scenarios of our VAR(3) model in case we change the price of aluminum. A hypothetical change of aluminum price from 0.01 to 0.24 points, respectively, from 3.1%% to 57.3% is applied to observe the potential

ability to predict such shocks to Montenegrin economy from outside, exogenous, meaning out of our direct control.

The first noticeable thing is that the model predicts inflation higher than the baseline model but closer to the baseline than in the oil price increase. The same behavior is observed with the GDP gap. It stays more relative to the baseline than in the case of oil price alternative scenarios.

Note, however, that so far, we have not been able to say anything about causality. This topic will be taken up in the following session.

3.4. Structural vector autoregressive model

There is no conceptual background that interprets VAR coefficients like multivariate regression models[290]. Sims was one of the first to interpret the VAR coefficients through impulse responses, a fascinating macroeconomics development[291]. What does the impulse response do? It observes the response of the dependent variable to shocks in the errors. The whole problem here is to identify these shocks, and once defined; we can observe the response of inflation and other variables in the VAR model[292]. Thus, interpretation then becomes easy. However, at the time being, we can observe only the composed reduced form errors, and we need them separate – individual – to know relation shock – error – dependent variable. Thus, the reduced form contains errors that are made up of a combination of structural errors that need to be identified[293].

Without SVAR analysis, one could reach wrong conclusions because of not individualizing errors in the structural VAR model. For example, suppose we anticipate that unemployment will increase. The macroprudential policymakers of the Government of Montenegro control to the best of knowledge the markups (m), the shadow economy,

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[290] Akaike, H., "Fitting autoregressive models for prediction," *Annals of the institute of Statistical Mathematics*, 1969, 21(2), 243-247.

[291] Sims, C. A., "Macroeconomics and reality," *Econometrica*, 1980, 48(1), 1-48.

[292] Caldara, D., and C. Kamps., "What are the effects of fiscal policy shocks? A VAR-based comparative analysis," *European Central Bank working paper series*, 2008, 877.

[293] Lütkepohl, H., *New Introduction to Multiple Time Series Analysis*. Berlin: Springer, 2005.

and the unemployment gap continues to widen. In that case, we cannot conclude that controlling better the markups led to a rise in unemployment. The markup control was endogenous to the anticipated unemployment. The markups-policy reacted to the expected unemployment. One could say that the unemployment would have been higher had the policymakers not taken any action or that it takes time for the markups-policy to impact reducing unemployment in Montenegro.

Thus, the policymakers' reaction was not exogenous, and this is not what we would like to calculate. In the meantime, we would like to measure and know the impact the policy has on the GDP gap and inflation in Montenegro. Based on this structure, we cannot tell apart the effect of the markups-policy into the other variables of the VAR model. From the perspective of fiscal policy, let us consider that the policymakers of Montenegro are expecting e decrease in demand, and then decrease the excise tax of oil, making higher the deficit. However, still, the output gap continues to widen. We might conclude incorrectly that reducing the excise tax of oil caused the output to decline. As in the example before, the same inference might be reached by deducing logically that the fiscal authorities' reaction was endogenous to the expected reduction in consumption, demand. We can not measure the impact of markups or excise tax while unemployment and market are reacting to other variables' movements. If many variables affect unemployment contemporaneously, we should aim to measure only the impact of the variable we are interested in examining. Thus, to trace the dynamics of policy, we need to identify solely exogenous shocks, autonomous activities to observe the Montenegrin economic reaction. This reaction is called an impulse response. We would like to know completely exogenous shocks to markups and excise tax, for example. The mechanism drives us to the *identification* of the structural model, which isolates purely exogenous shocks and gets the responses of the endogenous variables after these shocks hit the economy[294]. After identifying the structural errors, we can compute the responses of dependent variables and make predictions, for example, what will happen to inflation in Montenegro if fiscal authorities decrease the excise tax or control the shadow economy.

[294] Christiano, L. J., "Christopher A. Sims and Vector Autoregressions," *Scand. J. of Economics,* 2012, 114(4), 1082–1104.

It is time to note that the error terms in the reduced VAR form are composed of two or more shocks, and if the error terms of the reduced form are white noises, then the error terms of the structural error terms will be white noise processes too. Asteriou and Hall (2016) take two stationary simultaneous time series, y_t and x_t affected by current and past values and errors terms u_{yt} and u_{xt}white noise[295]:

$$y_t = \beta_{10} - \beta_{12}x_t + \gamma_{11}y_{t-1} + \gamma_{12}x_{t-1} + u_{yt} \quad (114)$$
$$x_t = \beta_{20} - \beta_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}x_{t-1} + u_{xt} \quad (115)$$

Equations (114) and (115) have a contemporaneous impact on each other. The matrix algebra of the above two equations would look like:

$$\begin{bmatrix} 1 & \beta_{12} \\ \beta_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} \quad (116)$$

$$Az_t = B_0 + B_1 z_{t-1} + u_t \quad (117)$$

$$A = \begin{bmatrix} 1 & \beta_{12} \\ \beta_{21} & 1 \end{bmatrix},\ z_t = \begin{bmatrix} y_t \\ x_t \end{bmatrix},\ B_0 = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix},\ B_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix},\ z_{t-1} = \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix}$$

$$\text{and } u_t = \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix}$$

It is crucial to note here that u_t error terms (shocks) are independent. Matrix *A* is essential in the process of identification. The *1s* in the diagonal of matrix *A* express the contemporaneous impact between endogenous variables. Coefficients β_{12} and β_{21} represent contemporaneous relations between y_t and $\beta_{12}x_t$, and x_t and $\beta_{21}y_t$, and we see them in matrix *A*[296]. Having a matrix, *A*, in front of z_t, emphasizes that we have two or more variables at time *t*, $\beta_{12}x_t$ and $\beta_{21}y_t$. The identification is the structural model. Multiplying equation (117) by the inverse of *A*, A^{-1}, we get:

$$A^{-1}Az_t = A^{-1}B_0 + A^{-1}B_1 z_{t-1} + A^{-1}u_t \quad (118)$$
$$z_t = G_0 + G_1 z_{t-1} + e_t \quad (119)$$

following $G_0 = A^{-1}B_0$, $G_1 = A^{-1}B_1$, and $e_t = A^{-1}u_t$. We find it essential to take a pause here and recall what the inverse of a matrix is. For example, let us get an inverse

[295] Asteriou, D., and S. G. Hall., *Applied econometrics, 3rd ed.* Basingstoke, United Kingdom: Palgrave MacMillan, 2015.

[296] Lanne, M., and H. Luetkepohl., "Structural Vector Autoregressions with Nonnormal Residuals," *Economics Working Papers*, 2005, ECO2005/25, European University Institute.

of a matrix A *3x3,* and we are going to do this by using cofactors and determinants. For instance, we have the following matrix:

$$A = \begin{bmatrix} 0 & 0 & 1 \\ 2 & -1 & 3 \\ 1 & 1 & 4 \end{bmatrix} \tag{120}$$

Proceeding with this example, we need to find the determinant of A, $|A| = detA$:

$$\begin{gathered} |A| = detA = 0\begin{bmatrix} -1 & 3 \\ 1 & 4 \end{bmatrix} - 0\begin{bmatrix} 2 & 3 \\ 1 & 4 \end{bmatrix} - 1\begin{bmatrix} 2 & -1 \\ 1 & 1 \end{bmatrix} \\ = 0[(-1 \cdot 4) - (1 \cdot 3)] - 0[(2 \cdot 4) - (1 \cdot 3)] + 1[(2 \cdot 1) - (1 \cdot (-1))] \\ = 0 - 0 + 1(2 + 1) = 3 \end{gathered} \tag{121}$$

the next thing we are going to use is cofactors:

$$\begin{bmatrix} +\begin{vmatrix} -1 & 3 \\ 1 & 4 \end{vmatrix} & -\begin{vmatrix} 2 & 3 \\ 1 & 4 \end{vmatrix} & +\begin{vmatrix} 2 & -1 \\ 1 & 1 \end{vmatrix} \\ -\begin{vmatrix} 0 & 1 \\ 1 & 4 \end{vmatrix} & +\begin{vmatrix} 0 & 1 \\ 1 & 4 \end{vmatrix} & -\begin{vmatrix} 0 & 0 \\ 1 & 1 \end{vmatrix} \\ +\begin{vmatrix} 0 & 1 \\ -1 & 3 \end{vmatrix} & -\begin{vmatrix} 0 & 1 \\ 2 & 3 \end{vmatrix} & +\begin{vmatrix} 0 & 0 \\ 2 & -1 \end{vmatrix} \end{bmatrix} = \begin{bmatrix} -7 & -5 & 3 \\ 1 & -1 & 0 \\ 1 & 2 & 0 \end{bmatrix} \tag{122}$$

the diagonal number stay where they are at, while the other elements about the diagonal are transposed:

$$\begin{bmatrix} -7 & 1 & 1 \\ -5 & -1 & 2 \\ 3 & 0 & 0 \end{bmatrix} \tag{123}$$

the 1 and -5 will switch places, the 1 and 3 switch places, and likewise, the 2 and 0 will switch places. The last thing we do is multiply every entry by $1/3$, and this will be our inverse matrix:

$$\frac{1}{|A|} adjA = \frac{1}{3}\begin{bmatrix} -7 & 1 & 1 \\ -5 & -1 & 2 \\ 3 & 0 & 0 \end{bmatrix} = A^{-1} \tag{124}$$

$$\begin{bmatrix} \frac{-7}{3} & \frac{1}{3} & \frac{1}{3} \\ \frac{-5}{3} & \frac{-1}{3} & \frac{2}{3} \\ 1 & 0 & 0 \end{bmatrix} = A^{-1} \tag{125}$$

and we have found the inverse matrix A^{-1} of A.

In equation (119), G_0 is $(n * 1)$ vector of constants, G_1 is $(n * n)$ vector of coefficients, e_t is $(n * 1)$ vector of white noise innovations, and it can be rewritten as:

$$y_t = g_{10} + g_{11}y_{t-1} + g_{12}\,x_{t-1} + e_{1t} \quad (126)$$
$$x_t = g_{20} + g_{21}y_{t-1} + g_{22}\,x_{t-1} + e_{2t} \quad (127)$$

Equations (114) and (115) are structural VAR while (126) and (127) are reduced form VAR. Because we did not impose any restrictions and that residuals are not orthogonal, equations (126) and (127) are reduced-form VAR. Since $e_t = A^{-1}u_t$, errors e_{1t} and e_{2t}, in equations (126) and (127), are made up of two innovations u_{yt} and u_{xt}[297].

Let's recall that multiplying any matrix by its inverse provides us with the identity matrix[298]:

$$A^{-1}A = I \quad (128)$$

White noise means that error terms are uncorrelated, so $E[e_t] = 0$ and finite variance[299]. An equation error term can be contemporaneously correlated with other equations' residuals but not correlated with their own lagged values and independent variables (as in any specified regression)[300]. Therefore, the reduced-form innovations are not orthogonal, completely uncorrelated. The structure of the contemporaneous variance-covariance matrix is as follows:

$$E[e_t\, e_t'] = \begin{bmatrix} \delta_{e_1}^2 & \delta e_1 e_2 \\ \delta e_1 e_2 & \delta_{e_2}^2 \end{bmatrix} \quad (129)$$

As we can notice from above, multiplying structural shocks by the inverse matrix gives us forecast errors:

$$e_t = A^{-1}u_t \quad (130)$$

[297] Brüggemann, R., H. Lütkepohl, and M. Marcellino., "Forecasting euro area variables with German pre-EMU data," *Journal of Forecasting*, 2008, 27(6), 465-481.

[298] Lütkepohl, H., *New Introduction to Multiple Time Series Analysis*. Berlin: Springer, 2005.

[299] Carter, B., *Op Amps for Everyone, 4th ed.* Oxford, UK: Elsevier, 2013.

[300] Beenstock, M., and D. Felsenstein., "Spatial Vector Autoregressions," Spatial Economic Analysis, 2007, 2(2), 167-196.

which are linear combinations of the structural shocks. Asteriou and Hall (2015) obtain e_{1t} and e_{2t}[301]:

$$e_{1t} = \frac{(u_{yt}+\beta_{12}u_{xt})}{(1-\beta_{12}\beta_{21})},\ and\ e_{2t} = \frac{(u_{xt}+\beta_{21}u_{yt})}{(1-\beta_{12}\beta_{21})} \quad (131)$$

When there is a surprise in inflation, for instance, we usually do not know what happened. A combination of factors, structural shocks, at the same time, could be affecting inflation in Montenegro. Fiscal policy, labor market, international innovations could be affecting all together in the meantime, and we would like to disentangle those factors by getting the structural model. The problem is that the SVAR can't be estimated directly, and it is a theoretical construct. It is non-observable. As Sims (1992) said, it is an interpretation of historical data[302]. We have only the evolution of the economic time series. According to Sims (1992), all variables should be treated equally, as endogenous, and no distinction should be made between endogenous and exogenous. The reduced VAR model has the same package of regressors. Thus, we start from a reduced-form VAR model, aiming towards the structural model, which isolates the exogenous shocks and measures these shocks' impact on the variables included in the VAR model. Consequently, we need to get matrix A, the so-called *identification*.

$$Z_t = G_0 + G_1 Z_{t-1} + e_t \quad (132)$$

We start from the reduced-form VAR model, and we pre-multiply it with matrix A and get the following results[303]:

$$AZ_t = AG_0 + AG_1 Z_{t-1} + Ae_t \quad (133)$$

following $G_0 = A^{-1}B_0$, $G_1 = A^{-1}B_1$, and $e_t = A^{-1}u_t$, and that identity matrix is $A^{-1}A = I$:

$$AZ_t = AA^{-1}B_0 + AA^{-1}B_1 Z_{t-1} + AA^{-1}u_t \quad (134)$$
$$AZ_t = IB_0 + IB_1 Z_{t-1} + Iu_t \quad (135)$$

[301] Asteriou, D., and S. G. Hall., *Applied econometrics, 3rd ed.* Basingstoke, United Kingdom: Palgrave MacMillan, 2015.

[302] Sims, Ch., "Interpreting the macroeconomic time series facts: The effects of monetary policy," *European Economic Review*, 1992, 36(5), 975-1000.

[303] Amisano, G., and C. Giannini., *Topics in Structural VAR Econometrics, second, revised and enlarged ed.* Berlin Heidelberg: Springer, 2012.

$$AZ_t = B_0 + B_1 Z_{t-1} + u_t \quad (136)$$

Equation (136) uncovers the structural model, the structural shocks, and the contemporaneous relations among variables. It is the way we can observe what happens to the economy of Montenegro once a shock hits the marketplace.

This section deals with the VAR model, the structural VAR specification and identification, impulse response analysis, and forecast-error variance decomposition. Once the reduced VAR form is estimated, we get the reduced form residuals e_{1t} and e_{2t}. The information we get from the estimation is consisted of g_{10}, g_{20}, g_{11}, g_{12}, g_{21}, and g_{22}, and we get a *2x2* symmetric variance-covariance matrix of the residuals. It sums up to nine coefficients: 6 coefficients, 2 variances, and 1 covariance. The number of coefficients, in the structural VAR, equations (114) and (115), is: β_{12}, β_{21}, β_{10}, β_{20}, γ_{11}, γ_{12}, γ_{21}, and γ_{22}, summing up to 8. Besides, we have the variances, but the structural shocks are independent, resulting in the covariance of 0. We have more unknowns than equations since the only information we have is the 9 parameters of the estimated reduced-form VAR model. How to solve the problem? The only solution is to impose a restriction on one of the structural parameters. It makes the number of unknown parameters in the structural model equal to the number of parameters known from the standard reduced-form VAR estimation model.

Where should we impose the restriction? The usual approach is to impose one restriction in matrix A, the so-called identification. We are limiting the relations of endogenous variables occurring during the same time (contemporaneous) of the structural model in matrix A[304]. The matrix A has two possibilities to be restricted: coefficient β_{12} or β_{21}. Let's say that we set $\beta_{12} = 0$, making matrix A look as follows:

$$\begin{bmatrix} 1 & 0 \\ \beta_{21} & 1 \end{bmatrix} \quad (137)$$

How could we determine what coefficient to set to zero? The answer is that based on economic intuition, we can impose a restriction on matrix A.

[304] Ouliaris, S., A. Pagan and J. Restrepo., *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation*. Institute for Capacity Development, 2018. E-book, available at https://www.eviews.com/StructVAR/structvar.html.

$$y_t + 0 = \beta_{10} + \gamma_{11} y_{t-1} + \gamma_{12} x_{t-1} + u_{yt} \quad (138)$$

$$\beta_{21} y_t + x_t = \beta_{20} - + \gamma_{21} y_{t-1} + \gamma_{22} x_{t-1} + u_{xt} \quad (139)$$

If $\beta_{12}, (\beta_{12} x_t), = 0$, then the contemporaneous effect of x_t on y_t is restricted to zero. Thus, a shock to x_t will have 0 effects contemporaneously to y_t, and only the lagged value of x_t, $\gamma_{12} x_{t-1}$, will affect y_t. On the other hand, equation (139) results differently because we have not imposed any contemporaneous restrictions. Shocks to y_t affect contemporaneously variable x_t (β_{21} coefficient). Imposing restrictions in matrix A, we also impose restrictions in the inverse of matrix A, A^{-1}[305].

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -\beta_{21} & 1 \end{bmatrix} \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ -\beta_{21} & 1 \end{bmatrix} \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ -\beta_{21} & 1 \end{bmatrix} \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} \quad (140)$$

$$\begin{bmatrix} 1 & 0 \\ -\beta_{21} & 1 \end{bmatrix} = A^{-1} \quad (141)$$

The zero in the last matrix, equation (141), is the restriction between the reduced-form residuals, the forecast errors, and the structural shocks. Forecast errors of y equal structural shocks to y: $e_{yt} = u_{yt}$. The product of the matrices results in the reduced-form VAR expressed in terms of the structural parameters as follows[306]:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ -\beta_{21}\beta_{10} + \beta_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ -\beta_{21}\gamma_{11} + \gamma_{12} & -\beta_{21}\gamma_{12} + \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{yt} \\ -\beta_{21} u_{yt} + u_{xt} \end{bmatrix} \quad (142)$$

Using the coefficients, g, obtained with the reduced -form estimation, we can build all the equations that will allow us to resolve the structural parameters:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} g_{10} \\ g_{20} \end{bmatrix} + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \quad (143)$$

based on: $g_{10} = \beta_{10}$, $g_{20} = -\beta_{21}\beta_{10} + \beta_{20}$, $g_{11} = \gamma_{11}$, $g_{12} = \gamma_{12}$, $g_{21} = -\beta_{21}\gamma_{11} + \gamma_{12}$, $g_{22} = -\beta_{21}\gamma_{12} + \gamma_{22}$. Since $e_{yt} = u_{yt}$ then, $var(e_{yt}) = \sigma_{uy}^2$, $var(e_{xt}) = \sigma_{ux}^2 + \beta_{21}^2 \sigma_{uy}^2$, and $cov(e_{yt} e_{yt}) = E(e_{yt})(u_{xt} - \beta_{21} u_{yt}) = -\beta_{21} \sigma_{uy}^2$. Substitute the estimated values for these 9 parameters $g_{10}, g_{11}, g_{12}, g_{20}, g_{21}, g_{22}, \sigma_{ey}^2, \sigma_{ey-er}$ in the 9 equations, to solve for: β_{21}, β_{10}, $\beta_{20}, \gamma_{11}, \gamma_{12}, \gamma_{21}, \gamma_{22}, \sigma_{vy}^2, and\ \sigma_{vx}^2$. Note that the structural shocks

[305] Vargas-Silva, C. "Monetary Policy and US Housing: A VAR Imposing Sign Restrictions," *Journal of Macroeconomics*, 2008, 30, 977-990.

[306] Arias, J. E., J. F. Rubio-Ramírez and D. F. Waggoner., "Inference based on SVARs identified with sign and zero restrictions: theory and applications," *Econometrica*, 2018, 86, 685-720.

can be recovered because we imposed that structural shocks to *y* are equal to *y* forecast errors, which are obtained from the reduced-form estimation[307]. Once we get coefficient β_{21} from the system of nine equations, we can compute *u*, given that $u_{xt} = e_{xt} + \beta_{21} u_{yt}$. But we know that $u_{yt} = e_{yt}$ because of the restriction we just imposed. Thus, $u_{xt} = e_{xt} + \beta_{21} e_{yt}$[308]. It is how we use the reduced-form residuals to get the structural shocks. As Sims (1980) says: "SVAR is useful because it isolates structural shocks and allows tracing out the VAR variable dynamics after one of those shocks hits the economy."[309] Therefore, imposing restrictions in matrix *A* identifies the SVAR. It is all about restrictions. The difference between the unknown and known elements is the number of restrictions required to identify the structural model. Let *n* be the variable number in the VAR so that we can count the unknown elements. We know that the diagonal of matrix *A* are *1s*. Thus, the unknown elements in matrix *A* are $n^2 - n$, but we need to add the *n* number of unknown variances of structural shocks *u*. Therefore, the total number of unknown elements would be $n^2 - n + n = n^2$. As far as the known elements, the estimation of the reduced-form VAR model allows us to get $(n^2 + n)/2$ distinct elements contained in the symmetric variance-covariance matrix of the errors: $E e_t e_t' = \sum_e$[310]. How to get to know the known elements? There are *n* distinct known elements from the diagonal plus $(n^2 - n)/2$ elements are found off the diagonal, summing up to the total known elements: $n + (n^2 - n)/2 = (n^2 + n)/2$. Thus, we need to impose $n^2 - (n^2 + n)/2$ restrictions which equal $(n^2 - n)/2$. In our case, we have 5 variables, and the number of restrictions that should be imposed is: $(n^2 - n)/2 = (5^2 - 5)/2 = 10$.

[307] Dungey, M. and R. A. Fry., "Identifying Fiscal and Monetary Policy in a Structural VAR," *Economic Modelling*, 2009, 26, 1147-1160.

[308] Sims, C. "A nine-variable probabilistic macroeconomic forecasting model," In J. Stock and M. Watson, eds., *Business Cycles, Indicators and Forecasting*. University of Chicago Press for the NBER, 1993.

[309] Sims, C., "Macroeconomics and Reality," *Econometrica*, 1980, 48(4), 1-48.

[310] Ouliaris, S., A. Pagan and J. Restrepo., *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation*. Institute for Capacity Development, 2018. E-book, available at https://www.eviews.com/StructVAR/structvar.html.

3.4.1. Impulse responses

After elaborating and analyzing the reduced-form VAR model, we come to impulse responses, showing us the variance in endogenous variables for each structural innovation at *t, t+1,* and so on[311]. It requires us to transform our structural autoregressive vector[312]:

$$Az_t = B_0 + B_1 z_{t-1} + u_t \tag{144}$$

and after successive iterations, we get[313]:

$$Z_t = G_0 + G_1(G_0 + G_1(G_0 + G_1 Z_{t-3} + e_{t-2}) + e_{t-1}) + e_t \tag{145}$$
$$Z_t = (I + G_1 + G_1^2 + \ldots + G_1^{\infty})G_0 + e_t + \sum_{i=1}^{\infty} G_1^i e_{t-i} + G_1^i X_{t-n-i} \tag{146}$$

As $i \to \infty$ *x* reduces to a sum of errors or into a sum of shocks, which is called the Wold Representation (1951) of *X*[314]:

$$X_t = \mu + \sum_{i=1}^{+\infty} G_1^i e_{t-i} + e_t \tag{147}$$

and assume $\psi_i = G_1^i$ then:

$$X_t = \mu + \sum_{i=1}^{+\infty} \psi_i e_{t-i} + e_t \tag{148}$$

If *X* has a Wold representation, then *X* is stable. The condition that guarantees stability is that *G* has eigenvalues smaller than *1* in modulus, and it is a prevalent result valid for any VAR(p)[315]. Since the VAR is stationary, the estimated reduced-form VAR has a moving average:

$$X_t = \mu + \sum_{i=1}^{\infty} \psi_i e_{t-i} \tag{149}$$

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[311] Pesaran, M. H. and Y. Shin., "Generalized Impulse Response Analysis in Linear Multivariate Models," *Economics Letters*, 1998, 58, 17-29.

[312] Sims, C., "Macroeconomics and Reality," *Econometrica*, 1980, 48(4), 1-48.

[313] Ouliaris, S., A. Pagan and J. Restrepo., *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation*. Institute for Capacity Development, 2018. E-book, available at https://www.eviews.com/StructVAR/structvar.html.

[314] Wold, H. O. A. "Dynamic Systems of the Recursive Type - Economic and Statistical Aspects," *Sankhya*, 1951, 11, 205-17.

[315] Beneš, J., and D. Vávra., "Eigenvalue filtering in VAR models with application to the Czech business cycle," *European Central Bank*, Working Paper Series 549, 2005.

Using the same old relation between the forecast errors and structural shocks, we find[316]:

$$X_t = \mu + A^{-1}u_t + \sum_{i=1}^{\infty} \psi_i A^{-1}u_{t-i} \quad (150)$$

or more compactly:

$$X_t = \mu + \sum_{i=1}^{\infty} C_i u_{t-i} \quad (151)$$

$c_{11,i}$ and $c_{12,i}$ are the responses of y and x to a change in u_{yt} and u_{xt} respectively. Note that $c_{11,0}$ is the effect at impact, $c_{11,1}$ is the effect of u_{yt} on y on t+1, and so on in succession:

$$\frac{\partial y_{t+k}}{\partial u_{yt}} = C_{11,k} \quad (152)$$

also, the cumulative effect is $\sum_{i=0}^{\infty} C_{11,i}$. It is the expression (152), the partial derivative, that we are interested in examining. These partial derivatives are called *impulse responses* since they show the response of the variable is the $y_t K$ periods ahead from t to a temporary one unit change in u_{yt}. We are primarily interested in the *dynamic response* of inflation to an *exogenous* shock that hits the Montenegrin economy. In our example, we need to identify a structural VAR(3) model and structural shocks using a recursive ordering. Our goal is to follow the footprints of internal and external shocks on the Montenegrin economy, specifically inflation. Since the Phillips relation changed across countries, we are interested in seeing the Montenegrin economy's case from an empirical perspective about inflation. Why? Montenegro's government must identify the shocks and measure their effect for policy reasons, especially in the dawn of entering the European Union. Based on this model, we are interested in generating forecasts and, for policy analysis, using our economic intuition to set restrictions. Since Montenegro's specifics as

[316] Watson, M.W., Vector Autoregressions and Cointegration, in R. Engle and D. McFadden (eds.), *Handbook of Econometrics*, Vol IV. Amsterdam: Elsevier, 1994.

a small euroized economy are crucial, we would like to see empirical results from this VAR model. Following Breitung *et at.,* (2004), the SVAR model is as follows[317]:

$$AX_t = A_1X_{t-1} + A_2X_{t-2} + \ldots + A_pX_{t-k} + \varepsilon_t \quad (153)$$

and X_t is a *(nx1)* vector of endogenous variables:

$$X_t = (p_t^o, p_t^a, un_t, gdp\_gap_t, \pi_t) \quad (154)$$

The matrix *A* is invertible, and it has *(n x n)* coefficients of contemporaneous relations on the endogenous variables. $A_i's$ are matrices *(n x n)* capturing the dynamics of variables, and ε_t is a *(n x 1)* structural shock vector. Our VAR(3) model, with three lags, was found to be not autocorrelated. It is confirmed by Wooldridge (2013) as the best model when it is from one to three lags[318]. The oil variable p_t^o, will be placed first. Why? Our economic intuition is that a shock to the oil price, either increased through excise tax or world market, affects all other variables contemporaneously. Oil and aluminum prices are vital variables that we are interested in tracing out their dynamics. Why? Because they are *exogenously* determined. These will point out the shocks that penetrate the global market to the Montenegrin economy. We are interested in tracing the endogenous variables such as GDP and unemployment to capture the effect these shocks have on inflation.

The variables in our VAR(3) model are ordered recursively. The first variable is the oil price, assuming it is contemporaneously exogenous to the other variables. It implies that the price of aluminum, unemployment, gdp_gap, and inflation do not determine the oil price at period *t.* Meanwhile, the price of aluminum is ordered second, while unemployment is third. The fourth is gdp_gap, and the last one is inflation, which is affected by all other variables. Overall, the first two variables represent exogenous shocks coming due to the world economy, impacting the Montenegrin market. The unemployment rate represents the labor market. The GDP gap represents the goods market, and inflation represents the behavior of the price-setting in Montenegro. Thus, we have internal and external shocks impacting the whole Montenegrin economy. First,

[317] Breitung, J., BrÄuggemann, R. & LÄutkepohl, H. (2004). Structural vector autoregressivemodeling and impulse responses, *in* H. LÄutkepohl & M. KrÄatzig (eds), *Applied Time Series Econometrics*, Cambridge University Press, Cambridge, pp. 159 - 196.

[318] Wooldridge, J. M., *Introductory Econometrics: A Modern Approach*. Ohio: South-Western, 2013.

we use Sims' (1980) orthogonalized impulse responses[319]. We will trace out the SVAR responses of the dependent variables to shocks in our model. Figure 32 contains macroeconomic variables and impulse responses to shocks. Each chart traces the response to Cholesky one standard deviation (d.f. adjusted) innovations ± 2S.E. Each column represents responses of variables to a shock coming from a variable. For example, the first column represents all variables' responses to one-unit standard deviation shock in the oil prices.

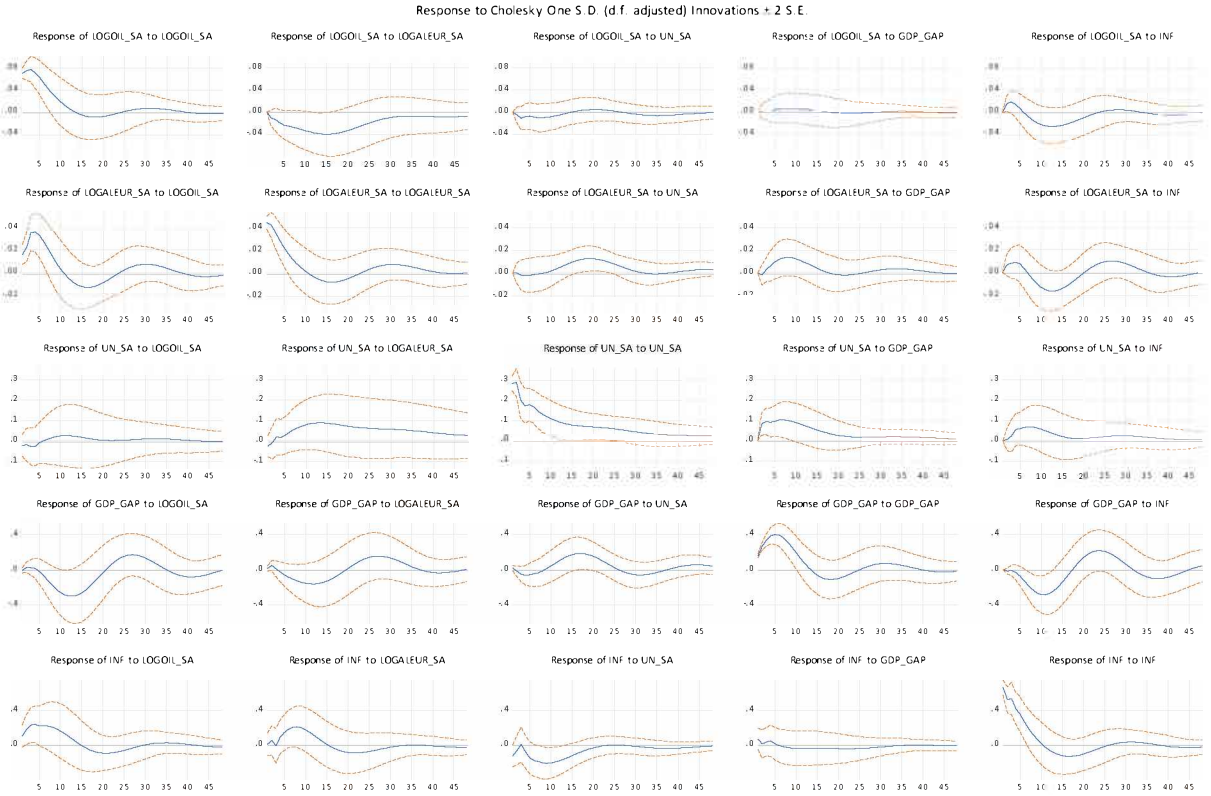

Figure 32: Impulse responses
Source: Author's calculations in EViews 11.

The impulse response to the oil price shock shows that aluminum price increases immediately, reaching the highest peak in the fourth month 0.035566 and then declining sharply and after 11 months becoming negative -0.001231. After 16 months it reaches the lowest point -0.012431. After this, the response of aluminum price starts to increase, reaching 0.007704 after 30 months. After that, it keeps declining with smoother oscillations and again becoming negative after 39 months. We can conclude that based

[319] Sims, C., "Macroeconomics and Reality," *Econometrica*, 1980, 48(4), 1-48.

on the above results, aluminum price response to oil price shocks has significant swings, from positive to negative, with a permanent negative impact on the price of aluminum. The pass-through from oil to aluminum is relatively quick, occurring only after a couple of months touching the peak. The persistence continues to drop drastically after precisely 12 months, from the time reaching the summit. The reason might be that after the economy is hit with the one-unit standard deviation shock in the oil price, the aluminum production cost decreased the markups (m) in price-setting in the labor market. Thus firms increased the prices to maintain the marginal profit. After 4 months, due to the lower demand for aluminum in the goods market equilibrium, the aluminum price declined sharply, becoming negative. Another reason could be that investments fell, and as a result, the aluminum price ended up contrary due to a one-unit standard deviation shock in the oil price.

Let us turn to the response of unemployment to Cholesky one-unit standard deviation shock in the oil price. For the first five months, the response of unemployment has no movements almost at all. It might happen because of the drop in registered employees. Also, the number of registered unemployed has slightly increased, especially from 2014 to 2016 (Monstat 2018)[320]. The informal sector of employment must be considered, which reaches approximately 30% of the registered employment. The unemployment rate to the unemployment ranges from 3.87 to 3.6, respectively, from 2006 till 2017. Based on Monstat (2018), the growth rate of registered employment ranges from 4.5% to 1.1%, showing a decline, while unemployment shows an increase in growth rate from -10% to 24%, respectively, from 2006 to 2017. In 2010, the employment growth rate showed a negative -7.13 growth rate. We need to emphasize that the relation between registered employment to registered unemployment and pensioners is around 1.1%. The aging of the Montenegrin population increased from 32.4 in the 1991 Census to 37.7 years, according to the Census data of 2011[321]. The aging index showing the relationship between the number of older people (65 years and over) and the number of young people (under 15) has significantly increased between the two censuses. In 1991 it was 32.55,

[320] Monstat, *https://www.monstat.me*, accessed, October 25, 2019.

[321] United Nations, Department of Economic and Social Affairs, Population Division. *World Population Ageing 2017 - Highlights* (ST/ESA/SER.A/397), 2017.

while in 2003, it rose to 58.18, and in 2011 it reached 66.81 (Monstat, 2014)[322]. As seen from Figure 31, after the seventh month, the response of unemployment to oil shock increases as expected.

Proceeding with the analysis further, we notice that the GDP gap keeps slightly positive for the first five months, decreasing to -0.300301 just after 13 months. The output significantly responded to the Cholesky one standard deviation oil price shock, meaning that the Montenegrin economy heavily depends on oil supplies.

The transmission takes about 13 months, hitting the deep bottom. Subsequently, it takes 7 months to reach 0, attaining a peak level of 0.170036 after 2 years and 3 months. After that, it starts declining slowly, reaching 0 again 34 months. This oil price innovation implication is that GDP_gap decreases quickly for a transitional economy as Montenegro, taking more than a year to recover. It suggests that the response of the output gap to the Cholesky one standard deviation oil price shock could reduce the supply of intermediate goods market and the demand for the final goods market in Montenegro, causing much damage to industrial production[323].

Inflation impulse response function to Cholesky one standard oil price shocks gradually increases after a lag of four months. After that, it declines to reach deflation of -0.002386 after 15 months, hitting the bottom of -0.089678 after 21 months. The transmission is evident since the economy slowed down, output hitting bottom after 13 months, while inflation after 21, a gap of 8 months between output and inflation hitting bottom. Only after 30 months, inflation becomes positive 0.004767. The increase in oil price makes the Central Bank and fiscal policymakers intervene to lower inflation. As the output decreases, inflation increases slowly. Output has reached the lowest level, while inflation keeps decreasing. After 13 months, while the output gap keeps increasing, inflation is still falling until the dynamic gap between output and inflation reaches, after 24 months, at -0.2111, the so-called stagflation. The increase in the oil prices affected demand in the

[322] Ibid.

[323] Lee, K., and Sh. Ni., On the dynamic effects of oil price shocks: a study using industry level data," *Journal of Monetary Economics*, 2002, 49, 823–852.

Montenegrin market, leading firms to change their investments, canceling projects. Notice that until output decreases within 12 months, inflation continues to increase, even for some months, keeping the same level and pushing inflation to a higher level than before the increase in oil price. In this case, the macroprudential fiscal policymakers in Montenegro intervened, adjusting the inflation with output. This whole adjustment process makes the economy go through a recession, with partial recovery. The adjustment process is mainly coordinated through the Montenegrin Government's expectations process seems to do well. While still there are some gaps, while output decreases inflation increases, most of the time, they comove. It proves the crucial point of expectation formation in the Montenegrin market and the dynamic effects of shocks. These economic fluctuations are a product of continuous innovations, either to aggregate supply or demand. That is why we need to identify these shocks and react to them with a proper policy; otherwise, they may lead to a recession.

Although we will later have the nominal exchange rate examined in another model, we would like to observe what happens if we add to the original VAR(3) model the nominal exchange rate! Will the impulse responses of the Montenegrin economy change? As expected, the Montenegrin economy's performance did not vary if we added the nominal exchange rate. If we compare the results, they are identical. The impulse responses of the variables in both cases have a similar impact on the innovations. Lastly, it confirms that the original model is a good one.

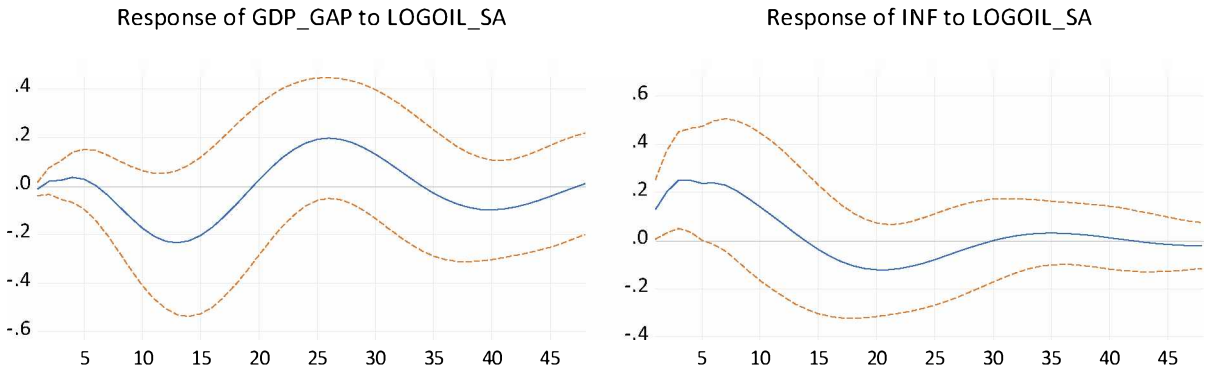

Figure 33: Impulse responses with exchange rate added to the VAR model
Source: Author's calculations in EViews 11.

We might keep adding, for instance, wages because they directly impact the price-setting and wage-setting relation in the labor market in Montenegro. They confirm, once more,

that the original model with 3 lags is stable. The added variable does add any change to the impulse responses of innovations in the Montenegrin economy. It confirms that our original VAR(3) model is not misspecified. Thus, the exogenous oil price shocks' exogenous movements are exogenous as expected, which was approved by adding some intuitive economic potential variables. Therefore, exogenous shocks were adequately identified. Including nominal exchange to better isolate the oil price innovations did not prove to add any new information based on evidence from Figure 33.

3.4.2. Forecast error variance decomposition

Knowledge about the forecast errors is useful to analyze the relationships among variables. The variance decomposition gives us a proportion of the variances of the forecast errors for y_{jt+h} into a percentage, explained by each of the shocks[324]. Thus, finding shocks u_t brings the question about the importance of one innovation versus another in explaining y_t. The forecast error variance decomposition has been used as an argument in discussing the origin of business cycles. Montenegrin policymakers need to know whether oil and aluminum price shocks are the primary external sources of inflation forecast errors at long horizons? Or, are demand shocks the primary internal sources of inflation forecast errors in Montenegro?

In our recursive ordering for *y* and *x,* all the one period forecast-error variance of *y* is due to shocks u_{yt} to itself, by construction. It is so because *y* was placed first in the ordering, and shocks to *x* do not affect *y* contemporaneously. At longer horizons, the explanatory share of shocks to *y* will diminish. Thus, the variance of the forecast errors should increase with the horizon. As seen in the forecasting section, the further we move into horizons, the higher the chance for uncertainty bands.

[324] Anderson, T., *An Introduction to Multivariate Statistical Analysis*, 3rd ed. New York: John Wiley, 2003.

In our two-variable conceptual example, the forecast errors take on a recursive ordering, meaning a sequential change. One could think of it as a timeline of events, with shocks hitting y first and then affecting the interest rate[325].

$$\begin{bmatrix} 1 & 0 \\ -\beta_{21} & 1 \end{bmatrix} \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} = \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \quad (155)$$

$$\begin{bmatrix} 1 \cdot (u_{yt}) + 0 \cdot (u_{xt}) \\ -\beta_{21}(u_{yt}) + 1 \cdot (u_{xt}) \end{bmatrix} = \begin{bmatrix} u_{yt} \\ -\beta_{21} u_{yt} + u_{xt} \end{bmatrix} = \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \quad (156)$$

Shocks to x_t do not affect contemporaneously (within the period) y_t. On the contrary, both shocks have a contemporaneously impact on x_t, as seen from equation (156). How much will be the effect of y_t on x_t? It depends on the size of β_{21}. Structural shocks, u_t will only be adequately identified if there is economic support for the restriction imposed to identify the VAR[326]. In our case, the restriction imposed is that $\beta_{12} = 0$. It should be justified based on economic intuition. It does have to make sense; otherwise, the effect might result in bringing wrong policies about the economic dynamics of Montenegro. Finding matrix A^{-1} and A, when one has a recursive ordering, is not hard, and with A^{-1} we get the impulse responses.

Any invertible matrix may be broken into two lower triangular factors – Cholesky factors[327]. It is a numerical technique to estimate a recursive ordering easily. To obtain the inverse of matrix A, we can get the Cholesky factor of the variance-covariance matrix of the forecast errors. It is a mathematical concept, and it does not have anything to do with economics. But the restrictions we make are purely economic intuition, which is reflected in the upper side of the matrix A and on its inverse A^{-1}. Based on those *0s*, EViews will get the impulse response calculations. It is a combination of mathematics,

[325] Lütkepohl, H., "Asymptotic distributions of impulse response functions and forecast error variance decompositions of vector autoregressive models," *Review of Economics and Statistics,* 1990, 72, 116–25.

[326] Forni, M., M. Hallin, M. Lippi, and L. Reichlin., "The generalized dynamic factor model: identification and estimation," *Review of Economics and Statistics*, 2000, 82, 540–52.

[327] Higham, N. J. "Cholesky Factorization," *Manchester Institute for Mathematical Sciences School of Mathematics*, EPrint 2008.116.

artistic judgment, and economic intuition. Why intuition? It is often challenging to justify the economics of recursive ordering.

Ouliaris *et al.* (2018) continue arguing that when one has a recursive ordering, the inverse of A, A^{-1}, is the Cholesky factor of $\sum_e$, the variance-covariance matrix[328]. In case we substitute expression that relates the forecast errors with structural shocks into the variance-covariance matrix of the forecast errors, it results like the following[329]:

$$E_{e_t e_t'} = \sum_e \tag{157}$$

$$E(A^{-1} u_t u_t' A^{-1\prime}) = \sum_e \tag{158}$$

Assuming that the variance-covariance matrix of the structural shocks is the identity matrix:

$$E_{u_t u_t'} = \sum_u = I \tag{159}$$

we get precisely that the variance-covariance matrix:

$$A^{-1} I A^{-1\prime} = \sum_e \tag{160}$$

the same as:

$$(A^{-1} A^{-1\prime}) = \sum_e \tag{161}$$

which is the product of two Cholesky factors, the inverse of A, A^{-1}, times its transpose $A^{-1\prime}$[330]. The inverse of A, A^{-1}, is the lower triangular, which is consistent with the recursive ordering. Note that when you normalize the variance-covariance matrix of the structural shocks, $\sum_u = I$, assuming that it is equal to the identity matrix, our matrix A will not have *1s* on the diagonal as we expected at the beginning. It only has to do with how we normalize our VAR. Either we have *1s* on the diagonal of A, or we impose that the variance of the structural shocks is 1.

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[328] Ouliaris, S., A. Pagan and J. Restrepo., *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation*. Institute for Capacity Development, 2018. E-book, available at https://www.eviews.com/StructVAR/structvar.html.

[329] Nicholas J. Higham. *Functions of Matrices: Theory and Computation*. Philadelphia, PA, USA: Society for Industrial and Applied Mathematics, 2008.

[330] Brezinski, C., The life and work of André Cholesky. *Numer. Algorithms*, 2006, 43, 279–288.

If correlations between the errors are low, the order is irrelevant. But usually, correlations are strong, and the order matters. Deciding the ordering (restrictions) to be imposed is crucial, and we need to use economic intuition to resolve it. It is impractical to try all possible orders. With 4 variables, there are 4!=24 possible orderings—too many. If we are sure that there is a recursive ordering or sequential chain, we must then know in what order the variables are recursive. The IMFx (2018) continues emphasizing that knowledge of the prediction errors can be precious in examining the relationships among the variables[331]. Assume that we know the coefficients G_0 and $G_1$and wish to project the values of Z_{t+1} conditional on the observed values of Z_t. If the equation:

$$Z_t = G_0 + G_1 Z_{t-1} + e_t \tag{162}$$

is advanced one period, we obtain:

$$Z_{t+1} = G_0 + G_1 Z_{t-1} + e_{t+1} \tag{163}$$

and the prediction error will be:

$$Z_{t+1} - EZ_{t+1} = e_{t+1} \tag{164}$$

For innovation in $t + 1$.

$$Z_{t+3} = G_0 + G_1(G_0 + G_1(G_0 + G_1 Z_t + e_{t+1}) + e_{t+2}) + e_{t+3} \tag{165}$$

$$Z_{t+3} - EZ_{t+3} = G_1^2 e_{t+1} + G_1 e_{t+2} + e_{t+3} \tag{166}$$

$$EZ_{t+n} = (I + G_1 + G_1^2 + \ldots + G_1^{n-1})G_0 + G_1^n X_{t+n} \tag{167}$$

It might also be expressed in structural error terms:

$$Z_{t+n} - EZ_{t+n} = e_{t+n} + G_1 e_{t+n+1} + G_1^2 e_{t+n-2} + \ldots + G_1^{n-1} e_{t+1} \tag{168}$$

The prediction error only for y and n steps ahead forward will be:

$$Z_{t+n} = \mu + \sum_{i=0}^{n} G_1^i A^{-1} u_{t+n-i} = \quad Z_{t+n} = \mu + \sum_{i=0}^{n} \psi_i A^{-1} u_{t+n-i} =$$

$$Z_{t+n} = \mu + \sum_{i=0}^{n} C_i u_{t+n-i} \tag{169}$$

[331] IMFx, Institute for Capacity Development, *Macroeconometric Forecasting*, 2018.

The variance of this prediction error is[332]:

$$Y_{t+n} - EY_{t+n} = c_{11,0}u_{yt+n} + c_{11,1}u_{yt+n-1} + \cdots + c_{11,n-1}u_{yt+1} + c_{12,0}u_{xt+n} + c_{12,1}u_{xt+n-1} + \ldots + c_{12,n-1}u_{xt+n} \quad (170)$$

$$\sigma_{y,n}^2 = \sigma_y^2\left[c_{11,0}^2 + c_{11,1}^2 + \ldots + c_{11,n-1}^2\right] + \sigma_z^2\left[c_{12,0}^2 + c_{12,1}^2 + \ldots + c_{12,n-1}^2\right] \quad (171)$$

The error variance increases as the projection horizon increases since the values of $c_{11,0}^2$ are necessarily positive. It is doable to decompose the prediction error *n* periods forward by contributing two shocks in our example[333]. The proportions of $\sigma_{y,n}^2$ attributable to each structural shock are[334][335]:

$$\frac{\sigma_y^2\left[c_{11,0}^2 + c_{11,1}^2 + \ldots + c_{11,n-1}^2\right]}{\sigma_{y,n}^2} \qquad \frac{\sigma_z^2\left[c_{12,0}^2 + c_{12,1}^2 + \ldots + c_{12,n-1}^2\right]}{\sigma_{y,n}^2} \quad (172)$$

Expression (172) shows the proportion of the changes of one variable attributable to shocks to itself and shocks to another variable. The latter is exogenous if u_{xt-i} fails to explain any changes in *y*. The restriction imposed above requires that the entire variance in the prediction error for *y* one-period forward be attributable to u_{yt-i}.

Now, let us turn to our empirical results of variance decomposition. The first part of Table 18 represents the forecast error variance of the oil price variable, which is exogenous and comes due to itself. As seen, we have set the horizons to be from 1 to 10 months forecast error variance. At short horizons, at month 1, the forecast error variance of oil price is due to itself 100%, as we see that in the column of LOGOIL_SA, month 1. Why? Since the oil price was placed first in the ordering, no other shocks affect it contemporaneously. As we see it from the columns of LOGALERU_SA, UN_SA, GDP_GAP, and INF, the first month has no impact contemporaneously at the LOGOIL_SA, and thus containing zeros. It comes from the fact that we first ordered the oil price as an independent variable from other variables. As horizons increase, for instance, from 1 to 2, we notice each variable's

[332] Hamilton, J., *Time Series Analysis*. Princeton, New Jersey: Princeton University Press, 1994.

[333] Favero, C., *Applied Macroeconometrics*. Oxford, UK: Oxford University Press, 2001.

[334] Eichenbaum, M., 1992. "'Interpreting the macroeconomic time series facts: The effects of monetary policy' : by Christopher Sims," *European Economic Review*, 1992, 36(5), 1001-1011.

[335] Enders, W., *Applied econometric time series*. Hoboken, New Jersey: Wiley, 3rd ed, 2010.

contribution and its corresponding shocks to the movements, forecast error variance, of oil price.

Table 18: Forecast error variance decomposition

Variance Decomposition of LOGOIL:

Period	S.E.	LOGOIL	LOGAL	UN	GDP_GAP	INF
1	0.070473	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.104573	96.43955	1.196515	0.216567	0.001241	2.146128
3	0.132607	94.05346	1.776276	0.800118	0.031466	3.338682
4	0.152519	92.63005	3.007427	0.888716	0.041664	3.432143
5	0.167123	91.38196	4.501467	0.932818	0.109911	3.073848
6	0.177492	89.96724	6.018904	1.083848	0.204564	2.725448
7	0.185245	88.04492	7.709810	1.300352	0.300350	2.644569
8	0.191537	85.58960	9.572234	1.496169	0.391146	2.950851
9	0.197071	82.64439	11.61932	1.635543	0.474784	3.625957
10	0.202276	79.34028	13.81909	1.717064	0.545365	4.578195

Variance Decomposition of LOGAL:

Period	S.E.	LOGOIL	LOGAL	UN	GDP_GAP	INF
1	0.047188	11.51427	88.48573	0.000000	0.000000	0.000000
2	0.067800	16.56238	82.44847	2.15E-06	0.073329	0.915817
3	0.084746	27.39790	70.90762	0.051217	0.168616	1.474643
4	0.097061	34.31334	63.09712	0.082194	0.547865	1.959488
5	0.105637	38.44080	57.95108	0.107956	1.301009	2.199155
6	0.111196	40.73391	54.73329	0.114156	2.318738	2.099909
7	0.114663	41.71547	52.65233	0.112071	3.541224	1.978902
8	0.116891	41.75111	51.19895	0.108410	4.821430	2.120098
9	0.118490	41.18286	50.00745	0.107710	5.999951	2.702032
10	0.119913	40.29248	48.85325	0.127219	6.964410	3.762645

Variance Decomposition of UN:

Period	S.E.	LOGOIL	LOGAL	UN	GDP_GAP	INF
1	0.285312	0.531419	0.721276	98.74731	0.000000	0.000000
2	0.414072	0.425844	0.385049	95.08352	4.061299	0.044283
3	0.471512	0.645777	0.493189	91.39653	7.158790	0.305711
4	0.514320	0.802195	0.533792	88.17241	9.070631	1.420967
5	0.556393	0.715748	0.702572	85.52381	10.68561	2.372258
6	0.595461	0.625222	1.093605	82.74026	12.26270	3.278214
7	0.628560	0.584043	1.761715	79.83687	13.69768	4.119695
8	0.656999	0.597446	2.602862	77.14465	14.81835	4.836698
9	0.682113	0.661382	3.569315	74.74631	15.66656	5.356429
10	0.704237	0.753692	4.643408	72.62948	16.29175	5.681672

Variance Decomposition of GDP_GAP:

Period	S.E.	LOGOIL	LOGAL	UN	GDP_GAP	INF
1	0.159984	0.153992	0.910271	1.317503	97.61823	0.000000
2	0.317459	0.746123	2.431321	0.676292	95.87789	0.268376
3	0.468198	0.606668	1.163761	1.617849	96.47122	0.140505
4	0.610431	0.421050	0.840535	2.050569	96.31289	0.374955
5	0.738905	0.357724	1.217938	1.979867	95.18390	1.260574
6	0.855572	0.877097	1.927946	1.793235	92.26277	3.138957
7	0.961903	2.275946	2.811741	1.552434	87.33575	6.024126
8	1.060773	4.558784	3.773445	1.296115	80.77912	9.592533
9	1.154226	7.514745	4.723474	1.104663	73.31718	13.33994
10	1.242685	10.82717	5.608961	1.063248	65.78529	16.71534

Variance Decomposition of INF:

Period	S.E.	LOGOIL	LOGAL	UN	GDP_GAP	INF
1	0.685676	2.506486	0.041461	3.108327	1.159379	93.18435
2	0.883497	5.712231	0.435832	2.313356	0.734785	90.80380
3	1.059628	8.752622	0.304302	1.617544	0.647839	88.67769
4	1.172512	11.41066	0.930138	1.696993	0.721727	85.24049
5	1.262393	12.88109	2.165884	2.703656	0.646343	81.60303
6	1.334657	14.31063	3.891369	4.085677	0.578561	77.13376
7	1.394508	15.59593	5.764598	5.499089	0.544452	72.59593
8	1.445952	16.60511	7.526025	7.020830	0.534670	68.31337
9	1.488882	17.30248	8.938035	8.548189	0.547631	64.66367
10	1.522646	17.72630	9.912354	9.936654	0.574743	61.84995

Cholesky Ordering: LOGOIL LOGAL UN GDP_GAP INF

Source: Author's calculations in EViews 11.

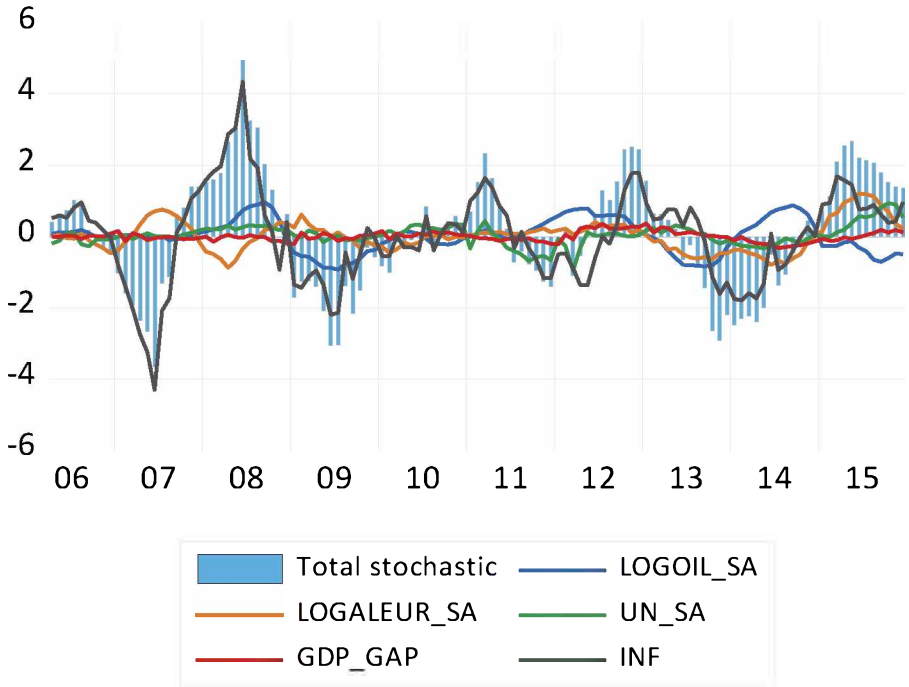
For instance, at the horizons of 2 months, the contribution of aluminum, unemployment, and inflation shocks to the movements of oil price increases from 0% to 1.19%, 0.21%, and 2.14%, respectively. And at longer horizons, for example, 10 horizons, the contribution of corresponding shocks increases to 13.81%, 1.71%, and 4.57%. Moving further, the forecast error variance of unemployment is mostly the result of shocks to itself at short horizons 98.74%. In contrast, at horizons of 10 months, the contribution of oil, aluminum, gdp_gap, and inflation is 0.75%, 4.64%, 16.29%, and 5.68%, respectively. At 24 moth horizons, the contribution is as follows: oil 1%, aluminum 15.50%, gdp_gap 15.74%, and inflation 5.13%, while at horizons of 48 months, the respective contribution is: oil 1%, aluminum 20.37%, gdp_gap 14.55%, and inflation 5.24%. Thus, we notice here that gdp_gap and inflation contribute to increasing forecast error variance

(movements). Still, aluminum is the leading shock contributing to the movement of unemployment in the Montenegrin labor market.

Next is the GDP gap in the line to see the variance, from 1 to 10 periods ahead forecast error, explained by the system's first orthogonal shock. At short horizons, month 1, most of the movements come from itself 97.61%. Still, at 10 months, shocks' impact increases: oil shock contributes at 10.82%, aluminum at 5.60%, unemployment at 1.06%, and inflation at 16.71%. At 24-month horizons, we have: oil 23.35%, aluminum 8.31%, unemployment at 9,31%, and inflation at 23.34%. The oil price impact increased from 10.82% to 23.35%, aluminum from 5.60% to 8.31%, unemployment from 1.06% to 9.91%, and inflation from 16.71% to 23.34%, at horizons from 10 to 24 months. We notice that each shock continues to have a greater impact as horizons increase.

At the variance decomposition of inflation, most of the variance at month 1 comes from itself 93.18%, but unemployment contributes with 3.10% even at the beginning and oil price with 2.50%.

Figure 34: Historical inflation decomposition using Cholesky weights



Source: Author's calculations in EViews 11.

At 10-month horizon, contribution of oil is 17.72%, aluminum 9.91%, unemployment with 9.93%, and gdp_gap with 0.57%.

If we increase the horizon to 24 months, then the impact of shocks are as follows: oil 17.82%, aluminum price (11.41%), unemployment with 13.62%, and gdp_gap 1.14%. We notice that the impact of oil price shock increases rapidly at the beginning, especially the first 6 months from 2.50%, 5.71%, 8.75%, 11.41%, 12.88%, and 14.31%, respectively. Figure 34 shows historical inflation decomposition, decomposing forecast errors to elements associated with structural shocks.

The empirical evidence follows the IS-LM-PC model, but not precisely, and the reasons that it does not follow it come from the fact that the Montenegrin economy is in transition, unemployment statistics are incomplete concerning registered and unregistered, and the presence of a shadow economy.

3.5. Non-recursive identification

For the following identification, the imposition of restrictions on the contemporaneous structural parameters in the short-run and long-run are as follows:

$$S = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \beta_{21} & 1 & 0 & 0 & 0 \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} & 0 \\ \beta_{41} & \beta_{42} & \beta_{43} & 1 & 0 \\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon^o \\ \varepsilon^a \\ \varepsilon^u \\ \varepsilon^g \\ \varepsilon^\pi \end{bmatrix} = \begin{bmatrix} u^o \\ u^a \\ u^u \\ u^g \\ u^\pi \end{bmatrix} \quad \&$$

$$F = \begin{bmatrix} 1 & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} \\ \beta_{21} & 1 & \beta_{23} & \beta_{24} & \beta_{25} \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} & \beta_{35} \\ \beta_{41} & \beta_{42} & \beta_{43} & 1 & 0 \\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon^o \\ \varepsilon^a \\ \varepsilon^u \\ \varepsilon^g \\ \varepsilon^\pi \end{bmatrix} = \begin{bmatrix} u^o \\ u^a \\ u^u \\ u^g \\ u^\pi \end{bmatrix} \qquad (173)$$

totaling the number of restrictions to 10, based on $(n^2 - n)/2 = (5^2 - 5)/2 = 10$. The first equation in (173) assumes that oil price is exogenous to the other variables. The second equation in (173) assumes that oil price is affected only by aluminum price innovations. Equation 3 assumes that unemployment is not affected by innovations in inflation, $\beta_{35} = 0$. Equation 4 assumes that neither in the short-run nor the long-run GDP gap is affected by inflation; as a result, we restricted in EViews 11, β_{45}= 0. Finally, inflation gets impacted by contemporaneous shocks of all variables in the system. We

have combined restrictions in the short and long run, which is done by doing restrictions in S and F matrices, totaling 10 restrictions. Specifying long-run restrictions in F is equivalent to imposing more complicated linear restrictions on S.

Table 19: Restricted VAR identification

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	-0.227213	0.007349	-30.91833	0.0000
C(2)	0.171102	0.049899	3.428967	0.0006
C(3)	0.156133	0.027842	5.607894	0.0000
C(4)	-1.468896	1.036117	-1.417692	0.1563
C(5)	0.545882	0.074521	7.325250	0.0000
C(6)	-0.379222	0.041698	-9.094498	0.0000
C(7)	0.095350	1.557152	0.061233	0.9512
C(8)	-0.064769	0.006505	-9.957373	0.0000
C(9)	0.456635	0.243175	1.877799	0.0604
C(10)	-0.467079	0.433262	-1.078052	0.2810
C(11)	0.070473	0.000581	121.2130	0.0000
C(12)	0.044389	0.000366	121.2131	0.0000
C(13)	0.283520	0.002339	121.2130	0.0000
C(14)	0.158067	0.001304	121.2130	0.0000
C(15)	5.869842	0.049206	119.2919	0.0000
Log-likelihood	3685.137			
LR test for over-identification:				
Chi-square(10)	395.1863		Probability	0.0000
Estimated A matrix:				
1.000000	0.000000	0.000000	0.000000	0.000000
-0.227213	1.000000	0.000000	0.000000	0.000000
0.171102	0.545882	1.000000	0.000000	0.000000
0.156133	-0.379222	-0.064769	1.000000	0.000000
-1.468896	0.095350	0.456635	-0.467079	1.000000
Estimated B matrix:				
0.070473	0.000000	0.000000	0.000000	0.000000
0.000000	0.044389	0.000000	0.000000	0.000000
0.000000	0.000000	0.283520	0.000000	0.000000
0.000000	0.000000	0.000000	0.158067	0.000000
0.000000	0.000000	0.000000	0.000000	5.869842
Estimated S matrix:				
0.070473	0.000000	0.000000	0.000000	0.000000
0.016012	0.044389	0.000000	0.000000	0.000000
-0.020799	-0.024231	0.283520	0.000000	0.000000
-0.006278	0.015264	0.018363	0.158067	0.000000
0.108555	0.013962	-0.120888	0.073830	5.869842

Estimated F matrix:

0.559932	-1.078073	-0.212509	-0.007564	-2.333817
0.171231	0.300597	0.216527	0.168855	-0.123108
0.320679	3.381867	4.250110	2.048638	11.75292
-1.849607	0.384114	1.913083	3.147017	-7.860592
1.610320	0.196131	-3.166156	-0.796151	17.70660

Source: Author's calculations in EViews 11.

Table 19 reports the contemporaneous coefficient estimates of oil price innovations based on the SVAR *non-recursive* model. These coefficients provide baseline intuition of the basic relationship that exists among the variables.

4. Forecast Combination Puzzle of Inflation

In advance, policymakers need to know the potential movements of inflation to prepare appropriate policy measures. Cecchetti et al., (2000), among other factors, highlight the impulse responses of the real economy to inflation[336]. Dées and Güntner (2016) disentangle the role of profit margins and unit labor costs as the primary determinants of price dynamics on the supply side across euro area countries and sectors using a panel VAR approach[337]. Even though inflation has been examined to a great extent in the previous sections, we find there is still sufficient space for enhancement. The novelty of this section is that it uses a combined prediction for the economy of Montenegro. This section uses high – dimensional dynamic models using a combination approach. It examines and compares the empirical results of various forecast combination puzzles of inflation[338][339].

The theory of combining different models of forecasts recommends that methods that weigh better forecasts more heavily will show a better performance than the simple combination forecast (Stock and Watson, 2004; Smith and Wallis, 2009)[340][341]. Our main statement, *ceteris paribus,* is that we should include aggregate determinants of inflation into the macro-econometric examination. Forecast combination puzzles are essential in the light of Montenegrin efforts to join the EU. First, conceptual specification, based on which empirical estimations of inflation determinants are examined, is not prevailing, combining empirical analysis and theory. Second, we identify three structural VAR and BVAR models recursively and combine them employing an equal and inverse MSE

[336] Cecchetti, S.G. R.S. Chu, and Ch. Steindel., "The unreliability of inflation indicators," *Current Issues in Economics and Finance*, 2000, 6, 1-6.

[337] Dées, S. and J. Güntner., "Forecasting Inflation Across Euro Area Countries and Sectors: A Panel VAR Approach," *Journal of Forecasting*, 2016, 36, 431-453.

[338] Hendry, D. F., and M. P. Clements., "Pooling of Forecasts," *Econometrics Journal*, 2002, 5, 1-26.

[339] Jore, A.S., J. Mitchell., and S. P. Vahey., "Combining forecast densities from VARs with uncertain instabilities, "*Journal of Applied Econometrics*, 2010, 250(4), 621–634.

[340] Stock, J. H., and M. W. Watson., "Combination Forecasts of Output Growth in a Seven-Country Data Set," *Journal of Forecasting*, 2004, 23(6), 405-430.

[341] Smith, J., and K. F. Wallis., "A Simple Explanation of the Forecast Combination Puzzle," *Oxford Bulletin of Economics and Statistics*, 2009, 71(3), 331-355.

weighting approach. VARs are critical empirical tools in modern macroeconomics, and they allow one to model macroeconomic data informatively[342].

We present here parameter estimates and the main characteristics of two more model examinations. The second identified SVAR model is as follows:

$$\pi_t = \beta_0 + \beta_1 \log(EF)_t + \beta_2 \log(EDGI)_t + \beta_3 CStock_t + \beta_4 \log(H)_t + \beta_5 Emp_t + \beta_6 GDP\_GAP_t + u_t \quad (174)$$

where π_t- denotes the inflation rate, *log* - natural logarithm so that the inflation function has a constant price elasticity, $\log(EF)_t$ – denotes the natural logarithm of economic freedom, $\log(EDGI)_t$ – denotes the logarithmic state of technology, $CStock_t$ – denotes the capital stock rate, $\log(H)_t$ – denotes the natural logarithm of human capital, Emp_t – denotes the labor force, GDP_GAP_t – indicates the GDP gap. We will extend the growth model, which is shown in expression (174). As long as Montenegro has set its national development strategy, it is valuable to examine how this set of variables that determine economic growth dynamics will impact inflation[343]. There is a debate among academics about the proxy for the state of technological progress[344][345]. We will proxy it by e-government development index (EGDI).

Model 3, in this section, examines how changes in money supply, exchange rates, productivity, and wages affect inflation in the Montenegrin economy. A complete European monetary union is a fundamental step toward political union[346].

$$\pi_t = \beta_0 + \beta_1 \log(EX)_t + \beta_2 \log(M2)_t + \beta_3 \log(W)_t + \beta_4 Prod_t + u_t \quad (175)$$

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[342] Del Negro, M., and F. Schorfheide., *Bayesian Macroeconometrics*. In Handbook of Bayesian Econometrics, Chapter 7, 293-387. Oxford University Press, 2011.

[343] Government of Montenegro, Economic Reform Programme for Montenegro (ERP), 2018-2020.

[344] Clarke, G. R. G., and S. J. Wallsten., "Has the Internet Increased Trade? Evidence from Industrial and Developing Countries," *World Bank Policy Research Working Paper 3215*, 2004.

[345] Meijers, H., "Does the internet generate economic growth, international trade, or both?," *International Economics and Economic Policy*, 2014, 11(1), 137-163.

[346] Alesina, A., and V. Grilli., "The European Central Bank: Reshaping Monetary Policy in Europe." *National Bureau of Economic Research, Working Paper* 7927, 2000.

where $\log(EX)_t$ - denotes the US dollar to euro logarithmic form of the nominal exchange rate, $\log(M2)_t$ - represents broad money as defined by the International Monetary Fund (IMF), Monetary and Financial Statistics Manual (2017), $\log(W)_t$ - logarithmic form of wages, and $Prod_t$ - denotes industrial production growth. Equation (175) incorporates both demand-pull and cost-push ingredients, starting from a balance between aggregate demand and aggregate supply.

How can we pool or combine these forecast puzzles into an optimal forecasting performance? Multiple forecasting performances are available to decision-makers before they confirm a macroprudential policy decision. Given the relative uncertainty associated with identifying the true DGP, should a single forecasting performance be employed? Or should we *average* over all the available forecasting performances? It is not convincing that one econometric model would be statistically preferable to others at *all* points of the forecast horizon. Combining individual forecasts offers a simple way of creating a sophisticated, more flexible forecasting model to explain inflation phenomena. An integrated combined forecast is a weighted average of *Z* forecasts[347][348]:

$$\hat{y}^{c}_{T+h} = \sum_{i=1}^{Z} w_{T,h,i} x_{T,h,i} \tag{176}$$

and choosing weights as denoted in expression (176) $w_{T,h,i}$, minimizes the risk related to the loss from making a forecasting error. The optimal weight for $x_{T,h,1}$ is:

$$w^{*} = \frac{\sigma^2_{T+h,3} - \sigma_{T+h,1,2,3}}{\sigma^2_{T+h,1} + \sigma^2_{T+h,2} + \sigma^2_{T+h,3} - 3\sigma_{T+h,1,2,3}} \tag{177}$$

more considerable weight is assigned to the more precise model and the vector of optimal weights w' with Z forecasts is:

[347] Bates, J. and C. W. J. Granger., "The Combination of Forecasts," *Operations Research Quarterly*, 1969, 20, 451-468.

[348] Zhang, B., "Real-time inflation forecast combination for time-varying coefficients models," *Journal of Forecasting*, 2019, 38(3), 175-191.

$$w' = \frac{u'\sum_{T,h}^{-1}}{u'\sum_{T,h}^{-1}u} \tag{178}$$

The estimator squared bias and the forecast variance estimator of the MSE loss function of a forecast is:

$$E\left[\left(y_{T+h} - x_{T,h,i}\right)^2\right] = \sum_{i}^{Z} w_{T,h,i}^2\, bias_{T,h,i}^2 + \sigma_y^2 + \sum_{i}^{Z} w_{T,h,i}^2\, Var_{T,h,i}^2 \tag{179}$$

The recursive MSE of an individual forecast is:

$$MSE_{T,h,i} = \frac{1}{T-h-1}\sum_{t=1}^{T-h}\left(y_{t+h} - x_{t,h,i}\right)^2 \tag{180}$$

and MSE weights, relative performance weights, are:

$$\omega_{T,h,i} = \frac{\frac{1}{MSE_{T,h,i}}}{\sum_{i=1}^{Z}\frac{1}{MSE_{T,h,i}}} \tag{181}$$

Computing relative performance weights - inverse MSE - employing either rolling or discounting windows allows more attention to be paid to the recent performance. Combining forecast puzzles implies diversification of risk. There are a few methods for aggregating forecasts that have been developed on the forecast combination, but we will employ the averaging and the inverse MSE. Furthermore, we provide an out-of-sample methodology, which can be used to construct tests that evaluate a time-series model's ability to predict (West, 1999)[349].

Before we proceed further with the examination of the combination forecast methodology, we see it reasonable to describe the structure of the economic freedom variable.

4.1. Empirical results

Based on the ADF and PP unit root tests and KPSS stationarity test, all variables are stationary, I(0). Visual inspection of the time series and statistical correlograms confirm

[349] West, K. D., "Asymptotic inference about predictive ability," *Econometrica*, 1996, 64, 1067-1084.

stationarity as well. Moreover, *t*-statistics and *p*-values test results reject the null hypothesis of unit-roots.

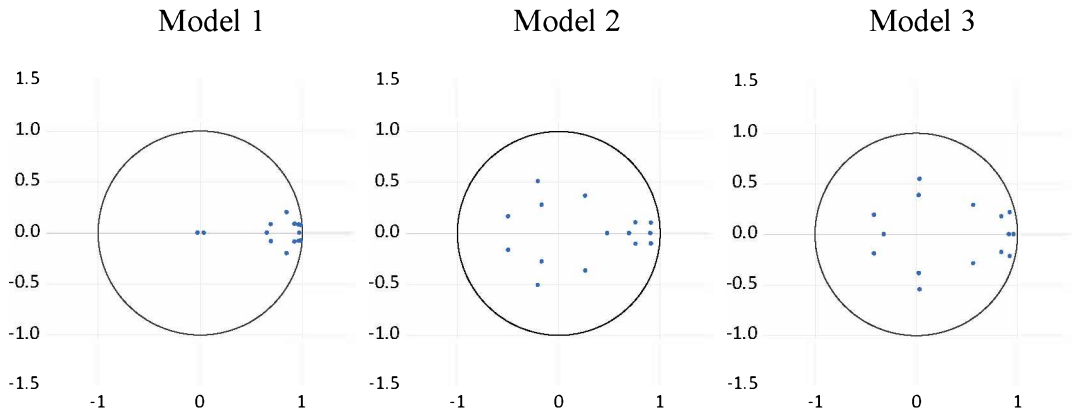

Figure 35: Inverse roots of AR characteristic polynomial for models 1, 2, and 3
Source: Author's calculations in EViews 11.

Testing for structural breaks is crucial for confidence bounds and forecasting purposes as well. Stability diagnostics (recursive estimates, Chow breakpoint test, Quandt-Andrews, and Bai-Perron) denote a parameter switch at a 5% significance level. Therefore, we include dichotomous variables. Recursively, we identify and estimate three SVAR and three BVAR models. A fitting lag is recommended for each of the lag length criteria (AIC, LR, FPE, SC, and HQ)[350]. As seen from Figure 35, all the inverse roots of the AR characteristic polynomial of models 1, 2, and 3 lie within the unit circles, confirming the stationarity of the VARs.

The fan charts, in Figures 36-38, show the forecasts for each model. We portray ten confidence intervals: from 90% to the mode. Visual inspection displays that the first model, in Figure 36, fits into a 9% confidence band the best (from 1.6% to 2.0% inflation).

It reveals a sustainable forecasting performance and an average inflation rate not higher than 1.5% above the three best performing EU Member states' inflation rate. The average rate of Cyprus (0.2%), Ireland (0.3%), and Finland (0.8%), as the best three performing

[350] Clark, T.E., and F. Ravazzolo., "Macroeconomic forecasting performance under alternative specifications of time-varying volatility," *Journal of Applied Econometrics*, 2015, 300(4), 551–575.

Member states, is 0.4% and, adding $1^{1/2}$ percentage points, the reference is 1.9%[351]. Model 2, in Figure 37, has more vibrations around the mode line than model 1.

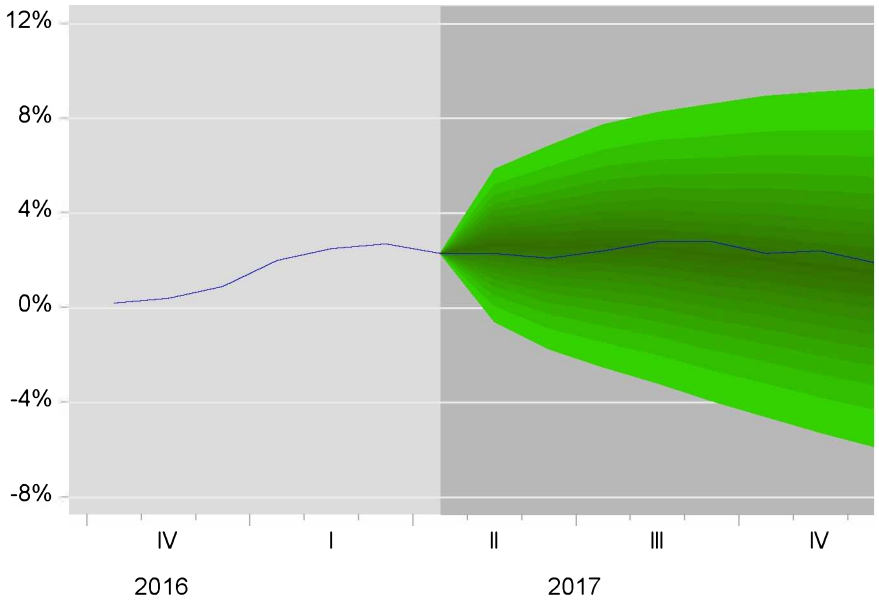

Figure 36: Fan chart of model 1
Source: Author's calculations in EViews 11.

Still, model 2 has valuable information to be considered for combined forecasts. As expected, model 3, in Fig. 33, having the external shocks (oil and aluminum LME prices), creates more fluctuations as horizons increase.

As expected, model 3, in Figure 38, having the exogenous shocks (oil and aluminum LME prices), creates more fluctuations as horizons increase.

The confidence bands increase with time and do not stop till 2017:12. Model 3 fits into 72-81% confidence bands in the second half of 2017. We include a certain number of variables within a forecasting model because adding more regressors to the examined model exacerbates the size problems[352]. We estimated three different SVAR models and

[351] European Commission. "Convergence Report. Institutional Paper 078," *European Economy,* 2018, ISSN 2443-8014.

[352] Clark, T. E. and K. D. West., "Using out-of-sample mean squared prediction errors to test the martingale difference hypothesis," *Journal of Econometrics*, 2006, 135, 155-186.

then compared their forecasting performance based on RMSEs. Besides, we computed combined predictions with these models.

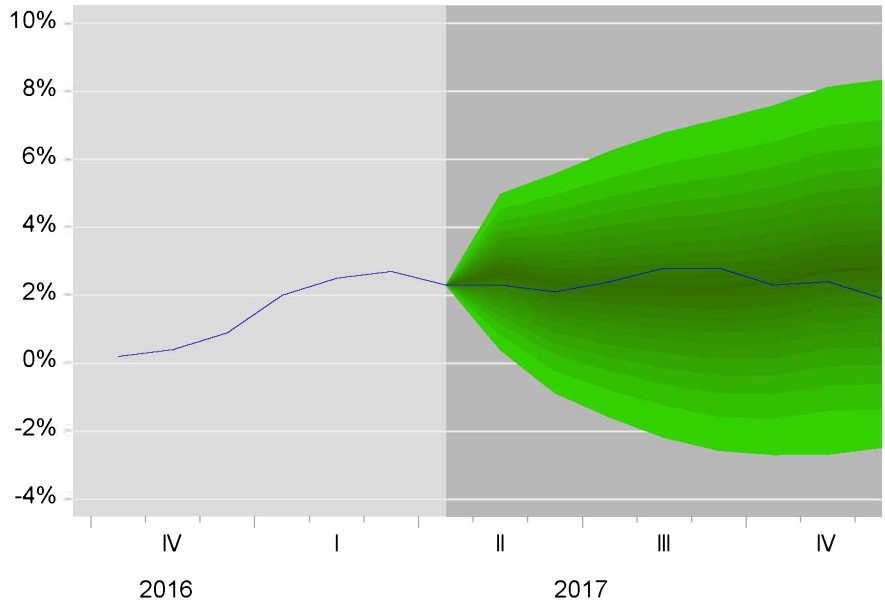

Figure 37: Fan chart of model 2
Source: Author's calculations in EViews 11.

Are our combined puzzle forecasts better or worse than the weighted aggregate of its parts? Each of the SVAR models has its interpretative and explanatory variables.

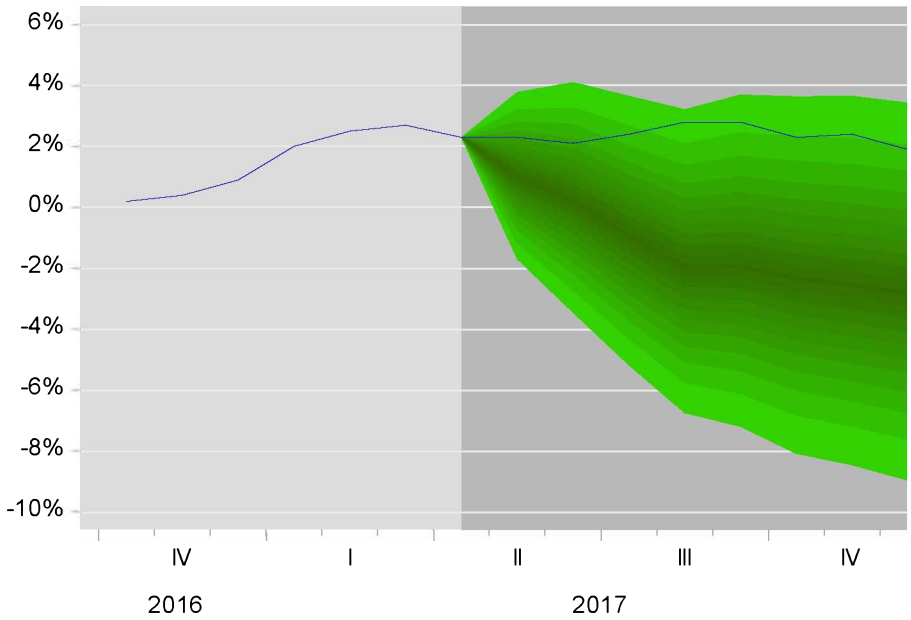

Figure 38: Fan chart of model 3
Source: Author's calculations in EViews 11.

The three SVAR models have been identified, estimated, and examined, predicting inflation the best. We set the sample from January 2006 to December 2016. We evaluate each using least squares (LS). The forecasting out-of-sample is from 2017:1 to 2017:12.

We examine the forecasting performances based on the RMSEs. The first model has the lowest RMSE (0.69), while the second model equals (2.35). As seen in Table 20, the third model appears to perform the worst according to RMSE, having a value of (3.71).

Table 20: Forecast evaluation statistics of model 1, 2, and 3

Forecast: INFF_1, INFF_2, INFF_3
Actual: INF
Forecast sample: 2017M01 2017M12

Included observations: 12	Model 1	Model 2	Model 3
Root Mean Squared Error	**0.6884**	**2.3466**	**3.7081**
Mean Absolute Error	0.6175	2.0865	3.4428
Mean Absolute Percentage Error	25.8427	90.341	145.0751
Theil Inequality Coefficient	0.1647	0.3364	0.9071

Source: Author's calculations in EViews 11.

Based on inverse MSE, the numerators of relative weights, are as follows: r1 = 2.11, r2 = 0.18, and r3 = 0.07. While the value of the denominator is rt = 2.36. The weights are to sum up to 1 by construction, and the relative weights are: w1 = 0.89244, w2 = 0.076802, and w3 = 0.030758.

Figure 39 shows our two new forecast combinations: equal and relative performance weights. On average, both combinations underpredict the actual inflation during the whole year of 2017. For the first three months - forecast horizon, the equal weights perform better than the inverse MSE weights, reaching inflation of 1.89%.

After this period, the INFF_MSE performs much better than the equal weights. The RMSE of equal weights (RMSE_C = 0.864771) is way better than the second and the third SVAR models, and the RMSE of relative performance (RMSE_MSE = 0.577499) is better than any of the SVAR models. Why are these results worthly of being noticed? They denote that considering all determinants of inflation reveals essential information for the CBCG: better forecasting.

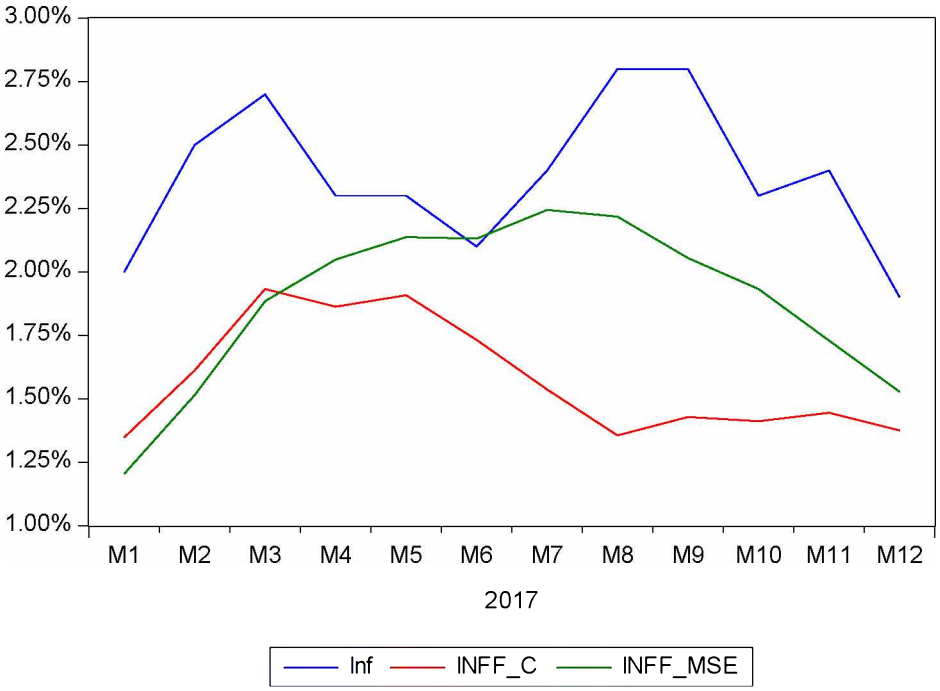

Figure 39: Combination forecasts: equal and inverse MSE weights
Source: Author's calculations in EViews 11.

Although the relative RMSE weights of model 2 and model 3 are relatively weak, upon combining into relative and average weights, they reveal robust knowledge for the policymakers: a lower RMSE. Using SVAR models, adding different variables continually increases the combined forecasting performance, resulting in a lower RMSE. We conclude that including appropriate SVAR forecasts in the forecast combination puzzle consistently reduces the RMSE of the combination forecasts. Suitably constructed forecasting combinations should replace traditional judgemental inflation forecasts. Thus, we find that a simple average combination outperforms all performances in the first quarter. The relative weight performance stays very close even in the first quarter and is the least sensitive until the end of December 2017. Traditionally in Montenegro, inflation forecasting has mainly been judgemental, making it difficult to replicate and justify. Noticeably, low-dimensional models omit essential information contained in the other variables. Thus, combination forecast puzzles that pool individual-predictor forecasting performances is the optimal solution for the Central Bank of Montenegro.

Figure 40 portrays forecast comparison of i) the actual inflation (inf), ii) inflation combined forecasts based on inverse MSE (inff_mse), iii) combined forecasts using equal weights (inff_c), iv) combined forecast using MSE-averaging of 5 forecasts (inf_f01_all),

v) forecast using model 1 (inff_1), vi) forecast using model 2 (inff_2), and vii) forecast using model 3 (inff_3).

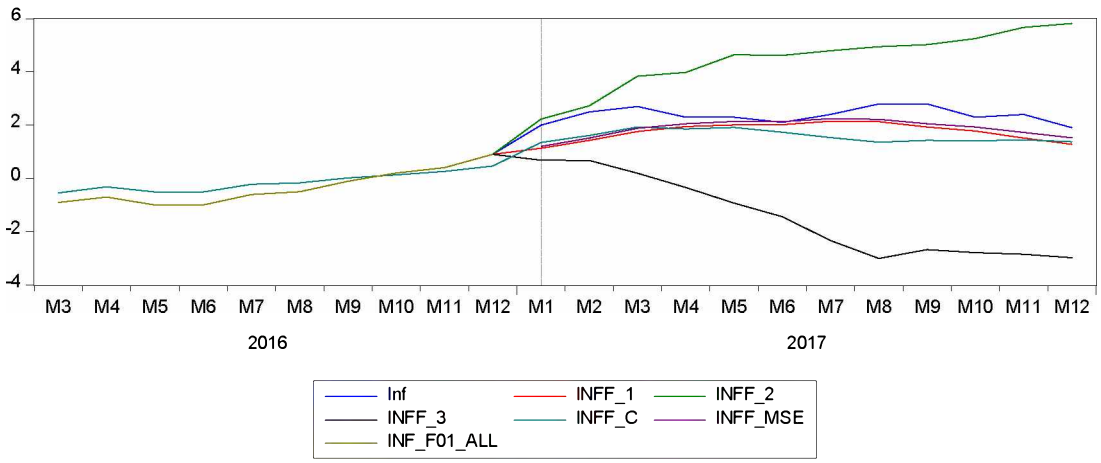

Figure 40: Forecast comparison
Source: Author's calculations in EViews 11.

The results are noticeable because the simple arithmetic average combination forecast (equal weights) outperforms the more sophisticated "optimal" forecast composites for the first three months. Afterward, from April to December 2017, the inverse MSE forecasting performance is the optimal linear composite since it minimizes the RMSE.

The performance of model 1 keeps up with the inverse MSE very near to the end of December 2017. Still, the simple average combination performs way better than both model 2 and model 3. The actual inflation results in (1.9%), the inverse MSE at (1.5%), the averaging (1.4%), model 1 at (1.3%), model 2 at (5.8%), and model 3 at (-3.0%) at the end of December 2017. Models 1-3 show forecasts that are sustainable and average inflation rate not more than 1.5% above the three best performing Member States' inflation rate: Although models 2 and 3 are way-off compared to the actual inflation, including these variables is significant to the CBCG[353]. The above results enable macroprudential policymakers to address, evaluate, compare, and implement the strength of using the dynamic composites of high-dimensional combination puzzles.

[353] Diebold, F. X. and P. Pauly., "The use of prior information in forecast combination," *International Journal of Forecasting*, 1990, 6, 503-508.

4.1.1. Sensitivity analysis

The policymakers of CBCG are highly interested to hypothetically see the responses of inflation in different sensitive scenarios, such as an increase in economic freedom index-internal innovations[354]. We consider it a leading indicator for inflation to which macroprudential policymakers should consider in Montenegro.

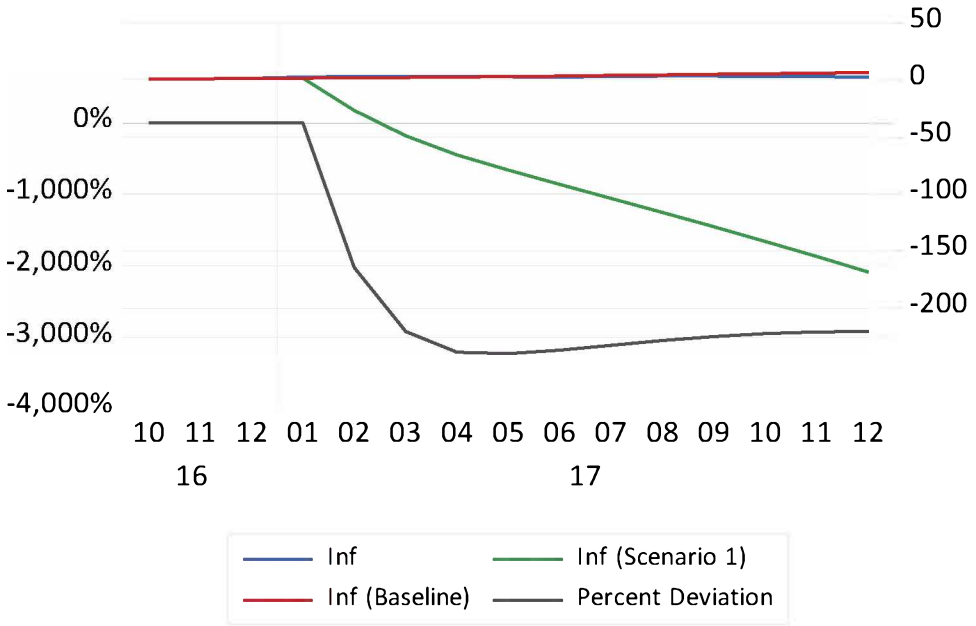

Figure 41: Economic freedom alternative scenario
Source: Author's calculations in EViews 11.

The impact of the economic freedom variable is multidimensional in Montenegro. The sensitive case scenario, in Figure 41, hypothetically increases the economic freedom index from 20% to 40% from 2017:1 till 2017:12. The dynamic effects can be traced out to inflation, as seen in Figure 41. We have to remind the reader that this is a deterministic simulation and dynamic solution performance. It employs predicted lagged values to bring a multi-period ahead forecasting. If we visually inspect inflation, in Figure 41, the alternative sensitive scenario could deflate the prices from 0% to -2020%.

[354] Groen, J. J. J., Paap, R., and F. Ravazzolo., "Real-time inflation forecasting in a changing world," *Journal of Business and Economic Statistics*, 2013, 310(1), 29–44.

Economic freedom appears to be crucial, and here we analyze the impulse responses and variance decomposition (Chan and Jeliazkov, 2009; Chan, 2013)[355][356]. In Figure 42, inflation directly starts to decline, especially in the first year, and then slowly increases. How can we describe the above results? The great news is that Montenegro is moving ahead towards the European Union, being a NATO member. Meanwhile, seeing progressive economic reforms in the real market can be anticipated from a forward-looking society to have a positive perspective. It implies a correction of price expectations P^e in relation to the current price level P.

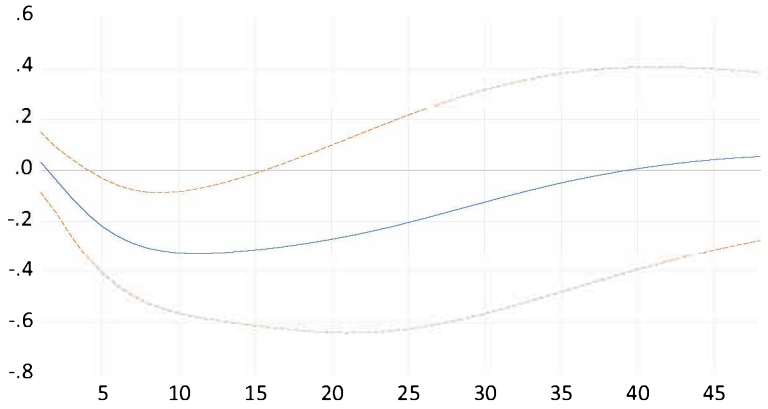

Figure 42: Response of inflation to economic freedom innovation
Source: Author's calculations in EViews 11.

As expected, the decomposition of forecast error variance of inflation to the economic freedom shocks is mostly the result of innovations to itself at short horizons, 96.53%.

The contribution of economic freedom shocks to the inflation rate movement increases to 9.13% after six months. The economic freedom contribution and its corresponding innovations to inflation's movement go up to 24.94%, at 12-month horizons. At 24-month horizons, the proportion of inflation movement due to economic freedom shocks reaches 35.89%.

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[355] Chan, J. C. C., and I. Jeliazkov., "Efficient simulation and integrated likelihood estimation in state-space models," *International Journal of Mathematical Modelling and Numerical Optimisation*, 2009, 1, 101–120.

[356] Chan, J.C.C., "Moving average stochastic volatility models with application to inflation forecast," *Journal of Econometrics*, 2013, 1760(2), 162–172.

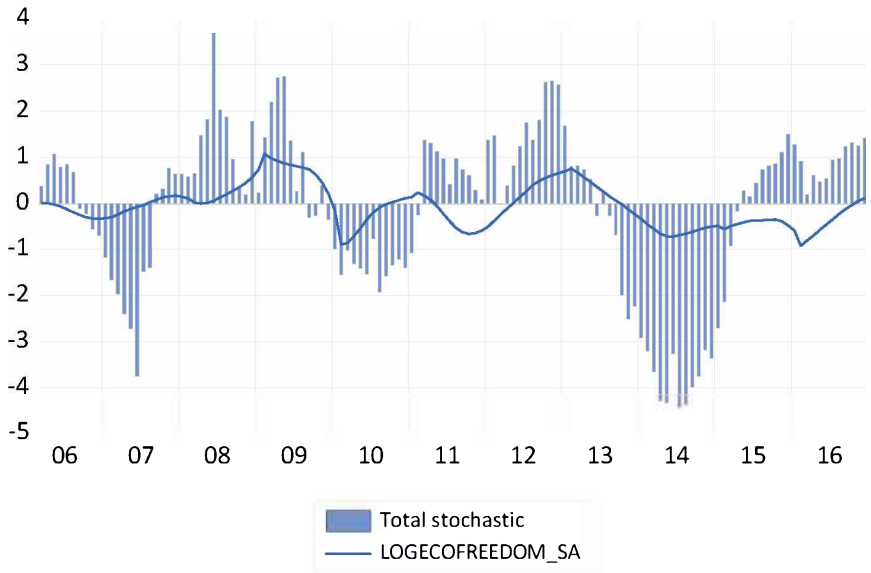

Figure 43: Historical inflation decomposition from economic freedom
Source: Author's calculations in EViews 11.

Finally, policymakers of CBCG could be interested in knowing how the nominal exchange rate shock would impact inflation. Figure 44 shows that two periods ahead, inflation response to the nominal exchange rate innovation increases to 0.06, and after six periods decreases to 0.00.

Given the high increase in meeting the Maastricht convergence criteria and the lack of methodological uniformity, we believe that the results shown here would appeal to policymakers. Although a few previous research papers have identified some methods that could be employed in forecasting inflation, such as internal and external variables, those methodologies had restrictions and difficulties in implementing on a national level. Thus, our results allow the policymakers to comprehend the factors incorporated in identifying the set of inflation dynamics and its expectations better and design more effective and efficient policy measures that can be used in Montenegro.

We reveal that among the individual-predictor forecasts, model 1 performs optimally, based on the RMSE. Model 1 performs even better than equal weights. Nevertheless, equal weights perform better than model 2 and model 3. This vital evidence indicates that economic freedom is critical in promoting and pushing sustainable growth. The main implications suggest that economic freedom is crucial in governing internal inflation and

sustainable growth in Montenegro. Alternatively, we increased oil prices in the previous section and economic freedom in this section.

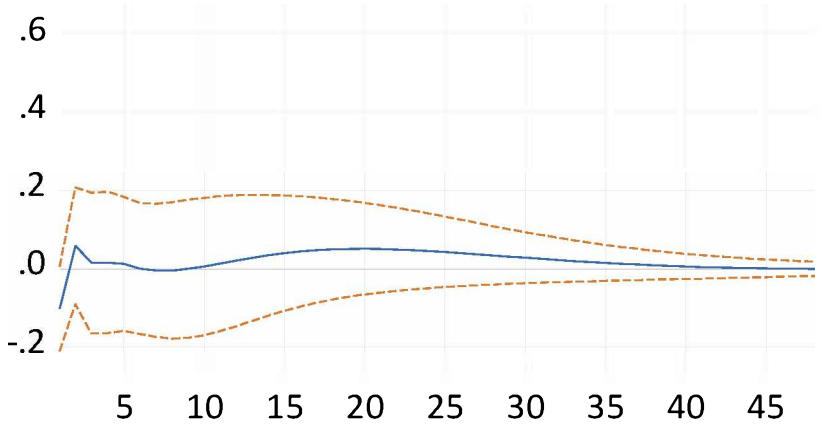

Figure 44: Inflation response to the nominal exchange rate innovation
Source: Author's calculations in EViews 11.

The inflation forecasting performance increases and sharply drops down, implying that Montenegrin economic government regulations are crucial. The impulse response results reveal that inflation responses to innovation on oil prices and economic freedom are essential. The forecast error variance decomposition of inflation is moved mainly from economic freedom and oil prices. In conclusion, the empirical findings provide macroprudential policymakers with an in-depth examination and understanding of the forecast combination models.

4.2. Bayesian VARs

What is the probability that a global economic shock will hit Montenegro in the upcoming month, March 2020, given that we know that a global economic crisis has already hit a country? We can estimate this probability using Bayes' theorem. A regression model with unknown coefficients β, the variance-covariance matrix $\sum_e$, and $e_t \sim nid\ N(0, \sum_e)$, Bayes' theorem is employed to combine the prior distribution of the parameters with the likelihood data function to produce a posterior distribution of coefficients β, viz[357][358]:

[357] Ouliaris, S., A. Pagan and J. Restrepo., *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation*. Institute for Capacity Development, 2018. E-book, available at https://www.eviews.com/StructVAR/structvar.html.

[358] K-H. Chin, X. Li., "Bayesian Forecast Combination in VAR-DSGE Models," *Journal of Macroeconomics,* 2018, 59, 278-298.

$$p(\beta \mid \sum_e, Y) = \frac{L(Y|\beta,\sum_e)\, p(\beta|\sum_e)}{p(Y)} \tag{184}$$

and consequently, we get that the posterior distribution is the likelihood function times the prior distribution:

$$p(\beta \mid \sum_e, Y) \propto L(Y \mid \beta, \sum_e)\, p(\beta \mid \sum_e) \tag{185}$$

In our case, the simplification would like $p(MNE \mid shock) = \frac{L(shock|MNE)\, p(MNE)}{p(shock)}$. The Bayes' theorem allows us to update our opinion based on new information. Yesterday's posterior beliefs (updated opinion) are today's prior (opinion to be updated). The idea about updating beliefs is core to Bayesian econometrics and can be used to test the hypothesis. We start with some idea or opinion, based on econometric inference, about how something works. Simulation methods of different types of priors get us different posteriors. In the case of the normal distribution of the prior β, normal distribution will have the posterior as well, and the matrix weighted average of the OLS estimates of the mode and mean of the prior β is:

$$\bar{b} = \left[\underline{V^{-1}} + \sum_e^{-1} \otimes (X'X)\right]^{-1}\left[\underline{V^{-1}}\,\underline{b} + (\sum_e^{-1} \otimes X')y\right] \tag{186}$$

The above expression (186) shows that the Bayesian methods tend to shrink the VAR estimated coefficients towards the prior mean, distant from the OLS estimates. Forecasting gains are exactly the just mentioned characteristic: shrinking the VAR estimates towards the prior mean.

VARs often end up with the over-fitting problem, which can result in imprecise forecasts. VARs have many parameters to estimate *n(np+1)*, often inaccurately because of limited data, and consequently, response functions and forecasts are not well-determined; thus, the number of coefficients easily proliferates[359]. Standard error bands tend to not account for parameter uncertainty, making forecasts to look more prices than they are really. The Bayesian method introduces *prior* distributions, including, *inter alia,* parameter

[359] Rummel, O., "Economic Modeling and Forecasting," *Centre for Central Banking Studies, Bank of England*, 2015, 1-54.

uncertainty[360]. Having a parsimonious model is the idea, a restricted number of parameters being estimated. Literature has emerged with practical solutions to omit some lagged values p in some equations, usually referred to as "best sub-set VARs." This section will apply Bayesian methods that set valuable prior distributions on the VAR coefficients' whole structure to get a parsimonious onset.

4.2.1. Forecasting with Bayesian vector autoregressions

Relative to our previous three VAR models, we estimated BVAR prior type of Litterman/Minnesota, Normal-Flat, Independent Normal-Wishart, Sims-Zha (normal-Wishart), and Giannone-Lenza-Primiceri to perform out-of-sample forecasting from January 2017 to December 2017. Our primary variable of interest is inflation (*inf*). Table 21 shows the results. There is an improvement in the forecasts.

The lowest RMSE for model 1 has BVAR, Normal-Flat prior type, and the values of hyperparameters are set to $\mu_1 = 0$, since we have proven that the VAR(2) is stationary, and $\lambda_1 = 0.1$, implying a strong prior for β. Standard deviations of the first variables in each equation are controlled through λ_1, shrinking the first-lag coefficients. Relative to the VAR parameter estimates, the lagged coefficients have shrunk.

Compared to the standard VAR estimates, the BVAR of prior Litterman/Minnesota shows to have the lowest RMSEs for model 2 (0.48967) and model 3 (1.27483), given the setting $\mu_1 = 0, \lambda_1 = 0.1,\ \lambda_2 = 0.99,\ \lambda_3 = 1$, and $\lambda_4 = 10$. A discernible difference is that the Litterman/Minnesota estimates are significantly smaller for each variable's first lag. We set $\lambda_2 = 0.99$ so that cross-lag variables play a significant role in each equation. Lambda 3 is set as $\lambda_3 = 1$, denoting no lag decay via $\iota^{\lambda 3}$.

Finally, $\lambda_4 = 10$ denotes parameter associated with exogenous variables. Minnesota assumes that the mean of coefficients $\beta_i^1\ i = 1, \ldots, n$ are unity, while the mean of all other coefficients are zero. Besides, we also assumed the covariance of errors is diagonal. In the Minnesota case, the distribution of β shows as a random walk behavior, since random

[360] Sims, C.A. and T. Zha., "Bayesian Methods for Dynamic Multivariate Models," *International Economic Review*, 1998, 39, 949-968.

walks are perceived to be right macroeconomic forecasters[361]. The primary advantage of Minnesota prior is that the posterior is a normal distribution.

Table 21: Forecasting using Bayesian estimation methods 2017:1-2017:12

Prior		Variable	RMSE	MAE
Standard VAR	Model 1	Inf	1.876233	1.493975
	Model 2	Inf	0.924197	0.80918
	Model 3	Inf	2.224169	1.997501
Minnesota	Model 1	Inf	3.902768	3.793592
	Model 2	**Inf**	**0.48967**	0.39565
	Model 3	**Inf**	**1.27483**	1.095986
Normal-Flat	**Model 1**	**Inf**	**0.9913**	0.924781
	Model 2	Inf	1.108264	0.967861
	Model 3	Inf	1.749179	1.57831
Normal-Wishart	Model 1	Inf	0.99558	0.928842
	Model 2	Inf	0.79153	0.688589
	Model 3	Inf	1.749503	1.577475
Indep. N-W	Model 1	Inf	1.365351	1.178597
	Model 2	Inf	0.749201	0.6695
	Model 3	Inf	2.110446	1.892409
Sims-Zha (N-W)	Model 1	Inf	2.97381	2.342177
	Model 2	Inf	0.660882	0.584204
	Model 3	Inf	1.642633	1.425595
Giannone, L & P	Model 1	Inf	1.789615	1.762234
	Model 2	Inf	1.320379	1.056946
	Model 3	Inf	1.654359	1.563016

Source: Author's calculations in EViews 11.

Let us see the forecasting performance of the best BVARs based on the RMSEs. Visual inspection shows that the first model, in Figure 45, fits the best into a 5% confidence band. It offers a sustainable forecasting performance, even within the 5% confidence band, and the average inflation rate is not more than 1.5% above the three best performing EU Member States' inflation rate.

[361] Del Negro, M., and F. Schorfheide., *Bayesian Macroeconometrics*. Handbook of Bayesian Econometrics, 2010.

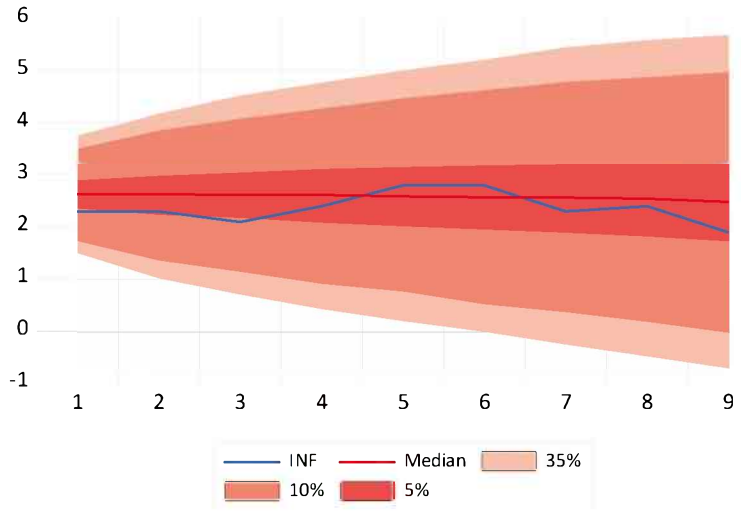

Figure 45: Forecasting performance of inflation model 1 using Bayesian Normal-Flat prior, 2017:4-2017:12

Source: Author's calculations in EViews 11.

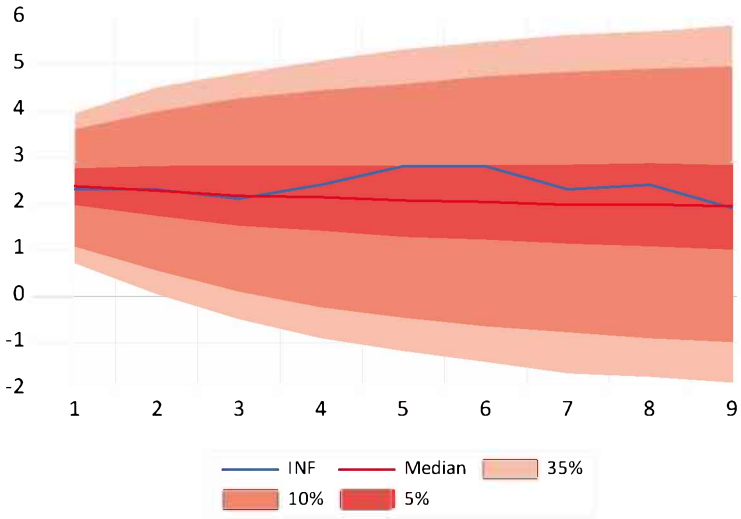

Figure 46: Forecasting performance of inflation model 2 using Bayesian Minnesota prior, 2017:4 2017:12

Source: Author's calculations in EViews 11.

Model 2, in Figure 46, has little oscillations around the mode, and it has valuable information sets to be considered by policymakers of Montenegro. As expected, model 3, in Figure 47, having the external shocks (oil and aluminum LME prices), creates more fluctuations than model 1 and 2. It fits into a 10% confidence band for the first six periods. After that, it converges into a 5% confidence band.

Even though model 3 shows higher oscillations around the mean, it has valuable information sets. They are essential for Bayesian forecasting combination in SVAR models with many predictors.

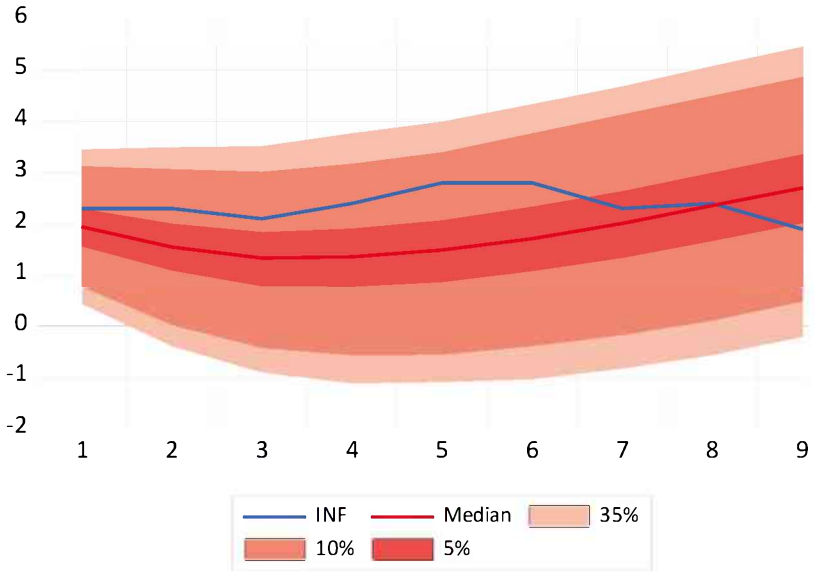

Figure 47: Forecasting performance of inflation model 3 using Bayesian Minnesota prior, 2017:4 2017:12

Source: Author's calculations in EViews 11.

4.2.2. Bayesian forecasting combination

This section is motivated by our previous combination findings' results, forecasting SVAR models, based on averaging and relative performance MSE weights. We extend the forecast combination in this section and consider Bayesian vector autoregressive priors to compare and examine their forecast performance. We test the hypothesis of whether Bayesian averaging, trimmed, and inverse MSE outperforms our previous findings, based on the RMSEs.

The relative weight numerators, based on inverse MSE, are as follows: r1 = 1.017634, r2 = 4.170555, and r3 = 0.615317, and the value of the denominator is rt = 5.803507. By construction, the relative weights should sum up to 1, and the relative weights are: w1 = 0.175348, w2 = 0.718627, and w3 = 0.106025.

Figure 48 shows our three new forecast combinations: equal and relative performance MSE weights. On average, the average weight combination underpredicts the actual

inflation until October 2017. The inverse MSE approach performs better than the average combination, as seen in Figure 48.

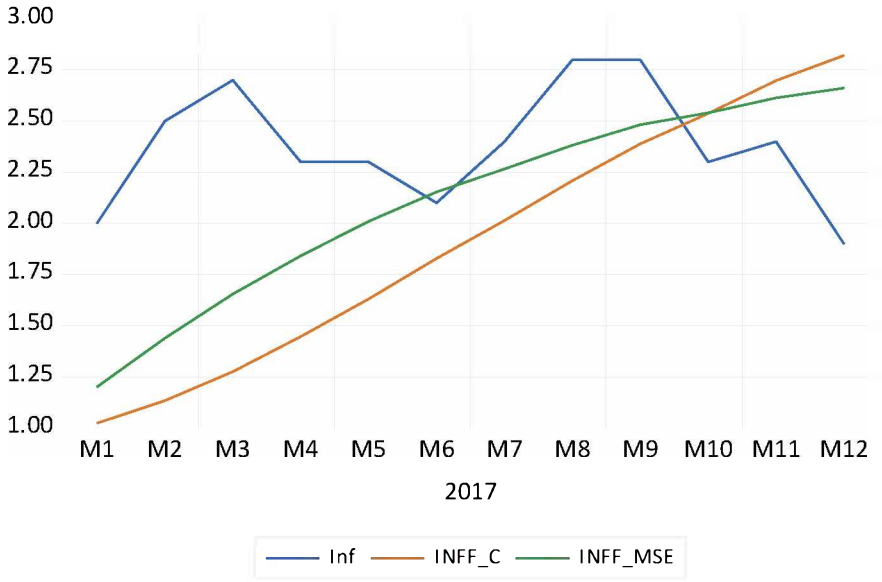

Figure 48: Bayesian combination forecasts: equal and inverse MSE weights
Source: Author's calculations in EViews 11.

The RMSE of equal combined Bayesian approach equals 0.804415, and the RMSE of the inverse MSE Bayesian approach equals 0.586937. We can conclude that the Bayesian combination produced two RMSEs better than the RMSEs of model 1 and model 2. Still, the RMSE of model 2 remains to be the lowest RMSE of all individual and combined Bayesian approaches.

4.3. Forecast comparison

Considering all determinants of inflation in Montenegro's market reveals crucial information for the CBCG: better prediction. Even though the relative weights of Bayesian VAR model 1 and model 3 are low, when combining into relative weights, they reveal robust information for the policymakers: a lower RMSE. Evidence shows that adding variables through different Bayesian prior models systematically increases the forecasting performance, lowering the RMSE.

Table 22 shows forecast comparison combinations, Bayesian and standard VAR, and the results show that standard VAR combination has a lower RMSE (0.577499) upon using the inverse MSE than the BVAR. On the other hand, the average combination of Bayesian

combination has a lower RMSE (0.804415) than the average weight standard VAR combination in terms of root mean square error.

Table 22: Comparison of BVAR and VAR combinations for 2017:1-2017:12

Combinations	Approach	RMSE
Standard VAR Combination	Average weights	0.864771
	Inverse MSE	**0.577499**
Bayesian VAR combination	Average weights	**0.804415**
	Inverse MSE	0.586937

Source: Author's calculations in EViews 11.

We conclude that including adequate Bayesian VAR forecasts in the forecast combination consistently reduces the combination forecasts' root mean square error. Both combinations are a critical tool for the policymakers of the Central Bank of Montenegro. The Bayesian VAR combination results confirm the standard VAR combination results that both the averaging and the relative performance weight approach lower RMSE.

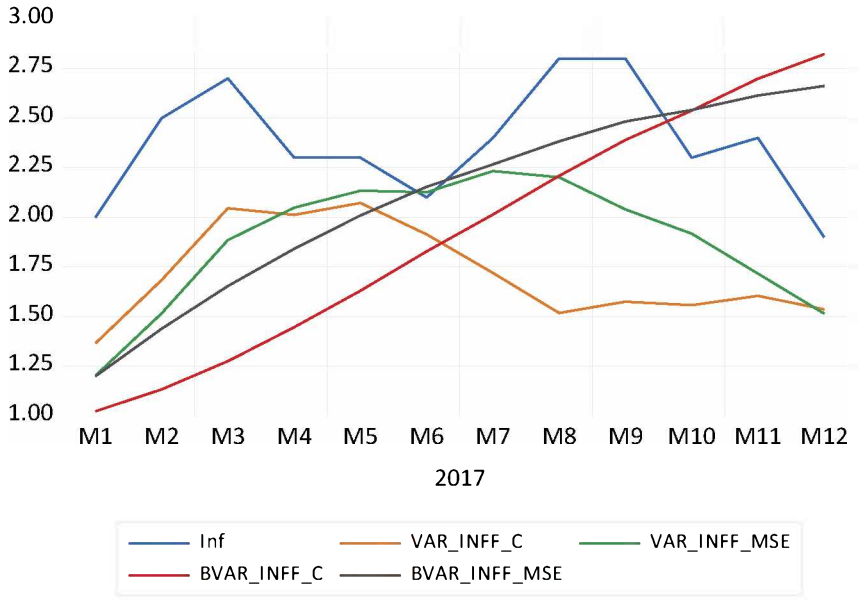

Figure 49: Forecast comparison of BVAR and VAR combinations
Source: Author's calculations in EViews 11.

Let us see the comparison of standard VAR and the Bayesian VAR forecast combinations from 2017:1-2017:12 graphically. For the first three months, the simple VAR arithmetic average combination forecast outperforms all sophisticated "optimal" forecast composites (2.045%). From April to June 2017, the inverse VAR MSE, the green line, is

the optimal linear composite forecast, being the closest to the actual inflation, the blue line (2.127%). The Bayesian inverse MSE takes over the leadership from July until December 2017, converging the best to the actual inflation (2.661%). We have reached a critical conclusion that both combinations have to be considered by the Government of Montenegro: the standard VAR combination performs the best forecasting for quarter I and II of 2017, while Bayesian VAR combination shows the best forecasting performance for quarters III and IV of 2017.

At the end of December 2017, the BVAR MSE combination inflation figures 2.661%. The BVAR average combination inflation figures 2.822%, the average weights approach of standard VAR figures 1.537%, and the inverse of standard VAR MSE figures 1.516%. Standard VAR combination models, average and relative performance, show forecasts that are sustainable and average inflation rate not more than 1.5% above the inflation rate of the three best performing EU Member states.

The average rate of the three best performing EU Member states is 0.4% and, adding $1^{1/2}$ percentage points, the reference is 1.9%. Even though BVAR combination models, average and relative performance, end up way off compared to the convergence EU criteria, incorporating these Bayesian combination models is essential for the CBCG[362]. The BVAR high-dimensional dynamic composite models empower forecasters.

[362] Diebold, F. X. and P. Pauly., "The use of prior information in forecast combination," *International Journal of Forecasting*, 1990, 6, 503-508.

5. Panel Data Econometrics

This section deals with cross country growth and inflation. The objective is not only to compare two subgroups: i) Montenegro (ME) and Serbia (SR) as candidate countries for the EU membership and ii) Croatia (CR) and Slovenia (SI), already in EU, but to highlight the Montenegrin case. Since the above two subgroups have set their national development strategies, it is worthy of analyzing how this onset of factors that determine economic growth dynamics affects inflation[363]. Robert M. Solow (1956) and Trevor Winchester Swan (1956) stress that government intervention is crucial in the sustainable economic growth process[364][365]. On the other hand, Paul M. Romer (1993) and Robert E. Lucas (1988) highlighted endogenous growth, focusing on knowledge, R&D, human capital, and technological progress[366][367]. The nexus between economic freedom (EF) and the endogenous growth model (EGM) has been shown in several studies[368][369]. Richard Cebula (2011) shows a positive relationship between EF and EGM by using panel data[370]. Klaus Friesenbichler (2018) uses a macroeconomic panel of OECD countries, which

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[363] Medic, R., "Econometric Analysis Of Inflation Determinants In Central And Eastern European Countries Based On Panel Models," *Ministry of Finance, Belgrade, Serbia*, 1-6/2009.

[364] Solow, R. M., "A Contribution to the Theory of Economic Growth." *The Quarterly Journal of Economics*, 1956, 70(1), 65-94.

[365] Swan, T. W., "Economic Growth and Capital Accumulation." *The Economic Record*, 1956, 32(2), 334-361.

[366] Romer, Paul M., "Two Strategies for Economic Development: Using Ideas and Producing Ideas." In *Supplement to the World Bank Economic Review and the World Bank Research Observer*, ed. Lawrence H. Summers and Shekhar Shah, 63-91. Washington, DC: World Bank, 1993.

[367] Lucas, Robert E., "On the Mechanics of Economic Development." *Journal of Monetary Economics*, 1988, 22(1), 3-42.

[368] Berggren, Niclas., "The Benefits of Economic Freedom: A Survey." *The Independent Review*, 2003, 8(2), 193-211.

[369] Gwartney, J., R. Holcombe and R. Lawson., "Economic Freedom, Institutional Quality, and Cross-Country Differences in Income and Growth," *Cato Journal*, 2004, 24(3), 205-233.

[370] Cebula, Richard., "Economic Growth, Ten Forms of Economic Freedom, and Political Stability," *Journal of Private Enterprise*, 2011, 26(2), 61-82.

replicates and expands previous estimates by Myung Hoon Yi and Changkyu Choi (2005), that broadband internet lowers transaction costs, thereby inflation. He studied 207 countries from 1991-2007 and showed that when the internet penetration rate increases by 1%, the inflation rate drops by 0.04%-0.13%[371].

5.1. Methodology of panel econometrics

The cross-sectional data range will be from 2006:1 to 2017:12, thus increasing the number of observations. To control for time trends in further examinations, we will include dummy variables. In our case, the sample set consists of a fixed period for all cross-sectional units, making the combined panel data matrix set balanced. Our econometric model, production function, is remodeled as follows:

$$y_{it} = \beta_{it} + \beta_1 \sum_{i=1}^{n} EGDI_{it} + \beta_2 \sum_{i=1}^{n} capital_{it} + \beta_3 \sum_{i=1}^{n} employ_{it} + \beta_4 \sum_{i=1}^{n} efree_{it} + \beta_5 \sum_{i=1}^{n} inf_{it} + \varepsilon_{it} \quad (187)$$

5.1.1. The fixed, random effects and cross-sectional dependence

The fixed-effects method treats the constant a_i specifically within each section *N*, as we can see in the following model:

$$Y_{it} = a_i + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots + \beta_k X_{kit} + u_{it} \quad (188)$$

$$\boldsymbol{Y} = \boldsymbol{G\alpha} + \boldsymbol{X\beta'} + \boldsymbol{u} \quad (189)$$

$$Y = \begin{pmatrix} Y_1 \\ Y_2 \\ . \\ . \\ . \\ Y_N \end{pmatrix}_{NT\,x\,1} \quad G = \begin{pmatrix} i_T & 0 & . & 0 \\ 0 & i_T & . & 0 \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ 0 & 0 & . & i_T \end{pmatrix}_{NT\,x\,N} \quad X = \begin{pmatrix} x_{11} & x_{12} & . & x_{1k} \\ x_{21} & x_{22} & . & x_{2k} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ x_{N1} & x_{N2} & . & x_{Nk} \end{pmatrix}_{NT\,x\,k}$$

$$\alpha = \begin{pmatrix} a_1 \\ a_2 \\ . \\ . \\ . \\ a_N \end{pmatrix}_{N\,x\,1} \quad \beta' = \begin{pmatrix} \beta_1 \\ \beta_1 \\ . \\ . \\ . \\ \beta_1 \end{pmatrix}_{k\,x\,1} \quad (190)$$

[371] Friesenbichler, Klaus., "Inflation and Broadband Revisited: Evidence from an OECD Panel. A replication study of Yi and Choi (*Journal of Policy Modeling*, 2005)." *International Journal for Re-Views in Empirical Economics*, 2018, 2: 2018-1.

For different cross-sections, we get different constant estimates because of the dummy inclusion in the model. Contrary to the fixed effects method, the constant varies in the random process within each sub-section. The Wald test, comparing the above methods, proposes to reject the null hypothesis that the pooled regression method is more appropriate than the fixed effects method, which outperforms the random effects method:

Table 23: Wald test

Test Statistic	Value	df	Prob.
F-statistic	103.3570	(11, 559)	0.0000
Chi-square	1136.927	11	0.0000

Source: Author's calculations in EViews 11.

The null hypothesis assumes that the series are independent of each other, as M. Hashem Pesaran (2004) proposes[372]:

$$LM_{adj} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=j}^{N-1}\sum_{j=i+1}^{N}\left[\rho_{ij}^2\frac{(T-K-1)\rho_{ij}-\mu_{Tij}}{\sigma_{Tij}}\right]\right) \rightarrow N(0,1) \quad (191)$$

Table 24: Residual cross-section dependence test

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	230.6607	6	0.0000
Pesaran scaled LM	64.85395		0.0000
Bias-corrected scaled LM	64.83996		0.0000
Pesaran CD	7.742262		0.0000

Source: Author's calculations in EViews 11.

Since N=4 and T=144 in our study, we use the LM test. The assumption is that the errors for different cross-sectional units are uncorrelated, and the results are as Table 24. The first line shows results for the Breusch-Pagan LM test. In this case, the value of the test statistic (230.66) is well into the upper tail of a χ_6^2, and strongly we reject the null hypothesis of no correlation at conventional significance levels. The next two lines

[372] Pesaran, Hashem M., "General Diagnostic Tests for Cross Section Dependence in Panels", *IZA Discussion Paper* 2004, No. 1240.

present results for the two scaled Pesaran tests. The Pesaran scaled and Breusch-Pagan LM tests are asymptotically standard normal, and the test statistic results of 64.85 and 64.83, respectively, strongly reject the null at conventional levels. While the test statistic value of 7.74 is significantly below the scaled LM tests. The Pesaran CD test still rejects the null at the conventional significance levels.

5.1.2. Panel unit roots

In the literature of panel unit root tests, there are a couple of standardized methods such as In Choi (2001); Jörg Breitung (2002); Andrew Levin, Chien-Fu Lin and Chia-Shang James Chu (2002); Kyung So Im, M. Pesaran and Yongcheol Shin (2003); and Nicholas Apergis and James Payne (2009)[373][374][375][376][377]. We will utilize individual and standard unit root processes to test the unit root and stationarity for Montenegro, Serbia, Croatia, and Slovenia. All variables in the model are tested on both levels and first differences.

The results of panel unit root tests are presented in Table 25. Based on the results of the panel unit root at level, capital stock contains unit roots according to PP and Kaddour Hadri (2000) up to 10% significance level[378]. The ADF, PP, and Hadri confirm non-stationarity for employment at the level.

[373] Choi, I., "Unit Root Tests for Panel Data," *Journal of International Money and Finance*, 2001, 20(2), 249-272.

[374] Breitung, J., "Nonparametric Tests for Unit Roots and Cointegration," *Journal of Econometrics*, 2002, 108(2), 343-363.

[375] Levin, A., Ch.-F. Lin and Ch.-Sh. J. Chu., "Unit Root Tests in Panel Data: Asymptotics and Finite-Sample Properties," *Journal of Econometrics*, 2002, 108(1), 1-24.

[376] Im, K. S., H. M. Pesaran, and Y. Shin., "Testing for unit roots in heterogeneous panels," *Journal of Economics*, 2003, 115(1), 53-74.

[377] Apergis, N. and J. Payne., "Energy Consumption and Economic Growth in Central America: Evidence from a Panel Cointegration and Error Correction Model," *Energy Economics*, 2009, 31(2), 211-216.

[378] Hadri, K., "Testing for Stationarity in Heterogeneous Panel Data", *The Econometrics Journal*, 2000, 3(2), 148-161.

Table 25: Panel unit root test results

Null: UR							Null:Stationary
Methods		Levin, Lin and Chu	Breitung t-stat	Im, Pesan and Shin	ADF Fisher Chi-sq	PP Fisher Chi-sq	Hadri Z-stat
Test in:	Variables						
Level	GDP	-4.90***	-2.01***	-2.90***	33.63***	20.03***	1.77
	CAP. ST.	-3.24***	-1.40*	-1.76**	14.62*	3.08	9.02
	EMP	-2.57***	-2.21**	-1.46*	12.35	2.78	2.88
	LOGEF	-1.63**	0.4	-0.76	9.56	31.44***	13.24
	LOGEGDI	-3.03***	0.05	-0.05	13.78*	26.56***	9.22
	INF	-3.05***	-2.56***	-2.26***	17.29**	18.95**	0.07***
First Diff.	GDP	-6.46***	-5.37***	-3.84***	51.64***	46.90***	-0.31***
	CAP. ST.	-4.09***	-2.18**	-1.79**	26.55***	27.89***	0.37***
	EMP	-2.90***	-2.27**	-4.92***	20.59***	58.03***	0.77***
	LOGEF	-4.15***	-1.81**	-1.67**	26.95***	27.22***	0.77***
	LOGEGDI	-3.28***	-1.70***	-5.24***	57.16***	60.78***	1.27***
	INF	-19.69***	-16.56***	-20.07***	804.54***	822.83***	-1.11***

Notes: ***, **, * implies 1%, 5%, and 10% significance levels.

Source: Author's calculation in EViews 11.

The logarithm of the economic freedom variable has a unit root at a level based on Breitung, IPS, ADF, and Hadri. The LOGEGDI is suggested to have unit roots based on Breitung, IPS, and Hadri. The D(CS), D(EMP), and D(LOGEF) reject the null hypothesis of IPS unit root at specified lag length 5, with probabilities of (0.0417), (0.000), and (0.0469), respectively. Stationarity is accepted at the first difference for all panel unit tests. The series are integrated of order I (1).

5.1.3. Panel cointegration test

We will now develop a panel cointegration model, and the precondition for running such a model is that variables at 1st difference become stationary. In case they cointegrate, then we have a long-run relationship between the dependent and the independent variables. We will apply Peter Pedroni (2004), Chihwa Kao (1999), and Soren Johansen's (1988) methodologies to test panel cointegration[379][380][381].

Table 26: Pedroni, Kao, and Johansen panel cointegration test results

	Stat	Weigh. St	t-Stat.	F. Trace	F. (max-eigen)
Panel v-Stat	2.29**	1.73**			
Panel rho-Stat	-0.49	-0.06			
Panel PP-Stat	-0.78	-0.06			
Panel ADF-Stat	-3.53***	-1.10			
Group rho-Stat	0.60				
Group PP-Stat	0.06				
Group ADF-Stat	-1.95**				
ADF			-2.20**		
None				58.69***	32.60***
At most 1					30.68***
At most 2					20.62***

Notes: ***, **, * implies 1%, 5%, and 10% significance levels.

Source: Author's calculations in Eviews 11.

[379] Pedroni, P., "Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis," *Econometric Theory*, 2004, 20(3), 597-625

[380] Kao, Ch., "Spurious Regression and Residual-Based Tests for Cointegration in Panel Data." *Journal of Econometrics*, 1999, 90(1), 1-44.

[381] Johansen, S., "Statistical Analysis of Cointegration Vectors," *Journal of Economics Dynamic and Control*, 1988, 12(2-3), 231-254.

Table 26 provides panel cointegration test statistics which evaluate the null against both the homogeneous and the heterogeneous alternatives. In the case of Pedroni, four of the eleven statistics reject the null hypothesis of no cointegration at the conventional size of 5%. Kao's residual test statistics reject the null hypothesis. Johansen's maximum likelihood cointegration approach confirms the results by Kao. Test results suggest that the variables have a long-run relationship since the p-value is less than 5%.

The unrestricted cointegration rank test, maximum Eigenvalue, reject the hypothesis that there is no cointegration among the variables. Meanwhile, the Trace test estimates three cointegration equations. Individual cross-sectional results of Trace test statistics for Montenegro, Serbia, Croatia, and Slovenia reject the null hypothesis of no cointegration. Maximum Eigenvalue test statistics reject the null hypothesis at 0.1 significance for all countries; for Montenegro and Croatia at the 0.05 conventional level, they reject the null of no cointegration.

5.2. Panel VECM of Montenegro, Serbia, Croatia, and Slovenia

The following variables constitute our VECM model, as follows:

$$Inf_{it} = gdp_{it}, capital\_stock_{it}, employment_{it}, logegdi_{it}, logecofreedom_{it}, dum2006, dum2007, dum2008, dum2009, dum2010, dum2011, dum2012, dum2013, dum2014 \quad (192)$$

Key variables are e-government and economic freedom, which are included to measure econometrically the impact of these shocks on Montenegro's inflation, Serbia, Croatia, and Slovenia and its economies. The sample period will be from January 2006 to December 2017, but for estimation purposes, the VECM model goes from January 2006 till December 2015. We will utilize the out-of-sample model to forecast variables from January 2016 till December 2017. It will be our tool to assess whether our model can predict actual inflation from 2016:01 onwards.

Including 8 lags in the test of lag exclusion or lag length criteria pertaining to deciding the number of lags to be applied in our VECM model, the Final predictor error FPE (7.03), Akaike information criterion AIC (-24.77), Schwarz information criterion SC (-23.61) and Hannan-Quinn information criterion HQ (-24.31) suggest 2 lags as the fitting lag length. In comparison, only sequential modified LR test statistic LR (98.95) suggests 8

lags. We select 8 lags, as we will see that any other number of lags is not enough for stationarity, like the appropriate lag length for our model. All the inverse roots of the AR characteristic polynomial lie within the unit circle, confirming the model's stationarity. The largest inverse root of the AR polynomial is 0.999859, accrediting our assessment of the VAR model's stationarity. Looking at notably 1st lags short-term error correlations), all the lines lie within the 2 standard error bounds suggesting no autocorrelation. Another back up to the suggestion of missing autocorrelation is non-noticeable continual wave sinusoidal and p=66.83% for lag orders up to 11. Moreover, since the p=0.1182, we cannot reject the null hypothesis of homoskedasticity.

The coefficients of unrestricted VECM are statistically significant for LOGEF and LOGEGDI since the corresponding *t-statistic* is 5.2741 and 5.7675, respectively. While for capital stock, employment and GDP are not significant estimates in the long run since the *t-stats* are less than 2. Imposing restrictions on the VECM, we test for weak exogeneity of employment and GDP by imposing A (3,1) = 0, A (6,1) = 0 on the fitted model (Table 27). We will treat inflation as the dependent variable in the long-run equation, B (1,1) = 1. The *p-value* of the test statistic for weak exogeneity is 0.2935. Thus, we can accept the null hypothesis that employment and GDP can be treated as exogenous. We will, therefore, continue to use this restriction in our baseline specification of the model. The coefficient of the ECM (Cointeq1) is negative (-0.092578) and significant (-5.22849) concerning inflation. The ECM coefficients of capital stock, LOGEF, and LOGEGDI are negative (-0.007126), (-4.23E-05), and (-0.000270), respectively, and statistically significant, (-3.35276), (-3.71723), and (-5.18872), respectively.

In contrast, the insignificance of the ECM coefficients of employment and GDP equations suggests that these variables are weakly exogenous to inflation. We argue that these results are reasonable since inflation, capital stock, economic freedom, and EGDI are endogenous (flow) variables dependent on each other. Employment and GDP take time to react to disequilibria in inflation relative to its long-run path. The ECM coefficient (-0.092578) implies that the mechanism corrects its previous period disequilibrium at an average speed of 9.25% monthly.

Table 27: Vector error correction estimates with restrictions

Cointegration Restrictions:							
B(1,1)=1, A(3,1)=0, A(6,1)=0							
Chi-square(2)	2.451771						
Probability	0.293498						
CointEq:	INF(-1)	CAP_ST(-1)	EMP(-1)	LOGEF(-1)	LOGEGDI(-1)	GDP(-1)	C
INF(-1)	1.0000	0.0601	0.0252	62.2855	1.04522	0.3128	**-262.2420**
		(0.1566)	(0.0197)	(12.4490)	(0.1838)	(0.1572)	
		[0.3838]	[1.2763]	**[5.0032]**	**[5.6867]**	**[1.9893]**	
Error Corr.:	D(INF)	D(C_ST)	D(EMP)	D(LOGEF)	D(LOGEGDI)	D(GDP)	
CointEq1	-0.0925	-0.0071	0.0000	-4.23E-0	-0.0002	0.0000	
	(0.017)	(0.0021)	(0.0000)	(1.1E-0)	(5.2E-05)	(0.0000)	
	[-5.228]	[-3.3527]	[NA]	[-3.7172]	[-5.18872]	[NA]	

Source: Author's calculations in Eviews 11.

Table 28: Granger causality results based on VECM - χ^2 independent variables

	statistics of lagged 1st differenced term/(p-value)						
Dep. Var.	**ΔINF**	**ΔCAP_ST.**	**ΔEMP**	**ΔLOGEF**	**ΔLOGEGDI**	**ΔGDP**	**ECTt-1**
ΔINF	--	10.161 (0.179)	2.350 (0.937)	**15.522 (0.029)****	**23.064 (0.001)*****	**14.381 (0.044)****	**-0.092 [-5.22]**
ΔCAP_ST.	**22.018 (0.0025)*****	--	9.404 (0.224)	0.446 (0.999)	7.290 (0.399)	8.415 (0.297)	**-0.007** [-3.35]**
ΔEMP	4.578 (0.711)	1.859 (0.967)	--	3.395 (0.846)	4.886 (0.673)	5.185 (0.637)	0.000 [NA]
ΔLOGEF	**16.127 (0.024)****	12.356 **(0.089)***	0.830 (0.997)	--	1.847 (0.967)	10.562 (0.158)	**-4.23E** [-3.717]**
ΔLOGEGDI	11.708 (0.110)	7.580 (0.371)	1.418 (0.985)	3.438 (0.841)	--	7.649 (0.364)	**-0.000** [-5.188]**
ΔGDP	13.647 **(0.057)***	1.133 (0.992)	3.095 (0.876)	7.896 (0.341)	2.786 -0.904	--	0.000 [NA]

Note: ***, ** and ** denotes significant at 1%, 5%, and 10% significance level, respectively. The figure in the parenthesis (…) represent as *p*-value and the figure in the squared brackets […] denote as t-statistic.

Source: Author's calculations in Eviews 11.

It also implies that, on average, 9.25% of deviation from the long-run equilibrium is smoothed in one month. In line with reasonable prior expectations, the sign of the ECM (Cointeq1) coefficient is significant and negative, indicating there is a long-run causality from economic freedom and EGDI to inflation. We must negate the sign of the coefficients shown in Table 27 because of how the equation is represented; it is normalized with all the variables on the left-hand side. The above results lie on a continuum with the new growth theory, which states that government regulation reduces inflation through increased efficiency, resource allocation, and increased FDI. The long-run equation looks as follows:

$$inf = 262.24 - 62.28\, log(economic\ freedom) - 1.05\, log(EGDI) \qquad (193)$$

We can notice from the long-run equation that employment is weakly exogenous since its impact is more concentrated in the short run. It happens to be our recommended model for forecasting. In front of every equation, there are ECM coefficients, which are taken literally from the estimated model. We can notice that for employment and GDP, the error correction term is set to zero.

Nicholas Apergis and James Payne (2010) emphasize that given the variables are cointegrated, a panel VECM is estimated to perform Granger-causality tests[382]. Next, having defined the lagged residuals as the error correction term, the following inflation dynamic error correction model is estimated (as well for the other variables):

$$\Delta INF_{it} = \alpha_{1j} + \sum_{p=1}^{k} \vartheta_{11ik} \Delta GDP_{it-k} + \sum_{p=1}^{k} \vartheta_{12ik} \Delta CapSt_{it-k} + \sum_{p=1}^{k} \vartheta_{13ik} \Delta Em_{it-k} + \sum_{p=1}^{k} \vartheta_{14ik} \Delta EGDI_{it-k} + \sum_{p=1}^{k} \vartheta_{15ik} \Delta EcoFree_{it-k} + \sum_{p=1}^{k} \vartheta_{16ik} \Delta Inf_{it-k} + \varphi_{1i} \varepsilon_{it-1} + u_{1it} \qquad (194)$$

where *i* denotes countries, *t* period, *k* lag length set at eight based on likelihood ratio tests, Δ is the first-difference operator, and u is the serially uncorrelated error term. The statistical significance of the partial F-statistics, associated with the corresponding right-hand side variables, determine the Short-run causality. The causality, for instance, running from capital stock to GDP, is tested by restricting $\vartheta_{62ik} = 0$. The null hypothesis

[382] Apergis, Nicholas and James Payne., "Energy consumption and growth in South America: Evidence from a panel error correction model," *Energy Economics*, 2010, 32(6), 1421-1426.

is that the lagged coefficients = 0, while the alternative hypothesis is that the lagged coefficients ≠ 0, and the direction is to reject the null hypothesis if the *p*-value of the chi^2-statistic is ≤ 0.05. Thus, we can estimate both long-run and short-run causality, respectively, on the χ^2 – test of the lagged first differenced terms for each right-hand side variable and the *t*-test of the error correction term. The test results are presented in Table 28. At the significance of 5%, 1%, and 5% level, respectively, we notice the Granger causality of LOGEF, LOGEGDI, and ΔGDP on ΔINF.

5.2.1. Panel dynamic forecasts

Data from 2016:1 until 2017:12 will be used to evaluate out-of-sample forecasting performance. Forecasting evaluation statistics are shown in Table 29. Notice that the ECM model can predict the actual behavior of inflation rather well. This result provides further evidence that the significant driving internal force behind the movement of inflation for ME, SR, CR, and SI, is innovations to economic freedom and EGDI.

Table 29: Forecasting evaluation statistics for ME, SR, HR, and SI

Fore. Eval. St.	**ME**	**SR**	**HK**	**SI**
Bias	0.13	0.84	-2.58	-0.73
MSE	0.25	4.12	10.71	1.14
RMSE	0.50	2.03	3.27	1.07
SE	0.24	3.41	4.03	0.60
MAE	0.42	1.73	2.66	0.85
MPE	8.25	-83.86	-137.23	-75.55
MAPE	72.19	398.04	233.56	92.15
Theil's U1	0.19	0.53	0.96	0.31
Theil's U2	1.01	3.47	1.59	0.85
Bias proportion	0.06	0.17	0.62	0.47
Variance proportion	0.364	0.163	0.046	0.217
Covariance proportion	0.568	0.666	0.331	0.306

Source: Author's calculations in Eviews 11.

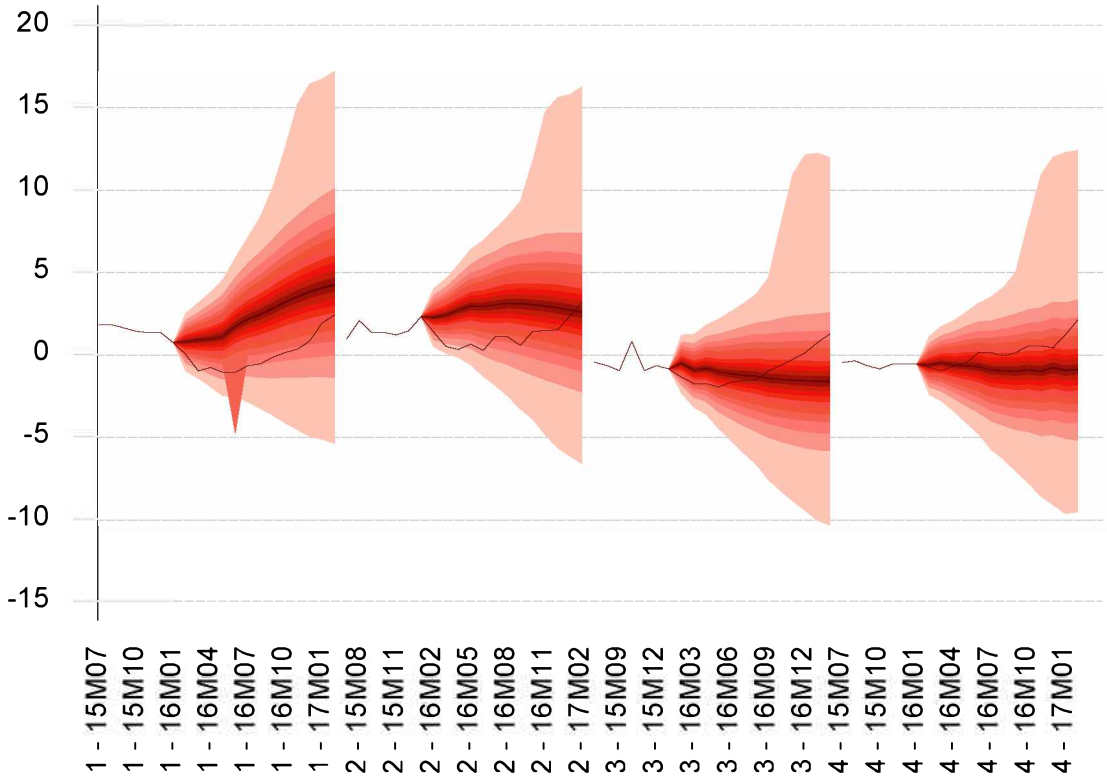

Figure 50: Panel fan chart 2016:1 – 2017:01
Source: Author's calculations in Eviews 11.

The deterministic – static (DS) shows the best strategic forecasting performance for Montenegro and Slovenia. While for Serbia and Croatia, the deterministic – dynamic (DD) proves to be the most appropriate forecasting performance. Two forecasting strategies were used as benchmarking: DD and DS. As seen in Table 29, a lot of Croatian and Slovenian covariance proportion goes to bias proportion, while Montenegrin to variance proportion and Serbian to both bias and variance proportion.

We increased e-government – scenario 1 and economic freedom – scenario 2, aggressively from 10% to 56%, for the period 2016:1 to 2017:12. Inflation drops down sharply based on the alternative forecasting scenario 1 for Croatia and Slovenia after the 1st quarter. It implies that the growth in technological progress has increased the real wages, lowered prices, and restructured the markets in terms of competitiveness for Slovenia and Croatia. Sensitive forecasting scenario 2 reveals a very sharp decline in inflation in all countries. This substantial literary evidence is in line with new growth theories that government regulations of economic activities reduce inflation through its

impact on GDP, by and large through increased efficiency, better allocation of resources, enhanced capacity utilization, and increased FDI.

5.2.2. Panel impulse response functions

The impulse response of inflation to the economic freedom shock shows that inflation decreases slowly in the first two quarters, reaching -0.061304 and increasing gradually up to 0.003734 after 11 months. Carefully, we have to observe how productivity and labor market expectations are formed in Figure 51.

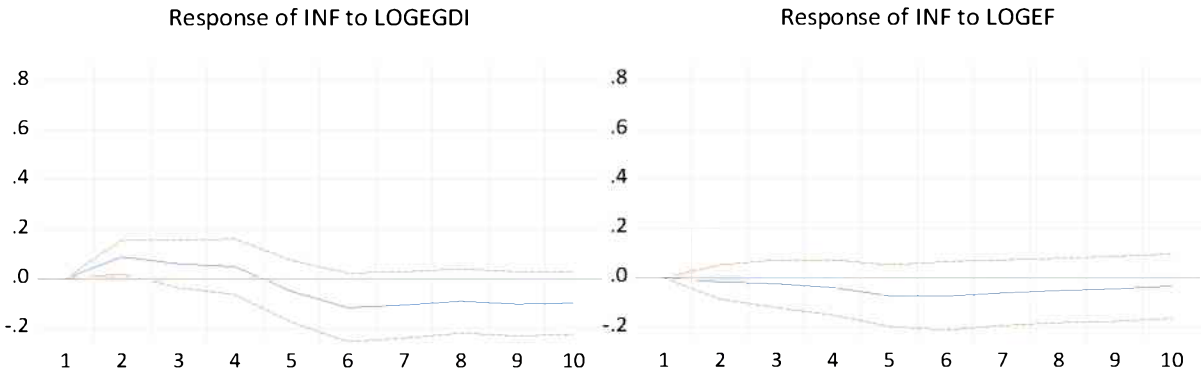

Figure 51: Panel impulse response functions
Source: Author's calculations in Eviews 11.

Since the examined countries are converging rapidly, this implies a correction of price expectations P^e regarding the current price level P. If society expects that the price level will decrease, then the real wages in PS relation should increase, shifting up the PS relation. The WS relation will change as well based on A^e, unemployment u, and institutional factors. The shift of the WS curve depends on the expected level of productivity. Hypothetically, if workers' expectations of productivity increase are higher than what firms expect, WS will shift more than the PS, increasing unemployment.

5.2.3. Panel variance decomposition

Now, let's turn to our empirical results of panel variance decomposition. Figure 52 represents the panel forecast error variance of inflation. We have set the horizons to be from 1 to 48 months forecast error variance. At short horizons (1 month), the forecast error variance of inflation is due to itself 100%. Why? Since the inflation was placed first in the recursive ordering, no other shocks affect it contemporaneously.

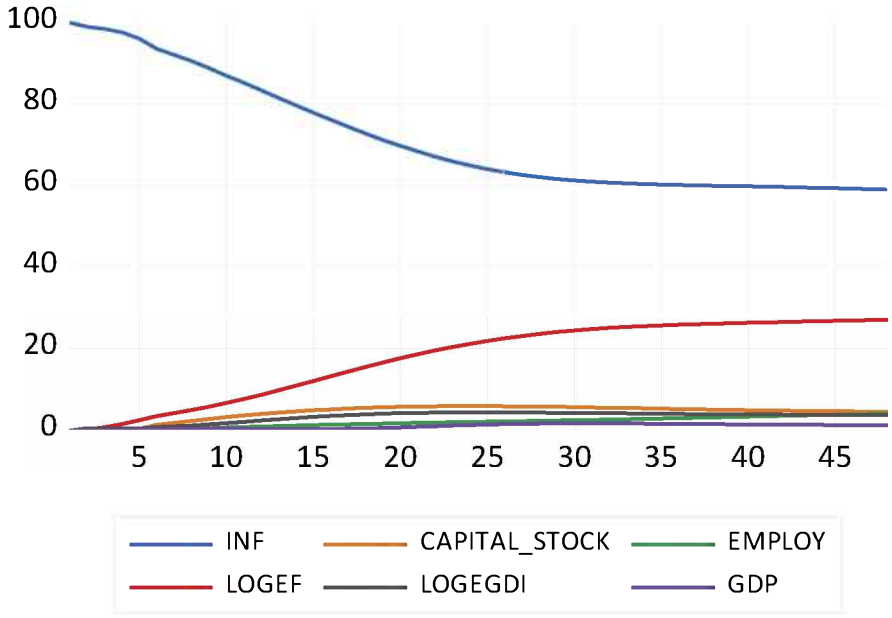

Figure 52: Panel variance decomposition of inflation
Source: Author's calculations in Eviews 11.

As horizons increase, we notice each variable's contribution and its corresponding shocks to the movements, forecast error variance, of inflation increases. For instance, at the horizons of 2 months, the contribution of capital stock, employment, LOGEF, LOGEGDI, and GDP to the movements of inflation increases from 0% to 0.023%, 0.1326%, 0.2791%, 0.5838%, and 6.21%, respectively. At longer horizons, for example, 10 months, the contribution of corresponding shocks increases to 3.2946, 0.7194, 6.7446, 1.8280, and 0.4376, respectively. In case we increase the horizon to 24 months, we notice that the contribution of economic freedom and its corresponding shocks to the movement of inflation increases to 21.1981%, being the greatest in contributing to the evolution of inflation, graphically notice that from Figure 52.

At short horizons, 1 month, economic freedom movements account for 73.2899%, and capital stock accounts for 26.5084%, even in the 1st month. At horizons of 10 months, shocks' impact increases: inflation contributes to 2.6475%, EGDI 0.2743 %, GDP 2.4458%, and employment at 0.8950%. At 24-month horizons, the contribution of inflation and its corresponding shocks to the movement of economic freedom increases to 26.6067%, but capital stock decreases to 9.4318%.

Moving further, the forecast error variance of EGDI is mostly the result of shocks to itself at short horizons 95.15613%. However, still, shocks of economic freedom contribute to

the movement with 0.4012%, employment 1.1064%, capital stock 2.9291%, and inflation 0.0017%. At horizons of 10 months, the contribution of inflation increases to 9.5589%. At 24 moth horizons, the contribution of inflation and its corresponding shocks to the movement of EGDI increases to 31.5340%.

This section has examined both the short-run and long-run effects of economic freedom and e-government on inflation, employing a panel data set for Montenegro, Serbia, Croatia, and Slovenia for the time span 2006:1 – 2017:12. Pedroni, Kao, and Johansen's heterogeneous panel cointegration tests disclose the long-run relationship between inflation, economic freedom, and e-government. The VECM suggests that a 1% increase in economic freedom and e-government reduces inflation by 62.28% and 1.05%, respectively. Besides, the Granger causality test is utilized to reveal the direction of the causal relationship. The PVECM is applied to forecast inflation using deterministic-stochastic simulation and dynamic-static solutions.

Forecasted measures such as bias proportion, variance proportion, SE, RMSE, covariance proportion, and Theil's U1 and Theil's U2 are used, confirming the forecasting performance strategies' results. The impulse response findings reveal that the response of inflation to a shock on economic freedom and e-government is essential. The forecast error variance decomposition of the inflation rate is moved mainly from economic freedom.

This section's empirical results provide policymakers with a more in-depth examination of the impact of economic freedom, e-government, and expectations on inflation. Furthermore, while governing price stability endogenously, as one of the Maastricht criteria, i.e., the euro convergence criteria, policymakers need to recognize and forecast the consequences of unlined government regulations in the design and implementation of a national sustainable growth that ensures future economic perspective. The macroprudential policymakers should proceed to improve economic freedom and e-government in the business ecosystems of the countries.

Conclusions

Montenegro is lined as a leader in the implementation process of modern monetary policy solutions, and many researchers have considered financial stability as a central bank target. Currently, only the Central Bank of Montenegro has explicitly stated financial stability as its primary goal, while many central banks have financial stability as a secondary goal.

Montenegro achieved the EU candidate status in 2010, and since June 2012, it has been in the process of negotiations. The euro Montenegro's present use will be addressed in the final phase of the negotiations. The country will participate in the economic and monetary union with a derogation from accession as a Member State. Following an evaluation of its fulfillment of the necessary conditions and the Council decision to this effect, Montenegro shall join the euro area.

As a prerequisite to joining, the inflation rate must be stable and low according to the Maastricht convergence criteria requirements for entering the EU. Explicitly, article 87v of the Law of the Central Bank of Montenegro says:" The primary goal of the Central Bank of Montenegro is to maintain price stability, and that without prejudice to the achievement of the objective referred to paragraph 1 of Article 87v, the Central Bank shall support the general economic objectives policy of the European Union, to contribute to the achievement of the European Union objectives set out in Article 3 of the Treaty on European Union." By opening Chapter 17 – Economic and monetary policy negotiations, the European Union carefully monitors the progress and implementation according to the *acquis* throughout the negotiating process. The main objective of price stability should be defined in compliance with: (i) Articles 127 (1) and (ii) Article 282 (2) of the Treaty on the Functioning of the European Union. The Government of Montenegro has to adapt its legislation in line with the EU law to adopt the euro: meet price stability and ensure economic convergence of the country. Convergence criteria report that the country has to have a sustainable price-performance, and the average rate of inflation should not be higher than 1.5% of the three best performing Member States.

Given the struggle macroprudential policymakers in Montenegro have had to define proper criteria to diagnose and examine the onset of inflation indicators, we felt

compelled to identify and investigate a methodological approach that the central Government of Montenegro can apply in designing anti-inflation and overall development strategy. Given the high increase of interest in meeting the Maastricht convergence criteria and the deficiency of any homogeneous methodology, we believe that the findings revealed in this doctoral dissertation will appeal to policymakers. Although previous researches have shown a few methods that could be applied in the forecasting inflation rate, such as external and internal variables, the methodologies revealed from those findings have been relatively restricted and not easy to administer on a national level in Montenegro. Thus, our results allow the policymakers to recognize the factors involved in identifying and knowing the onset of inflation dynamics and its expectations in Montenegro correctly and develop more efficient and effective policy measures that can be used nationally. In so doing, we hope that the doctoral dissertation advances the toolset required to combat many central policymakers' concerns in Montenegro, especially the CBCG.

Forecasting inflation phenomena implicates social, economic, and political interconnectivity, not just in Montenegro but worldwide. The interconnectivity and interdependence of countries are more than ever emphasized, and thus the consideration for sustainable development of Montenegro. Since Montenegro is headed towards integration into the European Union, it is of high importance for monetary authorities to reduce, maintain, and stabilize inflation to an acceptable level, or the target level, thus ensuring an age of sustainable development in the wave of globalization.

Even though inflation determinants have been analyzed to a great extent, we find there is still sufficient room for inflation examination. In 2018, the CBCG used the autoregressive integrated moving average (ARIMA) model (2,1,2) to forecast inflation. This dissertation's novelty is that it uses a combined prediction for the Montenegrin economy, using VAR and Bayesian VAR. This research employs high–dimensional dynamic models. It examines time-series data from 2006:1 – 2017:12. Systematically, it examines and compares the performance of different forecasting combination puzzles of inflation.

The reduced issue of time inconsistency, stabilization appears to be anchored. Montenegro, in 2002, stabilized the exchange rate through the euroization mechanism, which was the first step towards stabilizing inflation in Montenegro. Nevertheless, if we

go to the roots of inflation in Montenegro, we could identify internal and external factors. One of the potential problems might be the fiscal deficit. The authorities need to increase the revenues and reduce the expenditures or go financing, leading to inflation. Stabilization requires to fix the fiscal deficit. Another potential root might appear through the inflationary inertia, which comes from referring to the last period adjustment of wages and looking forward. Thus, it deals straight forward with the expectations formation and how much citizens believe in the prosperity of the future of Montenegro. This issue, as well, appears to be cut off in its roots since Montenegro's government has well-anchored its citizens' expectations. The ongoing case of global macroeconomic impacts of COVID-19 in the Montenegrin economy implicates that its citizens' expectations are well anchored. In case the policymakers keep adjusting the last period's inflation, it will exactly create the inflationary inertia.

To implement the above mentioned so far, the government needs to have well-grounded institutions. Well-oriented macroprudential strategic policymakers should not only rely on the benevolent authority who will do the proper thing. Institutions are the last longing fundamentals that move forward, in the right direction, implementing the policies. A government might reach its targeted inflation, but the question is the efficiency of the stabilization cost. There is a cost of reducing inflation to a targeted level. One of the measures used is the ratio of the accumulated excess of unemployment above the natural level to inflation reduction. For example, suppose the accumulated excess of unemployment above the natural level is 9%, and the inflation is 3%. In that case, the sacrifice ratio is 3%, meaning that for every single percentage point of reduction in inflation, the unemployment rate is 3% points above the natural rate of unemployment. If this is the case, then in 2017, it would mean 182,368 unemployed x 3% = 5,471. Thus, 5,471 more unemployed would be the cost of reducing 1% inflation in Montenegro. Thus, stabilization is not painless. The lower the level of the sacrifice ratio, the more efficient the stabilization mechanism. The sacrifice could be measured in terms of the euro cost of production loss to the percentage change in the inflation rate.

The authorities should fight the cost of maintaining price stability in Montenegro to reach the balance. As mentioned previously, even with the fiscal deficit in equilibrium, there might be some pressure coming from certain groups of workers or the authorities' lack of

credibility, creating inflationary inertia. Since Montenegro gave up its monetary instruments, its central policy role stays in the fiscal institutions. However, still, the CBCG, as one of the chain institutions in the stability process, must be autonomous. The chairman of the Central Bank's mandate is set by the law and thus autonomous, avoiding direct response to the executive power. The gained credibility for a stabilization program is the product of an independent central bank. It appears to be a high linkage between the index of autonomy of the Central Bank with the inflation rate: the more autonomous the central bank, the lower is the inflation rate. An independent Central Bank will convince foreign investors, so inflation will not burn their profits. The so far mentioned policies come from the demand side and institutions.

Holding the above in mind, one of the *key research questions* in this thesis is the analysis and determination of the optimal inflation rate, in fact, the study of the determinants that influence the achievement and maintenance of price stability in the country. Moreover, the next research question is analyzing *the main factors of inflation in Montenegro* and what *instruments* policymakers need to govern the inflation.

The first critical research assumption and hypotheses made to draw out and test its logical and empirical results is structured as follows:

H1: *Achieving and maintaining price stability* in Montenegro, as one of the goals of the central monetary authority in the country (and its instruments) on its path to the European Union and the European Monetary Union, is significantly contributed by the measurement of the impact of critical factors that determine the level of inflation in the country.

> It is important to emphasize that this is one of the main Montenegro's goals in fulfilling the criterion of being a functioning market economy, which is precisely defined in the set of closing benchmarks for the EU negotiation chapter 17, European and monetary union (opened on June 26, 2018). Montenegro is also obliged to adopt the required constitutional change to ensure that the primary objective of price stability is defined in accordance with Articles 127(1) and 282(2) of the Treaty on the Functioning of the European Union.

To prove this hypothesis, since many factors affect Montenegro's inflationary pressures, we examine three individual-predictive recursive and non-recursive structural vector autoregressive (SVAR) and three Bayesian SVAR models to investigate and forecast inflation determinants of Montenegro. We continue employing the average and inverse MSE combinations approach, and the data are examined from January 2006 to December 2016. Additionally, out-of-sample 12-month horizon forecasting is performed from January 2017 to December 2017. Model 1 examines external determinants. Model 2 examines the internal determinants of inflation. Model 3 relates to demand-pull and cost-push variables. Combining the above three forecasts, using an equal and inverse MSE weighting approach, we disclose four more RMSEs: two VAR equal and inverse MSE weights and two Bayesian VAR equal and inverse MSE weights. Besides, we use impulse responses to trace the effects of structural shocks on the endogenous variables and forecast error variance decomposition of shocks to variables.

Moreover, we use the panel vector error correction model (VECM) approach to forecast inflation dynamics and inflation expectations in Montenegro, Serbia, Croatia, and Slovenia from January 2006 to December 2015 out-of-sample 24-month horizon forecasting from January 2016 to December 2017. The objective of the panel cointegration approach is not only to compare two subgroups: i) Montenegro (ME) and Serbia (SR) as candidate countries for the EU membership and ii) Croatia (CR) and Slovenia (SI), already in EU, but to highlight the Montenegrin case. We employ alternative forecasting scenarios since the Central Bank of Montenegro wants to hypothetically have a forward-looking forecasting reaction of inflation in different sensitive scenarios, such as an increase in the oil price (external innovations) and economic freedom index-internal innovations.

This doctoral dissertation reveals and documents a significantly wider knowledge gap: both theoretical and empirical. We identified recursively and non-recursively three VAR and three Bayesian VAR models. Each model aggregates essential macroeconomic variables to forecast inflation in Montenegro. At the end of December 2017, the BVAR MSE combination inflation figures 2.661%: the BVAR average combination inflation figures 2.822%. The average VAR combination weights approach figures 1.537%, and the inverse of standard VAR MSE figures 1.516%. The standard VAR combination

models, average and relative performance, show a predicting performance that is sustainable. The average inflation performs not more than 1.5% above the three best performing Member States rate: Cyprus (0.2%), Ireland (0.3%), and Finland (0.8%). The average rate is 0.4% and, adding 1.5%, the reference is 1.9%.

We have reached a critical conclusion that both combinations have to be considered by the Government of Montenegro. The standard VAR combination performs the best forecasting for the quarter I and II of 2017, while the Bayesian VAR combination shows the best forecasting performance for quarters III and IV of 2017.

Even though BVAR combination models, average and relative performance, end up way off compared to the convergence EU criteria, incorporating these Bayesian combination models is significant for comparison purposes. The above results enable policymakers to address, evaluate, exploit, and compare the strength of using the high-dimensional dynamic composite forecast models.

The second critical research assumption and hypotheses made to draw out and test its logical and empirical results is structured as follows:

H2: Factors of inflation in the area of external demand that are crucial to maintaining price stability in the country, such as the Montenegrin economy and in the proposed model, are the price of energy and aluminum prices. In other words, the changes in the price of oil in the international market, expressed by the level of energy prices on the domestic market, as one of the key inputs for economic activities in the country, significantly determine the level of inflation. Montenegro's forward-looking and knowing the oil markets allows estimating the oil supply distribution, considering worldwide geographical and political events, and thus its consequences. Simultaneously, the price of aluminum affects the Montenegrin economy, which is also a stock market product. The more advancement of technological sophistication of KAP and its product diversification of aluminum (as the principal industrial export growth engine) – the greater assistance to policymakers to stabilize the trade balance, debt/GDP ratio, productivity growth, unemployment reduction, output gap, and consequently, limit external shocks to inflation in Montenegro, fixing price disparities and qualifying for the membership into the

EU/EMU. In other words, this research is focused on the measurement of the impact of oil prices and aluminum export growth on the average inflation rate in Montenegro.

Supply Shocks: Oil and Aluminum Prices

On the other hand, we have supply shocks, external disturbances to the Montenegrin economy. Governing external shocks is not directly into Montenegrin policy authorities' control and thus much more difficult to keep inflation stabilized. Usually, such shocks do not happen consistently, but they appear to be one-off shocks. The structure of the supply shocks comparing with the demand shocks are different. The following is suggested to absorb better external potential shocks:

- Montenegro needs to diversify some products further. Two indicators could assist the policymakers: Export Potential Indicator (EPI) and Product Diversification Indicator (PDI). By exporting products, Montenegro reveals its competitive products, the RCA. The EPI index indicates that electrical energy, aluminum not alloyed-unwrought, and wine of fresh grapes are the products with the most significant export potential from Montenegro to the world. The untapped potential (UP) of electrical energy, aluminum, and wine is 91.4$, 35.6$, and 8.5$ million, respectively. In our representative study, the untapped export potential sums up to 186.9$ million. This unused export potential should be considered by policymakers to see what can be done to improve the trade balance of Montenegro. On average, the percentage of untapped potential (UP) reaches 59.78%. Aluminum is the product with the best combination of the supply and demand out of Montenegro's products.
- be that investments fell, but as a result, the aluminum price ended up contrary.

- For the first five months, the response of unemployment has no movements almost at all to *oil price shocks*. It occurs because of the drop in registered employees, even though the number of registered unemployed has slightly increased, especially from 2014 till 2016. The informal structure must be considered as well, which reaches approximately 30% of the registered employment. The employment rate to unemployment ranges from 3.9 to 3.6 in the period from 2006 to 2017, respectively. Based on Monstat (2018), the registered employment

growth rate ranges from 4.5% to 1.1%, showing a decline, while the unemployment shows an increase in growth rate from -10% to 24%, respectively, from 2006 to 2017. In 2010, employment showed a negative -7.13 growth rate. We need to emphasize that the relation between registered employment to registered unemployment and pensioners is around 1.1%. The aging of the Montenegrin population increased from 32.4 in the 1991 Census to 37.7 years,

- The aluminum price response to *oil price shocks* has prominent oscillations, from positive to negative, with a permanent negative impact on aluminum's price. The pass-through from oil to aluminum is relatively quick, occurring after a couple of months, touching the peak. The persistence will continue to drop it drastically after 12 months, from the time reaching the peak. The reason is that after the economy is hit with the one-unit standard deviation shock in the oil price, the aluminum production cost lowered the price-setting (PS) curve in the labor market. Thus firms increase the prices to maintain the marginal profit. Only after four months, due to the lower demand for aluminum in the goods market equilibrium, the price declined sharply, becoming negative. It could be another reason, according to the Census data of 2011. The aging index, showing the relationship between the number of older people (65 years and over) and the number of young people (under 15), has significantly increased between the two censuses. In 1991 it was 32.55, while in 2003, it grew to 58.18, and in 2011 it amounted to 66.81. Finally, after the seventh month, the response of unemployment to oil shock increases as expected.

- The output significantly responds to the Cholesky one standard deviation oil price shock, meaning that the Montenegrin economy heavily depends on oil supplies. The transmission takes about 13 months, hitting the deep bottom. Subsequently, it takes 21 months to reach 0, attaining a peak level of 0.17% after two years and three months. In words: the oil price shock implication is that output declines rapidly for a transitional economy as Montenegro and gets more than a year to get back. It suggests that the response of the output gap to the Cholesky one standard deviation oil price shock could reduce the supply of intermediate goods market

and the demand for the final goods market in Montenegro, causing much damage to industrial production.

- The impulse response of inflation to Cholesky one standard oil price innovations starts increasing after a lag of four months, increasing gradually. After that, it declines, reaching deflation of -0.0023% after 15 months, hitting the bottom of -0.09% after 21 months. The transmission is evident since the economy slowed down, output hitting bottom after 13 months, while inflation after 21, a gap of 8 months between output and inflation hitting bottom. The broadest dynamic gap between output and inflation is reached after 24 months at -0.2111%, the so-called *stagflation*. Nevertheless, the dynamic gap has reached that stage since the increase in oil price affected Montenegrin market demand, leading firms to alter their investments, canceling projects. We notice that until output decreases within 12 months, inflation continues to increase, even for some months, keeping the same level and pushing inflation to a higher level than before the increase in oil price. In this case, the fiscal policymakers should intervene, adjusting the inflation and output. This whole adjustment process makes the economy go through a recession, with partial recovery. The adjustment process is mainly achieved through the expectations process, which in Montenegro seems to be well done. While still there are some gaps, while output decreases, inflation increases, most of the time, they comove. It proves the crucial point of expectation formation in the Montenegrin market and the dynamic effects of shocks.

The exogenous movements of oil price shocks are exogenous as expected to be, and this was confirmed by adding some intuitive economic potential variables such as wages and exchange rates. Therefore, exogenous shocks are adequately identified. Including nominal exchange to better isolate the oil price innovations did not prove to add any new information to the model.

- Contrary to oil price shock, the response of unemployment to aluminum's shock is marked by a faster rate of dynamics. The labor market in Montenegro reacts faster to shocks in aluminum than innovations in oil prices. Since the Aluminum

Plant in Podgorica is one of the leading growth engines, the transmission channels reflected in the labor market are directly portrayed.

- The dynamics of the GDP response to aluminum shocks compared with oil price shocks are very identical, but still, in the case of aluminum shock, GDP's response is faster. After four months, it reached to become negative, while at the oil price shock, it took to become negative five months. After this, the dynamics are identical.

- The inflation response to aluminum shock takes eight months to reach the peak, while at the oil price shock, inflation gets a peek at four months. It takes 16 months to hit bottom, while the oil price reached 0 at 15 months.

Aluminum remains a crucial export commodity for the industry of Montenegro. However, the strategic plans for KAP's future development depend on technological investments and investments in environmental protection. Meanwhile, within the EU accession process, Montenegro is committed to fulfilling all requirements of the ecological *acquis* and continues producing aluminum in line with the EU standards. Only, in that case, aluminum and all its components will continue to be the main export commodity of Montenegro. Besides, price fluctuations of oil market prices and aluminum stock prices at LME are the primary external factors that affect inflation and its stability in Montenegro.

The third critical research assumption and hypotheses made to draw out and test its logical and empirical results is structured as follows:

H3: Strengthening of the measures and state administration policies towards the development of *e*-services contributes to more effective and efficient public services provision, which affects GDP, productivity growth, unemployment, production gap and therefore stabilizes internal inflation shocks in Montenegro. Namely, one of the internal factors determining the inflation rate in Montenegro, in this survey, will be the level of developed *e*-services, included in the VAR and Bayesian VAR models, such as the EGDI index. Another important factor included in the VAR and BVAR models will be economic freedom since it is fundamental to what is regarded as economic progress. By

testing the hypothesis in the models, the correlation between the selected variables will be evaluated.

Demand shocks: expectations, EGDI, and economic freedom in Montenegro

We track the change in endogenous variables for each structural shock at t, $t+1 \ldots t+k$, from demand shocks: EGDI and economic freedom, combined with expectations. Our goal is to trace the effects of internal shocks to the economy of Montenegro, inflation. It is essential to emphasize the dynamics since they show a precise cause and effect relation between the shock and the variable that responds.

- The impulse response of EGDI to the *economic freedom shock* has significant oscillations, from negative to positive, with a permanent positive impact in the e-government development index. The pass-through from economic freedom to EGDI is relatively quick. The reason is that after the economy is hit with the one-unit standard deviation shock in the economic freedom, the expectations of productivity increase more than the real productivity, creating an unfavorable gap in the labor market. Workers expect higher wages than firms can afford. After four months, the expectations of citizens adjust to the new reality, that is until $EGDI^e$ and $EGDI$ are again equal. Another reason is that new technology investments took a while until the provider and the user functionalized and got used to the new system.

- As the capital stock variable is composed of FDI, it is no surprise that the real capital investors suspect the advancement of economic freedom. As a consequence, the investments are withdrawn. The capital stock responded negatively until 20 months, reaching -0.6. After this period, it starts to increase but slowly. It takes a while to convince foreign investors to bring their machinery and start production. Even though the GDP increases from the very start, the FDI decreases more, resulting in lower capital stock. In words: it implies that the government has to observe how foreign investors create and change their expectations.

- The response of human capital to Cholesky one-unit standard deviation shock in economic freedom starts to increase from the very beginning. It unfolds a critical perspective for students of Montenegro. Economic freedom hikes their expectations and views for a better future.

- The response of employment to economic freedom shock shows a smooth decline of employment, reaching -0.0003 after 22 months. After hitting bottom, it starts to increase slowly, reaching 0 after only 40 months. The labor market, society, and workers expected that the economy grows faster, which does not, creating an unfavorable gap in employment, increasing unemployment. The wage-setting (WS) relation will shift up by more than the price-setting (PC) relation, increasing unemployment's natural rate. The unadjusted gap remains higher for 20 months until expectations of productivity have adjusted to the new reality. Workers ask for a higher wage, and firms could not afford it. It leads to an increase in unemployment. After some period, workers and society will realize that firms have not increased their productivity, lowering their expectations, and accepting lower wages-increasing employment. The above fact suggests the policymakers should have an in-depth understanding of the adjusting mechanism of expectations.

- The response of GDP to the economic freedom shock keeps increasing until the 19^{th} month to 0.25%. In the first and second quarters, it increases than for the upcoming two quarters it remains pretty much the same level, steady. Thus, after the fourth quarter, it starts again to rise. This critical fact implies that economic freedom prospers when government authorities adequately anchor expectations. The mechanism of economic freedom is not strong enough to upgrade the economy alone. The citizens need to have a strong belief in the hands of macroprudential policymakers. *In words*: anchoring expectations with economic freedom brings prosperity.

Having the good news that the country is moving ahead towards the EU implies a correction of price expectations P^e, relating to the current price level P: increasing the real wages in price-setting relation. The wage-setting relation will change, as well, based

on A^e, unemployment u, and institutional factors captured by variable z: equilibrium of workers and firms' expectations of productivity. The adjustment process will occur until the equilibrium is reached in the free market: until workers and firms' expectations adjust to the new reality.

We have examined comparative inflation analysis of actuals, baseline, scenario 1 – an increase of EGDI, and scenario 2 – an increase of economic freedom. When economic activity is hit with positive economic freedom, inflation decreases drastically. The measures of economic freedom are based on 12 quantitative and qualitative factors, grouped into four broad categories, or pillars, of economic freedom: a) Rule of Law (property rights, government integrity, judicial effectiveness), b) Government Size (government spending, tax burden, fiscal health), c) Regulatory Efficiency (business freedom, labor freedom, monetary freedom), and Open Markets (trade freedom, investment freedom, financial freedom). The future thesis should examine each of the above components of economic freedom. Property rights are fundamental to what is generally regarded as economic progress, and with well-defined and enforced property rights, surplus production becomes a potential. The higher quality and more extensive the property rights are, the more efficient and productive the economy will be. In a globalized world, trade can be almost unimaginable without the well-defined property rights of transferable goods and services.

The forecasting performance shows that the economic freedom alternative scenario would increase human capital sharply compared to the scene of EGDI increase. The marginal impact of scenario 1 vs. scenario 2 is critical. This fact is significant for policymakers to increase the number of students: knowledge.

The introduction of the EGDI has changed the structure of the Montenegrin economy. The structural contour of the market changes due to introducing new technologies making the old ones obsolete. The early skills are less useful, while the new ones are in higher request. The old skilled generation is willing to work at least for the same wage, even accepting a lower salary. Still, the newly qualified generation has high expectations about the introduction of the new technological process. This process will shift the WS relation to the right if the new skilled generation outbalances the old skilled ones. As the modern age requires higher-skilled people, it is to be expected that higher education is a potential

variable. This wage inequality comes from the educational level as well. The decrease in employment in our case might arise from the fact that the demand for high-skilled workers is high, but the supply of the higher-skilled is low, resulting in a decrease in employment. As the adjustment process takes place in the labor market, we notice inflation adjusts as well. The more Montenegro closes to the EU, the higher will be demand for high-skilled workers. Still, in the meantime, some companies will keep demanding low skilled workers to stay competitive in the global market as the economic borders keep narrowing. It even increases the expectations of workers in the labor market. The co-movement of employment and inflation is rather close, which is under our explanation of the adjustment of $P^e \sim P$ and $A^e \sim A$.

Policymakers might consider it to balance the supply and demand of workers by specific sectors to balance wage inequality, which impacts further the economic activity and governing internal and external inflation factors in Montenegro. Only holders of masters' degrees lack an increase of demand in the average labor market, signalizing the policymakers that this high-skilled group should be motivated further because the overall economy of Montenegro does not utilize their potential.

- On the other hand, the inflation response to *EGDI shock* shows an increase in the first half of the year, then decreasing until the end of the second year, reaching zero. Thus, again, here we deal with the expectation mechanism. The adjustment process might take up to 24 months.

- The response of GDP to the EGDI shock is negative. It happens when productivity growth increases more slowly, but the expectations of workers keep growing. It is fascinating for Montenegro because this confirms the forward-looking, futuristic, reflected in the GDP, inflation, and employment. Thus, this specific mechanism leads to increasing employment (the high skilled outbalance the low-skilled) and, hence inflation. The adjustment mechanism of GDP is negative for the first six months then starts increasing. To conclude, the impact of EGDI on employment is high, which is one of the significant macroeconomic cornerstones of Montenegro.

We obtained impressive results from the panel dataset containing data for Montenegro, Serbia, Croatia, and Slovenia. The inflation variance decomposition is moved mostly from economic freedom. The empirical results clearly show the contribution of capital stock, economic freedom, and the corresponding shocks to the movements, forecast error variance of GDP.

- Under the alternative panel scenario, 1 – EGDI, GDP for Montenegro and Serbia predicts the economic growth even lower than the baseline, primarily for Montenegro, which shows how expectations of technological progress adjust slowly. This equilibrium happens only after 21 months for Montenegro, while for Serbia, after 14 months. While for Croatia and Slovenia, we see a very high increase in the GDP, leading us to conclude that the workers' expectations were absorbed very well from the markets. Moreover, inflation drops sharply based on the alternative forecasting scenario 1 for Croatia and Slovenia after the 1st quarter. It happens because the growth in technological progress has increased the real wages. In reality, it has lowered prices and restructured the market in terms of competitiveness for Slovenia and Croatia. While for Montenegro and Serbia, we see no significant oscillations. In words: institutional changes are suggested to synchronize the speed of the expectations in Montenegro and Serbia.

- As a potential factor, we have embedded an alternative scenario when economic freedom increases in the panel dataset: scenario 2. The channel of economic freedom is multidimensional. It affects production, government, consumers, investors, and revenues. The GDP increases enormously for all countries, forecasting a rapid growth for Montenegrin, Serbian, Croatian, and Slovenian economies of 4,826%, 4,644%, 5,983%, and 7,293%, respectively, in the period from January 2016 to December 2017. If we look at inflation, from January 2016 to December 2017, the alternative scenario could deflate the prices from 0% to -3,650%. It is significant for the CBCG to consider that through economic freedom, the CBCG could control the internal and external shocks to Montenegro's economic activity. Employment goes through the adjustment mechanism, especially Montenegro goes through a drastic drop – reaching -1,124% in the second quarter. It implies that the adjustment process goes through a very dynamic

oscillation within the first year. It coincides with some countries that entered the EU, such as Rumania, Bulgaria, and Croatia. There was a high flow of employment outside of their countries. Moreover, capital stock drops down, which comes from the fact that foreign investors wait until they get convinced that it is not a bubble, but it comes from the markets' internal restructure.

- We can notice that EGDI goes through the adjustment process, as well. At the very beginning, we see a drop in the EGDI. At the same time, after six months, it starts to increase and then keeps rising even more after the 1st year comparing to the initial year of the forecasting period, January 2016.

The above scenarios reveal which of the panel dataset alternative scenarios do impact more substantially inflation and economic activity in Montenegro, Serbia, Croatia, and Slovenia. The dynamic impact of economic freedom on inflation and GDP is enormous. The EGDI is noticeable in Croatia and Slovenia as a positive impact, while economic freedom appears throughout the countries.

Remarkably, this hypothetical assumption's impact hits all countries more or less with the same tide, except for Montenegro, in case of inflation, which is profoundly impacted by economic freedom. GDP increases enormously for all cross-sectional panel countries in case of the hit by economic freedom, but far more significant for Croatia and Slovenia when hit by EGDI innovation.

The inelasticity of the labor market, determined by these tensions, brings creative destruction. In words: the Government of Montenegro is recommended to take an in-depth look. There are more declining sectors, low in demand, than increasing ones, high in demand. The strategy should go towards that the computers should become more comfortable to use even for those low in high-skill jobs and take advantage of low-wage workers.

Demand-pull and cost-push variables

Model 2 has cost-push variables and demand-pull and: the nominal exchange rate, broad money (M2), wages, productivity growth, and inflation. The macroprudential policymakers and the CBCG are interested in examining and measuring shocks that

originate abroad, precisely the exchange rate. Since the nominal exchange rate volatility is often associated with significant disruptive effects, we have analyzed the impulse response of the euro nominal exchange rate to the Montenegrin economy.

- The impulse response to the positive *nominal exchange shock* indicates that initially, M2 falls immediately, followed by nominal exchange shock, until the second month. After a 9-month interval, the response of M2 reaches 0.001%. After that, it keeps increasing until the 19th month, reaching a peak of 0.009%. In words: after the euro appreciates, exports decrease, output decreases, and the trade deficit increases in Montenegro. To avoid a reduction in output, the Government must induce government spending to shift up the demand.

- The impulse response of wages to the nominal exchange rate shock has considerable oscillations, resulting in negative.

- As expected, productivity growth decreases from 2.5% to 0.9% in the first 3-month interval. After that, the response of productivity growth starts accelerating, and the maximum impact is reached at around 8 to 9 months, grasping 1.7%. After this, it keeps falling slowly and, after a 39-40 month interval, it reaches 0.

- The impulse response to the positive nominal exchange shock indicates that inflation initially increases immediately, followed by nominal exchange shock until the second month. It starts at -0.1%, and in the second month, it increases inflation to 0.06%. After this, inflation falls immediately to 0.01 in the 3rd month. In 48 months, inflation does not show prominent oscillations and keeps close to 0.

- The impulse response to the positive *M2 shock* indicates that initially, wages fall immediately, followed by the M2 until the third month, reaching -0.006%. Just after the 6-month interval, wages reach 0, and after 15 months, they increase to 0.008%. In words: as money penetrated the Montenegrin market, the expectations of the market and workers increased, but the real productivity did not improve. Consequently, the adjustment mechanism regulates the labor market in

Montenegro, and workers accept lower wages. From the month of 15 to 38, wages fall slowly, confirming the about conclusion and implication.

- Inflation impulse response to the positive M2 shock indicates identical movements to wages. First, inflation falls from 0.02% to -0.04% within the first two months, then increases to 0.18% after eight months. After this, inflation starts declining slowly and remains negative (-0.02) for the rest of the period.

Based on the above model, we can conclude that the Montenegrin macroprudential policymakers have to carefully pay attention to money supply and exchange rates to combine with fiscal policies. The Montenegrin government has to use fiscal policy to balance potential shocks that originate from abroad.

Stabilization policy in the wake of exogenous innovations, such as COVID-19, is the first-order concern for Montenegro's monetary and fiscal authorities. This dissertation documented that strengthening Montenegro's institutions, public administration, and using principal growth engine – exports – and product diversification makes Montenegro stronger to absorb global economic shocks.

Another substantial documentation is that the Montenegrin economy is vulnerable to external shocks, as it heavily relies upon capital inflows. Moreover, preserving human capital and keeping it in the country amounts to vital support and growth engine for macroeconomic stability and structural reforms in Montenegro. As the foreign investments will be very fragile after the outbreak of COVID-19, the stock market needs to be closely monitored by macroprudential policymakers. Since the structural reforms of supply shocks in Montenegro, through human capital and employment, trigger oscillations in aggregate demand more extensive than the shocks themselves, the policymakers are to make sure of not allowing firms to exit and create job destruction. In words: the series of effects would cause a recession in case intervention of conventional and non-conventional policies lacks. Inducing a high economic growth rate, leveraging the country's comparative advantages, has been documented in the thesis, and it can be achieved through securing law and order and appropriate subsidies. The upcoming central economic challenge for the policymakers of the Government of Montenegro and the CBCG is to manage the fiscal basket, lowering the public debt carefully.

Considering all the 2020 uncertainties, a full rebound to pre-COVID 19 GDP levels will take a few years. Even though a new synthesis, more harmonization of contemporary macroeconomists, regarding the recovery, appears to be in-sight and feel that they have the toolset needed to have an in-depth understanding of macroeconomics and designing policies, the health crisis has started in January 2020 and is continuing worldwide. Montenegro, as a small and open economy, has to reassess carefully daily future economic and development policies since a relatively small shock could lead to a macroeconomic crisis. In these circumstances, the CBCG independence position is crucial, which could influence the avoidance of more serious consequences with its instruments. Insufficient focus on financial institutions could be a source of failure. By and large, the role of an independent CBCG provision could avoid the problem. Thus, a *combination* of integrated factors is substantially documented in this thesis to be a consistent role model for maintaining price stability. In words: poor understanding of the interacted factors by a central bank and having the factors absent from macroeconomic models combines and creates a crisis. Large macroeconomic *integrated* models are lessons documented from this thesis to design macroprudential tools to keep stable and low inflation and avoid significant risks to the level of high public debt dangers. If history is any reference, starting from the recent economic history, modern economic systems will be hit yet by another source of shocks the macroeconomists have not analyzed so far in combination puzzles. Thus, for example, the adjustment mechanism of the 2008 Financial liquidity trap crisis of lowering interest rates did not prove to be operational in response to low output: the decline in total economic activity or production trends. Be it fiscal or monetary policy, the room is much more limited than thought previously, especially in Montenegro. In the upcoming recovery period, general fiscal stimulus will be less effective than usual since the Keynesian multiplier feedback is muted due to some sectors' shutdown. Monetary policy may have magnified effects by restricting company exits, as long as it is unimpeded by the zero nominal lower bound. At the time being of rewriting this doctoral thesis, the documented findings, withdrawn from the empirical combination puzzles in chapters 3, 4, and 5, will appeal to macroeconomic policymakers and bring closer arguments to understand better what is happening to use monetary and fiscal policy tools: to steer the economy back gradually to its growth and refocus on the path of growth. The combination puzzle findings of integrated factors, the so-called

combination puzzle recommend policymakers to take the *combined* position of new Keynesians and new growth theorists: the economic return to its natural level in the medium run, and the use of technological progress determinants. The *combination* policy tool, monetary and fiscal, addresses the best this question in our VAR and BVAR combined models.

In addition to the above, our documented results have some other interesting macroprudential policy implications. Firstly, it is crucial to investigate further why economic freedom increases positively affect GDP, and in particular, to analyze the growth of economic freedom in correlation with the reduction of the shadow economy and the attraction of investments. It may be a mixture of a combination of the following: a) increases of shadow economies, b) crowds out of selected private investments, and c)increases of debt burden for the benefit of a few groups. Secondly, the policymakers should consider the institutional improvements and control mechanisms to simultaneously reduce the impact of public debt growth on future development dynamics. Finally, evaluation of public sector expenditure, such as public sector bureaucracy, is to be examined with a continuous reduction of administrative barriers to business. In words: appropriate investments would not increase the public debt and normalize the economic freedom shock impact.

Another essential implication of this research is the assessment that Montenegro should effectively lead and end as soon as possible (reasonable medium-term).

Another fundamental implication of this research is the assessment that Montenegro should effectively lead and end as soon as possible (reasonable medium-term) the already opened chapters and overall *negotiation process* with the EU. Achieving full-fledged membership will strongly contribute to the country in raising the economy's competitiveness, overall economic outlook, and benefit from the EU budget to maintain price stability and protect the country against any other financial or health shocks. Besides, unemployment is an issue of serious concern in Montenegro and the need for structural reforms in that area. The unemployment level is too high, put another way - the output is lower than the natural level (potential), and the economy has a trade deficit. An increase in exports and their diversification will help on *both* the trade and output fronts.

Having shown all of the above, *future* research avenues should include a factor-augmented VARX and sign restrictions approach to a better and more complete picture of future shocks. This research has used SVAR parameter estimation methods that impose parametric restrictions on structure or impulse responses. Sign restrictions utilize information to generate many sets of impulse responses for uncorrelated shocks ε_t that satisfy the signs. The range of possible impulse responses, the compatibility of the data, the shape of responses in choosing a parametric model, and the isolation of specific shocks are the benefits of sign restrictions. A desirable *combination* of sign restrictions and parametric would bring the best results.

In conclusion, this doctoral dissertation's empirical findings provide macroprudential policymakers with an in-depth understanding of the role endogenous and exogenous determinants play in governing inflation with standard VAR and Bayesian *combination* models. Although previous research has identified several methods that could be used to predict inflation, such as internal and external variables, the methodologies developed from these studies have been limited and difficult to apply at the national level. Therefore, we value that the results of this research will enable policymakers to better understand the factors involved in recognizing the dynamics of inflation and inflation expectations in Montenegro and develop more effective measures and policies, which can be used at the national level. By doing so, we hope that our research work improves the set of tools needed to effectively address the challenges of managing external and internal inflation factors, which is crucial for maintaining price stability for macroprudential policymakers in Montenegro, especially the Central Bank of Montenegro.

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PROŠIRENI APSTRAKT

Inflacija je jedan od centralnih odnosno osnovnih makroekonomskih pokazatelja koji se temeljno ispituje od strane kreatora makroprudencijalne politike i makroekonomskih istraživača. Vlade je veoma zainteresovana za pouzdane prognoze inflacije. Prognoza inflacije je izazovno istraživanje. Značajan broj istraživača procijenio je i predvidio svojstva vremenskih serija inflacije. Opšta saglasnost ovih studioznih ispitivanja je da se osnovni trend i volatilnost inflacije tokom vremena znatno mijenjaju; međutim, još uvijek ne postoji konsenzus o najboljem načinu predviđanja dinamike inflacije. Prognoze inflacije bez grešaka od značaja su i za ostale subjekte u ekonomiji. Ekonomski akteri će donijeti svoje odluke o platama i cijenama na osnovu inflacionih očekivanja koje se formiraju i oslanjaju na tačnost prognoze inflacije.

Sa druge strane, nivo zavisnosti jedne male i otvorene ekonomije, poput Crne Gore, kao i dinamika njenih makroekonomskih indikatora, prošli su kroz značajne razvojne promjene poslednjih decenija. Neke od ovih promjena se ogledaju u obnovi nezavisnosti Crne Gore, dok se druge pripisuju ekonomskoj i političkoj orijentaciji ka Evropskoj uniji. Ove velike promjene donijele su značajno smanjenje volatilnosti makroekonomskog okruženja u Crnoj Gori: inflacija je ključni pokazatelj. Dakle, Vlada i makroprudencijalni kreatori politike Crne Gore preuzeli su dužnost i obavezu da kreiraju jasne makroekonomske politike sa namjerom da stabilizuju i učvrste inflaciju. Istovremeno, Evropska komisija eksplicitno izvještava o kriterijumima konvergencije u kojima performanse cijena moraju biti održive i prosječna stopa inflacije ne viša od 1,5 procentnih poena iznad stope inflacije tri države članice sa najboljim rezultatima.

Ova disertacija koristi širok spektar ekonometrijskih modela, od kojih svaki nosi robustne vremenske serije, i procenjuje i ocijenjuje njihove prognozne performanse kroz vrijeme i modele. Različite studije su vršile poređenja predviđanja na jednom određenom modelu. Međutim, ova disertacija fokusira se na objedinjavanje ključnih internih i eksternih faktora inflacije i izvođenje kombinacije predviđanja za isti događaj: budući da nema pojedinačno "najboljeg" modela. Bez obzira na postojanje mnogih visoko rafiniranih kombinacionih metoda, tačnost predviđanja je često najbolja kada se primijenjuje jednostavno prosiječno korišćenje na svim modelima. Mi koristimo pristup jednakih i relativnih težina performansi (inverzni MSE). Ovo je prvi put da je za ekonomiju Crne

Gore dobijeno kombinovano predviđanje, sugerišući višedimenzionalne dinamičke modele.

Ceteris paribus, naš glavni cilj je otkrivanje eksternih i internih determinanti inflacije u Crnoj Gori. Otkrivamo značajno širi jaz znanja: prvo, teorijska specifikacija, na osnovu koje se analiziraju empirijski determinante inflacije, koja kombinuje teoriju i empirijsku analizu, još uvijek nije opšteprihvaćena; drugo, izvođenjem identifikujemo tri strukturna VAR modela i kombinujemo ih sa jednakim i inverznim MSE pristupom ponderisanja. Ovaj pristup u dosadašnjim istraživanjima nije primijenjen na podatke o inflaciji u Crnoj Gori.

Cilj ove doktorske disertacije je empirijski istražiti i prognozirati determinante inflacije Crne Gore, koristeći kombinacione metode prognoze, od januara 2006. do decembra 2016. godine, i van uzorka 12 – mjesečnog predviđanja horizonta od januara 2017. do decembra 2017. godine. S obzirom da kreatori politike moraju da definišu odgovarajuće kriterijume za dijagnozu, odnosno prepoznavanje indikatora inflacije, glavni izazov kod ovog istraživanja je bila potreba da se razvije pristup i metodologija koju Vlada Crne Gore može koristiti, u istraživanju determinanti inflacije, a uskladu sa postepenim prilagođavanjem standardima koje je neophodno uvoditi u makroekonomskom upravljanju, a na putu pristupanja EU, odnosno Evropskoj monetarnoj uniji.

U radu se isputuju tri pojedinačna – prediktora SVAR modela za predviđanje inflacije. Takođe, koristimo pristup panel-vektorskog modela korekcije grešaka (VECM) za predviđanje dinamike inflacije i očekivanja inflacije u Crnoj Gori, Srbiji, Hrvatskoj i Sloveniji. Cilj pristupa panel kointegracije nije samo poređenje dvije podgrupe: i) Crna Gora (ME) i Srbija (SR) kao zemlje kandidati za članstvo u EU i ii) Hrvatska (CR) i Slovenija (SI), već u EU, već da istaknemo slučaj Crne Gore.

Model 1 ispituje unutrašnje determinante inflacije. Model 2 odnosi se na potražnju i rast troškova varijable. Model 3 ispituje spoljne determinante. Kombinujući navedena tri VAR i tri Bayesian VAR (BVAR) modela, otkrivamo još četri RMSE-a: (i) dvije VAR jednake i inverzne MSE težine, i (ii) još dva BVAR RMSE-a. Oni pokazuju performanse prognoziranja koja su održiva: prosječna inflacija ne viša od 1,5 p.p. iznad prosječne stope tri države članice sa najboljim performansama. Standardna VAR kombinacija daje

najbolje predviđanje za I i II kvartal 2017. godine, dok Bayesian VAR kombinacija pokazuje najbolje performanse predviđanja za III i IV kvartal za 2017.

Naši rezultati omogućavaju kreatorima politika Crne Gore da bolje razumiju faktore koji su uključeni u prepoznavanje dinamike inflacije i inflacionih očekivanja i razviju efikasnije regualtivu i mjere. Na navedeni način, ovo istraživanje unaprjeđuje i preporučuje potrebne metodološke alate, kombinujući prognoze, kako bi se kreatori markoprudencijalnih politika u Crnoj Gori efikasnije borili sa izazovima održavanja stabilnosti cijena.

Kao što je prethodno istaknuto, determinante inflacije su jedno od ključnih pitanja sa kojim su se kreatori makroekonomskih politika u Crnoj Gori neprekidno suočavali tokom proteklih decenija, a posebno od 2002. godine, nakon usvajanja eura kao zvanične valute. Država je status kandidata za Evropsku uniju postigla 2010. godine i u procesu je pregovora od juna 2012. godine. Kako je i navedeno u pregovaračkoj poziciji Unije, prilikom otvaranja pregovora, posebno otvaranja poglavlja o Evropskoj monetarnoj uniji, korišćenje eura kao zvaničnog sredstva plaćaja u Crnoj Gori biće razmotreno tokom završne faze pregovora o pristupanju Uniji. Okvirni scenario podrazumijevao bi da Crna Gora od pristupanja učestvuje u Ekonomskoj i monetarnoj uniji kao država članica sa izuzećem i formalno se pridružuje eurozoni nakon odluke Savjetaa u tom smislu, na osnovu procjene ispunjenosti potrebnih uslova (EU General Position, 2012).

Na osnovu zahtjeva tzv. Mastrihtskih kriterijuma za ulazak u EU (European Commission, Convergence Report, 2018), stopa inflacije mora biti stabilizovana kao preduslov za pridruživanje odnosno pristupanje Uniji. Otvaranjem pregovora o Poglavlju 17 - Ekonomska i monetarna politika, Unija pažljivo prati napredak u usklađivanju i primijeni pravne tekovine EU tokom čitavog procesa pregovora. Jedno od mjerila za ovo poglavlje je: Crna Gora je usvojila potrebne ustavne promjene. Ona mora da obezbijedi da se primarni cilj stabilnosti cijena definiše u skladu sa članovima 127(1) i 282 (2) Ugovora o funkcionisanju Evropske unije (Article 143 of the Constitution, 2012). Da bi usvojila odnosno koristila euro u skladu sa svim kriterijumima, Crna Gora mora uskladiti svoje nacionalno zakonodavstvo sa propisima EU i ispuniti preduslov stabilnosti cijena, kako bi osigurala ekonomsku konvergenciju. Kriterijumi konvergencije izričito izvještavaju: „Performanse cijena koja su održive i prosiječna inflacija ne veća od 1,5 p.p. iznad

prosječne stope inflacije tri države članice sa najboljim učinkom (European Commission, 2018)".

Iako je inflacija u velikoj mjeri analizirana, saznajemo da još ima dovoljno prostora za istraživanje. Novina ovog rada je u tome što koristi kombinovano predviđanje za ekonomiju Crne Gore. Ovaj rad predlaže upotrebu visokodimenzionalnih dinamičkih modela, ispitivanje podataka vremenskih serija za Crnu Goru od januara 2006. do decembra 2017. godine. Procjenjuje i upoređuje empirijske performanse različitih prognoziranih kombinacija inflacije (Hendry and Clements, 2001; Jore et al., 2010).

Cilj je otkriti determinante inflacije u Crnoj Gori u navedenom periodu i predvidjeti dinamiku inflacije, koristeći kombinovani pristup. Da bismo postigli taj cilj, rekurzivno procjenjujemo tri strukturna VAR identifikovana modela inflacije. Prvi model identifikuje primarne unutrašnje i nezavisne determinante inflacije (ekonomska sloboda i e-uprava). Model 2 ima varijable povlačenja potražnje i potiskivanja troškova (nominalni kurs, tražnja i depoziti privatnog sektora kao mjera širokog novca, zarade i rast industrijske proizvodnje), dok model 3 identifikuje osnovne spoljne i nezavisne determinante šokove ponude (cijene nafte i LME cijene aluminijuma). Teorija kombinovanja prognoza sugeriše da će metode koje koriste bolje prognozne performanse i različite pondere, imati bolji učinak od jednostavnih modela kombinacije prognoza.

Ceteris paribus, naše glavno stanovište je da bismo trebali uključiti agregatne determinante inflacije u makroekonometrijsku procjenu. *Kombinacije prognoza* su od suštinskog značaja u svjetlu crnogorskih napora da se ispuni ekonomske kriterijume pristupanja Evropskoj uniji.

Empirijske determinante inflacije su od suštinskog značaja. Faktori koji određuju inflaciju u naprednim i tranzicionim zemljama bili su tema mnogih empirijskih i teorijskih studija (Golinelli and Orsi, 2001; Egert, 2007; Blanchard et al., 2010; Koop and Korobilis, 2012; Apostolov and Josevski, 2016; Obradovic et al., 2017).

Sa druge strane, radovi koji se bave istraživanjem determinanti i analizom inflacije u Crnoj Gori su ograničeni. Članci koji su ispitivali inflaciju u našoj zemlji istakli su da bi samo strukturni višedimenzionalni modeli mogli tačno prognozirati inflaciju u Crnoj Gori (Lipovina – Bozovic et al., 2015; Mitrovic – Mijatovic and Ivanovic, 2017).

Lipovina – Bozovic et al., (2015) zaključili su da ARIMA modeli predviđanja ne mogu adekvatno predvidjeti inflaciju, zbog postojanja mnogih spoljnih faktora koji utiču na kretanje cijena u Crnoj Gori. Mitrović - Mijatović i Ivanović, (2017) utvrdili su da otvorenost Crne Gore pregrijava tražnju na tržištu nekretnina. Nadalje, novačana masa, akcize i spoljni šokovi takođe značajno utiču na inflaciju. Takođe, Međunarodni monetarni fond, u svom izvještaju Montenegro-Article IV Consultation, (2018) naglašava da 2 p.p. povećanja PDV-a i povećanje akciza dodaje otprilike 1 p.p. na inflaciju.

Budući da postoji relativno mali broj istraživačkih radova koji ispituju inflaciju u Crnoj Gori, razmotrili smo veliki broj empirijskih studija o determinantama inflacije. Za predviđanje inflacije predlažu se različite metodologije i indikatori. Cecchetti et al., (2000), između ostalih faktora, ističu impulsne reakcije realne ekonomije na inflaciju. Dées i Güntner (2016), koristeći panel VAR pristup, razdvajaju ulogu jediničnih troškova rada i profitnih marži kao osnovnih determinanta dinamike cijena u zemljama evrozone.

Yi i Choi (2005) su proučavali 207 zemalja od 1991-2007 i otkrili su da kada se stopa penetracije interneta poveća za 1%, inflacija opada za 0,04% -0,13%. Czernich et al., (2011) utvrdili su pozitivnu i značajnu vezu između širokopojasne veze i rasta za OECD: od 1996-2007.

Acemoglu (2009) tvrdi da postoji uvjerljiva empirijska podrška hipotezi da razlike u ekonomskim institucijama, a ne sreća, geografija ili kultura, uzrokuju razlike u prihodima po stanovniku, pa otuda i inflaciju. Heritage Foundation (2019) naglašava: „U ekonomski slobodnom društvu, pojedinci su slobodni da rade, proizvode, troše i ulažu na bilo koji način, uz tu slobodu, koju država ujedno štiti i ne ograničava“. Pozitivnu veza između ekonomske slobode (ES) i endogenog modela rasta (EMR) pokazalo je nekoliko studija (Berggren, 2003; Gwartney et al., 2004). Cebula (2011) gdje se potencira pozitivna veza između ES i EMR koristeći podatke iz panela. Hammermann i Flanagan (2007) zaključuju da bi veća liberalizacija pomogla da se smanje podsticaji rasta inflacije, a što je zasnovanu na istraživanju ekonomija u tranziciji sa 19 panela.

Pored navedenog, brzina tehnološkog napretka (A^e) i dinamički tempo očekivanja, koje društvo i radnici formiraju, presudni su i za oblikovanje očekivanja cijena (P^e), a mehanizam prilagođavanja može se veoma zakomplikovati (Blanchard, 2017).

Inovativne tehnologije mijenjaju strukturu tržišta, čineći staru tehnologiju zastarelom (Aghion i Hovitt, 2008). Takodje, smanjenje zaposlenosti u slučaju Crne Gore, može proizaći iz činjenice da je potražnja za visokokvalifikovanim radnicima značajna, ali je ponuda adekvatnih profila kadrova, koje tržište traži, nedovoljna: povećanje nezaposlenosti, svih obrazovnih nivoa, utiče na inflaciju.

U radu se takodje istražuju posljedice odricanja Crne Gore od nezavisne monetarne politike odnosno njenih ključnih instrumenata, što je dovelo do smirivanja inflatornih trendova. Polazeći i od iskustava nekih zemalja u razvoju, inflacija može postati niža i do 4%, kada se centralne banke i de jure obavezuju i de facto fiksiraju devizni kurs, u odnosu na slučajeve kada se samo de facto obavezuju (Ghosh et al., 2014). Euroizovane zemlje treba da imaju vrlo nisku prolaznu inflaciju, jer su njihove valute povezane sa valutom njihovih glavnih trgovinskih partnera (Del Cristo et al., 2012). U tom kontekstu, novačana masa očigledno ulazi u kratkoročne determinante inflacije (Lissovolik, 2003). Bobeica et al., (2019), što ukazuje da je verovatnije da se troškovi rada prenose na inflaciju cijena šokovima potražnje nego šokovima ponude.

Još jedan dio literature izučavan je u ovom radu, i to onaj koji istražuje vremenski - različite efekte šokova cijena nafte na dinamiku inflacije, što su istraživali Kilian (2009), Peersman i Van Robays (2012), te Baumeister i Peersman (2013). Oni pokazuju da su osnovni izvori cijena nafte ključne determinante inflacije. Choi et al., (2017) otkrivaju da povećanje globalnih cijena nafte od 10%, povećava domaću inflaciju za oko 0,4%, slično i kod razvijenih i kod zemalja u razvoju.

Sve veći značaj upravljanja inflacijom na pragu pristupanja EU motiviše autora da konceptualno i empirijski istražuje i predviđa determinante inflacije.

Iako su determinante inflacije u velikoj mjeri proučavane, otkrivamo znatno širi jaz u znanju. Prvo, konceptualna specifikacija, na osnovu koje se analiziraju empirijska ispitivanja determinanti inflacije, ne prevladava kombinovanjem teorije i empirijske analize. Drugo, identifikujemo rekurzivno tri strukturna VAR i tri BVAR modela i kombinujemo ih sa jednakim i inverznim MSE pristupom ponderisanja. Navedene metode nisu primijenjene na crnogorske podatke o inflaciji. VAR se pokazalo jednim od

ključnih empirijskih alata u savremenoj makroekonomiji i omogućavaju informativno modeliranje makroekonomskih podataka (Del Negro i Schorfheide, 2011).

Kritičke pretpostavke istraživanja i hipoteze iznjete da bi testirali njihov logički i empirijski rezultat strukturirane su na sljedeći način:

H1: Postizanju i održavanju stabilnosti cijena u Crnoj Gori, kao jednom od ciljeva centralne monetarne vlasti u zemlji (i njenim instrumentima), na putu ka Evropskoj uniji i Evropskoj monetarnoj uniji, značajno doprinosi i mjerenje uticaja ključnih faktora koje opredjeljuju nivo inflacije u zemlji.

> Važno je naglasiti da je ovo jedan od glavnih ciljeva Crne Gore u ispunjavanju kriterijuma uspostavljanja funkcionalne tržišne ekonomije, koja je precizno definisana u nizu zatvarajućih mjerila za pregovore sa EU u pregovaračkom poglavlju 17 - Evropska i monetarna unija (koje je otvoreno 26. juna 2018. godine). Crna Gora je takođe obavezna da usvoji neophodne ustavne promjene kako bi se osiguralo da se primarni cilj stabilnosti cijena definiše u skladu s članom 127(1) i 282(2) Ugovora o funkcionisanju Evropske unije.

H2: Faktori inflacije u zoni eksterne tražnje, koji ključno opredjeljuju održavanje stabilnosti cijena u zemlji, na primjeru crnogorske ekonomije i u predloženom modelu, su cijena energenata i cijena aluminijuma. Drugim riječima, promjene cijene nafte na međunarodnom tržištu, izražena nivoom cijena energenata na domaćem tržištu, kao jedan od ključnih inputa za ekonomske aktivnosti u zemlji, značajno opredjeljuju nivo inflacije. Istovremeno, na taj nivo utiče i cijena aluminijuma, koja je takođe berzanski prozvod. Što je naprednija tehnološka sofisticiranost KAP-a i što je veća diverzifikacija proizvoda od aluminijuma (kao glavnog motora rasta industrijskog izvoza), to je veća podrška kreatorima politika u cilju stabilizacije trgovinskog bilansa, odnosa duga/BDP-a, rasta produktivnosti, smanjenja nezaposlenosti, smanjenja proizvodnog jaza, i poslijedično, ograničavanja eksternih šokova inflacije u Crnoj Gori, smanjenja cjenovne nejednakosti i kvalifikovanja zemlje za članstvo u EU/EMU. Drugim riječima, ovo istraživanje e se fokusira na mjerenje uticaja izvoza aluminijuma na prosječnu stopu inflacije u Crnoj Gori, kao i analizu efekata promjene cijena energenata na svjetskom tržištu.

H3: Jačanje mjera i politika državne uprave ka razvoju e-usluga doprinosi efektivnijem i efikasnijem pružanju javnih usluga, što utiče na BDP, rast produktivnosti, nivo nezaposlenosti, proizvodni jaz i stoga stabilizuje interne šokove inflacije u Crnoj Gori. Naime, jedan od unutrašnjih faktora koji određuju stopu inflacije u Crnoj Gori u ovom istraživanju biće nivo razvijenih e-usluga, uključen u model regresije OLS, kao što je EGDI indeks. Testiranjem hipoteze u navedenom modelu, ocjeniće se postojanje korelacije između izabraih varijabli.

Da bi dokazali ove hipoteze, ovdje predstavljamo procjene parametara i glavne karakteristike tri modela. Prvi identifikovani rekurzivni SVAR model je sledeći:

$$\pi_t = \beta_0 + \beta_1 \log(EF)_t + \beta_2 \log(EDGI)_t + \beta_3 CStock_t + \beta_4 \log(H)_t + \beta_5 Emp_t + \beta_6 GDP\_GAP_t + u_t \quad (1)$$

gdje π_t označava stopu inflacije, log prirodni logaritam, tako da funkcija inflacije ima konstantnu elastičnost cijena, $log(EF)_t$ prirodni logaritam ekonomske slobode, $log(EDGI)_t$ logaritamsko stanje tehnologije, $CStock_t$ stopa zaliha kapitala, Emp_t prirodni logaritam ljudskog kapitala, Emp_t radna snaga, GDP_GAP_t označava jaz bruto domaćeg proizvoda.

Proširujemo model rasta, koji je predstavljen u izrazu (1). Budući da je Crna Gora postavila nacionalnu strategiju razvoja, dragocjeno je analizirati kako ovaj skup faktora, koji određuju dinamiku ekonomskog rasta, utiče na inflaciju (ERP, 2018-2020). Debata među istraživačima je šta bi trebalo predstavljati potvrdu stanja tehnološkog napretka u određenoj ekonomiji (Clarke i Wallsten, 2004; Meijers, 2014). U tom istraživanju,m možemo poći od indeksa razvoja e-uprave (EGDI) u modelu 1. EGDI uključuje karakteristike pristupa, kao što su infrastruktura i nivo obrazovanja, kako bi se odražavao kako zemlja koristi informacione tehnologije za unapređenje pristupa i uključivanje svojih ljudi (UN E-Government, 2019) .

Model 2 će ispitati kako promjene deviznog kursa, novčane mase, zarada i produktivnosti utiču na inflaciju u Crnoj Gori, koristeći rekurzivni strukturni VAR pristup. Ovdje posebno ističemo istraživanja koja procjenjuju da je evropska monetarna integracija, kompletna Evropska monetarna unija, istovremeno i suštinski, posredni korak, ka političkoj uniji (Alesina i Grilli, 2000):

$$\pi_t = \beta_0 + \beta_1 \log(EX)_t + \beta_2 \log(M2)_t + \beta_3 \log(W)_t + \beta_4 Prod_t + u_t \qquad (2)$$

gdje $log(EX)_t$ označava logaritamski oblik nominalnog kursa američki dolar za evro, $log(M2)_t$ mjera novčane mase definisana u Međunarodnom monetarnom fondu (MMF, Monetary and Financial Statistics Manual 2017), $log(W)_t$ logaritamski oblik zarada, i $Prod_t$ označava rast industrijske proizvodnje. Jednačina (2) uključuje sastojke privlačenja potražnje i potiskivanja troškova, polazeći od ravnoteže između agregatne tražnje i agregatne ponude. Cijene nafte i aluminijuma su kritične promijenljive u modelu 3 i mi smo zainteresovani za praćenje njihove dinamike. Zašto? Jer su egzogeno određene. To će ukazati na šokove koji sa globalnog tržišta dolaze u crnogorsku ekonomiju. Motor rasta produktivnosti Crne Gore u velikoj mjeri zavisi od izvoznog potencijala (Bogetić et al., 2013). Neusklađenost politike Kombinata aluminijuma Podgorica (KAP) prouzrokovala je pad vodećeg crnogorskog izvoznika. Bogetić et al., (2013) ističu da Crna Gora ne koristi glavni pokretač rasta - izvoz. Izvoz je transformisao mnoge male zemlje, posebno one sa značajnim prednostima u pogledu lokacije. Za period od 2007. do 2011. godine, odnos izvoza prema BDP-u u prosjeku je iznosio samo 39% u Crnoj Gori, dok je u Sloveniji 68%, Estoniji 78% i Malti 85% (Edgardo, 2008). Predviđa se da će BAT tehnologija biti uložena u iznosu od 50 miliona eura u aluminijumsku industriju do 2030. godine. Smanjila bi efekat staklene bašte (GHG) za 82,76% (što utiče na zdravlje i poljoprivredu) i diverzifikovala proizvode od aluminijuma (ERP, 2018-2020). Stoga su cijene nafte i aluminijuma predstavljaju značajne determinante koje treba uzeti u obzir u makroekonometrijskom predviđanju crnogorske ekonomije.

$$\pi_t = \beta_0 + \beta_1 \log(Oil)_t + \beta_2 \log(Alu)_t + \beta_3 Un_t + \beta_4 GDP\_GAP_t + u_t \qquad (3)$$

gdje $log(Oil)_t$ označava logaritamski oblik cijena nafte, $log(Alu)_t$ logaritam cijena LME aluminijuma i Un_t zarade. Ovaj model procijenjuje spoljne inovacije putem cijena nafte i aluminijuma.

Kako možemo objediniti ili kombinirati ove prognoze u optimalnu prognozu? Uopšteno govoreći, višestruke prognoze su dostupne donosiocima odluka prije nego što donesu odluku o politici. S obzirom na neizvesnost povezanu sa identifikovanjem optimalnog GDP-a, da li treba koristiti jednu (najbolju) prognozu? Ili bismo trebali (nekako) da prosiječimo sve dostupne prognoze? Nije vjerovatno očekivati da bi jedan statistički

model bio poželjniji od drugih u svim tačkama horizonta prognoze. Kombinovanje predviđanja pojedinačnih prediktora nudi jednostavan način izgradnje sofisticiranog, fleksibilnijeg modela predviđanja za objašnjavanje podataka.

Objedinjena - kombinovana prognoza je ponderisani prosek Z prognoza (Zhang, 2019):

$$\hat{y}_{T+h}^{c} = \sum_{i=1}^{Z} w_{T,h,i} x_{T,h,i} \tag{4}$$

a odabirom pondere $w_{T,h,i}$, minimalizuje se rizik povezan sa gubitkom zbog pravljenja greške u prognozi. Optimalana ponder za $x_{T,h,1}$ je:

$$w^{*} = \frac{\sigma_{T+h,3}^{2} - \sigma_{T+h,1,2,3}}{\sigma_{T+h,1}^{2} + \sigma_{T+h,2}^{2} + \sigma_{T+h,3}^{2} - 3\sigma_{T+h,1,2,3}} \tag{5}$$

a preciznijem modelu dodeljuje se značajniji ponder. Vektor optimalnih težina w' sa Z prognozama je:

$$w' = \frac{u' \sum_{T,h}^{-1}}{u' \sum_{T,h}^{-1} u} \tag{6}$$

Kvadratna pristrasnost i prognoza varijanse funkcije MSE gubitka prognoze je:

$$E\left[\left(y_{T+h} - x_{T,h,i}\right)^{2}\right]$$

$$= \sum_{i}^{Z} w_{T,h,i}^{2} \, bias_{T,h,i}^{2} + \sigma_{y}^{2} + \sum_{i}^{Z} w_{T,h,i}^{2} \, Var_{T,h,i}^{2} \tag{7}$$

Rekurzivni MSE pojedinačnih prognoza je:

$$MSE_{T,h,i} = \frac{1}{T-h-1} \sum_{t=1}^{T-h} \left(y_{t+h} - x_{t,h,i}\right)^{2} \tag{8}$$

MSE ponderi, relativne težine performansi, su:

$$\omega_{T,h,i} = \frac{\frac{1}{MSE_{T,h,i}}}{\sum_{i=1}^{Z} \frac{1}{MSE_{T,h,i}}} \tag{9}$$

Računanje relativnih pondera performansi (inverzni MSE) koristeći "rolling" prozore ili "discounting" omogućava da se više pažnje posveti nedavnim performansama. Kombinovane prognoze podrazumevaju diverzifikaciju rizika.

Sve variable su stacionarne, I (0), na osnovu jedinstvenih testova korjena ADF, PP i KPSS testa stacionarnosti. Vizuelni pregled i statistički korelogrami takođe prikazuju i potvrđuju stacionarnost. Rezultati testa *t*-statistike i *p*-vrijednosti odbacuju nultu hipotezu o jediničnim korijenima. Testiranje potencijalnih strukturnih lomova je presudno za utvrđivanje u svrhu predviđanja, kao i granica povjerenja. Dijagnostika stabilnosti, pod rekurzivnim procjenama – Chow breakpoint test – Quandt-Andrews – Bai-Perron, ukazuje na to da postoji promjena parametara na nivou značajnosti od 5%. Dakle, dodajemo dihotomne varijable.

Rekurzivno identifikujemo i procjenjujemo tri VAR i tri BVAR modela inflacije. Za svaki od kriterijuma (AIC, LR, FPE, SC i HK) predlaže se odgovarajuća dužina docnje. Odabrali smo dvije docnje kao odgovarajuću dužinu docnje za naš VAR model 1 i tri docnje za modele 2 i 3 (Clark i Ravazzolo, 2015).

Svi inverzni korijeni karakterističnog polinoma nalaze se unutar jediničnih krugova, što potvrđuje stacionarnost VAR modela 1, 2 i 3.

Otkrivamo da se prvi model najbolje uklapa u opseg pouzdanosti od 9% (od 1,6% do 2,0% inflacije). Pokazuje performansu predviđanja koji je održiv i prosječna inflacija ne veća od 1,5% iznad stope tri države članice sa najboljim učinkom: Kipar (0,2%), Irska (0,3%) i Finska (0,8%). Prosječna stopa je 0,4%, a dodajući $1^{1/2}$ procentnih poena, referenca je 1,9% (EC, 2018).

Model 2 ima više oscilacija oko "mode" nego model 1. Ipak, model 2 ima značajne skupove informacija koje treba uzeti u obzir za kombinovane prognoze. Kao što se i očekivalo, model 3 koji ima spoljne šokove (berzanske cijene nafte i aluminijuma), stvara veće fluktuacije kako se horizonti povećavaju.

U drugoj polovini 2017. godine, model 3 uklapa se u opsege pouzdanosti od 72-81%. Uključujemo određeni broj varijabli u model, jer dodavanje više regresora modelu predviđanja pogoršava probleme sa veličinom (Clark i West, 2006).

Procijenili smo tri različita modela, a zatim uporedili njihove prognozne performanse na osnovu greške srednjeg kvadrata. Pored toga, izračunali smo kombinovane prognoze sa ovim modelima. Da li su naše kombinovane prognoze bolje od ponderisanog zbira njegovih dijelova? Svaki od SVAR modela ima svoje objašnjenja varijable i jednu *y* varijablu. Tri SVAR modela su precizirana, procijenjena i ispitana koja mogu najbolje predvidjeti inflaciju.

Postavljamo uzorak na osnovu kojeg želimo da procijenimo modele, od januara 2006. do decembra 2016. Svaki od njih procijenjujemo pomoću najmanjih kvadrata. Uzorak predviđanja je od januara 2017. do decembra 2017. Pored toga, naredba "forecast" daje nam statistiku procijene za svaki model, čuvajući matrice. Pokretanje ovog dijela programa (koda) omogućava nam upoređivanje sposobnosti predviđanja svakog modela. Na osnovu RMSE, ispitujemo prognoze performansi. Prvi model ima najmanju grešku srednjeg kvadrata (0,69), dok je RMSE drugog modela (2,35). Izgleda da RMSE trećeg modela ima najlošije rezultate, imajući vrijednost (3,71), kao što se vidi u tabeli 19 u radu.

Možemo li napravi dodatni korak u istraživanju? Kombinovanjem gornje tri prognoze, sa jednakim ponderima i relativnim ponderima performansi (inverzni ponderi MSE), otkrivaju se još dva RMSE.

Zašto su ovi rezultati izuzetno značajni? Oni pokazuju da uzimanje u obzir svih determinanti inflacije na tržištu Crne Gore otkriva ključne informacije za CBCG: bolje predviđanje. Iako su relativni ponderi modela 2 i modela 3 relativno niski, kada se *kombinuju* u relativne pondere, oni otkrivaju vitalne i robusne informacije za kreatore makroprudencijalne politike: niži RMSE. Dokaz je da dodavanje varijabli, kroz SVAR modele, sistematski povećava performansu predviđanja, snižavajući RMSE. Zaključujemo da uključivanje adekvatnih SVAR prognoza u kombinaciju predviđanja dosljedno smanjuje osnovnu kvadratnu grešku prognoza kombinacije. Drugim riječima, adekvatno konstruisane kombinacije prognoza u Crnoj Gori trebale bi zamijeniti tradicionalne prognoze inflacije koje su se pokazale nedovoljno pouzdane. Štaviše, otkrivamo da, u prvoj četvrtini posmatrane godine, jednostavna prosječna kombinacija nadmašuje sve performanse. Pored toga, performansa relativnih pondera ostaje vrlo blizu, čak i za performanse u prvom kvartalu i najmanje je osetljiva do decembra 2017. godine. Jednostavniji, odnosno tzv. nisko-dimenzionalni modeli izostavljaju informacije sadržane

u ostalim promijenljivim. Stoga su kombinacione prognoze, koje udružuju pojedinačne prediktorske prognoze, optimalno rješenje za Centralnu banku Crne Gore.

Upoređujemo prognoze stvarne inflacije, kombinovane prognoze inflacije koristeći relativne pondere na osnovu inverznog MSE, kombinovane prognoze koristeći jednake pondere, kombinovanu prognozu koristeći srednje kvadratne greške, prognoze pomoću modela 1, prognoze pomoću modela 2 i prognoze pomoću modela 3. Na bazi sprovedenog istraživanja može se zaključiti da u početku posmatranog perioda (2017. godina), tokom prva tri mjeseca, jednostavna aritmetička prosječna prognoza kombinacije, nadmašuje sofisticiranije „optimalne" kompozitne prognoze.

Od aprila do decembra 2017. godine, inverzni MSE je optimalna linearna kompozitna prognoza, minimizirajući srednju kvadratnu grešku (MSE). Model 1 prati inverzni MSE do kraja, ali ipak, prosječna kombinacija ima bolje rezultate od Modela 2 i Modela 3. Na kraju decembra 2017. stvarna inflacija iznosi 1,9%, dok inverzni MSE 1,5%, u prosijeku 1,4 %, model 1 (1,3%), model 2 (5,8%) i model 3 (-3,0%). Modeli 1-3 pokazuju performanse predviđanja koje su održive i prosječna inflacija nije veća od 1,5% iznad stope tri države članice sa najboljim učinkom: Kipar (0,2%), Irska (0,3%) i Finska (0,8%). Prosječna stopa je 0,4%, a dodajući $1^{1/2}$ procentnih poena, referenca je 1,9% (EC, 2018).

Na kraju decembra 2017. kombinovana inflacija BVAR MSE iznosi 2,661%: BVAR prosječna kombinovana inflacija iznosi 2,822%. Prosječne težine kombinacije VAR približavaju se 1,537%, a obrnuto od standardnih VAR MSE 1,516%. Standardni modeli kombinacije VAR, prosječne i relativne performanse, pokazuju predviđanje performansi koje su održive.

Iako su modeli 2 i 3 daleko u poređenju sa stvarnom inflacijom, inkorporiranje ovih varijabli je značajno za Centralnu banku Crne Gore (CBCG). Gornji rezultati omogućavaju prognozerima da analiziraju, procijene, uporede i iskoriste snagu korišćenja visokodimenzionalnih dinamičkih kompozitnih modela prognoze.

U poređenju sa standardnim procjenama VAR, BVAR Litterman / Minnesota pokazuje da ima najniže RMSE za model 2 (0,48967) i model 3 (1,27483), s obzirom na $\mu_1 = 0$, $\lambda_1 = 0.1$, $\lambda_2 = 0.99$, $\lambda_3 = 1$, and $\lambda_4 = 10$, dok je za model 1 BVAR Normal-Flat ,

RMSE = 0.9913. Osetljiva razlika je u tome što su procjene Litterman / Minnesota znatno manje za prvo zaostajanje svake promjenljive.

Standardna VAR kombinacija ima niži RMSE (0,577499) pri korišćenju inverznog MSE od BVAR-a (0.586937). S druge strane, prosječna Bayesian VAR kombinacija ima niži RMSE (0,804415) od prosječne težine standardne VAR kombinacije u smislu ygreške srednjeg kvadrata (0.864771). Kao što smo već istakli, za prva tri mjeseca, jednostavna VAR aritmetička prosječna prognoza kombinacije nadmašuje sve sofisticirane „optimalne" kompozitne prognoze (2.045%). Od aprila do juna 2017. godine, inverzna VAR MSE, optimalna je linearna kompozitna prognoza, koja je najbliža stvarnoj inflaciji (2,127%). Bayesian inverzni MSE preuzima vođstvo od jula do decembra 2017. godine, konvergirajući najbolje u stvarnu inflaciju (2,661%).

Došli smo do kritičnog zaključka da Vlada Crne Gore mora da uzme u obzir obe kombinacije: standardna VAR kombinacija najbolje prognozira za I i II kvartal 2017. godine, dok Bayesian VAR kombinacija pokazuje najbolje prognozne performanse za kvartale III i IV 2017.

Zaključujemo da uključivanje adekvatnih Bayesian VAR prognoza u kombinaciju prognoza, suštinski smanjuje osnovnu srednju kvadratnu grešku predviđanja kombinacije. Obje kombinacije su kritično sredstvo za kreatore politike Centralne banke Crne Gore.

Panel ekonometrija je ispitivala i kratkoročne i dugoročne efekte ekonomskih sloboda i e-uprave na inflaciju, primijenom skupa podataka za Crnu Goru, Srbiju, Hrvatsku i Sloveniju za vremenski raspon 2006: 1 - 2017: 12. Heterogeni testovi kointegracije panela Pedroni, Kao i Johansena otkrivaju dugoročnu vezu između inflacije, ekonomskih sloboda i e-uprave. VECM predlaže da povećanje ekonomskih sloboda od 1% i e-uprave smanjuju inflaciju za 62,28%, odnosno 1,05%. Pored toga, koristi se Granger-ov test uzročnosti da bi se otkrio pravac uzročno-posljedične veze. PVECM se primenjuje za predviđanje inflacije pomoću determinističko-stohastičke simulacije i dinamičko-statičkih riješenja.

Koriste se predviđene mjere kao što su proporcija pristrasnosti, proporcija varijanse, SE, RMSE, proporcija kovarijanse i Theil U1 i Theil U2, što potvrđuje rezultate predviđanja

strategija učinaka. Nalazi impulsnog odgovora otkrivaju da je odgovor inflacije na šok za ekonomske slobode i e-vladu od suštinske važnosti. Razlaganje varijanse greške u prognozi stope inflacije proizilazi uglavnom iz indikatora nivoa ekonomskih sloboda.

CBCG je zainteresovana da hipotetički sagleda reakciju inflacije u različitim osetljivim scenarijima, poput povećanja cijene nafte (spoljne inovacije) i indeksa ekonomskih sloboda - interne inovacije (Groen et al., 2012). Smatramo ih vodećim pokazateljima inflacije na koje bi kreatori makroprudencijalne politike trebalo da reaguju u Crnoj Gori. Alternativni scenario počinje da utiče, odnosno da mijenja podatke od januara 2016. do decembra 2017. Hipotetički, povećavamo cijene nafte sa 0,5 na 2 poena, sa 14,01% na 48,43%. Istražujemo kakav bi bio uticaj povećanja cijena nafte u crnogorskoj ekonomiji, s obzirom da je kanal cijene nafte je u Crnoj Gori višedimenzionala, te utiče na proizvodnju, potrošače, investitore, kao i na politiku Vlade, posebno u domenu fiskalne politike.

Šok rasta cijena nafte mogao bi doći endogeno kao rezultat fiskalne konsolidacije. Troškovi proizvodnje povećavaju se rastom cijena nafte, što primorava kompanije da povećaju cijene, kako bi zadržale postojeću marginu profita. U slučaju porasta cijena nafte, potrošači više nemaju istu stvarnu vrijednost novca. Realne zarade im se smanjuju, što dovodi do povećanja nezaposlenosti.

Odlukom o fiskalnoj konsolidaciji i povećanjem akciza, proizvodni jaz se smanjuje. To navodi preduzeća da povećaju cijene, što dovodi do povećanja inflacije. Na redu je monetarna politika, preko CBCG, da poveća/utiče na kamatnu stopu, kako bi usporila rast inflacije. Dinamika smanjenja proizvodnje povezana sa porastom inflacije poznata je kao stagflacija. U slučaju da promjene cijena nafte (promjena akciza ili promjena cijena na berzi) u Crnoj Gori ne budu praćene promjenama očekivanja inflacije, tada će očekivanja ostati konstantna, a Vlada će imati mnogo lakši posao u makroekonomskom upravljanju.

Da li je realno da će očekivanja ostati konstantna? Šta određuje ova očekivanja? Ako čvrsto veruju u stabilnost makroekonomskog okruženja, tada se njihova očekivanja neće promjeniti. Naime, kompanije svoja očekivanja formiraju u vremenu velike dostupnosti informacija i razvoja društva znanja, počev od Interneta do brokera, vijesti, banaka i drugih agenata na tržištu širom svijeta (Giacomini, 2015).

Sprovedeno istraživanje takođe ukazuje na zaključak da je u Crnoj Gori i kanal ekonomskih sloboda višedimenzionalan. Osjetljivi scenario slučaja, u našem istraživanju, hipotetički povećava indeks ekonomskih sloboda sa 20% na 44% tokom cijele 2017. godine. Moramo imati na umu da je ovo deterministička simulacija - performansa predviđanja dinamičkog rešenja, koja koristi već predviđene docnje vrijednosti, da bi napravila predviđanje za više perioda unaprijed. Dakle, ovaj model automatski povećava šansu za povećanje vjerovatnoće za reziduale. Ako pogledamo inflaciju, alternativni osjetljivi scenario mogao bi da utiče na smanjenje nivoa cijena, čak i sa 0% na -207%.

Važno je pojasniti i zašto su se u istraživanju koristili strukturni VAR-ovi. Polazi se od činjenice da je CBCG zainteresovana za praćenje efekata šoka na inflaciju. Razmatramo događaj kada Crna Gora predviđa porast inflacije. CBCG povećava, odnosno utiče na kamatnu stopu, ali inflacija i dalje raste, kako se očekivalo. Moglo bi se pogrešno zaključiti da je povećanje kamatne stope dovelo do porasta inflacije. Međutim, reakcija je bila endogena za očekivanu inflaciju. Stoga, u istraživanju moramo identifikovati čisto egzogeni (politički ili drugi tip) šoka, da bismo mogli da pronađemo njegove dinamičke efekte: identifikujemo strukturni VAR. Impulsni odgovori prate efekte strukturnih šokova na endogene varijable. Funkcija impulsnog odziva će nam reći promjenu endogenih varijabli za svaki strukturni šok pri *t, t + 1* i tako dalje (Inoue i Kilian, 2016). Koristeći isti, ranije korišćen, odnos između prognoziranih grešaka i strukturnih šokova, Guerron-Quintana et al., (2017) naglašavaju:

$$X_t = \mu + A^{-1}u_t + \sum_{i=1}^{\infty} \psi_i A^{-1}u_{t-i} \tag{10}$$

ili kompaktnije:

$$X_t = \mu + \sum_{i=1}^{\infty} C_i u_{t-i} \tag{11}$$

$c_{11,i}$ i $c_{12,i}$ su odgovori *y* i *x* na promijenu u_{yt} i u_{xt}, respektivno. Takođe, treba imati u vidu da je $c_{11,0}$ efekat pri impakta, $c_{11,1}$ je efekat u_{yt} na *y* i tako redom:

$$\frac{\partial y_{t+k}}{\partial u_{yt}} = C_{11,k} \tag{12}$$

takođe, kumulativni efekat je $\sum_{i=0}^{\infty} C_{11,i}$.

Pošto smo ispitali tri SVAR i tri BVAR modela, tragamo za prihvatljivim nivoom inflacije, odnosnom održivim nivoom u odnosu na šokove cijena nafte od jedne standardne jedinice devijacije.

Reakcija impulsa na inflaciju, od jedne jedinice tzv. Cholesky standardne inovacije cijena nafte - počinje da se postepeno povećava nakon docnje od četiri mjeseca. Poslije toga, opada, dostižući deflaciju od -0,002 nakon 15 mjeseci. Dostiže dno od -0,09 nakon 21 mjeseca. Prenos šoka cijene nafte je evidentan. Treba imati na umu da porast cijena nafte ne može biti reakcija na ono što se dešava sa ostalim varijablama. To mora biti egzogeno. U ovom slučaju, „egzogeni" koraci Centralne banke Crne Gore, čine je zaista nezavisnom institucijom. Dakle, egzogeni šokovi su pravilno identifikovani. Riječima: s obzirom da je ekonomija usporila, proizvodnja je dosegla dno nakon 13 mjeseci, dok je inflacija dostigla najniži nivo poslije 21 mjeseca (jaz od 8 mjeseci između proizvodnje i inflacije). Već nakon 30 mjeseci inflacija postaje pozitivna, 0,0047. Dakle, povećanje cijene nafte tjera CBCG i kreatore fiskalne politike da intervenišu u cilju smanjenja inflacije.

Povećanje cijene nafte uticalo je na potražnju na crnogorskom tržištu, navodeći kompanije da promijene svoja ulaganja i otkažu planirane projekte. U roku od 12 mjeseci, dok se proizvodnja smanjuje, inflacija nastavlja da raste. U ovom slučaju intervenisali su kreatori fiskalne politike u Crnoj Gori, prilagođavajući inflaciju i proizvodnju. Ovaj proces prilagođavanja uglavnom se koordinira kroz proces očekivanja, koji je u Crnoj Gori solidno postavljen. Ovo prikazuje ključnu tačku: formiranje očekivanja u Crnoj Gori i dinamičke efekte šokova. Implikacija ovog šoka sa cijenama nafte je da proizvodnja brzo opada za tranzicionu ekonomiju kao što je Crna Gora, i treba joj više od godinu dana da se oporavi.

Pri dekompoziciji varijanse inflacije na naftne šokove, većina promjena, u prvom mjesecu, dolazi sama po sebi na nivo od 93,18%. Ovo ne bi trebalo da bude iznenađenje za kreatore ekonomske politike. Rezultat je našeg sistemskog pristupa u analizi navedenih varijabli. U dužim horizontima - 24 mjeseca, doprinos šokova varijablama kretanju ili prognozi varijanse greške inflacije povećava se na sledeći način: nafta (17,82%), cijena aluminijuma (11,41%), nezaposlenost (13,62%) i gdp_gap 1,14%. Učinak šoka cijena nafte se naglo povećava na početku, posebno u prvih šest mjeseci, sa 2,50%, 5,71%, 8,75%, 11,41%, 12,88% i 14,31%, respektivno.

U modelu 1 primijetili smo da su ekonomske slobode od presudnog značaja, pa stoga i ovdje analiziramo detektovane impulse i dekompoziciju varijanse (Chan i Jeliazkov, 2009; Chan, 2013). Inflacija odmah počinje da opada, posebno u prvoj godini, a zatim počinje vrlo sporo da raste. Kako možemo da protumačimo navedeno kretanje, tj. rezultate? Navedena istraživanja upućuju na zaključak da je Crna Gora izuzetno izložena dejstvu spoljnih determinanti inflacije, posebno promjenama cijena nafte, kao berzanske robe. Da nagle promjene ove varijable, imaju izuzetno izražen uticaj kako na nivo prozvodnje, tako i na zaposlenost, te na samu antiflacionu politiku. Na putu pristupanja EU, Crna Gora mora uzimati u obzir dejstvo ovih determinanti inflacije, koje dolaze sa medjunarodnog tržišta, te efikasnom i fleksibilnom makroprudencijalnom, i ukupnom makroekonomskom politikom, blagovremeno se prilagođavati promjenama eksterne tražnje i šokovima cijena nafte. Istovremeno, neophodno je ekonomskim i sturkturnim reformama, smanjivati ranjivost, odnosno povećavati otpornost na eksterne šokove. To podrazumeva korekciju očekivanja cijena P^e u odnosu na trenutni nivo cena P.

Konačno, očekivano, Choleski-jeva dekompozicija varijanse prognoze greške inflacije na inovacijama ekonomskih sloboda uglavnom je rezultat šokova *per se* u kratkim horizontima, do nivoa od 96,53%. Posle šestomjesečnog horizonta, doprinos šokova ekonomskih sloboda kretanju inflacije povećava se na 9,13% u ukupnoj kompoziciji. U 12-mjesečnim horizontima, doprinos ekonomskih sloboda i odgovarajućih šokova evoluciji inflacije iznosi 24,94%. U 24-mjesečnim horizontima, udio kretanja inflacije usled šokova uzrokovanim ekonomskim slobodama dostiže 35,89%.

Zaključno, doprinos ekonomskih sloboda kretanju inflacije je izuzetno značajan. Drugim riječima: u ekonomski slobodnom društvu pojedinci mogu slobodno raditi, proizvoditi, trošiti i ulagati. Kumulativno, takav ambijent pogoduje očuvanju cjenovne stabilnosti i kvalitetu prognoza ključnih makroekonomskih indikatora.

S obzirom na to da su kreatori politike morali da definišu odgovarajuće kriterijume za dijagnozu nastupa indikatora inflacije, cijenimo da je *dodata vrijednost* ovog istraživanja napor na identifikaciji posebnog pristupa i same metodologije prognoziranja nivoa inflacije, koju bi Vlada Crne Gore mogla koristiti u razvoju antiinflacione i ukupne strategije razvoja. S obzirom na veliki porast interesa za ispunjavanje kriterijuma konvergencije odnosno kriterijuma iz Mastrihta, kao i nedostatak ujednačene

metodologije prognoziranja nivoa inflacije, vijerujemo da će zaključci predstavljeni u ovom istraživanju koristiti kreatorima makroprudencijalne politike u sprovođenju jedne od ključih fukcija upravljanja ekonomskim sistemom, a to je održavanje cjenovne stabilnosti i posticanje rasta.

Savremeni uslovi iznenadne zdravstvene i narastajuće ekonomske krize, u uslovima rastuće sistemske neizvjesnosti, takođe potvrđuju značaj istraživanja poput ovoga. Drugim riječima, stabilizaciona politika u toku egzogenih šokova, kao što je *pandemija COVID-19*, prvo je pitanje za monetarne i fiskalne vlasti Crne Gore. Ova disertacija je dokumentovala da jačanje crnogorskih institucija, javne uprave i korišćenje glavnog pokretača rasta - izvoza - i diverzifikacije proizvoda u smislu jačanja izvoznog potencijala naše ekonomije, čini Crnu Goru snažnijom u apsorbovanju globalnih ekonomskih šokova.

Druga važan zaključak koji se može izvući na bazi sprovedenih istraživanja jeste da je crnogorska ekonomija (kao izrazito servisno orjentisana ekonomija) posebno osetljiva na spoljne šokove, jer se u velikoj mjeri oslanja na prilive kapitala i promjene eksterne tražnje. Štaviše, *očuvanje ljudskog kapitala i njegovo zadržavanje u zemlji* predstavljaju vitalnu podršku i pokretač rasta, ne samo za neophodnu makroekonomsku stabilnost, već i za jednako značajne i neophodne - strukturne reforme u Crnoj Gori. Budući da su strane investicije značajno smanjene uslijed izbijanja pandemije COVID-19, makrobonitetni kreatori politike moraju pažljivo nadgledati berzu i kretanja na međunarodnom tržištu. Budući da strukturne reforme šokova ponude u Crnoj Gori, kroz ljudski kapital i zapošljavanje, pokreću *oscilacije agregatne tražnje* opsežnije od samih šokova, kreatori politike moraju osigurati da firmama ne dozvole relativno lak izlazak iz sektora, koji bi povlačio i značajnija kolebanja na tržištu rada i gubitak značajnog broja radnih mjesta. Drugim riječima: niz efekata mogao bi prouzrokovati *recesiju* u slučaju da nedostaje intervencija, kako konvencionalnih, tako i značajnog broja nekonvencionalnih politika i mjera. Podsticanje visoke stope ekonomskog rasta, iskorišćavajući komparativne i konkurentske prednosti zemlje, dokumentovano je u tezi, a to se, *između ostalog*, može postići obezbjeđivanjem reda i zakona, striktne primjene jednakih normi za sve, snažnijih institucija, ali i državng intervencionizma balansiranog kroz odgovarajuće subvencije i druge oblike podrške privredi (posebno u uslovima kriza). Sve navedeno dobija posebno na težini, ako uzimamo u obzir turbulentne faktore sprege *zdravstveno-ekonomske* krize,

kada instrumenti fisklane polilike i politike upravljanja javnim dugom, postaju od presudne važnosti za stabilizaciju ekonomije i poboljšanje razvojne perspektive.

Uzimajući u obzir sve neizvesnosti koje je sa sobom donijela 2020. godina, kao i sagledavanje realnog oporavka ekonomije u srednjem roku, potpuni oporavak nivoa BDP-a, na nivo iz 2019. godine, prije COVID 19, svakako da može potrajati i nekoliko godina. Iako se čini da se nazire nova sinteza odnosno više usaglašenosti stavova savremenih makroekonomista po pitanju modela oporavka, te da oni cijene da posjeduju set alata potreban za dublje razumijevanje makroekonomije i dizajniranje budućih politika - dubina zdravstvene kriza koja je započela u januaru 2020. godine i nastavlja se širom svijeta, ipak tjera na oprez i dalja istraživanja. Crna Gora, kao mala i otvorena ekonomija, svakodnevno mora pažljivo preispitivati svoju buduću ekonomsku i razvojnu politiku, jer relativno mali šok može dovesti do ozbiljne makroekonomske krize. Nedovoljni fokus na finansijskim institucijama mogao bi biti izvor neuspjeha. U navedenim okolnostima, od presudnog je značaja pozicija *nezavisnosti* CBCG, koja bi svojim instrumentima mogla uticati na izbjegavanje ozbiljnijih posljedica.

Kombinacija integrisanih faktora je u velikoj mjeri dokumentovana u ovoj tezi kao dosljedan uzor za održavanje stabilnosti cijena. Sažeto rečeno: loše razumijevanje međufaktorskih indikatora od strane centralne banke i nepostojanje faktora iz makroekonomskih modela, kombinuje i stvara krizu. Lekcije velikih integrisanih makroekonomskih modela su dokumentovane u ovoj tezi, uz dizajniranje makrobonitetnih alata kako bi se održala stabilna i niska inflacija i izbjegli značajni rizici u odnosu na nivo javnog duga. Polazeći od novije ekonomske istorije, savremene privredne sisteme će pogađati još izvora različitih šokova koje makroekonomisti do sada nisu analizirali u kombinovanim zagonetkama. Tako se, na primjer, mehanizam prilagođavanja krize zamkama finansijske likvidnosti iz 2008. godine, uz snižavanje kamatnih stopa, nije pokazao operativnim kao odgovor na pad ukupne ekonomske aktivnosti odnosno kretanje proizvodnje. Bilo da je riječ o fiskalnoj ili monetarnoj politici, prostor je mnogo ograničeniji nego što se ranije mislilo, posebno u Crnoj Gori. U predstojećem periodu oporavka, opšti fiskalni podsticaj biće manje efikasan nego obično, jer su kejnzijanski multiplikatori prigušeni zbog gašenja nekih sektora. Monetarna politika može imati povećane efekte ograničavanjem izlaza preduzeća, sve

dok je neometana nultom nominalnom donjom granicom. U trenutku pisanja ove doktorske teze, dokumentovani nalazi, povučeni iz empirijskih kombinacija zagonetki u poglavljima 3, 4 i 5, privući će kreatore makroekonomskih politika i približiti argumente da bolje razumiju šta se dešava sa upotrebom alata monetarne i fiskalne politike: da se ekonomija postepeno oporavlja i usmjeri ponovo na putanju rasta. Nalazi komibinacije integrisanih faktora, tzv. kombinovane slagalice (*combination puzzle*) preporučuju kreatorima politike da zauzmu kombinovani stav novih kejnzijanaca i teoretičara novog rasta: ekonomski povratak na prirodni nivo u srednjem roku i upotreba determinanti tehnološkog napretka. Alat kombinovane politike, monetarni i fiskalni, najbolje se bavi ovim pitanjem u našim kombinovanim modelima VAR i BVAR.

Pored navedenih, dokumentovani rezultati ovog istraživanja obuhvataju i *dodatne* implikacije na makrobonitetnu politiku. Prvo, veoma je važno dalje ispitivati zašto povećanje ekonomskih sloboda ima tako pozitivan efekat na BDP, te posebno analizirati rast ekonomskih sloboda u korelaciji sa smanjenjem sive ekonomije i privlačenjem investicija. Drugo, kreatori politike treba da razmotre institucionalna poboljšanja i mehanizme kontrole, kako bi istovremeno težili da smanje uticaj rasta javnog duga na buduću razvojnu dinamiku. Na kraju, treba ispitati procjenu rashoda javnog sektora, odnosno strukturu ukupne javne potrošnje, uz kontinuirano smanjenje administrativnih barijera poslovanju. Drugim riječima: odgovarajućom kombinacijom investicija i okvira ukupne razvojne politike zemlje, mogao bi se kontrolisati njihov uticaj na rast javnog duga, čime bi se i normalizovali uticaji šoka ekonomskih sloboda.

Otkrili smo da među performansama predviđanja pojedinačnih prediktora model 1 ima najbolje rezultate na osnovu greške osnovnog kvadrata. Zavisi od trenutnih ekonomskih šokova i ekonomske slobode. Model 1 ima čak i bolje rezultate od kombinovanih jednakih pondera, ali usrednjavanje ima bolji učinak od pojedinačnog modela 2 i modela 3. Ovaj osnovni dokaz pokazuje da su ekonomske slobode od presudnog značaja za promociju održivog rasta. Glavne implikacije ove studije sugerišu da su ekonomske slobode izuzetno značajne u upravljanju inflacijom i održivim rastom u Crnoj Gori. Alternativno, povećali smo cijene nafte i ekonomsku slobodu, a predviđena inflacija se povećava, odnosno naglo opada: dakle, implicirajući da su vladini propisi o ekonomskim aktivnostima presudni. Rezultati impulsnog odgovora otkrivaju da su odgovori inflacije

na šok naftom i ekonomsku slobodu značajni. Dekompozicija varijanse inflacije premiješta se uglavnom iz ekonomskih sloboda i cijena nafte.

Zaključno, *empirijski rezultati* ove doktorske disertacije rada pružaju kreatorima makroprudencijalnih politika *detaljno razumijevanje modela kombinacije prognoza*.

Još jedna suštinska implikacija ovog istraživanja je ocjena da Crna Gora treba u što kraćem (razumnom srednjem roku) efikasno vodi i okonča *pregovarački proces* sa EU. Postizanje punopravnog članstva snažno će doprinijeti zemlji u podizanju konkurentnosti privrede i ukupnoj ekonomskoj perspektivi. Crna Gora, kao neto korisnica značajnih sredstava iz strukturnih i investicionih fondova EU, istovremeno dobija značajnu podršku u očuvanju stabilnosti cijena i zaštiti od mnogih (budućih) ekonomskih ili zdravstvenih šokova. Pored toga, nezaposlenost je pitanje koje ozbiljno zabrinjava sve ekonomske aktere u Crnoj Gori, zajedno sa potrebom za strukturnim reformama u toj oblasti. Nivo nezaposlenosti je visok, odnosno proizvodnja je niža od prirodne (potencijalne), uz visok trgovinski deficit. Povećanje izvoza i njihova diverzifikacija pomoći će i na trgovinskom i na proizvodnom frontu.

Polazeći od svega navedenog, *budući* putevi istraživanja trebalo bi da uključuju faktorski uvećani VARX i pristup ograničenja znakova, radi bolje i potpunije slike budućih šokova. Ovo istraživanje koristilo je metode za procjenu parametara SVAR koje nameću parametarska ograničenja na strukturu ili impulsne odzive. Ograničenja znakova koriste informacije za generisanje mnogih skupova impulsnih odgovora za nekorelirane šokove ε_t koji zadovoljavaju znakove. Opseg mogućih impulsnih odgovora, kompatibilnost podataka, oblik odgovora pri izboru parametarskog modela i izolacija specifičnih šokova su prednosti ograničenja znakova. Poželjna kombinacija ograničenja znakova i parametra donijela bi najbolje rezultate.

Iako su prethodni istraživački radovi identifikovali nekoliko metoda koje bi se mogle koristiti za predviđanje inflacije, poput internih i eksternih varijabli, metodologije razvijene iz tih studija bile su ograničene i teško ih je primijenjivati na nacionalnom nivou. Stoga cijenimo da će rezultati ovog istraživanja omogućiti kreatorima politike da bolje razumiju faktore koji su uključeni u prepoznavanje nastupa dinamike inflacije i inflacionih očekivanja u Crnoj Gori i razviju efikasnije mjere odnosno politike, koje se

mogu koristiti na nacionalnom nivou. Radeći tako, nadamo se da naš istraživački rad unapređuje set alata potrebnih za učinkovito suočavanje sa izazovima upravljanja spoljnim i unutrašnjim faktorima inflacije, što je od ključnog značaja za održavanje stabilnosti cijena odnosno za kreatore makroprudencijalne politike u Crnoj Gori, posebno Centralnu Banku Crne Gore.

Ključne riječi: *Makroekonometrijsko predviđanje; Inflacija; VAR i BVAR kombinacije prognoza; Panel ekonometrija; Funkcije impulsnog odziva;*

BIOGRAFIJA

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U cilju usavršavanja pohađao je IMF Macroeconometric forecasting studije. Takođe, dobitnik je brojnih nagrada tokom studiranja, između ostalog i Phi Theta Kappa međunarodnu skolastičku dekoraciju.

Autor je većeg broja naučnih radova iz oblasti makroekonomije. Aktivno učestvuje u mnogim međunarodnim aktivnostima kao i u izradi značajnih projekata.

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Potpisani: Martin M. Bojaj

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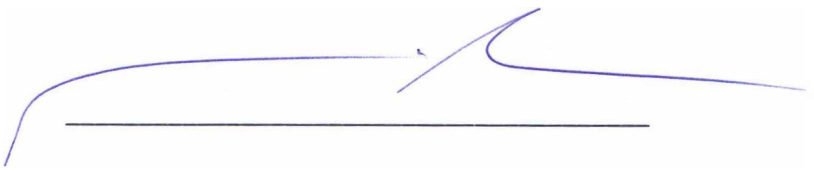

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