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External Debt and Manufacturing Sector's Performance in MINT Countries: Evidence from Dynamic Heterogeneous Panel Estimation Techniques

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Abstract
The study assesses external debt's impact on MINT countries' (Mexico, Indonesia, Nigeria, and Turkiye) manufacturing sector's performance during the 1980–2021 period, using dynamic heterogeneous panel methods (i.e. dynamic fixed effects, mean group, and pooled mean group estimators). The findings portray the presence of long-term relation between external debt and manufacturing performance (alongside external debt service, inflation rate, population size, exchange rate, FDI, and agricultural output) based on the Kao's residual cointegration test. The empirical outcomes portray a dampening impact of external debt on manufacturing sector's performance during the short and long term. Moreover, external debt servicing, FDI, population size, and inflation rate promote the sector's performance, but exchange rate (depreciation) hurts manufacturing performance. Furthermore, the Dumitrescu-Hurlin heterogeneous panel causality test portrays a one-way causality from external debt servicing (and exchange rate) to manufacturing sector's performance and a two-way causality between manufacturing sector and population (and FDI and agricultural output). Thus, policies aimed at lowering external debt, lessening exchange rate variability and inflation rate, and boosting inward FDI are recommended to promote the sector's performance.

Keywords Manufacturing sector · External debt · MINT countries · Dynamic panel techniques

JEL Classification C23 · C33 · L60 · N60 · F34 · H60

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Introduction

The significance of the manufacturing sector in economic development process cannot be overstressed. The newly emerging group comprising of Mexico, Indonesia, Nigeria, and Turkiye (i.e. MINT) was coined in line with the nations' potentials as manufacturing hubs and investment destinations. For example, Mexico has a strong manufacturing sector, particularly in industries like automotive, electronics, and aerospace (World Bank, 2021), which account for a significant share of its GDP and exports. Indonesia has seen considerable growth in her manufacturing sector, with industries like textiles, electronics, and automotive contributing to economic expansion (IMF, 2021). Nigeria has tried diversifying her economy and developing the manufacturing sector, focusing on agro-processing, textiles, and cement (World Bank, 2019). Efforts to promote industrialization and diversify the economy beyond oil have raised the potentials of industries including cement, food processing, and textiles as crucial to Nigeria's economic development (Ogbonna et al., 2021). However, Nigeria's manufacturing sector has faced various challenges including inadequate infrastructure, policy uncertainties, and limited access to finance (Oyewumi et al., 2020). Turkiye has a well-established manufacturing sector with strengths in automotive, machinery, and textiles (OECD, 2021; Central Bank of the Republic of Turkiye, 2021). Although Turkish manufacturing contributes significantly to employment creation and export earnings (Turkish Statistical Institute, 2021), the sector has faced challenges with respect to competitiveness, productivity and structural reforms.

Besides, the MINT nations have experienced varying levels of external debts over the years. Nigeria is currently faced with substantial external debt burden due to oil price volatility, fiscal mismanagement, and corruption (Iyoha & Oriakhi, 2019). The country has implemented debt relief programmes and pursued economic diversification to reduce its dependence on oil revenues (Onapajo & Balogun, 2018). Notwithstanding, Nigeria's external debt has increased in recent years, driven by the need to finance infrastructure projects and address fiscal challenges (Central Bank of Nigeria, 2021). Similarly, Indonesia also has a significant external debt, due largely to infrastructure investments (Hartadi & Hidayat, 2020; Warr, 2019). The government has implemented measures to manage its external debt, including diversifying funding sources and focusing on long-term debt (Bank Indonesia, 2021). Moreover, Turkiye has faced challenges with external debt sustainability, and its high external financing needs have raised concerns (IMF, 2021; OECD, 2021; Orazgani, 2020). In addition, Mexico's external debt has been influenced by fiscal deficits and currency depreciation (Cornejo & Schmidt-Hebbel, 2017; Mishkin, 2017). In the 1980s, the country faced a debt crisis that led to restructuring its external obligations (Ruíz, 2017). However, in recent years, Mexico's external debt has remained relatively stable.

The role of external debt on manufacturing sector's output or performance is a complex one (Hofman & Ma, 2020). For instance, external debt can provide financing for infrastructure development, technology transfer or adoption or upgrades, research and development, human capital development, market

expansion, and countercyclical policies (Adams & Cuevas, 2019; Dudley, 2018; Emily, 2024a; Manasse & Turrini, 2020; Sorensen et al., 2020). These can enhance manufacturing capabilities and productivity, competitiveness, market access, and export revenues via improved energy systems, transportation and telecommunication networks, trade promotion activities, diversification of customers' base, lower production costs, and efficient supply chain (Dudley, 2018; Duramany-Lakkoh et al., 2021; Foster et al., 2018; Krugman et al., 2021; World Bank, 2021). Toeing this line of thought, Mwiti and Gitagia (2023) portrayed long-term debt is a valuable tool for enhancing a firm's market value, cash flow stability, profitability, and overall financial health. Thus, external borrowing can enable MINT nations' manufacturing sector to acquire advanced technologies and expertise amongst others, leading to increased efficiency, improved product quality, and enhanced competitiveness in global markets (Abidin et al., 2021), and consequently growth of the sector (Berr et al., 2021).

Nevertheless, high debt levels can pose challenges. For instance, servicing debt obligations tend to limit fiscal space for investment in the manufacturing sector (Abidin et al., 2021). The obligations to repay borrowed funds on predetermined dates, particularly with long-term debt financing, place huge burden on manufacturing firms (Naomi, 2023). In addition, huge debt and uncertainty surrounding debt sustainability can crowd-out private investment and reduce fiscal space to support the manufacturing sector and its growth, thus causing exchange rate vulnerabilities (Abidin et al., 2021; Akkemik & Turhan, 2019; Dawood et al., 2024; Ghosh, 2018; IMF, 2019; Liu et al., 2023; Sowunmi, 2018). Moreover, exchange rate vulnerabilities and uncertainty stemming from external debt can result in low competitiveness of manufacturing exports and erosion of investors' confidence (Dong et al., 2021; Handoyo et al., 2023; Sowunmi, 2018). Other consequences of rising and unsustainable external debt levels are reduction in inward FDI and allocation of a significant portion of a nation's revenue to servicing debt. These in turn limit manufacturing sector's access to capital for productive investment, technology, and global markets (Celasun et al., 2017; Chen et al., 2024; World Bank, 2019), leading to declines in manufacturing sector's output or performance.

This research is motivated on the premise that manufacturing sector's performance is closely linked to a country's global competitiveness and key to economic diversification. Studying external debt impact on MINT countries' manufacturing sector allows policymakers and stakeholders to identify factors that can enhance competitiveness and promote diversification for them to explore their investment potentiality. Additionally, understanding the impact of external debt on the manufacturing sector can guide investment decisions and enhance economic stability in these countries. It can also aid them in designing effective policies and/or strategies to manage debt levels, promote sustainable manufacturing sector growth, and minimize potential negative impacts.

The research aims to contribute to extant literature in several ways. First, the research is a pioneering effort to evaluating external debt (stock and servicing) impact on MINT nations' manufacturing sector's performance. The choice of MINT is based on their uniqueness and shared similarity in terms of economic potentials, debt burden, and opportunity for investment. Second, to obtained robust conclusion

on external debt's influence on MINT nations' manufacturing sector, the research employs dynamic heterogeneous panel estimation techniques including dynamic fixed effects (DFE), mean group (MG), and pooled mean group (PMG) estimators. Amongst other things, the techniques accommodate both dynamic short- and long-term estimates and a possible heterogeneous dynamic adjustment process, thus, yielding better insights on external debt-manufacturing sector's performance relation. Also, the application of Dumitrescu-Hurlin heterogeneous panel causality tests provides an opportunity to understanding the direction of causality between the variables.

The remainder of the paper is structured as follows. Relevant empirical studies on external debt-manufacturing sector relation are presented in the "Literature Review" section, while the methodology is taken up in the "Methodology and Data" section. The "Results and Discussion" section comprises empirical findings and discussion. The study is concluded, and policy implications were provided in the "Conclusion" section.

Literature Gap

Given the noticeable impact of external debt on economic growth and development, there has been extensive research on external debt and certain macroeconomic variables (which influence manufacturing sector performance). However, the precise relation between external debt and manufacturing performance remains under-explored, particularly at both the country and cross-country levels. Additionally, existing studies on this relation yielded mixed findings, and there is a notable research gap with respect to MINT countries, despite their manufacturing sectors' potentials and current debt challenges. This research aims to fill this gap by evaluating the impact of external debt on the manufacturing sectors in MINT nations from 1980 to 2021, using dynamic heterogeneous panel methods (including, dynamic fixed effects, mean group, and pooled mean group estimators).

Literature Review

The literature suggests that external debt can impact a nation's manufacturing sector's performance. Mounting and unsustainable debts hurt the manufacturing sector via causing exchange rate vulnerabilities, reducing global competitiveness and export revenues, limiting businesses' access to credit and crowd-out private investment, creating uncertainty, and eroding investors' confidence (Abidin et al., 2021; Akkemik & Turhan, 2019; Celasun et al., 2017; Dong et al., 2021; Ghosh, 2018; IMF, 2019; Sowunmi, 2018; World, 2019). These in turn result to lowering manufacturing sector's performance. However, external debt can boost manufacturing sector capacity and output via increased access to finance for infrastructure development (such as transportation and telecommunication networks), technology transfer or adoption, human capital development, promotion of trade activities, market expansion, countercyclical policies, amongst others (Adams & Cuevas, 2019;

Dudley, 2018; Duramany-Lakkoh et al., 2021; Foster et al., 2018; Krugman et al., 2021; Manasse & Turrini, 2020; Sorensen et al., 2020; World Bank, 2021).

On empirical front, several researches exist concentrating on manufacturing sector's performance determinants and its impacts, both in developed, emerging, and developing nations. However, very little effort has gone into evaluating external debt (stock and servicing) impact on manufacturing sector. Some studies assessed external debt influence on sustainable economic growth and/or development (Aladejare, 2023; Dey & Tareque, 2020; Edo et al., 2020; Guei, 2019; Mohsin et al., 2021; Otieno, 2024; Sandow et al., 2022; Senadza et al., 2018), investment (Abdelaziz et al., 2019; Omosuyi (2024);;, financial development (Agyapong & Bedjabeng, 2020), infrastructural development (Kengdo et al., 2020), and carbon emissions (Bese et al., 2021). Others examined drivers of manufacturing sector's performance in emerging and developing nations (Larteya & Nigatu, 2021; Neoh & Lai, 2021; Onodje & Farayibi, 2020; Orji & Ezeanyaeji, 2022; Alugbuo et al., 2023; Yee & Bakar, 2023).

However, few studies concentrated on external debt-manufacturing sector performance relation in individual economy. For example, Ayyoub et al. (2012) adopted the OLS estimator to evaluate how external debt and external debt service impacts Pakistan's manufacturing sector's output growth over the 1989–2010 period. The findings portray a favourable influence of external debt but an adverse influence of debt servicing on manufacturing sector's output growth. Using panel estimator, Matelis and Huettinger (2014) found that external debt exerts a negative influence on the manufacturing sector, and debt servicing crowds out investment in the sector during the 1980–2011 period. Elsewhere, Naomi (2023) hired thematic literature review and established mixed impacts of debt financing on financial performance of manufacturing firm in Kenya. Using a dynamic GMM panel VAR regression and propensity score mapping in India, Tiwary (2023) found no evidence supporting a higher return on assets for firms with higher levels of foreign currency debt. But the propensity score mapping revealed a significant difference between debt servicing and the return on capital employed by firms. Ayuba et al. (2023) examined the interactive effects of external debt and infrastructure on industrial output in 29 SSA nations over the 2005–2021 period, using the panel autoregressive distributed lag (PARDL) model. The study found that external debt positively influenced industrial output growth in the long term but has a negative impact in the short term.

Investigating the impact of external debt on industrialization, Fogang & Tchitchoua (2020) utilized the panel smooth transition regression method to analyse data for 10 African franc zone countries from 1996 to 2017. They found a non-linear relation between external debt and industrialization, contingent upon external debt levels. Specifically, they identified a threshold of 58.91% of GDP. Below this threshold, external debt does not have a direct effect on industrialization, but once this level is exceeded, it becomes detrimental to industrial development.

In Nigeria, Osu (2019) and Nteegah & Olubiyi (2022) confirmed a strong positive influence of external debt on Nigeria's manufacturing sector. Also, Ahmad et al. (2020) examined the association between debt financing on Nigeria's listed companies during the 2008–2017 period. They observed a short-term debt insignificant influence and long-term debt positive effect on firm value. Chinemerem et al. (2022)

investigated the impact of deficit financing (encompassing domestic debt, foreign debt, budget deficit), and foreign exchange reserves on sectoral output, specifically in the manufacturing and services sectors, from 1986 to 2020. Using the ARDL estimator, they submitted that external debt has a negative but insignificant influence on manufacturing sector's output. Emily (2024a) employed the ARDL technique to assess fiscal policy variables' impact on Nigeria's manufacturing sector from 1987 to 2022 and claimed that external debt has a negative effect on manufacturing sector. Using similar methodology on fiscal policy indicators on the non-manufacturing industrial sector in Nigeria from 1987 to 2022, Emily (2024b) revealed a dampening influence of both external and internal debt on manufacturing industrial output.

Contrariwise, research elsewhere portrays an adverse impact of external debt (stock and servicing) on manufacturing sector's performance in emerging and developing nations including Botswana, Nigeria, and Sierra Leone (Kur et al., 2021). Yet, certain studies established an insignificant relation between the manufacturing sector and external debt (Chinemerem et al., 2022; Duramany-Lakkaoh et al., 2021; Mohammed & Ibrahim, 2022). Nevertheless, Emily (2024a, b) confirmed a diminishing influence of external debt on manufacturing output.

Based on surveyed literature, two conclusions are drawn. First, despite the plethora of researches on external debt including other potential drivers of manufacturing sector's performance, little attention has been paid to understanding external debt-manufacturing sector's performance nexus, both at country-level and cross-country perspective. Second, existing research reported mixed findings on external debt-manufacturing sector relation. Third, studies on the relation between the two are non-existent in MINT countries despite the nations' potentials in manufacturing and the debt challenges they currently face. Thus, this research extends the literature by evaluating the external debt (stock and servicing) impact on MINT nations' manufacturing sector during the 1980–2021 period, using robust estimation techniques including DFE, MG, and PMG.

Methodology and Data

Model Specification

To explore external debt impact on MINT countries' manufacturing sector, the study specifies the model:

$$lnMAN_{it} = \omega_1 lnEXD_{i,t} + \delta\prime Z_{i,t} + \eta_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

where $i = 1,2,\ldots,N$ is the number of countries and $t = 1,2\ldots,T$ denotes time. ω_1 and δ are slope coefficients. *ln* is natural log. *MAN* represents manufacturing sector performance (proxy by manufacturing sector value added in US dollars), and *EXT* is external debt stock (proxy by ratio of total external debt stocks to gross national income). *Z* is a set of control variables including debt service on external debt in US dollars, official exchange rate (proxy by annual average based on yearly averages of local currency units relative to the US dollar), total population, foreign direct

investment relative to the GDP, annual inflation rate, and agricultural output relative to the GDP). μ_t is unobserved time-specific effect, η_t represents country-specific effect, and $\varepsilon_{i,t}$ is independent and identically distributed error term. Except inflation rate, external debt, foreign direct investment, and agricultural output, all other variables are transformed into natural logarithm before analysis to reduce skewness. The data on all variables are sourced from the World Bank's World Development Indicators (WDI) database. Annual data used covers the 1980–2021 period. The variables description is contain in Table 1.

Estimation Technique

Having the length of time series (T) greater than the number of countries (N), the research employs dynamic fixed effects (DFE), mean group (MG), and pooled mean group (PMG) estimators. Although similar, the techniques vary in their treatment of the slope coefficients. For instance, the PMG technique (Pesaran et al., 1999) assumes homogeneous long-term coefficients across groups but allows the intercept, short-run slope coefficients, and error variance to vary across groups. In the MG technique (Pesaran & Smith, 1995), the intercept, short- and long-term slope coefficients, and the error variance are permitted to vary across countries. In contrast, the DFE estimator allows the intercept to differ across groups but assumes homogeneity of the short- and long-term slope coefficients. Generally, the techniques are favoured over the conventional methods due to their ability to accommodate long-term equilibrium and possible heterogeneous dynamic adjustment process (Ehigiamusoe & Lean, 2018).

Following Pesaran et al. (1999), a bivariate unrestricted error-correction representation of autoregressive distributed lagged (ARDL) (p,q) model is written as follows:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \vartheta_{ij}\prime x_{i,t-j} + \mu_i + \upsilon_{i,t} \tag{2}$$

where x_{it} is a $k \times 1$ vector of independent variables. ϑ_i are the $k \times 1$ coefficient vector. λ_{ij} are scalars. $\upsilon_{i,t}$ denotes the error term.

Equation (2) can be re-parameterized and expressed in an error-correction representation as follows:

$$\Delta y_{it} = \phi_i\left(y_{i,t-1} - \theta_i\prime x_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij}^{*} \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \vartheta\prime_{ij}^{*} \Delta x_{i,t-j} + \mu_i + \upsilon_{i,t} \tag{3}$$

where Δ represents the first difference operator. ϕ_i is the coefficient of the error-correction term and measures the speed of adjustment to long-term equilibrium, and $\theta_i\prime$ represents the vector of long-term parameters. The optimal lag length (p,q) is determined by the AIC. Since the DFE estimator assumes homogenous slope coefficients, it is used as the benchmark model, while the Hausman test of homogeneity of

Table 1 Data description

Variable	Position	Description	Sign	Source
Manufacturing sector performance	Dependent	Manufacturing sector value added in US dollars	–	WDI
External debt stock	Independent	Ratio of total external debt stocks to gross national income	Positive	WDI
Debt services	Independent	External debt services in US dollars	Negative	WDI
Official exchange rate	Independent	Annual average based on yearly averages of local currency units relative to the US dollar	Negative	WDI
Population	Independent	Annual total population	Positive	WDI
Foreign direct investment	Independent	Foreign direct investment relative to the GDP	Positive	WDI
Inflation rate	Independent	Annual inflation rate	Negative	WDI
Agricultural output	Independent	Agricultural output relative to the GDP	Positive	WDI

Source: Authors' compilation (2024)

long-term coefficients is done to assess the preferred model between MG and PMG estimators.

Results and Discussion

Summary Statistics and Correlation Analysis

The descriptive statistics for variables (Table 2) portray average of log of manufacturing output, external debt (% of GNI), log of external debt servicing, log of exchange rate, log of total population, FDI (% of GDP), inflation rate, and agricultural output (% of GDP) during the 1980–2021 period as 24.581 (US $76.2 billion), 42.622%, 23.226 (US $24.5 billion), 2.759 (1739.185/US $1), 1.415%, 22.507%, and 14.242%, respectively. Their corresponding standard deviations portray a wide variation in the data point. Further, the correlation analysis shows a weak but significant negative correlation between manufacturing sector output and external debt (and inflation rate). Also, a weak positive correlation exists between manufacturing sector output and exchange rate (and population and FDI) but a strong negative correlation between agricultural output and manufacturing sector. Moreover, the correlation between external debt service and manufacturing sector is strong, positive, and significant.

Table 2 Descriptive statistics and correlation matrix

	lnMAN	*EXD*	*lnDSER*	*lnEXCH*	*lnPOP*	*FDI*	*INF*	*AGR*
Mean	24.581	42.622	23.226	2.759	18.023	1.415	22.507	14.242
Std. dev	1.051	22.788	1.357	4.544	0.516	1.176	26.120	8.031
Min	24.562	39.622	23.455	2.528	17.954	1.364	10.454	14.133
Max	26.162	168.198	25.190	9.588	19.038	5.791	131.827	36.965
lnMAN	1.000							
EXD	−0.221***	1.000						
lnDSER	0.854***	0.121*	1.000					
lnEXCH	0.221***	0.127*	0.134*	1.000				
lnPOP	0.342***	0.056	0.217***	0.956***	1.000			
FDI	0.366***	−0.059	0.293***	0.153**	0.134*	1.000		
INF	−0.355***	0.279***	−0.198***	−0.557***	−0.566***	−0.199***	1.000	
AGR	−0.780***	0.044	−0.799***	0.179**	0.138*	−0.330***	0.044	1.000

Note: *MAN*, ratio of manufacturing output to GDP; *EXD*, external debt stock (% GNI); *EXCH*, official exchange rate; *POP*, total population (ages 15–64); *FDI*, foreign directing investment inflow (% of GDP); *INF*, inflation rate (%); *AGR*, agriculture, forestry, and fishing, value added (% of GDP). *ln* denotes natural log. Asterisks (***), (**), and (*) denote statistical significance at 1%, 5%, and 10% levels, respectively. Source: Authors' computation using EViews 12

Cross-Section Dependence Test

Prior to estimating external debt and manufacturing sector relation, a cross-section dependence (CSD) is conducted to ensure that assumptions underlying the use of panel data analyses are met, in addition to applying appropriate estimation techniques. Interestingly, cross-sectional correlations of errors are likely to emanate when employing panel data, and failure to take this into account can result in inconsistent estimates and drawing wrong inferences (Chudik & Pesaran, 2013; Ehigiamusoe & Lean, 2018). To determine the presence of cross-sectional dependence amongst MINT nations, four cross-section dependence (CSD) tests are conducted (Breusch-Pagan LM, Pesaran scaled LM, Pesaran CSD, and Baltagi-Feng-Kao bias-corrected scaled LM).

The results of CDS test (Table 3) portray that null hypothesis of "no cross-sectional dependence" is rejected for all variables, thus indicating the presence of interdependence amongst the nations.

Panel Unit Root Tests Results

Conducting unit root test is crucial before estimating any empirical relation using time-series data. This is to guide against obtaining meaningless results and drawing inaccurate inferences. The results of panel unit root tests (Table 4) using both the first-generation panel unit root tests (Levin-Lin-Chu (LLC), Im-Pesaran-Shin (IPS), and ADF-Fisher tests, and the second-generation test (Pesaran, 2007 CIPS test) present mixed outcomes. For instance, the first-generation tests suggest that debt servicing, exchange rate, FDI, inflation rate, and agricultural output are integrated to order zero, while manufacturing sector output and external debt and population are integrated at order 1. However, the results of Pesaran (2007) test (which account for cross-sectional dependence) portray that all variables (except debt service and population) are stationary at level.

Table 3 Results of cross-sectional dependence tests

CSD tests/variables	Breusch-Pagan LM	Pesaran scaled LM	BFK bias-corrected scaled LM	Pesaran CD
lnMAN	150.273***	41.648***	41.599***	11.789***
EXD	18.984***	3.748***	3.699***	2.023**
lnDSER	106.629***	29.049***	29.0004***	8.179***
lnEXCH	226.712***	63.714***	63.665***	15.049***
lnPOP	249.884***	70.403***	70.355***	15.808***
FDI	20.788***	4.269***	4.219***	3.337***
INF	22.462***	4.752***	4.703***	3.589***
AGR	140.622***	38.862***	38.813***	3.035***

Note: H_0, no cross-section dependence (correlation). $df = 6$. Asterisks (**) and (***) denote significance at the 5% and 1% level, respectively. *BFG* is Baltagi, Feng, and Kao (2012) bias-corrected scaled LM-CSD test. Source: Authors' computation using EViews 12

Table 4 Panel unit root tests

Variables/tests	First-generation tests			Second-generation test
	LLC	IPS	ADF Fisher	CIPS
lnMAN	−0.817	1.431	2.368	−2.413**
EXD	−0.736	−1.093	10.728	−2.330**
lnDSER	−3.095*	−1.131**	15.115***	−1.736
lnEXCH	−4.829***	−3.210***	30.843***	−3.030***
lnPOP	0.031	−1.386*	18.898**	−0.039
FDI	−2.641***	−2.445***	20.651***	−3.435***
INF	−6.438***	−5.184***	44.298***	−3.934***
AGR	−4.064***	−2.245**	17.250**	−2.269*
Δ*lnMAN*	−11.568***	−10.442***	94.742***	–
Δ*EXD*	−10.945***	−10.334**	93.415**	–
Δ*lnDSER*	–	–	–	−6.101***
Δ*lnEXCH*	–	–	–	–
Δ*lnPOP*	−2.482***	–	–	−2.557***
Δ*FDI*	–	–	–	–
Δ*INF*	–	–	–	–
Δ*AGR*	–	–	–	−5.360***

Note: Δ is first differenced notation, *LLC* denotes Levin-Lin-Chu test, *IPS* is Im-Pesaran-Shin test, and *CIPS* is Pesaran's (2007) cross-sectional augmented IPS (CIPS) test. Asterisks (***), (**), and (*) denote statistical significance at 1%, 5%, and 10% levels, respectively. Source: Authors' computation using EViews 12 (LLC, IPS, and ADF-Fisher tests) and Stata 14 (CIPS — *xtcips* package)

Cointegration Tests

The Kao residual cointegration test was adopted to assess presence of long-term relation between the variables. The result (Table 5) provides a robust support to reject null hypothesis of no cointegration between the variables at 1% level, thus portraying that long-term relation exists between them.

Table 5 Result of Kao residual cointegration test

Null hypothesis: no cointegration	*t*-statistic	Probability value
ADF	−8.458	0.000***
Residual variance	0.013039	
HAC variance	0.011067	

Note: Asterisk (***) denotes statistical significance at 1% level. Source: Authors' computation using EViews 12

Estimation Results

The results of panel estimation (Tables 6 and 7) report short- and long-term estimates of DFE, MG, and PMG models, alongside Hausman test results. Also, the cross-sectional short-term estimates for all countries are reported in Table 6. Since the results of Hausman tests portray that the PMG is preferred to MG and DFE estimators, the emphasis is on PMG estimation results.

The results of PMG (column III) portray that external debt has a significant adverse influence on manufacturing sector performance, during the long and short term, at 1% level and 5% level, respectively. A percentage increase in total external debt leads to worsening manufacturing sector performance by 0.906% during the long term and 0.936% during the short term. The negative relation between external debt and manufacturing sector is not consistent with Nteegah and Olubiyi (2022) and Osu (2019) finding that external debt promotes manufacturing sector's

Table 6 Panel estimation results of external debt and manufacturing sector relationship

Variables	Dependent variable:Δ*lnMAN*		
	DFE (I)	MG (II)	PMG (III)
Panel A: long-run estimates			
EXD	−0.0082 (0.0021)***	−0.0099 (0.0042)**	−0.0091 (0.0028)***
lnDSER	0.1154 (0.1034)	0.0167 (0.1322)	0.4316(0.1170)***
lnEXCH	−0.0586 (0.0355)*	−0.2948 (0.1253)**	−0.1159 (0.0292)***
lnPOP	2.3496 (0.3371)***	5.1321 (1.664)***	3.7396 (0.4866)***
FDI	0.0469 (0.0444)	0.0356 (0.0429)	0.0281 (0.0426)
INF	0.0045 (0.0025)*	0.0022 (0.0046)	0.0124 (0.0034)***
AGR	−0.0524 (0.0160)***	−0.0165 (0.0164)	0.0324 (0.0265)
ECT	−0.2253 (0.0465)***	−0.5189 (0.1004)***	−0.2083 (0.0863)**
Panel B: short-run estimates			
Δ*EXD*	−0.0085 (0.0009)***	−0.0096 (0.0025)***	−0.0094 (0.0015)**
Δ*lnDSER*	0.0102 (0.0247)	−0.0179 (0.0600)	0.0249 (0.0409)
Δ*lnEXCH*	−0.2122 (0.0524)***	−0.5057 (0.1033)***	−0.4549 (0.1217)***
Δ*lnPOP*	2.0713 (2.9559)	33.459 (17.1129)*	13.3678 (5.8022)**
Δ*FDI*	0.0082 (0.0102)	0.0149 (0.0099)	0.0129 (0.0072)*
Δ*INF*	0.0007 (0.0007)	0.0031 (0.0015)**	0.0042 (0.0017)**
Δ*AGR*	−0.0112 (0.0059)*	−0.0204 (0.0191)	−0.0114 (0.0118)
Constant	−4.3174 (1.4699)***	−43.1769 (24.9845)*	−11.0255 (4.3761)**
Hausman test (Prob.)	7002.19 [0.000]**	12.26 [0.092]	–
Observations	168	168	168
No. of countries	4	4	4
Log likelihood	–	–	215.915

Note: The optimal lag length is suggested by AIC. *DFE*, dynamic fixed effect; *MG*, mean group; *PMG*, pooled mean group. Values in (.) are standard error, and [.] is probability value. Asterisks (***), (**), and (*) denote statistical significance at 1%, 5%, and 10% levels, respectively. Source: Authors' computation using Stata 14

Table 7 Estimation results of external debt and manufacturing sector relation (country specific)

Regressors	Dependent variable:Δ*lnMAN*			
	Mexico	Indonesia	Nigeria	Turkiye
ECT	−0.3396 (0.0803)***	−0.0553 (0.0567)	−0.0633 (0.0275)**	−0.3749 (0.0847)***
Δ*EXD*	−0.0059 (0.0021)***	−0.0097 (0.0014)***	−0.0085 (0.0018)***	−0.0132 (0.0033)***
Δ*lnDSER*	0.1396 (0.0355)***	−0.0535 (0.0650)	0.0010 (0.0299)	0.0124 (0.1072)
Δ*lnEXCH*	−0.6725 (0.1034)***	−0.3473 (0.1219)***	−0.1626 (0.0752)**	−0.6373 (0.1533)***
Δ*lnPOP*	25.7487 (5.5365)***	9.8187 (1.7435)***	18.9295 (11.5221)*	−1.0258 (3.3304)
Δ*FDI*	0.0092 (0.0129)	0.0137 (0.0115)	−0.0030 (0.0168)	0.0317 (0.0231)
Δ*INF*	0.0044 (0.0007)***	0.0084 (0.0021)***	0.0001 (0.0014)	0.0038 (0.0014)***
Δ*AGR*	−0.0340 (0.0282)	0.0198 (0.0087)**	−0.0068 (0.0070)	−0.0247 (0.0153)*
Constant	−18.0353 (3.9059)***	−3.088 (3.1124)	−3.8329 (1.2669)***	−19.1453 (5.1039)***

Note: Values in (.) are standard error. Asterisks (***), (**), and (*) denote statistical significance at 1%, 5%, and 10% levels, respectively. Source: Authors' computation using Stata 14

performance in Nigeria. Given the enormous size of MINT nations' external debt stock, the outcome portrays that more external debt will worsen manufacturing sector performance either through the debt-overhang effect or the debt crowding-out effect. Moreover, external debt servicing is found to enhance manufacturing sector performance during the long term at 1% level of significance. An increase in debt servicing by 1% leads to improvement in manufacturing sector's performance by 0.4316% during the long term. Although external debt stock shows a negative influence on manufacturing output, external debt servicing may impact manufacturing sector positively via increased foreign capital inflow as an expansion in debt servicing portrays a country's capacity to repay both interest and principal on debt obligations.

In addition, exchange rate (depreciation) impacts manufacturing sector's performance negatively during long and short term at 1% level. A unit increase in exchange rate lowers manufacturing sector's performance by 0.1159% during the long term and 0.4549% during the short term. The outcome supports previous studies in Southern African countries, Nigeria and Sierra Leone (Duramany-Lakkaoh et al., 2021; Falaye et al., 2019; Mlambo, 2020; Nteegah & Olubiyi, 2022; Orji & Ezeanyaeji, 2022), and it suggests that exchange rate depreciation slows down manufacturing sector's performance. The decline in manufacturing output following depreciation is likely on account of inelasticity of the demand for local output by domestic and foreign market (Zhang, 2018).

Moreover, population size impacts manufacturing sector positively during the long and short term. Raising population by a percentage leads to manufacturing sector output expansion by 3.739% during the long term and 13.368% during the short term, at 1% level and 5% level, respectively. The finding supports Ayyoub et al. (2012) that expansion in population size boosts the performance of Pakistani's

manufacturing sector. Rising population size may benefit the manufacturing sector via increasing demand for the sector's output.

More so, FDI has an insignificant positive effect on manufacturing sector's output during the long term, but the relation is significant during the short term at 10% level of significance. A percentage increase in FDI raises manufacturing sector's performance by 1.298% in the short term. The finding supports prior researches in the Middle East and North African (MENA) and Southern African countries including Sierra Leone and Malaysia (Azolibe, 2021; Chandran & Krishnan, 2008; Duramany-Lakkaoh et al., 2021; Mlambo, 2020). The positive influence of FDI on manufacturing sector portrays the role of foreign capital inflow in stimulating the performance of the manufacturing sector in the MINT countries.

Also, inflation rate influences manufacturing sector's output positively during short and long term. The outcome implies that raising consumer price level by 1% will raise manufacturing sector's performance by 1.248% and 0.421% during long and short term, at 1% level and 5% level, respectively. The outcome substantiates the finding of Falaye et al. (2019) in Nigeria. The supportive role of inflation may be associated with the fact that the corresponding increase in the cost of production is not entirely borne by the producers but captured in the price of output and thus transferred to the consumer. While the demand for some products is likely to reduce, there is possibility for an increase in the performance of the overall sector, especially when significant outputs of the sector are necessities. Lastly, the error-correction term (ECT) in Table 5 is significant at 5% level, lower than one (1) and signed correctly, revealing that almost 20.83% of disequilibrium during the short term will be corrected in a year.

Results of the Country-Specific Short-Run Estimates

The results of country-level short-run coefficients (Table 7) reveal external debt stock to impact manufacturing sector's output negatively in all four countries. Compared with the 0.936% negative effect of external debt stock on manufacturing sector in the panel results, the country-level results portray that raising external debt by 1% adversely affects manufacturing sector performance by 0.588%, 0.965%, 0.846%, and 1.311% in Mexico, Indonesia, Nigeria, and Turkiye, respectively.

Regarding the other variables, the results portray debt service to significantly and positively influence manufacturing sector's performance in Mexico, but not in the remaining three. Moreover, exchange rate depreciation dampens manufacturing sector's performance in all four nations during the short term. A unit increase in exchange rate reduces manufacturing sector's output by 0.673%, 0.3473%, 0.163%, and 0.637% in Mexico, Indonesia, Nigeria, and Turkiye, respectively. In addition, population size enhances manufacturing sector's performance in all nations except Turkiye. Although FDI fails to impact manufacturing sector's performance significantly in all countries, inflation rate support manufacturing sector during the short term in all nations except Nigeria. Also, agricultural sector output promotes Indonesia's manufacturing sector during the short term, hurts Turkiye's manufacturing

sector, and is insignificant in influencing manufacturing sector output in Mexico and Nigeria.

Results of Causality Tests

The results of causality tests (Table 8) using the Dumitrescu and Hurlin (2012) heterogeneous panel causality test demonstrate the absence of significant causal relation between external debt and manufacturing sector. The outcome is inconsistent with previous research (Nteegah & Olubiyi, 2022; Osu, 2019), but the outcome supports the finding of Duramany-Lakkaoh et al. (2021). In addition, there is a one-way causality from debt service to manufacturing output, a two-way causal relation between manufacturing output and population (and FDI and agricultural output), and a one-way causality from exchange rate depreciation to manufacturing sector and from manufacturing sector to inflation rate.

Discussion of Findings

The research's main aim is to evaluate external debt influence on MINT nations' manufacturing sector's performance during the 1980–2021 period, using robust estimation methods like DFE, MG, and PMG estimators. The empirical outcomes portray that expansion in external debt stock impact MINT nations' manufacturing sector adversely during short and long term. Countries take external loan to provide governments with the opportunity to invest in human and physical capital (infrastructure) to facilitate the growth of sectors of the economy including overall economic activities. However, misallocation or inappropriate utilization of such loans will not only affect the ability to pay back but also hamper the growth of the sectors of the economy including the manufacturing sector.

Moreover, given the enormous size of the external debt stock of MINT nations, expanding external borrowing may impact the manufacturing sector via reduction in foreign investment in the sector. This can either be on account of debt-overhang

Table 8 Results of Dumitrescu-Hurlin panel causality tests

	lnMAN	*EXD*	*lnDSER*	*lnEXCH*	*lnPOP*	*FDI*	*INF*	*AGR*
lnMAN	–	0.906	4.227	1.193	3.365***	7.623***	3.284***	4.799***
EXD	1.906	–	0.435	1.802	15.527***	2.849**	2.716**	3.338***
lnDSER	2.184***	0.474	–	1.903	5.025***	9.373***	1.576	1.026
lnEXCH	10.119***	2.869**	2.194	–	5.023***	4.147***	3.909***	3.154***
lnPOP	10.016***	1.504	4.598***	1.219	–	5.316***	2.369*	2.629**
FDI	3.235***	1.374	3.032**	2.901**	1.759	–	1.019	0.327
INF	1.173	1.566	0.483	7.408***	5.391***	5.361***	–	2.767**
AGR	3.469***	1.180	2.496*	1.985	0.867	7.939***	1.054	–

Note: H_0 : x_{it} does not homogeneously cause y_{it}. Asterisks (***), (**), and (*) denote statistical significance at 1%, 5%, and 10% levels, respectively. Source: Authors' computation using EViews 12

effect (a situation in which accumulated debt discourage private investment due to an expected increases in tax to enable the government repay the debt) or debt crowding-out effect (a condition when receipts from exports are used to pay accumulated debt). In fact, even in a situation where the expansion in debt stock did not lead to an increase in tax, repaying debt obligations would lead to the shift in budgetary allocations away from some (or all) components of public expenditure in favour of interest payments (Abu et al., 2022). Recently, Nigeria's humongous external (and domestic) debt stock has necessitated the government to commit almost all of its annual revenue to debt servicing.

Furthermore, the supportive role of external debt servicing on manufacturing sector output contradicts economic theory since debt servicing facilitates the outflow of scare foreign capital, promotes balance of payment problem, and depletes external reserves. However, the outcome reflects the possibility of debt servicing acting as an indicator of a country's credit worthiness and/or capacity to service and repay its debts. This may lead to an increase in foreign direct and portfolio investment in critical sectors of the economy, including manufacturing, thus enhancing the sector's performance.

The dampening influence of exchange rate (depreciation) on manufacturing sector does not align with theory and/or assumption that devaluation of local currency causes domestic outputs relatively cheaper and more competitive in the global market. Exchange rate depreciation is supposed to strengthen the demand for domestic output and raise exports, thus leading to increases in the performance of the manufacturing sector (Zhang, 2018). Nevertheless, the finding of a negative impact exchange rate (depreciation) suggests the inelasticity of the demand of MINT nations' exports including their imports. This may be connected to the 'not too' impressive performance of countries' industrial sectors. The export of primary products and the huge reliance of manufacturers on imported raw materials and machinery may also be responsible for such relation. In Nigeria, for instance, where more than 90% of the export basket is made up of primary products (oil and gas) and the manufacturing (and/or industrial) sector is driven by imports of raw materials and machineries, depreciation has not improved the country's exports; rather, it has increased the import size and the demand for foreign currency, all of which slow down the manufacturing sector performance.

In addition, the positive influence of population size on manufacturing sector's performance may be viewed via two perspectives. First, greater manufacturing performance following increased population size may be associated with increased labour productivity. Second is the higher demand for the sector's output as the population increases.

Furthermore, the positive relation between FDI and manufacturing sector reflects the important role of foreign capital in propelling manufacturing output via technology transfer or adoption, managerial expertise and access to credit, amongst others. Also, the increasing effect of inflation on manufacturing sector's output illustrates that increased consumer price level will stimulate the performance of the manufacturing sector. The positive relation is not unconnected with the fact that manufacturers are able to push increased production costs to consumers via higher prices. Besides, if significant portion of the output are necessities, the increased prices will

not reduce the demand. In addition, rising and mild inflation provides an incentive for manufacturing sector's growth.

Conclusion

The research's primary object is to access external debt influence on manufacturing sector's performance in MINT nations (Mexico, Indonesia, Nigeria, and Turkiye) from 1980 and 2021 while controlling for external debt servicing, exchange rate, inflation rate, FDI, population size, and agricultural output. Employing the Kao residual cointegration test, the results portray evidence of a long-term relation between the variables. Moreover, results of the pooled mean group, mean group, and dynamic fixed-effects estimators portray a significant dampening impact of external debt stock on manufacturing sector's performance during the short and long term. In addition, debt service promotes manufacturing sector's performance during the short term, but exchange rate (depreciation) dampens manufacturing sector's performance in all four nations. Also, FDI, population size, and inflation rate influence the manufacturing sector positively, but agricultural sector possesses no significant influence on the manufacturing sector. Besides, the Dumitrescu-Hurlin heterogeneous panel causality test results portray the absence of causal relation between external debt stock and manufacturing sector. However, there is a one-way causality from external debt service (and exchange rate) to manufacturing output and a two-way causal relation between manufacturing output and population (and FDI and agricultural output).

Recommendations

Consequent on the empirical outcomes, the following recommendations are made. First, governments of the MINT nations are advised to design and implement strategies geared towards revitalizing and improving their manufacturing sector. This may include prioritizing businesses access to credit facilities, improvement in infrastructures (like roads, electricity, bridges, air and sea ports, and rail transportation), and the development of primary sectors or the backward-linkage sectors, such as the agricultural and mining sectors.

Additionally, since it was discovered that external debt stock presents a clear danger for the manufacturing sector performance, the governments are advised to review their fiscal policy stances. In most cases, when mismanagement/misallocation of public funds and unproductive expenditure are non-existent, available resources can sustain public spending. However, if the only option to finance public expenditure is through (external) debt, governments are encouraged to resist the urge and need to commit the loans to current expenditures and unproductive investments. It is recommended that loans be channelled to productive sectors of the economy and components of public expenditure. The spill-over and/or overall effects of such efforts make repayment very seamless and, therefore, ensure that debt spur growth including promotion of manufacturing sector growth.

Besides, governments (through the monetary authorities) are encouraged to pursue policies which will ensure the stability in exchange and inflation rates and facilitate the inward foreign capital to their economies, specifically the manufacturing sector. Since it is not possible to recommend efforts to increase the population size despite its positive influence on manufacturing sector, governments are encouraged to investment in human capital development. A small highly skilled and well-trained population is much more important and relevant than a large unskilled population. While the former will aid the social and economic development of the nation, the later may scuttle economic growth and development as they ensure an increase in the burden on the government. These policies can be complemented with the revision of the tax policy to address the issues of multiple taxations as in the case of Nigeria and the strengthening the quality of economic institutions in the countries.

Data Availability The data used for analysis are available upon request.

Declarations

Conflict of Interest The authors declare no competing interests.

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