UNIVERSITY OF BELGRADE
Faculty of Economics
and Business

ECONOMIC ANNALS

237

UDC: 3.33 ISSN: 0013-3264

EKONOMSKI ANALI, FOUNDED IN 1955
BY THE FACULTY OF ECONOMICS, UNIVERSITY OF BELGRADE
VOLUME LXVIII, NO. 237 / APRIL – JUNE 2023

ECONOMIC ANNALS

Publisher: University of Belgrade – Faculty of Economics and Business, Serbia

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Website: *http://www.ekof.bg.ac.rs/publikacije/casopisi/ekonomski-anali/*

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The journal is published quarterly
Annual subscription: 2400 RSD
Account No. 840-1109666-73
(Faculty of Economics and Business, Belgrade)
Circulation: 200 copies
UDC: 3.33 • ISSN: 0013-3264

Print

JAVNO PREDUZEĆE „SLUŽBENI GLASNIK" – Beograd, www.slglasnik.com

ECONOMIC ANNALS 237 / 2023

ECONOMIC ANNALS, Volume LXVIII, No. 237 / April – June 2023
UDC: 3.33 ISSN: 0013-3264

https://doi.org/10.2298/EKA2337007P

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EGALITARIANISM AND REDISTRIBUTIVE REFORM IN SERBIA AFTER 2000

ABSTRACT: *We investigate post-communist redistributive policies in Serbia, focusing particularly on the period after 2000. Our main argument is that market fundamentalism, which posits that the market is the most efficient solution for the post-communist transition, has failed to deliver on its promises. The expectation was that, after a temporary transitional sacrifice, the worse-off would benefit equally with the better-off by reaping the rewards of market economic reforms. The anticipated faster growth was supposed to generate more quality jobs as the most effective means to alleviate poverty. Unfortunately, growth has been sluggish, while inequalities in Serbia have experienced rapid and persistent growth since 2000. We look into redistributive reform measures to understand the reasons behind this outcome. Our approach combines applied political philosophy with economic policy analysis – a unique intersection of two social science disciplines. Firstly, our research explores the implicit and explicit normative foundations of post-communist economic reforms. Secondly, we identify and analyse a pivotal juncture of policy reform in the early 2000s. During this period, the newly-adopted neoliberal taxation and social policies were combined with class- and ethnic-based discriminatory approaches inherited from the pre-1990s socialist era and the post-socialist 1990s, respectively. This combination resulted in distinct, notably pro-rich redistributive patterns in Serbia.*

KEY WORDS: *Egalitarianism, equality of opportunity, distributive justice, public policy, redistribution.*

JEL CLASSIFICATION: D31, D63, P36, I38, P2

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1. INTRODUCTION

The most recent scholarship on transition and economic reforms in post-communist Central and Eastern Europe finds that the past 30 years have been years of unfulfilled expectations and broken promises (Krastev & Holmes, 2019; 2020; Szelényi & Mihályi, 2019; Ghodsee & Orenstein, 2021). What started in the early 1990s as an optimistic process of catching up with the West appears to have resulted in grave economic and social inequalities and democratic decline (Piketty, 2020; Auerbach & Petrova, 2022).

This general assessment hides the wide heterogeneity in inequality outcomes. While economic inequality increased more throughout the post-communist world than among the old EU member states (Blanchet et al., 2020), some countries managed to keep it at comparatively low levels. It is no small achievement that Slovakia, Slovenia, and Czechia still have the lowest Gini coefficient of equalised disposable income in the EU.[1]

Granted, even the designers and early advocates of the post-communist economic policy reforms never claimed that the post-communist transition would be easy (Blanchard et al., 1991). The first analyses predicted that radical economic reform would produce an economic slump, thus creating short-term winners and losers (Przeworski, 1991). While the reforms would be a painful process, they would eventually produce a J-curve shift. After each economy passes through "the valley of transition," everyone should eventually win, recovering their fortunes at varying speed. Unfortunately, this did not materialise. A significant number of losers never recovered even after the economy began improving.

One of the main reasons for the significant rise in inequality has to do with the concept of economic reforms, which were inspired by the then-dominant neoliberal discourse and policy success of the two Reagan and three Thatcher administrations of the 1980s (Appel & Orenstein, 2016; 2018; Fukuyama, 2022). The economic reforms in post-communist Europe were based on the idea of the superiority of the market (so-called market fundamentalism), unmistakably delivering rewards proportional to personal effort and merit.

[1] Eurostat. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di12 (Accessed: July 18, 2022)

Although even IMF researchers have admitted that the neoliberal concept of reforms had produced too few economic benefits and too much inequality (Ostry et al., 2016), more conventional reports on post-communist transition still emphasise the issues of growth, employment and macroeconomic stability, and capital flows, but remain silent about inequality – on which there is nothing to report (Kovtun et al., 2014; Roaf et al., 2014). Late-transition countries such as Serbia, along with other Western Balkan economies, kept on relying on the neoliberal concept of economic efficiency, merit, and equal opportunity, which serves as a driving force behind their current tax, social protection, and labour market policies (Žarković-Rakić & Vladisavljević, 2021).

Our research is about normative foundations of post-communist economic policy and their implementation. We argue that the Serbian version of neoliberal post-communist reforms in redistribution and social protection was especially unjust because it was based on a combination of old and new sets of discriminatory policies, resulting in unfair distribution leading to uniquely unequal outcomes. The first, class-based discrimination, was inherited from socialism, where it was aimed at small-scale private farmers and other citizens outside of the socialist sector. The neoliberal reforms extended this discrimination against the lower income strata in general. The second set of discriminatory policies was crafted in such a way to target certain ethnic minorities implicitly. It was developed during the rise of ethnic tensions in the late communist and early post-communist period (Drezgić, 2008), to be later merged with class-based discrimination through family policy reforms during the early transition.

We offer several insights in research on post-communist economic and institutional reforms. From the public policy perspective, we built on the previous research in this area (Pavlović & Arandarenko, 2011; Arandarenko & Pavlović, 2022). We argue that the neoliberal approach to post-communist reforms in Serbia (and by extension in other Western Balkan countries) favoured the better-off but was discriminatory toward the worse-off, especially if they belonged to certain social strata and ethnic minorities.

There is ample evidence that post-communist economic policies were neoliberal, as documented by Orenstein (2009), Bohle and Greskovits (2012), Bugarič

(2016), Appel and Orenstein (2016; 2018), Ther (2020), and others. However, the post-communist reforms were not only about making the unproductive and command-driven socialist economies work more efficiently. Crucially, the neoliberal policy approach contained a specific conception of justice and equal opportunity that favored certain social groups and handicapped others. This redistributive aspect has never been openly proclaimed because it would have run contrary to the initial promise of 1989, under which economic and political reforms would improve the lives of all. We also argue that post-communist economic policies were close to the utilitarian philosophy, where the sacrifice of some (aptly named "transition losers") was justified for the greater good of many.

From the political philosophy perspective, we draw on the egalitarian concept of equal opportunity, which we contrast with the neoliberal concept of equal opportunity. It is the latter, rather than the former, that inspired the post-communist market reforms after 1990. We believe that the absence of the egalitarian concept of equal opportunity from post-communist reforms is what explains the reform paths and growing inequalities in most of the post-communist world. Unlike the neoliberal and libertarian approaches that are either against equal opportunity (Cavanagh, 2002), or establish the equality of opportunity as a legal concept and insist on personal responsibility and choice (Mankiw, 2010), we contend that personal choice depends in the first place on social position, including but not limited to access to and quality of education and health services, and the material position of individuals at the start of their lives. One's early-life circumstances, such as parents' place in the wealth and income distribution, access to education, health, and other public services, are critically important in predicting individual life outcomes (Savage, 2015). Similarly, at a time of major economic and social transformations, the rules of the game radically change, and individuals might find themselves in a much worse position typically not so much due to lack of effort or skill, but rather due to unfavorable circumstances. The chances of success are equal only if all economic and social factors beyond individuals' control are equal. In this part of the argument, we draw on the egalitarian concept of distributive justice (Rawls, 1999; Scanlon, 1982; Barry, 2005) and luck egalitarianism (Rakowski, 1991; Dworkin, 2000; 2003; Segall, 2013; Frank, 2016).

The structure of the paper is as follows: Section 2 presents key aspects of the egalitarian theory of justice and examines relevant literature on the neoliberal underpinnings of redistributive economic policy in Serbia post-2000. In Section 3, we develop a normative framework rooted in the egalitarian concept of equal opportunity, which serves as the basis for evaluating neoliberal economic policies and proposing redistributive and rectificatory policy recommendations. Section 4 examines redistributive policies implemented in Serbia after 2000, including insights from key policy architects, to demonstrate that these policies have exacerbated inequalities and inflicted further hardships upon the worse-off – a departure from the promises made in 1989 in Central and Eastern Europe and in 2000 in Serbia. Finally, Section 5 provides concluding remarks.

2. TRANSITION AND DEBATES ON JUSTICE

Since Rawls published *A Theory of Justice* in 1971, the issue of social justice and redistribution has been high on political philosophers' theoretical agenda. Rawls' original idea was to justify the redistribution of resources against the then-dominant paradigm of utilitarianism and the principle of average utility. Rawls was specifically concerned with the version of utilitarianism proposed by Henry Sidgwick (1907)[2] and the idea that principles of justice can be reduced to the rational choice of one man (Rawls, 1999, p. 23–4). This version of utilitarianism was grounded in the benevolent spectator perspective, which, in Rawls's interpretation, justified the sacrifice of particular people if an act (or policy) increases average utility in society. Under this view, one person may, as a matter of temporary sacrifice, give up certain things "for the sake of a greater advantage later" (*ibid.* p. 21). In contrast, society, Rawls believed, must not embrace such a principle. Society must never sacrifice some social groups, however temporarily, for the greater advantage at a later point. The life of every individual is worth the same and we should not justify a society that allows a rise in average utility at the cost of the well-being of some people (*ibid.* p. 3). The crux of the problem here is

[2] In *A Theory of Justice*, Rawls refers to Sidgwick's *Methods of Ethics* (first published in 1874). But some of Sidgwick's policy views about distribution were also discussed in Book III of *The Principles of Political Economy* (first published in 1887).

that "utilitarianism does not take seriously the distinction between persons" (*ibid*. p. 24).[3]

Rawls' main theoretical device to construct fair principles of justice was the original position, which contained a veil of ignorance. It was supposed to suppress personal identities (specifically age, ethnicity, and class origin) and the talents of individuals who negotiate the principles of justice. The principles of justice selected in such a way (individuals negotiating behind the veil of ignorance) would help avoid a status-quo stalemate due to vested interests, and would have to be egalitarian, thus guaranteeing basic rights and also equal opportunities. This part of Rawls' theory is highly relevant for our analysis because of class and ethnic inequalities during Yugoslav communism and the post-communist period in Serbia discussed in Section 4.

The debate on justice has branched off into several directions and encompassed many different scholars. However, it was mainly about philosophical foundations and less about policy implications (Arneson, 2007). Interestingly enough, the fall of the Berlin Wall in 1989 and the breakdown of communism in Europe and Asia did not seem to inspire contemporary debates on justice in post-communism (Ivanov, 2023). Marxism and its concept of justice ceased to be official state ideology, but the participants in the general debates on justice remained silent on what would be a just transition (Ivanov, 2023).[4] Throughout the 1990s, there was no egalitarian conceptualisation of the post-communist transition, which is difficult to explain given that many of the leading egalitarian political philosophers (Rawls, Dworkin, Barry, etc.) were still intellectually active in the 1990s. They did debate distributive issues of their era but only in the US and Anglo-Saxon world. The topic of distributive justice in post-communist societies did not deserve a more prominent place in a more recent introduction to political philosophy (Wolff, 2006), and some suggested that distributive justice should not

[3] Granted, Rawls's theoretical problem was that, in *A Theory of Justice*, he himself wanted to derive non-utilitarian principles of justice from rational choice, which, as argued by Harsanyi, was impossible (Harsanyi, 1975). In the subsequent work (that led to the publishing of *Political Liberalism* in 1993), Rawls dropped rational choice and derived the principles of justice from the Kantian autonomy of the person (Pavlović, 2005; 2014).

[4] We leave out the discussions on transitional justice, mainly about human rights abuses during communism. We also leave out the newer concept of just transition in the context of adjustment to climate change.

even be among the primary objects of political philosophy anymore (Larmore, 2020, p. 5).

Early economic studies on inequality in former communist countries were mostly descriptive. An early general overview was provided by Milanović (1998). While Central and Eastern European countries managed to roll back inequality thanks to their social safety net (Garner & Terrell, 1998), the redistributive institutions in Russia were regressive, which increased inequality further (Commander et al., 1999).

Due to the apparent lack of engagement from political philosophers and welfare economists regarding the challenges faced during the post-communist era, the void was filled with the ascendancy of neoliberal discourse through what could be described as a Kuhnian paradigm shift (Aligica & Evans, 2009). These novel ideas found expression in informal agreements such as the Washington Consensus, and academic policy studies such as *Reform in Eastern Europe* (Blanchard et al., 1991), *The Road to a Free Economy* (Kornai, 1990), as well as numerous reports produced by the IMF, the World Bank, and the EBRD. This approach primarily drew from the prevailing economic policy discourse of the time, which encompassed Thatcherism, Reaganomics, economic rationalism, monetarism, neoconservatism, and market fundamentalism (Aligica & Evans, 2009). Intellectually, it was rooted in the traditions of the Chicago, Austrian, and Geneva schools. Notable economists who served as key influences in this tradition (albeit not explicitly identifying as neoliberals) included Milton Friedman, Gary Becker, George Stigler, Ludwig von Mises, and Friedrich A. Hayek (Slobodian, 2018; Fukuyama, 2022). While none of them embraced egalitarian political philosophy, a few, like Friedman, developed principles pertaining to social policy.

The first post-communist policymakers not only accepted neoliberalism as the main ideology and policy approach but became its avant-garde at the global level (Appel & Orenstein, 2016; 2018). They started a kind of race on who would implement neoliberal ideas better and more fully. In some countries, it was combined with class and ethnic discrimination. The latter was partly inherited from socialism (for example, to some degree in former Yugoslavia, as will be discussed in Section 4), or in some cases turned upside down, such as in Baltic states after they regained independence, with many long-time Russian residents

becoming ineligible for welfare benefits (Reardon, 1996; Bohle & Greskovits, 2012). Both class and ethnic discrimination implied the adoption of an intertemporal average utility principle under which the brighter future of all justified the temporary sacrifice of some – as opposed to the Pareto utility criterion.

Encouraged by the belief that the market will solve most post-communist social problems (the losers will find new jobs in the new private sector), Central European, Baltic, and eventually Western Balkan governments started to downsize social protection institutions such as free health care and free access to education, as well as to restrict a set of broad rights related to employment, which was practically universally enforced (except in Yugoslavia) under socialism, although a significant component of it was overemployment (Adam, 1984; Gimpelson, 2002).

Granted, the post-communist governments introduced residual programmes for poverty reduction, but the main long-term problem of the post-communist transition was not only poverty but growing inequality. The promise was that leaving communism and catching up with capitalism and the West would be beneficial for everyone ("the tide lifts all boats") and that nobody would be left behind. While temporarily in the valley of transition, countries should focus on dealing with poverty rather than inequality. The increase in inequality, which was low during socialism, was often seen as instrumental in shortening the duration of transition by sharpening the work incentives, as described in Milanovic (1998). This belief has important repercussions because most social programmes in the post-communist economies were about alleviating destitution and absolute poverty of the transition losers, but were not about containing inequality and facilitating equality of opportunity. Poverty indeed may have been reduced after a certain period of time, but inequality grew rapidly – by some nine Gini points on average during the first six years of transition (Milanovic, 1998) – and has stayed elevated or grown further ever since (World Inequality Database, 2020).

Beyond the averages, the spectrum of income inequality outcomes (measured by Gini coefficients) during the transition has roughly reflected the intensity of adoption and preservation of neoliberal policies. In a very simplified generalisation, countries of Central and Eastern Europe took a pragmatic

transition path, countries of the former Soviet Union and the Balkan countries opted for a market fundamentalist path, while Belarus largely abstained from reforms. Combined with initial positions along at least three additional dimensions (level of economic development; level of inequality; the universality of social protection instruments) this resulted in vastly different income inequality outcomes across the transition universe. The Czech Republic, Slovakia, and Slovenia managed to maintain the Gini coefficient in the mid-20s, as did Belarus, for different reasons. Croatia, Poland, and Hungary had Gini coefficients in the low-to-mid 30s during the past decade, while the Western Balkans, Romania, Bulgaria, and the Baltic states had Gini coefficients in the mid-to-upper 30s. Finally, Russia and other countries of the former Soviet Union had the highest income inequality, typically in the low-to-mid 40s.

3. TRANSITION AND EQUALITY OF OPPORTUNITY

In our interpretation, neoliberalism contained three implicit concepts that informed public policy in the post-communist transition. The first is individual choice (responsibility for one's actions), the second is that of merit and desert, and the third is that of formal equality of opportunity. Not all of these three concepts were explicitly formulated in economic policy reports and structural adjustment and reform programmes of the time because some of them come from political philosophy rather than from economic theory. But they were nevertheless present, and inspired public policy advisors and makers in post-communist economies.

a) Individual choice and responsibility

Responsibility for personal choice was famously introduced and formulated by Milton Friedman in *Capitalism and Freedom* (1962). Friedman contrasted individual liberty and individual responsibilities with a paternalistic state that helps individuals, thus diminishing individual responsibility in society. The state, in Friedman's view, had too much responsibility in fiscal and monetary policy matters, wage-setting, labour market legislation, education, and health, eroding the role of the market in these areas. The small role of the market, according to Friedman, led to poorer services and outcomes in these sectors. Friedman was known for his negative attitude toward government – when it gets involved, it makes things worse.

The idea of personal responsibility was embraced by most mainstream economists who had something to say about the post-communist reforms of the early 1990s. In its neoliberal form, it was carried to the extreme (Fukuyama 2022). It had its prominent advocates in Serbia too (e.g. Begović et al., 2008). The market was supposed to make people responsible for their choices and their destinies. But more than that, it was supposed to determine the right position for individuals in economic and social progress. Depriving individuals of an active and responsible role in economic and social progress by giving them more than they rightfully received on the market could make them parasitic agents of society (Begović et al., 2008, p. 46). On the other hand, highly productive individuals have a special role in creating the conditions for progress and growth, and a responsible state needs to support, rather than discourage, these valuable individuals.

b) Desert and merit

The market was not only understood as a more efficient tool to solve communism's problems. It was also designated as a criterion to determine the moral worth of a person and to judge their skills and positions. The only way to design a proper system of distribution is to take into account the contribution to society that each person makes. Those who can survive on the market are more valuable than those who cannot. They deserve what they have. Merit is the major concept to guide market allocations, and any kind of allocation from market interaction is fair. The idea was expressed by Gregory Mankiw in the form of Just Deserts Theory:

"People should get what they deserve. A person who contributes more to society deserves a higher income that reflects those greater contributions. Society permits him that higher income not just to incentivize him, as it does according to utilitarian theory, but because that income is rightfully his. This perspective is, I believe, what Robert Nozick, Milton Friedman, and other classical liberal writers have in mind. We might call it the Just Deserts Theory" (Mankiw, 2010, p. 295).

c) Equality of opportunity

As already pointed out, the primary long-term problem of the post-communist transition is not poverty but inequality. We, therefore, assign critical importance to the concept of equality of opportunity for our analysis. Equality of opportunity

as a fully developed concept has been almost entirely absent from the discussions of social justice in transition after 1990. It appears in international reports and documents only during the second part of the 2010s (EBRD, 2016; Peragine & Biagi, 2019), when most of the transitional processes and key distributive reforms were practically over.

This does not mean that some implicit concept of equality of opportunity was not present in the economic transformation of post-communist economies. On the contrary. It was, however, largely understood in legal and market terms. Equality of opportunity, so understood, is basically about careers being open to talents and merit. This is called formal equality of opportunity (Rawls, 1999). The basic idea is that only those who decided to invest effort to obtain knowledge, skills, and education should be awarded advantageous social positions (Arneson, 2013).

This formal concept of equality of opportunity was the underlying principle of public policy reforms in Central and Eastern Europe after 1990 – the market became the ultimate judge concerning who should benefit from the reform by advancing on the social ladder. This manner of assigning moral worth to individuals according to their market capabilities has recently been defined by the political philosopher Sandel as a "tyranny of merit," which created two different classes of people – winners and losers. They both deserve their social and economic positions, but, among the winners, it creates meritocratic hubris, while in the losers it creates humiliation, resentment, and shame (Sandel, 2020). This is one of the main causes for the rise of conservative and right-wing forces in Western democracies, but also for a great disillusionment with the post-communist project in general (Krastev & Holmes, 2019; 2020; Sandel, 2020; Liebich, 2022). In a similar vein, Collier (2018) proposes that the growing gap between winners and losers within rich Western nation-states is tearing the social fabric apart. While winners outsource solidarity with their less fortunate compatriots to the welfare state and take interest in global affairs and act as global citizens, losers remain loyal to their nation or race as their main remaining source of identity and pride, increasingly adopting right-wing ideologies.

In contrast to a formal understanding of equality, we define equality of opportunity as a three-dimensional concept that consists of rights, opportunities, and resources, and adopt the following definition: "[A]n opportunity to do or

obtain something exists for me if there is some course of action lying within my powers so that it will lead, if I choose to take it, to my doing or obtaining the thing in question" (Barry, 2005, p. 20).

We believe that this definition is suitable for transition, which we see primarily as a redistributive process. Transition is, therefore, essentially about creating new institutional design that determines who gets what in terms of rights, opportunities, and resources.

The formal concept of equal opportunities is starkly opposed to an egalitarian understanding of equal opportunities which, apart from rights and opportunities, focuses – crucially – on resources. The major point of this conceptualisation is that people may have rights and legal opportunities to do certain things, but may not have the resources to use these opportunities. We rely not only on the work of Brian Barry (2005), but also on some mainstream economists that more recently started to deploy this concept of equal opportunities in the EU, the EBRD, and World Bank reports by referring to a choices-vs-circumstances distinction (Peragine & Biagi, 2015; 2019).

The formal concept of equality of opportunity (career paths open to talents) was exclusively grounded in a reductionist understanding of rights, meaning that equal opportunities were respected if every person able to work had the right and obligation to compete in the market (Rawls, 1999; Arneson, 2013). Those who failed could only count on their own fallback (including insurance) income, wealth (if any), and family solidarity, before turning to government for last-resort assistance. This reductionism was wrong because it ignored not only the unequal socio-economic starting positions at the beginning of transition, but also the fact that transitional reforms reshuffled the entire structure of economy and society. Redistributing the opportunities and resources without a firm footing in egalitarianism, transition created new, or confirmed old, "circumstantial" and "luck" winners and losers. Equality of opportunity remained as elusive as ever.

4. IDEOLOGICAL UNDERPINNINGS, EVOLUTION AND OUTCOMES OF REDISTRIBUTION POLICY IN SERBIA

In this section, we attempt to sketch the main features of redistributive policies under socialism and during the neoliberal transition in Serbia. Our main claim is

that foundational principles and practical implementation of redistributive policies departed from the egalitarian concept of equality of opportunity both during communist rule and in the course of neoliberal socio-economic transformation.

a) Redistribution under socialism (1945-2000)

The socialist Serbian welfare state was in some important respects different from the Western welfare states. Declaratively, social policy measures were organised on the basis of solidarity and reciprocity, which are classical social-democratic principles, as well as "socialist humanism," which was a distinctive socialist self-management construct. The essential aim of social policy was to be "the concrete expression of the interests of working people and the accomplishment of human well-being and happiness" (Milosavljević, 1987). The need to emphasise the "interests of working people" and "socialist humanism" indicates the instrumental role of redistribution policy, and hints at its selective, rather than universal nature.

On the one hand, within the socialist sector of the economy, redistribution and social protection policies were meant to eliminate all forms of exploitation and to secure the realisation of the key distributional principle of socialism, preventing social differentiation not grounded on the principle of remuneration according to the results of work performed. On the other hand, the system was meant to facilitate "socialist development" by supporting the socialist sector and effectively discriminating against the private (non-socialist) sector of the economy and those engaged in it, comprising mainly farmers, self-employed workers, and members of a limited number of free professions, such as lawyers, musicians, and the like. It also discriminated against those outside of the formal employed labour force, including rural and urban underclasses. This discrimination was twofold – in terms of market exchange and in terms of access to social benefits and services.

In terms of market exchange, first and foremost, there were limits to owning property. Farmers were allowed to have up to ten hectares per family. They faced market exploitation through the so-called "price scissors" (Madžar, 1990), where the state as monopolistic buyer determined the prices of key agricultural products, typically below their full market value. In addition, it often delayed payments to farmers for prolonged periods, effectively charging farmers inflation

tax (seigniorage). Outside agriculture, small owners were allowed to employ a limited number of workers, (up to ten) provided that they worked alongside their employees and were subject to regulations restricting their capacity to make a profit and expand their business. It was only in response to the economic crisis of the 1980s that the regime significantly liberalised the environment for private sector activity through the Enterprise Law in 1988 (Bartlett, 2007).

Apart from market discrimination, farmers and other self-employed people faced discrimination in eligibility for social insurance programmes – pensions, health, unemployment, and housing. They had full access to education and limited free access to emergency health services and could join special pension schemes for self-employed or farmers, the latter providing much lower pension benefits than those in the socialist sector (Bartlett, 2013).

In contrast, the "working people" in the socialist sector, apart from benefitting from market distribution due to "price scissors" and other mechanisms, also enjoyed generous direct benefits provided by the extremely comprehensive Bismarck-type social insurance system that included not only pension, unemployment, and health insurance but also the possibility to obtain a "social" apartment – the size and quality of which were roughly proportional to professional status as well as to family size (Milanović, 1990), while the waiting period was negatively correlated with the power position within the firm or the Communist Party. In addition, many other social services and fringe benefits, such as vacation and child-care facilities, meal vouchers, and holiday allowance, were provided within socialist firms. Solidarity and reciprocity – these quintessential twin social-democratic principles – indeed existed to a large, but not full, extent among working people within the socialist sector.[5] However, they did not extend to citizens outside this sector. In a way, the generous welfare state was made possible within the socialist sector because of its exclusivity, and because the rest of the society subsidised it (Deacon & Stubbs, 2007).

When it comes to social assistance programmes, there was a rudimentary means-tested minimum income programme, for which it was difficult to qualify except

[5] Workers having more "production means" (that is, collective capital) at their disposal were in principle better off. The same applies to federal units – there was no effective mechanism to secure long-term convergence between republics and autonomous provinces (Gligorov, 2004).

for landless rural dwellers as well as workless urban families. There were several changes in the regime of child benefits, back and forth from means-tested to quasi-universal, but until the late 1980s the benefits hardly ever included children of parents employed outside the socialist sector (Matković et al., 2014).

Milanović (1993) aptly explained the ideological motives behind minimal poverty protection in socialism: "The socialist welfare system differs from the (Esping-Andersen's) three capitalist worlds by virtue of an almost total absence of transfer targeting…the Communist state, whose philosophical foundation is that everybody should work, preferably in the state sector, tends to regard the poor as unworthy of sympathy and aid… they are accidents who live at the societal margin" (Milanovic, 1993).

In an economy dominated by collective ownership controlled by the party-state, there was little need to introduce progressive direct taxation. For developmental and ideological reasons, instead of redistributing from the more to the less affluent, the government ensured that net redistribution went from the non-socialist to the socialist sector. But the key means to achieve this was through the quantitative limitation of property ownership and state control of market outcomes (pre-distributive intervention), as well as differentiated eligibility for transfers (redistributive intervention). With the government having all these powerful instruments at hand, progressive taxation was not only near redundant, but was also considered to go against the socialist principle that a person's pay should reflect their true work contribution.

During the last phase of communist rule in Serbia, between the late 1980s and the end of the 1990s, when class discrimination in redistribution started to wane, ethnic discrimination in family transfers reemerged in a somewhat disguised, but even more direct, form than before, when it was only a secondary consequence of the fact that some ethnic groups in Serbia were less represented in the socialist sector – primarily Roma, but also Albanians and Bosniaks. The politically charged issue of a declining Serbian population and a rapidly growing Albanian population was framed as a more neutral issue of "population-declining" vs. "population-expanding" regions (as aptly described in Drezgić, 2010). Allegedly to reduce these demographic disparities, a policy of regionally differentiated access to child benefits was proposed (Matković et al. 1999), in effect

discriminating against Albanian and Bosniak children. A related aspect of this policy, carried over from the earlier regulation, was the limit of eligibility for child benefits to four children per family, allegedly supporting "responsible parenting" (Rašević & Mijatović, 2002) while in practice discriminating mostly against Roma children.

b) Critical juncture – redistributive reforms post-October 2000

The October 2000 political change was certainly the most important critical juncture when it comes to reforms of redistributive policy in Serbia since 1945. The context for redesign was very unfavorable. After it restored previously suspended membership in the United Nations and key international financial institutions in early 2001, Serbia (still within FR Yugoslavia with Montenegro) became eligible for favourable World Bank IDA loans. One of the conditions for the use of these loans was that Serbia prepare a Poverty Reduction Strategy Paper (PRSP). Although on paper PRSPs were intended to add social dimension to structural adjustment programmes and to strengthen national ownership, the creators of the reforms very much followed the script of the Washington Consensus, and sometimes went even further. The role of the European Union was still minimal (Arandarenko, 2004).

The tax-benefit system was radically reconfigured between 2001 and 2003 with the comprehensive reforms of direct taxation, social insurance schemes, and social assistance programmes, and completed in 2005 with the introduction of value-added tax (VAT). The education system and the delivery of health services were also reformed, introducing additional elements of marketisation, a process that started as early as in the 1990s.

We do not discuss privatisation as a major instrument of wealth redistribution for two reasons. First, in the literature on Serbian transition, privatisation received considerably more attention than the changes in redistribution rules. Second, in the longer run, the impact of tax-benefit reforms is stronger because the initial distribution of resources impacted by privatisation would gradually be reshaped by the quasi-permanent features of the tax-benefit system. Still, a more detailed analysis of the choice of the privatisation method post-2000 and the impact of the privatisation process on wealth redistribution would further support our key argument. The new government opted for sales privatisation,

rejecting the existing insider privatisation (employer-employee buyout) regime as well as voucher privatisation as an alternative. Both alternative methods would have created, at least initially, a more disbursed ownership structure and would have led to lower wealth inequality.

Labour taxation reform

Contemporary writings of the architects of this radical labour taxation reform confirm that its design was not just a half-cocked imitation of the flat-tax revolutions in Eastern Europe fashionable at that time (with Russian reform of January 2001 serving as the closest model time-wise and in terms of design). On the contrary, it was a part of a relatively coherent reform design with a strong ideological underpinning. These ideas are quite clearly expressed in Arsic et al. (2001):

"Change(s) in the fiscal treatment of wages and salaries encompass: a) shift to the system of gross wage…; b) tax exemption for minimum wage was abolished; c) luncheon bonus and vacation vouchers are included in gross wage; d) introduction of minimum base for each qualification and a maximum one for levying contributions**.** [These reforms] have strong impact on depressed sectors (e.g. textile, metal processing etc.) in which the dominant part of take home income were previously nontaxable allowances. This puts the strong pressure on them to restructure or close down."

As is clear from the above quote, the reformed labour taxation system, introduced at the very start of the transition, put a heavy burden on low-wage workers as well as the firms that were the main source of their employment by increasing non-wage labour costs. This made such firms less attractive in the privatisation process and also discouraged new investment in labour-intensive sectors and regions (Arandarenko & Vukojević, 2008). "Strong pressure" was apparently too much pressure for many firms and workers in low-wage industrial sectors. Formal employment in manufacturing, according to national establishment survey data, plummeted by almost 50 per cent during the 2000s – from 620,000 in 2001 to less than 320,000 in 2010. Despite average GDP growth rates of around 5 per cent, formal employment in the rest of the economy (that is, excluding manufacturing) remained practically unchanged, at around 1,500,000 in both 2001 and 2010. The drop in total employment, according to a labour force survey, was double the

drop in formal employment, from some 2.9 million in 2004 to less than 2.3 million in 2010 (Arandarenko, 2011).

The overall taxation reform was guided by the principle that the "tax system should not fulfill social support function because it is not, by definition, targeted to the poor" (Arsic et al., 2001). This was an extremely purist interpretation of neoliberal recommendations regarding the taxation policy of the time, which, while arguing for the broadening of the tax base and a higher share of "less distortive" indirect taxes, preferred "moderately" progressive personal income tax rates and were not against lower indirect tax rates for essential products.

The initial reform of indirect taxation increased the prices of basic goods. Arsić et al. (2001) estimated that its total effect on the reduction in purchasing power of the population was some 6 per cent. This was offset by the reduction in contribution rates of 10 per cent, which resulted in an almost proportional increase in wages.

"However, the effects of tax reform are unevenly distributed, hitting adversely social layers whose wages are by 5 per cent or more below the average in Serbia, since they previously had the large share of non-taxable income (fringe benefits). Thus, in the case of these layers, the real wages grew (due to lowered contributions) less than 5 per cent, which compared to 6 per cent increase in the prices of basic goods, implies decrease in their real incomes" (Arsic et al., 2001).

The architects of the taxation reform were thus apparently undisturbed by the fact that its overall impact was such that the bottom half of wage earners (and most likely the bottom 55-60 per cent, since wage distribution is always denser below the average wage) saw their real take-home wages drop due to this taxation reform, while the opposite was true for the top half – with the gains becoming larger in absolute and, crucially, relative terms as one went up the wage ladder.

Pension system reform

One of the stated goals of labour taxation reform was to raise the future pensions of low-wage workers in "depressed sectors" by reducing their take-home wages and forcing them to pay higher contributions instead. However, the 2003 pension reform made this goal harder to achieve, even for those low-wage workers who

were able to preserve their jobs. The stated goals of the pension reform were, among others, the establishment of firmer links between the level of pension and paid contributions and the "reduction of overly liberal (that is, too generous) and redistributive elements in the system" (Matković, 2005). Thus, mirroring the labour taxation reform, pension benefits were intentionally decompressed by parametric reforms. The changes in retirement rules included the reduction of the ratio of minimum pension to average wage as well as the use of the entire wage history for the determination of pension benefits instead of the ten best years. These changes were introduced retroactively, with a profound impact on pension inequality. The new pension rules implied lower relative pensions for the circumstantial victims of the disastrous 1990s and jobless 2000s even though it was clear they could not have full agency over the fate of their firms or their own job prospects during the prolonged labour market slump.

The increase in pension inequality was one of the reasons for the increase in the share of pension expenditures in GDP, which required more additional financing from general taxation. In 2009, general tax revenues worth as much as 5 per cent of GDP had to be allocated to cover the deficit of the pension fund, while only 0.08 per cent of GDP was spent to top-up lower "earned" pensions to reach the level of the minimum pension (Stanić, 2010).

Although pensions are basically proportional to past earned wages of pensioners, the budget-financed part of these pensions is predominantly financed from indirect taxes, which account for over two-thirds of all tax revenues (excluding social contributions) and are known to be regressive. Furthermore, indirect taxes are paid by all, including those who are not, nor will ever become, beneficiaries of PAYG system. Thus, the joint distributional impact of pension benefits and their financing is somewhat regressive.

On the macroeconomic side, the increased pension expenditures have become one of the major sources of fiscal imbalances and have crowded out other potentially more pro-poor or pro-growth expenditures such as social investment (education, health, housing) or public investment (public infrastructure).

Social assistance reform

Non-contributory social protection schemes aimed at the poor became increasingly austere and most conditions were tightened compared with those of the previous regime. Targeting of social assistance became stricter and administration more complex, creating a large error of exclusion, while maintaining a very small error of inclusion (World Bank, 2015). Income ceilings for assistance eligibility were based on relatively low consumption needs. In the second half of the 2000s, the absolute poverty rate was estimated to be only 6–7 per cent, although the unemployment rate was around 20 per cent and large segments of the population were without regular income. Benefit amounts (also serving as eligibility thresholds) were indexed by the inflation rate, while other incomes grew much faster. In 2008, for example, expenditure on guaranteed minimum income benefits was only 0.14 per cent of GDP. However, due to strict and often discriminatory rules, only around 20 per cent of households in the poorest decile fulfilled all criteria to receive financial assistance, and the actual take-up was even lower (Arandarenko et al., 2013).

Programmatic statements on the nature of social protection reform insisted on the need to transform the role of the state, including by withdrawing social policy from enterprises, basing social protection on sound financing, and facilitating greater responsibility of the individual to provide security for him/herself and his/her family (Matković, 2005). In addition, as mentioned, one of the goals of the taxation system reform was to move the elements of non-targeted social policy from direct and indirect taxation to interventions targeted at the poor. In practice, it ended up in the near-denial of poverty. The poor and vulnerable people were left largely to fend for themselves.

In contrast to social assistance, the employment-based non-contributory schemes – which are as a rule insurance-based in other countries – became increasingly generous. For example, the duration of maternity leave was extended to one or two full years with a 100 per cent replacement ratio without a ceiling. This, by design, disproportionately benefitted upper-income deciles, while discriminating against mothers out of formal permanent employment (World Bank, 2015). More generous rules for the relatively narrow group of formally employed mothers led to an increase in the share of expenditures on maternal leave from 0.3 per cent of GDP

in 2002 to 0.7 per cent in 2017 (Stanić & Matković, 2017), which at the time was about four times more than expenditures on the minimum income guarantee.

Furthermore, public sector pay and employment grew significantly, converting, in a matter of only a few years, a public sector wage penalty (as identified by Lokshin & Jovanovic, 2003) into a public sector pay premium (Laušev, 2011; Vladisavljević, 2020). Moreover, some new macro-fiscally minor but symbolically important instruments of bottom-to-top redistribution were instituted, such as a growing number of well-paid sinecure positions on boards of public institutions and firms (Vuković, 2017), very generous untested national pensions for sports medalists and artists, etc.

c) The evolution of inequality after the critical juncture

By now it has become clear that the government's thriftiness when it comes to supporting the poor and vulnerable was not a result of the insufficient capacity of the state to collect public revenues. On the contrary, despite the "withdrawal of the state from untargeted social policy," tax collection and public expenditures kept pace with or grew somewhat faster than GDP growth. Fueled also by the privatisation proceeds, and later by the increases in VAT and excise rates, the share of public revenues and expenditures in GDP have consistently exceeded 40 per cent, which is among the highest globally within the group of middle-income countries.[6]

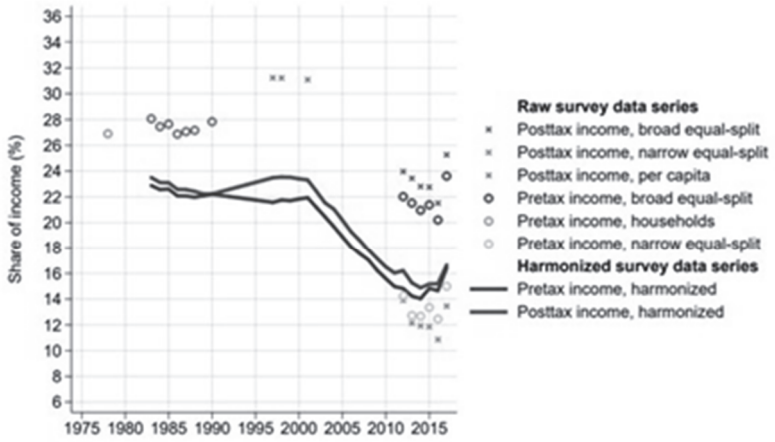
The above discussion illustrates most of the main features of the rather extreme variant of neoliberalism that was in charge of economic and social policymaking during Serbia's transition to a market economy. It was Sidgwickean (see Section 2), having a quintessential "benevolent observer" (a neoliberal policymaker) to judge what is just and good for the society as a whole and for those affected by the reform. It was millennialist, because of its readiness to sacrifice the welfare of large groups of vulnerable people in order to achieve the final goal – in this case, an efficient market economy. It consistently discarded any concerns regarding the Rawlsian concepts of just distribution and equality of opportunity by ignoring

[6] It is a remarkable and yet rarely mentioned fact that Serbia, Bosnia and Herzegovina, and Montenegro are the only three middle-income countries (out of a total of 110 countries according to the World Bank classification as of 2021) with the share of public spending (and revenues) above 40 per cent of GDP.

the fact that it was retrospective circumstances of lasting and deep economic crisis beyond their control rather than their own irresponsible choices that put workers in "depressed sectors", as well as other transition losers, in a dire position. Paradoxically, it remained "statist", keeping the oversized government revenues and using them in an increasingly discretionary fashion.

A spectacular synthetic graphic illustration of all these processes was recently offered by Blanchet et al. (2020) in Figure 1 below.

Figure 1. Serbia: Bottom 50% pretax and posttax income share (harmonization of survey data)



Notes. The figure shows how raw survey data sources covering different income concepts and equivalence scales are converted to a single harmonized pretax income and posttax income survey data series, where income is split equally among couples (narrow equal-split).

Source: Blanchet et al. 2020. Appendix: Figure A.3.21.2 Serbia: harmonization of survey data. Bottom 50% pretax income share, p. 431.

Without our going into detail (and potential criticism) regarding the innovative methodology applied in the paper by Blanchet et al. (2020), Figure 1 shows that the steady decline in the share of the bottom half in national income started around the time of the critical juncture in 2001 and continued without interruption for the next 14–15 years, falling from around 23–24 per cent to a nadir of under 15 per cent in 2013 and then recovering somewhat to 16–17 per cent in the following years, which were marked by a fiscal consolidation that temporarily reduced pension and wage inequality. This share is still the lowest in Europe among the 26 countries in the sample of Blanchet et al. (2020), even

though Serbia is closer to the European average than to the bottom in terms of the share of public revenues or expenditures in national income.

Furthermore, the lines of pre-tax and post-tax, post-benefit (disposable) income shares are very close to each other, suggesting that the bulk of sizeable gross redistribution facilitated by the government is horizontal, i.e. within groups of people on a similar income, rather than vertical, from upper to lower deciles. This is why the net redistribution (measured as the difference between post-tax and pre-tax shares) is almost non-existent. Again, in this regard Serbia is the least redistributive of 26 countries (see also Žarković-Rakić et al., 2019).

In principle, the downward trend in the income share of the bottom half of the population after 2000 can be analytically decomposed into factors impacting the distribution of market income and those affecting the distribution of disposable income. Market income inequality increased due to the increases in wage inequality (of which the regressive reform of labour taxation was an important part), the decline in employment and increase in unemployment (also impacted by the labour taxation reform), and the wealth redistribution through privatisation, which increased the share of non-labour incomes. Second, disposable income inequality increased due to shifts from quasi-universal to targeted non-contributory benefits (which especially affected the "next 30 per cent", those populating below-median income deciles above the two poorest) and from standard to reversed solidarity in the distribution of pensions among pensioners. Furthermore, with the shift toward indirect taxation, the bottom half also had to pay relatively more in taxes than the richer half.

5. CONCLUDING REMARKS

We have traced the philosophical roots of neoliberal redistributive reform in Serbia in the early 2000s to a reductionist understanding of equal opportunity as an individual's chance to freely participate in the market and to be entitled to his or her "just desert," solely on the basis of this participation. The main objective of the redistributive framework attached to this formal meritocratic condition was not to correct market income distribution, broadly following, for example, Rawlsian egalitarian principles. Instead, the new redistributive framework was based on a version of utilitarianism ready to sacrifice individual well-being for the higher social good – in this case, transition to a merit-based economic system

where everyone will get his or her "just desert", which will generate faster growth and eventually make the society richer. This secular millennialist promise of a Golden Age worthy of the sacrifice of the worse-off clearly goes against the spirit of Rawls' principles of distributive justice.

This utilitarian version of secular millennialism is what connects the socialist (pre-2000) and neoliberal (post-2000) welfare states in Serbia, despite obvious differences between them. Socialism's declared goal was to find the fastest route to create a prosperous and just society. Neoliberalism wanted to restore the "natural", market-based order, again to create growth that would eradicate poverty while unleashing creativity and entrepreneurship. Both valued growth over equality. While socialism trimmed inequality at the top at least, neoliberalism increased it throughout the entire income distribution. At first, under both systems, things worked reasonably well in terms of growth, until growth started to slow down and the transformation stalled at a point of slow growth and high inequality.

The neoliberal welfare state has kept some of the discriminatory features of the socialist welfare state, continuing discrimination against small-scale private farmers and some ethnic minorities, while extending it to the lower-income population in general. Instead of strengthening, or at least preserving, the otherwise limited progressive pre-distributive and redistributive features of the socialist welfare state to counterbalance the removal of limits to private ownership, which kept inequality in check during socialism, neoliberal policymakers further weakened these features by introducing inequality-enhancing reforms, practically across the board. Despite the promises, they failed to fuel economic growth and were unable to spread prosperity to the majority of the population. While this failure brought about the neoliberals' own electoral downfall in 2012, neoliberal redistributive policies, somewhat paradoxically, have largely survived. To this day, they remain the backbone of the Serbian tax-benefit system.

Acknowledgements

We would like to express our gratitude to the Open Society Foundation Serbia for their financial support towards this research. Additionally, we extend our thanks to the participants of the workshop held at the Institute for Philosophy and Social

Theory on February 21, 2022, where we presented the paper's outline. We are also grateful to William Bartlett, Branko Milanović, Danilo Vuković, and the two anonymous reviewers for their valuable feedback, comments, and suggestions.

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Received: January 17, 2023
Accepted: June 15, 2023

ECONOMIC ANNALS, Volume LXVIII, No. 237 / April – June 2023
UDC: 3.33 ISSN: 0013-3264

https://doi.org/10.2298/EKA2337037K

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THE EFFECTIVENESS OF BILATERAL INVESTMENT TREATIES IN ATTRACTING FOREIGN DIRECT INVESTMENT: THE CASE OF SERBIA

ABSTRACT: *Over the past several decades there has been increasing competition among countries to attract foreign direct investment, which is often hypothesised to positively affect the development of host countries. Bilateral investment treaties are one of the policy instruments the host countries often use as a means to encourage foreign direct investment inflows. In this study, we aim to explore the effectiveness of bilateral investment treaties in achieving these goals in the case of Serbia. Using the panel data on Serbia and its 198 partner economies observed in the period 2010–2019, we estimate a gravity model of foreign direct investment inflows by applying the Poisson pseudo-maximum likelihood method. We found that ratified bilateral investment treaties have a statistically significant positive effect on foreign direct investment inflows in Serbia. Furthermore, the quality of the treaties was found to positively affect the inflows, whereby the anti-discriminatory provisions seem to be the most important. The results imply that Serbia could attract more foreign direct investment by concluding new bilateral investment treaties and improving the quality of the existing ones.*

KEY WORDS: *bilateral investment treaties (BIT), foreign direct investment (FDI), investment promotion, Serbia*

JEL CLASSIFICATION: F21, F23, F53

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1. INTRODUCTION

In many countries, foreign direct investment is often perceived as a tool for the economic development of host countries. Foreign investment also often leads to economic development, improved export performance, technology transfer, and positive spillovers (Bjelić, 2018; Borensztein et al., 1998; Kastratović, 2020). Because of these potential benefits, potential host countries often face intense competition in attracting foreign direct investment.

Bilateral investment treaties may serve as an instrument to improve the environment for foreign investment in the host country. The provisions of the treaties offer concessions and protection to foreign investment under international law, stipulating the standards of treatment of the investment. Furthermore, the treaties provide the transparency of the conditions and legal framework of the host countries. Finally, through ratification of the treaties, host countries demonstrate their commitment to liberal foreign investment policies and the protection of investors' interests (Egger & Merlo, 2007; Neumayer & Spess, 2005). The aforesaid benefits should lower the investment costs and risks and lead to an increase in foreign direct investment flows between the countries which conclude the treaties (Egger & Merlo, 2012). For this reason, these treaties are often considered an instrument for attracting foreign direct investment. Considering that bilateral investment treaties limit the sovereignty of the host country, relegating the authority of the national judicial system to foreign arbitrations, it is particularly important to assess the potential benefits and rationale of their ratification.

The existing related literature provides conflicting evidence on the effects of bilateral investment treaties. In most developed countries with a stable and liberal environment for investment, bilateral investment treaties, for the most part, have a positive effect on foreign direct investment inflows (Dixon & Haslam, 2016; Falvey & Foster-McGregor, 2017; Kox & Rojas-Romagosa, 2020). However, the effects' size varies considerably depending on the host country observed (Brada et al., 2021). In contrast, in developing countries with a less stable environment for investment, bilateral investment treaties appear to be ineffective (Beri & Nubong, 2021; Frenkel & Walter, 2019). Therefore, the effects of bilateral investment treaties seem to be contingent upon the conditions in the individual host countries under consideration.

In this paper, we aim to explore how effective bilateral investment treaties are in terms of attracting foreign direct investment to Serbia. This is an interesting case study considering the indications of potentially positive effects (Grieveson et al., 2021), which so far have not been quantitatively and formally tested. In the process, we test two main hypotheses. According to the first one, ratified bilateral investment treaties have a positive effect on bilateral foreign direct investment inflows in Serbia. The second hypothesis states that higher-quality treaties lead to higher inflows of foreign direct investment.

We test the hypotheses by employing a gravity model of foreign direct investment flows to Serbia. We estimate the model using the sample of Serbia and its 198 partner economies observed in the period between 2010 and 2019 and by applying the Poisson pseudo-maximum likelihood estimator. Our results support both of our initial hypotheses, showing that bilateral investment treaties, particularly the high-quality ones, are an effective instrument for attracting foreign direct investment.

Our study adds to the previous related empirical studies by considering not only the effects of bilateral investment treaties on bilateral inflows of foreign direct investment in Serbia but also by exploring the role of the quality and contents of these treaties. In addition, we analyse the case of Serbia, which has previously not been the focus of similar empirical research. Finally, we employ a methodology which allows us to take into account zero investment flows, which are largely neglected in the related literature.

The remainder of this paper is structured as follows. Section 2 provides an overview of the related theoretical and empirical literature examining the effectiveness of bilateral investment treaties in attracting foreign direct investment. Section 3 discusses the methodology applied in our analysis, as well as the sample characteristics and data sources. In Section 4, we provide a descriptive analysis of the patterns of use of bilateral investment treaties in Serbia and their overall quality. Following this, in Section 5, we present and discuss the main findings of our empirical analysis. The final section presents the main conclusions.

2. LITERATURE REVIEW

There are both theoretical and empirical studies investigating the impact of bilateral investment treaties on foreign direct investment inflows. One of the few theoretical models derives a direct relationship between bilateral investment treaties and foreign direct investment (Egger & Merlo, 2012). It shows that bilateral investment treaties reduce the fixed costs of foreign affiliates' operations, which should, in turn, lead to an increased number of foreign affiliates and a larger scale of their activities in the host country.

The common aim of the relevant empirical studies is to test and quantify the effects of bilateral investment treaties on foreign direct investment inflows. The majority of these studies employ an augmented gravity model to describe foreign direct investment flows (Busse et al., 2010; Falvey & Foster-McGregor, 2017; Kox & Rojas-Romagosa, 2020; Singh, Shreeti et al., 2022). These studies provide some empirical evidence that bilateral investment treaties are often effective in attracting foreign direct investment. However, there is no consensus regarding this conclusion, as there are many notable exceptions.

All the related empirical studies can be classified into two main categories: single-country studies and multi-country studies. The studies in both categories are somewhat inconclusive.

For instance, Crotti et al. (2010) concluded that bilateral investment treaties encouraged foreign direct inflows in Australia, which they observed in the period between 1993 and 2007. Bhasin and Manocha (2016) drew a similar conclusion in the case of India, which they analysed in the period between 2001 and 2012.

In contrast, Dagbanja (2019) found no significant effects of bilateral investment treaties in the case of Ghana using a descriptive approach. Similar results were also found in the case of India (Singh et al., 2022). The insignificant results could be explained by the relatively lower level of institutional quality of the observed countries which cannot be substituted by the bilateral investment treaties, making the treaties ineffective.

Some of the first studies to investigate the effectiveness of bilateral investment treaties were multi-country studies. For example, Neumayer and Spess (2005)

found that the total number of signed and ratified bilateral investment treaties positively affects the aggregate foreign direct investment inflows in developing countries. More recent studies also report positive effects of bilateral investment treaties. For instance, Dixon and Haslam (2016) assessed such a positive effect in the case of 18 Latin American countries. North-South flows of foreign direct investment were also found to be positively affected by bilateral investment treaties, as evidenced by the study of the member countries of the Organisation of Economic Cooperation and Development (Falvey & Foster-McGregor, 2017). An analysis based on a sample of 19 Asian host countries suggests a similar conclusion, albeit with some regional heterogeneity (Mumtaz & Smith, 2018). Kox and Rojas-Romagosa (2020) used a sample of 8,500 country pairs in the period 2001–2012 in their study. They found strong positive effects of bilateral investment treaties. Positive but much less pronounced effects are reported for 16 member countries of the Regional Comprehensive Economic Partnership region observed in the period 2009–2018 (Uttama, 2021). Finally, bilateral investment treaties were found to nearly double the cross-border mergers and acquisitions in 139 countries observed in the period 1980–2014 (Bhagwat et al., 2021).

Contrastingly, the liberalisation of the investment regime through bilateral investment treaties has no effect on 48 African countries, as indicated by the results of Beri and Nubong (2021). A similar result is reported by Frenkel and Walter (2019). Perhaps the most closely related study to ours was conducted by Grieveson et al. (2021). They observed 22 transition countries in the period 1995–2017 and found no significant effects of bilateral investment treaties. However, their sample was somewhat limited as they only covered a minority of partner economies. Still, their results suggest that Serbia could be a notable exception to this general finding, although the authors did not analyse this case separately.

Our literature review suggests that the effects of bilateral investment treaties on foreign direct investment are, in general, positive. However, there are many exceptions. The empirical results vary for many reasons, including different sample sizes, characteristics of countries included in the sample, possible endogeneity issues, various methodological approaches, differences in control variables, and other model specification choices. The rigorous meta-analysis of these studies indicates that after all these differences are taken into account, bilateral investment treaties have, on average, small positive effects (Brada et al., 2021).

There are several notable shortcomings in most of the studies covered in this review. The determined effects in the studies are insufficiently precise, either because of the small sample size or sample heterogeneity. In addition, many studies observe aggregate inflows of foreign direct investment from the rest of the world. However, bilateral investment treaties by definition require a dyadic approach in the analysis. Another important gap in the existing literature is the neglect of the heterogeneity of bilateral investment treaties.

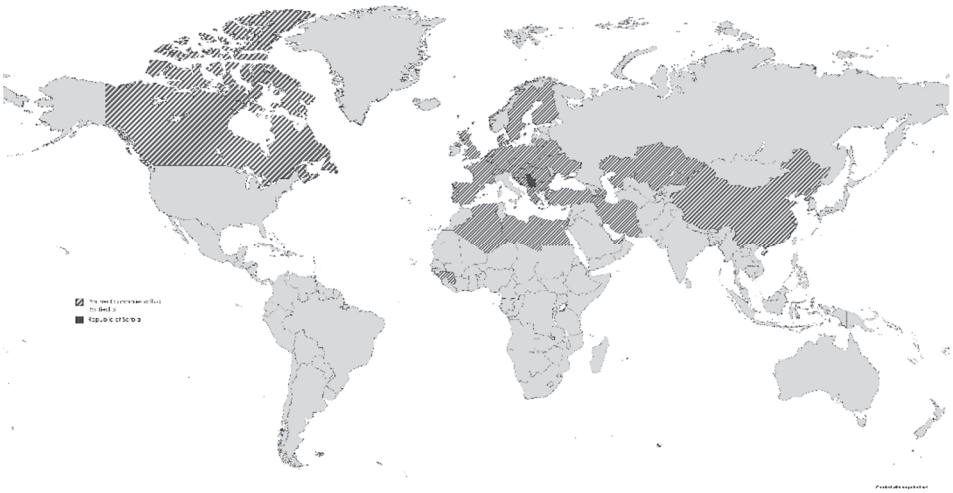
In this paper, we differentiate the treaties on the basis of their quality. By focusing on a single country, we construct a more homogenous sample in terms of foreign direct investment types and institutional framework, which should make the results more precise and relevant for policymakers. Finally, most of the related studies neglect nonlinearity and zero foreign direct investment flows when estimating a gravity model. We rectify this issue in this paper.

3. THE USE OF BILATERAL INVESTMENT TREATIES IN SERBIA

Serbia has a long history of using bilateral investment treaties. The oldest examples of these treaties which are still active were ratified during the period of Yugoslavia in the 1970s. The interest in bilateral investment treaties surged during the 2000s after Serbia adopted a liberal stance on foreign investment. In this period, Serbia ratified 37 bilateral investment treaties – over two-thirds of all the currently active treaties. This was followed by intensive inflows of foreign direct investment, which surpassed the level of 4.2 billion USD in 2006 (Kastratović, 2016). These dynamics reversed with the global financial crisis. After 2010, Serbia witnessed an unsteady recovery of the inflows, which started to exceed the pre-crisis levels in 2018. However, in 2020 there was another decrease in foreign direct investment inflows, which can largely be attributed to disruptions caused by the Covid-19 pandemic.

In 2022, Serbia had 47 active ratified bilateral investment treaties with nearly a quarter of its partner economies. With several notable exceptions, such as Russia, India, Ireland, Italy, and Norway, Serbia ratified bilateral investment treaties with most of the countries from which it has significant inflows of foreign direct investment. These partner economies are presented in the map in Figure 1. Over 57% of the partner economies belong to the group of developed economies.

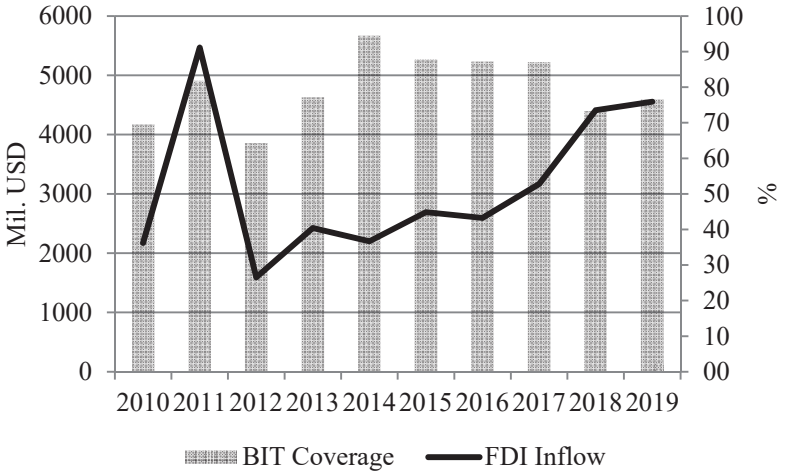
Figure 1: Countries with which Serbia has a Ratified Bilateral Investment Treaty (2022)



Source: Prepared by the authors.

We present foreign direct investment inflows in Serbia and the coverage of these inflows by bilateral investment treaties for the period 2010–2019 in Figure 2. In this period, bilateral investment treaties covered 79.9% of foreign direct investment inflows on average, with the increasing number of ratified treaties being followed by an increase in the coverage of the investment inflows, which, in certain years, surpassed a 90% share.

Figure 2: Foreign Direct Investment Inflows in Serbia and their Bilateral Investment Treaty Coverage (2010-2019)

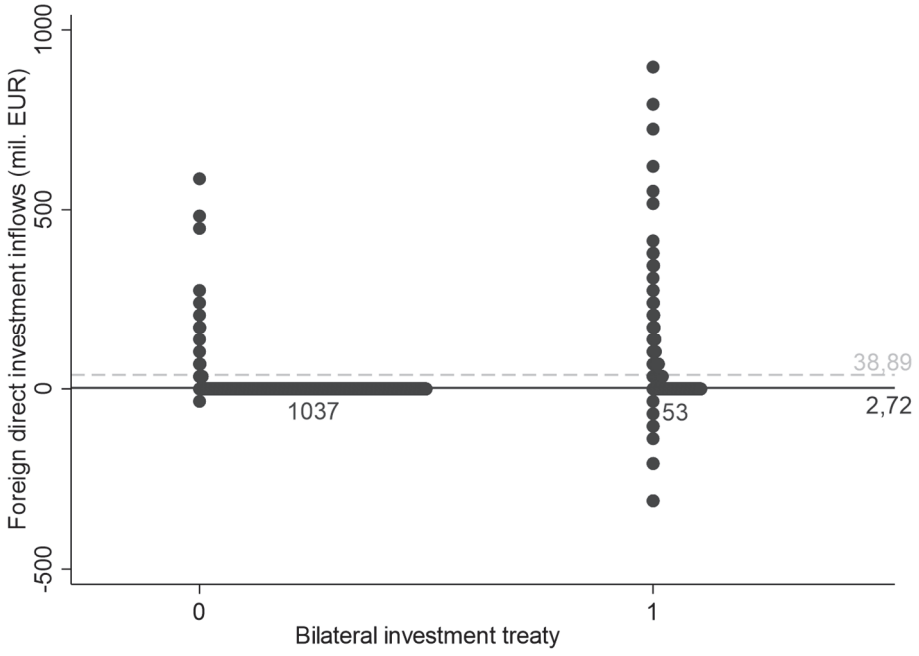


Source: Authors' calculation.

The comparison between foreign direct inflows from the economies with which Serbia has a ratified bilateral investment treaty and the ones with which it does not is presented in Figure 3. The comparison refers to the full sample, including 1,980 observations. The mean value of foreign direct investment inflows from countries with a ratified bilateral investment treaty is 38.89 million EUR, whereas the mean inflow from the other group equals 2.72 million EUR. The difference is statistically significant at the 1% significance level. Furthermore, there are significantly more zero investment flows between Serbia and partner economies without a ratified bilateral investment treaty.

The average value of the BITSel aggregate index is 1.50. According to the criteria of Chaisse and Bellak (2015), the bilateral investment treaties ratified by Serbia are moderate to high quality treaties. The consistently high quality of the treaties is particularly noticeable in relation to the temporal scope of the treaties, arbitration rules, national treatment of foreign investment, and the liberal regime of the transfer of funds. In contrast, the existing treaties are markedly lacking in terms of the breadth of investment definition, the use of umbrella clauses, coverage of indirect expropriations, and limitations to the most-favoured-nation treatment.

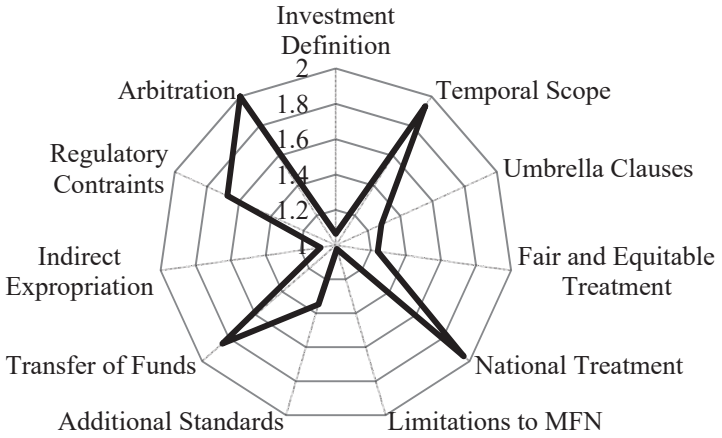
Figure 3: Distribution of Foreign Direct Investment Inflows to Serbia Dependent on the Bilateral Investment Treaty Status



Source: Authors' calculation.

We consider the quality of the existing bilateral investment treaties of Serbia by presenting the data on the BITSel index and its components in Figure 4.

Figure 4: The Quality of the Active Bilateral Investment Treaties of Serbia



Source: Authors' calculation.

It is expected that the provisions of the new and existing bilateral investment treaties will change as new initiatives regarding the contents of the treaties are promoted by the European Union and the United Nations Conference on Trade and Development. The standards defined in these initiatives were adopted by Serbia and the other countries in the region in 2020. On one hand, if implemented, some of these standards will improve the quality of the bilateral investment treaties. On the other hand, according to these standards, environmental, health, and labour standards need to be included in the preambles and other parts of the future bilateral investment treaties, which could increase the burden on foreign investors. Nevertheless, the modernisation of bilateral investment treaties could be an important step for Serbia in attracting foreign direct investment (Pavić, 2016).

4. METHODOLOGY

We base our empirical analysis on the augmented gravity model (Tinbergen, 1962). This class of models is predominantly used in the empirical analysis of international trade. However, its relevance has been confirmed for the analysis of

bilateral foreign direct investment flows (Deichmann et al., 2022; Mutti & Grubert, 2004). This model specification follows from the theories of asset trade and the knowledge-capital model and can successfully incorporate both horizontal and vertical types of foreign direct investment (Carr et al., 2001; Uttama, 2021). The model is generally considered to be a good framework for the analysis of foreign direct investment patterns and their major macro-level determinants (Blonigen, 2005; Crotti et al., 2010). In our study, we consider several specifications of the gravity model to describe the impact of bilateral investment treaties on foreign direct investment inflows, while controlling for the effects of other relevant factors. The baseline specification of our model can be represented by the following equation:

$$FDI_{ijt} = \beta_0 BIT_{ijt}^{\beta_1} GDP_{ijt}^{\beta_2} DGDPpc_{ijt}^{\beta_3} DIST_{ij}^{\beta_4} \exp(\delta_1 LANG_{ij} + \delta_2 CEFTA_{ijt} + \mu_{ij} + \lambda_t)\, \varepsilon_{it} \quad (1)$$

where FDI_{ijt} denotes inflows of foreign direct investment from country *i* to Serbia in the period *t*, BIT_{ijt} refers to variables encompassing the effects of bilateral investment treaties between country *i* and Serbia in the period *t*, GDP_{ijt} is the product of the gross domestic products of Serbia and the partner economy, DGDPpcijt is the difference in gross domestic product per capita, D_{ij} is the geographic distance between the capitals of country pairs, $LANG_{ij}$ is a dummy variable reflecting the common language of the country pairs, $CEFTA_{ij}$ is the common participation in the CEFTA 2006 agreement, μ_j refers to random individual effects which account for the unobserved heterogeneity of country pairs, λ_t refers to time effects, and ε_{it} is the error term.

Our dependent variable is the bilateral inflow of foreign direct investment expressed in EUR (FDI_{ijt}). The use of absolute foreign direct investment inflows is the most widely employed approach in the related empirical literature (Busse et al., 2010; Falvey & Foster-McGregor, 2017; Neumayer & Spess, 2005; Singh et al., 2022). We adopt this approach as it allows for a more direct estimation of the effectiveness of bilateral investment treaties and enables greater comparability of our results with the related literature.

In most of the relevant literature, zero investment flows are disregarded or transformed into arbitrary positive values. Both approaches could bias the results. For this reason, we use the Poisson pseudo-maximum likelihood approach, which

allows us to take into account the zero investment flows. In addition to only non-negative values, we consider absolute flows (which include both positive and negative values). The interpretation for this additional specification is slightly different, referring to the intensity of foreign direct investment flows, rather than the level of the investment inflows. However, the results change little when the alternative approach is followed, which is expected considering only a small fraction of the total number of observations contains negative investment values and are mostly related to special cases of sudden disinvestment, changes in intracompany loans, and valuations of foreign subsidiaries (Kox & Rojas-Romagosa, 2020). This is in line with the results of the meta-analysis of the related literature, which suggests that the choice of treatment of foreign direct investment flows does not have a significant effect on the determined effects of bilateral investment treaties (Brada et al., 2021).

The independent variable in the focus of our research is the bilateral investment treaty variable (BIT_{it}). In our baseline model, this variable is defined as a dummy variable taking the value 1 if there is a ratified bilateral investment treaty between the two observed countries in a given year and 0 otherwise. In this regard, we follow the approach of related empirical studies (Bhasin & Manocha, 2016; Crotti et al., 2010; Frenkel & Walter, 2019; Grieveson et al., 2021). We consider ratification dates rather than signing dates because the treaties only produce legal effects and provide protection to the investors on ratification.

The use of a single dummy variable to encompass the effects of bilateral investment treaties is problematic because such an approach implicitly assumes that all the treaties are homogenous. However, different treaties contain diverse provisions offering varying levels of investment protection. For this reason, we also consider the effects of their quality. For this purpose, we use the most widely used measurement of bilateral investment treaties quality – the BITSel index (Chaisse & Bellak, 2015). The index provides a single score of bilateral investment treaty quality by considering eleven types of provisions of the treaties. As the BITSel database does not contain values for Serbia, we follow the methodology provided by Chaisse and Bellak (2015) and map the contents of bilateral investment treaties using the content analysis approach, considering definitions of foreign investment used, the temporal scope of the treaty, the use of umbrella clause, the use of the "fair and equitable treatment" clause, the exceptions to the

national treatment, the exceptions to the most-favoured-nation clause, the use of additional standards regarding admission and establishment, the rules on the transfer of funds, the rules on indirect expropriation, arbitration rules, and the use of additional regulatory constraint, such as the explicit definition of environmental and labour standards. In addition to the most general value of the BITSel quality indicator, we calculate the values of subindices to investigate whether certain aspects of the bilateral investment treaties (including the quality of liberalisation – BITSel-lib$_{ijt}$, the anti-discrimination quality – BITSel-ad$_{ijt}$, the breadth of scope – BITSel-breadth$_{ijt}$, and the regulatory constraint quality of the treaties – BITSel-reg$_{ijt}$) affect the inflows of foreign direct investment to a greater or lesser extent.

Our control variables include some of the most widely used determinants of foreign direct investment in the related literature, including market size, the difference in gross domestic product per capita, common language (history and border), and participation in regional trade agreements.

The market size variable (GDP$_{ijt}$) captures the market-seeking foreign direct investment. The most commonly used approximation of market size in the related literature is gross domestic product (Busse et al., 2010; Falvey & Foster-McGregor, 2017). We determine the product of the gross domestic product of the observed country pairs rather than using separate variables for the gross domestic product of the destination and origin economies because the latter approach would lead to collinearity between the destination economy's gross domestic product and time effects. Furthermore, we considere the gross domestic product of both the destination country and the country of origin in order to remain consistent with the gravity model framework. In this regard, we follow the approach of empirical studies applying gravity models to describe the trade flows of a single country and its partner economies (Batra, 2006; Guan & Ip Ping Sheong, 2020; Rahman & Dutta, 2012). Alternatively, we control for market size using the population sizes (POP$_{ijt}$) of the observed countries, following the approach of Neumayer and Spess (2005). As gross domestic product and population are highly correlated, the two proxies for market size are used in separate specifications only to avoid multicollinearity problems. Larger integrated markets should generally allow for more firms to internationalise their operation and increase the capacity for a greater number of foreign affiliates. Both

of these should jointly be reflected on the macro level as the increase in bilateral foreign direct investment inflows. The variable also indicates that larger flows are established between larger countries, which is one of the basic ideas of the gravity model of trade.

Vertical foreign direct investment is controlled using the difference in gross domestic product per capita ($DGDPpc_{ijt}$). In the related literature, this variable is widely considered to reflect differences in factors endowments and labour skills, which is a crucial determinant for foreign direct investment (Bhasin & Manocha, 2016; Deardorff, 1998; Dixon & Haslam, 2016). It could also partially reflect differences in labour costs. Larger differences in skills should lead to larger bilateral flows of vertical foreign direct investment.

Distance between the countries ($DIST_{ij}$) is among the key variables of the gravity model and one of the most commonly used in the related literature (Bhasin & Manocha, 2016; Crotti et al., 2010; Falvey & Foster-McGregor, 2017; Kox & Rojas-Romagosa, 2020; Mumtaz & Smith, 2018). The geographic distance in our analysis is determined by using the circle formula and the data on latitudes and longitudes between the capitals of the observed countries. Larger geographic distances between the countries should, ceteris paribus, increase transportation costs. This could discourage the vertical foreign direct investment, which is associated with intensive cross-border flows of intermediary products. Additionally, the distance between the home and host country makes the coordination of business activities more difficult. This should negatively affect all types of foreign direct investment. Contrastingly, horizontal foreign direct investment should cut transport costs as sales of foreign affiliates replace traditional exports, so they could, to an extent, also be positively related to geographic distance. The net effect of these opposing forces should be captured by the coefficient of the distance variable.

Another frequently used variable in the majority of gravity models is common language ($LANG_{ij}$) (Bhasin & Manocha, 2016; Crotti et al., 2010; Falvey & Foster-McGregor, 2017). It is defined as a dummy variable taking the value of 1 when the country pair shares the same language and 0 otherwise. The variable reflects cultural proximity between the observed countries. A more familiar cultural environment should generally be more attractive for foreign investors and lower

the entry barriers they face. The cultural links between the countries are also explored through the use of the common history variable ($HIST_{ij}$), which shows whether the two countries were part of the same country in the past. Finally, the proximity between the countries is approximated using the common border variable ($BORDER_{ij}$). As the three proximity variables exhibit high correlation, we consider them in separate specifications to avoid the problem of multicollinearity.

Regional trade agreements are often hypothesised to affect foreign direct investment flows (Egger & Merlo, 2012; Grieveson et al., 2021; Kox & Rojas-Romagosa, 2020; Mumtaz & Smith, 2018). For this reason, we include a dummy variable to control for the effects of the participation of Serbia and some of its partner economies in the CEFTA 2006 agreement ($CEFTA_{ijt}$).

We estimate the gravity model by using the Poisson pseudo-maximum likelihood estimator, following the approach of Busse et al. (2010). This estimator is particularly suitable for use with samples containing a large portion of zero flows. In our sample, 55.05% of observations contain zero values of the dependent variable. Using simpler estimation techniques, such as generalised least squares, could bias the results in such circumstances. Therefore, we employ the Poisson pseudo-maximum likelihood estimator, which was shown to be highly suitable for the estimations of gravity-type models (Silva & Tenreyro, 2006). Moreover, this estimator is consistent in the presence of heteroscedasticity and allows for individual effects specification, which is important for accounting for multilateral resistance factors. The use of this approach allows us to estimate the gravity equation in its original multiplicative form, which is more theoretically consistent (Burger et al., 2009). As the introduction of fixed effects in the model would make the country pairs dummy variables collinear with time-invariant variables, and the time-invariant variables are important for the proper specification of our model, we control the heterogeneity of individual country pairs using the random intercept Poisson pseudo-maximum likelihood approach (Prehn et al., 2016). In our relatively large sample, the approach yields nearly identical estimates which differ little from the usual fixed-effects Poisson pseudo-maximum likelihood approach, while allowing us to estimate the effects of time-invariant variables.

Our analysis covers the period between 2010 and 2019. We restrict our analysis to this period because the methodology of compiling foreign direct investment data in Serbia was revised in 2010. For this reason, the inclusion of observations prior to 2010 could lead to comparability issues. In this period, we observe 198 partner economies of Serbia[1], which yields a total number of 1,980 observations. Since a few observations are missing for some of the control variables, the model estimation is based on between 1,823 and 1,969 observations, depending on the specification. The descriptive statistics of the sample are presented in Table A2 in the Appendix.

Descriptive statistics show that there is a great variety in terms of foreign direct inflows in Serbia. However, on average, the mean inflows are somewhat modest, which is driven by the lack of investment inflows from many countries. The statistics also reveal that Serbia has a ratified bilateral investment treaty with more than 22% of the partner economies considered. Finally, the statistics indicate considerable variety in partner economies' characteristics.

The results of the correlation analysis are presented in Table A3 in the Appendix. They show that foreign direct investment is significantly correlated with most of the explanatory variables considered. Moreover, the sign of the correlation coefficient is as expected. As for the potential multicollinearity problems, the closely related variables are, as expected, moderately and, in some instances, highly correlated. For this reason, these variables are estimated in separate specifications.

Our sample was constructed by combining several data sources. The data on foreign direct investment was provided by the National Bank of Serbia. The data on bilateral investment treaties are sourced from the International Investment Agreements Navigator database provided by the United Nations Conference on Trade and Development. Distance and the dummy variables of the gravity models come from the database provided by *Centre d'Etudes Prospectives et d'Informations* (CEPII). Finally, the United Nations Conference on Trade and Development provided the data on gross domestic product and population.

[1] The complete list of the considered partner economies is provided in Table A1 in the Appendix.

5. RESULTS AND DISCUSSION

We present our baseline model estimation results in Table 1. Models 1 and 2 are the specifications represented by Equation 1, where the first one is estimated using the sample of only non-negative foreign direct investment inflows, while the latter uses the sample including disinvestments. Models 3–5 refer to alternative specifications of Model 1, using different proxies for economy size and proximity. As evidenced by the Wald statistics and pseudo coefficient of determination, all the specifications are statistically significant and fit the data well. The Ramsay Regression Equation Specification Error Test results suggest no specification issues with any of the considered specifications.

The results suggest that bilateral investment treaties have a statistically significant positive effect on foreign direct investment inflows. The corresponding coefficients are statistically significant at the 5% significance level in the majority of specifications. These results are also economically significant as they indicate that bilateral investment treaties lead to an increase in annual foreign direct investment flows of between 69.78% and 96.39% depending on the specification. This implies that bilateral investment treaties are a highly effective tool for promoting and facilitating the inflows of foreign direct investment in Serbia. The reason for this could be the benefits foreign investors obtain from the treaties, which effectively lower the fixed costs and the risks associated with their investments.

Foreign direct investment inflows in Serbia are strongly affected by the size of the Serbian economy and its partner economies. This indicates the market-seeking motives of foreign investors in Serbia. In all specifications, the gross domestic product variable is statistically significant at the 1% level. The results do not change much if an alternative proxy for the economy size is used.

Table 1: The Effects of Bilateral Investment Treaties on Foreign Direct Investment Inflows

Model	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Variable					
BIT_{ijt}	0.665**	0.677**	0.531*	0.656**	0.651**
	(0.304)	(0.286)	(0.293)	(0.296)	(0.293)
GDP_{ijt}	0.050***	0.051***		0.050***	0.050***
	(0.007)	(0.007)		(0.007)	(0.007)
POP_{ijt}			0.000***		
			(0.000)		
$DGDPpc_{ijt}$	0.017***	0.017***	0.019***	0.017***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$DIST_{ij}$	-0.560***	-0.570***	-0.563***	-0.561***	-0.569***
	(0.113)	(0.110)	(0.114)	(0.113)	(0.115)
$LANG_{ij}$	0.258	0.233	0.133		
	(0.359)	(0.323)	(0.316)		
$CEFTA_{ijt}$	-1.481***	-1.588***	-1.481***	-1.304***	-1.131***
	(0.366)	(0.342)	(0.330)	(0.315)	(0.377)
$HIST_{ij}$				0.077	
				(0.271)	
$BORDER_{ij}$					-0.158
					(0.332)
Constant	3.547***	3.540***	3.651***	3.556***	3.595***
	(0.391)	(0.368)	(0.370)	(0.386)	(0.391)
Total Observations	1823	1969	1968	1823	1823
Wald	125.498	133.504	123.78	127.508	127.302
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pseudo R^2	0.528	0.519	0.486	0.528	0.528
RESET test (p-value)	0.781	0.711	0.086	0.782	0.790

Source: Authors' calculation.

Note: Robust standard errors are presented in the parentheses. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% significance levels, respectively. Wald denotes the Wald test statistics and the corresponding p-value, provided in the parentheses. RESET test refers to the results of the Ramsay Regression Equation Specification Error Test.

Differences in gross domestic product per capita between the partner economies also strongly and positively affect foreign direct investment inflows. The effect is statistically significant at the 1% significance level in all of the considered specifications. The results suggest that an increase in the difference in the gross domestic product per capita between Serbia and the partner economy of 1,000 USD leads to an increase in foreign direct investment inflows of 18.47%. This implies that vertical foreign direct investment is also highly important as some foreign investors in Serbia appear to be strongly driven by resource-seeking motives.

As expected in the gravity model, geographic distance between the partner economies is negatively related to foreign direct investment inflows in Serbia. The results reveal that increasing the distance between the capitals of countries by a thousand kilometres more than halves the value of foreign direct inflows to Serbia. The estimated coefficients are statistically significant at the 1% level in all specifications and their values are stable. Their significance paired with the significance of gross domestic product and population variables demonstrates the adequacy of the gravity model framework for the analysis of foreign direct investment flows.

The common language, history, and border variables are found not to have a significant effect on foreign direct investment inflows in Serbia. When compared to trade gravity models, cultural proximity seems to play a lesser role in determining the investment flows. This could be the result of modest outflows of foreign direct investment from the countries in the Western Balkan region with which Serbia shares the highest cultural proximity.

Finally, common CEFTA 2006 membership was found to negatively affect foreign direct investment inflows. The result could be explained by the narrow scope of investment-related provisions of the agreement, as it only explicates the common legal standards, while providing no framework for more complex issues such as dispute settlements, effectively offering the same or lower levels of protection to foreign investors in comparison to bilateral investment treaties.

In Table 2, we explore the effects of bilateral investment quality on foreign direct investment inflows in Serbia. Model 6 uses the most general proxy for the quality of bilateral investment treaties – the aggregate BITSel Quality index, whereas

Models 7–10 use the more narrowly defined indices, specifically quality of liberalisation, the anti-discrimination quality, the breadth of scope, and the regulatory constraint quality of the treaties, respectively.

Table 2: The Effects of Quality of Bilateral Investment Treaties on Foreign Direct Investment Inflows

Model	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)
Variable					
$BITSel_{ijt}$	0.405**				
	(0.190)				
$BITSel\text{-}lib_{ijt}$		0.298*			
		(0.176)			
$BITSel\text{-}ad_{ijt}$			0.703**		
			(0.306)		
$BITSel\text{-}breadth_{ijt}$				0.236***	
				(0.076)	
$BITSel\text{-}reg_{ijt}$					0.108
					(0.079)
GDP_{ijt}	0.050***	0.050***	0.050***	0.048***	0.052***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$DGDPpc_{ijt}$	0.017***	0.017***	0.017***	0.017***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$DIST_{ij}$	-0.567***	-0.587***	-0.554***	-0.490***	-0.639***
	(0.113)	(0.119)	(0.112)	(0.106)	(0.109)
$LANG_{ij}$	0.225	0.130	0.278	0.569	-0.002
	(0.349)	(0.334)	(0.362)	(0.417)	(0.292)
$CEFTA_{ijt}$	-1.442***	-1.406***	-1.504***	-1.567***	-1.291***
	(0.352)	(0.348)	(0.372)	(0.394)	(0.309)
Constant	3.547***	3.540***	3.651***	3.556***	3.595***
	(0.391)	(0.368)	(0.370)	(0.386)	(0.391)
Total Observations	1823	1823	1823	1823	1823
Wald	129.371	130.397	126.48	136.281	118.508
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pseudo R^2	0.526	0.522	0.529	0.545	0.519
RESET test (p-value)	0.760	0.819	0.772	0.553	0.799

Source: Authors' calculation.

Note: Robust standard errors are presented in the parentheses. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% significance levels, respectively.

Similar to the baseline model, these specifications are all statistically significant as a whole, providing a good fit for the data and showing no signs of specification issues.

The results presented in the Table 2 suggest that, in general, the quality of bilateral investment treaties matters for inflows of foreign direct investment. The estimated effect is statistically significant at the 5% significance level. The values of the estimates indicate that if Serbia provides the highest level of investment provisions to foreign investors, it could increase its inflows of foreign direct investment from the countries with which it has ratified such a favourable treaty by 49.97%. Looking at the individual aspects of the treaties' qualities, we can see that the highest positive effects on investment inflows could be realised by improving the anti-discrimination quality of the bilateral investment treaties. Increasing the breadth of the treaties' scope and liberalising the investment regime could also improve the inflows of foreign direct investment, albeit to a lesser extent. The corresponding coefficients are statistically significant at least at the 10% level. Finally, the regulatory constraint quality of the treaties has no significant effect on the investment inflows. This could imply that host countries' provisions of access to arbitration for foreign investors have become standard practice. Therefore, further improvements in this group of provisions bring little marginal benefit to investors. This is reflected in the lack of impact on the investment inflows.

The estimation of Models 6–10 may serve as a robustness check for the control variables. Regardless of the changes in specification, all the control variables previously presented in Table 1 maintained their statistical significance. Moreover, there was little change in the estimates' values. This indicates the stability of the obtained results.

A series of sensitivity tests were conducted using Models 11–16, and the results are shown in Table 3. Using Models 11 and 12, we explored the potential significance of time lags for the bilateral investment treaty variables. The results provide no evidence of a more complex lag structure for the independent variables in focus.

For the estimation of Models 13 and 14, we restricted our sample by excluding all offshore partner economies. The effects of bilateral investment treaties and their

quality remain statistically significant with similar coefficient values obtained using the full sample. The same is true for the control variables.

Table 3: Robustness Checks

Model	Model (11)	Model (12)	Model (13)	Model (14)	Model (15)	Model (16)
Variable						
BIT_{ijt}	1.908**		0.548*		0.653**	0.648**
	(0.832)		(0.321)		(0.307)	(0.314)
BIT_{ijt-1}	-0.437					
	(1.119)					
BIT_{ijt-2}	-0.588					
	(0.824)					
$BITSel_{ijt}$		1.218**		0.320		
		(0.604)		(0.195)		
$BITSel_{ijt-1}$		-0.29				
		(0.821)				
$BITSel_{ijt-2}$		-0.376				
		(0.597)				
GDP_{ijt}	0.047***	0.047***	0.062***	0.062***	0.051***	0.050***
	(0.007)	(0.007)	(0.005)	(0.005)	(0.007)	(0.007)
$DGDPpc_{ijt}$	0.015***	0.015***	0.018***	0.018***	0.017***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$DIST_{ij}$	-0.487***	-0.491***	-0.764***	-0.772***	-0.570***	-0.559***
	(0.115)	(0.114)	(0.092)	(0.091)	(0.120)	(0.117)
$LANG_{ij}$	0.383	0.347	0.039	0.003	0.243	0.106
	(0.422)	(0.409)	(0.345)	(0.334)	(0.359)	(0.479)
$CEFTA_{ijt}$	-1.567***	-1.522***	-1.406***	-1.368***	-1.474***	-1.286**
	(0.453)	(0.435)	(0.349)	(0.335)	(0.365)	(0.520)
Constant	3.302***	3.350***	3.852***	3.916***	3.569***	3.565***
	(0.427)	(0.413)	(0.396)	(0.371)	(0.397)	(0.403)
Total Observations	1445	1445	1771	1771	1529	1682
Wald	113.186	117.585	328.591	336.821	120.446	119.739
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pseudo R^2	0.517	0.515	0.587	0.586	0.497	0.514
RESET test (p-value)	0.451	0.392	0.144	0.147	0.886	0.780

Source: Authors' calculation.

Note: Robust standard errors are presented in the parentheses. ***, **, and * denote coefficients significant at the 1%, 5%, and 10% significance levels, respectively.

In Model 15, we further tested the robustness of our baseline model by excluding all the geographically distant partner economies from the sample.[2] This restriction had little effect on our empirical results. Finally, in Model 16 we excluded small partner economies which have a gross domestic product of less than a billion USD. In line with the previous robustness check, this change also made no significant difference for either the statistical or economic significance of the independent variables of the baseline model

The robustness of the results is further tested by estimating our baseline model using the subsamples for the periods 2011–2019 and 2010–2018. The results of these estimations are presented in Table A4 in the Appendix. As previously, all the specifications are statistically significant and show no signs of specification errors. Despite the change in the sample, both the existence of bilateral investment treaties and their quality remain statistically significant at the 5% level. Their economic significance, for the most part, also remained unchanged, as indicated by the coefficient values. The significance and the coefficient values for the control variable further show the stability of the determined results. Therefore, we can conclude that our empirical results are robust to changes in specification and sample.

6. CONCLUSION

In this paper, we considered the role of bilateral investment treaties in attracting foreign direct investment in Serbia. For this purpose, we used an augmented gravity model of foreign direct investment inflows to Serbia. We estimated the model using a sample of 198 country pairs observed in the period 2010–2019.

Our results suggest that the ratification of bilateral investment treaties has a strong and statistically significant effect on bilateral inflows of foreign direct investment in Serbia. Furthermore, the quality of the treaties also plays a significant role in attracting investment. The most important aspects of the quality in this regard appear to be the anti-discriminatory provisions of the treaties. Provisions liberalising the regime of foreign investment and the scope of treaties are also found to positively affect the investment inflows. The presented

[2] For this purpose, all the partner economies whose capital cities are further than 10,000 kilometres from the capital of Serbia were considered distant.

empirical results are robust to the use of alternative specifications, proxies, and samples. Therefore, the results support our initial hypotheses.

Our results are in line with the findings of other related single-country studies (Bhasin & Manocha, 2016; Crotti et al., 2010). They also support the previous findings of the majority of related multi-country studies (Falvey & Foster-McGregor, 2017; Kox & Rojas-Romagosa, 2020), and confirm the conjecture of Grieveson et al. (2021) in relation to Serbia. The intensity of the effects is also similar to the effects found in the related literature. The significant effects of the treaties' quality corroborate the hypothesis of Chaisse and Bellak (2015) and previous findings of Dixon and Halsam (2016). However, our results differ from the results of studies focusing on less developed countries (Beri & Nubong, 2021; Dagbanja, 2019). This could indicate that Serbia has a sufficiently stable and favourable institutional framework that allows the bilateral investment treaties to be effective.

The evidence provided by this study implies that the policymakers in Serbia could use bilateral investment treaties as an instrument for attracting foreign direct investment. Concluding bilateral investment agreements with countries that invest in Serbia or have the potential to significantly invest in the future but do not have an existing treaty might be particularly beneficial. The increase in inflows of foreign direct investment could also be achieved by renegotiating existing bilateral investment treaties and improving their quality, particularly in regard to anti-discrimination. Finally, the results may imply that the provisions made in the treaties appear credible to foreign investors.

It should be noted that in addition to the benefits of bilateral investment treaties considered in this study, treaties also place constraints on the economic policy of the host country. Therefore, it is important to coordinate the use of bilateral investment treaties with other aspects of economic policy. It is also noteworthy that bilateral investment treaties not only affect inflows of foreign direct investment but can also support the internationalisation of enterprises in Serbia. An interesting avenue for future research would be to consider the effects of the treaties on foreign direct investment outflows, or even the extent of internationalisation of Serbian companies.

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Received: March 09, 2023
Accepted: March 28, 2023

APPENDIX

Table A1: Partner Economies in the Sample

Afghanistan	Canada	Finland	Kuwait	Niger	South Africa
Albania	Cayman Islands	France	Kyrgyzstan	Nigeria	Spain
Algeria	Central African Republic	French Polynesia	Lao People's Democratic Republic	North Macedonia	Sri Lanka
Angola	Chad	Gabon	Latvia	Norway	Sudan
Anguilla	Chile	Gambia	Lebanon	Oman	Suriname
Antigua and Barbuda	China (People's Republic of)	Georgia	Lesotho	Pakistan	Sweden
Argentina	Chinese Taipei	Germany	Liberia	Palestinian Authority or West Bank and Gaza Strip	Switzerland
Armenia	Colombia	Ghana	Libya	Panama	Syrian Arab Republic
Aruba	Comoros	Greece	Lithuania	Papua New Guinea	Tajikistan
Australia	Congo	Grenada	Luxembourg	Paraguay	Tanzania
Austria	Costa Rica	Guatemala	Macau, China	Peru	Thailand
Azerbaijan	Côte d'Ivoire	Guinea	Madagascar	Philippines	Timor-Leste
Bahamas	Croatia	Guinea-Bissau	Malawi	Poland	Togo
Bahrain	Cuba	Guyana	Malaysia	Portugal	Tonga
Bangladesh	Curacao	Haiti	Maldives	Qatar	Trinidad and Tobago

Barbados	Cyprus	Honduras	Mali	Romania	Tunisia
Belarus	Czech Republic	Hong Kong, China	Malta	Russia	Turkey
Belgium	Democratic People's Republic of Korea	Hungary	Mauritania	Rwanda	Turkmenistan
Belize	Democratic Republic of the Congo	Iceland	Mauritius	Saint Kitts and Nevis	Turks and Caicos Islands
Benin	Denmark	India	Mexico	Saint Lucia	Tuvalu
Bermuda	Djibouti	Indonesia	Moldova	Saint Vincent and the Grenadines	Uganda
Bhutan	Dominica	Iran	Mongolia	Samoa	Ukraine
Bolivia	Dominican Republic	Iraq	Montenegro	Sao Tome and Principe	United Arab Emirates
Bosnia and Herzegovina	Ecuador	Ireland	Montserrat	Saudi Arabia	United Kingdom
Botswana	Egypt	Israel	Morocco	Senegal	United States
Brazil	El Salvador	Italy	Mozambique	Seychelles	Uruguay
Brunei Darussalam	Equatorial Guinea	Jamaica	Myanmar	Sierra Leone	Uzbekistan
Bulgaria	Eritrea	Japan	Namibia	Singapore	Vanuatu
Burkina Faso	Estonia	Jordan	Nepal	Sint Maarten	Venezuela
Burundi	Eswatini	Kazakhstan	Netherlands	Slovak Republic	Viet Nam
Cabo Verde	Ethiopia	Kenya	New Caledonia	Slovenia	Yemen
Cambodia	Faeroe Islands	Kiribati	New Zealand	Solomon Islands	Zambia
Cameroon	Fiji	Korea	Nicaragua	Somalia	Zimbabwe

Table A2: Descriptive Statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
FDI_{ijt}	1980	11.489	58.464	-322.233	885.04
BIT_{ijt}	1980	0.223	0.416	0	1
$BITSel_{ijt}$	1980	0.333	0.625	0	1.727
GDP_{ijt}	1969	1.708	7.542	0.000	106.753
$DGDPpc_{ijt}$	1969	10.45	26.689	-5.959	176.023
POP_{ijt}	1978	328.606	1244.93	0.044	12577.48
$DIST_{ij}$	1980	6.046	4.092	0.197	18.002
$BORDER_{ij}$	1980	0.04	0.197	0	1
$LANG_{ij}$	1980	0.025	0.157	0	1
$HIST_{ij}$	1980	0.025	0.157	0	1
$CEFTA_{ijt}$	1980	0.027	0.163	0	1

Source: Authors' calculation.

Note: FDI_{ijt} is expressed in millions of EUR, GDP in 10.000 million USD, POP in millions of people, DIST in thousands of kilometres, and BIT, BORDER, LANG, HIST, and CEFTA are all dummy variables.

Table A3: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) FDI_{ijt}	1										
(2) BIT_{ijt}	0.251*	1									
(3) $BITSel_{ijt}$	0.249*	0.997*	1								
(4) GDP_{ijt}	0.164*	0.100*	0.106*	1							
(5) $DGDPpc_{ijt}$	0.181*	0.133*	0.132*	0.137*	1						
(6) POP_{ijt}	0.072*	0.172*	0.180*	0.548*	-0.051*	1					
(7) $DIST_{ij}$	-0.199*	-0.518*	-0.514*	0.01	-0.066*	0.004	1				
(8) $BORDER_{ij}$	0.044*	0.322*	0.316*	-0.039	-0.063*	-0.045*	-0.285*	1			
(9) $LANG_{ij}$	0.005	0.223*	0.223*	-0.035	-0.057*	-0.039	-0.223*	0.784*	1		
(10) $HIST_{ij}$	0.029	0.223*	0.223*	-0.034	-0.035	-0.04	-0.222*	0.621*	0.795*	1	
(11) $CEFTA_{ijt}$	-0.003	0.208*	0.208*	-0.037	-0.067*	-0.041	-0.230*	0.659*	0.843*	0.645*	1

Source: Authors' calculation.

Note: * denotes statistically significant correlation at the 5% level.

Table A4: Sensitivity Analysis

Model	Model (17)	Model (18)	Model (19)	Model (20)
Variable				
BIT_{ijt}	0.740**	0.659**		
	(0.323)	(0.306)		
$BITSel_{ijt}$			0.449**	0.399**
			(0.201)	(0.190)
GDP_{ijt}	0.049***	0.049***	0.049***	0.049***
	(0.007)	(0.008)	(0.007)	(0.008)
$DGDPpc_{ijt}$	0.017***	0.018***	0.017***	0.018***
	(0.002)	(0.002)	(0.002)	(0.003)
$DIST_{ij}$	-0.541***	-0.536***	-0.549***	-0.544***
	(0.115)	(0.123)	(0.115)	(0.123)
$LANG_{ij}$	0.309	0.491	0.268	0.452
	(0.383)	(0.389)	(0.370)	(0.378)
$CEFTA_{ijt}$	-1.503***	-1.558***	-1.457***	-1.513***
	(0.393)	(0.424)	(0.376)	(0.409)
Constant	3.492***	3.378***	3.554***	3.436***
	(0.415)	(0.391)	(0.399)	(0.375)
Total Observations	1635	1654	1635	1654
Wald	117.648	97.284	121.412	101.013
	0.000	0.000	0.000	0.000
Pseudo R^2	0.526	0.511	0.524	0.509
RESET test (p-value)	0.746	0.366	0.771	0.384

Source: Authors' calculation.

Note: Models 11 and 12 refer to the baseline model presented by Equation 1 and estimated using the subsamples for periods 2011-2019 and 2010-2018, respectively. Models 13 and 14 are identical to Model 6, except that the two models were estimated using the aforementioned subsamples. Robust standard errors are presented in the parentheses. ***, **, and * denote coefficients significant at 1%, 5%, and 10% significance levels, respectively. Wald denotes the Wald test statistics and the corresponding p-value, provided in the parentheses. RESET test refers to the result of Ramsay Regression Equation Specification Error Test results.

ECONOMIC ANNALS, Volume LXVIII, No. 237 / April – June 2023
UDC: 3.33 ISSN: 0013-3264

https://doi.org/10.2298/EKA2337069Z

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INVESTIGATION OF THE SUNSPOTS AND GDP NEXUS: THE CASE OF BALKAN COUNTRIES

ABSTRACT: *The phenomenon known as sunspots refers to regions of the Sun's photosphere that are darker than their surroundings because their surface temperature is lower. The sunspot growth theory, however debatable, is one of the first explanations for economic development that explains how variations in the Sun's activity affect the business cycle. Jevons developed the sunspot hypothesis in 1875. To reevaluate this notion, this research uses correlation and regression analysis to explore the relationship between sunspots and GDP in the context of 11 Balkan nations over the years 1960–2021. By extending the sample of nations in panel regression models to include all nations on Earth, further robustness testing is accomplished. It was found that there exist significantly negative medium strength correlations between sunspots and gross domestic product values of 8 out of 11 Balkan countries. Similar findings were obtained using simple linear regression analysis. The results of the cross-country panel regression models further highlight the negative impact of solar activity on economic activity, which is also associated with nations that are located at higher latitudes.*

KEY WORDS: *sunspots; GDP per capita; Balkan countries; correlation and regression; H-P filter, panel data.*

JEL CLASSIFICATION: E32, F44, Q54.

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1. INTRODUCTION

The theory on the link between variations in the solar cycle and economic activity was first put forth by Sir William Herschel in 1801 (Herschel, 1801). Hyde Clarke, who noticed a link between 11-year solar cycles and economic activity, advanced this theory (Clarke, 1847). William Stanley Jevons was the first person to seriously consider this notion, however. A "wonderful coincidence", was how he described it. Sunspots, according to Jevons (1875), have an impact on the weather on Earth, which in turn affects crops and the global economy (Jevons, 1879). Jevons' sunspot idea, however, was disproved since there was no theoretical justification for it in the evidence. In economics, a random variable that is external to the economy and has no bearing on its foundations is referred to as "a sunspot". Rifts in the Sun's surface, known as sunspots, reveal a lower layer. The environment is cooler when there are more sunspots because the lower layer emits less light and heat than the surface. Sunspots, which wax and wane over a period of about 11 years, are the most well-known aspect of the Sun's activity, according to Eddy (1976). The physical effects of the Sun's influence on Earth are discussed by Lean (2015). Eastwood et al. (2017) provided a thorough literature review of the economic impact of space weather through various channels, including the power grid, the oil and gas industry, communications, ground transportation, satellite infrastructure, global navigation satellite systems, and aviation. Large magnetic storms are common around the peaks of the sunspot cycle, inducing powerful polar light (auroras). Extreme space weather events, such as geomagnetic storms, are widely known to pose a serious threat to infrastructure.

Sunspot activity, according to Alexander Chizhevsky's hypothesis, has had an impact on human history throughout time (Chizhevsky, 1924). The three-year maximum of the sunspot cycles, according to his research, were the time when the most significant historical events took place. The behaviour of people is negatively impacted by solar activity, according to Chizhevsky. He divided an 11-year period into four sub-periods: (1) a three-year period of minimum solar activity marked by passivity and autocratic rule, (2) a two-year period during which people organise under new leaders, (3) a three-year period of maximum excitability, revolutions, and war around the solar maximum, and (4) a three-year period of a gradual decrease in excitability until the people are apathetic.

According to Gorbanev (2012), peak solar activity somehow affects people's mental, and even physical, health, which in turn affects their behaviour and expectations. As a result, consumer demand and labour productivity change, causing the economy to experience cyclical oscillations. The data regarding the connection between solar cycles and business activity, specifically how they affect crops, was reviewed by Garcia-Mata and Shaffner in 1934. The authors discovered a statistically significant association between the variations in non-agricultural economic activity in the United States and solar cycles, despite the fact that the sunspot theory had been rejected. Sidis (1918) connected sunspot activity with the occurrence of revolutions, whereas Sorokin (1938) identified sunspot activity as a disregarded component in conflict.

Our study uses correlation and regression analysis to look at the effect of solar activity on the GDP of 11 Balkan nations. With the exception of Greece, the data for the various countries could only be obtained for periods of time that are relatively short. A robustness check was conducted by broadening the sample to include all nations using cross-country panel regression models. This was examined to see whether variations in solar activity across 11-year cycles have a discernible impact on variations in the gross domestic product per capita, the broadest gauge of economic activity; in other words, whether variations in solar activity have an impact on how individuals act, which has an impact on the economy. The two hypotheses to be tested are as follows:

H_1: Increased solar activity has a detrimental effect on the gross domestic product (GDP) per capita in the Balkans and other nations.

H2: Countries at higher latitudes are more adversely affected by solar activity.

The economies of the Balkan countries and other nations are anticipated to be significantly and negatively impacted by solar activity. Similar to how greater geomagnetic activity is reported to have a negative impact on countries at higher latitudes, so too should increased solar activity. Cross-country panel regression models with their three specifications, pooled OLS, fixed effects model, and random effects model, were employed for further analysis.

There are five sections in the paper. The most significant pertinent theoretical and empirical studies on this topic are presented and expanded upon in the

literature review. The data and methodology employed in this study are detailed in the methodology and data section. The primary findings of the analysis are presented in the results and discussion section. Concluding thoughts are presented in the last section.

2. LITERATURE REVIEW

This section presents and elaborates on a chronological literature review of the effect of solar activity on economic activity. Collins (1965) has shown that since 1871, the years in which the average number of sunspot counts surpassed 50 have always coincided with, or been followed by, a high percentage decline in stock markets. According to Dewey (1968), the Sun's 11-year cycle affects 43 different cycles, including those of stock and commodity markets, industrial output, and agricultural productivity. Using data from the years 1866 to 1973, Harrison (1976) investigated the relationship between agricultural yields (wheat, corn, cotton, and rice) and different solar cycle stages. The key conclusion was that lower yields and decreased sunspot activity are correlated with one another.

Sunspots contribute to variations in business to only a relatively minor extent. Gallegati and Mignacca (1994) estimate that they account for only about 4% to 5% of the variance in the series with a lag of one to two years. The authors described Jevons' hypothesis as an appealing but imperfect idea, yet they did not fully reject it. Based on information from the period between 1971 and 2001, Otsu et al. (2006) investigated relationships between the number of sunspots, the unemployment rate, and suicide mortality in Japan. With R equal to -0.17, there was a substantial inverse relationship between the sunspot count and unemployment. Sunspots' impact on the German economy between 1927 and 1932 was demonstrated by Weder (2006). Important information about economic activity can be found in sunspots. Weder highlights a quantifiable portion of output volatility that can be attributed to nonfundamental expectations and provides an explanation for the start of the German Depression. According to Jevons, ripples, or panics, seemed to occur periodically (Peart, 1991). Moods were derived from changes in economic indicators that were used to forecast investment returns.

On the basis of historical data, Modis (2007) found links between the GDP of the United States, the Dow Jones Industrial Average index, and the number of

sunspots. He provided solid evidence that there is a connection between stock market fluctuations and sunspot activity. Similar findings were made in a fairly systematic way for the GDP peaks that come before the sunspot peaks. According to McClellan (2010), sunspots are the hidden cause of unemployment. Maxima in the jobless rate in the United States coincided with sunspot activity peaks and occurred roughly three years later. In many areas related to human endeavour, including growth, inflation, demographics, sentiment, and stock market seasonality and waveform, solar phenomena have an impact on people and drive cyclical patterns that reoccur throughout time (Hampson, 2012). The relationship between solar cycle activity and the timing of recessions in the US and other G7 nations was examined by Gorbanev (2015). He discovered that throughout the course of the previous 77 years, recessions in the United States and the G7 countries coincided with solar activity maximums. In his 2012 paper, Gorbanev found a similar outcome when examining the connection between solar cycle maximums and rising jobless rates. The new pattern of financial and economic crises occurring throughout the world at times of solar activity minimums was also noted by Gorbanev (2020).

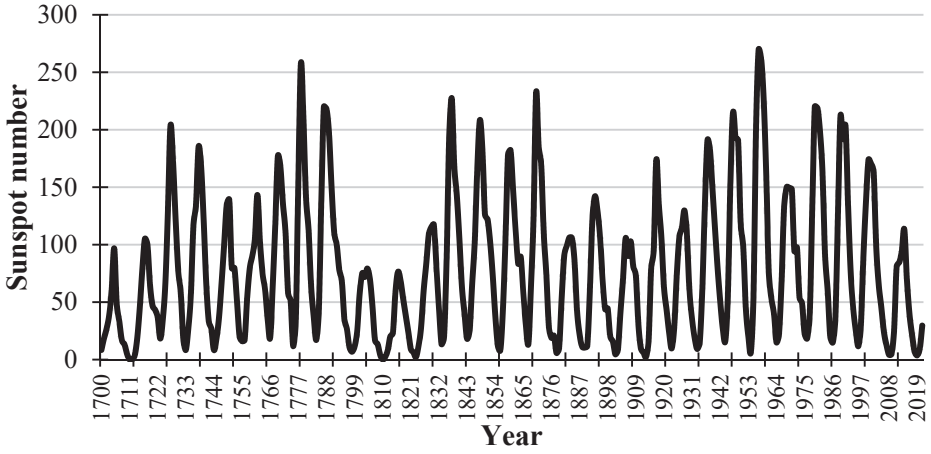
Gupta et al. (2015) used monthly data from January 1880 to September 2013 to examine if sunspots affect global temperatures. For both complete samples and sub-samples, conventional domain causality tests were unable to disprove the null hypothesis that sunspots do not affect world temperatures. Sunspots increase the Earth's geomagnetic activity, which alters people's psychology and behaviour, claim Dimitrijevic et al. (2016). As a result, stock markets are affected by waves of optimism and pessimism. Dimitrijevic et al. (2016) discovered a statistically significant negative association between the indexes of four stock markets (in Serbia, Slovenia, Croatia, and Hungary) and sunspot activity, as determined by sunspot number, between 2005 and 2012. Therefore, a rise in solar activity has a detrimental effect on stock markets and investment decisions. Using a vector error correction approach, Burakov (2017) evaluated a hypothesis regarding the impact of sunspot cycles on the Russian wheat market from 1990 to 2015. Sunspots, wheat yields, wheat prices, and non-performing loans (NPL) were all correlated over the long term, demonstrating the significance of solar activity for agricultural financing. Zhao (2019) estimated the negative effects of solar activity on the Canadian economy using a three-sector real business cycle model (RBC). Shocks to solar activity reduce output, consumption, and investment. More

specifically, for every percentage point increase in solar activity, the GDP per person fell by 0.26 per cent.

3. DATA AND METHODS

The purpose of this study is to examine the relationship between solar cycles and their subsequent effects on variations in the level of economic activity on Earth as measured by the gross domestic product per capita variable. The annual mean total sunspot number was monitored for the analysis. The occurrence of sunspots was initially tracked on a daily basis.

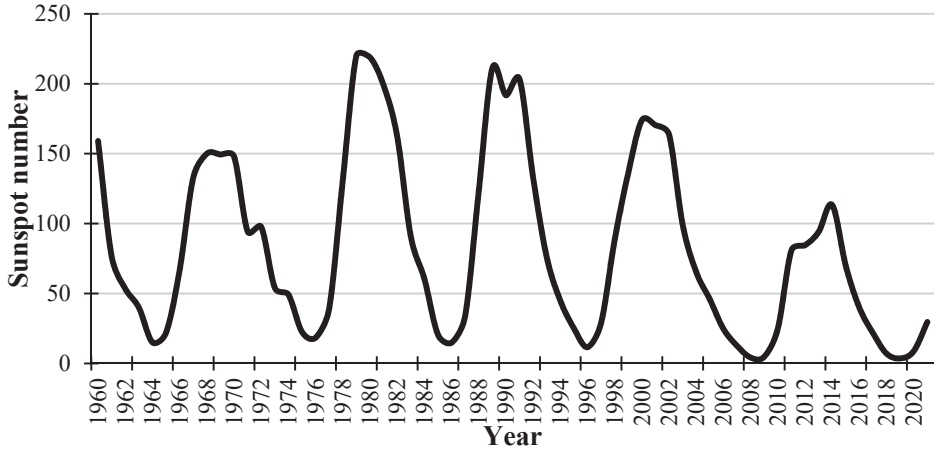
Figure 1. Yearly mean total sunspot number from 1700 to 2021



Source: WDC-SILSO (2022).

The occurrence of the sunspots were tracked annually because the gross domestic product is not calculated on a daily basis. A simple arithmetic mean of the daily total sunspot number across all days of each year was calculated to approximate the annual sunspot number (WDC-SILSO, 2022). It is feasible to identify the recurring patterns of the maximum and minimum number of sunspots by tracking the number of sunspots each year. The annual mean total number of sunspots from 1700 through 2021 is shown in Figure 1. This extremely long period of observation, more than 300 years, indicates a cycle of about 11 years between the highest and lowest annual sunspot number.

Figure 2. Yearly mean total sunspot number from 1960 to 2021



Source: WDC-SILSO (2022).

The period from 1960 onwards is the subject of the research because of restrictions on data collection for the gross domestic product per capita variable. Therefore, the annual mean total sunspot number for the years 1960 through 2021 is shown in Figure 2. The years 1964, 1976, 1986, 1996, 2008, and 2019 are those in which the number of sunspots each year was at its lowest. Contrarily, the years 1968, 1979, 1989, 2000, and 2014 have the highest number of sunspots observed in a single year. This means that there are six periods of minimum sunspot number and five periods of maximum sunspot activity. The next annual highest number of sunspots is anticipated to occur in 2025, following the 11-year cycle of repetition.

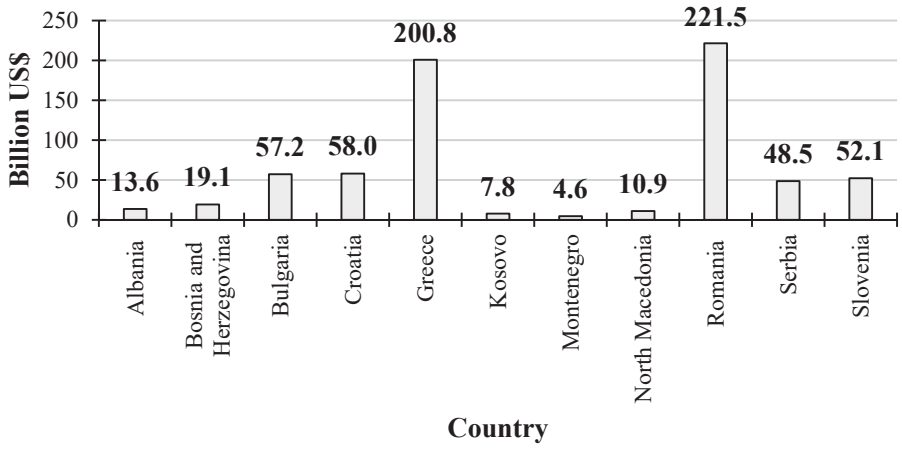
Table 1. Descriptive statistics of yearly mean total sunspot number from 1700 to 2021 and from 1960 to 2021

Statistics	Period	
	1700-2021	1960-2021
Mean	78.37	83.16
Median	65.15	68.30
Standard Deviation	62.05	64.52
Range	269.3	216.5
Minimum	0	3.6
Maximum	269.3	220.1
Sum	25234	5156
Count	322	62

Source: Authors' calculations.

Table 1 presents the main descriptive statistics data for the annual mean total sunspot number variable based on the time spans from 1700 to 2021 and from 1960 to 2021.

Figure 3. Gross domestic product of Balkan countries in 2021, constant 2015 US$, in billion US$



Source: World Bank (2023a).

The average of the annual means of the total sunspot number for the period 1960 to 2021 is somewhat greater than that for the period 1700 to 2021. However, the range of the yearly means of the total sunspot number is smaller between 1960 and 2021 than between 1700 and 2021. The annual mean total sunspot number variable was observed together with the gross domestic product variable. Only Balkan countries were initially monitored for the variable of gross domestic product, which is presented in constant 2015 US dollars (World Bank, 2023a). This sample of nations was chosen in an effort to depart from mainstream theory, which mostly focuses on the US, the G7, and developed OECD nations.

The following 11 nations are included among the Balkan nations: Albania, Kosovo, Montenegro, North Macedonia, Romania, Serbia, Slovenia, Bosnia and Herzegovina, Bulgaria, Croatia, and Greece. Figure 3 displays the gross domestic product for the Balkan nations in 2021. Three groupings of countries can be distinguished based on the value of their gross domestic products. With the greatest gross domestic product values, the first group includes Greece and Romania. Four nations make up the second group of Balkan nations with comparable gross domestic product values: Bulgaria, Croatia, Serbia, and Slovenia. The final group of five Balkan nations – Albania, Bosnia and Herzegovina, Kosovo, Montenegro, and North Macedonia – has the lowest projected gross domestic product in 2021 of all the Balkan nations.

Table 2. Descriptive statistics of gross domestic product variable, Balkan countries, constant 2015 US$, in billion US$

Country	Statistics						
	Count	Mean	Median	Std. dev.	Range	Min.	Max.
Albania	42	7.59	6.31	3.05	10.06	3.53	13.59
Bosnia and Herzegovina	28	13.11	14.88	4.40	16.67	2.44	19.11
Bulgaria	42	40.74	38.01	8.59	28.40	29.04	57.44
Croatia	27	47.66	49.28	6.81	24.49	33.56	58.05
Greece	62	158.75	160.02	58.20	224.06	41.91	265.97
Kosovo	14	6.18	6.12	1.02	3.22	4.58	7.80
Montenegro	25	3.57	3.71	0.66	2.18	2.60	4.78
North Macedonia	32	8.02	7.52	1.78	5.44	5.75	11.19
Romania	32	143.03	139.69	40.57	129.43	92.10	221.54
Serbia	27	34.50	37.68	7.97	27.32	21.21	48.52
Slovenia	27	39.56	41.47	7.07	25.63	26.42	52.05

Source: Authors' calculations.

Additionally, the results of the descriptive statistics for the Balkan countries, shown in Table 2, serve to support Figure 3 and the gross domestic product variable. The average values of the gross domestic product are shown in Table 2. The difference in the GDP between the Balkan countries can be seen. It should be emphasised that only Greek gross domestic product data were available over the whole observation period, which ran from 1960 to 2021. The gross domestic product figures for the other Balkan nations were only available for specific timeframes. All the Balkan nations have continuous data series until the year 2021, despite the fact that the number of data points for variables relating to gross domestic product differs between the Balkan nations. The most significant variation is the base year for which data on the gross domestic product was available. As an illustration, Kosovo's gross domestic product numbers for the years 2008 to 2021 are covered by just 14 data points.

Regression and correlation analyses were used to examine the association between the annual mean total sunspot number and the gross domestic product figures of the Balkan nations. The correlation analysis demonstrates whether there is a statistically significant linear relationship between the former and the latter. For each Balkan nation separately, the gross domestic product value serves

as the dependent variable in the regression models, while the yearly mean total sunspot number always serves as the explanatory variable. Unstandardised values of the variables were used in the analysis. The natural logarithm of the gross domestic product variable was used in the regression and correlation studies. Additionally, the yearly mean total sunspot number was first be expressed in absolute values before being converted to natural logarithms for the regression and correlation analysis. Furthermore, the regression and correlation analysis were conducted by taking into account lagged natural logarithms of total sunspot number.

In addition, both variables were then standardised in order to graphically illustrate and contrast the values of the gross domestic product of the Balkan countries and the yearly mean total sunspot number. Next, a Hodrick–Prescott high-pass filter was used to extract cyclical components from the standardised variables (Stata, 2022). The cyclical movement of the yearly mean total sunspot number and the gross domestic product variables could then be compared to determine whether or not there is a relationship between them. It is known that the yearly mean total sunspot number achieves the minimum and maximum values in a cyclical way; hence cyclical component examination and comparison are the subjects of this study. In the next step of the analysis, cross-country panel regression models with pooled OLS, fixed effects, and random effects specifications were employed to conduct a more thorough analysis. The sample of nations was widened to include all nations to obtain more reliable conclusions on how solar activity affects economic activity. Equation 1 gives the cross-country panel regression specification:

$$y_{it} = \beta_0 + \beta_1 solar\_activity_{t-1} + \beta_2 solar\_activity_{t-1} \cdot latitude_i + \beta_3 unemp\_rate_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

where y represents the gross domestic product per capita in constant 2015 US dollars as a measure of economic activity. These data came from OECD National Accounts data files and World Bank national accounts statistics (World Bank, 2023b). The variable $solar\_activity$ represents the annual variability in sunspot frequency observed with a one-year lag. As a result, this variable serves as a stand-in for solar activity measurement. The $latitude$ variable takes values between 0 and 100, with 0 denoting the equator, and represents the country's absolute

latitude as measured by distance from the equator. Data were obtained from DistanceLatLong (2023) for this variable. A variable called $solar\_activity_{t-1} \cdot latitude_i$ with a lag of one period was created to quantify the impacts of solar activity on economic activity depending on the country's latitude. The unemployment rate (World Bank, 2023c), $unemp\_rate_{i,t-1}$, was added as a control variable to the regression equation to establish a causal relationship between the variables of interest and prevent research bias. Along with the pooled OLS model, two additional panel cross-country regression models with fixed effects and random effects were generated to account for the heterogeneity of the nations. The Hausman test and the loglikelihood ratio test were used to distinguish between the aforementioned models and determine which model best fits the data. For the panel estimations, time-series data were available from 1973 through 2021. Overall, 217 nations and dependencies were taken into account in the analysis of the entire sample of nations from around the world. The two panel models were estimated to perform a robustness check, one with the control variable and the other without it.

4. RESULTS AND DISCUSSION

Correlation and regression analysis were used to examine the link between the annual mean total sunspot number and variables relating to the gross domestic product in the Balkan nations. The existence of cyclical and random time-series components is evident in the yearly mean total sunspot number variable (Figure A1). The gross domestic product variable, on the other hand, also has a few time-series components, mostly trend and random components, although with varying intensities. Consequently, it was decided to use transformed values for the variables.

Table 3. Correlation coefficients between yearly mean total sunspot number (Sunspot) and gross domestic product (GDP) variables, Balkan countries

Country	n	Sunspot & log GDP	Log Sunspot & log GDP	Log Sunspot (lag t-1) & log GDP
Albania	42	-0.4575***	-0.4764***	-0.5027***
Bosnia and Herzegovina	28	-0.0609	-0.1525	-0.1099
Bulgaria	42	-0.5040***	-0.5415***	-0.5617***
Croatia	27	-0.4407**	-0.4408**	-0.3339*
Greece	62	-0.1159	-0.2130*	-0.1015
Kosovo	14	-0.1837	-0.0682	-0.0253
Montenegro	25	-0.6519***	-0.6051***	-0.5625***
North Macedonia	32	-0.3912**	-0.4295**	-0.4209**
Romania	32	-0.5464***	-0.5688***	-0.5530***
Serbia	27	-0.4573**	-0.4270**	-0.3893**
Slovenia	27	-0.3919**	-0.4108**	-0.3156

Source: Authors' calculations.

Note: The correlation is statistically significant at the * 0.10 level, ** 0.05 level, *** 0.01 level.

Table 3 presents the values of the correlation coefficients between the annual mean total sunspot number and the gross domestic product in the Balkan countries. Observing the log gross domestic product variable, it can be seen that there is a negative association between the annual mean total sunspot number and the variables relating to the gross domestic product for all the Balkan countries. Montenegro, Romania, and Bulgaria appear to have the strongest correlations between the two variables. However, for three Balkan nations – Bosnia and Herzegovina, Greece, and Kosovo – there is no statistically significant correlation between the annual mean total sunspot number and the gross domestic product. Similar findings are obtained and a comparable conclusion can be drawn when the lagged natural logarithms of total sunspot number are examined. In this case, there is no statistically significant correlation between the annual mean total sunspot number and the gross domestic product of Slovenia.

Table 4. Estimates of simple linear regression coefficients, with GDP as the dependent variable, Sunspot as the exploratory variable, Balkan countries

Country	n	Sunspot & log GDP	Log Sunspot & log GDP	Log Sunspot (lag t-1) & log GDP
Albania	42	-0.0027357***	-0.1644958***	-0.0028878***
Bosnia and Herzegovina	28	-0.0005857	-0.066594	-0.0010617
Bulgaria	42	-0.001558***	-0.0966481***	-0.0016679***
Croatia	27	-0.0012532**	-0.0568636**	-0.000954*
Greece	62	-0.0008272	-0.0916487*	-0.0006829
Kosovo	14	-0.0008261	-0.0094206	-0.0001117
Montenegro	25	-0.0022776***	-0.0952803***	-0.0019447***
North Macedonia	32	-0.0014311**	-0.080335**	-0.0014389**
Romania	32	-0.0025521***	-0.1358553***	-0.0024139***
Serbia	27	-0.0021164**	-0.0896351**	-0.0018099**
Slovenia	27	-0.001387**	-0.0659405**	-0.001122

Source: Authors' calculations.

Note: The regression coefficient is statistically significant at the * 0.10 level, ** 0.05 level, *** 0.01 level.

The findings in Table 4, which presents the estimates of the simple linear regression coefficients obtained from the linear regression analyses, are consistent with the inferences drawn from the results of the calculated correlation coefficients in Table 3. The results in Table 4 show that the rise in the annual mean total sunspot number has the greatest effect on the average decline in the Albanian and Romanian gross domestic products. Once more, in Bosnia and Herzegovina, Greece, and Kosovo, the effect of the rise in the annual mean total sunspot number on the gross domestic product is not statistically significant. The findings are similar to those of earlier investigations. According to Poluyakhtov and Belkin (2011), the solar cycles closely correlate with both the US and the world gross domestic products. Using this data, Poluyakhtov and Belkin predicted that there would be worldwide economic crises in 2013–2014 and 2018–2019. In addition, they used a 9-quarter moving average for both series to take out noise and the effects of sudden shocks that would have made the 11-year cycle in the data harder to see. It was discovered that GDP growth slowed down in the years immediately preceding the sunspot maximum. In the case of the US

economy and the advanced nations of the G7, Gorbanev (2012) discovered only a weak association between the GDP statistics and sunspots using quarterly seasonally adjusted series beginning in 1948. In the original series, he applied the Hodrick–Prescott filter to determine departures from the long-term trend.

The cyclical components of the variables annual mean total sunspot number and gross domestic product are compared in Figure A1 in the Appendix. The original values of the variables were first standardised, and then the Hodrick–Prescott filter was used to remove the cyclical component so that extracted cyclical components could be directly compared. There is a clear cyclical component associated with the indicated changes in the yearly mean total sunspot number variable. In contrast, the gross domestic product variable has substantially lower values of the cyclical component. It might prove to be too challenging to compare the development of the annual mean total sunspot number to the development of the gross domestic product when the values of both variables are used. Therefore, we compare the occurrence of the maximum and minimum values instead.

Table 5. The occurrence of maximum and minimum values of the yearly mean total sunspot number and gross domestic product variables of Balkan countries across 11-year periods, using the Hodrick–Prescott filter

Variable	Country	Years	
		Minimum	Maximum
Yearly mean total sunspot number		1965; 1977; 1987; 1996; 2009; 2018	1967; 1979; 1989; 2000; 2014; 2021
Gross domestic product	Albania	1985; 1992; 2006; 2020	1989; 1996; 2008; 2018
	Bosnia and Herzegovina	2003; 2012; 2020	2008; 2019
	Bulgaria	1992; 1999; 2014; 2020	1988; 1996; 2008; 2019
	Croatia	2001; 2014; 2020	2008; 2019
	Greece	1968; 1974; 1987; 1993; 2005; 2012; 2020	1973; 1979; 1991; 1998; 2008; 2019
	Kosovo	2014; 2020	2019
	Montenegro	2005; 2012; 2020	2008; 2019
	North Macedonia	2003; 2012; 2020	2000; 2008; 2019
	Romania	2003; 2010; 2020	1996; 2008; 2019
	Serbia	2014; 2020	2008; 2019
	Slovenia	2009; 2020	2008; 2019

Source: Authors' calculations.

Table 5 highlights the years in which the annual mean total sunspot number and gross domestic product variables were recorded at their maximum and minimum values during the course of the 11-year periods. For simpler comparison, Figure A2 also displays the emergence of the maximum and minimum values graphically in the form of a timeline. These maximum and minimum values of the cyclical components are based on the original standardised values of the variables. In all Balkan nations, the minimum and maximum values of the GDP variable appear to occur in nearly the same years. Additionally, compared to the maximum values of the gross domestic product variable, the minimum values of the annual mean total sunspot number variable tend to occur with a slight lag. If the maximum values of the annual mean total sunspot number variable and the minimum values of the gross domestic product variable are compared, the same conclusion can be drawn. We can infer that the gross domestic product of 8 of the 11 Balkan countries is negatively impacted by an increase in sunspot numbers. Greece, Kosovo, and Bosnia and Hercegovina are the outliers. This conclusion may highlight the inconsistent nature of the data, but it may also suggest some causes for these exceptions. Greece has the greatest number of sunny days per year compared to other Balkan nations; hence, its gross domestic product may not have been impacted. Kosovo is the youngest state in Europe. Therefore, the discordance in the data could be caused by the short time period of the GDP data. A civil conflict in Bosnia in the early 1990s had a significant impact on the time series of GDP statistics. However, these are merely conjectural explanations that should be treated with caution. Additionally, it should be remembered that a variety of factors, not just solar activity, affect variations in the gross domestic product. The impacts of solar activity on the GDP per capita of Balkan nations are shown in Table 6.

Table 6. The effects of solar activity on the GDP per capita of Balkan countries

Dependent variable: Log GDP per capita (constant 2015 US$)	Models (with control variable Unemp)			Models (without control variable Unemp)		
Independent variables	Pooled OLS	Fixed effects	Random effects	Pooled OLS	Fixed effects	Random effects
Constant	10.92623*** (0.30711)	9.73546*** (0.19874)	9.80120*** (0.25822)	9.26243*** (0.29442)	9.32106*** (0.11003)	9.27943*** (0.26305)
Log(Sunspots (t-1))	0.01734 (0.05245)	-0.03581** (0.02521)	-0.03309 (0.025167)	-0.05809*** (0.05780)	-0.05491** (0.02168)	-0.05492** (0.02168)
Log(Sunspots (t-1) X Latitude	-0.05146 (0.05288)	-0.05209** (0.02454)	-0.05001** (0.02454)	-0.04399 (0.05879)	-0.05343** (0.02193)	-0.05335** (0.02193)
Log(Unemp (t-1))	-0.70322*** (0.06738)	-0.017918** (0.07139)	-0.20613*** (0.06992)			
Diagnostics						
Adjusted R squared	0.29277	0.84877	0.15990	0.01793	0.86371	0.16085
S.E. of regression	0.61476	0.28428	0.28628	0.74501	0.27753	0.27656
Prob. (F-stat.)	<0.001	<0.001	<0.001	0.01672	<0.001	<0.001
Mean dependent var.	8.76309	8.76309	8.76309	8.71611	8.71611	8.71611
Akaike info criterion	1.87884	0.36699		2.25782	0.31118	
Durbin-Watson stat.	0.04172	0.10454	0.10164	0.01384	0.10820	0.10571
Hausman test	Chi-square stat. 7.09, Prob. 0.069			Chi-square stat. 1.14, Prob. 0.56		
Loglikelihood ratio test	Cross-section F 115.38, Prob. 0.0, Cross-section Chi-square 447,36, Prob. 0.0			Cross-section F 213.24, Prob. 0.0, Cross-section Chi-square 691.58, Prob. 0.0		
Sample/Cross-sections	1992-2021/10	1992-2021/10	1992-2021/10	1973-2021/11	1973-2021/11	1973-2021/11
Observations	284	284	284	345	345	345

Notes: Standard errors in parentheses, * denotes p<.10, ** p<.05, and *** p<.01.
Source: Authors' calculations.

In our study, the independent variables are the logarithmic values of sunspot activity, sunspot activity times latitude, and unemployment rates, all of which are lagged by one period. The dependent variable is the logarithmic value of gross domestic product per capita expressed in 2015 constant US$. Ten Balkan

countries are represented in the sample of data, which spans the years 1992 to 2021, and there are a total of 284 observations. In contrast, the time period in the model with the removed control variable is larger, spanning the years 1973 through 2021, with a total of 345 observations. According to the Hausman and loglikelihood ratio tests, fixed effects models are preferred, with the exception that random effects models are preferred in models without a control variable, even if the results of both specifications are fairly comparable in that situation. Lower values of the Akaike information criterion also indicate adoption of the fixed effects model as the best fit of the data. The estimated model is well described by its explanatory variables, as evidenced by the extremely high R squared value of 0.85 in the fixed effects model. The independent variables included in the model are statistically significant when the F-stat probability value is zero. The Durbin-Watson test result is nearly zero, indicating a potential positive autocorrelation. The findings for the estimated model are as follows: (1) There is a significant and negative relationship between annual variations in solar activity, as measured by the number of sunspots, and GDP per capita in the Balkan countries, ranging from 0.03 to 0.05 percentage points; (2) There is a significant and negative relationship between solar activity and GDP per capita, depending on the latitude of the country. Our findings with and without the control variable unemployment are comparable. In line with economic theory, there is also a negative and statistically significant link between unemployment and GDP per capita. Expanding the sample to include all nations in the world allowed for a robustness check that led to more comprehensive results. Table 7 presents the impact of solar activity on the GDP per capita of various nations. Data are available from 1973 to 2021 without considering the control variable unemployment and from 1992 to 2021 when this variable is taken into account in the specifications. The whole sample included 211 nations and dependent territories.

Table 7. The effects of solar activity on GDP per capita of countries worldwide

Dependent variable: Log GDP per capita (constant 2015 US$)	Models (with control variable Unemp)			Models (without control variable Unemp)		
Independent variables	Pooled OLS	Fixed effects	Random effects	Pooled OLS	Fixed effects	Random effects
Constant	7.18917*** (0.08825)	8.87563*** (0.02828)	8.86518*** (0.10323)	7.55861*** (0.06930)	8.890*** (0.02286)	8.95037*** (0.09660)
Log(Sunspots (t-1))	-0.03196*** (0.01989)	-0.04454*** (0.00505)	-0.04584*** (0.00504)	-0.36097*** (0.01654)	-0.04025*** (0.00532)	-0.04192*** (0.00532)
Log(Sunspots (t-1) X Latitude	0.31588*** (0.01485)	-0.02541*** (0.00521)	-0.02379*** (0.00521)	0.34091*** (0.01194)	-0.04397*** (0.00535)	-0.04189*** (0.00534)
Log(Unemp (t-1))	0.20257*** (0.02270)	-0.06359*** (0.01119)	-0.06108*** (0.01114)			
Diagnostics						
Adjusted R squared	0.10383	0.96968	0.09172	0.09064	0.95180	0.07005
S.E. of regression	1.39014	0.25569	0.25658	1.42872	0.32893	0.32979
Prob. (F-stat.)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mean dependent var.	8.43153	8.43153	8.43153	8.43914	8.43914	8.43914
Akaike info criterion	3.49744	0.14499		3.55179	0.63861	
Durbin-Watson stat.	0.02742	0.09276	0.08877	0.02764	0.06362	0.06121
Hausman test	Chi-square stat. 37.37, Prob. 0.0			Chi-square stat. 37.93, Prob. 0.0		
Loglikelihood ratio test	Cross-section F 826.55, Prob. 0.0, Cross-section Chi-square 18,113.87, Prob. 0.0			Cross-section F 729.94, Prob. 0.0, Cross-section Chi-square 25,388.89, Prob. 0.0		
Sample/Cross-sections	1992–2021/184	1992–2021/184	1992–2021/184	1973–2021/211	1973-2021/211	1973-2021/211
Observations	5,294	5,294	5,294	8,571	8,571	8,571

Notes: Standard errors in parentheses, * denotes p<.10, ** p<.05, and *** p<.01.

Source: Authors' calculations.

The findings from panel regression models for all the countries across the globe support those found for the Balkan countries, i.e., they are quite comparable, thus supporting both our hypotheses. The key point is that this estimate allows for a better evaluation of the impact of solar activity on the GDP per capita of a country

depending on latitude, which was not possible for the Balkan countries, which are situated at latitudes ranging from 39° to 46° North. The influence of solar activity on a country's GDP per person is roughly 0.04, according to estimates. This result is in line with earlier findings in this field (Batu & Zhao, 2021). According to the empirical data of Batu and Zhao (2021), there is a poor correlation between sunspot volatility and GDP in OECD nations. The authors claim that the economic sectors most severely impacted by space weather are those that deal with information and communication. It was discovered that the gross domestic product in OECD nations declines on average by at least 0.06 per cent for every 1 per cent rise in solar activity, which is a statistically significant effect of solar activity, the finding being comparable to the result obtained in this study. Additionally, a one percentage point increase in solar activity results in a 1.07 percentage point decrease in production in the information and communication industry. Higher latitude nations are more strongly affected by the impacts of extreme solar activity, which is the same result as ours. According to Zhao (2019), who used data from Canada, every percentage point rise in solar activity results in a 0.26 percentage point decline in real GDP per capita. Sunspots could only account for 3% of Canada's gross domestic output fluctuation.

5. CONCLUSIONS

Using data for Balkan nations, this paper sought to reevaluate Jevons' sunspot theory. The following can be used to sum up the main findings: (1) The results of the correlation and regression analyses show that sunspots and gross domestic products have significant and negative medium correlations and regressions for 8 of the 11 Balkan countries; (2) The results of the cross-country panel-regression models show that there is a statistically significant and negative relationship between increased sunspot activity and economic activity both for Balkan countries and for all other countries in the world; (3) Nations at higher latitudes are more negatively impacted by solar activity. The fundamental conclusions reached in this research, that an increase in solar activity has a negative effect on economic activity, are therefore equivalent to those of the earlier studies. The two hypotheses of the paper were found to be valid, but more investigation is required to obtain a more definitive conclusion. The uneven distribution of GDP statistics for the Balkan countries is one of the paper's limitations. For instance, time-series data, for Greece spans 62 years, compared to just 14 years for Kosovo. In addition,

data on GDP per capita and unemployment rates were unavailable for numerous small countries. Future studies should examine how solar activity affects economic activity by examining other macroeconomic factors including inflation, stock market fluctuations, recession forecasting, the onset of epidemics, and others. The separation of nations into groups such as the G7 and EU 27 as well as in-depth research of only major economies such as the United States, Germany, France, Japan, and the United Kingdom, among others, are further comparative analysis techniques that could be used., The United States is the nation for which this approach would be most appropriate since the effect of solar activity on GDP could be measured there with the greatest degree of precision. The reason is that even though the United States as a nation was involved in major global wars, the conflicts were fought elsewhere, and hence the damage to GDP was not as severe. Another crucial point is that because it is a huge country, the potential effects of external influences on its economic activity are mitigated.

Future research may need to change the research sample to provide for adequate comparison analysis, particularly for nations without complete historical data (such as Kosovo, which has only 14 data points). Differentiating between nations' income levels and the resulting influence of solar activity in the panel cross-country regression models could provide more analysis. Missing data for some of the important variables, particularly for small nations and when taking into consideration a variety of countries, is one of the main issues when analysing all countries (i.e., the World). The results that have been provided by this research lead to the conclusion that Jevons' sunspot theory is still valid and cannot simply be dismissed as unfounded.

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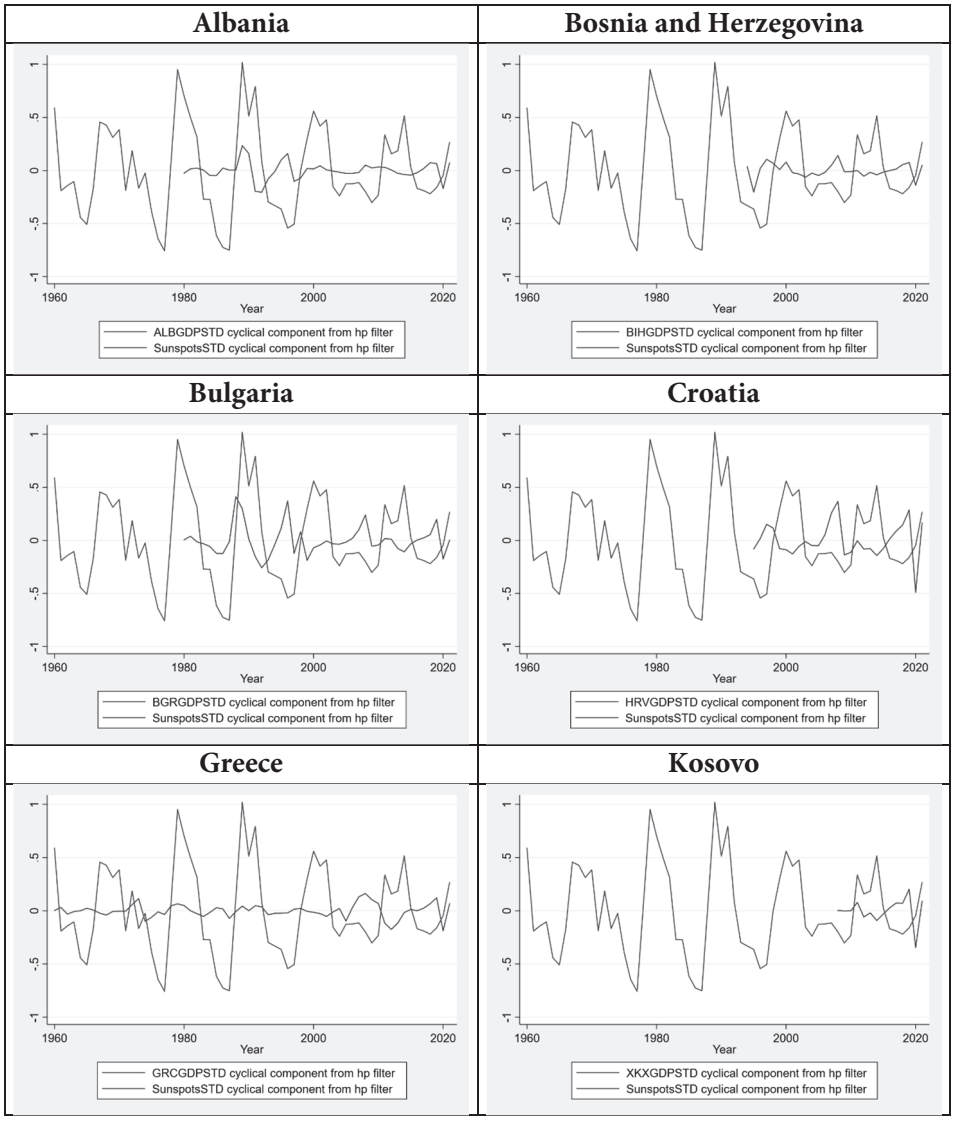
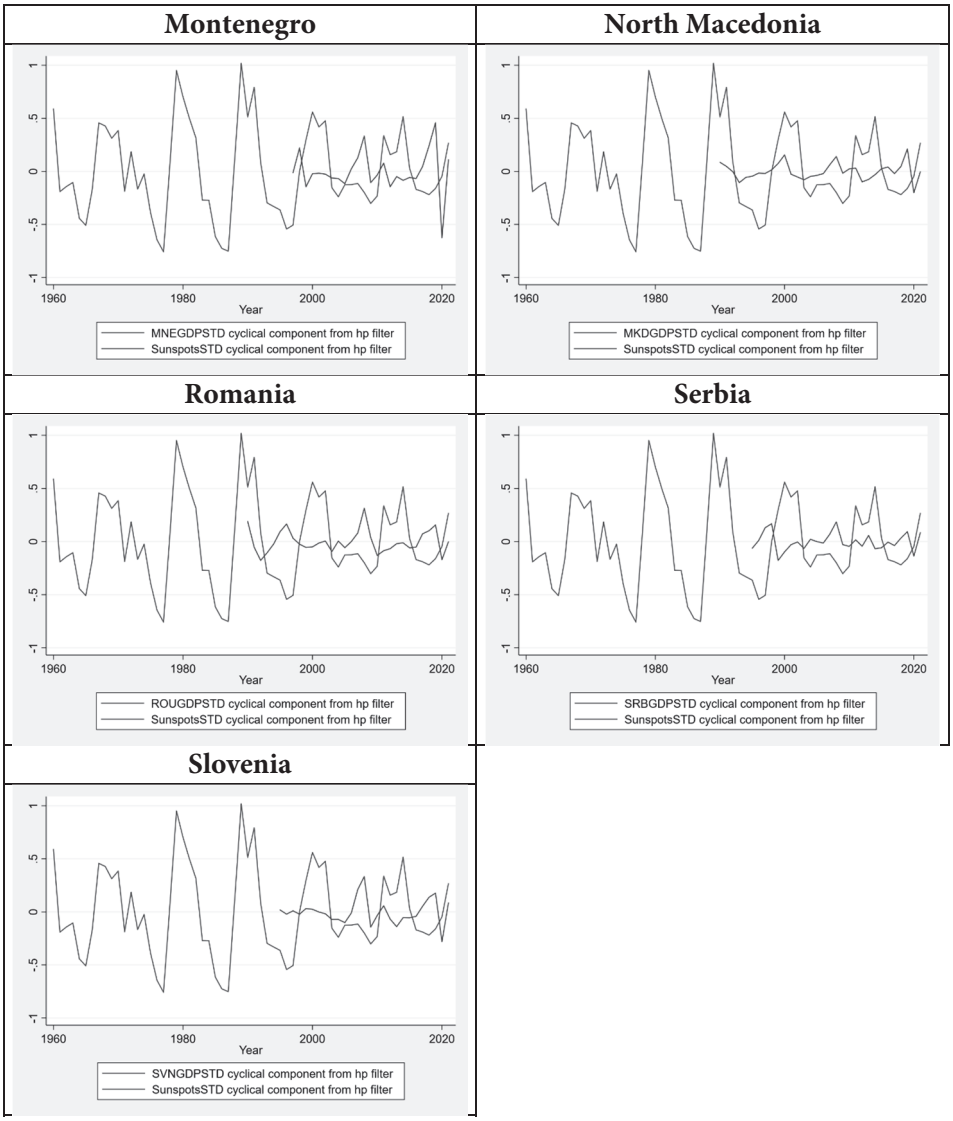
Received: February 28, 2023
Accepted: May 10, 2023

APPENDIX

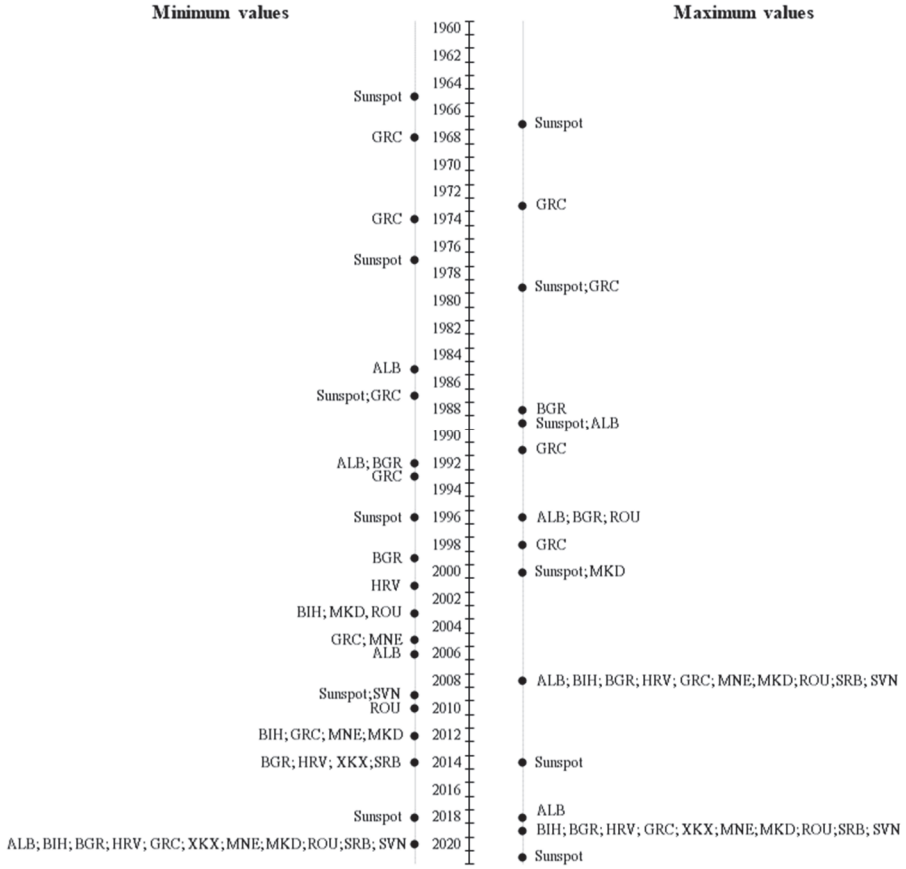
Figure A1. Cyclical component comparison of yearly mean total sunspot number and gross domestic product variables, standardised original values of variables, Hodrick-Prescott filter, Balkan countries





Source: Authors' calculations.

Figure A2. The timeline of occurrence of maximum and minimum values in 11-year periods of gross domestic product and yearly mean total sunspot number variables, cyclical component based on standardised original values of variables, Hodrick-Prescott filter, Balkan countries



Source: Authors' calculations.

ECONOMIC ANNALS, Volume LXVIII, No. 237 / April – June 2023
UDC: 3.33 ISSN: 0013-3264

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https://doi.org/10.2298/EKA2337097J

FINANCIAL DEVELOPMENT AND INNOVATION-LED ECONOMIC GROWTH: EMPIRICAL INSIGHT FROM SUB-SAHARAN AFRICA

ABSTRACT: *The body of literature on the nexus concerning innovation, the development of financial systems, and economic growth has gained increasing attention in recent times. However, it is observed that the majority of studies are conducted in developed and emerging economies. This study is unique in its own right by exploring the effect of innovation and financial development on economic growth using panel data for 30 sub-Saharan Africa (SSA) countries from 2001–2018. The study employed symmetric panel ARDL, common correlated effect ARDL, and asymmetric panel ARDL. Our empirical findings revealed a long-run effect of innovation and financial development on the economic growth of SSA. This means that expansion of the financial sector and better innovation activities in SSA stimulate long-term economic growth. Robustness tests provided consistent results with the baseline findings. The study therefore recommends that to promote sustained economic growth and development in the region, policy makers must collectively work in close collaboration with relevant stakeholders in enhancing regional financial reforms and innovative activities.*

KEY WORDS: *economic growth, innovation, financial development, sub-Saharan Africa*

JEL CLASSIFICATION: G15, O31, O40, 043

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1. INTRODUCTION

In recent times, theoretical and empirical studies on the nexus between innovation, financial development, and economic growth have attracted attention from academics, policy makers, researchers, and development practitioners. This is because innovation and financial development are believed to be important tools for promoting economic growth and the sustainable development of nations (Abdu & Jibir, 2018; Ho et al., 2018; Mtar & Belazreg, 2020; Santi & Santoleri, 2017; Pradhan et al., 2021). In the literature, there are three strands of studies on innovation and financial development-led growth. The first category consists of the studies that explore the link between innovation and growth (Abdu & Jibir, 2018; Bernier & Plouffe, 2019; Santi & Santoleri, 2017). According to their findings, growth is achieved through scientific discoveries that bring new ideas and knowledge in solving complex problems and providing solutions that promote overall advancement in society.

The second body of literature examines the role of financial development in promoting economic growth. Levine (1997) stresses that financial development remains a prerequisite in solving the problem of underdevelopment. There are several studies that support this postulation – arguing that financial services provide a foundation for future development through the accumulation of capital, technological progress, and capital intermediation (Ang & Kumar, 2014). Broadening and deepening of financial products across the world widened risk preferences and reduced transaction costs, which has led to the expansion of the market and the economies of nations (Pradhan et al., 2014). However, there are studies that show instances when financial development impedes the economic development of nations (Zhu et al., 2020; Levine, 1997). Financial development may lead to a banking crisis and metamorphose into an economic crisis, thereby negatively affecting the economy, including innovation activities (Zhu et al., 2020; Levine, 1997).

The third strand of literature explores the nexus between financial development and innovation. Numerous studies have found that there is a strong positive relationship between innovation and financial development (Trinugroho et al., 2021). Financial development increases the availability of the resources dedicated to the research and development (R&D) sector to promote innovative activities (Ho et al., 2019). A sound financial system helps in assembling resources for R&D

funding and diversifying risks (Trinugroho et al., 2021). In line with this argument, recent literature on financial development-led innovation claims that the financial system promotes innovation programmes through the provision of the services. needed In so doing, it lowers transaction costs and facilitates long-term investment in risky but profitable sectors of the economy (Levine, 1997; Meierrieks, 2014; Tee et al., 2014).

Empirical evidence on the effects of financial development and innovation on growth remains largely conflicting and inconclusive, which calls for further exploration principally in the case of developing countries of Africa. In contrast to studies conducted in developed countries, previous studies of African regions did not combine both innovation and financial development in a single growth model. This exposes the weakness of the previous studies given the strong linkage between innovation and financial development in promoting growth. Zhu et al. (2020) and Laeven et al. (2015) stress that models of economic growth mostly ignore financial development. It was Romer (1990) and Aghion and Howitt (1992) that added to the core models of endogenous technological change. In the innovation-led growth hypothesis, it is paramount to know that financial development determines how best society distributes funds to firms and households. Aghion et al. (2005) posit that variations in financial development remain a crucial factor in influencing the allocation of resources to innovative activities for businesses.

Thus, the debate in this area continues to attract attention, especially in developing countries, which are constantly under pressure to enact policies supporting job creation, innovation and scientific discoveries, and societal welfare, with this pressure having only intensified in recent times. Thus, this study aims to conduct an anatomy of innovation and financial development-led growth within the context of sub-Saharan Africa (SSA).

Sub-Saharan Africa remains the poorest region in the world. According to the World Bank (2021), up to a remarkable 48.5% of the people in SSA are living on less than $1.25 per day. Despite this disturbing statistic, the future development of the region remains bright as the gross domestic product per capita for 2021 stood at $1,645 million, which shows an increase of 9.57% compared to the previous year (World Bank, 2021). In addition, SSA nations have, in recent years,

undertaken financial, trade, and political reforms – which is assumed to have meaningfully enhanced their financial systems and innovative activities (Bekana, 2021; Jibir et al., 2019). A study of this nature is therefore critical in order to explore the underlying linkages between financial development, innovation, and economic growth of the region. It is therefore believed that the outcome of this study would serve as an indispensable element for designing better developmental agenda for the region. This research is appropriate given that an overhaul of the financial system and an innovative approach to business models has lately been acknowledged and emphasised by the policy makers in SSA as part of their efforts to achieve goals 8 and 9 of the United Nations Sustainable Development Goals (SDGs).

This study hopes to make three specific contributions. First, this paper complements the existing literature that focuses on economic growth and development in sub-Saharan Africa. It adds to the body of knowledge in this area, as prior results are mixed (Galindo & Mendez; 2014; Hsu et al., 2014). Second, it is a truism that African countries lag behind other regions in terms of commitment to innovative and financial reforms. In contrast to some regions, such as East and South Asia, which have made a significant commitment to R&D and other reforms in their financial sector, Africa remains the most backward region in terms of innovation and financial development. Within the continent, sub-Saharan Africa deserves special attention. Thus, this study focuses on SSA to explore the nexus between innovation, financial development, and growth. These variables, to the best of our knowledge, have not been examined simultaneously in previous studies. In addition, we apply more than one methodological framework and a large number of SSA countries that have not been investigated in this manner in previous studies. This is used to ensure robustness and provide better findings for policy prescription.

The remainder of the paper is structured in the following ways. Section 2 provides a robust review of literature. Section 3 anchors the data and methodology. Data analysis and interpretation are carried out in section 4 and the last section concludes the paper.

2. REVIEW OF LITERATURE AND HYPOTHESIS DEVELOPMENT

2.1. Innovation and Economic Growth

Schumpeter (1912) pioneered studies on the nexus between innovation and long-run economic growth. He contends that a perfectly competitive equilibrium refers to a situation whereby an economy is stationary and there is an absence of profits, interests, investments, and involuntary unemployment. The equilibrium is thus analogous to a circular flow in which the same products are continuously manufactured utilising the same technology, and the process perpetuates itself until economic development occurs. Economic development occurs due to 'carrying out of new combinations'– referring to innovations (Schumpeter, 1912). Profit-seeking entrepreneurs are the main source of innovations through *creative destruction* (Schumpeter, 1942; Aghion & Howitt, 1992). Creative destruction is a kind of business cycle, whereby nations experience economic expansion as entrepreneurs innovate and the innovations are widely imitated. However, if the existing products or services are out of fashion, economic downturn sets in; entrepreneurs go back to the drawing board to innovate again. The economy contracts because it takes time for the innovation to be widely spilled over to other sectors.

Both exogenous and endogenous growth theorists all agree that innovation and, by the same token, technological progress remain the key factor driving long-term economic growth (Aghion & Howitt, 1992; Romer, 1986; Cass, 1965; Solow, 1956). While Solow and his followers are of the view that technological progress is determined outside the growth models, Romer and other endogenous growth theorists argue that technological progress is endogenously determined. Romer (1990) asserts that technological progress comes about as people respond to market incentives to make monopolist profits, and as a result, they invest huge resources to produce technical knowledge. These investments include private expenditure on R&D and human capital investment. The stock of R&D and human capital determines the capacity of enterprises to produce new knowledge. Thus, technological progress is endogenous.

Still, according to Romer (1990), *non-rivalry* and *non-excludability* are the essential properties of scientific knowledge or technology. Technological progress is non-rival as the cost of utilising it continuously is negligible, even zero at the extreme. Once new knowledge is produced, 'it can be used as often as desired'

(p.4) at very small additional cost relative to the costs of producing the knowledge. Technological change is partially non-excludable given that innovators cannot easily prevent other people from copying or imitating new knowledge. Romer (1990) concludes that a production function with technology as one of its inputs cannot be a constant-return-scale function, that is, the function is not convex. Thus, technology contributes to long-term economic growth by increasing the productivity of innovative firms and through the spill-over effect on other sectors.

Given the robustness and popularity of endogenous growth theories, there are burgeoning studies empirically exploring the association between innovation and economic growth across countries. These studies utilise different proxies of innovation, including R&D efforts, patent applications and grants, citations of science and technical journal papers, high-tech exports, and many more. Ultimately, there are 3 distinct bodies of studies analysing the relationship between innovation and economic growth. The first body provides evidence that innovation impacts economic growth *directly*. Pece et al. (2015), focusing on three Central and Eastern European countries for the period 2000–2013, discover that R&D efforts and the number of registered patents and trademarks spur economic growth. Conversely, Gyedu et al. (2021) report that innovation is negatively significant in G7 countries while only R&D is positively significant in BRICS (Brazil, Russia, India, China, and South Africa). Sesay et al. (2018) argue that the national innovation system (NIS), instead of fragmented innovation of business entities, remains fundamental to promoting broad-based economic growth. They demonstrate this empirically using BRICS data for the period 2000–2013.

In a country-specific study, Law et al. (2020) find that patent applications discourage economic growth while patent grants promote the Malaysian economy, implying that quality (not the quantity of) innovation is vital to economic growth in Malaysia. Similarly, Jian et al. (2021), using a GMM estimator on 1978–2017 data for Chinese provinces, find that patent grants are directly responsible for differences in regional economic growth. Wang et al. (2022), based on 2011–2019 data for 31 provinces and cities in China, find that both financial innovation and technological innovation (R&D and patent applications) promote economic growth. Finally, Nazir et al. (2021), using the

ARDL model on 1970–2016 data for China, India, and Pakistan, show that financial innovation boosts economic growth across all the periods.

The second body of literature claims that the innovation-growth link is not a black-box sort of relation. Innovation affects economic growth conditioned by other factors such as institutions, social filters, human capital, etc. Countries endowed with strong institutions tend to be more innovative as the institutions increase the incentives to innovate, and high innovative capacity results in high economic performance (Bekana, 2020; Hadfield, 2008; Kiertisak, 2016). For sub-Saharan African and European countries, respectively, Bekana (2020) and d'Agostino and Scarlato (2018) confirm that quality institutions guarantee equal opportunities and raise the incentive to innovate. This amplifies the exogenous impact of the knowledge base on economic growth accordingly. Akcigit et al. (2023) develop a theoretical model of the links between political connections, innovation, and economic growth. They analyse Italian data for the period 1993–2014 and demonstrate that political connections impede innovations through the low entry of innovative firms and reallocation, which ultimately reduces economic growth. Innovation as conditioned by financial development (Fagiolo et al, 2020), human capital (Cinnirella & Streb, 2017), and social filters represented by urbanisation, social capital, privatisation etc. (Xiong et al., 2020) promotes economic growth.

The third body examines causal relationships between innovation and economic growth. Within this strand of literature, some studies find evidence in line with the hypothesis that innovation Granger-causes economic growth (Maradana et al., 2017; Pradhan et al., 2018; Pradhan et al., 2021, Sarangi, et al., 2022). Some other studies confirm that as economies grow and become richer, they raise their investment in R&D and, thus, their innovative capacity improves (Avila-Lopez et al., 2019). While Avila-Lopez et al. (2019) and Kurniawati (2020) observe feedback causality between innovation and economic growth, Mtar and Belazreg (2021) find no causality between them.

Based on the literature review, it is clear that innovation impacts economic growth positively by raising the productivity of labour and capital inputs as well as by means of knowledge spillovers to other sectors. However, there is evidence of reverse causality between them as affluent economies can afford to invest

heavily in research and development or science and technology to improve their innovative capacity. Again, the effect of innovation on economic growth is conditioned on other factors

***H_1**: Innovation enhances economic growth through productivity improvements of traditional inputs of capital and labour.*

2.2. Financial Development and Economic Growth

It was Schumpeter (1912), then Goldsmith (1969) and Hicks (1969) who first provided a more sophisticated theoretical discourse on the connection between finance and economic growth. Schumpeter contended that financial intermediaries, instruments, and markets make resource allocation highly efficient by identifying and funding entrepreneurs with innovative ideas. Thus, finance spurs economic growth and development through technological innovation. John Hicks (1969) extended Walter Bagehot's argument that a good financial system triggered off industrialisation in England via capital mobilisation for productive projects. In addition to the efficient allocation of resources, Banerjee and Newman (1993) claim that financial systems curtail income inequalities and increase the fortunes of less-wealthy individuals, thereby submitting that easing credit constraints in the system could accelerate economic growth. Aghion et al. (2010) also theorise that efficient financial systems facilitate economies to weather financial crises effectively by minimising macroeconomic volatility. By easing credit constraints, financial systems empower firms to borrow and invest wisely, especially during economic downturns when it is cheap to borrow and collateral values are also low. Hence, efficient and developed financial systems enhance economic growth and, at the same time, streamline countercyclical investments, which neutralise the severity of economic fluctuations (Aghion et al., 2018).

In summary, Levine (2005) highlights and discusses five major mechanisms through which financial systems boost economic growth: generating information and capital allocation, monitoring firm's activities, risk minimisation, increasing savings, and enabling exchange. Nevertheless, Lucas (1988) counter-argues that finance is an overemphasised driving force of economic growth and argues that labour, capital, and technical progress are the fundamentals of economic growth and development.

On the empirical front, there are therefore three strands of literature in this area. The first body of literature establishes evidence that financial development indeed spurs economic growth. Yang (2018) consistently observes that financial development significantly promotes output growth across low, middle, and high-income countries through physical capital and technical progress channels. Similarly, Abeka et al. (2021), Ehigiamusoe (2021), and Olayungbo and Quadri (2019), focusing on sub-Saharan Africa, find that finance strongly stimulates output growth in the region. Abeka et al. (2021) further observe that the effect is larger on economies with stronger telecommunication infrastructure.

In a country-specific study, Olorogun et al. (2020) find evidence that finance leads to output growth by applying the ARDL model to Nigerian data (1978–2018). In the same vein, Nguyen et al. (2022) and Sarwar et al. (2020) discover that financial development has a linear and positive effect on growth of output in emerging market economies. Again, studies on Latin American and European countries show that financial crises checkmate the impact of finance on output growth (Asteriou & Spanos, 2019; Santana, 2020). Regarding Asian countries (China, Japan, India), Wu et al. (2020) find that financial development matters greatly in their respective economic growth process.

The second body of literature shows that financial development retards output growth. Irrespective of national income level, Cheng et al. (2020) show that financial development has been persistently negative in influencing economic growth. They construct and apply a composite index of financial development. They further argue that inefficient financial systems result in speculation, lower investment, and misallocation of resources. Likewise, Rahman et al. (2020), using the Markov switching methodology and the composite index of financial development, discover that financial development negatively affects economic growth.

The last strand of literature claims that financial development is asymmetrical or non-linear in influencing economic growth, that at some points the effect is positive while at other points the effect is negative. For example, Chen et al. (2020), using NARDL, find evidence in Kenya that positive changes in financial development boost economic growth in the short run and negative changes dampen economic growth in the long run. These studies conclude that the impact

of financial development on economic growth is conditioned by the pattern of shocks to the financial sector.

From the preceding literature review, there is much evidence that financial development promotes output growth irrespective of the region or national income level. However, the composite measure of financial development tends to exert negative impacts on output growth.

***H_2**: Financial development spurs economic growth through physical and technological progress.*

3. METHODOLOGY

3.1. Data Sources and Variables

This study collects the data for the period 2001–2018 for 30 sub-Saharan Africa countries. The choice of countries and period is determined by data availability and the sub-regional distribution of the countries. This study used annual data collected from the WDI (World Development Indicator) of the World Bank data base (World Bank, 2021). Economic growth is taken as a dependent variable and is measured by GDP per capita (current US$). Moreover, there are several studies based on innovation, but the literature does not directly specify a single indicator or proxy for innovation. Several studies (Hsu et al., 2014; Pradhan et al., 2018) measure innovation differently using different measures. However, other studies observed that the proxies have many shortcomings (Thomson, 2009; Moser, 2013). Some researchers argue that productivity growth is a good approximation of innovation. The proposition of Jorgenson (2011) on innovation has been empirically validated by Hall (2011). In Table 1, we define the variables and show their units of measurement and sources of the data.

Table 1: Variables, Measurement and Sources of Data

	Variables	Measurement	Source
Dependent Variable	Economic Growth	GDP per capita (current US $)	WDI of the World Bank
Independent variables	Innovation	Citation index of scientific and technical journal articles	WDI of the World Bank
	Financial Development	Share of Private Credit to GDP	World Bank Financial Structure Database.
Control Variables	Trade Openness	Import plus export as a share of GDP	WDI of the World Bank
	Capital Stock	Capital stock as a percentage of gross domestic product	WDI of the World Bank

Source: Authors' construction

Fazlioğlu et al. (2019) used different proxies for innovation (product, process, and organisational). Looking at innovation from a different angle, Bekana (2021) measures innovation using the citation index of scientific and technical journal publications. Following the approach of Bekana (2021), we use the citation index of scientific and technical journal publications as a proxy for innovation. We also use domestic credit to the private sector (percentage of GDP) to represent financial development, which was previously applied by several studies (Ang et al., 2010; Ang & Kumar, 2014; Baltagi et al., 2009; Zhu et al., 2020). Several other factors are likely to influence growth, including trade openness and capital stock as a percentage of GDP (Grossman & Helpman, 1990; Romer 1990; Young, 1991, Jibir et al., 2018; Cooke, 2010). Following the previous studies, we take the share of total trade (percentage of GDP) as a proxy for trade openness and gross capital formation (percentage of GDP) for capital stock.

3.2. Empirical Model Specification and Estimation Techniques

To empirically investigate the connection between innovation, financial development, and GDP per capita, we set up a baseline model in which innovation and private credit as a share of GDP determine the countries' GDP

per capita over the years. Consistent with the previous literature, equation (4) specifies our empirical model:

$$GDPPerK_{it} = \alpha_0 + \beta_1 Innovat_{\ it} + \beta_2 FinDevt_{it} + \beta_3 TradOpen + \beta_4 Capital_{it} + \varepsilon_{it} \qquad (1)$$

where $GDPPerK_{it}$ is GDP per capita (current US$), which is the proxy for economic growth; $Innovat_{it}$ stands for innovation; $FinDevt_{it}$ represents financial development; $TradOpen_{it}$ is trade openness; $Capital_{it}$ is the capital stock; ε_{it} is an error term; and β represents the parameters to be computed, all for country *i* at time *t*.

Our estimation strategy follows these sequential stages. After data cleaning, we first test the presence of cross-sectional dependence (CD), and then apply the second generation panel unit root to test the level of integration for each variable. If none of the variables is stationary at second difference, I(2), we then check for long-run relationships between the variables using panel co-integration tests, such as the Pedroni and the Kao panel co-integration tests. Given the possibility of a combination of I(0) and I(1), we finally apply panel autoregressive distributed lag (ARDL) estimators to check the short-run and long-run effects of innovation and financial development on economic growth. This is especially the case when a long-run relationship is detected.

The panel data is analysed using a panel autoregressive distributed lag (ARDL) model with three estimators – mean group (MG), pooled mean group (PMG) and dynamic fixed effect model (DFE) estimation. These estimators are applied to examine the short-run and long-run association between innovation, financial development, and economic growth. The MG estimator gives room for heterogeneity in the short- and long-run relationships and this estimator is appropriate for a large sample as it is sensitive to permutations and outliers (Pesaran et al., 1999). In contrast, the PMG estimator limits long-run relationships to being homogenous across all units but allows heterogeneous short-run relationships. Finally, the DFE estimator, which is usually a two-way effect, restricts the error correction, slope coefficient, and short-run coefficient to demonstrate non-heterogeneity across the units (Baltagi et al., 2000). Following the available literature on panel data, we use the mean group and the pooled mean group to select the appropriate estimator between MG, PMG and DFE. We use the Hausman test to see if there are any significant differences between these

estimators. Equation (2) specifies the panel ARDL (m, n) model as proposed by Pesaran et al. (1999):

$$y_{it} = \sum_{j=1}^{m} \gamma_{ij} y_{it-j} + \sum_{j=0}^{n} \vartheta_{ij}^{'} x_{it-j} + \mu_{it} \quad (2)$$

In equation (2), subscript i = 1, 2,…, N represents the country, t = 1, 2,…, T represents the periods, m serves as the number of lags for the dependent variable and n is the lag number of the independent variables, where y_{it-j} represents a $k\times1$ vector, ϑ_{ij} serves as a $k\times1$ co-efficient vector, μ_t is error term and γ_{ij} represents a vector of scalars. By parameterising equation (2), we derive the error correction form as in equation (3):

$$dy_{it} = \phi_i y_{it-1} + \beta'_i x_{it} + \sum_{j=1}^{m-1} \gamma_{ij}^{*} dy_{it-j} + \sum_{j=0}^{n-1} \vartheta_{ij}^{*'} dx_{it-j} + \mu_{it} \quad (3)$$

Equation (4) is a re-specification of equation (3):

$$dy_{it} = \phi i \, (y_{it-1} - \theta'_i x_{it}) + \sum_{j=1}^{m-1} \gamma_{ij}^{*} dy_{it-j} + \sum_{j=0}^{n-1} \vartheta_{ij}^{*'} dx_{it-j} + \mu_{it} \quad (4)$$

where $\theta_i = -\beta_i/\phi_i$ is the long-run relationship between y_{it} and x_{it} while $\gamma_{ij}^{\star}$ and ϑ_{ij} show the short-run coefficient of y_{it} and x_{it}. The term ϕ_i represents the error-correction coefficient, which is used in the equation to measure the speed of adjustment of y_{it} due to a change in x_{it}. Should the effect be negative, this represents convergence to long-run equilibrium. However, if ϕ_i is found to be positive, it means that the equilibrium does not converge in the long run, which further indicates that there is no long-run relationship in the model.

Given the possibility of CD in the panel data, we introduce a common correlated effect to account for contemporaneous correlation. By creating and incorporating indicators of weighted cross-sectional averages of regressors into MG and PMG, we compute the common correlated effect mean group (CCEMG) and the common correlated effect pooled mean group (CCEPMG), respectively (Pesaran, 2006).

As a robustness check, we also estimate asymmetric or non-linear panel ARDL models as recommended by Shin et al. (2014) to check the asymmetric response of long-run and short-run changes in innovation and financial development in economic growth. By decomposing the changes in variables of interest into positive change (d^+) and negative change (d^-), we specify asymmetric panel ARDL estimators in equations (5) and (6).

$$y_{it} = \phi_i y_{it-1} + \sum_{j=1}^{m-1} \gamma_{ij}^{*} dy_{it-j} + \sum_{j=0}^{n-1} \vartheta_{ij}^{*'} (d_{it-j}^{+} + d_{it-j}^{-}) + \sum_{j=0}^{n} \vartheta_{ij}^{*'} dx_{it-j} + \mu_{it} \quad (5)$$

By re-parameterising equation (5), we derive equation (6):

$$\Delta y_{it} = \phi i \left[y_{it-1} - \theta'_i (d_{it-j}^{+} + d_{it-j}^{-}) - \theta'_i x_{it} \right] + \sum_{j=1}^{m-1} \vartheta_{ij}^{*} \left(d_{it-j}^{+} + d_{it-j}^{-} \right) + \sum_{j=0}^{n-1} \vartheta_{ij}^{*'} dx_{it-j} + \mu_{it} \quad (6)$$

4. RESULTS AND DISCUSSION

4.1. Summary Statistics of Variables and Correlation Analysis

Table 2a contains the summary statistics with natural log GDP per capita representing economic growth, scientific and technical journal articles standing for innovation and private credit as a proportion of GDP serving as financial development. The table reports the descriptive statistics for total trade as a share of GDP, which is a proxy of trade openness, and capital stock measured by gross capital stock as a percentage of GDP.

Table 2a: Summary Statistics of Variables

Summary	Economic Growth	Innovation	Fin. Devt.	Trade Open	Gross Capital
Mean	7.0047	4.7225	3.5159	4.4274	3.7698
Maximum	9.7369	9.4750	4.5290	5.5043	4.6064
Minimum	4.8877	3.0395	3.0506	3.0920	3.0829
Std. Dev.	1.0292	1.4297	0.2857	0.3939	0.2094
Skewness	0.6035	1.1930	0.9567	0.2281	0.3510
Kurtosis	2.7980	4.1239	3.6453	3.4918	3.7160

Source: Authors' computation using Stata 17.0

The mean value of economic growth is the highest, followed by those of innovation, trade openness, gross capital stock, and financial development. Except for economic growth, which is mesokurtic, all of the variables are positively skewed and leptokurtic. Table 2b signifies that there is a weak correlation between the variables as the correlation coefficients are considerably below 0.30.

Table 2b: Pairwise Correlation Analysis

Summary	Economic Growth	Innovation	Fin. Devt.	Trade Open	Gross Capital
Economic Growth	1				
Innovation	0.230	1			
Fin. Devt.	0.203	-0.140	1		
Trade Open	0.100	-0.065	0.106	1	
Gross Capital	0.157	-0.117	0.1167	0.049	1

Source: Authors' computation using Stata 17.0

The table shows the highest correlation coefficient is between innovation and economic growth (0.230), followed by that between financial development and economic growth (0.203). This means there is no possibility of multicollinearity.

4.2. Cross-Sectional Dependence Test

In Table 3, we show the results of the CD tests, Breusch-Pagan LM, Pesaran scaled LM, bias-corrected scaled LM, and Pesaran CD, in which all the variables are significant at the 1% level of significance.

Table 3: Cross-sectional Dependence Test

Series	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
Economic Growth	5803.88***	182.02***	181.14***	75.65***
Innovation	4660.05***	143.24***	142.36***	64.74***
Fin. Devt.	3180.04***	93.07***	92.18***	35.05***
Trade Open	1841.44***	47.68***	46.80***	5.70***
Gross Capital	1367.48***	31.61***	30.73***	8.85***

***, **, * show the significance level at 1%, 5% and 10%, respectively

Hence, we reject the null hypothesis of no cross-sectional dependence. The presence of cross-sectional dependence suggests that the second generation unit root tests are the most appropriate.

4.3. Second Generation Unit Root Test

In Table 4, the second generation unit root test using cross-sectional Im-Pesaran (CIPS) as propounded by Im, Pesaran and Shin (2003) and cross-sectional augmented Dickey-Fuller (CADF) show that two out of the five variables are non-stationary at a level I(0) but become stationary after taking their first difference, I(1). Economic growth, innovation, and gross capital are stationary at level, i.e. I(0), whereas financial development and trade openness become stationary after taking the first difference, i.e. I(1). Therefore, the panel ARDL model is suitable for a mixed level of integration. Thus, we apply the panel ARDL approach to explore the long-run and short-run impacts of innovation and financial development on economic growth.

Table 4: Second Generation Unit Root Test

Variables	CIPS		CADF	
	I(0)	I(1)	I(0)	I(1)
Economic Growth	-2.654***	----	-2.196**	----
Innovation	-3.070***	----	-2.220**	----
Fin. Devt.	-2.119*	-3.884***	-1.982	-2.664***
Trade Open	-1.545	-3.951***	-1.323	-2.829***
Gross Capital	-2.406***	----	-2.376***	----

***, **, * show the significance level at 1%, 5% and 10%, respectively.

4.4. Panel Co-integration Results

The Pedroni and Kao tests are the two variants of panel co-integration tests shown in Table 5. In both tests, the null hypothesis is that there is no co-integrating relationship. The p-value is found to be significant in both tests, suggesting rejection of the null hypothesis of no co-integrating association. As a result, the results indicate the existence of a co-integrating connection between economic growth and the independent variables incorporated in the model.

Table 5: Panel Co-Integration Test

	Pedroni				Kao	
	Statistics	**p-Value**	**Weighted Statistics**	**p-Value**	**Statistics**	**p-Value**
Panel PP-Statistic	-2.6535	0.004	-3.08499	0.001	ADF -5.118897	0.000
Panel ADF-Statistic	-1.7366	0.0412	-1.84049	0.0328		
Group PP-Statistic	-3.6162	0.0001				
Group ADF-Statistic	-2.5818	0.0049				

Source: Authors' computation using Stata 17.0

4.5. Dynamic Panel Autoregressive Distributed Lag (ARDL) Models

In Table 6, Panel A provides the results of innovation-growth models, where innovation clearly impacts output growth in both the short and long runs. Innovation is only significant in the long run of the DFE model. Given that ECM is negative and significant in all the models under Panel A, innovation alongside the control variables jointly leads to economic growth in the long run. Panel B in Table 6 indicates that financial development is only statistically significant but negative in the PMG model, suggesting that a quality financial system retards economic growth in the long run.

Table 6: Panel Autoregressive Distributed Lag (ARDL) Models

		Panel A			Panel B			Panel C		
	Variable	**MG**	**PMG**	**DFE**	**MG**	**PMG**	**DFE**	**MG**	**PMG**	**DFE**
	Innovation	0.175	0.020	0.337***				0.694**	0.110	0.408***
		(0.323)	(0.120)	(0.104)				(0.326)	(0.111)	(0.118)
	Fin. Devt.				0.060	-0.646**	0.004	-1.771**	-0.931***	-0.335
					(0.994)	(0.282)	(0.323)	(0.786)	(0.302)	(0.275)
Long Run	Trade Open	-0.238	0.494***	0.301	0.016	1.135***	0.337	-0.195	1.099**	0.336*
		(0.695)	(0.189)	(0.187)	(1.080)	(0.173)	(0.250)	(0.473)	(0.175)	(0.19)
	Gross Cap.	-0.105	0.441**	-0.139	5.029*	0.784***	-0.153	0.278	0.816***	-0.187
		(0.828)	(0.172)	(0.257)	(2.722)	(0.122)	(0.342)	(0.619)	(0.118)	(0.262)
	Constant	0.068	0.621	0.982***	0.338	0.279***	0.988***	0.792	0.367***	1.146***
		(0.921)	(0.068)	(0.239)	(0.910)	(0.044)	(0.267)	(0.977)	(0.054)	(0.271)
	ECT	-0.353***	-0.185***	-0.202***	-0.31***	-0.169***	-0.154***	-0.465***	-0.167***	-0.2***
		(0.047)	(0.021)	(0.024)	(0.050)	(0.023)	(0.018)	(0.062)	(0.025)	(0.024)
	Innovation	0.115	-0.032	0.075				-0.145*	-0.013	0.003
		(0.102)	(0.070)	(0.049)				(0.087)	(0.07)	(0.05)
Short Run	Fin. Devt.				0.178	-0.156	-0.099	0.147	-0.06	-0.062
					(0.201)	(0.159)	(0.072)	(0.165)	(0.187)	(0.071)
	Trade Open	0.079	0.046	0.088	0.166	0.070	0.069	0.076	-0.137	0.013
		(0.123)	(0.087)	(0.060)	(0.147)	(0.086)	(0.061)	(0.109)	(0.087)	(0.062)
	Gross Capital	0.257	0.267***	0.022	0.282**	0.310***	0.019	0.007	0.131	0.05
		(0.164)	(0.097)	(0.061)	(0.126)	(0.098)	(0.062)	(0.125)	(0.092)	(0.061)
	CD	33.61***	64.68***	45.45***	7.55***	52.53***	1.19	6.04***	-4.93***	32.15***
	Resid	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
	AR	33.07***	321.2***	30.87***	23.14***	117.4***	37.73***	43.29***	116.73***	43.68***
	Haus.							11.65***		9.08*

Note: Values in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively. **Source**: Authors' computation using Stata 17.0

However, the long-run effects of financial development in the MG and DFE models are positive but insignificant. Similar to innovation-growth models, financial sector development alongside the control variables jointly leads to economic growth in the long run since the ECT is negatively significant in all the models.

Concerning Panel C in Table 6, innovation and financial development have no significant effects on output growth in the short run for the MG, PMG, and DFE models. In the long run for the MG model under Panel C, however, innovation and financial development significantly affect economic growth. While innovation is positively significant, financial development is negatively significant in the model. Financial development is negatively significant in the PMG model as against the positive and significant innovation in the PMG and DFE models under Panel C. All the variables in the models under Panel C jointly promote economic growth in the long run for the SSA region given the negative significance of the ECT in the models. The models under Panel C have further confirmed that innovation matters more than financial development in boosting the economic growth of the SSA countries, especially in the long run.

To find out which model is more efficient under Panel C, we conduct Hausman tests and the results are reported in Table 6. The PMG model is more efficient than the MG model but the DFE model is the most efficient among them since the results are statistically significant. We conduct cross-sectional dependence tests for all the residuals of the models and the results confirm the presence of cross-sectional dependence in all but the DFE model under Panel B. This could make the results biased unless the cross-sectional issue is addressed. This means the ARDL framework in Table 6 overlooks contemporaneous correlation across countries occasioned by unobserved factors. This could render the parametric and non-parametric estimators inconsistent. To address the problem of cross-sectional dependence, we estimate panel ARDL models with common correlated effects and Table 7 reports the results.

4.6 Panel ARDL Models - with Common Correlated Effect

Table 7 reveals the common correlated effect PMG (CCEPMG) and common correlated effect MG (CCEMG) estimates for innovation, financial development, and the combined models. Under Panel A, the CCEMG signifies that innovation

has positive and significant short- and long-run effects on GDP per capita. The CCEPMG model under Panel A in Table 6 also indicates that innovation has positive but insignificant impacts on the GDP per capita in both the short and long runs. Interestingly, the error correction terms in all the models, irrespective of panels, are negatively significant at 1%, suggesting that the models converge to the long-run equilibria even if there is any disturbance. Panel B in Table 6 also shows that financial development enhances economic growth in the short and long runs of the CCEMG model, but it is only significant in the long run. In contrast, the CCEPMG estimator demonstrates that financial development retards economic growth irrespective of the periods, but it is insignificant in all the periods.

In Table 7, CCEMG estimates under Panel C indicate that innovation spurs economic growth in both short and long terms, but it is only significant at 1% in the short run. The estimates also report that financial development has positive and negative but insignificant effects in the short and long runs, respectively. Similarly, the CCEPMG estimator under Panel C finds that innovation enhances economic growth insignificantly across the periods. Conversely, the CCEPMG estimator finds that financial development is consistently negative, albeit only significant in the short run, in influencing GDP per capita. None of the control variables is observed to be significant in determining economic growth. Across all the estimations in all the panels, residual tests confirm that the residuals are I(0), implying that the commonly correlated effect estimators are valid even if there is a serial correlation in the error term (Pesaran, 2006).

Table 7: Panel ARDL Models - with Common Correlated Effect

		Panel A		Panel B		Panel C	
	Estimator	**MG**	**PMG**	**MG**	**PMG**	**MG**	**PMG**
	Variable						
Long Run	Innovation	1.140**	0.132			0.364	0.061
		(0.449)	(0.155)			(0.475)	(0.225)
	Fin. Devt.			1.478*	-0.187	-0.131	-0.387
				(0.871)	(0.133)	(1.498)	(0.441)
	Trade Open	-0.293	-0.062	-0.641	-0.081	1.339	-0.113
		(0.514)	(0.231)	(0.422)	(0.053)	(1.163)	(0.258)
	Gross Capital	0.506	0.046	0.066	-0.055	2.644	-0.014
		(0.591)	(0.173)	(0.483)	(0.054)	(1.668)	(0.179)
	Constant	-32.131	0.925	-3.249	-0.247	-15.238**	-0.448
		(24.137)	(2.145)	(5.208)	(1.675)	(7.557)	(1.714)
Short Run	Error Corr. Term	-0.878***	-0.844***	-.963***	-0.795***	-0.925***	-0.812***
		(0.182)	(0.118)	(0.149)	(0.120)	(0.165)	(0.157)
	Innovation	0.280***	0.009			0.413***	0.001
		(0.084)	(0.033)			(0.146)	(0.037)
	Fin. Devt.			0.376	-0.160	0.291	-0.292**
				(0.242)	(0. .312)	(0.325)	(0.146)
	Trade Open	-0.029	-0.050	0.197	-0.091	0.004	-0.089
		(0.160)	(0.069)	(0.190)	(0.211)	(0.345)	(0.079)
	Gross Capital	-0.003	0.019	-0.035	-0.085	-0.176	0.001
		(0.140)	(0.070)	(0.150)	(0.126)	(0.239)	(0.071)
CD		4.05[0.000]	2.73[0.006]	9.07 [0.000]	2.88 [0.004]	2.01 [0.045]	3.22[0.001]
AR		11.366***	21.953***	4.049**	19.094***	5.993**	4.611***
Residual		I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
RMSE		0.11	0.10	0.11	0.11	0.12	0.10
R-Squared		0.44	0.45	0.46	0.47	0.32	0.38
Observations		510	510	510	510	510	510

Note: Values in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively.

Source: Authors' computation using Stata 17.0

Nonetheless, all the common correlated effect estimators in Table 6 still suffer cross-sectional dependence. Chudik and Pesaran (2015: 14) posit that for commonly correlated effect estimator(s) to be valid two conditions should be met: "a sufficient number of lags of cross-sectional averages must be included in individual equations, and the number of cross-sectional averages must be at least as large as the number of unobserved common factors." Our dataset has met the first condition, but we find it difficult to meet the second condition, as including more lags of averages renders our models inestimable due to relatively small

sample sizes. Overall, the estimates point to the beneficial impacts of innovation on economic growth as expected but give us conflicting findings on the effect of financial development.

4.7. Dynamic Panel Autoregressive Distributed Lag (ARDL) Models with Moderator

To see the combined effect of innovation and financial development, we have created a new variable by interacting innovation with financial development (INNO*FIN.DEVT) as in Table 8. Before the interaction, we created centred variables (mean of the variable minus variable) for innovation and financial development, then multiplied the centred innovation and centred financial development. Table 8 shows the results of the dynamic panel ARDL model by including moderation of innovation and financial development. The finding indicates that the interaction term has no impact on economic growth in the long run, whereas in the short run the term has a significant and positive impact on economic growth at the significance level of 10% for the mean group model and 1% for the dynamic fixed effect model. The Hausman test between the MG, PMG, and DFE models rejects the null hypothesis of the efficiency of the PMG and DFE models. Thus, based on the Hausman test, the MG model, in which innovation and financial development jointly affect the economic growth in the short run for SSA countries, is the accepted model.

Table 8: Panel Autoregressive Distributed Lag (ARDL) Models with Moderator (INNO*FIN.DEVT)

	Estimator	**MG**	**PMG**	**DFE**
	Variable	**Coefficient**	**Coefficient**	**Coefficient**
Long Run	INNOVATION	1.700	0.061	0.459***
		(1.562)	(0.067)	(0.108)
	FIN. DEVT.	-3.757	-0.160	-0.290
		(3.334)	(0.179)	(0.249)
	TRADE OPEN	-1.381	0.180*	0.339**
		(1.239)	(0.107)	(0.174)
	GROSS CAPITAL	-0.919	-0.162	-0.231
		(0.539)	(0.154)	(0.244)
	INNO*FIN.DEVT	-0.221	0.072	-0.079
		0.539	(0.062)	(0.025)
Short Run	ECT	-0.620***	-0.070***	-0.218***
		(0.086)	(0.025)	(0.025)
	INNOVATION	-0.055	-0.001	-0.005
		(0.140)	(0.195)	(0.050)
	FIN. DEVT.	0.004	-0.068	-0.058
		(0.081)	(0.082)	(0.070)
	TRADE OPEN	0.029	0.052	0.027
		(0.042)	(0.045)	(0.061)
	GROSS CAPITAL	-0.022	0.022	0.054
		(0.073)	(0.055)	(0.061)
	INNO*FIN.DEVT	0.202*	-0.200	0.081***
		(1.114)	(0.165)	(0.025)
	Cons	4.600***	0.502***	1.139***
		(0.812)	(0.193)	(0.268)
Hausman test b/w MG vs PMG		Chi-square test value 32.821***		
Hausman test MG vs DFE		Chi-square test value 3351.686***		

Note: Value in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively.

4.8. Robustness Check: Asymmetric Panel ARDL

Given the inconsistent effects of financial development on economic growth, we conduct a panel non-linear ARDL analysis on the dataset as we suspect asymmetric effects of financial development in the models. Table 9 provides the results on the asymmetric effects of financial development and innovation on economic growth in the sub-Saharan African sub-region. The estimators in the table fail to differentiate the asymmetric links between changes in innovation and financial development across the periods. The coefficients of innovation (+) and innovation (-) exhibit a positive sign except in the short run of PMG, where the coefficients are negative. However, the coefficients of financial development (+) and financial development (-) show a negative sign. This suggests that both the negative and positive aspects of innovation exert a positive effect on GDP per capita, whereas GDP per capita responds to positive and negative shocks of financial development negatively. Under the DFE estimation, innovation (+) and innovation (-) are statistically significant in both the short and long term. Financial development (+) and financial development (-) are statistically significant in the long run for the PMG estimator. Except in the short run of the PMG estimator for financial development, Wald tests fail to reject the presence of asymmetric relationships in both the short and long runs of the estimators. Our robustness checks have corroborated our findings under symmetric panel ARDL estimations in Tables 5 and 6.

Table 9: Asymmetric Panel ARDL Estimates

	Estimator	MG	PMG	DFE
	Variable	**Coefficient**	**Coefficient**	**Coefficient**
Long Run	Innovation (+)	0.642	0.059	0.381***
		(0.624)	(0.100)	(0.120)
	Innovation (-)	0.600	0.057	0.392***
		(0.623)	(0.101)	(0.121)
	Fin. Devt. (+)	-0.236	-1.154***	-0.256
		(0.663)	(0.338)	(0.280)
	Fin. Devt. (-)	-0.235	-1.183***	-0.223
		(0.685)	(0.338)	(0.284)
	Trade Open	0.509	1.0697***	0.344*
		(0.381)	(0.177)	(0.191)
	Gross Capital	1.239*	0.909***	-.1579743
		(0.634)	(0.130)	(0.265)
Inn-Asym (Wld)		0.58[0.448]	0.01[0.930]	0.15[0.694]
FD-Asym (Wld)		0.00[0.973]	1.20[0.273]	1.41[0.236]
	Error Correction Term	-0.410***	-0.155***	-0.200***
		(0.096)	(0.024)	(0.024)
	Innovation (+)	0.242	-0.045	0.130**
		(0.190)	(0.110)	(0.067)
	Innovation (-)	0.252	-0.026	0.134**
		(0.191)	(0.107)	(0.069)
	Fin. Devt. (+)	-0.0001	-0.296	-0.103
		(0.391)	(0.258)	(0.084)
	Fin. Devt. (-)	-0.009	-0.305	-0.101
		(0.399)	(0.260)	(0.086)
	Trade Open	0.031	-0.057	0.081
		(0.225)	(0.136)	(0.061)
	Gross Capital	0.208	0.203*	0.013
		(0.242)	(0.111)	(0.062)
	Cons	-0.028	0.486***	1.075***
		(1.171)	(0.073)	(0.276)
CD		6.56[0.000]	51.86[0.000]	31.21[0.000]
AR		11.70***	129.64***	20.80***
Residual		I(0)	I(0)	I(0)
Inn-Asym (Wld)		0.63[0.427]	0.33[0.563]	0.76[0.384]
FD-Asym (Wld)		0.89[0.345]	5.96[0.015]	0.24[0.622]
Observations		510	510	510

Note: Values in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively.

Source: Authors' computation using Stata 17.0

4.9. Robustness Check: Dynamic Panel Model Two-Step System GMM

As a further test on the robustness of our results, we estimated the dynamic panel model (two-step system generalised method of the moment). Table 10 shows the estimated results of the two-step system GMM model. In applying this model, we proceed as follows: we first run pooled OLS, fixed effect, and random effect models. Based on the Hausman test as shown in Table A1 and Table A2 (Breusch and Pagan Lagrangian multiplier test) in the Appendix, we choose the fixed effect model as both tests are significant at the 1% level. Then we test heteroscedasticity in the fixed effect model through the modified Wald test as described in the Appendix (Table A3). The significance of the Wald test indicates the presence of heteroscedasticity. We remove the heteroscedasticity by using robust standard errors. We then apply the Durbin–Wu test as reported in the Appendix (Table A4), with the significant coefficient indicating the presence of endogeneity. Thus, we move towards GMM models. To choose between difference and system GMM, we apply pooled OLS (see Appendix Table A5a), the fixed effect model (Table A5b), and the difference GMM (Table A5c). The coefficient of difference GMM is the same as under the fixed effect model, which indicates choosing system GMM rather than difference GMM. Therefore, we apply a two-step system GMM. We then address the problem of instrument proliferation by limiting the number of lags to the order of 2. We next remove the problem of autocorrelation by adding another lag of economic growth in the model. Table 10 shows our final two-step GMM model, which is robust to standard error and free from autocorrelation and instrument proliferation. It shows that economic growth in the previous period significantly and positively influences the current period's economic growth. Moreover, financial development significantly and negatively affects economic growth. The findings from the two-step GMM model are in line with our earlier results in Table 6 and Table 7.

Table 10: Dynamic Panel Model: Two-Step System GMM

Economic Growth	Coef.	St.Err.	t-value	Sig
Economic Growth $_{t-1}$	.973	.068	14.33	***
Economic Growth $_{t-2}$	-.042	.063	-0.66	
Innovation	.032	.041	0.79	
Fin. Devt.	-.379	.135	-2.81	***
Trade Open	.069	.085	0.82	
Gross Capital	-.091	.099	-0.92	
Constant	1.759	.536	3.28	***
Mean dependent var	7.087	SD dependent var		1.009
Number of obs	480	Chi-square		99020.343

*** p<.01, ** p<.05, * p<.1

5. DISCUSSION OF RESULTS

The result of innovation, in the long run, is found to be positive and statistically significant at the 1% level. This result provides support for theoretical postulations on the impact of innovation on economic growth (Aghion & Howitt, 1992; Romer, 1986; Cass, 1965; Solow, 1956). Similarly, the finding is in line with previous empirical studies on innovation and economic growth (Jian, et al., 2021; Maradana et al., 2017; Sesay et al., 2018; Pradhan et al., 2018; Pradhan et al., 2020; Sarangi et al., 2022; Wang et al., 2022). These studies documented that innovation incentivises economic growth, and achieving economic growth leads to higher productivity. Further, our results support the hypothesis that innovation enhances economic growth through productivity improvement.

The result of the study also shows that financial development has a positive and significant effect on economic growth in the long run at the 1% significant level. This signifies that higher financial services are linked with greater output growth. Recent financial development through innovation, such as the use of technology in providing banking and other financial services, has greatly promoted financial inclusion, which in turn stimulates the growth and development of SSA. Inventions such as automatic teller machines (ATMs), electronic payment platforms, and internet banking, among others, have considerably enhanced the running of financial systems in SSA during the last two decades. Apart from the

provision of financial services, an additional argument that financial development stimulates output growth is its ability to boost the funds available for investment in risky and demanding areas that have a direct link with the growth of output. These findings are in line with previous empirical studies (for example Abeka et al., 2021; Nguyen et al., 2022; Sarwar et al., 2020; Olorogun et al., 2020). In this regard, our result supports the hypothesis that financial development spurs economic growth. Hence, efficient and developed financial systems enhance economic growth and at the same streamline countercyclical investments, which neutralise the severity of economic fluctuations (Aghion et al., 2018).

However, the short-run effect of innovation, in contrast to the long-run impact, was found to be insignificant, implying that innovative activities take a longer time to materialise and create output. This finding is in line with a study by Gyedu et al. (2021) that found that R&D efforts, patents, and trademarks (as proxies of innovation) are negatively significant in G7 countries. In addition, the financial sector in SSA is still subject to high levels of shocks and government intervention, indicating a tendency to have a weak connection with growth of output – especially in the short run.

The outcomes concerning the impacts of the control variables included in the model are in line with our expectations. For instance, the trade openness result was found to be positive and statistically significant at the 10% level. The findings are in line with those of previous studies on trade openness and economic growth (Kumari et al., 2021; Raghutla, 2020). Trade openness is well thought of in some research as a basis for additional exposure to innovation through the transfer of technology. There is, in addition, the recognition that the shifting structure of trading and other cross-border activities in the region with China and other developed and emerging countries has caused expansion in technology transfer which is critical in improving innovation and financial development. Trade openness may also contribute to economic growth by facilitating access to products and services, increasing resource allocation efficiency, and increasing total factor productivity through the diffusion of technology and knowledge. Thus, promoting trade with a greater financial complexity may facilitate businesses to more easily obtain financial resources to sustain innovative activities (Hanley, et al., 2011). Another important explanatory variable included

in the model is capital stock – comprising physical and human capital. The findings provide evidence of a positive effect of capital stock on economic growth – supporting the empirical evidence and theories within the economic growth literature (Jibir & Abdu, 2018; Romer, 1986; Cass, 1965; Solow, 1956). Similarly, the findings from the robustness check using the two-step GMM model are in line with our earlier results.

6. CONCLUSION AND POLICY IMPLICATION

This study employed symmetric panel ARDL, common correlated effect ARDL, and asymmetric panel ARDL to investigate the association between innovation, financial development, and economic growth using data for 30 developing countries from SSA. This study is timely given that an overhaul of the financial system and innovative approach to business models has lately been acknowledged and emphasised by the policy makers in SSA as part of their efforts to achieve goals 8 and 9 of the United Nations Sustainable Development Goals (SDGs).

The findings of the paper reveal among other things that innovation and financial development have a positive and significant long-run effect on the economic growth of sub-Sahara Africa. Our findings offer reliable results consistent with several theoretical likelihoods and fresh empirical evidence in the region and beyond. This implies that the long-run growth of the SSA economies is fundamentally connected with the quality of innovation and financial development. In addition, long-term economic growth also depends on creating and maintaining an environment that fosters innovation and financial inclusion and provides incentives for the use of new technology. This means that the application of newly invented inputs and technology and utilisation of modern financial services would promote growth and development. The findings provide new facts concerning how SSA nations can sustain their economic growth through devising approaches supporting financial development and quality innovation.

However, in the short run, financial development and innovation are found to be statistically insignificant in promoting the economic growth of the region. This means that new technologies in the financial sector and new inventions are not being adopted in the short run at the rate needed to support growth and development. It takes time before conceived ideas can be translated into a

meaningful invention that can support output growth. The result suggests that firming up the financial system through satisfactory economic policies may promote the region's financial inclusion in the long term and, in the end, stimulate economic growth. Thus, economic policies geared toward strengthening the region's financial sector may expand its innovative capacity as well, which in turn stimulates output growth.

Our findings of a positive and significant impact of innovation and financial development together with capital stock and trade openness suggest that these variables favourably determine the output growth of the region. These findings support modern endogenous growth theories that emphasise the role of financial development, innovation, and capital stock in growth and development.

The study recommends that policy makers in the region must work in close collaboration with stakeholders in financial institutions and business enterprises in enhancing innovative activities through supporting inventions and scientific discoveries. The financial system forms a central factor in the growth of output. In this regard, governments in the region need to unceasingly expand the allocative efficiency of the financial system, which stimulates regional development. There is also a need for policy makers in the region to enact relevant policies to ensure rigorous regulation and supervision of the financial sector to deliver stability, which will pave the way for achieving the financial inclusion agenda of the sustainable development goals (SDGs) in the region.

Governments in the region can equally play a significant part in creating a legislative framework supporting the advancement of innovation financing through strengthening patent protection across the region. Similarly, there is a need to synchronise the innovative activities in the region by ensuring a strong linkage between research institutes, industries, and tertiary education centres in promoting innovative activities**.** Similarly, governments in the region need to design a well-functioning technological infrastructure by working together through interactive and synergistic approaches with the private sector and other stakeholders as such a well-equipped technological infrastructure remains a strategic cornerstone in upholding regional innovation and financial development.

This study provides robust findings through the use of numerous econometric techniques and a large number of countries from the region, allowing an adequate generalisation of the results to be made for the purpose of policy prescription. However, one area that requires further exploration by future researchers is the use of more than one measure of innovation and financial development in analysing the relation between the variables and economic growth.

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Received: September 29, 2022
Accepted: June 07, 2023

APPENDIX

Table A1: Hausman test to choose between REM and FEM

	Coef.
Chi-square test value	39.072
p-value	0

Table A2: Breusch and Pagan Lagrangian multiplier test for random effects

	Coef.
chibar2(01)	3637.63
Prob > chibar2	0.0000

Table A3: Modified Wald test for group wise heteroscedasticity in fixed effect regression model

	Coef.
chi2 (30)	959.54
Prob>chi2	0.0000

Table A4: Tests of endogeneity

	Coef.
Durbin (score) chi2(1)	8.31309 (p= 0.0039)
Wu-Hausman F(1,444)	8.35662 (p = 0.0040)

Compare the co-efficient of Lagged DVs to choose between System and Difference GMM (Table A5a, Table A5b, and Table A5c)

Table A5a: Pooled OLS

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Economic Growth $_{t-1}$	.981	.007	143.51	0	.968	.995	***
Innovation	-.001	.004	-0.13	.896	-.009	.008	
Fin. Devt.	-.031	.022	-1.38	.168	-.074	.013	
To	.032	.012	2.64	.009	.008	.056	***
Gross Capital	-.06	.032	-1.91	.056	-.122	.002	*
Constant	.383	.141	2.72	.007	.106	.66	***

Mean dependent var	7.045	SD dependent var	1.020
R-squared	0.981	Number of obs	510
F-test	5558.438	Prob > F	0.000
Akaike crit. (AIC)	-555.921	Bayesian crit. (BIC)	-530.515

*** $p<.01$, ** $p<.05$, * $p<.1$

Table A5b: FE model

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Economic Growth $_{t-1}$	.795	.021	38.31	0	.752	.837	***
Innovation	.086	.029	3.00	.006	.027	.145	***
Fin. Devt.	-.084	.067	-1.25	.223	-.221	.054	
Trade Open	.071	.052	1.38	.179	-.034	.176	
Gross Capital	-.015	.041	-0.36	.719	-.1	.07	
Constant	1.12	.32	3.50	.002	.465	1.774	***

Mean dependent var	7.045	SD dependent var	1.020
R-squared	0.867	Number of obs	510
F-test	407.764	Prob > F	0.000
Akaike crit. (AIC)	-664.430	Bayesian crit. (BIC)	-643.258

*** $p<.01$, ** $p<.05$, * $p<.1$

Table A5c: Diff-GMM

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Economic Growth $_{t-1}$	.795	.039	20.44	0	.715	.874	***
Innovation	.077	.044	1.75	.091	-.013	.167	*
Fin. Devt.	-.094	.073	-1.29	.205	-.242	.054	
Trade Open	.203	.122	1.67	.105	-.045	.452	
Gross Capital	.116	.153	0.76	.452	-.195	.428	
Mean dependent var		7.087	SD dependent var			1.009	
Number of obs		480	F-test			.	

**** p<.01, ** p<.05, * p<.1*

ECONOMIC ANNALS, Volume LXVIII, No. 237 / April – June 2023
UDC: 3.33 ISSN: 0013-3264

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https://doi.org/10.2298/EKA23371375

MODELLING THE INFLUENCE OF FINANCIAL INCLUSION ON THE REMITTANCE-GROWTH NEXUS IN NIGERIA

ABSTRACT: *In this paper, we explore the nexus between remittances and Nigeria's economic growth over the period 1996 to 2020 from the perspective of financial inclusion (FI). The fully modified ordinary least square (FMOLS) and Granger (1969) causality methodologies were employed. The findings of the FMOLS show that the increasing flow of remittances can significantly contribute to the growth of the Nigerian economy. Also, the interaction of financial inclusion and remittances has a significant impact on the country's development. The study concludes that the interaction of remittances with the measures of financial inclusion will lead to economic growth at a faster rate than when there is no interaction with financial inclusion. Using the Granger causality test, the study revealed that the relationship between financial inclusion and economic growth is a unidirectional one. It shows that the impact of financial inclusion on growth is conditional on remittances. Therefore, Nigeria's authorities need to work to strengthen all existing institutional weaknesses that allow questionable transactions in financial markets and to promote a more inclusive financial sector that will reduce the number of unbanked individuals in the country.*

KEY WORDS: *remittances, economic growth, financial inclusion, Nigeria*

JEL CLASSIFICATION: C13; G00; F24; F63

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1. INTRODUCTION

Globally, the attention of governments and policymakers is focused on leveraging financial inclusion and remittances as catalysts for precipitating economic growth and achieving sustainable development in many countries where large segments of society are excluded from the financial systems (Mader, 2016; Feghali et al., 2021). To complement the efforts of policymakers, financial economists and development scholars in recent times have focused on the consequences of international remittance flows, financial inclusion, and economic growth (Sobiech, 2019). It is argued that strengthening the financial system through financial inclusion policies would directly impact remittance inflows, and the latter would impact economic growth (Toxopeus & Lensink, 2008; Mashayekhi & Branch, 2015, Chuc et al, 2022). By improving financial inclusion, it is anticipated that the economic welfare of citizens will increase because cumulative savings of households and businesses have the propensity to increase consumption, augment income shocks, create a payment history for savers and increase future credit access (Feghali et al., 2021).

In the developing context, remittances play a vital role in the promotion of financial inclusion. The extant literature reports that an increase in remittances can influence the behaviour of households towards financial institutions (Anzoategui et al., 2014) owing to its capacity to change the financial habits of individuals. Moreover, remittances positively influence the demand for financial services in home countries as beneficiaries/recipients become more inclined to open bank accounts with formal financial institutions (Mashayekhi & Branch, 2015). The cause-effect relationships among remittances, financial inclusion, and economic growth were brilliantly explicated by Chuc et al. (2022), who found that international remittances positively impact the level of financial inclusion, which subsequently impacts economic growth. Consequently, financial inclusion has an important role in strengthening the growth-enhancing impact of remittances on recipient countries.

In Nigeria, the current situation of financial inclusion and remittances calls for structural improvement. Reliable reports indicate that Nigeria is one of the seven developing economies with a large unbanked population, corresponding to almost 50% of the global 1.7 billion unbanked adults (Demirguc-Kunt et al., 2018; Adegbite & Machethe, 2020). The remittance profile of Nigeria also requires

policy interventions. Bolarinwa & Akinbobola (2021), who examined Nigeria and three other countries, found that past remittances had a significant role in the current financial development of Kenya and Nigeria. As a result, these countries need to develop their financial sectors in order to attract more remittances. Worse still, the household-level data on remittances received by households in Kano Nigeria were found to have a negative impact on education and investment in productive enterprises; hence, remittances do not cushion the effects of poverty (Adamu & Kabuga, 2016).

From the foregoing, remittances would be a valuable component of infrastructure financing in developing countries (Yoshino et al., 2020). Theoretically, remittances smooth household spending and thereby reduce production volatility (Dash, 2020). They benefit the recipient country's financial sector (Berk Saydaliyev, et al., 2020et al., 2020) by facilitating access to loans for investment by indigenous firms (Aggarwal et al., 2011). Furthermore, remittances can help boost the growth of a migrant's home country by providing a boost to household spending. According to Aggarwal et al. (2011), remittances can also help alleviate poverty in communities. The literature also contends that remittances help the migrant's country increase its internal savings (Connell & Conway, 2000; Sahoo & Dash, 2013). An increased household income typically results in increased savings rates in emerging countries. Likewise, remittances provide critical capital flows for the development of investment by allowing for the importation of capital and intermediate commodities (Chami et al., 2008). A review of recent events reveals that remittance inflows have risen dramatically and have surpassed other inflows that have historically figured prominently in developing countries (Dridi et al., 2019; Chuc et al., 2022) and have been considered a possible source of finance for sustainable development (Chuc, et al., 2022). Following the COVID-19 pandemic, the World Bank (2021) predicted a 19.7% decline in remittances to low- and middle-income countries (LMICs) to $445 billion in 2020. However, Nigeria's diaspora remittances inflows significantly exceeded the World Bank's prediction for 2021, increasing to $14.2 billion in the third quarter of 2021 and up from $12.9 billion in the same period of 2020, thanks to the impact of post-COVID economic recovery efforts by the Nigeria government.

Why have remittances become a front burner issue? Remittance inflows have become an important issue among policymakers because the quantum of funds

remitted back to home countries by international migrants outweighs official development flows (ODFs) in middle-income countries and is comparatively larger than foreign direct investment (FDI) in low-income countries (Toxopeus & Lensink, 2008; Hassan et al., 2016; Murshed & Rashid, 2020; Chuc et al., 2022). In addition, a considerable amount of empirical literature suggests that remittances are catalysts for economic growth and financial development in poverty-ridden developing and emerging economies (see Adeniyi et al., 2015; Cismaș et al., 2020; Knoerich, 2017; León-Ledesma & Piracha, 2004; Meyer & Shera, 2017; Ratha, 2003; Sarma & Pais, 2011; Sobiech, 2019; Terry et al., 2004). Additionally, an ample number of studies have demonstrated that financial development is a vital component of the development of disadvantaged countries due to its ability to provide financing solutions (see Olagbaju & Akinlo, 2018; Anetor, 2020). These studies have led to a second set of empirical literature arguing that remittances and financial development are not mutually exclusive but that financial development tends to lessen the overall growth-inducing effects of remittances (Giuliano & Ruiz-Arranz, 2009). Specifically, Nyamongo et al. (2012) asserted that financial deepening appears to exacerbate remittances' positive effect on growth. It can be concluded, however, that no financial inclusion metrics nor an indicator for raising access to formal financial services is available in the previous literature. It is therefore likely that divergent results can be attributed to methodologies, sample scope, and financial inclusion metrics. There has only been a handful of studies in the past that examine the causal relationship between remittance inflows and regional development (De Vita & Kyaw, 2009; Donou-Adonsu et al., 2020; Nayak & Yingnan, 2019). The goal of this study is to provide a comprehensive analysis of the relationship between remittances, financial inclusion, and economic growth. This study attempts to fill a major gap in this field by examining the relationship between remittance inflows and the latter two issues.

Due to the complexity of the financial system, it is often difficult to determine this relationship. This is why it is important for researchers to understand the link between these three factors. The causation argument's direction is critical since in pursuing sustainable economic growth, remittance inflows and inclusive financial services have become critical issues in the line of activities aimed at revitalising the Nigerian economy. The preceding explanation demonstrates that the Nigerian government views remittances as a critical source of funding.

Notably, remittances to Nigeria have been volatile over the years, implying the necessity for reversals that exert significant pressure on domestic market circumstances. As a result, it is necessary to increase remittance flows, assist financial institutions, and attract further capital flows. Thus, given the commitments of stakeholders, financial sector expansion will have an effect on remittance inflows to Nigeria. The issue is whether financial inclusion through remittances into Nigeria is sufficient to spur economic progress. On the other hand, significant remittance inflows could have a detrimental effect on the country's growth process, resulting in external shocks and inflationary pressures. We argue that if remittance inflows are not accompanied by solid financial policies that promote an equitable financial system, their impact on the economy may be negligible. Hence, this study empirically examines the interactive effect of financial inclusion on remittance inflows-economic growth in Nigeria from 1996 to 2020 using time series data. In specific terms, the research questions are: (a) What is the impact of increasing the flow of remittances on the growth of the economy? (b) What is the interactive impact of financial inclusion and remittances on a country's development?

The present investigation demonstrates that access to financial services does not imply utilisation. Access to financial infrastructure often does not signify growth in the economy. Rather, it entails a state in which a growing proportion of a country's excluded populations cannot access and use formal financial services. In four different ways, this paper contributes to existing studies. First, it attempts to analyse the influence of financial inclusion on the remittance-economic growth nexus in Nigeria. This is despite contradictory findings in underdeveloped nations when the various indicators of financial development are used with divergent methodologies. Second, this study employs a composite index of financial inclusion (FIPHY) that is computed using principal component analysis (PCA). The distinctiveness of the PCA lies in its ability to eliminate the correlation and redundant details present among the variables. Information and communication technology (ICT) has been hailed as a vital aspect of promoting financial inclusion due to its involvement in bridging the financial infrastructure gap in many African nations and its ability to enhance social and economic inclusion (Kpodar & Andrianaivo, 2011; World Bank Group, 2016). In consonance with this, this study also follows Ajide et al. (2020) to measure financial inclusion with the measures of ICT (FIICT). Third, the study measures

institutional quality with the institutional quality index (IQINDX), which is computed by averaging the six governance indicators. The selection of the variable is consistent with Olaniyi and Oladeji (2020). Fourth, while remittances have increased dramatically, evidence of an adverse nexus between remittances and economic growth has emerged (Chami et al., 2012), implying the possibility of an indirect causal relationship. The current study addresses this lacuna by examining the direction of causality between remittance inflows, economic growth, and financial inclusion in Nigeria. Last, our study emphasises that statistical analytical techniques such as the fully modified ordinary least squares (FMOLS) will shed light on the relationship between remittance inflows, financial inclusion, and economic growth in Nigeria. The rest of this study is arranged as follows. Section 2 presents a discussion of the associated empirical and theoretical literature. Section 3 discusses the methodology. Section 4 focuses on the empirical results, while Section 5 concludes the study.

2. REVIEW OF RELATED LITERATURE

This section reviews existing knowledge about the issue to obtain a better grasp of it based on the project's aims and objectives. Over the years, remittances have garnered much attention in the financial economics literature and have produced a range of findings. The first empirical view argues that remittances boost growth by providing capital for economic development, generating employment, enhancing the growth of the economy, and assisting recipient countries in reducing their current account deficits (León-Ledesma & Piracha, 2004; Meyer & Shera, 2017; Ratha, 2003; Terry et al., 2004). Cismaş et al. (2020) discovered that remittances do not increase economic growth. Similarly, Bandura et al. (2019) argued that while remittances aid economic development, they hamper financial development in 14 SADC countries. Additionally, a substantial body of empirical research has shed light on the nexus between remittances and financial development or inclusion. Remittances hypothetically transmit or influence financial development by enhancing demand for savings instruments, thereby stimulating households' financial capacity. Consequently, their demand for bank accounts may increase, as financial institutions provide households with a secure location to store their transitory surplus money (Misati et al., 2019; Berk Saydaliyev, et al., 2020; Muktadir-Al-Mukit & Islam, 2016). Furthermore, remittances can contribute to financial inclusion by increasing recipients' chances

of obtaining loans from official banks and other financial institutions (Berk Saydaliyev et al., 2020). This may boost financial institutions' willingness to lend to previously opaque borrowers.

However, the literature on remittances and financial inclusion has clearly evolved in a fragmented manner, producing inconsistent results. The first empirical argument asserts that remittances boost senders' and recipients' use of financial services (Anzoategui et al, 2014; Orozco & Fedewa, 2005; Berk Saydaliyev, et al., 2020). The studies suggested that remittances' positive effect on financial inclusion is due to the increase in demand for bank accounts (Ambrosius & Cuecuecha, 2016). However, another viewpoint argued that these remittances may not lead to an all-encompassing financial system. (Ambrosius & Cuecuecha, 2013; Brown et al., 2013; Calderon et al., 2008; Chami & Fullenkamp, 2013; among others). In 2013, Chami and Fullenkamp noted that there was a negative correlation between financial inclusion and remittances. Berk Saydaliyev et al. (2020) recently argued for the importance of institutional quality in developing countries receiving high returns. Likewise, scholars have shown that political stability and institutional quality are important factors that can influence financial inclusion or remittance-growth nexus (see Adekunle et al, 2020; Ajide et al., 2017; Dabla-Norris et al., 2020; Ozili, 2021; Ogede, 2019). Meanwhile, studies such as Kabakova and Plaksenkov (2018) and Sharma and Kukreja (2013) previously argued that the technology aspect of financial inclusion encompasses new banking technologies such as internet and mobile banking, on which increased reliance has been placed to improve financial inclusion (Kabakova & Plaksenkov, 2018). Bala et al. (2017) claim, using dynamic panel methods, that financial development promotes economic growth in African OPEC member nations. Similarly, Chebab et al. (2020) believe that financial development was significantly and favourably associated with economic growth in resource-rich Middle Eastern and North African (MENA) nations from 1987 to 2015. Following the turning point, the findings suggest that increased financial development has a negative impact on economic growth.

Nevertheless, the literature on financial inclusion's involvement in the remittance-growth nexus is scant. As a result, the current study identifies the necessity to alleviate the disadvantages by undertaking a detailed examination of

the effect of financial inclusion on the remittances-economic growth nexus. Flowing from the foregoing empirical review, we hypothesise the following:

Hypothesis 1: Increasing the flow of remittances can significantly contribute to the growth of the economy.

Hypothesis 2: The interaction of financial inclusion and remittances can significantly impact a country's development.

3. METHODOLOGY

3.1 Theoretical framework and model specification

This study relies on the work of Mankiw et al. (1992), Sobiech (2019), and Saydaliyev et al. (2020), which we subsequently modified to establish the nexus between remittance inflows, financial inclusion, and economic growth. The model is given as:

$$y_t = a_0 + a_1 A_t + \varepsilon_t \tag{3.1}$$

where y_t represents economic growth and A represents remittance inflows from citizens to the rest of the world due to global integration and the investment drive to fill funding gaps caused by research and growth, human capital, and technical spillover effects. The role of remittances on economic growth is at the forefront of the foreign capital inflows-growth discourse. The argument is that, on the one hand, remittance-growth theory posits that remittance inflow results in rising returns to scale. On the other hand, the neoclassical model emphasises declining returns to the marginal product in the long run (Adams & Klobodu, 2016). a_0 and a_1 are the parameters, while ε_t is the error term. The financial development literature has attached a vital role to financial inclusion in the growth process. Financial inclusion can directly have implications for economic growth through its growth-reducing role if the economy is financially excluded and growth-enhancing tendencies if the economy is financially inclusive (Gurley & Shaw, 1955; Sethi & Acharya, 2018). Consequently, we augment equation (3.1) to include the measure of financial inclusion (FI). Thus, equation (3.1) is re-specified as:

$$y_t = a_0 + a_1 A_t + FI_t + \varepsilon_t \quad (3.2)$$

In addition, FI can also indirectly have implications for economic variables without remittances being an exception. This study hypothesises that an all-encompassing financial structure can facilitate the flow of remittances and ultimately influence the economy through the channel of remittances. Hence, we augment equation (3.2) to include the interaction of remittances and financial inclusion.

$$y_t = a_0 + a_1 A_t + a_2 FI_t + a_3 FI_t * A_t + \varepsilon_t \quad (3.3)$$

Institutional quality (IQINDX) is crucial in guaranteeing an enhanced financial system and a suitable regulatory framework for remittance inflows. This study augments equation (3.3) to include the measure of institutional quality and other growth-determining factors such as foreign direct investment (FDI), trade openness (TRADE), and gross fixed capital formation (GCF). Representing the notations of equation (3.3) and in a log-linear format, equation (3.3) is given as:

$$\ln GDPP_t = a_0 + a_1 \ln REM_t + a_2 \ln FI_t + a_3 \ln FI_t * REM_t + a_4 ln GCF_t + a_5 ln FDI_t + a_6 ln IQINDX_t + a_7 ln TRADE_t + \varepsilon_t \quad (3.4)$$

where LNGDPP is the natural log of GDP per capita, REM is the remittances received, and FI is a vector of both the physical access measure (FIPHY) and ICT measure (FIICT) of financial inclusion. $FI * REM$ is the interaction of remittances with the measures of financial inclusion; GCF, IQNDX, FDI, and TRADE are defined earlier. On incorporating the proxies of financial inclusion into equation (3.4), the model to estimate the effect of financial inclusion on the remittance-growth nexus is given as follows:

$$\ln GDPP_t = a_0 + a_1 ln REM_t + a_2 \ln FI_t + a_3 ln FIPHY_t * REM_t + a_4 ln FIICT_t * REM_t + a_5 ln GCF_t + a_6 \ln FDI_t + a_7 ln IQINDX_t + a_8 \ln TRADE_t + \varepsilon_t \quad (3.5)$$

In terms of the a priori expectation, remittances may have either a direct or indirect relationship with economic growth, depending on whether they are utilised for investment purposes or otherwise ($a_1 \gtrless 0$). Studies such as Iqbal and Satter (2008) and Vargas-Silva (2008) support a positive relationship, while Barajas, Gapen, Chami, Montieland, and Fullenkamp (2009) report the existence

of a negative nexus. In addition, the coefficient of the interaction between remittance inflows and the measures of financial inclusion is expected to be positive ($a_3, a_4 > 0$). Furthermore, the coefficients of $a_5, a_6, a_7 > 0$ are predicted to be positive because they are growth-enhancing (Haider et al., 2016). In view of the preceding discussion, the paper employs various econometric procedures to capture the economic analysis of the three variables in Nigeria. First, a pre-estimation assessment is conducted using descriptive statistics that aid in describing and summarising the data properties in clear way (Gujarati & Porter, 2009). The study further performs a unit root and cointegration to determine the stationarity and long-run co-movement of the variables. It then proceeds to estimate a cointegrating regression, 6+ specifically, using the fully modified ordinary least square. This method makes it possible to take into account the serial correlation effects in the independent variables. Hence, the FMOLS model provides cointegrating regression estimates that are optimal and unbiased.

3.2 Data and sources

The objective of this study is to examine the effects of financial inclusion on Nigeria's growth-remittances nexus. The research is based on data collected from 1996 to 2020, which are mainly influenced by the availability of global data sources such as the World Development Indicators and the World Governance Indicators. The dependent variable is economic growth, which is gauged using the real gross domestic product per capita (GDPPC). The usage of this measure is in accordance with Adrián Risso and Sánchez Carrera (2019) and Brueckner and Lederman (2018). The key regressors are remittances received and financial inclusion, whereas the control variables are foreign direct investment (FDI), gross fixed capital formation (GCF), trade openness (TRADE), and institutional quality (IQINDX). The study captures remittances using remittances received as a percentage of GDP, and its adoption aligns with Meyer and Shera (2017) and Barajas et al. (2009). Financial inclusion has been measured within the financial development literature with variables including automated teller machines (ATMs), account ownership at a financial institution (ACNT), and commercial bank branches (BRCH) (Ahamed & Mallick, 2019; Park & Mercado, 2021; Sarma, 2016). Since the sole use of these indicators can provide only partial and incomplete information about the comprehensiveness of the financial system (Sarma, 2016), and there is a high correlation between these variables, this study

employs a composite index of FI (FIPHY) and FI (FIICT) computed using principal component analysis (PCA), as reported in Table 1 below.

Table 1. The principal composite index of FIICT and of FIPHY.

Principal components	ICT access		Physical access			Statistics		
	FBB	MOB	ATM	ACNT	BRCH	Proportion	Cumulative (%)	Eigen
1st comp (FIICT)	0.707	0.707	---	---	---	0.792	0.792	1.583
2nd comp	-0.707	0.707	---	---	---	0.208	1.000	0.416
1st comp (FIPHY)	---	---	0.695	0.715	-0.079	0.578	0.578	1.736
2nd comp	---	---	0.278	-0.166	0.946	0.362	0.940	1.085
3rd comp	---	---	-0.664	0.679	0.314	0.060	1.000	0.177

Comp: principal component; **Source:** Authors' calculation

Thus, using this principal component analysis of ATM, ACNT, and BRCH, the composite index of FI (FIPHY) is used to gauge the physical access index of financial inclusion following Ogede and Tiamiyu (2023) as reported in Table 1. Likewise, this study measures FI with the index of ICT (FIICT), which is generated through principal components analysis of mobile cellular subscriptions per 100 people (MOB) and fixed broadband subscriptions per 100 people (FBB). The distinctiveness of the PCA lies in its ability to eliminate the correlation and redundant details present among the variables. Information and communication technology (ICT) has been hailed as a vital aspect in promoting FI due to its involvement in bridging the financial infrastructure gap in many African nations and its ability to enhance social and economic inclusion (Kpodar & Andrianaivo, 2011; World Bank Group, 2016). This study therefore follows Ajide et al. (2022) in using the measures FI with the measures of ICT (FIICT) as mentioned above. The study also aligns with Khan et al. (2020) to measure FDI as foreign direct investment inflows as a percentage of GDP. Gross fixed capital formation is used to measure the level of investment. The selection of this measurement is in line with Meyer & Shera (2017). Trade openness (TRADE) is gauged using trade as a percentage of GDP, and its selection is in accordance with Khan et al. (2020). Last, the study measures the quality of institutions with the institutional quality index (IQINDX), which is computed by averaging six governance indicators. The selection of the variable is consistent with Olaniyi and Oladeji (2020).

4. RESULTS AND DISCUSSION

4.1. Summary statistics and correlation

Table 2 presents the descriptive statistics of the variables. The table reveals that the statistical measures of the series are statistically independent. From the table, all the variables except institutional quality are positive in their means, thereby giving an increasing tendency for all the variables except institutional quality. The average income per person is $2,095.33, while the highest and lowest values are $2688.27 and $1,416.52, respectively. Remittances received average 3.98% of GDP, while the physical access measure of financial inclusion, namely, ATM numbers, account ownership, and the number of commercial bank branches, average 22, 32.76, and 4.71, respectively. As for the ICT access measure of financial inclusion, mobile cellular and fixed broadband subscriptions average 40.79% and 0.020%, respectively. FDI, capital formation, institutional quality, and trade openness average 1.43%, 24.12%, -1.11%, and 37.65%, respectively. In addition, GDP per capita appears to be the most dispersed variable, while fixed broadband subscription is the most stable variable. Our data consist of both positively and negatively skewed series and, similarly, are either leptokurtic or mesokurtic in kurtosis. The table further reveals that all the variables except account ownership at a financial institution and commercial bank branches are normally distributed.

The results of the Phillips Perron and Dickey-Fuller tests are consistent, as displayed in Table 3. The first-order difference results of the PP and the ADF tests reveal that the variable sequences are not stationary at the level. However, when the first-order difference is taken into account, the variable sequences become stationary. The results of the unit root tests suggest that the presence of a long-run co-movement between the independent and dependent variables is possible. This study conducts the bounds test cointegration technique to ascertain the presence of long-run cointegration between the dependent variable and the independent variables. The bounds test is useful because it is applicable irrespective of the order in which the series is integrated. Table 4 presents the result of the bounds cointegration test between the measure of economic growth and our regressors when financial inclusion is proxied by the physical access measure of financial inclusion and when it is measured by the ICT proxy. The bounds test compares F-statistics against the critical values. The result reveals that

the F-statistics of both the physical access proxy of financial inclusion (7.086) and the ICT measure of financial inclusion (6.752) exceed all the critical values of the lower and upper bounds at the 10%, 5%, and 1% levels of significance. The study rejects the idea that there is no cointegration between economic growth, remittances, and financial inclusion. It shows that there are long-run relationships between these factors and various other control variables.

Table 2. Description of variables

Variables	Notation	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
GDP per capita (constant 2015 US$)	GDPPC	2095.334	2688.267	1416.516	461.426	-0.301	1.555	2.554
Remittances, received (% of GDP)	REM	3.979	8.312	0.581	2.257	-0.036	1.840	1.408
Automated teller machines (per 100,000 adults)	ATM	7.220	16.930	0.040	6.933	0.268	1.326	3.220
Account ownership at a financial institution (% of pop.)	ACNT	32.764	44.442	29.668	5.495	1.340	3.059	7.490 *
Commercial bank branches (per 100,000 adults)	BRCH	4.711	6.560	0.400	1.503	-1.715	6.227	23.098 ***
Fixed broadband subscriptions (per 100 people)	FBB	0.020	0.063	0.000	0.023	0.618	1.773	3.161
Mobile cellular subscriptions (per 100 people)	MOB	40.787	99.073	0.013	36.695	0.138	1.400	2.745
Foreign direct investment, net inflows (% of GDP)	FDI	1.428	2.900	0.195	0.759	0.258	2.066	1.186
Gross fixed capital formation (% of GDP)	GCF	24.117	40.553	14.169	8.572	0.474	2.009	1.962
Institutional quality (average of RQ, GE, PS, VA, CC, RL)	IQINDX	-1.106	-0.995	-1.265	0.077	-0.237	2.001	1.192
Trade (% of GDP)	TRADE	37.645	53.278	20.723	9.124	-0.088	2.219	0.668

Note: *p < 0.05; **p < 0.01; ***p < 0.001; Max: maximum; Min: minimum; RQ: regulatory quality; GE: government effectiveness; PS: political stability and absence of violence/terrorism; VA: voice and accountability; CC: control of corruption; RL: rule of law.

Table 3. Unit root results

Test Variables	Augmented Dickie Fuller (ADF)				Phillip Perron (PP)				Integration order
	Level		1st difference		Level		1st difference		
	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.	t-stat	Prob.	
GDPPC	-1.737	0.401	-4.228 **	0.004	-1.338	0.595	-5.412 ***	0.000	I (1)
REM	-2.098	0.247	-4.689 ***	0.000	-2.125	0.237	-4.600 **	0.002	I (1)
ACNT	-1.619	0.458	-4.176 **	0.004	-1.672	0.432	-4.176 **	0.004	I (1)
BRCH	0.022	0.952	-4.216 **	0.004	-0.118	0.937	-4.216 **	0.004	I (1)
FIPHY	-1.598	0.468	-3.330 ***	0.026	-1.258	0.631	-3.330 *	0.026	I (1)
FBB	-1.341	0.588	-5.801 ***	0.000	-2.063	0.260	-4.909 ***	0.001	I (1)
MOB	0.816	0.992	-3.739 *	0.010	0.571	0.986	-3.758 **	0.010	I (1)
FIICT	0.807	0.992	-3.802 **	0.009	0.565	0.986	-3.827 **	0.009	I (1)
FDI	-1.549	0.488	-7.464 ***	0.000	-1.550	0.491	-7.595 ***	0.000	I (1)
GCF	-1.411	0.560	-2.941 **	0.006	-1.448	0.542	-2.960 **	0.005	I (1)
IQINDX	-2.772	0.078	-5.542 ***	0.000	-2.792	0.075	-5.541 ***	0.000	I (1)
TRADE	-2.350	0.166	-5.773 ***	0.000	-2.254	0.194	-8.341 ***	0.000	I (1)

Note: *p < 0.05; **p < 0.01; ***p < 0.001; I (0): integrated of order zero; I (1): integrated of order one

Table 4. Bound cointegration test results

Model	F-statistics	Bounds		Conclusion
		Upper	Lower	
Financial inclusion (physical access proxy)	7.086	2.85 ***	1.85 ***	cointegration
		3.15 **	2.11**	
		3.77 *	2.62 *	
Financial inclusion (ICT proxy)	6.752	2.85 ***	1.85 ***	cointegration
		3.15 **	2.11**	
		3.77 *	2.62 *	

Note: *, **, and *** denote 1%, 5% and 10% statistical levels of significance

4.2. Econometric results and discussion

This section elaborates on the empirical findings of the study. The results for fully modified ordinary least squares are displayed in Tables 5 and 6. The results of the causal relationship are presented in Table 7.

4.2.1 FMOLS results

Tables 5 and 6 show the FMOLS findings for the relationship between remittances, financial inclusion, and economic growth in Nigeria when financial inclusion is measured by physical access and ICT proxies, respectively. Table 5 shows that at 0.898 adjusted R^2, the model has a good fit. Therefore, the effects of the various explanatory variables on the growth of the economy were able to explain almost 90% of the variation in the overall economic growth. Remittances play a positive role in the growth of the economy by increasing the level of economic activity by 0.031%.

Table 5. Fully modified OLS result of the effect of financial inclusion (proxied by physical access) on the remittances-economic growth nexus.

Variables	Coefficient	Std. Error	t-statistics	Prob.
REM	0.031 **	0.009	3.439	0.003
FINCPHY	0.174 ***	0.024	7.250	0.000
FINCPHY x REM	0.223 ***	0.021	10.619	0.000
FDI	-0.001	0.002	-0.431	0.673
TRADE	0.095 ***	0.019	5.148	0.000
GCF	0.022 ***	0.002	-9.090	0.000
IQINDX	0.366 *	0.145	-2.530	0.022
Constant	7.802 ***	0.185	42.114	0.000

Diagnostics

Adj. R^2	J-B Normality of residuals	J-B probability	Autocorrelation (Q-stat)	Partial Autocorrelation
0.898	1.699	0.428	absence	Absence

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Table 6. Fully modified OLS result of the effect of financial inclusion (proxy with ICT) on the remittances-economic growth nexus.

Variables	Coefficient	Std. Error	t-statistics	Prob.
REM	0.010 *	0.005	2.163	0.033
FINCICT	0.360 ***	0.037	9.616	0.000
FINCICT x REM	0.036 ***	0.009	-4.178	0.001
FDI	-0.012	0.011	-1.039	0.314
TRADE	0.002 **	0.001	2.884	0.011
GCF	0.013 ***	0.001	-14.265	0.000
IQINDX	0.389 ***	0.063	-6.168	0.000
Constant	7.558 ***	0.077	97.984	0.000
Diagnostics				
	J-B Normality of residuals	J-B probability	Autocorrelation (Q-stat)	Partial Autocorrelation
Adj. R^2				
0.983	1.512	0.470	absence	Absence

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Table 6 shows that the effect of remittances on economic growth is not considerably different. This conclusion also implies that there is no doubt about remittances' ability to boost economic growth. This result is consistent with the findings of Cazachevici et al. (2020) and Meyer & Shera (2017) but contradicts the outcome of Sobiech (2019). In addition, Table 5 demonstrates that the physical access indicator of financial inclusion is significantly and positively associated with economic growth. In summary, a one percentage point increase in access to ATMs, bank branches, and the ability to own an account at a financial institution stimulates economic growth by 0.174 per cent. In agreement with this, when the ICT measure is used to proxy financial inclusion, Table 6 shows that the positive effect of financial inclusion on economic growth remains vibrant. In essence, a one percentage point increase in ICT factors will exert a 0.360% increase on economic growth. Although the physical access and ICT measure of financial inclusion are positive in their signs, the higher magnitude of the ICT measure suggests that faster economic growth will be realised through the ICT measure of financial inclusion. The positive impact of financial inclusion on

economic growth is consistent with the findings of Kim et al. (2018) and Sethi and Sethy (2019). The result of the effect of the interaction of financial inclusion and remittances on economic growth reveals that the interaction of both measures has a magnifying and significant effect on economic growth in Nigeria. A one percentage point increase in the interaction of the physical measure and the ICT measure of financial inclusion will raise the level of economic growth by 0.223% and 0.036%, respectively. In essence, the interaction of remittances with the measures of financial inclusion will lead to economic growth at a faster rate than when there is no interaction with financial inclusion. The result implies that in the presence of an inclusive financial economy, the economic growth benefits of remittances will increase. In terms of the control variables, foreign direct investment exerts a negative, but insignificant, effect on economic growth. The result is consistent with that of Ayenew (2022). Trade openness, capital formation, and institutional quality are positively and statistically significantly related to economic growth. Furthermore, the result shows that the residuals of the models are normally distributed and do not suffer from either partial or total autocorrelation.

Table 7. Causal pathway results

Hypothesis	F-statistics	Probability	Causal Pathway
GDPPC to REM	0.753	0.485	One-way causality
REM to GDPPC	3.990	0.033 *	
FINCPHY to GDPPC	4.246	0.028 *	One-way causality
GDPPC to FINCPHY	1.356	0.283	
FINCICT to GDPPC	3.492	0.288	One-way causality
GDPPC to FINCICT	1.334	0.046 *	
FINCICT*REM to GDPPC	1.767	0.199	One-way causality
GDPPC to FINCICT*REM	3.630	0.042 *	
FINCPHY*REM to GDPPC	5.646	0.013 **	One-way causality
GDPPC to FINCPHY*REM	1.313	0.294	
GCF to GDPPC	9.513	0.002 **	One-way causality
GDPPC to GCF	0.250	0.782	
FDI to GDPPC	6.250	0.009 **	One-way causality
GDPPC to FDI	2.710	0.094	
IQINDX to GDPPC	0.367	0.698	One-way causality
GDPPC to IQINDX	3.602	0.042 *	
TRADE to GDPPC	1.092	0.357	No causality
GDPPC to TRADE	2.578	0.098	

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Furthermore, this study conducts Granger (1969) causality tests to ascertain the causal relation between remittances, financial inclusion, and economic growth. Table 7 presents the results of the causal relationships between our variables. It reveals that the null hypothesis of no causality is rejected for the relationship between remittances and economic growth; the relationship between the interaction of remittances and physical access of financial inclusion and economic growth; the relationship between the physical access measure of financial inclusion and economic growth; the relationship between the ICT measure of financial inclusion and economic growth;, the relationship between gross fixed capital formation and economic growth; and the relationship between foreign direct investment and economic growth. This implies that there exists only a unidirectional relationship that runs from remittances, the interaction of remittances and physical access, to the physical access measure of financial inclusion. The findings also indicate that economic growth is primarily driven by

fixed capital formation, foreign direct investment, and financial inclusion associated with ICT investments. A one-way causal relationship is also found between economic growth and remittances, as well as any ICT measurement of financial inclusion. The study does not disprove the idea that trade openness does not cause economic growth. It is consistent with the findings of previous studies (Kim et al., 2018; Sethi & Sethy, 2019) that suggest financial inclusion can lead to higher economic growth.

5. CONCLUSION AND POLICY IMPLICATIONS

Remittances are front and centre within the discourse on foreign capital inflows and growth. Studies have found that some of the impacts are positive, while others are nonsignificant or even negative. It is possible that the mixed results are attributable to an important role played by financial inclusion (FI) during economic growth. The literature argues that financial inclusion can directly have implications for economic growth, as it has a growth-reducing effect if the economy is financially excluded and growth-enhancing tendencies if the economy is financially inclusive. This study examines the effect of financial inclusion (FI) on the remittance-economic growth nexus in Nigeria over the period 1996 to 2020. The FMOLS approach has been applied to ascertain the role of financial inclusion in the remittance-economic growth linkage. Furthermore, the Granger (1969) causality approach is used to ascertain the causal relation between remittances, financial inclusion, and economic growth in Nigeria.

The study reveals that remittances from abroad have a positive influence on the country's economic growth. The study also found that the increasing number of financial inclusion households has a significant positive effect on the country's economic growth. It shows that the ICT measure can be used to determine the impact of financial inclusion on the country's growth. Although the physical access and ICT measure of financial inclusion are positive in their signs, the higher magnitude of the ICT measure suggests that faster economic growth will be realised through the ICT measure of financial inclusion. It has also been shown that the interaction of remittances and financial inclusion has a significant impact on Nigeria's growth. It is expounded that the increase in remittances due to increased financial inclusion will lead to a faster rate of economic growth than if the country had not had this interaction. Economic growth is negatively affected by foreign direct investment, although it is not significant. In line with Ayenew

(2022), these results are promising. In fact, trade openness, capital formation, and institutional quality exhibit a positive and statistically significant relationship with economic growth. The findings of the Granger (1969) causality test reveal that there is only a unidirectional relationship running from remittances, the interaction of remittances and physical access, the physical access measure of financial inclusion, the ICT measure of financial inclusion, gross fixed capital formation, and foreign direct investment to economic growth. A one-way causality is also found from economic growth to the interaction of remittances and ICT measures of financial inclusion and institutional quality. In contrast, the study reports a positive causality running from financial inclusion to economic growth.

As a consequence of these findings, the study suggests that the appropriate authorities should make concerted efforts to remove all inherent weaknesses in Nigeria's institutional mechanisms that enable questionable dealings in financial markets, leaving Nigeria's financial system uncompetitive and unproductive, resulting in reduced production. These efforts will lead to a rise in institutional values in Nigeria and can be accomplished by stepping up the battle against corruption, insecurity, violent behaviour, and violent extremism; by enhancing the rule of law and regulatory quality; by encouraging transparency; and by lessening inept government activities in order to guarantee long-term improvements in the institutional context. Hence, to increase economic growth in Nigeria, both measures of financial inclusion and remittances need to be considered together, with the aim of reducing the number of unbanked populations through the establishment of an inclusive financial sector. By encouraging remittance recipients to use financial services, the government can hope to spur growth given that excessive availability of these services without their being used may be wasteful and resource-intensive in Nigeria. According to research by Chuc et al. (2022), a more integrated financial system can assist migrants in sending money back home and keeping money in banks. Therefore, remittances placed in banks will significantly boost the number of families with access to financial services. This will also contribute to the economic expansion of the nation. Consequently, more capital will be allocated to productive investment initiatives.

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Received: May 30, 2022
Accepted: March 06, 2023

ECONOMIC ANNALS, Volume LXVIII, No. 237 / April – June 2023
UDC: 3.33 ISSN: 0013-3264

https://doi.org/10.2298/EKA2337165C

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ASYMMETRIC REACTIONS OF STOCK PRICES AND INDUSTRIAL OUTPUT TO EXCHANGE RATE SHOCKS: MULTIPLE THRESHOLD NONLINEAR AUTOREGRESSIVE DISTRIBUTED LAG FRAMEWORK

ABSTRACT: *Motivated by swings in the exchange rate of many developing economies which exert influence on firms' input costs, output, stock prices, and profits, the study investigated the asymmetric reactions of stock prices and industrial output to various shocks in the exchange rate in Nigeria using a multiple threshold nonlinear autoregressive distributed lag model and high frequency series from January 1999 to December 2021. Empirical results suggest that stock prices and industrial output react asymmetrically in the opposite direction to exchange rate depreciation. It further indicates that the reactions of both stock prices and industrial output to exchange rate changes are sensitive to the size of shocks. Exchange rate shocks above the 25th percentile significantly and inversely affect both stock prices and industrial output, and the effects of exchange rate shocks on stock prices and industrial output become pernicious if above the 75th percentile. The main economic implication of the empirical finding is that in the upper quantile, both exchange rate depreciation and appreciation hurt industrial output, and hence, stock values. Thus, the multiple threshold nonlinear autoregressive distributed lag results suggest that the reactions of both stock prices and industrial output to exchange rate changes are highly sensitive to the extent of the shocks.*

KEY WORDS: *stock prices, industrial output, exchange rate, shocks, asymmetric reactions, nonlinear autoregressive distributed lag model, Africa.*

JEL CLASSIFICATION: B41, C32, C52, E44, N27.

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1. INTRODUCTION

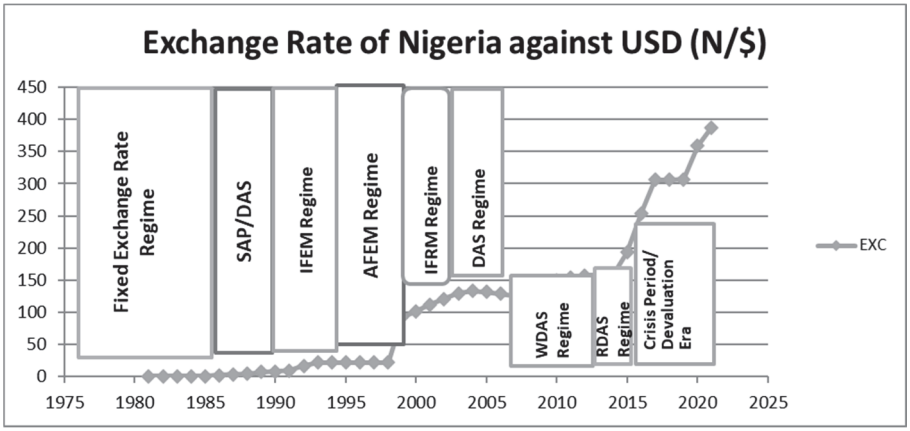
In recent times, economists and decision-makers in transition and developing economies have attached great importance to research on the connection between changes in currency value and stock prices. Since the 1997–1998 East Asian currency crisis, which caused a sharp decrease in the region's stock markets, numerous scholars have explored the connection between a nation's exchange rate and its stock market movement. Exchange rates are hypothetically related to stock market performance (Dornbusch & Fischer, 1980). The flow-oriented exchange rate concept holds that changes in currency value influence global efficiency and the trade balance, which has an effect on the revenue and output of firms. Since the current value of a company's cash inflows is reflected and factored into stock prices, stock prices are sensitive to currency movements (Dornbusch & Fischer, 1980; Phylaktis & Ravazzolo, 2005). The fragile Nigerian economy with highly intractable and pervasive macroeconomic instability maintains a dual exchange rate regime which has been in place for decades. The distinctive feature of the focus of this study revolves around massive swings in exchange rates, which have been exerting huge and unprecedented influence on firms' input costs, output, profits, and stock prices.

Considering how currency changes impact on stock prices, there are various viewpoints on this issue. Accordingly, the first perspective posits that changes in the value of a currency cause a rise in total exports and, hence, boost firms' output and profits. An increased business profit results in a huge boost in a nation's stock prices (Sui & Sun, 2016). The second perspective argues that depreciation of the home currency increases input prices, which reduces enterprises' profits and pushes down stock prices (Bahmani-Oskooee & Saha, 2016a). In contrast to the first view, the second perspective postulates the opposite effect of the exchange rates-stock values nexus. The third viewpoint, however, contends that local currency gains may have the opposite effect on domestic multinational corporations' shareholders by depreciating their stock value (Bahmani-Oskooee & Saha, 2016b). Contradictory theories about how changes in a country's currency affect the output of businesses and stock prices have led to empirical research on the possibility that currency changes asymmetrically affect businesses' output and stock market value (Habibi & Lee, 2019).

Thus, depending on the extent of transmission, the severity of shocks, and the level of susceptibility of firms to currency swings, different levels of currency swings may have varying effects on a firm's output, profit, and, consequently, stock prices (Bartram, 2004; Luqman et al., 2021). Exchange rate swings can range from mild to severe, contingent on the quality of policy interventions by monetary and fiscal authorities. Numerous studies on the asymmetric relationship and variability between the variables have been motivated by this (Fapetu et al., 2017; Luqman et al., 2021; Lakshmanasamy, 2021). For an open economy such as Nigeria, where any developments on the world market affect exchange rate swings and consequently determine stock market efficiency through firm output, determining the extent to which exchange rate shocks spread to industrial output and stock prices is of extreme significance. The expansion of every economy is crucial, and the stock market and industrial output are no exception (Okpara & Odionye, 2012; Zubair, 2013; Fapetu et al., 2017; Javangwe & Takawira, 2022).

The Nigerian currency market has recorded various degrees of changes since the mid-1980s (CBN, 2021) with the worst case being recorded since 2015. As indicated in Figure 1, since the 1980s when the structural adjustment programme (SAP) was introduced in the country, different exchange rate regimes have been introduced to stabilise the market. The remarkable aspect is the phases of exchange rate depreciation the market has undergone.

Figure 1: Exchange Rate Regimes and Exchange Rate Changes in Nigeria



Source: Authors' plot

Evidently, Nigeria's currency has weakened markedly in recent years. Relative stability existed in the market between 1981 and 1998, which may be regarded as an era of minor changes. Between 1999 and 2014, there was a moderate change in exchange rate depreciation as the Nigerian naira depreciated from ₦21.9 in 1998 to ₦92.6 and subsequently gradually moved to ₦153.6 in 2014. This period may be regarded as an era of moderate fluctuations in the exchange rate. Between 2015 and 2021, the market recorded major changes which have been regarded as a currency crisis period (CBN, 2021). During this period, the rate of exchange jumped by 144% to ₦387.7 in 2021 (CBN, 2021). The industrial sector output recorded its all-time low during this same period, recording a decline of -16.8% in the fourth quarter of 2016, and improved slightly to a decline of -2.6% in July 2021 (NBS, 2021; CBN, 2021). Consequently, it is imperative to decompose exchange rate shocks into mild, moderate, and severe, and examine how stock prices and industrial production respond to these diverse shocks in the exchange rate. Empirically, degrees of shocks may influence one or more variables asymmetrically (Pal & Miltra, 2015, 2016; Odionye & Chukwu, 2021; Li & Guo, 2022).

Several studies exist on the exchange rate-stock price and industrial output nexus in developing countries, including Nigeria, but a greater number of the studies focus on either the symmetric influence (Okpara & Odionye, 2012; Zubair, 2013; Fapetu et al., 2017) or the exchange rate-stock price asymmetry nexus and/or the industrial output-currency change nexus (Effiong & Bassey, 2018; Akanni & Isah, 2018; Adeniyi & Kumeka, 2020; Okere et al., 2021). None of the studies reviewed considered the effect of various shocks on stock prices and industrial production, or studied whether the responses of stock values and industrial production to currency depreciation are contingent upon the magnitude of the change. Empirically, this aspect is lacking in the stock-price-industrial output-exchange rate nexus literature. It has been established empirically that, contingent upon the severity of shocks, exchange rate swings can be transmitted at a distinct magnitude to a variable (Miltra, 2016, 2015; Luqman et al., 2021; Li & Guo, 2022). The closest work to this study in Nigeria is the work of Uche et al. (2022) on the household consumption-exchange rate nexus in selected countries in Africa. This study departs from Uche et al. (2022) by investigating the asymmetric reactions of stock prices and industrial output to various shocks in the exchange rate in Nigeria using the multiple threshold non-linear autoregressive distributed lag

model by decomposing the shocks in the exchange rate into mild shock, moderate shock, and severe shock.

This study further departs from Uche et al. (2022) in three main respects. First, it concentrates on the degree of the currency weakening shocks transmitted to stock prices and industrial output, whereas Uche et al. (2022) studied the exchange rate change-household expenditure asymmetric nexus. Second, this study uses the 25th and 75th percentiles as the lower and upper quantiles respectively, whereas Uche et al. (2022) used the 30th and 70th quantiles. Third, this study employs the Zivot-Andrews unit root test to account for structural breaks, unlike Uche et al. (2022).

The main contribution to knowledge is the emphasis on the degree of currency weakening shocks, which is probably due to the intensity of the effects of misaligned exchange rates transmitted to stock prices and industrial output. In terms of the broad objective, the study investigates the asymmetric reactions of stock prices and industrial output to exchange rate shocks in Nigeria using a multiple threshold nonlinear autoregressive distributed lag model and high frequency series from January 1999 to December 2021. Hence, the study hypothesises whether stock prices and industrial output asymmetrically react to exchange rate shocks in Nigeria. The rest of the article is organised as follows: section 2 surveys the related literature, section 3 explains the methodology used, section 4 discusses the empirical results and findings, while section 5 highlights the conclusion and policy implications of the findings.

2. LITERATURE REVIEW

2.1 What does theory tell us?

Dornbusch and Fisher's (1980) flow-oriented models are based on the current account or trade balance. According to this model, changes in currency affect a country's productive capacity, which determines the firms' predicted future cash flows and their stock values, in addition to their global competitiveness and current account surplus positions. The unsurprising hypothetical inter-relation is that changes in exchange rates affect a firm’s ability to be competitive since many firms take loans in hard currencies to finance their activities, which may adversely affect a firm’s stock price. Contingent upon whether a firm exports goods/services or uses many foreign products, the impact can be equal in two

different directions. An exporting firm rises both in worth and value, thereby raising prices of their stocks. Conversely, a domestic currency appreciation lowers an exporting firm's revenue because of decreased demand for its goods abroad. Consequently, the value of stocks will drop. This is contrary to the situation of an importing firm as the exchange rate changes (Dornbusch & Fisher, 1980; Abdalla & Murinde, 1997; Phylaktis & Ravazzolo, 2005).

2.2 Empirical Literature

Many studies on the currency change-stock price and industrial output connection deal with developing countries, including Nigeria, but most of the studies have focused on either a symmetric or an asymmetric exchange rate-stock price nexus and/or exchange rate-industrial output connection. None of the studies reviewed have considered the effect of multifarious shocks on stock prices and industrial production. It has been established that, contingent on the severity of the shock in a volatile variable, exchange rate swings are transmitted at distinct magnitudes to a variable (Pal & Miltra, 2016, 2015; Luqman et al., 2021; Li & Guo, 2022). The work closest to this study in Nigeria is the study by Uche et al. (2022) on the extreme household consumption-exchange rate dynamics in selected countries in Africa. Departing from Uche et al. (2022), this study investigates how stock prices and industrial output respond to various degrees of exchange rate shocks.

Zubair (2013) investigated the relationship between exchange rate and stock price index in Nigeria between January 2001 and December 2011. The work partitioned the study period into pre-crisis era and post-crisis era. It utilised a VAR model to establish a link between the variables. The study's result showed no direction of the link between the variables. This contradicted an earlier study by Okpara and Odionye (2012) that employed a similar method but different data frequency and found a one-way direction of causality. The discrepancies in the results may be a result of the particular data frequency employed.

Effiong and Bassey (2018) examined the stock price-exchange rate movement nexus in Nigeria. Their study utilised nonlinear ARDL using monthly data from January 2001 to December 2016 and found an asymmetric effect of exchange rate on stock prices. They also found that currency depreciation has a stronger pass-through effect on stock prices than appreciation does in the long run. This result

gives credence to a study on diverse exchange shocks transmittable to value of stocks.

Akanni and Isah (2018) used the ARDL and nonlinear ARDL models to ascertain the asymmetric effect of currency swings on stock prices in Nigerian firms. The study's result suggested a symmetric effect for most companies except for a few conglomerates, which showed evidence of symmetry. In a related and more recent study, Adeniyi and Kumeka (2020) investigated the asymmetric influence of currency changes on firms' stock prices in Nigeria between December 2001 and December 2017. The study also adopted both ARDL and nonlinear ARDL and found no indication of any influence. They recommended firms should not make decisions based on information on the exchange rate.

Mroua and Trabelsi (2019) explored the nexus between exchange rates and stock market indices in BRICS nations namely Brazil, Russia, India, China, and South Africa. The study utilised a panel GMM model and a panel ARDL model to ascertain the causal relationship between all stock market returns and exchange rate changes in the BRICS countries. The ARDL results suggest that exchange rate swings impact on the stock market indices for each of the BRICS nations.

Mohamed and Elmahgop (2020) examined whether an asymmetric link subsist between stock values and the exchange rate in Sudan. The study's motivation was anchored in this possibility since prior studies had not examined Sudan. Adopting the nonlinear ARDL, the study observed an asymmetric response of Sudanese stock prices to exchange rate changes both in the short term and long term. It concluded that modelling a linear function of the investigated series may produce a result that will mislead policy makers. In another related study, Amewu et al. (2022) examined the stock index-exchange rate connectivity in the COVID-19 era in Ghana. In order to capture the influence of COVID-19, the study partitioned the sample into two sub-samples of pre-COVID-19 era and COVID-19 era. The study utilised the wavelet estimation approach and observed, amongst others, that a link exists between elevated COVID-19 cases and exchange rate changes in the investigated nation. It further showed evidence of a weak link between the Ghanaian cedi and stock prices.

Mesagan et al. (2021) examined the effect of the domestic currency on the capital market and financial sector in Nigeria from symmetric and asymmetric

perspectives using data from January 2010 to April 2018. The work employed both linear and nonlinear ARDL models and the result showed an inverse connection between the exchange rate and the financial index in the short to long term. Using the same data frequency and models, Okere et al. (2021) investigated the existence and degree of symmetry in the nexus between exchange rate, oil prices, and stock prices in Nigeria. The ARDL shows that the relationship between the exchange rate and stock prices is not significant both in the short-run and long-run, whereas a short-term and long-term direct association exists between oil prices and stock prices.

Another study by Uche et al. (2022) explored the relationship between expenditure on household consumption and the relative change in exchange rate movement. The study employed the MTNARDL model on quarterly data for several selected African countries. Their results showed an asymmetric response of consumption expenditure to changes in the exchange rate of all the countries case-studied except Nigeria.

3. METHODOLOGY

3.1 Data and their Features

The secondary data used are high frequency (monthly) series from January 1999 to December 2021 inclusive. Data on the nominal exchange rate and data on stock prices (measured in naira) were sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin (2021). The data for industrial output were converted from annual series to monthly series using a quadratic match-sum process in EViews version 12.0. The quadratic match-sum is a valuable procedure that converts data from its original form to a higher frequency form and allows seasonal adjustment by dropping end-to-end dispersion (Shahbaz et al., 2018; Sharif et al., 2020; Uche & Effiom, 2021).

3.2 Model Specification

Following Li and Guo (2022), this study adopted the MTNARDL model as developed by Pal and Mitra (2015, 2016) for the United States to examine the asymmetric reactions of stock prices and industrial output to various exchange rate shocks. The MTNARDL model utilised the NARDL by Shin et al. (2014) such

that the predictor variables are decomposed into non-negative and non-positive partial sum parts to measure the asymmetric influence.

The first step is to model ARDL in line with Pesaran et al. (2001) in its general form as

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \Delta Y_{t-1} + \sum_{i=0}^{p} \alpha_i \Delta Z_{t-1} + \phi_1 Z + \varphi ECT + \mu_t \quad (3.1)$$

where Y is the response variable and Z represents the predictor variables. The error correction term (ECT) measures the rate of convergence to equilibrium, ϕ is the long-run parameter, and α_i measures the short-term coefficient.

Following the economic viewpoint that exchange rate changes can determine industrial output and stock prices, the simple form of the model is as follows:

STP = f (ECR) and INP = f (ECR) (3.2)

where STP represents stock prices, ECR is the exchange rate, and INP represents industrial output.

Following equation (3.1), the ARDL model is expressed in equations (3.3) and (3.4) thus:

$$\Delta LNSTP_t = \varphi_1 LNECR_t + \varpi ECT + \sum_{t=1}^{r} \pi_j \Delta LNSTP_{j-t} + \sum_{i=0}^{s} \eta_i \Delta LNECR_{t-i} + \varepsilon_t \quad (3.3)$$

$$\Delta LNINP_t = \varphi_1 LNECR_t + \varpi ECT + \sum_{t=1}^{r} \pi_j \Delta LNINP_{j-t} + \sum_{i=0}^{s} \eta_i \Delta LNECR_{t-i} + \varepsilon_t \quad (3.4)$$

where STP, ECR, and INP are as described above, LN = natural log, η represents the short-run coefficients, and φ denotes the long-run coefficient in both models. ε represents a white noise stochastic term, Δ is the difference operator, and r and s represent the lag values. The coefficient of ECT measures the degree of convergence to equilibrium. Exchange rate (ECR) depreciation varies in degrees such as mild, moderate, and severe. In Nigeria, exchange rate depreciation has

passed through phases such as mild depreciation regimes which require no policy intervention by the central bank, moderate depreciation which requires some levels of policy intervention by the monetary authority, and the severe depreciation era, with this era provoking drastic measures, including rationing of foreign currency supply, as recorded in the country from 2015 till today (CBN, 2021). Thus, the exchange rate (ECR) is decomposed into three shocks, namely mild (ECR_MIS), moderate (ECR_MOS), and severe shocks (ECR_SES).

To incorporate the asymmetric components in equations (3.3) and (3.4), we separated the predictor variable (ECR) into negative and positive segments consistent with Shin et al. (2014). In this study, the ECR is specified as follows:

$$LNECR_t = LNECR^0 + \text{LNECR}_t^{pos} + \text{LNECR}_t^{neg} + \varepsilon_t \tag{3.5}$$

In equation (3.5), ECR^{pos} and ECR^{neg} represent an increase (depreciation) and a decrease (appreciation), respectively.

Depreciation and appreciation are specified as (3.6) and (3.8);

$$LNECR_t^{pos} = \sum_{j=1}^{r} \Delta LNECR_{t-j}^{pos} = \sum_{j=1}^{s} \max(\Delta \text{LNECR}_j, 0) \tag{3.6}$$

$$LNECR_t^{neg} = \sum_{j=1}^{m^1} \Delta LNECR_{t-j}^{neg} = \sum_{j=1}^{m^2} \min(\Delta \text{LNECR}_j, 0) \tag{3.7}$$

Based on (3.6) and (3.7), the study expresses the non-linear ARDL as

$$\begin{aligned} \Delta LNSTP_t = {} & \varphi_1 LNECR_t^{pos} + \varphi_2 LNECR_t^{neg} + \varpi ECT + \sum_{j=1}^{r} \pi_j \Delta LNSTP_{t-j} \\ & + \sum_{i=0}^{s} \eta_i \Delta LNECR_{t-j}^{pos} + \sum_{i=0}^{s} \eta_i \Delta LNECR_{t-j}^{neg} + \varepsilon_t \end{aligned} \tag{3.8}$$

$$\Delta LNINP_t = \varphi_1 LNECR_t^{pos} + \varphi_2 LNECR_t^{neg} + \varpi ECT + \sum_{j=1}^{r} \pi_j \Delta LNINP_{t-j} + \sum_{i=0}^{s} \eta_i \Delta LNECR_{t-j}^{pos} + \sum_{i=0}^{s} \eta_i \Delta LNECR_{t-j}^{neg} + \varepsilon_t \quad (3.9)$$

The first two components on the right-hand side measure the long-run asymmetric effects, the third component is the error correction term, and the last two are the short-term asymmetric coefficients. The short-run and the long-run asymmetric effects can be examined using the standard Wald test. There is no long-run asymmetric effect if $\phi_1 = \phi_2 = 0$. The bounds test is utilised to ascertain the existence of a cointegration relation.

3.3 Multiple Thresholds and their Justification

As stated earlier, this study adopted multiple thresholds as advanced by Pal and Mitra (2015, 2016) as an alternative to the one-threshold approach by Shin et al. (2014) and because of its merit in decomposing the predictor into different quantiles so as to ascertain the asymmetric effect of the predictor variable based on mild, moderate, and severe shocks.

Therefore, this study, somewhat consistent with Li and Guo (2022) albeit with a little modification, initiated two thresholds at the 25th and 75th percentiles to divide the exchange rate shocks into three partial sums thus:

$$LNECR_t = LNECR^0 + \text{LNECR}_t^{mis} + \text{LNECR}_t^{mos} + \text{LNECR}_t^{ses} \quad (3.10)$$

where the right-hand components of equation (3.10) are the partial sums estimated as:

$$\text{LNECR}_t^{mis} = \sum_{j=1}^{p} \lambda_j \Delta \text{LNECR}_j^{mis} = \sum_{j=1}^{p} \Delta LNECR_j^I (\Delta LNECR_j \le \tau_{25}) \quad (3.11)$$

$$\text{LNECR}_t^{mos} = \sum_{j=1}^{p} \lambda_j \Delta \text{LNECR}_j^{mos} = \sum_{j=1}^{p} \Delta LNECR_j^I (\tau_{25} < \Delta LNECR_j \le \tau_{75}) \quad (3.12)$$

$$\mathrm{LNECR}_t^{\mathrm{ses}} = \sum_{j=1}^{p} \lambda_j \Delta \mathrm{LNECR}_j^{ses} = \sum_{j=1}^{p} \Delta LN\,\mathrm{ECR}_j^{I}(\Delta LNECR_j > \tau_{75}) \tag{3.13}$$

where I (.) represents the dummy term that meets the requisite in (.) when it is equal to unity and zero otherwise.

The multiple threshold nonlinear ARDL is expressed for the two models as in (3.14) and (3.15):

$$\Delta LNSTP_t = \sum_{j=1}^{3} \phi_k LNECR_{t-i}^{\lambda_j} + \varpi ECT + \sum_{j=1}^{r} \pi_{ij} \Delta LNSTP_{t-j} + \sum_{j=1}^{3} \sum_{i=0}^{s} \eta_{kj} \Delta LNECR_{t-j}^{\lambda_j} + \varepsilon_t \tag{3.14}$$

$$\Delta LNINP_t = \sum_{j=1}^{3} \phi_k LNECR_{t-i}^{\lambda_j} + \varpi ECT + \sum_{j=1}^{r} \pi_{ij} \Delta LNINP_{t-j} + \sum_{j=1}^{3} \sum_{i=0}^{s} \eta_{kj} \Delta LNECR_{t-j}^{\lambda_j} + \varepsilon_t \tag{3.15}$$

where the first right-hand term is the long-run term; ECT measures the speed of adjustment to equilibrium; λ is the exchange rate shock; subscript j is the rate of shock (j = 1, 2, and 3) with 1 representing mild shocks (mis) for changes below or equal to the 25th percentile change, 2 representing moderate shocks (mos) with changes above the 25th percentile but below the 75th percentile changes, and 3 representing severe shocks (sos) for changes above the 75th percentile; and ε = iid (0, σ). The null hypothesis of no cointegration is expressed as $\phi_1 = \phi_2 = \phi_3 = 0$.

A rejection of the hypothesis suggests a long-run nexus in the model. The study applied the Wald test to examine for short-run and long-run symmetry. The MTNARDL model has been widely used in recent times given its merits over the NARDL as it enables the study of the impact of asymmetric degrees of shock on the response variables (Pal and Mitra, 2015, 2016; Li & Guo, 2022). The rationale for the choice of MTNARDL is that variables need not be integrated of order two. Furthermore, it requires a large sample size as the sample size reduces as the number of thresholds increases. A two-threshold model requires a minimum of 90 samples (where n > 30) for it to be adequately large for estimation (Li & Guo, 2022). The sample observation of this study is adequately large as it has more than 250 observations in each series.

3.4 Estimation Techniques

The descriptive statistics of the model variables were obtained. An optimal lag length selection test was conducted using information criteria. The Zivot-Andrews (1992) unit root test, which accounts for structural breaks, and a conventional ADF unit root test by Dickey & Fuller (1979) were conducted. To examine whether model variables are cointegrated, the study conducted the bounds cointegration test.

4. EMPIRICAL RESULTS

4.1 Descriptive Analysis

The descriptive statistics of the variables of the model are presented in Table 4.1:

Table 4.1: Descriptive Statistics

Statistics	STP	INP	ECR	ECR_MIS	ECR_MOS	ECR_SES
Mean	26879.9	1269.3	182.9	-26.54	1.91	121.9
Median	25988.9	1154.9	150.5	-30.8	1.74	93.35
Maximum	65652.4	3375.7	411.7	0.000	4.01	368.4
Minimum	4890.8	68.6	86.0	-46.7	0.00	0.000
Std Dev	12358.9	961.1	84.8	15.97	1.15	96.58
Skewness	0.31	0.54	1.15	0.33	0.3	0.97
Kurtosis	3.11	2.16	3.04	1.55	2.42	2.69
J_B Stat	4.56	22.09**	60.85**	29.32**	7.81*	43.23**

Source: *Authors' compilation*

Note: *** (*) rejection of null hypothesis at the 1% (5%) level of significance*

The average value for mild shocks (ECR_MIS) is negative, while those of moderate shocks (ECR_MOS) and severe shocks (ECR_MOS) are positive. The standard deviation indicates volatility in severe shocks given its statistics, while those of mild and moderate shocks exhibit relatively low volatility. All the variables except stock prices (STP) are not normally distributed, as determined by the Jarque Bera normality test statistics. The kurtosis statistics indicate a normal peak for STP, ECR, and severe shocks, while the other variables are platykurtic (<3). The descriptive statistics were carried out before the variables were log-transformed to enable us to ascertain their true behavioural patterns.

4.2 Optimal Lag Selection Result

The optimal lag length was selected using lag length information criteria as presented in Table 4:

Table 4.2 Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1916.449	NA	333.824	14.324	14.364	14.340
1	107.381	3987.247	9.85e-05	-0.712	-0.551	-0.647
2	152.501	87.882	7.52e-05	-0.981	-0.699	-0.868*
3	166.738	27.412	7.24e-05	-1.020	-0.618	-0.859
4	180.601	26.382	6.98e-05	-1.057	-0.534	-0.847
5	192.035	21.502*	6.85e-05*	-1.075*	-0.799*	-0.816
6	198.676	12.339	6.98e-05	-1.057	-0.293	-0.751
7	201.825	5.782	7.29e-05	-1.014	-0.129	-0.658
8	206.325	8.159	7.55e-05	-0.980	0.025	-0.576

***** *indicates lag order selected by the criterion*

Source: *Authors' compilation*

Table 4.2 indicates that lag order 5 is the optimal lag length on the basis of Akaike information criteria (AIC), Schwarz criteria (SC), final predictor error (FPE), and the likelihood ratio (LR) test.

4.3 Unit Root Test Results

The time series characteristics of the variables were examined to ascertain the order of integration. The study adopted both the conventional stationarity test approach (ADF) and the regime shift approach which accounted for structural breaks (Zivot-Andrews, 1992). The summary of the result is shown in Table 4.3. Evidently, except for the exchange rate (LNECR) and exchange rate severe shock (ECR_SES), which were stationary in level form in the Zivot-Andrews (1992) unit root test, the series became stationary after first difference in both tests. The choice of the optimal lag for each of the series was guided by information criteria.

Table 4.3: Unit Roots Test Results

	ADF_URT				Zivot-Andrews unit root test (ZAURT) with breaks					
Variables	**Level**	**1st diff**	**I (d)**	**Lag**	**Level**	**B-P**	**1st diff**	**B-P**	**I(d)**	**Lag**
LNECR	-0.03	-12.1**	I (1)	0	-5.35**	2015/05	-	-	I (0)	2
LNSTP	-2.37	-14.3**	I (1)	1	-3.1	2002/11	-6.8**	2021/12	I (1)	4
LNINP	-1.22	-5.86**	I (1)	3	-3.5	2014/02	-4.4**	2016/02	I (1)	3
LNECR_MIS	-1.85	-12.5**	I (1)	1	-3.6	2007/07	-12.9**	2021/12	I (1)	1
LNECR_MOS	1.30	-14.9**	I (1)	0	-3.9	2017/05	-10.4**	2017/05	I (1)	1
LNECR_SES	-0.14	-12.1**	I (1)	0	-5.99**	2016/05	-	-	I (0)	1

Source: *Authors' compilation*

Note: *** (*) shows the variable is stationary at the 1% (5%) level of significance*

The ADF unit root test result indicates uniform order of integration, while the Zivot-Andrews unit root test result shows varying order of integration. This result upholds the view that unit root results are sensitive to structural breaks as failure to account for structural breaks can lead to misleading inference (Perron, 1989, 1997; Odionye & Chukwu, 2021). The requisite condition for estimating the MTNARDL model is satisfied given that none of the variables was integrated of order two, hence the need for the cointegration test.

4.4 Cointegration Test Results

Given that the condition for the bounds cointegration test in the MTNARDL model is satisfied, the study estimated the bounds cointegration test within the model frameworks of ARDL. The results of the NARDL, MTNARDL, and the summary are presented in Table 4.4:

Table 4.4: Bounds Cointegration Test Result

	ARDL			NARDL			MTNARDL		
Response Variable	**F-Stat**	**I(0)**	**I(1)**	**F-Stat**	**I(0)**	**I(1)**	**F-Stat**	**I(0)**	**I(1)**
LNSTP	4.5*	3.62	4.16	2.1	3.1	3.87	4.4**	2.79	3.67
LNINP	5.1*	3.62	4.16	6.1**	3.1	3.87	4.9**	2.79	3.69

Source: *Authors' compilation*

Note: *** (*) indicates rejection of null hypothesis at the 1% (5%) level of significance.*

Table 4.4 indicates that there exists a long-run relationship between industrial output (LNINP) and exchange rate swings (LNECR) since the null hypothesis of no cointegration is rejected on the basis of the data and the three models, while no cointegration exists for stock prices (LNSTP) as the null hypothesis cannot be rejected using the NARDL model. However, based on ARDL and MTNARDL, stock prices and exchange rate are cointegrated.

Thus, we estimated the ARDL model on the basis of equations (3.3) and (3.4) and the selected lag value. The results are presented in Table 4.5:

Table 4.5: Summary of ARDL

	Response Variable (LNSTP)		**Response Variable (LNINP)**	
Predictors	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
Panel I		**Short-Run Result**		
D(Y(-1))	0.138*	2.307	0.241**	4.018
D(Y(-2))	0.088	1.465	0.193**	3.171
D(Y(-3))	0.121*	2.026	0.138*	2.301
D(Y(-4))	-0.131*	-2.182	0.089	1.592
D(Y(-5))	0.129**	2.604		
D(LNECR(-1))	-0.127*	-2.119	-0.099**	-3.924
ECT(-1)	-0.021**	-2.752	-0.005**	-3.924
Panel II		**Long-Run Result**		
LNECR	-0.518	-1.057	-2.161**	-3.993
Constant	7.653	3.018	-3.456	-1.243
R^2 (adj. R^2)	0.79 (0.77)		0.62 (0.61)	
Panel III		**Robustness Checks**		
J-B Test		91.921**		8292.65**
B-G Serial test		0.972		0.122
B-P-G Het test		0.877		1.918
R-RESET test		1.600		1.566
CUSUM	Stable			Stable
CUSUM sqr.	Stable			Unstable
Recursive coeff.	Stable			Stable

Source*: Authors' compilation* **Note:** *** (*) shows the variable is stationary at the 1% (5%) level of significance. Y is the response variable for the respective model (LNSTP/LNECR). The B-G Serial test represents the q order of autocorrelation, the B-P-G Het is the test for constant variance, R-RESET represents the test of the model specification.*

The short-run coefficients result in panel I indicates that both share prices and industrial outputs respond inversely to a rise in the exchange rate. This conforms with the conventional wisdom that both share prices and industrial output respond negatively to exchange rate variation. This result supports the findings of Mesagan et al. (2021), and Akanni and Isah (2018). Specifically, a one per cent depreciation in the exchange rate will lead to a 0.13% and a 0.1% decline in share prices and industrial output in the short run, respectively. Interestingly, a one per cent depreciation in the exchange rate will reduce industrial output by 2.2% in the long run, whereas stock prices respond inversely but insignificantly to currency weakening in the long run. This suggests that the adverse effect of the exchange rate on industrial output will be more in the long run than in the short run. The lag values of the response variables suggest that the variables reinforce their current values. The error correction terms show a low degree of convergence to equilibrium for both models. Specifically, about 2% and 0.5% of disequilibrium in stock prices and industrial output, respectively, converge to equilibrium within one month. The coefficients of determination suggest that the models are well fitted. The robustness checks on the estimated models indicate that the residuals are not normally distributed. These results further confirm the necessity of using a non-linear model for the estimation. The tests of autocorrelation confirm the non-existence of serial correlation in both models. In addition, the residuals exhibit constant variance, while both models were well specified as indicated in the heteroskedasticity test and Ramsey REST test, respectively. The graphs of the CUSUM, CUSUM square, and recursive coefficients show the stability of the parameters in the stock price-exchange rate model, whereas in the industrial output-exchange rate model they show stable parameters in the CUSUM and recursive coefficients, but unstable parameters in the CUSUM square graph.

In order to explore the asymmetric reactions of stock prices and industrial output to exchange rate depreciation and appreciation, this study estimated the non-linear ARDL model in equations (3.8) and (3.9) as presented in Table 4.6:

Table 4.6: Summary of NARDL Results

	Response Variable (LNSTP)		**Response Variable (LNINP)**	
Predictors	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
Panel I		**Short-Run Result**		
D(Y(-1))	0.142*	2.396	0.232**	3.924
D(Y(-2))	0.099	1.678	0.194**	3.238
D(Y(-3))	0.111	1.871	0.145**	2.461
D(Y(-4))	-0.141*	-2.355	0.101	1.825
D(Y(-5))	0.120**	2.003		
D(LNECR_POS(-1))	-0.374**	-2.989	-0.112**	-2.902
D(LNECR_NEG)	-0.674	-0.621	0.913	0.879
D(LNECR_NEG(-1))	-1.238	-1.104		
D(LNECR_NEG(-2))	0.767	0.685		
D(LNECR_NEG(-3))	0.819	0.732		
D(LNECR_NEG(-4))	-3.502**	-3.247		
ECT(-1)	-0.025**	-2.889	-0.021**	-4.955
Panel II		**Long-Run Result**		
LNECR_POS	-0.749	-0.904	0.655**	3.113
LNECR_NEG	0.639	0.162	-5.688**	-5.882
Constant	9.564**	23.017	5.236	37.563
R^2 (adj. R^2)	0.63 (0.60)		0.74 (0.72)	
Panel III		**Robustness Checks**		
J-B Test		98.46 **		7969.76**
B-G Serial test		1.384		0.449
B-P-G Het test		1.953		1.78
R-RESET test		1.749		3.44*
CUSUM	Stable			Marginally stable
CUSUM sqr.	Stable			Unstable
Recursive coeff	Stable			Stable
SR_Wald		8.01**		3.81*
LR_Wald		4.2**		6.01**

Source*: Authors' compilation*

Note: *** (*) shows the variable is stationary at the 1% (5%) level of significance. Y is the response variable for the respective model (LNSTP/LNECR). B-G Serial test represents the q order of autocorrelation, B-P-G Het is the test for constant variance, R-RESET represents the test of the model specification. SR_ Wald represents the short-run Wald test of symmetry; LR _Wald is the long-run test of symmetry.*

As indicated in panel I of Table 4.6, both stock prices and industrial output asymmetrically react inversely to variations in exchange rate in the short run. The coefficients of the exchange rate indicate that a one per cent depreciation in exchange rate reduces stock prices and industrial output by 0.37% and 0.12%, respectively. This supports the conventional wisdom that currency depreciation increases firms' input costs as most firms depend on foreign inputs for production. The high cost of raw materials arising from currency depreciation leads to a decrease in firms' output and profit and hence reduces stock prices. This may explain the decline in industrial output to an all-time low in 2016 following the currency depreciation in 2015, with the resultant economic recession. The manufacturing sub-sector experienced a fall in imports of factor inputs of 56% in 2021 due to a shortage of foreign currency (CBN, 2021; NBS, 2021). This finding supports the findings of Mesagan et al. (2021) and Akanni and Isah (2018). The short-run result suggests that exchange rate appreciation does not significantly influence either variable in the short run. This implies that exchange rate appreciation would reduce stock prices if it lasted up to four months as the value of foreign investors' shares would fall, and the investors would be worried about their investments and may want to sell their shares, which would cause a further decline in share prices. The coefficients of lag of response variables indicate positive reinforcement of their current values. The long-run result indicates that currency depreciation improves industrial output in the long term, while appreciation worsens it. Thus, industrial outputs may decline due to the panic sale of shares by foreign investors occasioned by currency appreciation.

The error correction terms for the two models are 2.5% and 2.1% of the disequilibrium in stock prices and industrial output, respectively, which could be corrected every month, suggesting that it would take between 40 and 47 months for disequilibrium to be corrected. The R^2 and the adjusted R^2 indicate that the models are well fitted. The tests of robustness of the models show that the residuals are not normally distributed. These results justify the use of an alternative nonlinear model for the estimation. The tests of autocorrelation confirm the non-existence of serial correlation in both models. The residuals exhibit constant variance. While the stock prices model is well specified, as indicated in the Ramsey RESET test, the same cannot be said of the industrial output model, as the null hypothesis of a well-specified model is rejected at the

5% level of significance. The residuals exhibit constant variance, as evidenced by the test of heteroskedasticity. The CUSUM, CUSUM square, and recursive coefficients graphs indicate stability of the parameters in the stock market-currency changes model whereas the industrial output-currency changes model shows unstable parameters in the CUSUM square graph, marginally stable in the CUSUM graph, and stable parameters in the recursive coefficients graph. The Wald test of symmetry confirms the asymmetric reactions of industrial output and stock prices to the exchange rate in Nigeria as the null hypothesis of symmetry was rejected in both models. Finally, the results of the asymmetric reactions of stock prices and industrial output to exchange rate shocks are presented in Table 4.7:

Table 4.7: Summary of MTNARDL Results

	Response Variable (LNSTP)		Response Variable (LNINP)	
Predictors	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
Panel I		**Short Run Result**		
D(Y(-1))	0.183**	3.042	0.231**	3.753
D(Y(-2))	0.070	1.161	0.172**	2.804
D(Y(-3))	0.085	1.418	0.098	1.620
D(Y(-4))	-0.114	-1.888	0.093	1.617
D(Y(-5))	0.109	1.873		
D(LNECR_MIS_POS)	-151.192	-1.332	-26.759	-0.897
D(LNECR_MIS_NEG(-1))	77.440	0.678	36.521	1.225
D(LNECR_MOS_NEG(-1))	215.020	1.867	-1.044**	-2.221
D(LNECR_MOS_POS(-1))	-0.214**	-4.248	-34.682**	-2.188
D(LNECR_MOS_POS(-2))	170.156	1.436		
D(LNECR_SES_NEG(-1))	38.683	0.324	49.576	1.613
D(LNECR_SES_NEG(-2))	23.995	0.207	-0.081**	-2.111
D(LNECR_SES_POS(-1))	163.553	1.423	-64.137**	-2.099
D(LNECR_SES_POS(-2))	-3.879**	-3.393	-76.230**	-2.507
ECT(-1)	-0.027**	-3.524	-0.001**	-5.005
Panel II		**Long Run Result**		
LNECR_MIS_POS	-1.204	-1.185	-33.166	0.132
LNECR_MIS_NEG	49.027	0.735	3.318	0.009
LNECR_MOS_POS	-1.804**	-2.210	-0.346**	-5.969
LNECR_MOS_NEG	120.388	1.185	0.019	0.019
LNECR_SES_POS	-5.293**	-4.596	-43.452**	-7.955
LNECR_SES_NEG	-0.204**	-3.078	-0.331	-3.905
Constant	9.996**	24.518	0.719	0.019
R^2 (adj. R^2)	0.70 (0.65)		0.72 (0.69)	
Panel III		**Robustness Checks**		
J-B Test		3.7		4.06
B-G Serial test		1.09		0.43
B-P-G Het test		1.78		0.92
R-RESET Test		1.63		1.29
CUSUM	Stable			Stable
CUSUM sqr.	Stable			Unstable
Recursive coeff.	Stable			Stable
SR_Wald		4.617**		3.48*
LR_Wald		3.996*		3.01*

***Source**: Authors' compilation.*

Note: *** (*) shows the variable is stationary at the 1% (5%) level of significance. Y is the response variable for the respective model (LNSTP/LNECR). B-G Serial test represents the q order of autocorrelation, B-P-G Het is the test for constant variance, R-RESET represents the test of the model specification. SR_Wald represents the short-run Wald test of symmetry; LR _Wald is the long-run test of symmetry. LNECR_MIS represents the mild shocks in the exchange rate, LNECR_MOS depicts the moderate shocks in the exchange rate; LNECR_SES represents the severe shocks in the exchange rate. POS is positive (depreciation) while NEG means negative (appreciation).*

This study decomposed shocks in the exchange rate into lower and upper quantiles in line with Li and Guo (2022). Whereas Li and Guo used 30th and 70th quantiles for lower and upper quantiles, the study used the 25th and 75th percentiles to construct three thresholds of shocks to estimate the reactions of stock prices and industrial output to exchange rate shocks in Nigeria.

Panel I of Table 4.7 indicates that mild shocks in the exchange rate (LNECR_MIS_POS and LNECR_MIS_NEG) are not a significant cause of variations in stock prices and industrial output. This means that changes within the 25th percentile of the exchange rate insignificantly affect both industrial output and stock prices. As anticipated, stock prices and industrial output respond significantly in the opposite direction to moderate shocks in exchange rates. Specifically, a moderate positive change in the exchange rate inversely influences both stock prices and industrial output. This upholds the assertion that a huge depreciation negatively affects firms' output and profit and hence stock prices. The result also indicates that severe shocks in the exchange rate (LNECR_SES_POS) inversely affect both variables. Obviously, the coefficients of LNECR_SES_POS of (-3.88) and (-76.23) for the stock prices (LNSTP) and industrial output (LNTNP) models, respectively, are greater than those of the moderate shocks of LNECR_MOS_POS (-0.21 and -34.68). This means that the reactions of stock prices and industrial outputs to currency weakening are sensitive to the size of the shocks in the exchange rate and thus implies that, as the country's exchange rate shock increases high and above the 75th percentile (severe shocks in the exchange rate), its effect on both share prices and industrial output in the country becomes more pernicious in the short-term. The error correction term (ECT (-1)) indicates a low degree of convergence to equilibrium.

Similarly, the long-run result in panel II points to the fact that moderate and severe shocks in the exchange rate inversely influence both industrial output and stock prices. It further indicates that during severe shocks, both exchange rate depreciation and appreciation will have devastating effects on both share values and industrial output. It also confirms the short-run analysis that the long-run reactions of stock prices and industrial output to exchange rate shocks are asymmetrically sensitive to percentile variation in the exchange rate. This result corroborates the findings of Uche et al. (2022), who found the response of

household expenditure of selected African countries to exchange rate dynamics to be sensitive to quantile change.

The diagnostic tests confirmed the validity of the result as the residual satisfies the condition of normal distribution, constant variance, and absence of serial correlation as indicated by the J-B test, the B-P-G heteroskedasticity test, and the B-G Serial test, respectively, in both models. In addition, the short-run and long-run Wald tests indicate that the stock prices and industrial output are asymmetrically connected to currency weakening. The coefficients of the model variables are highly stable in the case of the stock prices model given the CUSUM, CUSUM square, and recursive graphs, whereas in the case of the industrial output model there is mild stability in the parameters as the CUSUM and recursive parameter graphs show stability, but the CUSUM square indicates unstable parameters.

5. CONCLUSION AND POLICY IMPLICATIONS

Motivated by swings in the exchange rate of many developing economies which regularly exert influence on firms' input costs, output, stock prices, and profits, the study investigated the asymmetric reactions of stock prices and industrial output to multifarious shocks in the exchange rate in Nigeria using a newly developed MTNARDL model and monthly data from January 2009 to December 2021.

The ARDL result indicates that stock prices and industrial output react inversely to upward swings in the exchange rate. Similarly, the NARDL results indicate an asymmetric nexus between the variables and that stock prices and industrial output react in the opposite direction to exchange rate depreciation, upholding the conventional wisdom. Using the MTNARDL model, the study found evidence that the reactions of both stock prices and industrial output to variations in exchange rate are sensitive to the extent of the shock: mild, moderate, or severe. In specific terms, the results indicate that exchange rate shocks below the 25^{th} percentile do not affect the variables, but as shocks increase beyond the 25^{th} percentile, they significantly and inversely affect both stock prices and industrial output. However, the impacts of exchange rate shocks on stock prices and industrial output become damaging if they are extremely large, beyond the 75^{th} percentile. The empirical results further suggest that stock prices and industrial

output react asymmetrically in the opposite direction to exchange rate depreciation. Furthermore, they indicate that the reactions of both stock prices and industrial output to exchange rate variations are sensitive to the size of shocks.

The main economic implication of the empirical finding is that in the upper quantile, both exchange rate depreciation and appreciation are detrimental to industrial output and, hence, the value of stocks in Nigeria. The main contribution to knowledge is the emphasis on the degree of currency weakening exchange rate shocks, which is likely due to the extent of the impacts of a misaligned exchange rate transmitted to stock prices and industrial output. The study recommends that the monetary authority should be proactive in policy intervention to ensure stability in the foreign exchange market, since large and extensive exchange rate swings will have a devastating impact on industrial output and firms' stock values.

It is important to note a core shortcoming of the study is the lack of monthly data from January 2022 to July 2022. Two main possible directions for further studies are, first, to conduct a comparative analysis between any two top African economies and, second, to conduct a panel data analysis of selected African economies.

Acknowledgement: *Authors are pleased to acknowledge three anonymous and independent expert reviewers for their valuable comments and suggestions after assessing the scientific quality of the article.*

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Received: July 27, 2022
Accepted: March 16, 2023

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