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Article

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The effect of the global COVID-19 pandemic on the secondary sector in Côte d'Ivoire

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ABSTRACT

This research investigates the repercussions of the global COVID-19 pandemic on the secondary sector of Côte d'Ivoire during the period 2020–2022. Using two-stage generalized random effects (G2SLS) instrumental variable (IV) models is a statistical method used in econometrics, particularly in the context of instrumental variable (IV) models. In the context of the study, G2SLS helps in establishing the causal impact of the COVID-19 pandemic on the secondary sector while accounting for potential endogeneity issues. This study comprehensively analyzes the effects of COVID-19, and economic performance, country factors, structural characteristics, responses to fiscal and monetary policies, and overall growth in industrial production. Expanding its focus to a comparative analysis with Nigeria, Egypt, South Africa, China, and France, this research uses a robust econometric approach to unravel the complex dynamics of the secondary sector. From a cross-national perspective, this study provides nuanced insights for policymakers and stakeholders. The findings of this study could contribute to secondary sector public policy strategy-making and instruments definitions to resist similar threats.

IMPACT STATEMENT

This study examines the effects of the COVID-19 pandemic on Côte d'Ivoire's secondary sector. By employing advanced econometric models, it assesses both immediate disruptions and long-term structural changes in industrial production and employment. The research also includes comparative analysis with other countries to provide broader insights. The findings highlight the need for robust public policies and strategies to strengthen the sector's resilience against future crises, emphasizing the importance of economic diversification and adaptive policy measures for sustainable recovery and development.

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1. Introduction

The outbreak of the COVID-19 pandemic in early 2020 has precipitated an unparalleled global crisis, with profound disruptions across economic sectors worldwide. In Côte d'Ivoire, a nation with a diverse economic base, the secondary sector—encompassing manufacturing and industrial activities—has been particularly impacted. This sector is vital, contributing significantly to GDP, employment, and the country's broader development goals. The present study examines the depth of the pandemic's impact on these industries, assessing the shifts in operational dynamics and the resilience of this sector amidst global health emergencies. This paper aims to analyze the specific challenges and adaptations within this sector, providing a detailed account of the pandemic's short-term disruptions and long-term implications for Côte d'Ivoire's economic landscape.

This study presents a comprehensive analysis of the impacts of the COVID-19 pandemic on the secondary sector in Côte d'Ivoire. This study examines into the complex challenges faced by this sector,

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with a focus on the disruptions and adaptations that have reshaped its operational environment. The novel coronavirus (Nicola et al., 2020) SARS-CoV-2, first identified in Wuhan, China, in December 2019, quickly became a global menace, precipitating widespread health and socioeconomic consequences.

During COVID-19, the number of confirmed cases increases (Keho, 2017), which often leads to a subsequent rise in deaths due to the spread of the virus. The number of confirmed cases and deaths (Worldometer, 2023) in Côte d'Ivoire as of December 31st, 2020, 2021, and 2022 were 22,490, 71,004, and 87,941, respectively, with 137,714 deaths and 831 additional cases. These data not only inform public health response but also help develop strategies to mitigate the spread of the virus. In Côte d'Ivoire, the pandemic's escalation was marked by a significant rise in confirmed cases and associated mortalities, which profoundly influenced public health responses (Holmes et al., 2020) and necessitated the formulation of strategies to mitigate the virus's spread.

Despite extensive global coverage, existing research often lacks a detailed, localized analysis of how these global disruptions specifically affected the secondary sectors of developing economies such as Côte d'Ivoire. This gap is particularly evident in the scant empirical focus on intra-sectoral impacts and the effectiveness of sector-specific responses. Consequently, this study aims to fill these gaps by examining the nuanced impacts of the pandemic on industrial production, supply chains, and the labor market within this context. Furthermore, this study evaluates the breadth and effectiveness of governmental and policy responses intended to mitigate these effects.

Empirical evidence suggests a significant deceleration in the secondary sector's activities in Côte d'Ivoire due to the pandemic. The adverse effects on industrial (Brockova et al., 2021) production, coupled with disruptions in trade volume and commerce, led to a notable decline in production and employment within the sector. Additionally, the pandemic highlighted vulnerabilities in global supply chains, influencing the availability of essential raw materials and components required for manufacturing (Barone et al., 2023) activities (Barone et al., 2023). In response, the Ivorian government and others worldwide have implemented a range of measures, including fiscal stimulus packages, monetary policy adjustments, and targeted sectoral supports, to cushion the economic (Ashraf, 2020; Bavel et al., 2020) blow.

This research evaluates the extensive impact of the COVID-19 pandemic on the secondary sector in Côte d'Ivoire, highlighting both the immediate effects and the enduring consequences for the sector. The study aims to illuminate the resilience of industrial activities within developing economies amid global health crises and critically assesses the effectiveness of policy interventions.

The primary objective of this research is to investigate the profound influence of the COVID-19 pandemic on the secondary sector in Côte d'Ivoire, with a particular focus on its industrial component. This investigation delves into the general impact of pandemics on economic sectors, with a specific emphasis on the challenges posed by COVID-19 to developing economies and the pre-pandemic state of the secondary sector in Côte d'Ivoire, including its economic contributions and existing challenges.

Furthermore, the study explores the immediate ramifications of the pandemic on production, employment, and supply chains, as well as its long-term effects on the sector's sustainability and growth. This study also conducts a thorough assessment of governmental and policy responses, providing an overview of interventions and evaluating their effectiveness in addressing the crisis.

This research enhances the understanding of the economic and social consequences of the pandemic, providing essential insights for sustainable development. Section 2 reviews previous literature, systematically examining studies on pandemics and economic sectors. It specifically analyzes the impact of COVID-19 on developing economies and assesses the pre-pandemic conditions of Côte d'Ivoire's secondary sector, including its economic contributions and challenges. The section also explores the direct impacts of COVID-19 on production, employment, and supply chains, as well as the long-term implications for the sector. Additionally, this research evaluates the government interventions and policies implemented to mitigate the pandemic's effects.

Additionally, this paper introduces a theoretical framework that clarifies the relationship between the industrial sector and the impact of COVID-19. Section 3 details the methodologies used in this study, while Section 4 presents and discusses the findings. The research offers deeper insights into the pandemic's long-term effects on sustainable development and provides concrete recommendations for future economic and social strategies to enhance the resilience and recovery of the sector.

2. Literature review

2.1. *Pandemics and economic sectors*

Research highlights the profound impact pandemics have on global and national economies, disrupting economic sectors with varying severity. Historical examples such as the Spanish Flu and the 1918–1919 H1N1 influenza pandemic (Anyanwu & Salami, 2021; Barro et al., 2020) have demonstrated significant reductions in workforce productivity and economic output, resulting in a detrimental ripple effect throughout the global market. These studies not only illuminate the extensive economic consequences of pandemics but also emphasize the vulnerability of specific sectors. Sectors (Baldwin & Di Mauro, 2020; Xu et al., 2020) reliant on stable supply chains and physical labor are particularly susceptible to the disruptive forces of these catastrophic events. The impact of pandemics extends far beyond the healthcare sector, affecting every facet of society and the economy. This necessitates a multi-dimensional understanding and proactive measures by governments, organizations, and individuals to mitigate their devastating effects. Collaborative efforts and robust strategies are essential to safeguard economies and minimize the aftershocks of these unprecedented crises. Studies such as those by Jeong et al. (2022) on labor market changes and Cajner et al. (2020) on the US labor market during the pandemic (Cajner et al., 2020; Jeong et al., 2022) provide insights into the immediate and lingering economic disruptions caused by global health crises.

2.2. *Impacts of COVID-19 on developing economies*

The COVID-19 pandemic has uniquely influenced developing economies, given their constraints in healthcare infrastructure, economic diversification, and fiscal capacities to manage crises. Recent studies highlight that developing countries have faced severe economic disruptions, largely due to their dependency on informal sectors and scant social safety nets, which have magnified social and economic (Cueto et al., 2022) challenges. This dependency has placed a significant strain on their ability to effectively manage and mitigate the adverse impacts of this global (Maloney et al., 2023) health crisis. The consequences of the pandemic have echoed across these economies (Wagner et al., 2021), affecting livelihoods, employment rates, and overall socioeconomic stability. As governments grapple with these challenges, the existing vulnerabilities of these nations have been further exposed and intensified, presenting a daunting task of addressing the multifaceted dimensions of this crisis—health, economic (Iyengar et al., 2021), and social. The path to recovery for these economies is fraught with obstacles, necessitating robust internal and external support to rebuild and strengthen their foundations. The global (Sharma, 2022) community must acknowledge the urgency of this situation and collaborate to provide necessary assistance helping these countries not only recover but also build systems that are more resilient for the future. Only through persistent and collective efforts can we hope to alleviate the burden on developing nations and mitigate the long-term repercussions of this unprecedented crisis.

2.3. *The secondary sector in Côte d'Ivoire pre-COVID-19*

2.3.1. *Economic contribution*

Before the pandemic, the secondary sector in Côte d'Ivoire, which encompasses manufacturing, construction, and utilities, was a pivotal growth area, contributing significantly to the country's GDP and employment rates. The sector experienced remarkable growth, spurred by government-led industrial policies strategically designed to diversify the economy (Dago et al., 2022; Yeo, 2023) away from its traditional agricultural base. These policies aimed to cultivate a vibrant economic landscape, unlocking new opportunities for sustainable (Coulibaly, 2016) development and enhancing the overall socioeconomic well-being of the Ivorian people. Focused efforts on building a solid foundation for various industries within the secondary sector were central to these strategies. The government's commitment aimed to stimulate job creation, attract investment, spur innovation, and foster technological advancements, further driving Côte d'Ivoire's economic (Drengk & Madugu, 2023; Simon et al., 2018) progress and positioning it as a regional powerhouse in West Africa. With a forward-thinking vision and steadfast dedication to nurturing a robust secondary sector, Côte d'Ivoire was on a trajectory towards long-term

prosperity and inclusive growth. However, the onset of the global pandemic introduced significant challenges and disruptions, causing setbacks to the once-thriving secondary sector.

2.3.2. Pre-pandemic challenges

Despite experiencing significant growth and expansion over several years, the sector has encountered numerous challenges that have impeded its progress. One of the primary obstacles faced is the inadequate infrastructure, which has severely restricted the sector's potential for further expansion and modernization. Additionally, there is a persistent and detrimental issue of limited access to credit, which poses a major hindrance for businesses in securing necessary funding for their development. Furthermore, a significant challenge (Andreoni et al., 2021; Moyo, 2020) arises from a profound skills mismatch within the workforce, where the skills possessed by workers do not align with the evolving demands of the sector. Consequently, this disparity has worsened the sector's difficulties in adapting to changing market dynamics (Yapo, 2019), hindering its overall growth and success. These critical challenges, as highlighted by the World Bank in 2019, have played a pivotal role in hindering the sector's ability to thrive and adapt in a dynamic market (Delardas et al., 2022; Khanthachai, 2019; Tan et al., 2024) environment. However, relentless efforts are continuously being made to overcome these hurdles, to create a more prosperous future for the sector. These efforts encompass a comprehensive range of strategies, initiatives, and reforms aimed at addressing and overcoming the aforementioned challenges. By doing so, the sector can unlock its full potential, fostering further growth, innovation, and development for all stakeholders involved.

2.4. Impact of COVID-19

2.4.1. Effects on production, employment, and supply chains

The initial effects of the unprecedented and extensive pandemic on the secondary industry in Côte d'Ivoire were significant and wide-ranging. Major disruptions in production were observed as strict lockdown measures interfered with normal operations, presenting unprecedented challenges to businesses in the sector. Notably, the manufacturing and construction sectors were particularly hard hit, experiencing significant declines in employment (Barth-Jaeggi et al., 2023). The restrictions imposed by the pandemic (Dupas et al., 2023) resulted in widespread job losses, leaving many workers facing uncertainty and economic struggles. The manufacturing sector, which plays a crucial role in the country's economy (Amani et al., 2023), saw a substantial decrease in the number of workers, worsening an already difficult situation. Additionally, the disruptions in both domestic and global supply chains had a devastating impact on the secondary industry in Côte d'Ivoire. Movement and trade restrictions impeded the flow of goods, causing disruptions in the availability of raw materials, intermediate products, and finished goods. This disruption affected businesses of all sizes and levels of the supply chain. These initial effects, as pointed out by Jomo in (2020), and McKibbin in 2023, emphasize the complex and extensive repercussions of the pandemic (Jomo & Chowdhury, 2020; McKibbin & Fernando, 2023) on the secondary industry in Côte d'Ivoire. Addressing the challenges faced by businesses, workers, and supply chains requires innovative and collaborative efforts to mitigate the damage and establish a resilient and sustainable recovery.

2.4.2. Long-term implications for the sector

The sector is expected to experience significant transformations in the long run (Rocard et al., 2021), with increased automation and the possible relocation of certain industries to bolster supply chain resilience. Additionally, various sectors, including construction, which heavily rely on public and foreign investment, may face an extended period of economic (Aigbavboa et al., 2022; Kramo & Koné, 2023) decline due to global uncertainties and the impact of recent events. These changes and challenges in the sector will require a comprehensive assessment and strategic planning to navigate through the evolving landscape (Porath, 2023) successfully. Companies must adapt and adopt innovative approaches to thrive and remain competitive in the dynamic (Moşteanu, 2024) and ever-changing market. By leveraging technology and embracing sustainable practices, businesses can optimize operations, improve efficiency, and create new opportunities for growth and development (Combaz, 2020; Pokou, 2020).

Furthermore, collaboration and partnerships across different sectors play a vital role in overcoming the challenges and achieving sustainable economic recovery. Governments, businesses, and stakeholders need to work together, sharing resources, expertise, and best practices to navigate the uncertainties and shape a prosperous future for the sector. With careful planning, investment in skills development, and the implementation of effective policies, the sector can emerge resilient and position itself as a catalyst for economic growth and social development. By capitalizing on emerging trends, such as digitalization, renewable energy, and smart infrastructure, the sector can not only recover from the current setbacks but also contribute to the overall economic diversification and transformation of the country.

2.5. Government and policy responses

2.5.1. Overview of interventions

In response to the unprecedented global pandemic, that has had a significant impact on numerous lives. The Government (Koloma & Bah, 2022) has implemented proactive measures to address the resulting consequences. Recognizing the urgent need for economic stability and the preservation of livelihoods, a comprehensive range of actions has been swiftly executed. These actions include strategic fiscal stimulus packages aimed at boosting the economy, restrictive measures to contain the virus, crucial subsidies directed towards deeply affected industries, and forward-thinking programs designed to support and empower small and medium enterprises, which play an important role in the nation's economy (Mohsen, 2022; Napo, 2022). Through the implementation of these multifaceted strategies, the Government (Andrews et al., 2021) has consistently worked towards stabilizing the economy and safeguarding valuable jobs that are essential to prosperity and collective well-being.

2.5.2. Assessment of their effectiveness

Preliminary assessments suggest that while the government measures have commendably contributed to alleviating immediate economic ramifications, their ability to facilitate a lasting and robust recovery remains uncertain and requires further scrutiny. The persistence of critical hurdles, such as prompt and efficient execution, and ensuring equal opportunities for vulnerable businesses and individuals, necessitates devoted attention and collaborative endeavors. Recent studies conducted by the Organization for Economic (Ella et al., 2022; Ferhi & Kamel, 2024) Co-operation and Development (OECD) and other research efforts indicate that the current measures have had a significant impact on the economy. However, their long-term effects are yet to be ascertained, demanding thorough analysis to determine their effectiveness (Gomes et al., 2022; Nguyen-Van & Terraz, 2021; Soete et al., 2021) in guaranteeing a sustained and strong resurgence. These evaluations underscore the need for comprehensive and holistic strategies that address the complex challenges faced by both companies and individuals during these unprecedented times. To overcome these formidable challenges, it is crucial to swiftly and effectively implement these measures. Furthermore, utmost importance must be given to ensuring fair and equitable access to support for the most vulnerable enterprises and individuals. By prioritizing these fundamental aspects, collaborative efforts can be cultivated to unlock the potential for a resilient and enduring economic recovery.

2.6. Theoretical framework

Theoretical frameworks are crucial for understanding the complex interplay between the industrial sector and the impacts of the COVID-19 pandemic. These frameworks highlight the importance of endogeneity, which underscores the interconnectedness between variables in the secondary sector (Adeboye et al., 2023) and external shocks caused by the pandemic, leading to unpredictable business outcomes. This interconnectedness necessitates a thorough examination of the relationships between environmental factors and sector-specific variables.

This study addresses a critical gap by analyzing the impacts of pandemics, particularly COVID-19, on the economic performance, structure, and policy response of the industrial sector within a developing economy context. Unlike existing literature that offers broad generalizations about the economic impacts of health (Cevik, 2020) crises, this research focuses on sector-specific dynamics and recovery

mechanisms. It also enhances our understanding of the long-term implications of pandemics (Muhtarom, 2021) on industrial landscapes, often overlooked in broader economic studies. The concept of endogeneity is employed to explore how internal sector dynamics and external economic shocks reinforce each other. Understanding this relationship is vital for assessing the resilience of the industrial sector in adapting to and recovering from pandemic impacts. The use of homoscedasticity ensures the reliability of statistical models examining industrial dynamics (Benson & Fortune, 2022) during a pandemic. Assuming consistent variability in responses across the sector regardless of the pandemic's severity allows for predictions that are more accurate and inferences about the sector's resilience and adaptive responses. Extensive research in health economics provides foundational insights into the immediate disruptions and long-term changes in the industrial landscape caused by pandemics (Hale et al., 2021; Tan et al., 2022). These insights are crucial for understanding the deceleration and subsequent recovery of Côte d'Ivoire's real GDP growth rate, which dropped to 2% in 2020 from an average of 8% from 2012 to 2019 but showed signs of recovery with an average growth (Bank, 2023) rate of 7.2% over the 2021–2022 period, as reported by the African Bank Development (2023). By integrating these theoretical concepts and empirical findings, this research provides a comprehensive perspective on the industrial sector's dynamics during a pandemic. It addresses how economic consequences, public health crises, and policy responses are interconnected, leading to a nuanced understanding of the challenges and resilience mechanisms within the industrial landscape. This theoretical framework offers valuable empirical insights that can guide future policy and economic resilience strategies, ensuring robust preparation and response frameworks for similar future crises.

3. Methodology

3.1. Research strategy and approach

This study examines the impact of the global COVID-19 pandemic on Côte d'Ivoire's secondary sector. This section details the methodology, data sources, and variables assessed to understand this impact. A quantitative research strategy is employed to analyze the pandemic's effects on Côte d'Ivoire's secondary sector. Additionally, a comparative analysis includes similar sectors in developed and developing countries such as Nigeria, Egypt, South Africa, China, and France. This approach enables a comprehensive understanding of the pandemic's effects across different economic environments and development stages.

3.1.1. Data collection

The data spans from January 2020 to December 2022, focusing on high-frequency monthly data to accurately depict the pandemic's initial repercussions. Data sources include internationally renowned databases such as the World Bank, Our World in Data, Worldometers, and Trading Economics. These databases provide extensive statistics on COVID-19 cases, economic indicators (GDP, inflation), and policy interventions during the pandemic. Key data sources are:

- World Bank Database: Offers a wide range of global economic indicators.
- Trading Economics: Provides economic metrics such as GDP growth, exports, and imports.
- Our World in Data: Comprehensive datasets on COVID-19 health impacts and global responses.
- Worldometers: Real-time COVID-19 statistics, including infection rates and mortality.
- CEIC Data: Detailed economic and financial statistics.

These sources were selected for their reliability and the breadth of data they provide, which is essential for conducting comparative evaluations of countries at different stages of industrial and economic development.

3.1.2. Sample selection

The research focuses on the secondary sector in Côte d'Ivoire, supplemented with data from selected developed and developing nations for comparative analysis. Countries were chosen based on their economic structure, level of industrialization, and data availability quality.

3.1.3. Data analysis

The collected data underwent both descriptive and inferential statistical analysis. Initially, descriptive analysis was performed to summarize the data and identify patterns. Inferential statistics were then used to assess the causal effects of the pandemic on the secondary sector, employing the two-stage generalized least squares (G2SLS) instrumental variable (IV) model and logarithmic transformations. Microsoft Excel was utilized for preliminary data management and visualization, while Stata facilitated in-depth statistical analysis, including complex econometric models such as the G2SLS IV model. All data were sourced from publicly available or approved databases, with strict adherence to ethical standards and copyright regulations. Sensitive information was anonymized, and data were handled responsibly to prevent misinterpretation or misuse.

3.1.4. Research limitations

The study acknowledges constraints such as potential biases in secondary data, inconsistent data quality across sources and limited applicability of findings to the observed timeframe and selected economic fields. Despite these limitations, the research provides in-depth insights into the diverse impacts of COVID-19 on Côte d'Ivoire's secondary sector and other nations. It addresses gaps in the literature by detailing the pandemic's economic implications, policy effectiveness, and recovery trends. This study offers valuable information for decision-makers and stakeholders in the economic and healthcare sectors.

3.1.5. Variables

This research analyzed various factors to understand the implications of the COVID-19 pandemic on Côte d'Ivoire's secondary sector. These factors include economic performance, health outcomes, structural attributes, and fiscal and monetary strategies, providing comprehensive insights into the pandemic's consequences. The variables examined include economic performance indicators such as growth of industrial production and average growth of intellectual property. Health-related variables such as confirmed COVID-19 cases and deaths quantify the virus's spread and impact on public health. Structural characteristics such as manufacturing GDP percentage and services GDP percentage highlight each sector's contribution to the country's GDP. Fiscal and monetary policy variables, such as the economic support index and GDP budget expenditure, evaluate the government's measures in economic support and resource allocation during the pandemic.

3.1.6. Ethical considerations

This research adhered to strict ethical principles to ensure integrity and ethical conduct. Key ethical factors were addressed, including prioritizing informed consent, ensuring confidentiality, and implementing data security measures. The study focused on economic data and maintained transparency and honesty throughout, reporting findings truthfully. The potential impact of the findings was evaluated to provide valuable insights for stakeholders and policymakers. The research complied with ethical guidelines from regulatory bodies and aligned with international standards, contributing significantly to understanding the pandemic's impact on Côte d'Ivoire's secondary sector.

3.2. Empirical modelling

With the study geared toward ascertaining the impact of COVID-19 on the secondary sector of Côte d'Ivoire relative to its major trading partners, a panel data regression method is the ideal approach. This panel comprises of Côte d'Ivoire, Nigeria, Egypt, South Africa, China, and France. Essentially, this method (Reyna, 2007) remedies variable omission bias stemming from heterogeneity within the dataset, which can culminate in spurious regression. In its relaxed form, the model is specified as:

$$Y_{it} = \alpha_i + \beta X_{it} + \mu_i + e_{it} \quad (1)$$

where Y_{it} denotes the dependent variable, α_i is the intercept, X_{it} is the vector of all independent variables, μ_i represents the entity-specific error term and e_{it} is the overall error term. However, further specification of the model entails two dynamics that have been extensively covered in literature: Fixed Effects

(FE) and Random Effects (RE). The underlying assumption that differentiates the two is that idiosyncratic factors influence the regressors with the former being preferred if such an effect is present and the latter preferred in an absent scenario. The ultimate choice between the two was determined by further diagnostic tests explored in the preceding sections. Fitting the model to the study yielded Eq. (2) below:

$$SSP_{it} = \alpha_0 + \sum_{j=0}^n \beta_{2i} D_{t-j} + \sum_{j=0}^n \beta_{3i} SC_{t-j} + \sum_{j=0}^n \beta_{4i} PE_{t-j} + e_{it} \quad (2)$$

where SSP_{it} is a proxy for secondary sector performance captured by industrial production growth, the decline in workplace mobility, and nominal export growth; DF_{t-j} denotes domestic COVID-19 factors such as confirmed cases, deaths, Oxford stringent index, and excess deaths; SC_{t-j} represents the structural characteristics of the Ivorian economy and its major trading partners, which comprise the percentage contribution to the GDP of the manufacturing sector, service sector, tourism sector, imports, and exports; PE_{t-j} denotes both fiscal and monetary policy effects such as fiscal spending as a percentage of GDP and changes in the policy rate; e_{it} is the overall error term; $i = 1, 2, 3, \dots, 6$; $t = 1, 2, 3, \dots, 36$.

Primarily, Eq. (2) uses industrial production growth as the base dependent variable. The restricted form of the panel model is specified as:

$$IPG_{it} = \alpha_0 + \sum_{j=0}^n \beta_{2i} ConfCas_{t-j} + \sum_{j=0}^n \beta_{3i} MSofGDP_{t-j} + \sum_{j=0}^n \beta_{4i} FSofGDP_{t-j} + e_{it} \quad (3)$$

Where IPG is the Industrial Production Growth; $ConfCas$ is the number of confirmed COVID-19 cases; $MSofGDP$ is the contribution of the manufacturing sector to GDP, and $FSofGDP$ is the fiscal expenditure as a percentage of GDP. Variants in the model entail relaxing the restricted model to account for other factors. However, because of the endogenous nature of vector variables, this study employs an 'instrument variable' specification. With domestic COVID-19 factors seemingly highly endogenous, a G2SLS fixed/random-effects IV regression model is employed contingent on the outcome of the Hausman test. The newly instrumented Eq are as follows:

$$IPG_{it} = \alpha_0 + \sum_{j=0}^n \beta_{2i} IV_{t-j} + \sum_{j=0}^n \beta_{3i} MSofGDP_{t-j} + \sum_{j=0}^n \beta_{4i} FSofGDP_{t-j} + e_{it} \quad (3a)$$

$$IV_{it} = \tau_0 + \gamma_{2i} Deaths_{t-j} + \gamma_{3i} OxfStrIndx_{t-j} + \gamma_{4i} ExcDeath_{t-j} + e_{it} \quad (3b)$$

where $IV = ConfCas = Deaths \ OxfStrIndx \ ExcDeath$

Similarly, to further ascertain the robustness of the results, this study employs the other aspects of secondary sector performance as dependent variables as indicated in Eq. (4) and (5) below):

$$WPM_{it} = \alpha_0 + \sum_{j=0}^n \beta_{2i} IV_{t-j} + \sum_{j=0}^n \beta_{3i} MSofGDP_{t-j} + \sum_{j=0}^n \beta_{4i} FSofGDP_{t-j} + e_{it} \quad (4)$$

$$NEG_{it} = \alpha_0 + \sum_{j=0}^n \beta_{2i} IV_{t-j} + \sum_{j=0}^n \beta_{3i} MSofGDP_{t-j} + \sum_{j=0}^n \beta_{4i} FSofGDP_{t-j} + e_{it} \quad (5)$$

Where WPM denotes Workplace Mobility and NEG is nominal export growth. It should be noted that Eq. (4) and Eq. (5) also undergo the same IV regression as specified in Eq. (3). As previously mentioned, this study employs several diagnostic tests such as the Hausman model choice test and the Breusch-Pagan-Test for homoscedasticity. Based on the results, several remedies are employed to ensure that the properties of the Central Limit Theory (CLE) adhere to. In essence, this ensures that the inferences drawn from this study are representative, valid, and reliable for efficient policy implications.

4. Research findings and discussions

4.1. Descriptive statistics

Several nuances regarding the study period can be deduced from Table 1. First, for the dependent variables, all of the secondary sector performance variables are positively skewed which suggests that there

Table 1. Descriptive statistics.

Variables		Mean	Std. Dev	Min	Max	Skewness	Kurtosis	Observations
IPG	Overall	4.146435	12.92785	−53	44.12	0.1569411	5.989855	N = 216
	Between	0	4.379327	0.0444444	10.50556	0	0	n = 6
	Within	0	12.29117	−48.89801	47.92255	0	0	T = 36
WPM	Overall	−0.4714861	25.15337	−69	73	0.3528134	3.619511	N = 216
	Between	0	13.43967	−21.81556	15.21861	0	0	n = 6
	Within	0	21.94246	−52.6151	57.3099	0	0	T = 36
NEG	Overall	43.07556	14.65917	13.57	76.96	0.085636	2.308315	N = 216
	Between	0	14.89585	22.8806	62.6075	0	0	n = 6
	Within	0	5.396837	33.7625	57.42806	0	0	T = 36
ConfCas	Overall	3080906	8997178	0	8.49e + 07	5.198802	37.7309	N = 216
	Between	0	4630639	48567.75	1.20e + 07	0	0	n = 6
	Within	0	7937071	−8963547	8.42e + 07	0	0	T = 36
OxfStrInd	Overall	45.87449	24.34588	6.48	87.96	0.0768563	1.723193	N = 216
	Between	0	14.60338	26.09278	71.50972	0	0	n = 6
	Within	0	20.3514	10.57949	100.3417	0	0	T = 36
ExcDeath	Overall	311.6339	936.5432	−1151.4	8859.28	5.126273	38.57963	N = 216
	Between	0	551.427	16.78444	1421.277	0	0	n = 6
	Within	0	789.0129	−2261.043	2249.637	0	0	T = 36
ManufGDP	Overall	3.845	14.70473	−53	102.2	1.626877	13.48225	N = 216
	Between	0	4.384677	−0.6386111	10.50556	0	0	n = 6
	Within	0	14.14686	−48.59667	106.6033	0	0	T = 36
ServcofGDP	Overall	56.30611	8.453409	43.79	71.16	0.4410859	2.120256	N = 216
	Between	0	9.202695	44.74	70.60667	0	0	n = 6
	Within	0	0.746462	55.35611	57.95611	0	0	T = 36
ExpofGDP	Overall	12.89856	19.92634	−42	67.03	0.3336908	3.477319	N = 216
	Between	0	3.397592	6.275	15.40889	0	0	n = 6
	Within	0	19.68234	−36.52505	71.62356	0	0	T = 36
ImpofGDP	Overall	15.29023	26.39443	−50	99.8	0.2811165	3.124639	N = 216
	Between	0	6.566055	5.7225	24.27167	0	0	n = 6
	Within	0	25.70158	−55.10171	90.81856	0	0	T = 36
TourofGDP	Overall	4.105	0.9117787	2.8	5.9	0.2910404	2.085637	N = 216
	Between	0	0.8225536	3.2	5.1	0	0	n = 6
	Within	0	0.514674	3.248333	4.968333	0	0	T = 36
FiscExp	Overall	−6.455556	1.499478	−10	−4.2	−0.7858348	2.97164	N = 216
	Between	0	0.7010046	−7.366667	−5.533333	0	0	n = 6
	Within	0	1.355368	−9.822222	−4.022222	0	0	T = 36
ChangeinR	Overall	5.425463	4.502916	0.1	16.75	0.7089886	2.210532	N = 216
	Between	0	4.766119	0.3055556	12.55556	0	0	n = 6
	Within	0	1.121738	4.041574	12.22157	0	0	T = 36

are frequent small positive values with extreme negative means. This connotation is further substantiated by the kurtosis values. For instance, Industrial Performance Growth (IPG) is leptokurtic, indicating a scenario of extreme negative values. Similarly, workplace mobility (WPM) seems to be leptokurtic, which corroborates its negative mean value. Similarly, most Domestic COVID-19 factors are also positively skewed and leptokurtic. As, the point of reference for the current study, the number of Confirmed Cases (ConfCas) and Excess Deaths (Exceaths) depict the highest leptokurtic values. This implies the presence of extreme values. Additionally, the aforementioned sentiments can be expressed as structural characteristics of the secondary sector. However, the policy effects of Fiscal Expenditure (FiscExp) depict varied statistics. With negative skewness, it appears that the panel countries expressed extreme expenditures by their governments during the 2020–2022 period. However, it is noteworthy that Domestic COVID-19 factors retain the highest variation as deduced from the standard deviation values. This speaks volumes of the expeditious growth of the COVID-19 pandemic, which, according to the current study, might have affected the secondary sector of the countries in context. The preceding section zeroed in on such interlinkages.

4.2. Empirical findings

4.2.1. Random effects regression results

As discussed in Section 3.2, the Hausman test is executed on the model specification. The results show that the Random Effects (RE) model is ideal for the data. Thus, the restricted version of the model shown, in Eq. (3), was computed using a random effects annotation. The same applies to the relaxed versions.

The results are displayed in Tables 2–4 for all proxies of the secondary sector performance variables. As can be noted, due to the level of skewness in some variables like ConfCas and OxfStrIndx, the study transforms these variables using the natural logarithm to remedy any possible skewed results. In essence, such adjustments change the model to a level-log form. With IPG as the dependent variable, as displayed in Table 2, the restricted model depicts a positive and significant influence from confirmed COVID-19 cases and the manufacturing sector's contribution to GDP while fiscal expenditure retains an insignificant negative impact. Stepwise relaxation of the controls revealed crucial insights. For example, domestic factors such as the Oxford Stringent Index on COVID-19 and Excess COVID-19 deaths and structural characteristics of the secondary sector, such as the service sector's contribution to GDP, gain significance and traction with progressive relaxation. The power of variable addition is illustrated in Figure 1.

However, a close inspection of the explanatory power of the model and the changes thereto as captured by the R-squared shows that relaxing the model does not have a profound effect. This was further corroborated by the graphical representation of the added variable effect in Figure 1. Moreover, the sign

Table 2. Random effects regression results (Dependent Variable = IPG).

IPG	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
InConfCas	−7.0237** (3.5835)	−7.0851* (4.4282)	−7.9101 (6.7283)	−7.7932 (6.8831)	−7.7144 (6.6049)	−7.7122 (5.5699)	−7.0680 (5.3471)	−8.0214 (5.4876)
OxfStrIndx		−0.0431 (0.0345)	−0.0614** (0.0304)	−0.0613** (0.0303)	−0.0577** (0.0286)	−0.0538** (0.0263)	−0.0376** (0.0179)	−0.0382* (0.0215)
InExcDeaths			−2.8484*** (0.0004)	−2.8559*** (0.0004)	−2.8667*** (0.0004)	−2.8924*** (0.0004)	−2.9269*** (0.0003)	−2.9319*** (0.0003)
ManufGDP	0.7403*** (0.1911)	0.7324*** (0.1903)	0.7222*** (0.1903)	0.7222*** (0.1911)	0.7046*** (0.2047)	0.7002*** (0.2053)	0.6864*** (0.2105)	0.6860*** (0.2131)
ServcofGDP				−0.0066* (0.0733)	−0.0065* (0.0731)	−0.0066 (0.0781)	0.0558* (0.0334)	0.0480 (0.0688)
ExpofGDP					0.0332 (0.0433)	0.0263 (0.0403)	0.0182 (0.0381)	0.0184 (0.0399)
ImpofGDP						0.0189 (0.0153)	0.0177 (0.0154)	0.0173 (0.0151)
TourofGDP							1.2072 (0.7474)	1.1877* (0.6280)
FiscExpofGDP	−0.2423 (0.3827)	−0.5774 (0.3789)	−0.5428 (0.3635)	−0.5566** (0.2494)	−0.6178*** (0.1630)	−0.6726*** (0.1601)	−0.4223*** (0.1128)	−0.4256*** (0.0902)
ChangeinR								−0.0152 (0.1292)
R-squared	0.6955	0.7001	0.7078	0.7078	0.7098	0.7108	0.7152	0.7152

Note. *** indicates 0.01 and ** indicates 0.05, and * indicates 0.1. Values have been rounded up to 4 decimal places.

Table 3. Random effects regression results (Dependent Variable = WPM).

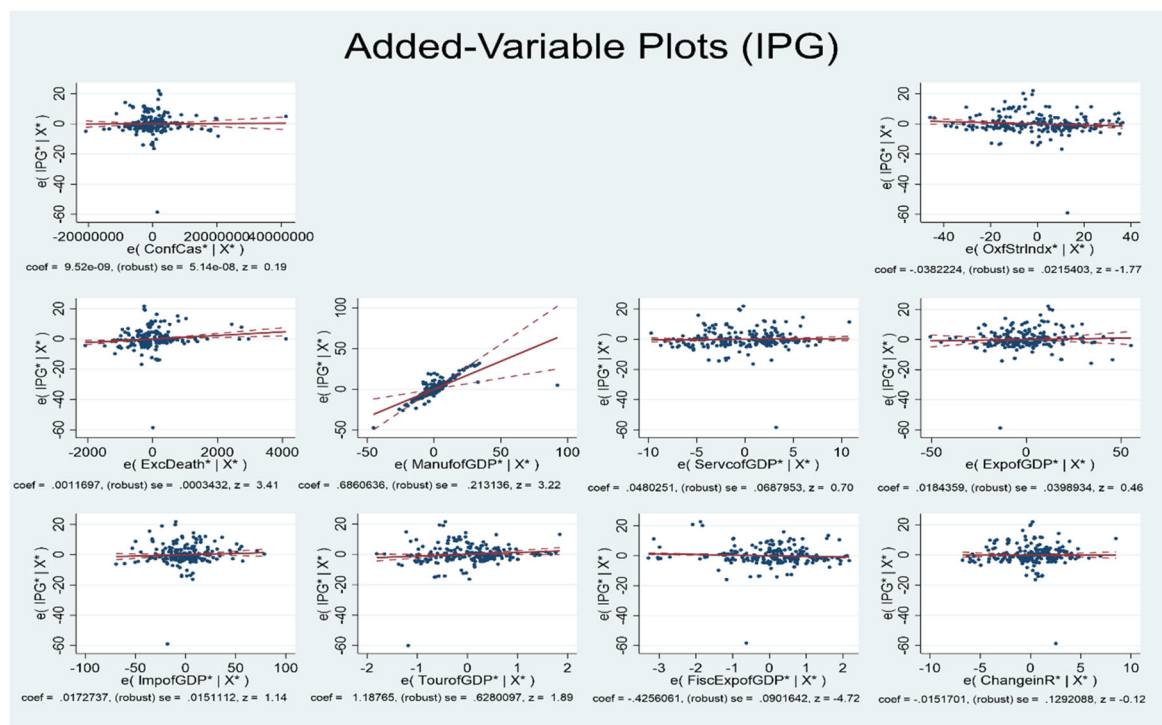
WPM	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
InConfCas	−6.6253 (5.1927)	−6.2020 (5.6974)	−5.9747*** (2.7221)	−6.3706** (3.2503)	−7.7169* (4.8231)	−7.7219* (4.8262)	−7.5047* (4.6904)	−7.4733 (5.3363)
OxfStrIndx		−0.5900*** (0.2109)	−0.7036*** (0.1660)	−0.6875*** (0.1578)	−0.6639*** (0.1472)	−0.6364*** (0.0263)	−0.4910*** (0.1111)	−0.4814*** (0.1115)
InExcDeaths			−4.7310*** (1.5983)	−5.3438** (2.7264)	−5.3914** (2.7507)	−5.5205 (2.8166)	−5.7684 (5.2951)	−5.6992 (4.8715)
ManufGDP	0.2177** (0.0852)	0.1720 (0.1604)	0.1088 (0.1510)	0.1049 (0.1299)	−0.0088 (0.1324)	−0.0400 (0.1643)	−0.1639 (0.1823)	−0.1582 (0.1706)
ServcofGDP				−1.1098*** (0.3264)	−1.1089*** (0.3269)	−1.1098*** (0.3408)	−0.5493*** (0.1951)	−0.4209 (0.6625)
ExpofGDP					0.2149*** (0.0594)	0.1659** (0.0646)	0.0927* (0.0552)	0.0882 (0.0556)
ImpofGDP						0.1337 (0.1515)	0.1224 (0.1111)	0.1292 (0.1218)
TourofGDP							10.8465*** (3.0882)	11.1704** (4.3371)
FiscExpofGDP	4.7158** (2.0757)	0.5526 (2.3945)	0.7678 (2.2980)	−1.5418 (2.5751)	−1.9369 (2.7021)	−2.3237 (2.6524)	−0.0745 (1.7935)	−0.0191 (1.7804)
ChangeinR								0.2520 (0.1611)
R-squared	0.1541	0.3854	0.4644	0.5532	0.5746	0.5882	0.6816	0.6822

Note. *** indicates 0.01 and ** indicates 0.05, and * indicates 0.1. Values have been rounded up to 4 decimal places.

Table 4. Random effects regression results (Dependent Variable = NEG).

NEG	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
InConfCas	-6.8477 (6.0713)	-7.2757 (7.9045)	-6.0711** (3.0974)	-7.0405 (4.8693)	-7.0595 (5.1162)	-7.0620 (6.5674)	-6.9393 (6.6679)	-7.1135 (6.5718)
OxfStrIndx		-0.1560*** (0.0145)	-0.1500*** (0.0451)	-0.1748*** (0.0425)	-0.1703*** (0.0414)	-0.1595*** (0.0343)	-0.1178*** (0.0183)	-0.1402*** (0.0157)
InExcDeaths			-2.3484** (1.1982)	-2.8322** (1.4451)	-2.8452** (1.4316)	-2.9168* (1.8234)	-3.0181 (2.3332)	-3.3628 (2.6577)
ManufGDP	-0.0011 (0.0365)	-0.0373** (0.0171)	-0.0203 (0.1210)	-0.0145 (0.0407)	-0.0367 (0.0302)	-0.0489 (0.0300)	-0.0845*** (0.0272)	-0.0979*** (0.0268)
ServcofGDP				1.6359*** (0.1947)	1.6360*** (0.0307)	1.6357*** (0.1942)	1.7965*** (0.1259)	1.4952*** (0.1753)
ExpofGDP					1.4743 (0.5240)	0.0226 (0.0299)	0.0016 (0.0309)	0.0122 (0.0247)
ImpofGDP						0.0526** (0.0210)	0.0494*** (0.0071)	0.0333* (0.0176)
TourofGDP							3.1112** (1.5022)	2.3512** (1.0840)
FiscExpofGDP	1.8514*** (0.4448)	1.0929*** (0.3305)	-1.8531 (2.6468)	1.5514*** (0.4724)	1.4743*** (0.5240)	1.3221** (0.5111)	1.9673*** (0.4718)	1.8374*** (0.3320)
ChangeInR								-0.5912*** (0.2254)
R-squared	0.0497	0.0980	0.3194	0.8879	0.8903	0.8965	0.9191	0.9295

Note. *** indicates 0.01 and ** indicates 0.05, and * indicates 0.1.
Values have been rounded up to 4 decimal places.

**Figure 1.** Added-variable plots (Dependent Variable = IPG).

of most of the coefficients for domestic COVID-19 factors contradicts the apriori expectation as conventionally such a negative externality is expected to hurt the performance of the manufacturing sector. This could point to a possible endogeneity problem thus prompting the use of Eq. (3a) to rectify such statistical deviations. To verify the robustness of the relationships found using IPG as the dependent variable, the second scenario entails the use of WPM as the dependent variable. With COVID-19 and the subsequent lockdown effective in most countries between 2019, and 2020, working from home became the order of the day owing to the traveling restrictions imposed as preventive measures. As such, as in the previous case, the apriori connotes the negative impact imposed by the pandemic on such a secondary sector performance metric. As shown in Table 3, the restricted model shows a positive significant

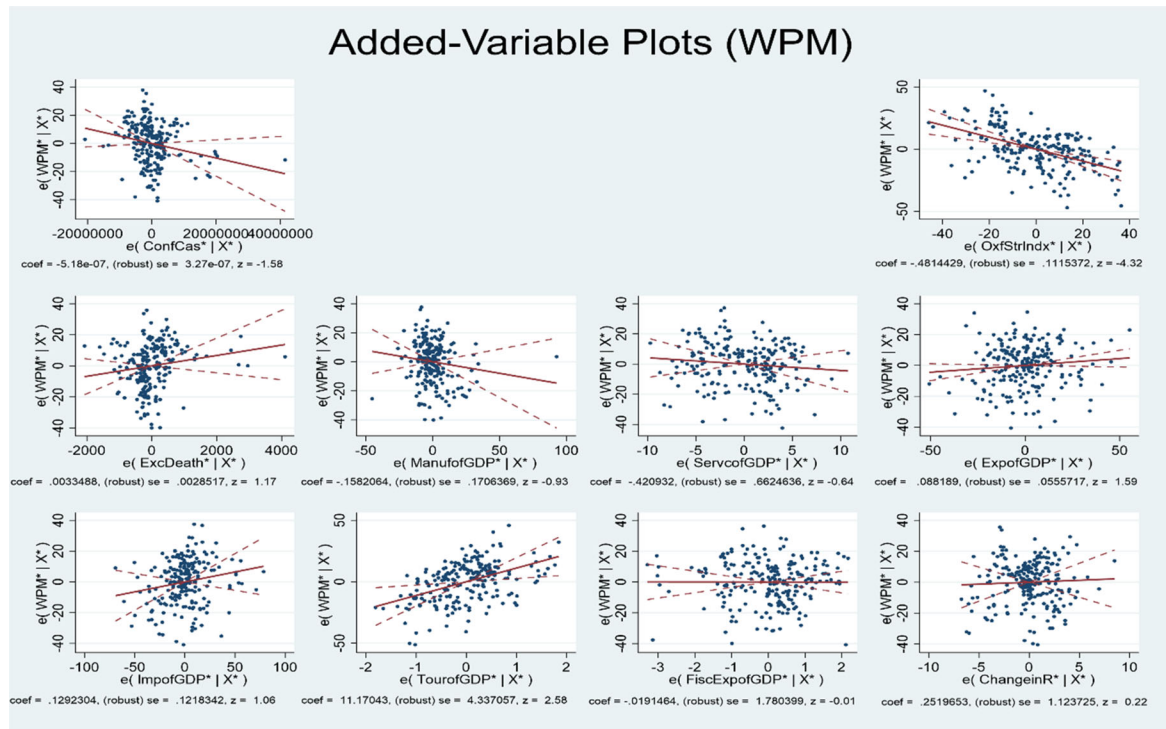


Figure 2. Added-variable plots (Dependent Variable = WPM).

influence from structural characteristics and policy effects but a negative and insignificant influence from domestic COVID-19 factors. Relaxing the model to account for the other vector variables shows that variables such as Confirmed COVID-19 cases, Oxford Stringent Index, and Excess COVID-19 deaths gain significance at different levels, which confirms the apriori. Additionally, only the service sector has a significant, albeit negative, influence. Unlike IPG, the added variable influence with WPM appears to have a profound effect, as evidenced by the significant change in the explanatory power of the model from 15 percent to 68 percent. A graphical representation of these dynamics is shown in Figure 2.

This means that, on average, an increase in domestic COVID-19 factors leads to a reductive impact on the performance of the secondary sector for the panel countries. The significant additive impact of the manufacturing sector is explained by the inclusion of other sectors such as service and tourism in Figure 2. In the fully relaxed model, only the Oxford Stringent Index and the Tourism sector's contribution to GDP have significant negative and positive influences respectively. These results point out the suppression effect intrinsic to the model restriction.

The third scenario, with NEG as the dependent variable, presents a similar case of confirmed apriori influence of domestic COVID-19 factors. Nonetheless, crucial insights posited by this model adjustment include the gain in the significance of most structural characteristics and policy effects. The leap in explanatory power from 5 percent to 93 percent vindicates the added-variable influence. Figure 3 illustrates this influence.

Despite the endogeneity, signs deduced from the previous two scenarios, with net export growth, the variables exhibit a minimal change in sign thus underscoring the validity of the relationships in Figure 3. Additionally, as per the goodness of fit, NEG appears to be an ideal proxy for secondary sector performance relative to the previous two. Nevertheless, with domestic COVID-19 factors as the point of reference, any deviation from the qualities of the CLE, such as the presence of endogeneity must be remedied. It then follows that a caveat must be taken when interpreting the results of the three scenarios. To that end, this study uses the G2SLS random-effects IV regression to account for such a problem. The following section presents a robustness check of the preceding results.

4.2.2. G2SLS random-effects IV regression results

Running a G2SLS IV regression for the random effects model, as specified by Eq. (3a) and (3b), helps remedy the presence of endogeneity. As alluded to earlier, domestic COVID-19 factors exhibit a high

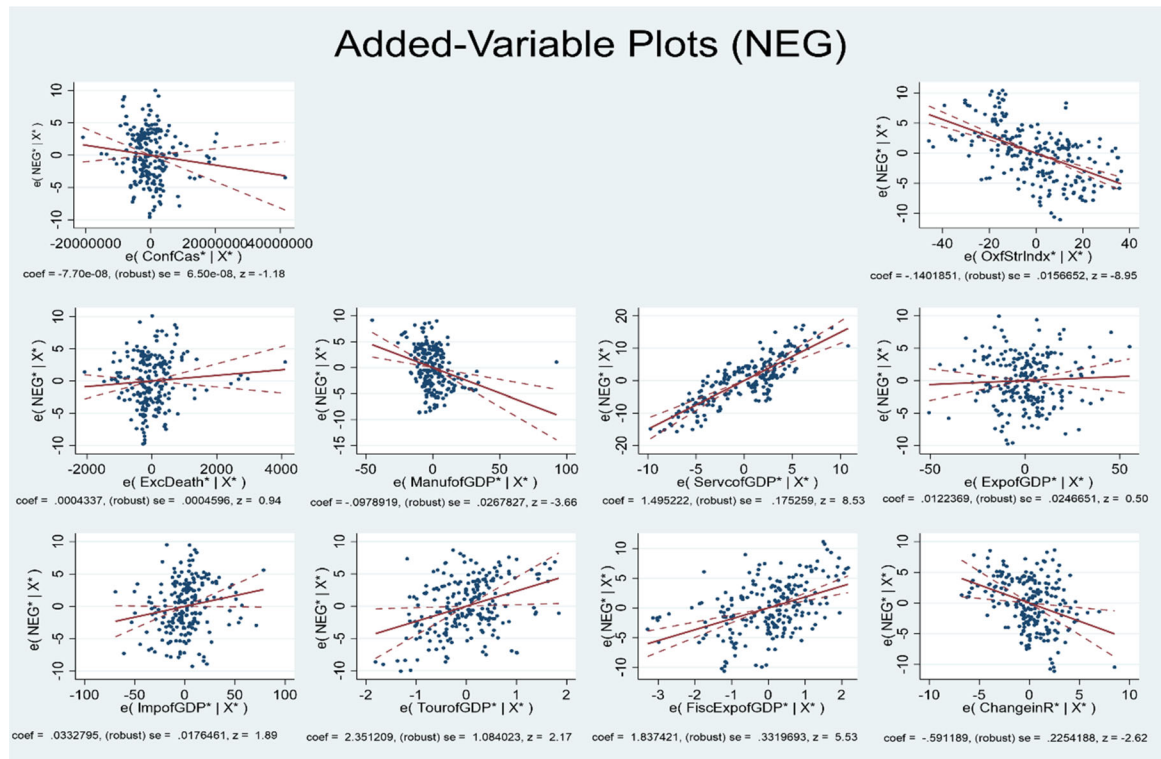


Figure 3. Added-variable plots (Dependent Variable = NEG).

Table 5. G2SLS random effects IV regression results (Dependent Variable = IPG).

IPG	(1)	(2)	(3)	(4)	(5)	(6)
InConfCas	-6.7878** (3.4632)	-6.6180*** (2.4017)	-6.6596** (4.1623)	-6.7055** (3.4212)	-6.7670** (3.4526)	-6.7645** (3.4515)
ManufGDP	0.7447*** (0.0355)	0.7441*** (0.0357)	0.7203*** (0.0388)	0.7125*** (0.0392)	0.6951*** (0.0398)	0.6941*** (0.0401)
ServcofGDP		-0.1131 (0.0728)	-0.1019 (0.0721)	-0.0917 (0.0720)	-0.0201 (0.8070)	-0.0379 (0.1121)
ExpofGDP			0.0414 (0.0285)	0.0320 (0.0297)	0.0205 (0.0299)	0.0212 (0.0301)
ImpofGDP				0.0264 (0.0220)	0.0225 (0.0219)	0.0214 (0.0224)
TourofGDP					1.3461** (0.6532)	1.3084* (0.6749)
FiscExpofGDP	-0.3399 (0.3603)	-0.5843 (0.3944)	-0.6443 (0.3977)	-0.7127* (0.4020)	-0.5365 (0.4095)	-0.5248 (0.4128)
ChangeinR						-0.0402 (0.1751)
R-squared	0.6935	0.6910	0.6958	0.6994	0.7071	0.7072

Note. *** indicates 0.01 and ** indicates 0.05, and * indicates 0.1. Values have been rounded up to 4 decimal places.

potential for endogenous causality owing to their very nature. The results for the first regression scenario, as shown in Table 5, indicate that the model achieves considerable stability and significance in terms of the influence imposed by the instrumented variable ConfCas. This means that ceteris paribus, an increase in the confirmed cases of COVID-19 had a curtailing effect on the growth of industrial performance for the countries in context. As Srivastava (2022) asserts, the acceleration of COVID-19 cases slowed down manufacturing (Srivastava, 2022) growth worldwide on the grounds of supply chain disruption. With China being the main supplier of goods and materials, a surge in COVID-19 cases in China meant that industrial production in several countries is below the optimal level as companies dealt with production hiccups. Another crucial attribute brought to the fore by COVID-19 (Ivanov, 2021) was the repurposing of the domestic industrial sector. With demand for essential products taking center stage, companies had to adjust their production lines while companies producing non-essential products faced

an inventory obsolescence problem. Inherently, the domestic industrial sectors experienced structural change due to a shift in demand.

Aside from the statistical significance of the results, another crucial aspect worth noting is the economic significance thereto. Evidently, coefficients for COVID-19 retain more economic significance with due reference to the three dependent variables for secondary sector performance. Such transmission effects entail implications for the economic outlook of Côte d'Ivoire. With African governments championing for manufacturing-based economies, external shocks like COVID-19 impose constraints that render such efforts futile thus being counterproductive. Additionally, import substitution is one of the conduits for the realization of such goals. Import substitution inertly empowers the exporting base of a country. With the COVID-19 lockdown, exports dwindled and as can be seen in [Tables 5–7](#) coefficients for imports as a percentage of GDP retained more economic significance. This further deepens the trade imbalance that has plagued most African economies. As such, not only did COVID-19 retain short-term implications for the Ivorian economy but also affected long-term monetary aggregates.

As alluded to, the external shocks levelled by the COVID-19 stimulated changes within the domestic secondary sector. In an ideal state, where the fiscal mandate and supplementary targets revolve around a manufacturing-based economy, metrics such as contribution of the manufacturing sector to GDP are bound to have a positive influence on secondary sector proxies like IPG, NEG, and WPM. However, as the results for the model variants in [Tables 5–7](#) show, such an influence is only present in a restricted

Table 6. G2SLS random effects IV regression results (Dependent Variable = WPM).

WPM	(1)	(2)	(3)	(4)	(5)	(6)
InConfCas	−7.4522 (5.8144)	−6.1739** (3.1499)	−6.2628** (2.5672)	−6.4202 (4.4648)	−7.0320 (5.1193)	−7.1391 (5.8018)
ManufGDP	0.2336** (0.1125)	0.2798** (0.1093)	0.1070 (0.1152)	0.0455 (0.1128)	−0.1401 (0.0962)	−0.1141 (0.0955)
ServcofGDP		−1.4683*** (0.2230)	−1.4018*** (0.2140)	−1.3260*** (0.2072)	−0.5577*** (0.1953)	−0.1015 (0.2670)
ExpofGDP			0.3033*** (0.0847)	0.2200** (0.0856)	0.1082 (0.0723)	0.0885 (0.0718)
ImpofGDP				0.2109*** (0.0634)	0.1700*** (0.0529)	0.1970*** (0.0533)
TourofGDP					14.3238*** (1.5805)	15.2937*** (1.6074)
FiscExpofGDP	4.3545*** (1.2185)	1.8092 (1.2081)	1.3027 (1.1803)	0.7338 (1.1570)	2.6334*** (0.9909)	2.3535** (0.9832)
ChangeinR						1.0201** (0.4170)
R-squared	0.1375	0.2399	0.2942	0.3427	0.5470	0.5611

Note. *** indicates 0.01 and ** indicates 0.05, and * indicates 0.1. Values have been rounded up to 4 decimal places.

Table 7. G2SLS random effects IV regression results (Dependent Variable = NEG).

NEG	(1)	(2)	(3)	(4)	(5)	(6)
ConfCas	−6.5686*** (2.5460)	−6.5058** (3.3193)	−7.0620 (5.4786)	−7.6126 (6.8311)	−7.2418 (5.8208)	−7.6882 (5.6934)
ManufGDP	0.0048 (0.0236)	−0.0005 (0.0253)	−0.0096 (0.0319)	−0.0319 (0.0309)	−0.0851*** (0.0265)	−0.0909*** (0.0263)
ServcofGDP		1.1368*** (0.1942)	1.5890*** (0.0592)	1.6175*** (0.0568)	1.8376*** (0.0538)	1.6811*** (0.0735)
ExpofGDP			0.0646*** (0.0235)	0.0345 (0.0235)	0.0024 (0.0199)	0.0093 (0.0198)
ImpofGDP				0.0762*** (0.0174)	0.0644*** (0.0146)	0.0552*** (0.0147)
TourofGDP					4.1083*** (0.4354)	3.7580*** (0.4425)
FiscExpofGDP	1.5532*** (0.2813)	1.8377 (0.3132)	2.4236 (0.3268)	2.2230*** (0.3171)	2.7669*** (0.2730)	2.7920*** (0.2707)
ChangeinR						−0.3132*** (0.1148)
R-squared	0.1013	0.7883	0.8402	0.8545	0.8988	0.9020

Note. *** indicates 0.01 and ** indicates 0.05, and * indicates 0.1. Values have been rounded up to 4 decimal places.

version as it is relaxed away in subsequent variants. In addition, the service sector become a major driver of the GDP as compared to the manufacturing sector. The negative coefficient thereto implies that labor mobility is constrained under such economic restructuring. This, in turn, coincides with the nature and severity of the Covid-19 preventive measures.

Similar to the uncorrected scenario, the explanatory power of the restricted model is sufficiently high and shows little change from the un-restrained model, which affirms the robustness of the relationships envisaged. Figure 4 plots the changes in the explanatory power.

In contrast, the results for the second and third scenario specifications show in Figure 4 that the significance of domestic COVID-19 factors as captured by ConfCas fades with further relaxation of the model. At lower levels of relaxation (Models 1, 2 and 3), ConfCas has a significantly negative impact on secondary sector performance at different levels of significance. Nonetheless, similar to the specified random effects results for Eq. (3), the G2SLS results for WPM and NEG depict a tremendous change in explanatory power with every added variable. This result confirms the robustness of the results. Figure 5 shows, the changes in the explanatory power of the models.

It is also crucial to underscore the underlying finding of structural change in the secondary sector, which is reoccurring, with every specification of Eq. (3), be it with or without IV regression. Significant strides in the explanatory power of the models were registered when the model was relaxed for both the service sector and tourism as a percentage of GDP in Figure 5. These two key aspects characterize the pendulum swing in sectoral contributions during the COVID-19 pandemic. With labor mobility restricted as a preventive measure, as evidenced by the results in Tables 6 and 7, the service sector

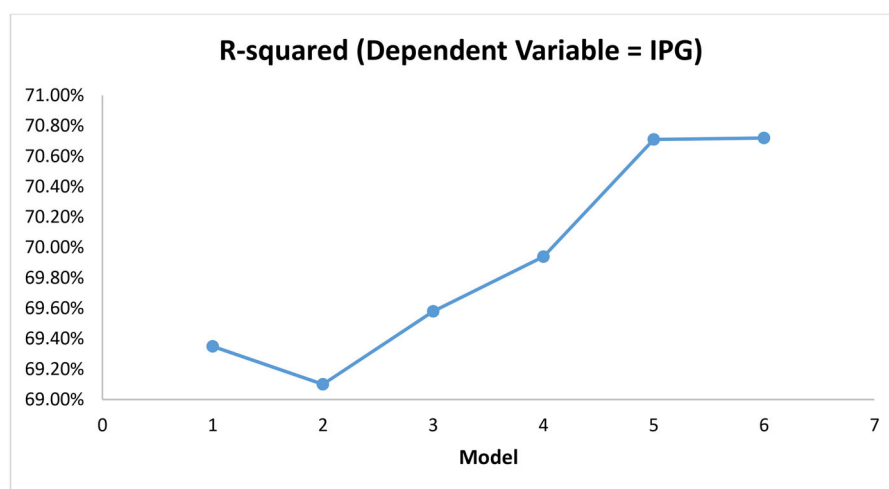


Figure 4. Changes in explanatory power (Dependent Variable = IPG).

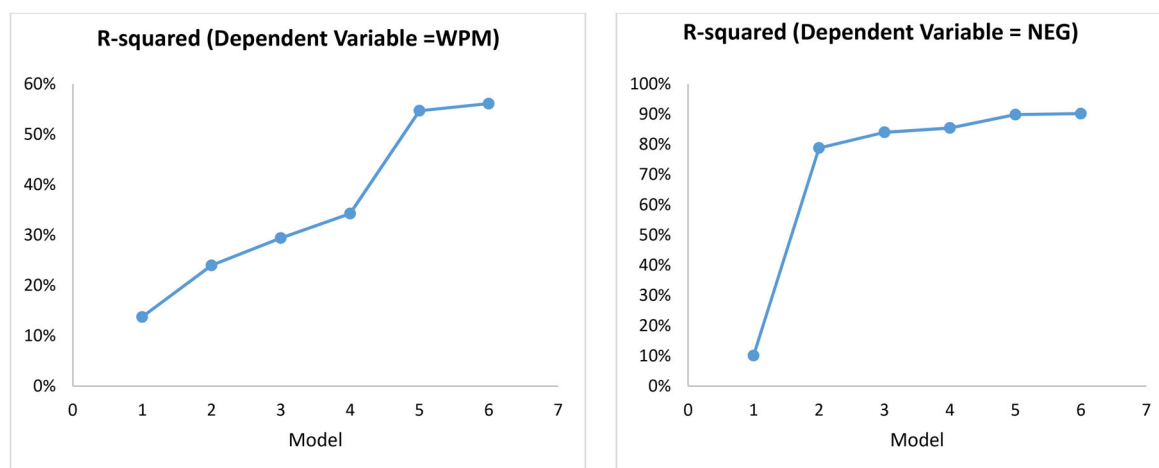


Figure 5. Changes in explanatory power (Dependent Variables = WPM, NEG).

became an anchor for most economies while tourism suffered a huge blow. With countries such as Côte d'Ivoire, South Africa, France, and Egypt ranked as top tourist destinations, such a negative externality presents bottlenecks for economic prosperity in the short term.

4.2.3. Discussion

The results of this study provide a comprehensive understanding of the impact of the COVID-19 pandemic on Côte d'Ivoire's secondary sector from 2020 to 2022. The G2SLS random effects IV regression models highlighted significant disruptions in industrial production growth (IPG), workplace mobility (WPM), and nominal export growth (NEG). Industrial production growth (IPG) was significantly hindered by increased COVID-19 cases, which disrupted supply chains, labor availability, and demand. Lockdowns and travel restrictions exacerbated these issues, leading to a notable decline in industrial activity. The sector's dependency on stable supply chains made it particularly vulnerable to these disruptions. Workplace mobility (WPM) declined sharply due to lockdowns and social distancing measures, influencing the manufacturing and construction sectors. Reduced mobility disrupted normal operations and decreased productivity, underscoring the critical role of worker movement in maintaining economic activities. Nominal export growth (NEG) also suffered as COVID-19 cases rose. Disruptions in global trade and decreased international demand led to a significant drop in exports. This situation highlighted the need for resilient and diversified export strategies to mitigate such impacts in the future. Interestingly, the service sector provided a buffer during the pandemic, partially offsetting manufacturing declines and emphasizing the importance of economic diversification. This resilience suggests that enhancing the service sector could be strategic for future economic stability. Governmental policy responses, including fiscal spending, monetary adjustments, and targeted industry support, were somewhat effective in mitigating immediate economic pressures. However, a more balanced and comprehensive policy approach is necessary for sustained recovery. Recommendations include promoting service sector development, implementing balanced fiscal and monetary policies, improving infrastructure, investing in workforce training, and ensuring resilient international trade operations. In conclusion, the COVID-19 pandemic significantly influenced Côte d'Ivoire's secondary sector, revealing vulnerabilities and highlighting the need for strategic policy measures, economic diversification, and infrastructure development to build resilience and support sustainable growth.

5. Conclusion

This study aimed at appraising the impact of the COVID-19 pandemic on the performance of the secondary sector in a panel of countries including Côte d'Ivoire, Nigeria, Egypt, South Africa, China, and France. To this end, the study employed a random effects panel data regression method with a complementary IV regression to remedy the endogeneity problems prevalent with some vector variables. Primarily, Côte d'Ivoire is the base country for analysis. Monthly data from January 2020 to December 2022 were utilized, as this period perfectly captures the post-COVID-19 window of observation. The results of the uncorrected random effects regression yielded conflicting nuances. The IPG regression reveals a significant positive influence of domestic COVID-19 factors on secondary sector performance, which contradicted the economic theory on externalities thus suggesting a pending diagnostic problem. Relaxing the models to embody more independent variables confirms the presence of endogeneity as the coefficient of the aforementioned factors experiences a change in sign.

Further specification of the model to include WPM and NEG as dependent variables precipitate a significantly negative impact of domestic COVID-19 factors on secondary sector performance at different levels of relaxation and significance. To control for spurious results, this study uses the G2SLS random effects IV regression to remedy the apparent endogeneity problem, as observed by the change in the sign of coefficients in the first step. The results yield interesting nuances. First, ConfCas, as a proxy for domestic COVID-19 factors, has a significantly negative impact on secondary sector performance for panel countries at different levels of relaxation and significance. This implies that the proliferation of COVID-19 cases was commensurate with the reductive performance in the secondary sector metrics. Second, the structural changes highlighted in the results indicate the importance of economic-base diversification for any country. The externality of COVID-19 negatively affected the earmarked backbone

of the economy, secondary sector, and underscored the viability of the service sector. This then implies that Côte d'Ivoire's fiscal mandate could be enhanced by accounting for such key sectors that keep the economy afloat vis-à-vis external shocks. The resource curse, as well documented in the literature, hinges on overinvestment in one sector, such that other sectors are underdeveloped. As such, in the face of a negative externality such as COVID-19, a well-diversified economy relies on the vibrancy of the service sector thus smoothing out the negative impact. Third, significance of the coefficient for change in policy rate's influence on nominal export growth (NEG) connotes the economical potency of monetary aggregates. It then makes sense that there is need for better balance between fiscal and monetary policies as they both seem to affect secondary sector's performance. This then substantiates the postulations of a need for a comprehensive approach to improve the Ivorian economy rather than the silo form as it has previously been the case.

To that end, the study recommends a multi-level public investment approach to enhance the economic base and remedy the previously mentioned vulnerabilities. Particularly, the study underscores the importance of the service industry, which falls under the tertiary sector. Inasmuch as African economies focus on the primary and secondary sector, results of the study do confirm that such overdependency is not economically sustaining.

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Authors' contributions

All authors approved the composition of the study and suggested ideas for its completion. Dago Dogo Armand formulated the methodology, software, and first written essay. Dago Dogo Armand collected data. Yu Pei anticipated the analysis, confirmation, formulation, and evaluation. Yu Pei performed adjustments and supervision. All authors have read and approved the final document.

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Data availability statement

Data for the study is obtained from publicly available sources and can be made available upon request.

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