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The Gender Wage Gap in EU Countries and its Relation to the Educational Attainment and Type of Employment
Genderové rozdíly v odměňování v EU a jejich vazba na úroveň vzdělání a typ pracovního úvazku
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The Application of Lagrange Multipliers in Consumer Choice Theory
Využití Lagrangeových multiplikátorů v teorii spotřebitelské volby



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Editorial

Editorial

JAN MERTL

Dear readers,

also in 2022, we bring you the results of research activities submitted to the ACTA editorial office and subjected to a rigorous peer review process. In the activities of the editorial office, we emphasize the incorporation of the reviewers' comments into the final form of the article, as well as an initial assessment of the suitability of the topics treated in terms of the focus of our journal. This issue brings together authors from Nigeria, Germany, and two Czech universities of economics, and the topics are additionally topical in relation to the macroeconomic impact of the covid-19 pandemic. Thus, it can be said that we are continuing the journal's long-standing intention of contributing to the development of the socio-economic knowledge base as well as considering the significant impulses that affect the economy, financial markets, and socio-economic systems.

The first paper focuses on international trade theory and examines the relationship between trade openness, foreign direct investment and income inequality in Nigeria between 1981 and 2019. The findings show that an increase in trade openness in the short run reduces income inequality. Given that the paper focuses on the situation in a developing country, but one of the richest within Africa, this analysis is of great interest in terms of estimating the effects of international trade on the income structure of the country.

The second article looks at gender pay gaps in relation to education and type of employment and assumes that the causes of the gender pay gap are not clear-cut. The aim of the paper was to investigate whether educational attainment and type of employment can influence the value of the gender pay gap in EU countries between 2006 and 2020. Using GMM and Granger causality tests, it was possible to find that in most cases the selected variables focusing on educational attainment and type of employment did not explain any part of the gender pay gap. These results could be related to the fact that education is available to both genders with virtually no major constraints. Some workplaces may require a minimum percentage of women; the quality of parental leave policies, the day-care system and legislative protection for women on parental or maternity leave may be relevant. The results show that there may be other variables that may influence the values of the gender pay gap in the analysed regions of the European Union.

The third paper examines the effect of coronavirus pandemic on exchange rate volatility for the period February 29, 2020 to March 31, 2021 in the context of Nigeria. The findings revealed that daily reported cases of COVID-19, daily deaths and cumulative deaths have a positive effect on the volatility of the Nigerian exchange rate. Coronavirus significantly affected all macroeconomic indicators including exchange rate. The results can assist policy makers in devising strategies that can stabilize the economy and health sector to reduce the impact of the pandemic on the citizens.

The fourth paper focuses on economic theory, specifically the consumer choice theory developed by I. Fisher, F. Edgeworth, V. Pareto and J. Hicks. The three-dimensional utility function is presented as an alternative to indifference curves. In mainstream textbooks, indifference curves are used together with the budget constraint to determine the consumer's optimum, which is located at the point where the budget line is tangent to the indifference curve. In this paper, the consumer's optimum is shown directly using a section of the three-dimensional utility function subject to the budget constraint and using Lagrange multipliers.

The last, fifth research paper analyses various online price indices with the consumer price index in Germany during the Covid-19 pandemic from 2019 to 2021. It is found that online prices are more dynamic, volatile and respond directly to external market influences than brick-and-mortar store prices, which are reflected in the consumer price index of the German Federal Statistical Office. A significant deviation between the calculated online price indices and the German consumer price index was found. From a macroeconomic point of view, these are interesting cues in terms of measuring the price level during periods of significant price fluctuations.

The research articles are complemented by a report on the results of the project Improving the digital competences of university teachers.

I would like to thank the authors for submitting high quality articles, the reviewers for their careful judgments and wish the readers a pleasant reading as well as a wonderful summer.

doc. Ing. Jan Mertl, Ph.D.

Executive Editor of ACTA VŠFS

Milí čtenáři,

i v roce 2022 vám přinášíme výsledky výzkumných aktivit, zaslané do redakce ACTA a prošlé pečlivým recenzním řízením. V činnosti redakce klademe důraz na zpracování připomínek recenzentů do výsledné podoby článku a také na prvotní vyhodnocení vhodnosti zpracovávaných témat z hlediska zaměření našeho časopisu. V tomto čísle se sešli autoři z Nigérie, Německa a dvou českých ekonomických univerzit a témata jsou navíc aktuální ve vztahu k makroekonomickým dopadům pandemie COVID-19. Lze tak říci, že pokračujeme v záměru, který časopis dlouhodobě má a přispívá tak k rozvoji sociálně-ekonomické znalostní báze i zohlednění významných impulzů, které na ekonomiku, finanční trhy a sociálně-ekonomické systémy působí.

První článek se věnuje teorii mezinárodního obchodu a zkoumá souvislost mezi otevřeností obchodu, přímými zahraničními investicemi a příjmovou nerovností v Nigérii v letech 1981–2019. Zjištění ukazují, že nárůst otevřenosti mezinárodního obchodu v krátkodobém horizontu snižuje příjmovou nerovnost. Vzhledem k tomu, že se článek soustředí na situaci v rozvojové zemi, avšak jedné z nejbohatších v rámci Afriky, je tato analýza velmi zajímavá z hlediska odhadu vlivů mezinárodního obchodu na strukturu příjmů v zemi.

Druhý článek se zabývá rozdíly v odměňování žen a mužů ve vazbě na vzdělání a druh zaměstnání a vychází z toho, že příčiny rozdílů v odměňování žen a mužů nejsou jednoznačné. Cílem článku bylo prozkoumat, zda může mít úroveň dosaženého vzdělání a typ pracovního úvazku vliv na hodnotu genderového mzdového rozdílu v zemích EU v letech 2006–2020. S využitím metody GMM a Grangerova testu kauzality bylo možné zjistit, že ve většině případů vybrané proměnné zaměřené na dosažené vzdělání a typ zaměstnání nevysvětlovaly žádnou část genderového mzdového rozdílu. Tyto výsledky by mohly souviset s tím, že vzdělání je pro obě pohlaví dostupné prakticky bez větších omezení. Na některých pracovištích může být požadováno minimální procentní zastoupení ženami; význam může mít kvalita politiky rodičovské dovolené, systém denní péče a legislativní ochrana žen na rodičovské či mateřské dovolené. Výsledky ukazují, že mohou existovat jiné proměnné, které mohou ovlivnit hodnoty genderového mzdového rozdílu v analyzovaných regionech Evropské unie.

Třetí článek zkoumá vliv pandemie koronaviru na volatilitu směnných kurzů v období od 29. února 2020 do 31. března 2021 v podmínkách Nigérie. Zjištění ukázala, že denně hlášené případy COVID-19, denní případy úmrtí a kumulativní případy úmrtí mají pozitivní vliv na volatilitu nigerijského směnného kurzu. Koronavirus významně ovlivnil všechny makroekonomické ukazatele včetně směnného kurzu. Výsledky mohou pomoci tvůrcům politik při vytváření strategií, které mohou stabilizovat ekonomiku a zdravotnictví, aby se snížil dopad pandemie na občany.

Čtvrtý článek se zaměřuje na ekonomickou teorii, konkrétně teorii spotřebitelské volby vyvinutou I. Fisherem, F. Edgeworthem, V. Paretem a J. Hicksem. Trojrozměrnou užitkovou funkci prezentuje jako alternativu k indifferenčním křivkám. V učebnicích hlavního proudu jsou indifferenční křivky spolu s rozpočtovým omezením používány k určení optima spotřebitele, které se nachází v bodě, kde je rozpočtová přímka tečnou indifferenční křivky.

V tomto článku je optimum spotřebitele ukázáno přímo pomocí řezu trojrozměrné uživatelské funkce podléhající rozpočtovému omezení a pomocí Lagrangeových multiplikátorů.

Poslední, pátý článek analyzuje různé online cenové indexy s indexem spotřebitelských cen v Německu během pandemie COVID-19 v letech 2019 až 2021. Bylo zjištěno, že ceny na internetu jsou dynamičtější, volatilnější a reagují přímo na vnější tržní vlivy než ceny kamenných obchodů, které se odrážejí v indexu spotřebitelských cen německého Spolkového statistického úřadu. Byla zjištěna významná odchylka mezi vypočtenými indexy online cen a německým indexem spotřebitelských cen. Z makroekonomického hlediska se jedná o zajímavé podněty z hlediska měření cenové hladiny v období jejích významnějších fluktuací.

Odborné články doplňuje zpráva o výsledcích projektu Zvyšování digitálních kompetencí vysokoškolských učitelů.

Děkuji autorům za zaslání kvalitních článků, recenzentům za pečlivé posudky a přeji čtenářům příjemné čtení, jakož i krásné léto.

doc. Ing. Jan Mertl, Ph.D.

výkonný redaktor ACTA VŠFS

Trade Openness, FDI and Income Inequality: New Empirical Evidence from Nigeria

Otevřenost obchodu, PZI a příjmová nerovnost: Nová empirická zjištění z Nigérie

JIMOH S. OGEDE, OLUKAYODE E. MAKU, BAMIDELE O. OSHINOWO
& MOJEED M. OLOGUNDUDU

Abstract

A huge number of empirical literature has carried investigation on trade openness-income inequality nexus globally. However, there are areas of knowledge gap on the part of the impacts of FDI inflows on inequality to the Nigerian economy. As a result of this knowledge gap and growing concern for variations in methodologies and scope which makes the debate on nexus between trade openness, FDI and income inequality not beyond controversy. Hence, this study examines the nexus between trade openness, FDI and income inequality in Nigeria between 1981 and 2019 using ARDL methodology. Our findings show that trade openness exerts a negative effect on income inequality in the short-run. This implies that rising trade openness leads to decline in inequality. Equally, the study finds that FDI is negatively related to income inequality. The findings are in tandem the theoretical prediction of Stolper-Samuelson's theorem in case of Asia that trade openness and FDI inflow impact income inequality. The findings on government expenditure also exerts a positive effect on inequality. Given that proxies for institutional and macroeconomic determinants demonstrate a diverse variety of indications and effects, this study suggests a policy stimulus aimed at enhancing economic and social structures while also stimulating FDI influx potential in order to raise household incomes.

Keywords

trade openness, income inequality, ARDL, Nigeria

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Abstrakt

V empirické literatuře se objevuje množství studií o vztahu mezi otevřeností obchodu a nerovností příjmů v celosvětovém měřítku. V oblasti dopadů přílivu přímých zahraničních investic na nerovnost v nigerijské ekonomice však existují mezery ve znalostech. V důsledku těchto chybějících znalostí a rostoucích obav z rozdílů v metodikách a rozsahu není debata o souvislostech mezi otevřeností obchodu, přímými zahraničními investicemi a příjmovou nerovností uzavřena. Tato studie proto zkoumá souvislost mezi otevřeností obchodu, PZI a příjmovou nerovností v Nigérii v letech 1981–2019 s využitím metodiky ARDL. Naše zjištění ukazují, že otevřenost obchodu má v krátkodobém horizontu na příjmovou nerovnost nega-

tivní vliv. To znamená, že rostoucí otevřenost obchodu vede k poklesu nerovnosti. Studie také zjistila, že PZI negativně souvisí s příjmovou nerovností. Tato zjištění jsou v souladu s teoretickou předpovědí Stolper-Samuelsonova teorému na příkladu Asie, že otevřenost obchodu a příliv PZI ovlivňují příjmovou nerovnost. Pozitivní vliv na nerovnost mají také zjištění týkající se vládních výdajů. Vzhledem k tomu, že zástupné ukazatele institucionálních a makroekonomických determinant vykazují různorodé náznaky a účinky, navrhuje tato studie politické podněty zaměřené na posílení ekonomických a sociálních struktur a zároveň na stimulaci potenciálu přílivu PZI s cílem zvýšit příjmy domácností.

Klíčová slova

otevřenost obchodu, nerovnost příjmů, ARDL, Nigérie

1 Introduction

Africa is gifted with pool of wealth and economic viability, but it has struggled to offer opportunities and a means of subsistence for all of its inhabitants, and poverty remains a severe issue majority of her population (Ogede, 2020). For decades, Sub-Saharan Africa (SSA) has seen a significant increase in economic imbalance and extreme poverty (DESA, 2019). Ten of the world's most unequal countries were indeed recorded in Africa. Income inequality has grown in tandem with a slew of inequity societal standards and a skewed allocation of service supplies (UNDP, 2017). Surprisingly, this viewpoint closely portrays Nigeria's current situation of inequality. Between 1986 and 2010, Nigeria's income distribution statistics revealed that the top 20% of earners earned half of the country's income, peaking at 52.1% in 1998, while the bottom 20% received only 5.0% of total earnings and the following 20% received around 10%. In 2018, the wealthiest 20% of Nigeria's population held 42.4% of the country's income (World Development Indicator, 2020).

Furthermore, numerous hypotheses have been advanced to explain widening income disparity (see Bigsten, 2016; Odedokun & Round, 2004; Anyanwu, 2016). One of these hypotheses outline how rising market integration in sectors such as openness to trade and foreign direct investment (FDI) have impacted income inequality around the globe, which have been at the center of social science debates. However, a significant portion of the empirical literature on the relationship between trade openness and income inequality has emerged (see Feenstra and Hanson, 1996; Meschi & Vivarelli, 2009; Jaumotte, Lall & Papageorgiou, 2013; Rahim, Abidin, Ping, Alias & Muhamad, 2014; Roser and Cuaresma, 2016; Barusman & Barusman, 2017; Roy & Roy, 2017; Maku, Adesoye, Babasanya & Adelowokan, 2018; Ogwumike, Maku & Alimi, 2018; Heimberger, 2019; Roser & Cuaresma, 2016; Dorn, Fuest & Potrafke, 2021). In recent times, studies have provided evidence that FDI and trade openness contribute to exacerbating income inequality; while another stance argues that FDI and trade openness contribute to reducing income inequality due to country's abundant resources (Barusman and Barusman, 2017; Malikane & Chitambara, 2017; Khan and Nawaz, 2019; Topuz & Dağdemir, 2020; Aigheyisi, 2020; Xu, Han, Dossou & Bekun, 2021). The above debates reveal that the relation between openness to trade, FDI and income inequality, are not beyond controversy owing to its sensitive to methodology and high-quality data.

The relationship between trade openness and income inequality is theoretically centered on the Stolper-Samuelson principle, which claims that global integration increases income inequality within industrialized countries while reduces inequality within developing countries. Several theoretical contributions, on the other hand, have exposed the inadequacies in the Stolper-Samuelson assumptions and given a number of alternative channels and repercussions for how globalization effects income disparities (see Robertson 2004; Goldberg & Pavcnik 2007; Meschi & Vivarelli 2009; Roser & Crespo Cuaresma, 2016). Anecdotal evidence suggests that countries that participate in global trade expand faster and have higher living standards. Aside from that, it is frequently assumed that the benefits of increased growth are shared by the poor. It's been quite difficult to ascertain how the poor have benefited, especially when considering aggregate data. One cause for concern is that when trade expands, many other elements, such as technology and macroeconomic factors, shift. To the best of our understanding, the erstwhile studies on the subject in Nigeria and Africa at large is sparse and the few provide mixed outcomes which cannot be generalized as a true reflection of each country in the region (see Aigheyisi, 2020; Xu et al, 2021).

As a result, the current study seeks to investigate the impact of trade openness and foreign direct investment on income disparities in Nigeria from 1981 to 2019. The study makes four important contributions. First, empirical study into the relationship between trade openness, FDI, and inequality has been largely ignored in Nigeria. This study explores the relationship between trade openness, FDI, and inequality in Nigeria using the autoregressive distributed lag (ARDL) approach. In addition, to account for omitted variables, the current study considers institutional variables such as schooling. It is worth emphasizing that respected and robust institutions will help to close the country's inequality gap. Three, our findings add to the current body of knowledge on the relationship between income inequality and foreign direct investment in a net oil exporting nation like Nigeria. Finally, our findings will contribute to current research in this field and will be useful to policymakers in Nigeria and other developing countries in Africa as a region in terms of trade returns and macroeconomic concerns. Our findings reveal that trade openness exerts a negative effect on income inequality in the short-run, suggesting that rising trade openness leads to decline in inequality. Equally, the study finds that FDI is negatively related to income inequality. The findings are in tandem the theoretical prediction of Stolper-Samuelson's theorem in case of Asia that trade openness and FDI inflow impact income inequality. Section two presents a related literature on the subject. Section three and four discusses methodology, and results respectively. Section 5 concludes the study.

2 Review of related empirical literature

Economic growth has often been given priority as an anti-poverty measure while the negative links between growth and inequality have been largely ignored by policy makers. However, the word globalization has been used interchangeably as trade openness in the literature while the research linking trade openness to inequality has been intense over two decades. According to Lindert and Williamson (2001) and O'Rourke (2001), global inequality has increased due to differences between countries rather than within countries. As a result, the effects of globalization on intra-country inequality will be highly variable. The direction of the impact on intra-country inequality is decided by the participating country's strategy

for exploiting it. Poor governance and non-democracy may be the root causes of intra-country inequality in laggard countries, rather than globalization. Lindert and Williamson (2001) classified the impact of globalization on inequality into five conclusions. According to Talbot (2002), a new variety of global unfairness has imposed itself over the previous condition, explaining growing global inequality. Talbot (2002) uses the example of coffee production and transnational business capital control. One of the most notable consequences of nineteenth-century globalization, according to Bata and Bergesen (2002), was an increase in global inequality. They go on to state that studying the reasons of rising inequality, as well as comprehending how the global system works and the consequences of globalization in the twentieth century, is vital.

From 1980 to 2012, Maku et al (2018) compare the effects of globalisation on human welfare in 16 SSA nations that are both substantially and weakly globalised. The comparison analysis found a mixed result in some situations and a unidirectional result in others when using panel fixed effects. In general, countries with higher levels of globalisation have improved their human welfare metrics more than those with lower levels of globalization. Heimberger (2019) examines the nexus between openness and inequality for data set consisting of 1254 observations and adopt meta-analysis and meta-regression methodology. The findings show that openness to trade has a small-to-moderate positive impact on income inequality. Dorn, Fuest, and Potrafke (2021) examine the impact of trade openness on income inequality in 139 countries during 1970 and 2014. According to the study's conclusions, the consequence varies per country. Trade openness benefits some very poor significantly in emerging and developing economies, but not all of the poor. Furthermore, the findings demonstrate that trade openness exacerbated income disparities in the majority of developed economies, with outliers driving the effect. Trade openness has a major impact on inequality in China and other developing nations, according to the research.

In recent times, studies have provided mixed evidence on FDI and trade openness nexus. The first group argue that FDI and trade openness contribute to worsening of income inequality; while another stance argues that FDI and trade openness contribute to reducing income inequality (Brueckner & Vespignani, 2017; Malikane & Chitambara, 2017; Khan & Nawaz, 2019; Topuz & Dağdemir, 2020; Aigheyisi, 2020; Xu, et al 2021). For instance, the findings of Barusman and Barusman (2017) on debate focussing on the United States from 1970 and 2014 reveal that trade openness increases income inequality. Such that an increase in trade volume leads to a wider income gap as more income goes to the top 10% wealthiest people in the United States. The findings also confirm that there is a negligible effect of FDI inflow on income inequality in the United States. Khan and Nawaz (2019) carried out another investigation on Commonwealth of Independent States (CIS) from 1990 to 2016 using system-generalized method of moments (SYS-GMM) methodology. The findings reveal trade openness and FDI have significant impacts on income inequality when interacted with inequality, proxy with Gini-index. The findings further provide divergent outcomes when trade to openness and FDI were interacted with education, suggesting a crucial link at which inequality is impacted. Recently, Aigheyisi (2020) investigates the impact of foreign direct investment (FDI) and its interaction with trade openness on income inequality in Nigeria from 1981 to 2015 using dynamics ordinary least square method (DOLS). The findings reveal that FDI inflows positively affect income inequality. However, the interaction between FDI and trade openness negati-

vely affects income inequality suggesting that greater openness of the economy to international trade would engender reduction of income inequality caused by FDI in the country. Xu et al (2021) explore the relationship between trade openness, foreign direct investment (FDI), and income inequality in Sub-Saharan Africa (SSA) spanning from 2000 to 2015. They use the generalized method of moment (GMM) technique. The data reveal that FDI and income have a statistically significant negative connection with income inequality, meaning that as FDI and per capita income rise, so does income inequality.

3 Data and Methodology

3.1 Data and variable description

The study employed the annual time series data of Nigeria from 1981 to 2019. The variables used including their measurement, definition and source are presented in Table 1 while justification for selecting the country and time frame has stated in the previous discussion. The data were sourced from different agencies and databases like Standardized world inequality database, CBN Statistical Bulletin, and World Development Indicator (WDI). The crucial variables of interest in this paper are income inequality, FDI, and trade openness. Income inequality is gauged by the Gini coefficient index, which is a scale from 0 to 100. However, the definitions and methodologies for estimating the Gini index are similar among these references (Lecuna, 2019; Mocan, 1999; Ogede, 2020). The study also explores foreign direct investment to gauge the impact of financial integration. Approaches for estimating trade openness, in general, differ in several studies significantly. However, this study defines it as a trade balance stated as a proportion of the GDP in equation (1), following the work of Ogede (2004), Ogwumike et al. (2018), and Maku, et al (2018).

$$OP = \frac{\{X+M\}}{GDP} \quad (1)$$

Where X and M represent import and export respectively. Also, the study uses government expenditure (GEXP) as a percentage of government expenditure to GDP while financial capital to the private sector (FCPS) is explored to gauge the impact of financial development. The study employed secondary school enrolment as an alternative to inequalities in human resources as a ratio of the gross national product. Meanwhile, literature provides conflict outcomes with regards to the impact of human capital on inequality (see Acemoglu, 2002; Lemieux, 2006).

Table 1: Variable measurement, definition, and sources

Variable (s)	Measurement	Source
Income Inequality (INQ)	Index	Standardized world inequality
Trade openness (OP)	(Import + Export)/GDP	CBN Statistical Bulletin
Government Expenditure (GEXP)	% GDP	CBN Statistical Bulletin
Financial capital to the private sector (FCPS)	% of GDP	WDI
Foreign Direct Investment (FDI)	% of GDP	WDI
Real Gross Domestic Product (GDP)	GDP at constant 2010 prices in billions	CBN Statistical Bulletin
Secondary school enrollment Education (EDU)	% of gross enrolment	WDI

3.2 Model specification

The model developed by Jeffery (2007) is adapted to forecast the relationship between trade openness, foreign direct investment, and income inequality in Nigeria. Our method, on the other hand, varies in several ways from this one. For example, the previous study focused on Commonwealth countries; in our case, we centered on Nigeria. Second, the prior study used school enrollment and inflation as a control variable; as a result, we used government spending and financial credit to the private sector as a proportion of GDP, both of which are important determinants in determining income disparity. The model specifies income inequality as a function of trade openness, foreign direct investment and economic growth. Thus, the equation is stated functionally as:

$$INQ = f(OP, FDI, Gr) \quad (2)$$

Where: GINI is Gini coefficient; OP and FDI are vector of trade openness and foreign direct investment respectively, and Gr is gross domestic product. In mathematical form, it becomes:

$$INQ_t = \alpha_0 + \beta'OP_t + \beta_1Gr_t + \mu_t \quad (3)$$

The variables remain as defined; β' is vector of the parameters of trade openness; α_0, β are parameters; t is time; μ is error term. Trade openness and foreign direct investment have both direct and conditioned effects on income disparities. Taking previous data into consideration, we might conclude that FDI will always raise income disparity, whereas trade openness will redistribute income in certain circumstances, such as access to education, increased government spending, and access to capital. We use the regression mode to incorporate the interaction terms of trade openness variables and the degree of education or growth in order to assess the impact of trade openness on income inequality (3), to becomes:

$$INQ_t = \alpha_0 + \beta'OP_t + \beta_1Gr_t + \beta_2GEXP_t + \beta_3FCPS_t + \beta_4EDU_t + \beta_5FDI_t + \mu_t \quad (4)$$

Where: GINI is Gini coefficient measuring income inequality; OP is a vector of trade openness indices measured by trade openness; Gr is gross domestic product proxy of economic growth; GEXP is government expenditure to GDP; FCPS is financial credit to private sector to GDP; EDU is secondary school enrolment ratio; FDI is the financial integration; α_0, β_{1-5a} are parameters; t is time; μ is error term. Consequently, the study used the ARDL estimation technique to achieve the objective of this study. This technique is preferred because it computed both the short and long-run estimates of the model. This methodology was developed by Pesaran and Shin (1999) and Pesaran et al (2001). The model is specified as:

$$\begin{aligned} \Delta INQ_t = & \alpha_0 + \sum_{i=1}^p \beta_i \Delta INQ_{t-i} + \sum_{j=0}^q \beta_{0i} \Delta OP_{t-j} + \sum_{j=0}^q \beta_{1i} \Delta Gr_{t-j} + \sum_{j=0}^q \beta_{2i} \Delta GEXP_{t-j} + \\ & \sum_{j=0}^q \beta_{3i} \Delta FCPS_{t-j} + \sum_{j=0}^q \beta_{4i} \Delta EDU_{t-j} + \sum_{j=0}^q \beta_{5i} FDI_{t-j} + \delta_1 INQ_{t-1} + \delta_2 OP_{t-1} + \\ & \delta_3 Gr_{t-1} + \delta_4 GEXP_{t-1} + \delta_5 FCPS_{t-1} + \delta_6 EDU_{t-1} + \delta_7 FDI_{t-1} + \mu_t \end{aligned} \quad (5)$$

All variables remain as earlier described while $\delta_1 - \delta_7$ are parameters for the long-run relationship between INQ and the explanatory variables. $\beta_{0i} - \beta_{5i}$ are parameters for the short-run relationship between INQ and the explanatory variables.

4 Results and Discussion

4.1 Preliminary results

This section addresses the empirical evidence on the relationship between income inequality, FDI, and trade openness. The descriptive statistics and statistical properties of the series under investigation are presented in Table 2. The table demonstrates that the mean of INQ is not distant from its maximum and minimum values. This demonstrates that the series has most likely not suffered as a result of the variability during the time period under consideration. Given that the probability of its Jarque-Bera (J-B) test is less than 0.05, the series is not distributed normally. Given that it is larger than 3, the series is negatively skewed despite possessing a leptokurtic kurtosis.

Table 2: Descriptive Statistics

	INQ	FDI	FCPS	OP	EDU	GEXP	GDP
Mean	37.903	1.553	9.210	16.951	22.261	3.726	34690.67
Median	43.500	1.159	8.169	11.247	25.178	2.091	23688.28
Maximum	44.000	5.791	19.626	56.534	56.205	9.448	71387.83
Minimum	0.000	0.257	4.958	0.098	0.000	0.911	13779.26
Std. Dev.	14.728	1.234	3.556	16.678	17.826	2.838	20237.78
Skewness	-2.223	1.738	1.195	0.609	-0.071	0.795	0.674
Kurtosis	5.942	6.070	3.999	2.115	1.725	2.166	1.882
Jarque-Bera	46.169	34.9578	10.902	3.679	2.674	5.241	4.986
Probability	0.000	0.000	0.004	0.158	0.263	0.073	0.083

Interestingly, on FDI, the highest value is greater than the mean value, indicating that the series may fluctuate. The series is leptokurtic and favourably skewed. According to the Jarque-Bera test, the series is not regularly distributed. FCPS is demonstrated to have a maximum value of around 20% of GDP, with a mean value of 9.2 percent. While not normally distributed, the series is favourably skewed with a leptokurtic kurtosis. The OP series is demonstrated to have a maximum value that is significantly greater than the minimum value. The series features a positively skewed and normally distributed platykurtic kurtosis. EDU is reported to have a mean more than twice lower than its maximum value suggesting that secondary enrolment in Nigeria has suffered several episodes of fluctuations. The series is negatively skewed with a platykurtic kurtosis and is normally distributed. GEXP and GDP both have maximum values that are larger than the mean values. These series are positively skewed, normally distributed, and possess platykurtic kurtosis. The correlation matrix is reported in table 3 and explains the level and extent of the direction of the relationship among the variables.

Table 3: Correlation Matrix

	GINI	EDU	FCPS	FDI	GEXP	GLOB	Gr
INQ	1	0.076	0.215	0.370	0.121	0.119	0.257
EDU		1	0.459	-0.042	0.619	0.374	0.405
FCPS			1	0.114	0.839	0.726	0.783
FDI				1	0.084	-0.039	0.012
GEXP					1	0.835	0.807
OP						1	0.952
Gr							1

Table 4 shows the results of the stationary test utilizing the augmented Dickey-Fuller (ADF) tests. The results of the variables' stationarity tests are presented at both levels and first difference. After validating the stationarity of our variables, we use the ARDL bound test to see if there is a long-run link between them, as well as estimate both the short-run and long-run estimates of our parameters.

Table 4: Augmented Dickey-Fuller (ADF) unit root test

Variable(s)	Level			First Difference			Stationary Status
	None	Constant	Constant and trend	None	Constant	Constant and trend	
INQ	-0.733	-2.380	-1.379	-4.243***	-4.127***	-4.867***	I(1)
EDU	-1.511	-2.265	-2.169	-7.628***	-7.538***	-7.506***	I(1)
FCPS	0.471	-2.255	-4.097**	-5.691***	-5.732***	-5.638***	I(1)
FDI	-2.130**	-3.933***	-3.851***	-8.133***	-8.019***	-7.973***	I(0)
GEXP	-0.176	-1.113	-2.855	-5.728***	-5.697***	-5.617***	I(1)
OP	2.050	0.764	-2.541	-3.952***	-4.355**	-4.549**	I(1)
Gr	2.526	-0.097	-2.403	-2.158**	-3.434**	-3.352*	I(1)

4.2 Empirical Results

Table 5 shows the results of the ARDL bound tests for demonstrating the long-run relationship among the variables using the Akaike Information Criterion (AIC) to automatically determine the lag duration. The crucial boundaries were chosen using Pesaran et al. (2001) values for the restricted intercept and no trend. F-statistics at k = 6 were used to test the hypothesis against the critical bound values at various significance levels. The F-statistic

values are higher than the critical values at the upper bound levels, according to the findings of the ARDL bound test shown in Table 5. As a result, we reject the null hypothesis that no cointegration exists for the four models at the 1%, 5%, and 10% levels. As a result, no long-term relationship exists between 1981 and 2019. Based on the evidence of no long-run relationship between the estimated variables, we estimated short-run parameters, which are shown in Table 5.

Table 5: ARDL bounds test result for Cointegration

Dependent variable	Functions				F-statistics	
Income Inequality (INQ)					2.756031	
	10%		5%		1%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Critical bound values	2.12	3.23	2.45	3.61	3.15	4.43

Table 6 presents the empirical results of relationship between trade openness, FDI and income inequality in Nigeria. The short-run result shows that trade openness exerts a negative effect on income inequality. This implies that rising trade openness leads to decline in inequality. This is in line with the a priori expectation. All else equal, a percentage increase in trade openness will result in about 0.86 per cent of income inequality. This negative effect of trade openness on inequality is however not statistically significant at 5%. The findings oppose the theoretical prediction of Heimberger (2019). Our findings show that FDI is negatively related to income inequality. All else held constant, the more financially integrated is Nigeria with the rest of the world, the lower the inequality. The output shows that inequality drops by 0.55 for every 1 percent rise in financial integration. This relationship is however not statistically significant. The finding is tandem with the finding of Xu et al (2021) on selected Sub-Saharan Africa (SSA) countries, and in contrary to the empirical examination by Aigheyisi (2020) who argued that FDI inflows positively affect income inequality.

The control variables have varied effects on income inequality. Economic growth, proxy with gross domestic product is observed to exert a positive effect on inequality. This implies that higher economic growth leads to higher inequality. More specifically, a 1 percent rise in gross domestic product will induce a rise in inequality by about 1.16 per cent, all else remaining constant. This relationship is also statistically significant at the 0.05 level of significance for this study. Government expenditure also exerts a positive effect on inequality. That is, the higher the spending by the government, the more the inequality. More precisely, a 1 percent rise in government expenditure will result in growth in inequality by about 1.2. This positive effect is not statistically significant at the 0.05 level of significance. On the other hand, credit to the private sector is negatively related to inequality. In essence, more credit to the private sector led to lower inequality. More specifically, a 1 percent rise in credit to the private sector leads to a decline in inequality by about 1.01. This effect is however not statistically significant given that the t-statistics of the coefficient of credit to the private sector is greater than the 0.05 threshold for this study. Finally, education

and inequality are shown to be negatively related. That is, the higher the educational attainment, the lower the inequality. According to the result, a 1 percent rise in education will lead to a fall in inequality by about 0.035. This effect is also not statistically significant at the 0.05 level given that the t-statistics of the coefficient for education is greater than the 0.05 level that was set for this study.

The adjusted R2 of the model indicates that the model has a satisfactory fit, as the explanatory variables account approximately 47 percent of variance in inequality. Additionally, the probability value of F-statistics for the joint significance of the influence of the predictor factors on inequality demonstrate that their effects are jointly significant when the probability value of the F-statistics is less than the 0.05 threshold for this study. Furthermore, the F-statistics is greater than the 0.05 allowed for this investigation, according to the Breusch-Pagan-Godfrey Heteroskedasticity Test. As a result, the study conclude that the residual term of the model does not suffer from heteroscedasticity, and the result also affirms using the normality and Breusch-Godfrey Serial Correlation LM Tests.

Table 6: Trade openness, FDI and income inequality nexus in Nigeria

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GINI(-1))	0.0108	0.23911	0.04508	0.9645
D(GLOB)	-0.8633	0.48717	-1.77202	0.0902
D(LRGDP)	116.03	52.3353	2.21702	0.0373**
D(GEXP)	1.1705	1.78279	0.65657	0.5183
D(FCPS)	-1.0106	1.06563	-0.94838	0.3532
D(EDU)	-0.0353	0.15403	-0.22908	0.8209
D(FDI)	-0.5476	1.63318	-0.33529	0.7406
ECT(-1)	-0.3779	0.18035	-2.09517	0.0479**
Adj. R2	0.47			
F-stat	3.2887***			
Models' diagnostic and stability test				
Normality test		6.0606		{0.0483}
Serial correlation		0.54456		{0.5885}
Heteroscedasticity test		2.2639		{0.0857}

***, ** and * represent statistical significance level at 1%, 5% and 10%, respectively.

The values in parenthesis "{}" reveal the non-acceptance of the null hypothesis at a 5% level.

5 Conclusion and Recommendations

A huge number of empirical literature has carried investigation on trade openness-income inequality nexus globally. However, there are areas of knowledge gap on the part of the impacts of FDI inflows on inequality to the Nigerian economy. As a result of this knowledge gap and growing concern for variations in methodologies and scope which makes the debate on nexus between trade openness, FDI and income inequality not beyond controversy. Consequently, this study set out to empirically examine the nexus between trade openness, FDI and income inequality in Nigeria between 1981 and 2019 using ARDL methodology. Our findings show that trade openness exerts a negative effect on income inequality in the short-run. This implies that rising trade openness leads to decline in inequality. This is in line with the a priori expectation. Equally, the study finds that FDI is negatively related to income inequality. Economic growth exerts a positive effect on inequality, implying that higher economic growth leads to higher inequality. The findings are in tandem the theoretical prediction of Stolper-Samuelson's theorem in case of Asia that trade openness and FDI inflow impact income inequality. The findings on government expenditure also exerts a positive effect on inequality. That is, the higher the spending by the government, the more the inequality. On the other hand, credit to the private sector is negatively related to inequality. In essence, more credit to the private sector led to lower inequality. Finally, education and inequality are shown to be negatively related. That is, the higher the educational attainment, the lower the inequality.

Given that proxies for institutional and macroeconomic determinants demonstrate a diverse variety of indications and effects, this study suggests a policy stimulus aimed at enhancing economic and social structures while also stimulating FDI influx potential in order to raise household incomes. Furthermore, there should be a strong desire to invest in social infrastructure, accelerate the process of openness, and divert trade flows to industries that deliver structural transformation.

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The Gender Wage Gap in EU Countries and its Relation to the Educational Attainment and Type of Employment

Genderové rozdíly v odměňování v EU a jejich vazba na úroveň vzdělání a typ pracovního úvazku

MARIE LIGOCKÁ

Abstract

The issue of wage inequality between men and women is widely discussed today. Different developments in individual EU countries characterize different wage values between men and women. As the empirical literature shows, the causes of the gender pay gap are not clear. The paper aimed to examine whether the level of education attained and the type of working hours can affect the value of the gender pay gap in EU countries from 2006 to 2020. Using the GMM method and Granger's causality test, it was possible to find that the selected variables focused on educational attainment and type of employment did not explain any part of the gender pay gap in most cases. These results could be related to the fact that education is available for both sexes practically without significant restrictions. In some workplaces, a minimum percentage of women may be required. The quality of parental leave policy, the daycare system, and the legislative protection of women on parental or maternity leave, which have affected the labor market situation, may be important. These findings indicate that there may be other variables that may affect the values of the gender pay gap in the analyzed regions of the European Union. Granger causality in the opposite direction is attributed to significant labor flows.

Keywords

educational attainment, EU countries, full-time work, gender wage gap, part-time work, GMM method, Granger causality

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G00, G10, E20

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Abstrakt

Problematika mzdové nerovnosti mužů i žen je v dnešní době velmi diskutovaná. V jednotlivých zemích EU je typický odlišný vývoj hodnoty mzdového rozdílu mezi muži a ženami. Jak ukazuje empirická literatura, příčiny rozdílů v odměňování žen a mužů nejsou jednoznačné. Cílem příspěvku bylo prozkoumat, zda může mít úroveň dosaženého vzdělání a typ pracovního úvazku vliv na hodnotu genderového mzdového rozdílu v zemích EU

v letech 2006–2020. S využitím metody GMM a Grangerova testu kauzality bylo možné zjistit, že ve většině případů vybrané proměnné zaměřené na dosažené vzdělání a typ zaměstnání nevysvětlovaly žádnou část genderového mzdového rozdílu. Tyto výsledky by mohly souviset s tím, že vzdělání je pro obě pohlaví dostupné prakticky bez větších omezení. Na některých pracovištích může být požadováno minimální procentní zastoupení ženami; význam může mít kvalita politiky rodičovské dovolené, systém denní péče a legislativní ochrana žen na rodičovské či mateřské dovolené, která ovlivnila situaci na trhu práce. Tato zjištění ukazují, že mohou existovat jiné proměnné, které mohou ovlivnit hodnoty genderového mzdového rozdílu v analyzovaných regionech Evropské unie. Existující Grangerova kauzalita v opačném směru je přisuzována významným tokům pracovní síly.

Klíčová slova

úroveň dosaženého vzdělání, země EU, práce na plný úvazek, genderové rozdíly v odměňování, práce na částečný úvazek, metoda GMM, Grangerova kauzalita

Introduction

According to the European Commission (2019), women in the EU are less present in the labor market than men; the gender employment gap stood at 11.7% in 2019. Women also earned on average 14.1% less per hour than men in 2018, which means that women earn less per hour than men. In the European Union countries, the development of the gender wage gap is detected. According to European Parliament (2022), *“the gender pay gap is the difference in average gross hourly earnings between women and men. It is based on salaries paid directly to employees before income tax and social security contributions are deducted.”*

A prevailed decrease in gender wage gap size in 2020 compared to 2006 (as a figure in Appendix 1 shows). The falling of the value gender wage gap is determined in all countries under examination except Bulgaria, Hungary, France, and Latvia, which detected an increasing value of the gender wage gap in 2020 compared with 2006. However, the highest absolute values of the gender wage gap were in Netherland, Austria, Slovakia, and Estonia in 2006. The highest gender wage gap values are evident in Germany, Austria, Latvia, and Estonia in 2020. There are obvious changes in the development of men's and women's remuneration in the monitored countries in the monitored period.

On the other hand, the lowest values of the gender wage gap were monitored in Poland, Romania, Slovenia, and Belgium in 2006; in 2020, it was in Slovenia, Poland, Luxembourg, and Romania. The most significant relative decrease in the value of the gender wage gap is evident in Luxembourg (93%), Romania (69%), Slovenia (61%), and Ireland (52%) in comparison with 2006 and 2020. In contrast, a relative increase in the value of the gender wage gap is evident in Bulgaria (2%), France (3%), Hungary (19%), and Latvia (48%) in comparison with 2006 and 2020. Despite different gender wage gap development, this paper tries to detect if selected factors could explain some gender wage gaps.

However, many different factors are discussed in relation to the gender wage gap. Socio-economic variables (changes in education, potential experience, industry, tenure, etc.) are

considered essential sources of wage inequality by Al-farhan (2010). Possible experience and personal characteristics could explain part of the gender wage gap. Workers with good characteristics who are paid more tend to work in workplaces that pay more, as Mumford and Smith (2004) argued. The importance of workplace characteristics, experience, skills, and its related investment to human capital in explaining the gender wage gap is also shown by Fitzenberger and Wunderlich (2000), Pointner and Stiglbauer (2010), Antonczyk et al. (2010), and Redmond and McGuinness (2017). Then education can be another factor that influences wage differentials (Lauer 2000; Livanos and Pouliakas, 2012; Machin and Puhani, 2003). Moreover, there could be lower-wage gaps for highly-educated women than for low-educated women (Addabbo and Favaro 2011). Low-educated women could suffer from monopolistic wage discrimination due to their preferences and lower degree of mobility (Mussida and Picchio 2013). The low degree of mobility could be related to gender preferences. The role of women in family development is often emphasized; it is also connected with the adverse effects of career interruptions and household responsibilities (Böheim et al., 2013; Livanos and Pouliakas, 2012; Myck and Paull, 2004). This factor potentially has an ambiguous effect as more successful women can afford a career break, but the cost of being out of the labor market is higher (Chevalier, 2007).

An important factor could play parental leave policy and the daycare system (Albrecht et al., 2001; Kanellopoulos and Mavromaras, 2002), labor market characteristics (Albrecht et al., 2004), and different training costs due to the expectation of future career interruptions in women (de la Rica et al., 2005; de la Rica et al., 2008). Women tend to be more represented in part-time work, which is poorly remunerated and is connected with less training and investment in human capital (Blackaby et al., 2005; Harkness, 1996; Matteazzi et al., 2017). The progress in instituting a legal and institutional framework can be less critical (Jolliffe and Campos, 2005; Yaish and Kraus, 2003). The central part of the gap remains unexplained as Böheim, et al. (2020), García-Aracil (2007), Addabbo and Favaro (2011), and Böheim et al. (2007) claimed; that the difference could be caused by attitude, commitment, unfair discrimination against women, and other factors.

The reasons behind the gender pay gap are not simple and clear. In relation to the findings of the empirical literature, the paper is focused on examining the effect of the educational attainment and type of employment on the value of the gender wage gap in EU countries from 2006 to 2020. The contribution is divided into the following sections. The first section is the Introduction, then the Review of the literature follows. The other section is Data and methodology; further, the sections Results and Discussion are presented, and the final section is the Conclusion.

1 Review of the Literature

According to the OECD (2020), compared to men, women are less likely to work full-time, more likely to be employed in lower-paid occupations, and less likely to progress in their careers. Then, the level of education is associated with the level of wages. Theoretically, workers with higher educational attainment should be paid more than those with lower levels of education; generally, there is evidence of differences in wages for men and women with the same level of education (Livanos and Nunez 2010). This paper is focused

on analyzing whether these facts could affect the value of the gender wage gap in EU countries. Following this, the literature presented in this section focuses exclusively on the relationship between the gender wage gap and the educational attainment and type of employment in European countries.

The size of the gender wage gap is changing over time; the development in the gender wage gap changes is different in individual countries. A decreasing value of wage inequality is, according to Böheim et al. (2020), caused by the relative improvement of women's observed and unobserved characteristics. The decreasing tendency of the gender pay gap is also evident in the study of Myck and Paull (2004), Böheim et al. (2013), and Böheim et al. (2007). In contrast with Böheim et al. (2020), Böheim et al. (2013) found that the raw gender wage gap is still mainly due to the labor market experience, occupation, industrial segregation, and labor market attachment.

Many studies show that educational attainment can explain a specific part of the gender wage gap; for example, Mussida and Picchio (2013) showed that low educated women have lower incomes than men. Mussida and Picchio (2013) also found evidence of sticky floors for ordinary educated women and unchanged evidence of a glass ceiling for highly educated women. The persistence of the glass ceiling effect found evidence also Albrecht et al. (2001). The results suggest that the gender wage gap cannot be explained by the gender differences in age, education, sector, industry, and industry. Similar findings as Mussida and Picchio (2013) detected by de la Rica et al. (2008) and Addabbo and Favaro (2011), and it that the gender wage gap depends on workers' education attainment. After that de la Rica et al. (2005) showed that there is a different size of gender wage gap depending on educational attainments. Then, Lauer (2000) showed that female human capital is less valued in terms of wages; educational attainment explains a large part of the gender wage gap. The same to Lauer (2000) also, Livanos, and Pouliakas (2012) determined that gender differences in the type of degree studied could be the factor that affects the gender pay gap.

Moreover, Livanos and Nunez (2010) show that educational attainment is different across analyzed countries. Finally, in consistence with de la Rica et al. (2008) and Addabbo and Favaro (2011) is García-Aracil (2007). They detected that education (foreign language proficiency and computer skills) is significant in explaining the value of the gender wage gap. However, the most important seems to be job characteristics.

The importance of explaining the value of the gender wage gap could also play the type of employment. In the empirical literature, Chevalier (2007) presents that the gender gap is also influenced by career break expectations and argues that women with a more traditional view concerning childrearing have less intensive search behavior. The gender wage gap is by type of employment explained by Albrecht et al. (2004). Albrecht et al. (2004) present a positive selection of women in full-time work; this selection is due to the education and experience of about two-thirds, and the remainder is unobservable. The importance of the type of employment suggests Blackaby et al. (2005). They determine that women are disproportionately represented in temporary appointments and that these posts are poorly remunerated compared to permanent positions. Harkness (1996)

shows that part-time work belongs to factors that can influence the gender wage gap; this suggests that part-time women are low-paid because they are low-skilled and face less discrimination than full-time working women. Different impact of full-time and part-time working females is detected by Fitzenberger and Wunderlich (2000). Fitzenberger and Wunderlich (2000) also argued that the gender pay gap could be caused by different work careers, skills, and investments in human capital. Matteazzi et al. (2017) demonstrated that the gender wage gap tends to be higher in countries where part-time employment is more widespread at the macro level. The results also suggest that the full-time gender pay gap remains unexplained primarily.

Some findings also show that employment and educational attainment could not explain the value of the gender wage gap. Rosholm and Smith (1996) determined that the gender pay gap is not affected by an adverse selection effect. Then, the examination of García et al. (2001) did not confirm the importance of educational attainment in the value of the gender wage gap explanation. The findings of Redmond and McGuinness (2017) demonstrated that the gender wage gap is unexplained in some countries, predominantly in Eastern Europe. Similarly, Redmond and McGuinness (2017), Grandner and Gstach (2012), and Kanellopoulos and Mavromaras (2002) think that wage inequality is exclusively a matter of discrimination. Other significant findings are evident in Antonczyk et al. (2010) study, which shows that wage policy-related effects contribute to an increase in the gender wage gap. García et al. (2001) detected that the gender gap is related to job characteristics rather than worker characteristics such as education. Complex information provides the results of Machin and Puhani (2003). Machin and Puhani (2003) demonstrated differences between wages of men and women in consideration of age, industry, region, part-time, and public sector employment. It also seems to be the workplace where the employee works, consistent with Mumford and Smith (2004). Moreover, Al-farhan (2010) shows that wage inequality could be explained by changes in workers' characteristics and changes in the wage structure. Further, Antonczyk et al. (2009) explained wage inequality through personal characteristics differences.

2 Data and Methods

In the paper, there is an analyzed relationship between the gender wage gap in European countries and educational attainment and type of employment over the period 2006–2020. The initial year 2006 is defined because this year is an available complex oldest dataset for countries under examination. On the other hand, the end year is 2020 because of the availability of complex latest data. In this way, it was possible to include the most significant sample of data for the analyzed problematics and the geographic locality. The subject of the analysis are European Union countries with the required available dataset; specifically, Austria, Germany, Poland, Czechia, Slovak Republic, Hungary, Bulgaria, Romania, Slovenia, Estonia, Latvia, Lithuania, Belgium, France, Netherlands, Luxembourg, Sweden, Denmark, Finland, and Ireland. For research purposes, countries are divided into groups Central Europe (Austria, Poland, Czechia, Slovak Republic, and Hungary), East Europe (Romania, Slovenia, Estonia, Latvia, and Lithuania), West Europe (Germany, Belgium, France, Netherlands, Luxembourg) and North Europe (Sweden, Denmark, Finland, Ireland). Other EU countries could not be included due to missing data for some of the monitored

indicators (in particular, the countries of southern Europe). In the case of Spain, Italy, and Portugal, data were available, but the sample of Southern European countries would be too small for subsequent statistical analysis. Selected exogenous factors are the percentage of women with below upper secondary education (L1), percentage of women with upper secondary and post-secondary non-tertiary education (L2), percentage of women with comprehensive tertiary education (L3), percentage of women on full-time employed (PU) and percentage of women on part-time employed (CU). However, analyzed exogenous variables are defined in accordance with empirical literature, the relation between the value of gender wage gap and variables focused on educational attainment and type of employment in European conditions investigated, for example, Mussida and Picchio (2013), de la Rica et al. (2008), Lauer (2000), Albrecht et al. (2004), Harkness (1996) and Machin and Puhani (2003). The annual data are from the database Eurostat and OECD databases.

In the beginning, the time series were subjected to the unit root test. There was selected the Levin - Lin - Chu panel unit root test. The empirical research shows that the Levin - Lin - Chu panel unit root test has (Hlouskova and Wagner, 2005) the slightest tendency to distort data and is characterized by the highest power. Like Hlouskova and Wagner (2005), Westerlund and Breitung (2009) determined that the local power of the Levin - Lin - Chu panel unit root test is higher than the power of the Im-Pesaran-Shin panel unit root test. Therefore, Breitung and Pesaran (2005) emphasized using panel unit root tests due to the statistical power. Similarly, as Hlouskova and Wagner (2005), Breitung and Pesaran (2005) considered the Levin - Lin - Chu panel unit root test as least prone to data bias, they emphasized a significant advantage of its use on smaller data samples.

Further, the linear relationship between the gender wage gap and selected variables focused on educational attainment and type of employment follows. For analysis, there can be used Pearson correlation coefficient can be expressed as (Pesaran 2015):

$$\hat{\rho}_{YX} = \frac{\sum_{t=1}^T \left(x_t - \bar{x} \right) \left(y_t - \bar{y} \right)}{\left[\sum_{t=1}^T \left(x_t - \bar{x} \right)^2 \sum_{t=1}^T \left(y_t - \bar{y} \right)^2 \right]^{1/2}} = \frac{S_{XY}}{(S_{YY} S_{XX})^{1/2}} \quad (1)$$

where X (gender wage gap) and Y (variables focused on educational attainment and type of employment) are observations of the gender wage gap and analyzed variables focused on educational attainment and type of employment, the Pearson correlation coefficient reaches values $<-1, 1>$.

For a deeper analysis of the relationship between variables, the Generalized method of moments (GMM) estimation is employed. A considerable advantage of the GMM method is that it does not require full knowledge and probability distribution, for example, as the maximum likelihood. The GMM estimations only demand the specification of a set of

moment conditions that the model should satisfy Mátyás (1999). In the empirical literature, for example, on the simplicity of implementing the GMM method and obtaining the required estimates, show Garcia et al. (2003). Then, the use of the GMM method in finance is emphasized by Jagannathan et al. (2002). Jagannathan et al. (2002) state that the GMM method overcomes dynamic asset pricing models. Therefore, strong distributional assumptions may not be made because the variables analyzed may be serially correlated and conditionally heteroscedastic. Hansen (1982) argues that the GMM method has made an econometric evaluation of asset-pricing models possible under more realistic assumptions regarding the nature of the stochastic process governing the temporal evolution of exogenous variables. The relationship between factors under examination can be mathematically expressed as follows (Hall 2005):

$$Y_{it} = \beta_0 + \beta_1 * \Delta Y_{it-1} + \beta_2 * X_{1it} + \beta_3 * X_{2it} + \dots + \beta_n * X_{nit} + \varepsilon_{it} \quad (2)$$

where Y_{it} presents endogenous dependent variable (gender wage gap), β_0 is constant, $\beta_1 \dots \beta_n$ demonstrate estimated coefficients and ε_{it} is error term of the model. The exogenous variable present, ΔY_{it-1} which means the delayed value of gender wage gap from the previous year and factors $X_1 \dots X_n$ represents analysed variables focused on educational attainment and type of employment. Variable t is the time period and i present analysed regions.

The analysis of the short-term causality of the relationship between the gender wage gap and selected variables follows. The definition of causality implies that $Y_{i,t}$ is causing $X_{i,t}$ provided some β_{2i} is not zero. Similarly $X_{i,t}$ is causing $Y_{i,t}$ if some β_{1k} is not zero. There is also necessary to note that causality, in Granger's sense, cannot be identified as the relation determining that the cause can induce the effect (Granger, 1969; Osińska, 2011). The causal model can be mathematically expressed as follows (Beyzatlar et al., 2014; Granger, 1969):

$$\Delta Y_{i,t} = \beta_0 + \sum_{k=1}^p \beta_{1k} \Delta Y_{i,t-k} + \sum_{k=0}^p \beta_{2k} \Delta X_{i,t-k} + \varepsilon_{i,1t} \quad (3)$$

$$\Delta X_{i,t} = \varphi_0 + \sum_{k=1}^p \varphi_{1k} \Delta X_{i,t-k} + \sum_{k=0}^p \varphi_{2k} \Delta Y_{i,t-k} + \varepsilon_{i,2t} \quad (4)$$

where Y_t and X_t represent the gender wage gap, respectively analyzed variables reflected educational attainment and type of employment. The cross-section unit is symbolized by i , and k is the number of periods. Coefficients ε_{1i} and ε_{2i} are uncorrelated stationary random variables and t denotes the time period. The number of lags is present by p . The autoregressive coefficients are symbolized by β_k , and the regression coefficients by φ_k . According to the Akaike information criterion, the Schwarz Criterion is optimal lag length 1.

3 Results

First, all-time series were tested for stationarity using the Levin, Lin & Chu Panel Unit Root Test. As can be seen from Table 1, stationarity at the level was detected at the gender wage gap at a significance level of 1% for Central Europe, L1 at a significance level of 1% for Eastern Europe, and 5% for Central Europe and Northern Europe. After that, stationarity at the level was found for factor L3 at a significance level of 1% for Central Europe and

Eastern Europe, and variable PU at a significance level of 1% for Eastern Europe. The other monitored variables were stationary for the first difference at the significance level of 1% and 5%. It means that the time series with a gender wage gap was stationary at the first difference at the 1% level of significance in the case of Eastern Europe, West Europe, and Northern Europe. The time series with the L1 indicator were stationary at the significance level of 1% for West Europe, and the L2 factor was stationary at the significance level for all monitored regions. For the L3 variable, the stationarity at the first difference at the 1% significance level is evident for West Europe. While the stationarity at the 5% significance level is evident for Northern Europe. The stationarity for the first difference at the significance level of 1% is monitored for the CU indicator in all analyzed regions. While for PU time series, the first difference in stationarity is visible for Central Europe and West Europe at a significance level of 1% and for Northern Europe at a significance level of 5%.

Table 1: Results of Levin, Lin & Chu Panel Unit Root Test

Variables	Central Europe	Eastern Europe	West Europe	Northern Europe
Gender wage gap	-6.1973* I(0)	-4.4766* I(1)	-6.4963* I(1)	-6.2147* I(1)
L1	-1.9938** I(0)	-7.1861* I(0)	-4.7864* I(1)	-1.8268** I(0)
L2	-6.5835* I(1)	-6.2787* I(1)	-5.7728* I(1)	-4.3625* I(1)
L3	-2.3583* I(0)	-9.3391* I(0)	-3.8362* I(1)	-1.6696** I(1)
CU	-5.5742* I(1)	-4.8750* I(1)	-5.4365* I(1)	-2.2592* I(1)
PU	-5.6181* I(1)	-4.8901* I(0)	-4.9507* I(1)	-2.3204** I(1)

Source: Author's calculations

Note: *, ** and *** denote significance at the 1%, 5% and 10% levels. There is the Levin, Lin & Chu test statistic in the table. I(0) means stationary at the level, and I(1) means stationary at first difference.

Descriptive statistics for the time series used are available in Annex 2. As can be seen from the data, the highest maximum wage gap between men and women is found in the case region of Central Europe. Then, it turns out that the highest value of women with lower secondary education is in Western Europe (37.9%). On the other hand, the most significant percentage of women with a complete tertiary education is evident in Northern Europe (56.02%). Closer descriptive statistics of women with upper secondary and post-secondary non-tertiary education show that the most significant percentage of women with this education is in Eastern Europe (74.6%). In the case of part-time employed, the maximum value of 75.49% for women is visible in region Western Europe for part-time employed.

In comparison, the highest value of 97.9% is found in the region of Central Europe for full-time employed. Looking at the Jarque-Bera statistics, it is clear that some time series are characterized by skewness and sharpness, which do not correspond to the normal distribution. This fact is not non-standard for financial data, which sometimes face a slight difference in the observed values compared to the previous period. In this case, it has been assumed that there is a leptokurtic distribution of the data.

Then, the correlation coefficients between the gender wage gap and the educational attainment and type of employment are calculated in Table 2. The results indicate a linear relationship between the gender wage gap in analyzed EU regions and factors L1–L3 reflected educational attainment and variables CU and PU, which characterized type of employment. The negative correlation between the L1 indicator and the gender wage gap indicates that the growth of women with lower upper education should reduce the value of the gender pay gap. It is evident in the countries of Central Europe, Eastern Europe, and Northern Europe. The opposite situation is evident in the countries of Eastern Europe. In the case of the L2 factor and the gender wage gap, an exceptionally positive correlation is detected (Eastern Europe, West Europe, Northern Europe). It means that the growing proportion of women with upper secondary and post-secondary non-tertiary education should increase the value of the gender wage gap. In the case of the linear relationship between the L3 indicator and the gender wage gap, negative correlations prevail (Eastern Europe, West Europe, Northern Europe). It means that the growing proportion of women with comprehensive tertiary education should reduce the value of the gender wage gap. Then, it can be seen that there is a predominant positive correlation between the gender wage gap and part-time work (Central Europe, Eastern Europe, Northern Europe). It means that an increase in the share of women part-time employed should increase the value of the gender wage gap. In contrast, the growing proportion of full-time women employed should decrease the value of the gender wage gap. There was no statistically significant correlation coefficient between L1 and the gender wage gap in Northern Europe, and therefore, the linear relationship between the analyzed variables was not strong.

Table 2: Correlation coefficients between gender wage gap and analysed variables

Variables	Central Europe	Eastern Europe	West Europe	Northern Europe
L1	-0.5942*	0.3104*	-0.2889**	-0.0057
L2	-0.4410*	0.3485*	0.7760*	0.6898*
L3	0.6313*	-0.6533*	-0.7529*	-0.3267**
CU	0.1934***	0.3023*	0.3761*	-0.4498*
PU	-0.1944***	-0.3023*	-0.3758*	0.4489*

Source: Author's calculations

Note: *, ** and *** denote significance at the 1%, 5% and 10% levels.

Then, the linear relationships between analyzed variables are not confirmed by deeper analysis using the GMM method, as Table 3 shows. The results suggest that analysis variables focused on educational attainment and type of employment did not explain any part of the gender wage gap. It means that any part of the gender wage gap couldn't be explained by educational attainment and by type of employment. These results are not consistent, for example, with Harkness (1996) and Blackaby et al. (2005), who showed that part-time women are low-paid and low-skilled. Then, the results are not consistent with Addabbo and Favaro (2011) and Laur (2000), who detected that women's educational attainment is significant in explaining the value of the gender wage gap.

Table 3: Results of GMM method

Variables	Central Europe	Eastern Europe	West Europe	Northern Europe
L1	-1.3034	-0.7455	-1.0100	-0.3030
L2	-2.3683	-2.7779	-0.8393	-0.2512
L3	-2.3700	-3.0158	-1.1621	-0.3383
CU	-9.2998	-8.7202	3.7013	-0.5975
PU	-9.2949	-11.1676	3.8885	-0.6788
S. E. of regression	2.1743	10.6352	3.1765	4.1316
J-statistic	6.7128	1.2065	5.0238	3.4179

Source: Author's calculations

Subsequently, the presence of causality in the granger sense was tested between the variables. It is due to the possibility of comparing the results of applications of another method. As mentioned in the section Data and Methodologies, it is necessary to work with the assumption that causality in Granger's sense cannot be identified as the relation determining that the cause can induce the effect (Osińska, 2011). As shown in Table 4, the null hypothesis was generally confirmed. Namely that there was no causality in the Granger sense between the gender wage gap and the observed variables L1, L2, L3, CU, and PU. However, there are two cases where the causality in the opposite direction going from the gender wage gap to the variables L2 and L3 was detected in West Europe. The linear relationship between variables confirmed is also evident. The causality in the opposite direction going from the gender wage gap to the variable L3 was significant at the 10% level.

Table 4: Results of Granger causality test

Null Hypothesis	F-Statistic	Prob.
Central Europe		
CU→gender wage gap	0.2097	0.6480
Gender wage gap→CU	0.0618	0.8042
L1→gender wage gap	0.6307	0.4291
Gender wage gap→L1	0.0721	0.7888
L2→gender wage gap	0.1141	0.7362
Gender wage gap→L2	0.5418	0.4635
PU→gender wage gap	0.2134	0.6452
Gender wage gap→PU	0.0602	0.8067
L3→gender wage gap	1.4279	0.2351
Gender wage gap→L3	0.3432	0.5594

Eastern Europe		
L1→gender wage gap	0.94110	0.3341
Gender wage gap→L1	0.30327	0.5830
CU→gender wage gap	0.66436	0.4168
Gender wage gap→CU	0.50871	0.4772
L2→gender wage gap	0.00225	0.9623
Gender wage gap→L2	2.53068	0.1145
PU→gender wage gap	0.55123	0.4594
Gender wage gap→PU	0.51508	0.4745
L3→gender wage gap	0.31227	0.5774
Gender wage gap→L3	0.32508	0.5697
West Europe		
L1→gender wage gap	0.3152	0.5758
Gender wage gap→L1	0.5296	0.4685
CU→gender wage gap	0.0732	0.7872
Gender wage gap→CU	1.3433	0.2493
L2→gender wage gap	0.0187	0.8913
Gender wage gap→L2	5.0515**	0.0269
PU→gender wage gap	0.0714	0.7899
Gender wage gap→PU	1.3711	0.2445
L3→gender wage gap	0.6912	0.4078
Gender wage gap→L3	3.2389***	0.0751
Northern Europe		
L1→gender wage gap	0.0177	0.8943
Gender wage gap→L1	0.0106	0.9181
CU→gender wage gap	0.0082	0.9278
Gender wage gap→CU	0.2987	0.5862
L2→gender wage gap	1.8181	0.1813
Gender wage gap→L2	2.6681	0.1063
PU→gender wage gap	0.0078	0.9296
Gender wage gap→PU	0.2852	0.5947
L3→gender wage gap	0.0873	0.7684
Gender wage gap→L3	0.0026	0.9588

Source: Author's calculations

Note: *, ** and *** denote significance at the 1%, 5% and 10% levels.

4 Discussion

First, the correlation coefficient between the gender wage gap and selected factors was calculated. The results showed that the negative correlation between the L1 indicator and the gender wage gap prevails. It could be related to the fact that wage differences may not manifest themselves significantly in the case of low-skilled work. However, the different correlation outcomes in Eastern Europe may reflect, for example, another system of tax advantages, specific labor market differences in Eastern and Western European countries, different types of working conditions, and financial valuations. To some extent, this may be due to certain specifics that have not completely disappeared along with the economic and social transformation.

A prevailing positive correlation is evident in the case of upper secondary education (L2) and the gender wage gap. This linear relationship could be affected by structure and quality of education, study programs studied by men and women, type of employment, specific labor market, financial compensation of people in these jobs, and share of women and men in these work positions. Depending on the evolution of these factors, countries could be more discriminated against by low-educated women because they could suffer from occupational segregation and wage discrimination (Mussida and Picchio, 2013). Another reason could be the discrepancy between education and practice. For example, after completing her education, a woman could go on maternity and parental leave, which made it impossible for her to continue her education in the field. It could theoretically translate into lower financial rewards compared to male counterparts.

The higher share of women with comprehensive tertiary education (L3) could mean that women could have better training, other types of investment in human capital, and better pay conditions (Fitzenberger and Wunderlich, 2000). This tendency is detected in the countries of Eastern Europe and Northern and Western Europe. It could be related that highly-educated and highly-qualified women could be affected by lower-wage gaps (Ad-dabbo and Favaro, 2011). Then, the opposite linear relationship between the gender wage gap and factor L3 is detected in Central European countries. It means that an increase in the share of women with comprehensive tertiary education should cause an increase in the value of the gender wage gap. There could be the possibility of the problem of a “glass ceiling”, misogyny, different types of prejudices, occupational sex segregation and types of studied fields, and subsequent career opportunities in the given areas.

There is also a positive correlation between the gender pay gap and part-time employed women in most cases and a negative correlation between the gender pay gap and full-time employed women. Negative perceptions of part-time work may be related to the need to reconcile work and family. Theoretically, part-time work would not have to be associated with greater career advancement and greater initiative on the part of the employee. It may not be attractive to employers and could result in lower financial rewards and fewer incentives to train and fund other training programs for part-time employees. Only possible reasons for linear relationships between variables are discussed above. The deeper analysis was further made using the GMM method and Granger causality for the possibility of comparing different methods.

As the results of both methods showed, the above-assumed relationships were generally not confirmed. The application of different methods showed only slight differences in the results. The findings suggest that more important variables could affect the value of the gender wage gap. It means that results could be influenced by the fact that the findings of empirical literature show that all of the significant parts of the value of the gender wage gap remain unexplained (Böheim et al., 2007; Matteazzi et al., 2017; Redmond and McGuinness, 2017). The unexplained part is often related to unfair discrimination against women (Böheim et al., 2007; Livanos and Nunez, 2010), characteristics of individual countries (for example, labor market status, competencies required at work, specifics of the workplace, the impact of higher education on the labor market, etc.) (Antonczyk et al., 2010; García-Aracil, 2007). Important also could be unobserved characteristics such as differences in tastes. For example, differences in risk aversion, women could be discouraged from obtaining specific skills, attitudes, and commitments (Böheim et al., 2020; Böheim et al., 2013), the existence of human capital endowments, gender convergence in wage determining characteristics (Redmond and McGuinness, 2017), industry specifics, habits, traditions in society, and other factors. Only in the case of the application of Gender causality was the existence of the causality in the opposite direction going from the gender wage gap to the variables L2 and L3 in West Europe determined. This result may be because the countries included in the group of Western European countries had the highest average annual wages (in 2020). There may be more competition in the labor market and more pressure on higher education and qualifications, which may lead to a difference in financial rewards. It is confirmed by the Dorn and Zweimüller study (2020), which demonstrates that Europe has labor flows from poorer to richer countries. That is, from east to west. At the same time, Dorn and Zweimüller (2020) state that migrants from Eastern Europe have lower education on average, so this could be reflected in financial rewards. And this could lead to a growing need to supplement education.

Conclusion

The paper's objective was to examine the effect of the educational attainment and type of employment on the value of the gender wage gap in EU countries from 2006 to 2020. In European countries, there are different tendencies in gender wage gap development. The empirical research focuses on detecting the variables that could help find factors that affect the value of the gender wage gap. This paper was focused comprehensively on European Union regions (Central Europe, Eastern Europe, West Europe, and Northern Europe). First, a linear relationship was determined between some analyzed variables of educational attainment, type of employment, and values of the gender wage gap.

Further, a deeper analysis using the GMM method and Granger causality test was applied. But the application of the methods shows that selected variables focused on educational attainment (L1–L3) and type of employment (CU, PU) did not explain any part of this gender wage gap in most cases. These results could be related to the fact that education is available for both genders practically without limitations (it means women are not prohibited from studying in any programs). There may also be a specified share of women in some workplaces (for example, according to the corporate governance codices (in some countries), publicly traded companies have to have a minimum percentage representation

of women on the supervisory board). There may be recommended representation of women on the board of directors), quality of parental leave policy, the day-care system, legislative protection of women on parental or maternity leave, which influenced participation in the labor force. These findings show different variables could affect the values of the gender wage gap in analyzed European Union regions. Only in the case of Granger causality was causality evident in the opposite direction going from the gender wage gap to the variables L2 and L3 in West Europe. This fact is connected with significant labor flows.

The results also indicate that this is not simple and clear to determine factors that could affect the value of the gender wage gap. The findings of empirical research also show that most of the existence of the gender wage gap remains unexplained (Böheim et al., 2007; Matteazzi et al., 2017). The unexplained part could be explained by many different types of factors, for example, unfair discrimination against women, characteristics of the labor market, specifics of workplaces, experiences, risk aversion, attitude, etc. (Antonczyk et al., 2010; García-Aracil, 2007; Böheim et al., 2013; Böheim et al., 2007; Livanos and Nunez, 2010).

The research also had some limitations, first was the availability of datasets for countries under examination, length of time series, and the integrity of the dataset used for a possible explanation of the gender wage gap values. There is space for future research. The problematics of educational attainment and type of employment can be examined in other countries or possibly different types of factors and their relation to the value of the gender wage gap.

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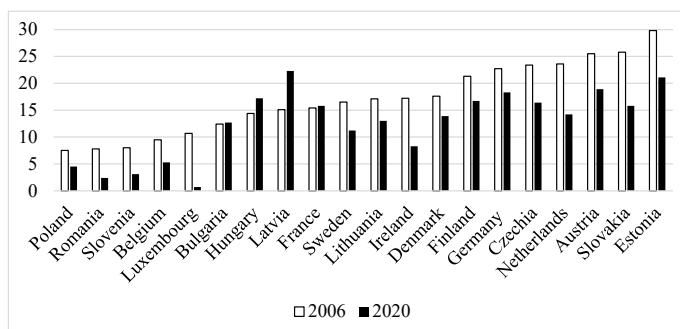
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Appendix 1: Comparison of gender wage gap size in analysed countries in 2006 and 2020 (at median)



Source: OECD (2022), author's calculations

Appendix 2: Descriptive statistics

Central Europe

Variable	Gender wage gap	L1	L2	L3	CU	PU
Mean	13.7833	14.3910	51.6669	33.9420	10.2406	89.7604
Median	13.3000	11.8979	51.3000	34.1500	10.8371	89.2000
Maximum	30.9000	30.9000	62.4000	52.4366	18.28238	97.9000
Minimum	-0.9000	3.7000	41.1756	11.3000	2.1436	81.7176
Std. Dev.	7.5900	8.0994	4.7086	10.9175	4.0655	4.0701
Skewness	0.4895	0.5679	-0.0616	-0.3525	-0.6481	0.6472
Kurtosis	2.6579	2.0443	2.4226	2.2726	2.7944	2.7961
Jarque-Bera	4.0342	8.2641**	1.3068	3.8483	6.4605**	6.4393**
Probability	0.1330	0.0160	0.5202	0.1459	0.0395	0.0399

Eastern Europe

Variable	Gender wage gap	L1	L2	L3	CU	PU
Mean	17.6933	14.3824	61.5204	24.0957	16.1174	83.8787
Median	19.6000	12.8000	60.3000	24.1000	9.8900	90.1000
Maximum	26.2000	26.2000	74.6000	38.8356	47.7219	95.8000
Minimum	4.5000	6.4004	49.0582	12.3000	4.2034	52.3000
Std. Dev.	6.0062	5.7515	7.1587	6.5614	14.7965	14.7955
Skewness	-0.7878	0.4870	0.1474	0.1376	1.4487	-1.4487
Kurtosis	2.5407	1.9381	1.9236	2.2257	3.2527	3.2529
Jarque-Bera	8.4182**	6.4884**	3.8922	2.1099	26.4342*	26.435*
Probability	0.0148	0.0389	0.1428	0.3481	0.0000	0.0000

West Europe

Variable	Gender wage gap	L1	L2	L3	CU	PU
Mean	13.8346	24.1693	42.0063	33.8215	45.5450	54.4512
Median	15.4000	24.3000	39.9000	34.0000	41.3646	58.6000
Maximum	23.6000	37.9000	61.4000	53.3740	75.4925	72.5655
Minimum	0.7000	14.2248	21.3576	20.2000	27.4344	24.5000
Std. Dev.	6.0928	6.0232	9.5477	7.5225	15.7088	15.7163
Skewness	-0.1774	0.1616	0.8736	0.2815	1.0008	-1.0011
Kurtosis	1.9489	2.3200	3.0922	2.5351	2.6361	2.6368
Jarque-Bera	3.8455	12.9360*	1.7715	9.5666*	1.6658	12.9413*
Probability	0.1462	0.0015	0.4123	0.0083	0.4347	0.0015

Northern Europe

Variable	Gender wage gap	L1	L2	L3	CU	PU
Mean	15.6261	17.7354	38.4964	43.7647	30.1868	69.8165
Median	15.6500	16.9500	38.6500	43.6500	32.2767	67.7500
Maximum	21.3000	30.0000	43.7000	56.0232	38.4492	81.8000
Minimum	8.3000	6.4586	33.0076	33.5000	18.1930	61.6000
Std. Dev.	2.6589	5.6114	2.8497	5.8781	6.3559	6.3506
Skewness	-0.0395	0.2048	-0.1860	0.0146	-0.7183	0.7161
Kurtosis	2.8989	2.4727	1.9553	2.0186	1.9991	1.9968
Jarque-Bera	0.0411	7.6639**	1.1146	3.0744	2.4099	7.6445**
Probability	0.9796	0.0216	0.5727	0.2149	0.2997	0.0218

Source: Author's calculations

Note: *, ** and *** denote significance at the 1%, 5% and 10% levels.

Effect of COVID-19 Pandemic on Foreign Exchange Rate Volatility: The Nigeria experience

Vliv pandemie Covid-19 na volatilitu měnového kurzu: zkušenost Nigérie

ABRAHAM OKETOYIN GBADEBO

Abstract

The outburst of the Covid-19 brought anxiety that led to social distancing, staying at home, restrictions in traveling locally and internationally, and finally, the financial instability globally as many economic activities shut down. Consequently, the study examined the effect of the coronavirus pandemic on exchange rate volatility from February 29, 2020, to March 31, 2021. The study utilized two-time series data which were sourced from daily reports on covid-19 from the Nigerian Centre for Disease Control (NCDC) and daily exchange rates US\$/NigerianN from the Central Bank of Nigeria (CBN) statistical bulletin. The study used Error Correction Model (ECM) to analyze the data. The bound test was used in the survey to establish a level of association between the independent variables and the regressor set. The findings revealed that daily reported COVID-19 instances, daily death cases, and cumulative death cases had a positive effect on Nigerian exchange rate volatility. Conversely, confirmed cumulative coronavirus cases do not impact the exchange rate in Nigeria in the short run. Coronavirus significantly affected all macroeconomic indices, including the exchange rate. The study will be helpful to the government and its agencies in the determination of the palliatives for the needy citizens. It will also help the policymakers to develop strategies that can stabilize the economy and health sector to reduce the effect of the pandemic on the citizenry.

Keywords

COVID-19 Pandemic, Foreign Exchange Rate Volatility, Error Correction Model

JEL Codes

I15, F31, C22

DOI

<http://dx.doi.org/10.37355/acta-2022/1-03>

Abstrakt

Vypuknutí Covid-19 přineslo úzkost, která vedla k sociálnímu odloučení, pobytu doma, omezením v cestování na místní i mezinárodní úrovni a nakonec k celosvětové finanční nestabilitě, protože mnoho ekonomických aktivit bylo zastaveno. Studie proto zkoumala vliv pandemie koronaviru na volatilitu směnných kurzů v období od 29. února 2020 do 31. března 2021. Ve studii byly použity údaje ve dvou časových řadách, které pocházely z denních zpráv o covid-19 od Nigerijského centra pro kontrolu nemocí (NCDC) a denních směnných kurzů USD/Nigerian ze statistického bulletinu Nigerijské centrální banky (CBN). Studie použila k analýze dat model korekce chyb (ECM). K určení úrovně asociace mezi nezávislými proměnnými a souborem regresorů byl v průzkumu použit test vázanosti.

Zjištění ukázala, že denně hlášené případy COVID-19, denní případy úmrtí a kumulativní případy úmrtí mají pozitivní vliv na volatilitu nigerijského směnného kurzu. Naopak potvrzené kumulativní případy koronaviru nemají v krátkodobém horizontu na směnný kurz v Nigérii vliv. Koronavirus významně ovlivnil všechny makroekonomické ukazatele včetně směnného kurzu. Studie bude užitečná pro vládu a její orgány při určování opatření pro potřebné občany. Pomůže také tvůrcům politik při vytváření strategií, které mohou stabilizovat ekonomiku a zdravotnictví, aby se snížil dopad pandemie na občany.

Klíčová slova

pandemie COVID-19, volatilita devizového kurzu, model korekce chyb

1 Introduction

The financial crisis caused by the pandemic in 2020 revealed certain signals on the global economy, including a fall in Gross Domestic Product (GDP), an increase in unemployment rates, and deficit numbers from the world's top thrifts (World Health Organisation, 2020). It also fine-tunes volatility in the foreign exchange market. The major losers in this regard are emerging economies, which must spend reserves to protect against currency devaluation at the most inconvenient periods (WHO, 2020).

However, as some developed economies start recovering, central banks and national governments are weighing the influence and timing of narrowing off monetary and fiscal support as a result of anxieties over prospective inflationary stresses against the prospect of decelerating the stride of the global economic recovery. These worries are compounded by the emergence of new disease (Delta and omicron) variants and rolling pandemic hotspots that challenge national efforts to contain infections and fully restore economic activities (WHO 2021). Furthermore, the United Nation Department of Economic and Social Affairs (2022), cites a brew of other problems that are slowing down the global economy, aside from new waves of COVID-19 infections, including persistent drops in the labour market and lingering supply-chain challenges caused by the pandemic and Ukraine/Russian war, and rising inflationary pressures.

The pandemic outbreak was triggered by the economic crisis, which was exacerbated by the lockdown and social isolation measures. The significant devaluation of emerging market currencies, on the other hand, had nothing to do with the strengths and imbalances of each country's balance of payments, particularly in Africa. The trickle in exchange rates for developing market currencies was caused by COVID-19's dual tremor: an unprecedented decrease in economic activity combined with an episode of global risk aversion equivalent in severity to the Lehman crisis of 2008–2009. These two factors contributed to an increase in the developing risk premium and, as a result, a decrease in current account financing (portfolio flows and foreign credit lines), which has become more unstable.

Among emerging market countries, Verduzco, Santiago, García, Correia, Carrascal, Castro, García, Carrasco, Calle, & Sabido, (2020) identified four separate groups: '(i) those with current account residues and, as a result, currency steadiness; (ii) those with a deficit and steady funding; (iii) those with a deficit and flow-dependent finance; and (iv) those with

unmaintainable current account overages'. Countries with a high current account excess, such as China (the world's largest autonomous creditor) and the oil-producing countries, are included in the first group of exporters of savings. The two middle assemblages are made up of nations that have current account shortfalls that are manageable in the long run (with either stable or flow-dependent funding). In addition to rising Europe, non-oil exporting Asian nations (such as Indonesia and the Philippines) and popular Latin American nations such as Mexico, Brazil, Colombia, and Peru are included in the scope of the study. However, the spectrum is comprised of nations that have large and unsustainable current account deficits, which are typically the result of structural factors (large structural deficits), low productivity, and a reliance on external savings, particularly portfolio and credit flows, as well as other factors. Countries such as Turkey, Argentina, Nigeria, and South Africa are included in this category because they are experiencing balance of payments difficulties and severe changes in their operations or exchange rates from 2019.

The volatility in exchange rates has been worsened in recent times by the low-interest-rate policies implemented by central banks throughout the world. Under normal circumstances, national economies respond to market volatility by lowering interest rates to stimulate economic activity and restore stability. The ability to borrow money is no longer available in a world with zero interest rates, and currency takes on this function, resulting in increased exchange rate instability.

Previous studies such as Albulescu (2020) (United States of America), Zhang Hu, and Ji (2020), Al-Awadhi, Alsaifi, Al-Awadhi, & Alhammad (2020) (China), Akanni and Gabriel (Nigeria) (2020) (Nigeria), and Onali (2020) (United States of America) contained a relatively high rate of confirmed cases. However, substantial research has been conducted to determine the origins and drivers of exchange rate volatility (Ben-Omrane & Savaşer, 2017; Choudhry and Hassan, 2015; Coudert, Couharde, & Mignon, 2011). Also, numerous studies have shed light on the economic and social consequences of the pandemic economic and social consequences. As the epidemic approached, a rapidly expanding body of studies investigated how financial factors reacted to the event (Goodell 2020, Albulescu 2020, Zhang et al. 2020, Akanni et al. 2020, and Onali 2020). Benzid & Chebbi 2020, and Ali & Tokhy 2020) have investigated the relationship between the COVID-19 pandemic and exchange rate volatility, but no such study has been conducted in Nigeria to the best knowledge of the researcher. As a result, this is the first time that an investigation into the influence of the COVID-19 plague on exchange rate volatility will be conducted in Nigeria.

The primary objective of this study was to investigate the effect of COVID-19 pandemic variables on the volatility of Nigeria's exchange rate. Hence, the specific objectives are to:

- examine the effect of daily coronavirus incidences on the volatility of Nigeria's foreign exchange rate instability
- investigate the outcome of accumulated coronavirus incidences on the volatility of Nigeria's foreign exchange rate.

- analyze the influence of daily coronavirus mortality cases on Nigerian foreign exchange rate unpredictability.
- evaluate the influence of coronavirus cumulative death cases on foreign exchange rate instability in Nigeria

The rest of the paper shall be structured as follows: Section two discusses theoretical and empirical reviews of the past literature, Section three deals with methodology, Section four explains the results and discussion of findings; lastly, Section five deliberates on the conclusions and recommendation.

2 Literature Review

2.1 Theoretical Review

The risk society theory was developed by Beck (1992) and Giddens (2002). Modern developments, according to the theory, are accompanied by the duplication of risks in this situation, created risks lead to the progressive formation of a risk society (Giddens, 2002). Human intervention exacerbates and manages "manmade risks". "A methodical approach of coping with hazards and insecurity created and introduced by modernity itself," according to risk society (Beck, 1992). "Risk" is employed by Beck in the contexts of hazard and susceptibility. The premise behind this study is that there are unintended and unanticipated side effects of contemporary life that harm innovation (Wimmer & Quandt, 2006). These side effects have a significant impact on human society. Through human migration, a healthy risk in Wuhan (China) became a pandemic, affecting all countries worldwide and resulting in millions of fatalities.

2.2 Review of Empirical Literature

Gen-Fu. Hao-Chang, Qiang, & Chun-Ping (2021) The study delves into the impact of COVID-19 and the relevant government reaction strategies from January 13, 2020, to July 21, 2020, exchange rate volatility in twenty (20) nations was evaluated using the Generalized Method of Movements (G.M.M.) approach. The findings showed that an increase in confirmed cases corresponds to an increase in exchange rate volatility, consequently, Governments' different responses to the epidemic, such as school closures, constraints on domestic mobility, and public education campaigns, all contribute to exchange rate unpredictability. They concluded that the quick spread of COVID-19 in 2020 deeply wedged world economies. Thus, attempts to bail out the economy through government interferences led to exchange rate instability. The outcome of this study gives invaluable data and insights to politicians and financial investors all across the world.

Banerjee, Kumar, and Bhattacharyya (2020) examined the impact of COVID-19 on India's foreign currency rate volatility and stock market performance. The study lasted 48 days and employed secondary data. At various pre-and post-lockdown stages, the growth rate of confirmed cases (Growth C), an exchange growth rate (G.E.X.), and the SENSEX value stayed constant. The SENSEX index represents the total value of the stocks of 30 specific

firms listed on the Bombay Stock Exchange (B.S.E.), whereas the G.E.X. index represents exchange rate growth. Using Vector Auto-Regressive (V.A.R.) models, the study attempts to capture any possible changes over time. The result revealed a positive association between the pace of growth of confirmed cases and the rate of growth of the exchange rate, as well as a negative correlation between the enhanced degree of coronavirus established cases and the rate of advancement of the SENSEX value. A resourceful analysis revealed that as the number of identified instances increased, the economy grieved a blow, which was reflected by the depreciation of the Indian rupee. The stock exchange directory, too, agonized from a negative impression. However, with the addition of a V.A.R. model, the result observed that a rise in confirmed COVID-19 cases had no meaningful impact on the exchange rate or the SENSEX index.

Benzid et al. (2020), assess the influence of Covid-19 cases/related fatalities in the United States on exchange rate volatility. Data collected included US\$/EUR€, US\$/Yuan¥, and US\$/Livre and Sterling£ exchange rates. The GARCH (1,1) model was used to anticipate the daily instability of three exchange rate series including the US\$, which enabled the study to be successful. The findings showed that a rise in the number of incidents and deaths (both recorded in logs) in the United States has a favourable influence on the exchange rate. The results are useful for anyone who wishes to make predictions about the volatility of exchange rate futures.

Ali et al. (2020), investigated the impact of COVID-19 on currency exchange instability in Egypt. The study used supplementary sources. The independent variables in this study were daily coronavirus cases and cumulative coronavirus cases. Instead, the exchange rate served as the dependent variable. The result showed a negative influence on the currency exchange rate between the United States dollar (US\$) and the Egyptian pound (EG£). In addition. The findings also revealed a positive and statistically significant relationship between the cumulative number of coronavirus cases and fluctuations in currency exchange rates.

Abu Bakar and Rosbi (2020) investigated the Impact of Coronavirus Disease (COVID-19) on the Equity Market and Currency Exchange Rate. The study designated two types of time series data namely KLSE index and currency exchange rate for USD/MYR as dependent variables. The period between January 2020 and March 2020 was the surveillance period selected. They used Spearman rank correlation analysis between changes of KLSE index and currency exchange rate. The result showed a positive association between changes in the KLSE index and currency exchange rate. They concluded that (COVID-19) creates a significant effect on the equity market index and currency exchange rate.

Onali (2020) examined the influence of COVID-19 occasions and related mortality on the United States stock market (Dow Jones and S&P 500 indexes) after controlling for changes in trading volume and instability potentials, as well as day-of-week impacts, Analysis of secondary data collected from the United States and six other countries were carried out with the use of the GARCH 1.1 model. The referendum was piloted between April 8, 2019, and April 9, 2020, online. Findings showed that Covid-19 reported instances had an influence on stock market returns in all nations in the sample save the United States,

Although the number of recorded victims in Italy and France has a deleterious effect on stock market returns. The result further revealed that the volatility index (V.I.X.) yields have a positive effect on stock market returns using the V.A.R. models. Finally, Markov-Switching simulations demonstrated that, by the end of February 2020, the extent of the negative impact of the V.I.X. on stock market returns had grownup thrice from its pre-election levels.

Albulescu (2020) examined the effect of authorized statements concerning new cases of contagion and death ratio on the financial markets volatility index (VIX). The findings revealed that the new cases reported in China and outside China have a mixed effect on financial volatility, the death ratio positively influences VIX, with that outside China causing more influence. In addition, the findings observed that the more the number of affected countries, the higher the financial volatility becomes.

Zhang et al. (2020) investigated the effects of the coronavirus on global financial markets in the United States. Daily data up to March 27, 2020, were collected. The result showed that global financial market risks increased the reaction to the pandemic. The findings further revealed that international stock market links exhibit distinct differences in patterns before and after the pandemic's declaration and that governmental responses increase the level of uncertainty in global financial markets even more.

Chukwuka and Ekeruche (2020) examined the economic penalties of the COVID-19 outbreak in Nigeria. The findings showed that Nigeria's economy is expected to grow by 2.5 percent in the Gross Domestic Product (G.D.P.) in 2020 but was reduced due to the epidemic. Consequently, a significant increase in the nation's debt disbursement obligations. The results concluded that the revenue ratio staying at 60% during a period of dipping oil prices has been a prime cause of concern for policymakers since it would make it problematic for the economy to develop in the future.

Akanni et al. (2020) looked at the economic impact of COVID-19 on the Nigerian economy. "It has been determined that the COVID-19 pandemic has resulted in interruption of operations and economic instability, which according to the United Nations and development agencies has cost the world around \$2 trillion since the inception of the pandemic" (Akanni et al. 2020). The findings highlighted some of the factors to include: social alienation, staying at home, spending limitations, and supply factors, such as declining or stopping manufacturing and output, which all hurt economic growth.

Saha, Bhattachrya, Roy, Basu, Roy, and Maity (2008) investigated the relationship between the epidemic and the Indian rupee's value as of January 1, 2008. The findings observed the unpredictable market condition, the unstable stock market, and, the volatility of B.S.E. stock prices. This is in contrast to prior research, which indicated that the Sensex and the stock prices of leading corporations listed on the Bombay Stock Exchange were favourably associated.

Choudhry et al. (2015) examined the function of exchange rate volatility in inducing the actual imports of goods and services into the United Kingdom from three important emer-

ging markets: Brazil, China, and South Africa. The study used the asymmetric autoregressive distributed lag (ARDL) technique to analyze collected the monthly data from January 1991 to December 2011. The result revealed a positive relationship between volatility and international business and consequently a significant positive association between the financial crisis and UK imports. The findings also observed a causal relationship between exchange rate volatility and UK imports. Finally, the result displayed a significant effect on all the third countries' samples included in the study.

Coudert et al. (2011) examined the impact of global financial chaos on the exchange rate strategies in developing countries. The study selected a sample of 21 emerging countries from January 1994 to September 2009. The outcome showed that most of the countries studied exhibited a higher proportionate level of exchange rate instability than the global financial pressure. The results further revealed the spread of contagion effect from one emerging currency to other currencies in the neighbourhood.

2.3 Stylised Facts

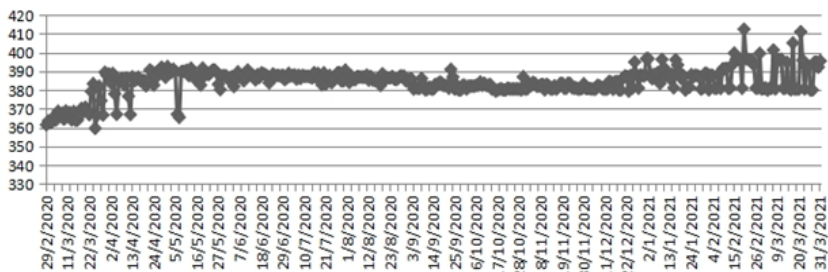
Table 1: COVID-19 cases and deaths among Ten hardest-hit countries worldwide as of December 12, 2021

S/N	Countries	Total Number Infected	Daily Average Number of New Cases in the last 7 days	Total Number of Deaths	Change in Average new Deaths last 7 days vs previous 7 days
1.	United States	49,387,208	120,000	791,514	1,600
2.	India	34,656,822	8,600	473,952	670
3.	Brazil	22,157,726	9,000	616,018	190
4.	Great Britain	10,620,535	48,000	146,281	120
5.	Russia	9,692,411	32,000	278,131	1,200
6.	Turkey	8,945,807	21,000	78,215	200
7.	France	8,091,667	45,000	120,883	110
8.	Germany	6,291,621	55,000	104,047	320
9.	Iran	6,141,335	3,400	130,356	75
10.	Argentina	5,346,242	2,200	116,703	16

Source: Adopted by the Author from Statista Corporate Solutions

Figure 1 illustrates the trend in US\$/Nigerian ₦ exchange rate movement in the period under study (29/2/2020 to 31/3/2021). It shows fluctuation, which ranges from ₦359.56/US\$1 as of 25/3/2020 and peaked at ₦412.44/US\$1 as of 22/2/2021 less than one-year interval. The statistics show an unbalanced trend for the period under review.

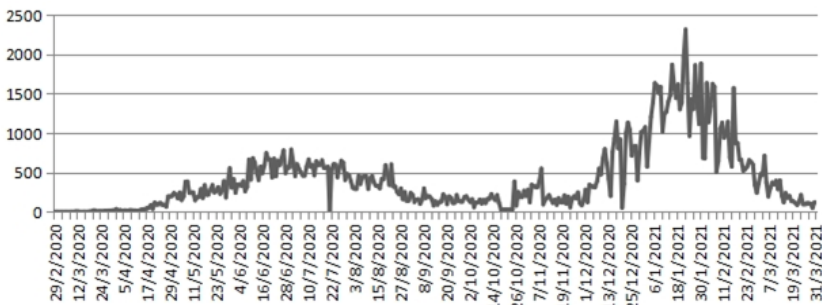
Figure 1: Trend in daily US\$ / ₦ Exchange rate movement from 29/2/2020 to 31/3/2021



Source: Own estimation using Central Bank of Nigeria (CBN) Statistical Bulletin various issues

Figure No. 2 exemplifies the trend of daily COVID-19 confirmed cases that started with one (1) on 29/2/2020 and rose to 779 occurrences on 27/6/2020. The figure plunged to zero (0) as of 21/7/2020. It rose to 604 cases on 23/7/2020, just within a space of two (2) days. On 17/10/2020, it dropped to 113 patients before it rose to 548 patients on 8/11/2020. The statistics showed a leap to 1145 cases on 17/12/2020, which was more than double of reported confirmed cases as of 8/11/2020. COVID-19 confirmed cases recorded an unprecedented increase to 2341 cases on 22/1/2021 before its gradual decline and nose-dived to 86 instances on 31/3/2021. The highest reported confirmed cases revealed a rise of 80% when compared with 1301 confirmed cases of 19/1/2021, a space of three (3) days interval.

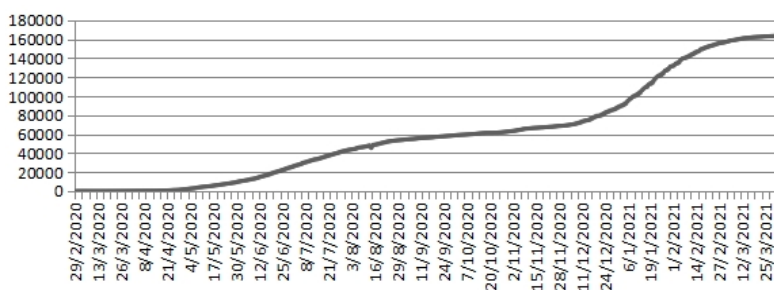
Figure 2: Trend in daily confirmed cases in Nigeria from 29/2/2020–31/3/2021



Source: Own estimation using NCDC data

Figure 3 illustrates trends in cumulative coronavirus confirmed cases for the period under review from 29/2/2020 to 31/3/2021. It is the accumulation of daily established instances that increases overtime the period. Figure No. 3 shows a linear trend. It rose from 67 cases as of 25/3/2020 to 163,235 cases as of 26/3/2021. It implies an increase of 2435.34% within one year.

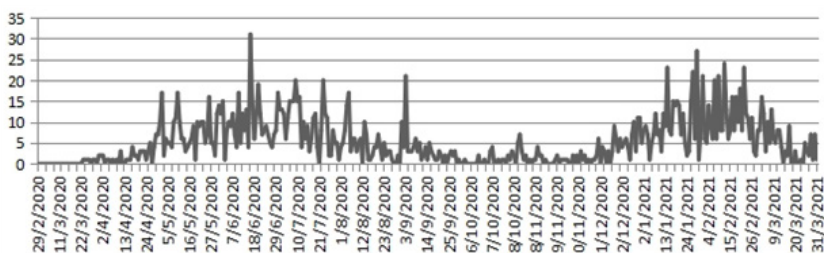
Figure 3: Trend in cumulative confirmed cases in Nigeria from 29/2/2020–31/3/2021



Source: Own estimation using NCDC data

As explained in figure No. 4, the daily coronavirus death cases range from zero (0) instances to 31 cases. Figure No. 4 recorded a zero (0) COVID-19 everyday death case on 29/2/2020, which rose to seventeen (17) COVID-19 daily death cases as of 2/3/2020. It declined to five (5) COVID-19 daily COVID-19 death cases as of 11/6/2020 but peaked at thirty-one (31) COVID-19 daily death cases on 16/6/2020. The COVID-19 daily death cases dropped to two (2) as of 26/7/2020. The statistics rose to twenty-one daily COVID-19 death cases as of 3/9/2020. Figure No. 4 daily COVID-19 death cases further increased to twenty-three (23) as of 14/1/2021, which declined to three (3) as of 25/1/2021. It rose to twenty-seven (27) as of 29/1/2021. However, the daily COVID-19 death cases experience a drop to twenty-four (24) on 12/2/2021, with a subsequent decline by eight (8) as of 3/3/2021. The reported daily COVID-19 death cases dropped to three (3) as of 26/3/2021. The statistics also showed that there were some other days without reported everyday COVID-19 death cases besides 29/2/2021.

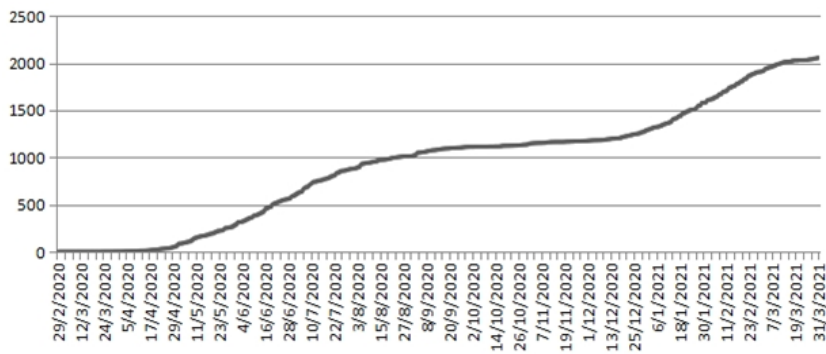
Figure 4: Trend in daily death confirmed cases in Nigeria from 29/2/2020 to 31/3/2021



Source: Own elaboration using NCDC data

Figure No. 5 reflects a linear trend, but the first twenty-three (23) days are without reported daily COVID-19 death cases. The first confirmed everyday COVID-19 death case was on 23/3/2020. Figure No. 5 showed a flat trend between 23/3/2020 and 14/4/2020 with daily COVID-19 death cases ranging from one (1) or two (2).

Figure 5: Trend in Death Toll Cases in Nigeria from 29/2/2020 to 31/3/2021



Source: Own elaboration using NCDC data

3 Methodology

3.1 Sample of the study

The sample used for this study is daily data covering 29/2/2020 to 31/3/2021 which is 394 days which translates to 1970 observations. This period was chosen because it constitutes the time with steadily reported cases and thereafter there was a break-in of reported cases by NCDC. The data was estimated using the Ordinary Least Square method (O.L.S) to obtain the optimal lag length ARDL was adopted.

3.2 Data collection

Daily data for daily confirmed reported cases, cumulative coronavirus confirmed reported cases, daily death reported cases, and cumulative death toll cases from Nigeria Centre for Disease Control (NCDC) website while daily US\$/₦ exchange rates movement was obtained from the Central Bank of Nigeria (CBN) Statistical Bullet. The dependent variable of the study was exchange rate volatility while the independent variables include: daily coronavirus confirmed cases, cumulative coronavirus cases, daily coronavirus death cases, and cumulative coronavirus death case

3.3 Model Specification

$$EXCR = f(DCC+CCC+DDC+CDC) \dots\dots\dots(1)$$

Where: EXCR = US\$/₦ Daily exchange rates,
DCC = Daily coronavirus confirmed cases,
CCC = Cumulative coronavirus confirmed cases,
D.D.C. = Daily coronavirus death cases, while
CD.C. = Cumulative coronavirus confirmed cases
(Benzid et al. 2020 & Ali et al. 2020)

Representing equation (i) econometrically gives:

$$ESCRit = \beta_0 + \beta_1 DCC_{it} + \beta_2 CCC_{it} + \beta_3 DDC_{it} + \beta_4 CDC_{it} + \varepsilon_{it} \dots \dots \dots (2)$$

Where: β_0 = Intercept, $\beta_1 - \beta_5$ = Coefficient of predictor variables, represents error term
Pesaran, Shin, and Smith. 2001, used the A.R.D. Bounds testing method for cointegration written

$$\Delta \ln ERV_t = \alpha_1 + \sum_{i=0}^p \beta_i \Delta \ln ERV_{t-i} + \sum_{i=0}^p \theta_i \Delta \ln DCC_{t-i} + \sum_{i=0}^p \delta_i \Delta \ln CCC_{t-i} + \sum_{i=0}^p \rho_i \Delta \ln DDC_{t-i} + \sum_{i=0}^p \tau_i \Delta \ln CDC_{t-i} + \mu_t \dots \dots \dots (3)$$

Where μ_t = error correction term and Δ is the first difference operator.

α = The drift component and β = the long-run multipliers.

LDCC = Log of Daily Coronavirus Confirmed Cases

LCCC = Log of Cumulative Coronavirus Confirmed Cases

LDDC = Log of Daily Coronavirus Death Cases

LCDC = Log of Cumulative Coronavirus Death Cases

LEV = Log of Exchange Rate Volatility

β_i = Coefficient of Exchange Rate Volatility

θ_i = Coefficient of Daily Coronavirus confirmed Cases

δ_i = Coefficient of Cumulative Coronavirus confirmed Cases

ρ_i = Coefficient of Daily Coronavirus Death Cases

τ_i = Coefficient of Cumulative Coronavirus Death Cases

α_1 = Intercept

Δ = First Difference Operator

μ_t = White Noise Stochastic Error Term

Therefore, equation (3) is estimated using the ordinary least squares (O.L.S.) method. The ARDL method estimates $(p + 1)k$ number of regressions calculated to obtain the optimal lag length for each variable in the equation, and the choice between different lag lengths are made by using information criteria such as Akaike (A.I.C.) or Schwarz criterion (S.C.). Schwarz information criterion (S.C.) is preferred to A.I.C. because it tends to define more parsimonious specifications (Pesaran et al. 2001). Thus, if there is evidence of cointegration among the variables, the long-run model in equation (4) is estimated. Similarly, the ARDL specification of the short-run dynamics is derived by constructing an error correction model of the form:

$$\Delta \ln ERV_t = \alpha_1 + \sum_{i=0}^p \beta_i \Delta \ln ERV_{t-i} + \sum_{i=0}^p \theta_i \Delta \ln DCC_{t-i} + \sum_{i=0}^p \delta_i \Delta \ln CCC_{t-i} + \sum_{i=0}^p \gamma_i \Delta \ln DDC_{t-i} + \sum_{i=0}^p \rho_i \Delta \ln CDC_{t-i} + \omega ECM_{t-1} + \mu_t \dots \dots \dots (4)$$

Where E.C.M. t is the error correction model and is defined as:

$$ECM_t = \Delta \ln ERV_t - \alpha_0 + \sum_{i=0}^p \beta_i \Delta \ln ERV_{t-i} + \sum_{i=0}^p \theta_i \Delta \ln DCC_{t-i} + \sum_{i=0}^p \delta_i \Delta \ln CCC_{t-i} + \sum_{i=0}^p \gamma_i \Delta \ln DDC_{t-i} + \sum_{i=0}^p \rho_i \Delta \ln CDC_{t-i} \dots \dots \dots (5)$$

All coefficients of the short-run equation are coefficients relating to the short-run dynamics of the model's convergence to equilibrium, and ω in equation (4) above represents the speed of adjustment.

4 Results and Discussions

Table 2: explains the descriptive statistics of the variables used in the regression analysis reported including Exchange rate (EXCR), Daily Coronavirus Confirmed Cases (DCCC), Cumulative Coronavirus Confirmed Cases (CCCC), Daily Coronavirus Death Cases (DCDC), and Cumulative Coronavirus Death Cases (CCDC) have averages of 0.116, 290.3, 18101, 5.683, and 397.3 respectively. (EXCR), (DCCC), (CCCC), (DCDC), and (CCDC) have the median of 0.956, 4.401, 0.600, 2.503 and, 37.60 correspondingly. The maximum of 24.283, 790.3, 54008, 31.281, and 1013.0 for (EXCR), (DCCC), (CCCC), (DCDC), and (CCDC) respectively. 23.701, 0.009, 1.321, 0.003 and 0.002 are for minimum. However, in the case of Standard deviation, the rule of thumb is that the standard deviation of any variable should be equal to zero or close to zero, which implies that the deviation from the mean must be minima overtime for the chosen series to be less volatile. The standard deviation of (EXCR), (DCCC), (CCCC), (DCDC), and (CCDC) are 0.531, 0.229, 0.779, 0.551, and 0.374. Therefore, all the variables conform to the rule of the thumb.

Table 2: Descriptive Statistics

	lnEXCR	lnDCCC	lnCCCC	lnDCDC	lnCCDC
Mean	0.116	290.3	18101	5.683	(397.3)
Median	0.956	4.401	0.600	2.503	37.60
Maximum	24.283	790.3	54008	31.281	1013.0
Minimum	23.701	0.009	1.321	0.003	0.002
Std. Dev.	0.531	0.229	0.779	0.551	0.374
Skewness	0.034	0.012	0.011	0.328	1.002
Kurtosis	2.111	1.811	1.024	2.128	3.521
Jarque-Bera	1.162	2.024	1.013	4.016	3.121
Probability	0.094	0.109	0.215	0.115	0.051
Sum	10.031	117.07	11.110	33.021	20.032
Sum Sq. Dev.	5.114	11.109	5.070	14.014	8.914
Observations	384	384	384	384	384

Source: Own estimation (CBN & NCDC database) using E-view 10

The skewness of (EXCR), (DCCC), (CCCC), (DCDC), and (CCDC) are 0.034, 0.012, 0.011, 0.328, and 1.002, respectively. In this series, skewness has a normal distribution. Skewness examines the spread of the data and the distance of these data values to the mean. The closer the data values are to the average, the closer S.D. to zero. In this sequence, all the variables are regular and conform to the decision rule of statistics. The Kurtosis for the variables is 2.111, 1.811, 1.024, 2.128, and, 3.521 respectively. Kurtosis looks at the height and how peak is the values of the variables. Thus, the optimal threshold for Kurtosis is three (3). Thus, four out of five variables of this Study are below the optimal verge of Kurtosis (Platy-kurtic) while cumulative coronavirus death cases operated above the optimal threshold

value (leptokurtic). The Jarque-Bera for (EXCR), (DCCC), (CCCC), (DCDC), and (CCDC) include 1.162, 2.024, 1.013, 4.016 and 3.121 respectively. The Study deals with daily data series that are highly volatile; hence Jarque-Bera Statistics test becomes sacrosanct. It is a test statistic for normal distribution in terms of the series stability and volatility over time. The null hypothesis for the test implies normal distribution in terms of the series stability and volatility over time.

Table 3 presents the results of correlation analysis which is essential to establish the level of association among the variables used in the regression analysis. The study aims to determine the association between exchange rate volatility and COVID-19 pandemic variables, which has implications for their inclusion in the same models. The results suggested that the correlation coefficients between these two variables were moderate and can co-exist in the same model

Table 3: Correlation Analysis Results

	lnEXCR	lnDCC	lnCCC	lnDDC	lnDCD
LnEXCR	1.000				
lnDCC	0.112	1.000			
lnCCC	0.201	0.072	1.000		
LnDDC	0.139	0.232	0.117	1.000	
LnDCD	0.501	0.242	0.182	0.288	1.000

Source: Own estimation (CBN & NCDC database) using E-view 10

Table: 4 displays the projected results of unit root tests from the standard Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests

Table 4: It is necessary and easy to test for the presence of unit roots when examining time series models since they are critical in the analysis of time-series data. The presence of a unit root implies that the time series under research is non-stationary, whereas the lack of unit roots suggests that the stochastic process under inquiry is static (Iyoha and Ekanem, 2002). Most macroeconomic time series data are not static at their levels because some variables may be too little or too large to the point that they may never return to their predicted mean, as is the case in most cases. It became necessary to do a unit root test or a stationarity test to fully comprehend the integration of the variables as a result of this. As a result, the Phillip-Peron (P.P.) and Augmented Dickey-Fuller (A.D.F.) tests (Phillips and Perron, 1988) with and without intercept were used in the study. The study indicates that the examined variables are non-stationary if the absolute value of the P.P. and A.D.F. statistics is less than the 1 percent, 5 percent, and 10 percent critical values. According to the alternate hypothesis, the absolute value of the PP and ADF tests is larger than the 5 percent critical value, indicating that the variable under consideration is stationary. The test for stationarity for the variables used in this study is therefore essential and reasonable before proceeding with the ARDL bounds test, as previously stated. However, it is essential to examine if the variables are stationary to prevent producing erroneous fin-

dings. Assume that the variables in the study are either at levels or first-differenced static for the sake of the limits testing method and that the F-statistics for bounds testing have been generated for the bounds testing procedure. The stationarity of the variables was determined in the study using the ADF and P.P. methods. The results from the A.D.F. and Phillip Perron tests in table 4.3 showed that all the variables became stationary at the first difference (with and without trends) except for exchange rate volatility (ERV) and Daily Coronavirus Death Cases (DCDC) that were stationary at levels. All the variables were significant at (1%, 5%, and 10%) level

Table 4: Results of Unit Root Test

	Augmented Dickey-Fuller (A.D.F.)				Phillip Perron (P.P.)				
Variable	Level								
	Constant	Constant and Trend	None	Prob	Constant	Constant and Trend	None	Prob	Decision
LERV	-6.1551**	-6.2706***	-6.8238*	0.001	-8.0217	-8.5594	-8.4029**	0.0000	I(0)
LDCC	0.5968	-1.8011	-1.8301	0.112	2.8456	-2.1210	2.8512	0.1188	I(1)
LCCC	-0.6349	-2.4121	-0.6291	0.210	0.8091	-2.8491	-3.4865	0.1812	I(1)
LDDC	-2.0886	-5.1561**	-3.0236**	0.034	-7.2758*	-8.2412*	-7.5185*	0.0005	I(0)
LCDC	0.2251	-2.4150	-2.9480**	0.005	1.0573	-2.9512	1.6851	0.2114	I(1)
First Difference									
	Constant	Constant and Trend	None	Prob	Constant	Constant and Trend	None	Prob	Decision
LERV	None	None	None	0.000	None	None	None	0.0000	I(0)
LDCC	-6.1551**	-6.2706***	-15.2100*	0.000	-6.0217*	-5.5594*	-5.4029*	0.0000	I(1)
LCCC	-3.4694**	-3.4337***	-5.7737*	0.002	-3.4889**	-2.8455**	-16.1061*	0.0000	I(1)
LDDC	None	None	None	0.001	None	None	None	0.0000	I(0)
LCDC	-3.3378*	-2.9315***	-2.9536**	0.004	-6.3248**	-8.2410*	-8.9911*	0.0000	I(1)

Note: ***, **and * implies statistical significance at 1%, 5% and 10% level respectively

Source: Own estimation (CBN & NCDC database) using E-view 10

Table 5 reveals ADRL bounds cointegration tests. It showed the calculated F-statistic when the regression focused on LERV, the proxy for the exchange rate volatility, and the impact of COVID '19 pandemic variables. From the estimated Bounds test, results depicted that the F-statistics of 27.6 is more significant at all levels for the upper and lower critical values. Therefore, the study does not reject the null hypothesis with cointegration. The study established a long-run cointegration relationship among the dependent and independent variables in the model. The estimated coefficients of the short-run relationship between the COVID '19 pandemic variables and exchange rate volatility produced mixed and expected results in line with the diversity of existing literature evidence. Hence, the short-run ARDL estimates presented in table 5 indicated a positive and significant relationship between three independent variables and exchange rate volatility with coefficient values. It displays that a unit increase in the selected independent variables will lead to

a positive change in the exchange volatility in the short run. The (0.5104), (LDCC), (LCCC) and (LDDC) had a positive relationship each with variability/volatility of exchange rate at 1%, 7%, 3.8%, level correspondingly with a coefficient value (0.5104), (0.0374), and (0.0711) respectively. It implies that LDCC, LCCC, and LDDC have a significant positive relationship with exchange rate volatility. The result corroborated the Study of (Gen-Fu et al. 2021, Benzid et al. 2020 & Ali et al. 2020).

Table 5: ARDL Bounds Test for Co-integration Relationship

Model	Computed F-Statistic	
LERV.	27.633	
Bounds Level	I(0) Bound	I(1) Bound
1% critical Value	3.93	5.23
5% critical Value	3.12	4.25
10% critical Value	2.75	3.79

Source: Own estimation (CBN & NCDC database) using E-view 10

In table 6 on the other hand, LCDCC has a positive but insignificant correlation with exchange rate fluctuation. Consequently, Table 6 gives the short-run dynamic coefficients associated with the long-run relationships obtained from the E.C.M. equation. The error correction term is appropriate for the model. It implies that deviations from the long-term macroeconomic stability adjust quickly.

Hence, the short-run impact of COVID'19 seemed not to be serious in Nigeria, particularly and the African continent, as speculated by United Nations and W.H.O., due to the minimal death toll recorded.

Table 6: ARDL Short-Run Estimates – E.C.M. Coefficient Results

Dependent Variable: LREV				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LDCC)	0.037365	0.075488	0.494979	0.0711
D(LCCC)	0.071071	0.077691	0.914790	0.0381
D(LDDC)	0.510350	0.090037	5.668225	0.0000
D(LCDC)	0.010166	0.023311	0.436103	0.1120
ECM(-1)	-0.549480	0.128008	-4.292544	0.0003
ECM = LREV + (0.037*LDCC + 0.071*LCCC + 0.510*LDDC + 0.010*LCDC)				
R-Squared = 0.9559		Adjusted R-Squared = 0.9446		
F-Statistic = 19.35 (0.0000)		Durbin-Watson Stat = 1.9324		

Short-Run Diagnostic Tests

Serial Correlation LM Test = 1.0527 (0.5114)

Heteroskedasticity Test (ARCH) = 0.2286 (0.5924)

Jarque-Bera (Normality Test) = 1.1449 (0.5931)

Ramsey RESET Test = 0.3479 (0.5608)

Note: *, ** and*** denote significance at 1%, 5% and 10% levels respectively

Source: Own estimation (CBN & NCDC database) using E-view 10

From table 7 the null hypothesis for the long-run series test implies normal distribution. There are three (3) conventional levels of statistical significance in econometrics namely 1% (0.01), 5% (0.05) and 10% (0.10) in this study. Therefore, the decision rule is that if the computed probability values for the test are greater than the chosen probability values, the Study will not accept the null hypothesis; otherwise, the study will accept it. In table 4.5, at 1%, 5%, and 10% significance levels, all the computed probability values for the series are within 1% (0.01) & 5% (0.05), and 10% (0.10) the chosen probability values, which imply that we do not reject the null hypothesis at 1%, 5% and 10% significant levels, meaning that all the series enjoyed normal distribution. Only cumulative coronavirus death cases had 11.2%, the hypothesis which the Study did not accept.

The projected coefficients of the long-run relationship between the COVID-19 pandemic variables and exchange rate volatility produced results in line with the diversity of existing literature evidence. Hence, the short-run ARDL estimates presented in table 4.6 indicated a positive and significant relationship between four independent variables and exchange rate volatility with coefficient values. It displays that a unit increase in the selected independent variables will lead to a positive change in the exchange volatility in the long run. The (LDCC), (LCCC) and (LDDC) had a positive relationship each with variability/volatility of exchange rate at 1%, 2%, 7%, and 9% level respectively with a coefficient value (0.014063), (0.301299), (0.065399) and (0.141036) respectively. It implies that LDCC, LCCC, LDDC, and LCDC have a significant positive relationship with exchange rate volatility. It indicates that all the selected covid-19 variables positively correlated with the exchange rate volatility in the long run. The finding was corroborated by (Gen-Fu et al. 2021, Benzid et al. 2020 & Ali et al. 2020).

Table 7: Long-Run ARDL Estimate and Coefficient Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LDDC	0.065399	0.034745	1.882256	0.0702
LCCC	0.301299	0.220119	1.368800	0.0177
LDCC	0.014063	1.166416	0.012057	0.0015
LCDC	0.141036	1.210034	0.116555	0.0989
C	0.957735	3.012207	0.317951	0.1529
@TREND	0.004112	0.007886	0.521413	0.6062

Note ***,** and * denote significance at 1%, 5% and 10% levels respectively

Source: Own estimation (CBN & NCDC database) using E-view 10

The null hypothesis for the long-run series test implies normal distribution. There are three (3) conventional levels of statistical significance in econometrics namely 1% (0.01), 5% (0.05) and 10% (0.10) in this study. Therefore, the decision rule is that if the computed probability values for the test are greater than the chosen probability values, the Study will not accept the null hypothesis; otherwise, the Study will accept it. In table 6, at 1%, 5%, and 10% significance levels, all the computed probability values for the series are within 1% (0.01) & 5% (0.05), and 10% (0.10) the chosen probability values, which imply that we do not reject the null hypothesis at 1%, 5% and 10% significant levels, meaning that all the series enjoyed normal distribution.

5 Conclusion and Recommendations

This paper delivers a simple and original statistical analysis of the impact of the COVID-19 pandemic on exchange rate volatility in Nigeria. The coronavirus has claimed thousands of lives and brought significant threats to countries from all over the World. The exchange rate actions have witnessed fluctuations due to the COVID '19 pandemic. The present results show that exchange rate risks have increased considerably in response to the covid-19 pandemic. Individual and national reactions are related to the harshness of the eruption in Nigeria. The great uncertainty of the pandemic and its associated economic losses has caused the exchange rate to become highly volatile.

Policy reactions to control the virus and level the exchange rate fluctuation are needed; however, most countries cannot cope with these defies. The exchange rate in most nations is responding differently to national-level policies and the general development of the pandemic.

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The Application of Lagrange Multipliers in Consumer Choice Theory

Využití Lagrangeových multiplikátorů v teorii spotřebitelské volby

PETR MACH

Abstract

This article deals with the consumer choice theory developed by Irving Fisher, Francis Edgeworth, Vilfredo Pareto, and John Hicks. A three-dimensional utility function is presented as an alternative to indifference curves. In mainstream textbooks, the indifference curves together with the budget constraint are used to find the optimum of a consumer graphically at a point where the budget line is a tangent line to an indifference curve. In this article, a vertical cross-section of the three-dimensional utility function and the Lagrange multipliers are applied to find the optimum of a consumer directly from the three-dimensional utility function subject to the budget constraint.

Keywords

consumer choice, consumer optimum, indifference curves, three-dimensional utility function

JEL Codes

B13, B21, C31, D11

DOI

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Abstrakt

Článek se zabývá teorií spotřebitelské volby vyvinutou Irvingem Fisherem, Francisem Edgeworthem, Vilfredem Paretem a Johnem Hicksem. Trojrozměrnou užítkovou funkci prezentuje jako alternativu k indifferenčním křivkám. V učebnicích hlavního proudu jsou indifferenční křivky spolu s rozpočtovým omezením používány k určení optima spotřebitele, které se nachází v bodě, kde je rozpočtová přímka tečnou indifferenční křivky. V tomto článku je optimum spotřebitele ukázáno přímo pomocí řezu trojrozměrné užítkové funkce podléhající rozpočtovému omezení a pomocí Lagrangeových multiplikátorů.

Klíčová slova

spotřebitelská volba, optimum spotřebitele, indifferenční křivky, trojrozměrná užítková funkce

1 Introduction

Consumer choice theory is one of the most fundamental concepts in economics. After all, it embodies the very definition of economics as a choice among alternatives subject to

scarcity. Every year millions of students around the world learn of the indifference curves, the budget line, and the consumer optimum in undergraduate courses of elementary economics. The consumer choice model also serves for the derivation of the shape of the demand curve, one of the most frequently used economics curves. And it is, of course, used to derive the utility-possibility frontier, a key concept in welfare economics. In short, consumer choice theory is a crucial concept in economics.

In this article, the most common definition of economic science is reminded to emphasise the importance of the indifference analysis. Then the history of the discovery of indifference curves in economic thought is described. A three-dimensional utility function is used to demonstrate the fundamentals of consumer choice theory, and Lagrange multipliers are applied as a tool to find the optimal choice of a consumer. A methodological note is taken regarding the usefulness of the application of the utility function in economics vis-à-vis the fact that it is hardly possible to estimate one's utility function. Finally, a recommendation is made regarding the usage of a three-dimensional utility function for didactical and analytical purposes. Briefly, the objective of this paper is to present clearly a possibility of teaching the concept of utility using a three-dimensional utility function subject to a budget constraint.

2 Definition of Economics

Several definitions are used to describe economic science. Probably the most common one is by British economist Lionel Robbins, who wrote that *"Economics is the science which studies human behaviour as a relationship between given ends and scarce means which have alternative uses."*¹

Similarly, American economist Murray Rothbard later wrote: *"(Human) action involves the employment of scarce means to attain the most valued ends. Man has the choice of using the scarce means for various alternative ends, and the ends that he chooses are the ones he values most highly."*² Then he added that *"various ends are ranked in the order of their importance. These scales of preference may be called happiness or welfare or utility or satisfaction or contentment."*³

Whatever the definition, it is assumed that there are limited resources and that people make choices about how to spend these resources among alternative uses. This is precisely what consumer choice theory applies in a model where a consumer with a limited budget chooses between two goods: The scarce means is the budget constraint; the alternative uses are the two goods that an individual can buy and consume, and people make choices according to their preferences or to their utility as represented by the indifference curves.

1 Robbins (1932), p. 15.

2 Rothbard (1962), p. 17.

3 Rothbard (1962), p. 18.

3 The history of indifference curves

A typical picture in economics textbooks shows a two-dimensional graph with axes representing quantities of two goods, X and Y, the budget line showing all combinations of the two goods that the consumer can buy within a limited budget and with given prices of the two goods. Indifference curves represent such combinations of the two goods that give the consumer an equal satisfaction. The point at which the budget line is a tangent line to an indifference curve represents the optimal choice because all other combinations lying on the budget line intersect lower indifference curves and therefore provide lower utility.

Before the establishment of the indifference analysis in economic science, economists described utility only as a two-dimensional function where total utility depended on the quantity of only one good consumed. For instance, Alfred Marshall in his *Principles of Economics* (first published in 1890) formulated the law of diminishing marginal utility: *"The marginal utility of a thing to anyone diminishes with every increase in the amount of it he already has."*⁴ Marshall, however, did not think of the utility function as of a function of more independent variables.

The inclusion of alternative goods as independent variables into the utility function was revolutionary because it substantialized the very definition of economics, which is about choices from alternatives.

Consumer choice theory, with indifference curves, a budget line and optimum was developed mainly by Francis Ysidro Edgeworth, Irving Fisher, Vilfredo Pareto, and John Hicks (in this order), whereas Edgeworth was probably the first man who used the term indifference curve.

In 1891 Francis Ysidro Edgeworth published the book *Mathematical Psychics: An Essay on the Application of mathematics to the Moral Sciences*. He defined the system of two consumers X and Y trading two goods in quantities x for y . He formulated their three-dimensional utility functions, with the dimension of utility "sticking up perpendicularly from the paper": *"Let P , the utility of X, one party, $= F(x, y)$, and Π , the utility of Y, the other party, $\Phi = (x, y) \dots$ Consider $P - F(x, y) = 0$ as a surface, P denoting the length of the ordinate drawn from any point on the plane of xy (say the plane of the paper) to the surface. Consider $\Pi - \Phi(x, y)$ similarly."*⁵

Then he defined the contract curve and coined the term "indifference [curve]" (without actually depicting it): *"It is required to find a point (x, y) such that, in whatever direction we take an infinitely small step, P and Π do not increase together, but that, while one increases, the other decreases. ... It is here proposed to call [the locus] the contract curve. ... Consider first in what directions X can take a small step ... It is evident that X will step only on one side of a certain line, the line of indifference, as it might be called."* (Edgeworth, 1891, p. 21)

⁴ Marshall (1930), p. 93.

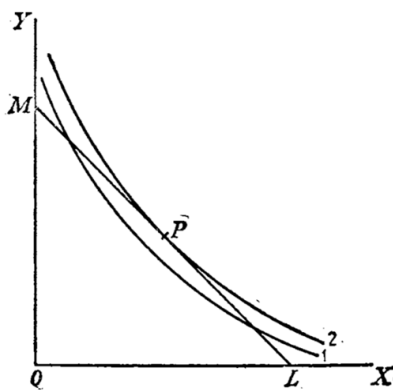
⁵ Edgeworth (1891), p. 20-21.

Irving Fisher used indifference curves in his doctoral dissertation in 1892. In 1926 the work was published under the title *Mathematical Investigations in the Theory of Value and Prices*. Fisher wrote: "Consider horizontal sections of [three-dimensional utility function] surface, that is sections parallel to the plane of A and B axes. Each section forms a curve which may be called an indifference curve. It is the locus of points representing all consumption-combinations of A and B which have a given total utility."⁶ and "[The individual] will select his combination in such manner as to obtain the maximum total utility, which is evidently at the point... where (AB) is tangent to an indifference curve."⁷

Vilfredo Pareto published his theory of indifference curves in the Italian *Giornale degli Economisti e Annali di Economia* in 1900. He wrote: "On each point of the plane x, y – supposed horizontal – let us erect perpendiculars equal in length to the [utility] of the point at the foot of the perpendicular. The set of points thus obtained will represent a surface, the indifference lines of which are the projections of the level curves. These curves themselves may be called lines of indifference on the surface."⁸

John Hicks presented indifference curves in 1930s (Hicks, 1934 and Hicks, 1939). In 1939 John Hicks in his book *Value and Capital* presented a clear graph with axes X and Y representing the quantities of two goods, the budget line and a set of two indifference curves of which one intersects the budget line at two points, and one touches the budget line at the optimum (see Figure 1). Nowadays a similar picture can be found in all mainstream economics textbooks.

Figure 1: Hicks's Consumer optimum with the budget line and the indifference map



Source: Hicks, 1939, p. 16

As Hicks explained, "It is only when the [budget] line ... touches an indifference curve that utility will be maximized. For at a point of tangency, the consumer will get on to a lower indifference curve if he moves in either direction."⁹

⁶ Fisher (1926), p. 70.

⁷ Fisher (1926), p. 72.

⁸ Pareto (2008), p. 474.

⁹ Hicks (1939), p. 17.

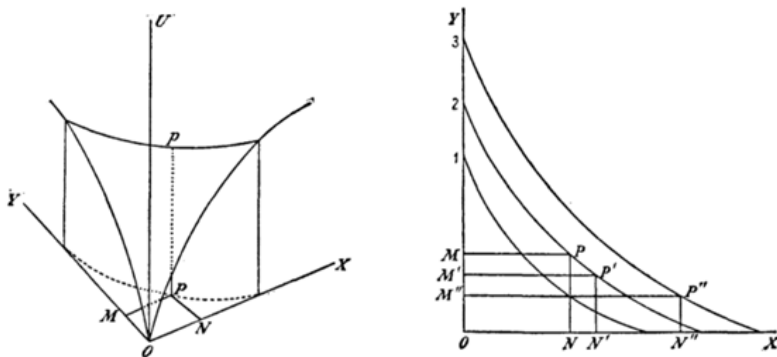
Hicks presented indifference curves as a practical derivation from a three-dimensional utility function. In a three-dimensional graph, the vertical axis represents the total utility and the horizontal axes X and Y represent quantities of the two goods.

Hicks was aware of the fact that drawing and analysing three-dimensional graphs was impractical and complicated. He, therefore, saw a model in which the third dimension was represented by the contour lines – the indifference curves – in a two-dimensional graph as a simplification in comparison with a three-dimensional spatial function. See Figure 2 for Hick's depiction of the utility function both in three dimensions and in two dimensions.

As Hicks put it, *"When we are interested in two commodities, we can draw a utility surface... but three-dimensional diagrams are awkward things to handle. Fortunately having once visited the third dimension we need not stay there. The third dimension can be eliminated, and we can return to two... The contour lines of the utility surface...are the indifference curves."*¹⁰

Indifference curves are nothing but a conversion of the utility function from three dimensions into more practical two dimensions.

Figure 2: Hicks's Three-dimensional utility function and the indifference curves



Source: Hicks, 1939, p. 15

Since the discovery of indifference curves, economists have not been interested in the three-dimensional utility function anymore, because it is impractical in comparison with the two-dimensional graph of indifference curves.

¹⁰ Hicks (1939), p.13.

4 A modern display of the three-dimensional utility function

In the 21st century, however, the usage of three dimensions is not that awkward any more. With a wide availability of spreadsheet applications, the utility theory of Edgeworth, Fisher, Pareto, and Hicks can be refreshed, and the three-dimensional utility function can be presented in a modern way.

So, let us formulate the utility function knowing that the indifference map – the set of the infinite number of indifference curves – is a two-dimensional representation of a three-dimensional utility function. Total utility U is the dependent variable, and Q_X and Q_Y , the quantities of the two goods X and Y , are the independent variables.

$$U = f(Q_X, Q_Y)$$

There are some underlying assumptions regarding the utility function.

First, it starts at the origin of the axes since it is assumed that if the consumer consumes none of X and none of Y he gains no satisfaction from consumption.

Second, the function is concave as each additional increase in consumption of any of the goods increases the utility by less than any previous increase.

Third, total utility grows even if the quantity of one of the goods remains at zero. This condition distinguishes the utility function from a technically similar production function where it is necessary, as it is assumed, to employ both factors of production to produce something. Therefore, the Cobb-Douglas function, usually used by economists to describe the production function, does not fit for the description of the utility function.

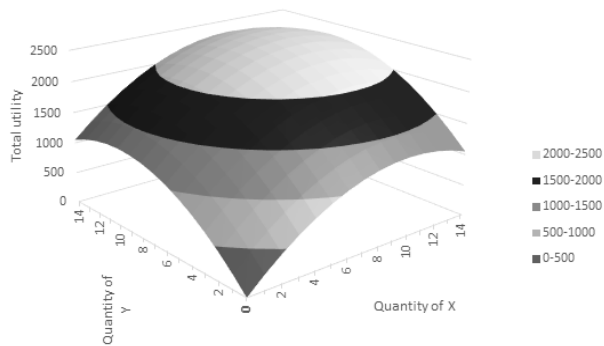
A simple mathematical function complying the above-mentioned assumptions is a quadratic polynomial passing through the origin of the Cartesian coordinate system.

$$U = aQ_X - bQ_X^2 + cQ_Y - dQ_Y^2$$

This total utility is the sum of the utility gained from the consumption of only X ($U_X = aQ_X - bQ_X^2$) and the utility gained from the consumption of only Y ($U_Y = cQ_Y - dQ_Y^2$)

This utility function can be represented by the three-dimensional graph of a paraboloid (see Figure 3).

Figure 3: A three-dimensional utility function



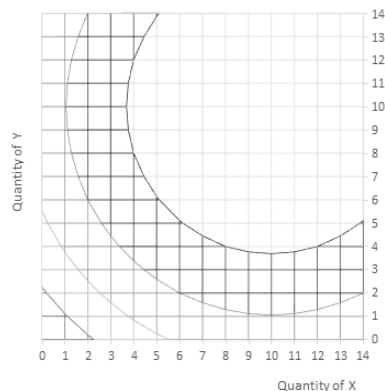
Source: Author

A contour map can be derived out of this three-dimensional graph (see Figure 4), whereas a contour line of a three-dimensional function of two independent variables is a curve along which the function has a constant value.

Like in geography where a three-dimensional landscape can be transformed into a contour map, called a topographic map, a three-dimensional utility function can be transformed into a contour map called an indifference map.

In topography, contour lines represent the points of an equal elevation, while in economics, contour lines called indifference curves join points giving the consumer an equal utility.

Figure 4: Contour lines of a three-dimensional utility function



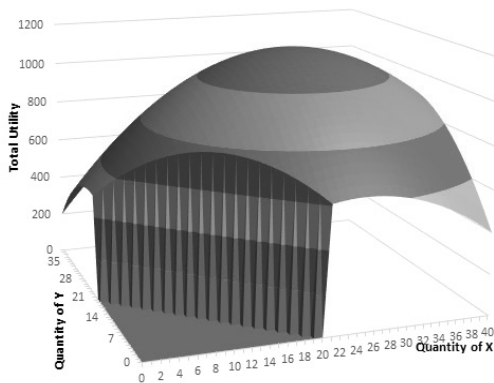
Source: Author

5 A three-dimensional optimum

A graphical method to find the optimum of a three-dimensional function subject to a constraint is to make a vertical cross-section and to find its minimum or maximum.

The consumer optimum (i.e. the maximum of the utility function subject to the budget constraint) is the maximum of the vertical cross-section of the three-dimensional utility function, erected from the budget line (see Figure 5).

Figure 5: The three-dimensional consumer optimum



Source: Author

In a contour graph, the optimum of a consumer lies at the point at which the budget line is a tangent line to an indifference curve, which is the well-known picture of consumer choice in most economics textbooks.

6 Lagrange multipliers

With the reapplication of a three-dimensional utility function, also an algebraic solution to the utility maximisation problem can be applied.

An algebraic method to find the maximum of a multi-dimensional function subject to a constraint is Lagrange multipliers named after Italian-French mathematician Joseph-Louis Lagrange.

This method can be as well applied in economics to find the consumer optimum, subject to a budget constraint.

The optimisation problem here is to find the maximum of the utility function $f(Q_X, Q_Y)$ subject to the budget constraint $g(Q_X, Q_Y) = 0$.

A new variable λ (lambda) is introduced to create the Lagrangian expression

$$L = f(Q_X, Q_Y, \lambda) = f(Q_X, Q_Y) - \lambda \cdot g(Q_X, Q_Y)$$

for which the partial derivatives with respect to Q_X and Q_Y ($\partial L / \partial Q_X$ and $\partial L / \partial Q_Y$) are found and set equal to zero.

Together with the budget constraint $g(Q_X, Q_Y) = 0$, three equations with three unknown variables are available. It allows finding the solution – the maximum of the original utility function, subject to the budget constraint.

The budget constraint for two goods is

$$P_X \cdot Q_X + P_Y \cdot Q_Y - \beta = 0$$

where P_X is the price of good X, P_Y is the price of good Y, and β is the size of the budget.

So, we search the solution for the set of the three equations

$$\frac{\partial L}{\partial Q_X} = 0$$

$$\frac{\partial L}{\partial Q_Y} = 0$$

$$P_X \cdot Q_X + P_Y \cdot Q_Y - \beta = 0$$

which gives the optimum Q_X and Q_Y .

Have the following numerical example.

A consumer has a monthly credit of EUR 100 on his mobile phone. He or she spends it on two goods, the text messages and the calls, with a text message costing EUR 0.5 and a call costing EUR 1.0. Assume (arbitrarily) that the utility function describing his satisfaction from texting and calling can be approximated as

$$TU = 180Q_T - Q_T^2 + 160Q_C - Q_C^2$$

The budget constraint is

$$0.5 \cdot Q_T + 1.0 \cdot Q_C - 100 = 0$$

Create the Lagrange function

$$L = 180Q_T - Q_T^2 + 160Q_C - Q_C^2 - \lambda(0.5 \cdot Q_T + 1.0 \cdot Q_C - 100)$$

Set the partial derivatives equal to zero to find the maximum

$$\frac{\partial L}{\partial Q_T} = 180 - 2Q_T - 0.5\lambda = 0$$

Hence,

$$Q_T = \frac{180 - 0.5\lambda}{2} = 90 - 0.25\lambda$$

$$\frac{\partial L}{\partial Q_C} = 160 - 2Q_C - 1.0\lambda = 0$$

Hence,

$$Q_C = \frac{160 - 1.0\lambda}{2} = 80 - 0.5\lambda$$

Substituting this to the budget constraint

$$0.5 \cdot Q_T + 1.0 \cdot Q_C = 100$$

gives

$$0.5 \cdot (90 - 0.25\lambda) + 1.0 \cdot (80 - 0.5\lambda) = 125 - 0.625\lambda = 100$$

$$\lambda = 40$$

Hence,

$$Q_T = 90 - 0.25\lambda = 80$$

$$Q_C = 80 - 0.5\lambda = 60$$

In this example, the consumer will spend his monthly credit of EUR 100 so that he sends 80 text messages and makes 60 calls.

7 Discussion

It can be objected that the usage of a (three-dimensional) utility function is useless and impractical as we can hardly estimate one's utility function.

After all, Pareto believed that bypassing a three-dimensional utility function with two-dimensional indifference curves is practical because, according to Pareto, indifference curves can be found.

It was pointless, according to Pareto, to analyse a three-dimensional utility function which can hardly be measured. It is sufficient to analyse indifference curves themselves, which are “a direct result of experience”.

In his *Letters to Maffeo Pantaleoni* in 1899 he gave the following example: “Here is a child. I ask him: ‘Which would you rather have, ten cherries and ten dates, or 9 dates and 11 cherries?’ ‘I would prefer the first combination.’ ‘What would you say to 9 cherries and 15 dates?’ ‘It is the same to me as 10 dates and 10 cherries.’ Now I have two points, *a* and *b*, of the indifference curves. Others points could be found by the same method.” (Pareto, 1999, p. 171)

We can argue that even if indifference curves, unlike the utility function itself, can be measured directly, they are but a reflection of the utility function. Whether we are able to estimate the utility function or not, the utility function exists.

Consider an analogy with temperature. Before the thermometer was invented, it was difficult or even impossible to measure temperature, but yet different levels of warmth existed. A person does not need to have a thermometer to recognise whether to wear a sweater or just a T-shirt.

Similarly, one does not need to have a “utility-meter” to recognise whether to watch TV one more hour, whether to eat one more cake, or whether to turn up the volume of music by one degree.

People behave as if they knew their utility functions and maximised them subject to a budget or time constraint.

As American economist Milton Friedman put it, a billiard player also does not calculate the strengths and directions of his strikes and still, he is able to aim the ball where he wants it. Although he does not calculate the strikes, the strikes are as if he had calculated them. The same applies to the nature and the behaviour of species, e.g. the position and density of leaves on a tree. The leaves are positioned as if they knew the physical laws and deliberately moved to optimise the received sunlight. We know that neither the billiard player nor the leaves on a tree calculate how to behave, but they behave as if they have calculated it. If they did not, they would have to go and leave a niche to others.

In his book *Essays in Positive Economics*, Friedman wrote: “Consider the problem of predicting the shots made by an expert billiard player. It seems not at all unreasonable that excellent predictions would be yielded by the hypothesis that the billiard player made his shots as if he knew the complicated mathematical formulas that would give the optimum directions of travel, could estimate accurately by eye the angles, etc., describing the location of the balls, could make lightning calculations from the formulas, and could then make the balls travel in the direction indicated by the formulas.”¹¹

Of course, that the billiard player does not calculate directions and strengths, the point is that he behaves as if he did because otherwise, he would not be an expert billiard player.

¹¹ Friedman (1953), p. 12-13.

"Let us turn now to an...example, this time a constructed one designed to be an analogue of many hypotheses in the social sciences. Consider the density of leaves around a tree. I suggest the hypothesis that the leaves are positioned as if each leaf deliberately sought to maximize the amount of sunlight it receives, given the position of its neighbours, as if it knew the physical laws determining the amount of sunlight that would be received in various positions and could move rapidly or instantaneously from any one position to any other desired and unoccupied position."

*"Is the hypothesis rendered unacceptable or invalid because, so far as we know, leaves do not "deliberate" or consciously "seek", have not been to school and learned the relevant laws of science or the mathematics required to calculate the "optimum" position, and cannot move from position to position? Clearly, none of these contradictions of the hypothesis is vitally relevant; the phenomena involved are not within the "class of phenomena the hypothesis is designed to explain"; the hypothesis does not assert that leaves do these things but only that their density is the same as if they did."*¹²

For the same reason, it entirely makes sense to analyse a three-dimensional utility function in consumer choice theory. Although no one calculates Lagrange multipliers, no one calculates the derivatives, and no one draws down their indifference curves and budget line when shopping, people behave as if they did it.

8 Conclusion and recommendation

This article showed how a three-dimensional display could be useful in economics, specifically in consumer choice theory. It was explained how the mathematical method of the Lagrangian multipliers and the graph of a vertical cross-section could be applied in economics to determine consumer optimum.

The author of this article believes that it would be useful to include a three-dimensional utility function into economics textbooks. With modern graphical methods, displaying three-dimensional functions would help students understand the fundamental principles of utility and consumer choice.

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¹² Friedman (1953), p. 12.

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Differences between Online Prices and the Consumer Prices Index During Covid-19 in Germany

Rozdíly mezi cenami na internetu a indexem spotřebitelských cen v období Covid-19 v Německu

ROBERT LASKOWSKI

Abstract

The purpose of this paper is to examine various online price indices with the consumer price index in Germany during the Covid-19 pandemic from 2019 to 2021. This investigation refers to 9,977 items of the product category stationery and drawing supplies, whose sales prices were automatically recorded and evaluated by Amazon.de and idealo.de on a daily basis through web scraping. The official consumer price index of the German Federal Statistical Office of the 3rd Stella level is available for this product category, which makes a direct comparison possible for this study. It was found that online prices are more dynamic and volatile and react directly to external market influences than the prices of stationary trade, which are reflected in the CPI of the German Federal Statistical Office. A deviation of up to 11.7% between the calculated online price indices (OPI) and the German consumer price index (CPI) was found. Especially the value-added increase on 01.01.2021 shows a deviation effect of 9.7% to the CPI. It could be determined that the online price indices and the CPI showed the same trends, but with different characteristics. While Amazon's OPI was still in line with the CPI in 2020, deviations of over 6% were observed in 2021. The prices of other online shops already showed significant deviations from the CPI within the first lockdown in April 2021, which was imposed by the government to contain the Covid 19 pandemic in Germany and forced the stationary trade to close down across the country.

Keywords

inflation, online price index, consumer price index, ecommerce, online trade, statistical office, Amazon, Idealo

JEL Codes

G00, G10, E20

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Abstrakt

Cílem tohoto článku je prozkoumat různé online cenové indexy s indexem spotřebitelských cen v Německu během pandemie Covid-19 v letech 2019 až 2021. Toto šetření se týká 9 977 položek produktové kategorie psací a rýsovací potřeby, jejichž prodejní ceny

byly automaticky zaznamenávány a vyhodnocovány na denní bázi prostřednictvím web scrapingu na stránkách Amazon.de a idealo.de. Pro tuto kategorii výrobků je k dispozici oficiální index spotřebitelských cen německého Spolkového statistického úřadu 3. stupně Stella, který pro tuto studii umožňuje přímé srovnání. Bylo zjištěno, že ceny na internetu jsou dynamičtější a volatilnější a reagují přímo na vnější tržní vlivy, než ceny stacionárního obchodu, které se odrážejí v indexu spotřebitelských cen německého Spolkového statistického úřadu. Byla zjištěna odchylka až 11,7 % mezi vypočtenými indexy online cen (OPI) a německým indexem spotřebitelských cen (CPI). Zejména zvýšení přidané hodnoty k 1. 1. 2021 vykazuje odchylný vliv 9,7 % vůči indexu spotřebitelských cen. Bylo možné zjistit, že OPI a CPI vykazují stejné trendy, ale s odlišnými charakteristikami. Zatímco v roce 2020 byl OPI společnosti Amazon stále v souladu s CPI, v roce 2021 byly pozorovány odchylky přesahující 6 %. Ceny ostatních internetových obchodů vykazovaly výrazné odchylky od indexu CPI již v rámci první výluky v dubnu 2021, kterou zavedla vláda za účelem omezení pandemie Covid 19 v Německu a která si vynutila uzavření kamenných obchodů v celé zemi.

Klíčová slova

inflation, index online cen, index spotřebitelských cen, e-commerce, online obchodování, statistický úřad, Amazon, Idealo

1 Introduction

The purpose of this paper is to examine online prices in comparison with the official consumer price index of the German Federal Statistical Office and the statistical offices of the German states. This investigation is triggered by an announcement of the German Federal Statistical Office that consumer prices could not be collected in the same quality and quantity as usual during the government-imposed lockdowns at pandemic times (German Statistics Office, 2022).

After the WHO declared the pandemic on March 11, 2020, various measures were initiated in Germany to contain the Corona virus and protect the health care system (Räker et al., 2021). In addition to wearing mouth-nose protection, measures were taken primarily to limit contacts between individuals. People were urged to stay at home, companies had to close their production facilities, and service companies were no longer allowed to offer their services. Stationary trade was also closed on a large scale to protect people. Hardware stores, stationery shops, clothing stores and even hairdressers had to close their stores due to the law. Only food and beverage stores, as well as stores that satisfied people's basic needs, were allowed to open. At the end of the day, these restrictive measures became known as Lockdown and Lockdown "Light" and will probably go down in history books as such. The state repeatedly tried to loosen the lockdowns and partial lockdowns with sporadic relaxations, but then had to reinstate them when new waves of viruses appeared.

The order of the day was that everyone who could do their work from home should stay in the home office. This created an increased demand for office supplies and stationery to make private rooms and homes fit for work. Home office workers now needed paper, pens,

printers, monitors, staplers, hole punches, binders, and erasers at home. Office and stationery accounted for 1.5% of online retail, led by CE/electrical at 24.5% and fashion and accessories at 23.1%. In 2020 alone, the share of office and stationery products purchased online increased from 24.3% to 30.8% year-on-year (Trend Monitor, 2021). This means that just under one in three items in this class of goods is already purchased online.

With the area-wide closure of stationary trade, online trade received a gigantic boost. Those who had previously closed their minds to buying goods on the World Wide Web were now forced to satisfy their demand online. In 2020 alone, online trade in Germany grew by 23% to 72.8 billion euros (Online Monitor, 2021). The forecast for 2021 was already estimated at 85 billion euros, which already accounts for 18% of total consumer spending, if food is not included. This means that almost every fifth euro is already spent online by consumers. As the level of digitization in a society increases, so does the proportion of goods and services purchased online by consumers (Charbonneau et al., 2017).

For the calculation of the consumer price index, the statistical offices of the federal states manually collect prices predominantly in stationary trade with the support of up to 600 commissioned price collectors (German Statistics Office, 2022). From 650 goods classes, about 300,000 prices are normally recorded at various locations in Germany in all possible stores. These prices are then forwarded by the federal states to the German Federal Statistical Office. Only a few prices, such as rental car conditions or insurance rates, are already recorded centrally online. Although the recording of price points via scanner data and web scraping is on the rise, it has so far only been a small component in price collection. In the future, new price collection capabilities are expected to reduce and replace manual effort (Hansen, 2020a).

Online retail reacts much faster to external market influences due to modern software and AI solutions, making it more volatile but also more adaptable (Cavallo, 2015). Prices are constantly compared and adjusted by online stores and online marketplaces in an automated way. The best offer wins the customer (Chevalier and Goolsbee, 2002). The customer already has several offers for one and the same item from different sellers on marketplaces such as Idealo, Amazon and Ebay. The buyer can already decide on the cheapest offer for one and the same item on one website.

Idealo.de is a price comparison portal that compares prices of different items and different online stores. Users can use this online portal to find out in which online store they can buy their desired item at the lowest price. This circumstance basically leads to the fact that the consumer is always informed where he can obtain his products at the lowest price and the demand is channelled to the cheapest supplier. Competition in online retail is highly price-driven (Cavallo, 2018), which usually means that the cheapest provider also gets the most sales. The successes of Amazon, Ebay and Zalando are due to this effect. A large demand is served by a small number of suppliers.

2 Research question and hypothesis

Due to the general shift in sales from bricks-and-mortar retailing to online retailing in conjunction with dynamic pricing systems, it is hardly possible to survey the "true" inflation or determine the correct consumer price index according to traditional surveys (Hansen, 2020b). However, especially during the government restrictions due to the pandemic, respectively the lockdowns in April and December 2020, price collection could not be carried out in the usual quality and quantity, as stationary retailers were largely closed across the country.

Office and stationery stores were closed and consumer demand shifted even more to online retail. Additionally, goods class sales were driven by corporate home office arrangements. Since price collectors can hardly have been able to collect prices for certain goods classes on a stationary basis, the quality and accuracy of the consumer price index must have suffered as well. The goods class stationery and painting supplies will serve as an example for this research to determine the deviations between online prices and the consumer price index during the pandemic.

This leads to the following research question: How high is the deviation of the official consumer price index from the online prices of the goods class stationery and painting supplies? Based on the online market behaviour described above, it can be assumed that prices in online retail are more favourable than prices in stationary retail or lower than the official consumer price index (Cavallo, 2016).

However, the increased demand in online retail during the pandemic measures must in turn have led to an increase in prices in online retail. Compared to brick-and-mortar retail, the online market is occupied by only a few market participants with national to global positions. This means that there is a significant increase in demand in relation to the existing supply during the period under review. The hypothesis of the paper is that the consumer price index, collected exclusively from online prices, must be higher than the official consumer price index of the German Federal Statistical Office. Online retail demand has been strongly channelled in the 2020 and 2021 pandemic years. Thus, the availability of goods had a greater influence on supply than price.

3 Data and Methods

The retail giant Amazon acts as both a seller and a marketplace on its website. As a seller, Amazon buys goods from manufacturers and then resells them to consumers on its website in its own name and for its own account. Amazon determines the selling price and shipping costs for these items. However, Amazon also acts as a marketplace where other online sellers and online shops (general called sellers) can offer the same goods. In the marketplace, Amazon has no influence on the selling prices. Each seller of goods is allowed to set their own selling price. At the end of the day, most of the fast-moving consumer goods (FMGC) are offered by Amazon and a lot of other sellers or online shops. For example, the same coffee maker is offered by Amazon and by multiple sellers. When the customer gets to the Amazon detail page of the coffee maker, he sees different offers

for the coffee maker. One offer is Amazon and many more are from other sellers. The consumer is free to choose who to buy the coffee maker from. However, Amazon already puts the best offer for the consumer in the Buy Box. The Buy Box is a synonym for the best offer from price and shipping costs, moreover, the customer finally buys the item.

Thus, the Amazon offer is also always opposed by a marketplace offer from another seller. With this principle, Amazon creates competition on its own website. With the battle of all sellers for the Buy Box, the best possible offer from price and shipping costs is determined for the consumer. For this purpose, sellers as well as Amazon use modern computer-aided price adjustment systems that fully automate the battle for the Buy Box. If a seller wins the Buy Box because it has the best offer, it still has to pay Amazon a marketplace fee or a brokerage fee.

Competition among all sellers for the Buy Box determines the best offer for the consumer. Because of its market power, Amazon is also always the focus of competition regulators. However, since competitive behaviour on Amazon primarily serves the customer, Amazon escapes impending restraints. This is because dominant market positions of individual market participants generally lead to the expectation of high prices. In Amazon's case, this behaviour is rather beneficial for the consumer.

Idealo is a price comparison portal. Consumers can search for products there to find the best offer on the web. Idealo scans different online stores for the current offer and displays them on their website. The best offer from price and transportation costs presumably gets the most inquiries and sales. In the case of the coffee maker, the consumer can search for this model on Idealo. Idealo now displays all online stores including the sales price and shipping costs that sell this coffee machine. All online stores with the respective offer of the coffee maker are directly linked and easy to find for the buyer.

For our investigation, we are interested in several parameters. First, we want to determine the inflation of the Buy Box price on Amazon, since it designates the price, moreover, the consumer bought the product on Amazon. In addition, we are interested in the best price from Idealo, since this price presents the best offer on the Internet among all web stores. Third, we evaluate the best offer of a seller who uses Amazon as a marketplace.

With the help of analysis and scraping software, we can draw on 9,977 items with daily online prices in the stationery and painting supplies goods class for this study. Our sample includes items from ten different manufacturers with 17 different brands. Of these products, the best daily price was scraped daily on www.idealo.de during the period from January 01, 2019 to December 31, 2021. On www.amazon.de, the best seller price, the current Amazon price and the Buy Box price were scanned daily. For each of these prices, we create online price indices and compare them with each other and with the official consumer price index of the German Federal Statistical Office. The German Federal Statistical Office provides the consumer price index for the goods classes individually, including the stationery and painting supplies category. Thus, a direct comparison within the category is possible for this study. The prices from 2019 serve as the base year before the pandemic and the prices from 2020 and 2021 reflect the data basis within the pandemic.

Table 1: Data collection scheme: daily Buy Box price, daily best price on Idealo, daily best seller price.

Products Office	01.01.2019			02.01.2019			...	31.12.2021		
	Idealo	Seller	Buybox	Idealo	Seller	Buybox		Idealo	Seller	Buybox
Product 0001	8,34 €	8,34 €	7,12 €	6,99 €	8,39 €	7,12 €		8,99 €	8,77 €	8,49 €
Product 0002	5,74 €	5,88 €	5,99 €	5,77 €	6,39 €	5,77 €		5,54 €	5,54 €	5,55 €
Product 0003	20,32 €	18,64 €	19,45 €	17,89 €	17,89 €	19,45 €		21,33 €	23,49 €	21,33 €
...										
Product 9977	9,99 €	9,99 €	10,98 €	10,98 €	11,55 €	10,98 €		11,59 €	11,47 €	11,89 €

Inflation in Germany is determined on the basis of the change in the consumer price index from month to month of the previous year. The German State Statistical Offices record prices of 650 goods classes and 300,000 articles and report them to the German Federal Statistical Office to determine inflation (German Statistics Office, 2021). In our analysis, we restrict ourselves to the goods class stationery and drawing materials of the 3rd Stellar level, SEA CPI no. 0954 (German Statistics Office, 2022).

Table 2: German Federal Statistical Office 3rd Stellar Level Inflation from January 2020 to December 2021 for the Goods Class Stationery and Drawing Materials (SEA CPI No. 0954).

Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
1.70	0.80	1.50	1.90	2.20	3.00	1.10	0.50	0.10	0.10	-0.50	0.50
Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
1.70	2.50	1.50	0.80	0.50	0.10	2.60	4.10	4.30	4.00	3.90	2.40

For our investigation, we check whether the sample is representative. Since we do not know the size of the population for our study, we can use the simplified form of the equation for determining a representative sample size (1). In equations (2) and (3) we set $\pi = 0.5$ to ensure that the sample contains the true value even in the worst case. The π -value can range from 0% to 100% and is usually not known in advance of a sample investigation. With $\pi = 0.5$, it is ensured that the equation for determining the sample with $\pi(1 - \pi)$ obtains its maximum. With $\pi = 0$ and $\pi = 1$, the margin of error $E = 0$. To ensure a high confidence level in our sample of at least 99%, we set $z = 2.58$, as you see in equation (2) and (3). We determined the z -value using the z -value table of the standard normal distribution (Taherdoost, 2016).

$$E = z * \sqrt{\frac{\pi(1-\pi)}{n}} \quad (1)$$

n = sample size, π = proportion of the characteristic in the population, z = width of the confidence interval, E = margin of error

In our case:

$$E = 2.58 * \sqrt{\frac{0.5(1-0.5)}{1,858}} = 0.03 \text{ (with the smallest sample size, } n=1,858) \quad (2)$$

$$E = 2.58 * \sqrt{\frac{0.5(1-0.5)}{5,117}} = 0.02 \text{ (with the largest sample size, } n=5,117) \quad (3)$$

With our smallest valid sample size of $n = 1,858$ in the first month of our study (January 2021), we must allow for a margin of error of $E = 3\%$. That is, our results may differ by 3% up or down. The confidence interval decreases to 2% in our sample in the last month (December 2021) of our study with a valid sample size of $n = 5,117$.

$$n = \frac{z^2 * \pi(1-\pi)}{E^2} \quad (4)$$

Confidence level: z-value from table Standard normal distribution (Kotrlík and Higgins, 2001): 90% → 1.65, 95% → 1.96, 99% → 2.58

The minimum sample size for an unknown population is calculated (5), with a maximum permissible margin of error of 3% and a confidence level of 99% (Taherdoost, 2016).

$$n = \frac{2.58^2 * 0.5(1-0.5)}{0.03^2} = 1,849 \quad (5)$$

With at least 1,850 item prices per month per day, the resilience of the study is given.

We calculate the price index from all three data series, from Amazon buy box (6), from the best idealo price index (7) and from the best seller price index (8). We determine a monthly average price per article if there are at least ten daily prices of an article per month. We determine the price index per item and form the monthly average from all item indices. We use the Laspeyres index formula for the calculations of the online price index, which is also used in the calculation of the consumer price index and the Harmonized Index of Consumer Prices (Camba-Mendez et al., 2002).

Calculation Buy Box price inflation (BBI):

$$BBI = \sum_{t=0}^t \frac{BB_t - BB_{t-1}}{BB_{t-1}} \quad (6)$$

Calculation best Idealo price inflation (IDI):

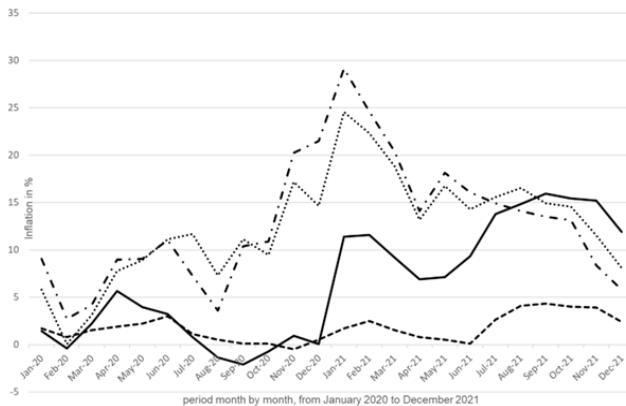
$$IDI = \sum_{t=0}^t \frac{ID_t - ID_{t-1}}{ID_{t-1}} \quad (7)$$

Calculation best seller price inflation (SEI):

$$SEI = \sum_{t=0}^t \frac{SE_t - SE_{t-1}}{SE_{t-1}} \quad (8)$$

t = period month, t-1 = same month, previous year, BB = buy box price, ID = best Idealo price, SE = best seller price, BBI = buy box price inflation, IDI = Idealo price inflation, SEI = seller price inflation

Figure 1: Comparison of German Federal Statistical Inflation with Buy Box price index, Idealo price index and best seller price index in the period January 2020 – December 2021



4 Results

The evaluation of the data is quite surprising, as the samples deviate strongly from the official inflation rate. In general, however, in figure (1) one can see that the indices at least show the same trend or direction. Thus, when German inflation falls, the indices in the samples also fall. Buy Box inflation, which stands for the selling price of an item on Amazon at the end of the day, still goes reasonably hand in hand with official inflation in 2020, but then diverges significantly as of January 2021.

The second half of 2020 is characterized by lockdowns and partial lockdowns (figure 1). Retail is mostly closed and consumers are forced to make their purchases online. In addition, there is an increased demand of stationery and office supplies in private households due to home office regulations. The explosion of demand in online retail, driven by more customers and more demand, explains the price increase. Since sellers can also gain the Buy Box and thus influence the Buy Box price as well. The Buy Box inflation is also influenced by the seller price. The German Federal Statistical Office collects prices for office supplies and stationery only in brick-and-mortar stores, most of which were closed, which certainly leads to the moderate inflation rate.

The rising inflation rates of the Seller and Idealo prices in the second half of 2020 are interesting. Both curves run parallel and almost on top of each other, which suggests a strong correlation. The Idealo and Seller inflation still increase significantly during the period of the VAT cut compared to the Amazon prices and peak at 29.1% in January 2021 compared to the previous year. We explain this effect with an increased demand, especially in smaller online stores. Amazon is already partially sold out of individual items, which causes prices in other online stores to rise.

While Amazon Buy Box inflation is negative in the second half of 2020 due to the temporary reduction in VAT (-3%), it jumps from 0% to 11.4% in January 2021. For the same month, the German Federal Statistical Office publishes an inflation rate of just 1.7% for this goods class. The divergence of around 10% between Buy Box inflation and official inflation will remain until the end of 2021. Traditionally, Amazon negotiates new purchasing conditions and new purchase prices with suppliers for the following year, which could indicate the jump. That Amazon is using the VAT increase to raise prices is also obvious. Extremely rising energy prices, low availability of goods due to a shortage of raw materials and an increased demand for goods are an additional explanation for the rising prices at the turn of the year. The significant increase in Buy Box inflation and official inflation in the second half of 2021 is due to the renewed VAT adjustment (+3%) on 01.01.2021.

5 Discussion

Online prices and offline prices are not the same (Cavallo, 2016). Online prices are highly volatile and can adapt immediately to new market conditions. This effect is again driven by computer-aided price adjustment systems, which are already used to a large extent in online retailing (Hansen, 2020b). And it is already known that online prices can have an impact on inflation (Cavallo and Rigobon, 2016).

This research was able to confirm this effect. Online prices have their own dynamics, are more adaptive and are under strong competition. This study and also previous studies suggest that online prices need to be given greater importance in the collection of CPI and inflation (Cavallo, 2016). Without the inclusion of online prices in the calculation of the CPI, an accurate determination of inflation is no longer possible. Initial prices are already collected online, but are not yet automated and computerized (Hansen, 2020a).

These studies refer exclusively to the pandemic period of 2020 and 2021 and only to the goods class "painting supplies and stationery". In January and February 2021, the indices examined were still at a similar level, only to show significant differences over the course of the next two years. In December 2021, the online indices seem to have adjusted back to the level of the official CPI. Further research will be needed to determine whether the significant deviations in the online indices over the pandemic period were temporary or whether this trend will continue. In addition, the effect in other euro area countries should be investigated. Coronavirus containment measures were similar across European countries. Stationary trade was subject to severe restrictions and online trade experienced a shock in demand, which suggests a similar increase in online prices.

One theory prior to the study was that the cargo ship "Ever Given", which ran aground in the Suez Canal at the end of March 2021 and thus brought international cargo traffic to a standstill in parts, could have had a significant influence on sales prices. This theory that this single event acutely influenced prices could not be established on the basis of this study. Nevertheless, the worldwide increase in demand for raw materials and the resulting rise in prices in Germany are certainly a driver of the relatively high inflation rates compared to the last five years in Germany.

Important macroeconomic decisions depend on the inflation rate, which makes it necessary to determine it almost exactly. If the inflation rate is not correctly determined, this can lead to incorrect or mismeasured measures on the part of the government and financial institutions. A suitable example is the key interest rate of the European Central Bank, the level of which is significantly influenced by the inflation rate of a state. In addition, the inflation rate influences a state's decisions on the deferral of interest and loans, the level of subsidies and the buying and selling of government bonds.

6 Conclusion

Using a sample of 9,977 items in the stationery and drawing supplies goods class, it was found that the determined online price index of Amazon Buy Box and the best Idealo price within the pandemic in 2020 and 2021 deviated significantly from the figures of the German Federal Statistical Office. The closures of brick-and-mortar retail during the lockdowns to contain the pandemic caused demand in online retail to really explode, which caused prices for goods to rise. The effect in the stationery and painting supplies goods category was certainly reinforced by the fact that home office regulations were introduced. Private households had to equip themselves with office supplies in order to be able to do their work at home. The research was able to show that online retail prices differed by up to 11.7% from the official figures.

Moreover, it was found that Idealo prices and Seller prices do not go hand in hand as expected when compared to Amazon Buy Box price in pandemic times. While Amazon Buy Box prices still showed inflation around zero in the second half of 2020, Idealo and Seller prices already increased by 21.5% and on Idealo by 14.7% year-on-year. This effect can be explained by the fact that smaller online stores and online sellers on Amazon (Seller) are taking advantage of the increased demand to raise prices.

The shortage of raw materials and global logistics problems also make goods scarce, which in turn leads to higher prices. The Seller price increases compared to the Buy Box price because the Seller is only waiting for the situation that Amazon has no more inventory to then fill the Buy Box with a higher price. Here the seller shows patience and waits for his chance. Basically, everything sold in the pandemic years and also at almost any price. As a seller, you just had to be patient until your competitor sold his goods and then offer his goods for a higher price. The synchronous behaviour of Idealo price inflation and seller inflation points to the effect.

The German Federal Statistical Office was unable to collect prices in stationary retail as usual during the imposed lockdowns (German Statistics Office, 2022). The number of prices collected was severely limited, and in addition, prices in stationary retail are not as volatile. In addition, only supermarkets and discounters sold stationery and painting supplies as a marginal product range, whose pricing is in turn based on more competition and basically already calculates with lower margins. Supermarkets and discounters are not specialist retailers and therefore generally offer lower prices. In addition, the commissioned price collectors will not have found a suitable substitute for every article in the price survey, which distorts the official inflation rate.

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*The Results of the Project Higher Education
Teachers' Digital Literacy Improvement
Výsledky projektu Zvyšování digitálních
kompetencí vysokoškolských učitelů*

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The ongoing Fourth Industrial Revolution and the environment of digitalisation have a significant impact on the whole society. This development also affects the education system, especially higher education teachers. It is necessary to adequately respond to the mentioned changes, as confirmed by the international document 'Horizon Report' or the national document 'Digital Education Strategy for 2020'. According to these documents, modern teachers need to use digital technologies to support pedagogical approach and didactic practice. Therefore, the University of Finance and Administration (VŠFS) educates its teachers also in the field of digitalisation. For this reason, in 2020, 2021 and 2022 VŠFS implemented the European Economic Area (EEA) project focused on improving the digital literacy of higher education teachers (EHP-CZ-MOP-2-003).

The University of Finance and Administration, as a project applicant, is truly international. Since its foundation VŠFS has always paid attention to scientific work and international cooperation. It continuously organises international conferences and scientific seminars, solves a number of research tasks and participates in professional projects for state institutions and private companies. VŠFS has been and is a partner university of international projects focused on Corporate Social Responsibility (Erasmus), Competence in EuroPreneurship (EU), and Competencies of Higher Education Teachers (EEA). VŠFS has also been developing cooperation with foreign universities and participating in international programs of student exchange, summer school and Erasmus Plus programme. These days it has a large number of foreign students.

The University of Agder (UoA), as a project partner, works systematically to increase their international research collaborations through participating in more EU projects, increasing researchers' mobility and strategic collaboration with selected institutions and countries. The university has several H2020 projects, mainly in the fields of information and communication technology. The University of Agder coordinates the project 'iTrack', among others, and it is also part of several Interreg and Creative Europe projects. EU projects gather Europe's researchers and research groups, and in collaboration with the business sector, they resolve challenges for the community and technology sector. The University

of Agder is a member of the University of the Arctic (UArctic). UArctic is a cooperative network of universities, colleges, research institutes and other organizations concerned with education and research in and about the North.

The objective of this project was to improve the digital literacy of higher education teachers. The objective was accomplished by sharing digital literacy via bilateral teaching mobility. The project has been almost carried out in line with the project plan and with the objective set. The all planned mobilities from VŠFS to UoA (2 participants in November 8–12, 2021, 4 participants in April 25–29, 2022) have been carried out. However, despite careful planning and a flexible approach only 1 mobility out of 2 from UoA to VŠFS (1 participant in December 13–17, 2021) had been implemented. The second mobility from UoA was planned in May 23–27, 2022; unfortunately, the participant from UoA cancelled the mobility claiming heavy workload due to a sick colleague. Implemented activities fulfil the program indicators. At the same time, the goal to improve the digital literacy of higher education teachers is being achieved.

A wide range of activities have been carried out at UoA. According to the pre-defined plan, the activities started with teaching shadowing in subjects focused on Business English and statistics topics (here it is necessary to mention the advanced digitalization of classrooms, modern ICT and its active use during sessions). Equally important was the following test and visit of the university's video and audio laboratory, where it is possible to record educational videos or audio podcasts at a highly professional level (this possibility of education has proven itself not only during the SARS-CoV-2 situation, but also it is an essential element of distance education in the current environment). Also, the discussion with the management of the faculty about ethics in education at UoA, career growth of higher education teachers, their salaries and much more were very stimulating, fruitful and interesting.

The intensive project programme continued at the university's second campus and other departments. Among the plethora of inspiration, it can be mentioned the professionally built laboratories of the Faculty of Health and Sport Sciences. They are equipped with the necessary software and digital reality. At the same time, they are conceived as real places for research, development and innovation of facilities for disadvantaged people. The project participants also attended an international workshop on digitalization of maths teaching, a training course on digital technology and its use in teaching, and an interdisciplinary meeting on development of a business game. Another outstanding activity, which precisely fulfilled the objectives of the project, was the visit to the university laboratories for future teachers. Designed for students of all ages, this lab offers all didactics activities from the physical to the digital.

At VŠFS a project workshop was undertaken. It was held in hybrid form, being realized in the congress centre of VŠFS and via MS Teams as well. Over 50 participants were present in this hybrid environment. The opening topics were presented; the structure and principles of higher education in Norway, a programme for quality in education, and other social matters. Among the broader topics were the 'flipped classroom', interdisciplinary teaching with 'ActionBound', digital games as an education method, and the peer-tea-

ching approach. However, the main theme was 'The Escape Room as a tool in teaching and assessment'. It is an HTML game in which the goal is to "escape" by solving various puzzles. The puzzles are tied to subject knowledge, general knowledge, ability to find solutions, ability to cooperate, and so on. This was then followed by teacher shadowing and a top management faculty meeting.

The project allowed teachers improve their digital communication with students. The need for the education of higher education teachers in the fields of didactics, digitalisation, applications, and more, is a necessity of time. Society development, digitalisation, and student requirements increase tenfold. Sharing of the experiences of teachers between the Czech Republic and Norway helped reduce these differences. The Czech project participants gained theoretical backgrounds and knowledge of the education system in Norwegian higher education. Using such a project and training, teachers will improve their pedagogical skills at the level of soft skills as well as hard skills. Higher education teachers supported by this project will thus be able to lead adequate teaching in the digital environment, by digital methods and digital approaches allowing for a more professional approach to higher education students.

The text is based on the project documentation and was supported by the EEA project 'Higher Education Teachers' Digital Literacy Improvement' (EHP-CZ-MOP-2-003).

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