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International trade, technology, and labour share: a BRICS analysis

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DECLARATION

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Abstract

This research paper comprehensively analyses the complexities of international trade and technology adoption related to labour share within the BRICS nations (Brazil, Russia, India, China, and South Africa). As these diverse countries have experienced rapid trade expansion in recent decades, this study's primary question is: How does international trade and technological innovation impact the labour share of income in the BRICS countries) from 1991 to 2022?

Despite the trade growth, the BRICS countries face challenges with labour share dynamics, income inequality, and high unemployment rates. The relationship between trade openness, technology innovations, and labour share in these emerging economies may show different trends than in developed countries. While trade has risen, it has not translated into equitable growth in labour income share.

The random effects regression and the generalised methods of moments estimation results for 1991 - 2022 analyse labour share dynamics in BRICS countries. Trade liberalisation and technological innovations show minimal impact on labour share across the random effects models and generalised methods moments estimations, highlighting the importance of other variables, such as labour policies and skills development, to address income distribution related to labour share.

These findings underwrite an understanding of how global economic factors shape income distribution in the BRICS countries. The study aligns with discussions in the Ricardian, Heckscher-Ohlin-Stolper-Samuelson theorem, which forecasts that shifts in factor demands and income distribution will increase trade and technological change.

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1. Introduction

The study of international trade explores the fascinating interaction between trade flows, labour demands, and how income is distributed, drawing on the foundational framework of David Ricardo, Karl Marx, and Heckscher-Ohlin-Stolper-Samuelson. The frameworks provide a reliable and informative theoretical foundation for understanding how international trade and technological progress mould economic outcomes, thus significantly impacting income distribution and labour share. 1991 - 2022 is significant due to global and country economic expansion and transformation. The early 1990s saw economic liberalisation and global integration marked by monumental occurrences including the Soviet Union collapse in Russia (Logue, 2022), China's economic reforms (Stiftung, 2024a), and the political and economic liberation of South Africa (Stiftung, 2024b). These historic events catalysed opened economies through heightened global integration in trade, technology advancements and adoptions, thus influencing labour markets, distributions of income, and productivity across the BRICS countries. Studying this period allows for a comprehensive analysis of these emerging economies that adapted and benefited from trade opportunities and technological adoptions. This study period sheds insights on broader economic patterns, growth and structural reforms. The study also uses a dummy year variable to account for major structural reforms from 2009 onwards (when the BRICS group officially became an organisation) to highlight the impact of trade liberalisation and technology innovation and adoption on labour share from when the BRICS organisation initiated its collaborations.

International trade encompasses productivity and unique country endowments such as capital, natural resources, and land. The Ricardian trade model explains how these differences between countries drive trade. The model illustrates how countries benefit by specialising in what it is best at producing and balancing these resources with their technology to produce goods efficiently. Previously, governments have been apprehensive about global competition with the fear that global competition might harm domestic industries. This lead to import restrictions and export subsidies intended to protect domestic markets and grow the economy through international trade (Krugman et al., 2018). Over time, Asian economies have shown notable growth

through adopting international trade and modifying their economies to succeed in a competitive international market.

The comparative advantage theory, as discussed by David Ricardo, discusses the economic gains countries attain when they specialise in goods they produce efficiently, goods that they can produce efficiently and at lower costs (Dean et al., 2020). This concept highlights how countries can improve their economies and living standards by focusing on their strengths and engaging in trade. Expanding on Ricardo's ideas, the Heckscher-Ohlin theory includes capital alongside labour to develop the notion of international trade (Suranovic, 2010). The Heckscher-Ohlin theory explains how countries' specialisation shapes trade patterns. The theory predicts that countries with abundant labour will gain more from trade, while countries abundant in capital tend to see returns affected as trade progresses. In the Heckscher-Ohlin-Stolper framework, trade is shaped by globalisation, technological advancements, and shifts in economic frameworks, especially in countries like the BRICS group (Dunne and Edwards, 2006).

Globalisation has reduced trade barriers and is prominent and vital in global integration through organisations such as the World Trade Organisation, which initiated trade among developed and emerging economies and created a tightly interconnected global economy (Anjum and Perviz, 2016). The surge in digital technology has enabled businesses to reach new global markets worldwide and improve production efficiency through economies of scale (Ayesha, 2023). This technological transformation is essential in understanding how trade influences income distribution and economic outcomes, especially in growing developing economies within the BRICS countries.

Real-world studies support these theories, displaying that countries tend to export goods they specialise in, for example, trade between the United States and Britain; over time, both exported goods that played towards their strengths, proving how comparative advantage moulds global trade dynamics. The substantial export growth of China and Russia's role as a leading exporter of hydrocarbons demonstrates how

trade in goods drives economic expansion across domestic sectors (World Trade Organization, 2019).

Understanding these dynamics is necessary for investigating how technological progress, trade patterns, and shifts in income distribution work together within the BRICS economies. These insights reflect broader global economic trends and critical implications for policymaking and approaches to progressing sustainable economic development and equitable growth.

1.1. Problem statement

The labour share represents a portion of the total national income paid to workers. Labour and capital income – income earned by asset owners, i.e., land, machinery, patents, or buildings – equals total national income. Labour share of income is commonly used to measure inequality and progress towards reducing inequality between and within countries (Stockhammer, 2015, International Labour Organization, 2024). The labour share has displayed a global decline in the past two decades. In recent ILO estimates and data projections of the share of labour income, a further downward trend in the share of labour income is observed, adding to the existing negative trend. 2019 recorded the labour share of income at 52.9%. In 2022, labour share of income declined to 52.3%. IOL estimates for 2023 and 2024 are that the share of labour income remains 52.6% or below (International Labor Organization, 2023)

The global labour share of income is deeply rooted in labour share structural changes in the international market, including the increasing integration of global trade, capital-intensive technologies, and shifts in labour demand (Chatterjee and Naka, 2022). The trend observed is relevant when considering emerging economies like the BRICS bloc, where rapid industrial development and integration into global markets have reframed the dynamics between labour and capital.

Focusing on BRICS countries is of interest due to the diversity and scope of these economies, in conjunction with their crucial role in international trade. For example, China and India represent large, growing economies with extensive technological innovation, manufacturing capacity and information technology. However, the productivity level has yet to fully translate into proportional wage growth for labourers. Furthermore, as capital-intensive industries expand, shifts often reduce the labour share of income. In contrast, South Africa, Brazil, and Russia have an abundance of natural resources. However, Russia and Brazil's heavy reliance on natural resource exports - oil and agricultural products - has lead to the labour share of income being influenced by the instability of global commodity prices. With the BRICS countries all exhibiting varying levels of economic development, the variety brings forth an opportunity for a deeper analysis of how international trade and technological innovation impact labour demand in these different contexts.

This study's main goal is to establish the correlation between labour share and factor demand. This research focuses on the emerging economies of the BRICS countries to understand how these dynamics play out in diverse, rapidly developing economies. The study uses econometric methods to investigate the relationship between trade, technology adoption, and labour share.

The central hypothesis is that technological innovations, qualified by international trade for labour, significantly influence economic growth and labour market demands. According to the Heckscher-Ohlin-Stolper-Samuelson framework, the research investigates the factors surrounding international trade and labour demand. It investigates how international trade impacts the distribution of capital and the labour share of income. International trade impacts labour demand, shifting labour towards and away from low-skilled labour. This dynamic is seen in China, where rapid technological implementation has improved production and efficiency but contributed to labour share decline (Karabarbounis and Neiman, 2014, International Labour Organization, 2024).

Moreover, the study aims to identify effective policies that could promote job creation while encouraging technological innovation, which ultimately contributes to more

equitable economic development and informs policy decisions for sustainable and comprehensive growth, all in the context of the BRICS countries. The BRICS framework provides an invaluable scope for such an analysis due to the distinct economic models, each country's global influence, and development levels.

1.2. Research questions

1. How does trade openness affect the labour share of income in the BRICS countries?
2. How do technological advancements impact the BRICS countries' economic growth and labour market outcomes?
3. What is the significant association between technological innovation and changes in labour shares across the BRICS countries?

1.3. Research objectives

1. To theoretically examine trade and labour share theories to find the impact of international trade and technology innovations on labour share.
2. To assess trends in international trade and its contribution to labour and capital outcomes in the BRICS countries.
3. To investigate the significance of trade openness and technology innovations on labour share in the BRICS countries through statistical analysis (random effects model and generalised methods of moments)

1.4. Research Methodology

The methodology will comprehensively analyse the relationship between technological innovation, trade dynamics, and the distributional impacts of labour share within the BRICS bloc. The analysis will include an investigation of how technological changes and trade patterns interact to shape the allocation of labour income. Secondly, the robustness of these relationships should be examined, with random effects robust standard error estimation and generalised methods moments where labour share is

the dependent variable and technology and trade are the independent variables. Related techniques were applied by Guerriero and Sen (2012). Nonetheless, the study's focus is on Brazil, Russia, India, China, and South Africa from 1991 - 2022.

1.5. Paper outline

Chapter 1 highlights the background of the study and motivates and the problem statement through, specifying the research question, research objectives, and methodology techniques.

Chapter 2 will provide the literature review on trade theory (Ricardian comparative advantage and Heckscher-Ohlin-Stolper-Samuelson approaches) and labour share theory (Ricardian and Marxist approaches) to review the BRICS economic standing, labour share frameworks, trade openness, and technological progress shifts and dynamics. Chapter 2 will also review empirical evidence of emerging economies, including the BRICS bloc, for accurate life analysis.

Chapter 3 will provide the study's methodology and inform on the data and statistical techniques used to explore the direct relationship between the BRICS countries' labour share, trade liberalisation, and innovative technology.

Chapter 4 will provide the study's findings and how the findings are reviewed studies.

Chapter 5 will present the summation and conclusion of the study, alongside policy recommendations for real-life application and future studies.

2. Literature review

This chapter reviews literature on trade, explores trade flows and their impact on factor demand using the Heckscher-Ohlin-Stolper-Samuelson framework to understand this relationship. Special consideration is directed to trade, technology, and their worth to the economy through labour share distribution.

2.1. Trade theory

Trade is explained by labour productivity and differences in countries' resources, including capital, mineral resources, and land. The Ricardian trade model explains how differences in countries' resources primarily drive trade among countries. The Ricardian comparative advantage model exhibits how a country's resources (relative factor abundance) and its technological capabilities dictates the intensity of factor usage to produce diverse output (Krugman et al., 2018).

Krugman et al. (2018) noted how, in the 16th century, modern international trade came with much competition that made governments concerned over the negative impacts of competition on the prosperity of domestic industries. Governments intervened to protect the domestic market by limiting imports or subsidising exports. Trade works hand in hand with economic growth worldwide, and many economies have, in the last few decades, shown the most growth, including China, Japan, South Korea, and India. These countries have experienced economic growth through aligning their economies with international trade. The concepts of comparative and absolute advantage need to be understood to understand trade and the gains of trade. Trade occurs because of comparative advantage (Dean et al., 2020).

The summary is based on Hosanna (2023) and includes several factors facilitating international trade. One key driver is the transformation in knowledge, technology, and transportation. They highlight that globalisation has facilitated rapid development in these three divisions and international trade and trading activities. The 2018 IMF World Outlook Report findings show that globalisation has strengthened the transmission of technology and skills globally. Knowledge transfer and technology sharing have shown

up through the international use of patents and trade, facilitated through globalisation, thus boosting international competition. Emerging economies have also developed innovation activities and increased efficiency, making their productivity growth more substantial than in developed economies. Hence, the gap in income across countries is actively being bridged. Between 2004 to 2014 the outcomes were substantial as technology and skills transfers accounted for about 40% of productivity growth across sectors within emerging economies. Furthermore, pioneers in technological progress advance themselves from each other's novelties. Subsequently, economies that were considered smaller economies have evolved to be prominent contributors in the cutting edge of global technology e.g. China and Korea (IMF, 2018).

Furthermore, the basis of comparative advantage emphasises that an economy can improve its profitability by exporting items it produces with lower production costs. Countries then generate higher revenue for these goods, thus optimising their economic activity and improving domestic income (Krugman et al., 2018, Hosanna, 2023). Economic liberalisation through reductions in government trade barriers and trade tariffs is a policy that plays a significant role in driving economic growth and increasing competitiveness (Krugman et al., 2018).

2.2. Comparative advantage

A pioneer of the comparative advantage framework, David Ricardo, explains the theory by stating that a good is produced at a lower cost than another good. Comparative advantage is based on opportunity cost (Dean et al., 2020). Krugman et al. (2018) define *opportunity cost* as trade-offs that offer prospects of an equally beneficial arrangement in global production. Using the rationale of Krugman et al. (2018) to explain opportunity cost, the study uses an example of Ethiopia and China. It takes Ethiopia 5 hours to harvest 1 ton of coffee and 20 hours to produce one car, while China takes 10 hours to harvest 1 ton of coffee and 10 hours to produce one car. Ethiopia’s opportunity cost of harvesting 1 ton of coffee is a quarter of producing a car and its opportunity cost of producing a car is 4 tons of coffee). China’s, opportunity cost of harvesting 1 ton of coffee is one car and its opportunity cost of produce one car is 1 ton of coffee. Hence, Ethiopia benefits from comparative advantage in coffee

bean production as its trade-off of a car is lower than China's 1 car. Conversely, China benefits from comparative advantage in manufacturing cars because its opportunity cost, 1 ton of coffee, is lower than Ethiopia's 4 tons of coffee. Ethiopia should focus on producing coffee, and China should focus on manufacturing cars. Both countries can efficiently acquire the necessary goods by specialising in their comparative advantage and trading areas.

This comparative advantage framework implies that a country's resource endowment (labour and capital), determines the country's specialisation. In the BRICS bloc, the countries have a comparative advantage in agricultural raw resources, IT services, food products, oil and gas, textiles, and manufactured goods (Beyene, 2015). Labour-abundant countries, like China and India, benefit from comparative advantage in labour-oriented sectors. Capital-abundant countries like Russia, may specialise in capital-intensive sectors due to their hydrocarbon resources. When countries specialise, their production is based on their comparative advantage and trade increases, potentially increasing workers' income. However, the labour share of income can diminish notably in capital- or technologically dominant sectors. As more sectors adopt labour-saving technologies and increase productivity, this only sometimes increases wages equivalently to benefit workers as much as capital owners (International Labour Organization, 2024, Beyene, 2015).

While technological innovations advance international trade and competitiveness, they also streamline traditional labour-capital production. Therefore, technological innovation redirects comparative advantage toward capital-intensive sectors, thus reducing labour's bargaining power and replacing low-skilled jobs and, subsequently, the labour share of income. Therefore, technological innovations in BRICS countries-India and China-have transformed sectors from labour-intensive manufacturing to more capital-intensive, high-tech production (International Labour Organization, 2024, Karabarbounis and Neiman, 2014).

Comparative advantage assists in explaining sectoral trade patterns in BRICS economies. For instance, Brazil, Russia and South Africa have comparative advantages in agriculture, raw materials, and energy resources, which may be considered capital-intensive. In contrast, China and India primarily had comparative advantages in labour-intensive manufacturing; however, through technological advancements, China has shifted some of its industries towards capital and technology-intensive industries (Chatterjee and Naka, 2022). As economies evolve, the essence of comparative advantage is modified, specifically income distribution between capital and labour. This results in a decline in labour's share of income through the domination of technology in capital-intensive sectors.

Comparative advantage is related to technological innovations and international trade, explaining why certain BRICS countries have focused on specific industries. Integrating technology shifts the scope of comparative advantage, impacting labour share of income. Advancements in technology heighten capital profits while reducing the demand for physical labour and the labour share of income, even as national incomes grow due to trade and technology innovations. Krugman et al. (2018) illustrate empirical evidence of the Ricardian model. In the early 1950s, the United States had higher output production than Britain in most manufacturing sectors, giving the United States an absolute advantage. Despite this, both countries exported a similar volume of commodities, suggesting Britain had a comparative advantage in specific sectors, even with lower productivity. A 1963 study by Bela Balassa analyses data from 26 manufacturing sectors by comparing the ratios of the United States to British exports with the ratios of the United States to British labour output. The results revealed a strong positive correlation between comparative output and export volumes. Overall, the Ricardian model shows how countries export goods with higher efficiency.

2.3. Heckscher-Ohlin theory

As opposed to the Ricardian model, the Heckscher-Ohlin framework also known as factor-proportions theory, put forth by Eli Heckscher and Bertil Ohlin, adds a second factor of production (Suranovic, 2010). Its two countries, two factors of production, and two goods variants, enables interactions between cross-border markets, resource

markets, and goods markets, through highlighting the link between country's factors of production and their use in producing different goods (Uddin, 2021). The Heckscher-Ohlin model illustrates how shifts in the demand and supply of one market can influence factor markets. Trade openness improves economic efficiency but redistributes between factors of production, benefitting some while others lose from trade. According to the Heckscher-Ohlin model, through private capital ownership in production, income through capital in the form of rents is generated for the owner. Hence, workers earn wages for their contributions to production (Suranovic, 2010).

Heckscher-Ohlin theory extends that trade is expected to increase workers' income levels in labour-abundant countries while potentially decreasing returns on natural capital in capital-deficient countries. Conversely, the opposite effect is anticipated in countries that are labour-efficient and capital-abundant. International trade incentivises countries to specialise in producing goods that use the country's surplus production factors (Hosanna, 2023). Moreover, trade generates profits from output by facilitating global trade movements (Batra and Casas, 1976).

The Heckscher-Ohlin model is applicable in understanding the correlation between technology and the labour share of income in the BRICS bloc. As displayed in the IOL's 2024 report, with technological evolution and capital becoming increasingly automated, traditional dynamics of the labour share of income are disrupted and will often decrease in both labour- and capital-abundant countries, altering the traditional dynamics predicted by the Heckscher-Ohlin model (International Labour Organization, 2024).

In the BRICS countries, particularly China and India, technology's fast adoption has lead to significant wage disparities between skilled and unskilled labour. Furthermore, there is growth in labour for skilled workers and lower wages or stagnant wages for unskilled workers. The above is consistent with the Heckscher-Ohlin model (Wood, 1998, Jain, 2018). Brazil, South Africa, and Russia are more capital-abundant through natural resources. Therefore, through the technological lens, the Heckscher-Ohlin

model would predict that capital-intensive sectors -oil, gas, and metal ores- would dominate, reducing the labour share income as capital owners gain from trade, especially in technology-reliant sectors.

2.4. Heckscher-Ohlin-Samuelson theory

The Heckscher-Ohlin-Samuelson expands on the Heckscher-Ohlin framework by adding a trade model that features two countries, two factors, and two sector. Under the Heckscher-Ohlin-Samuelson framework, two countries manufacture identical two goods with identical productive methods that have identical constant returns to scale, however produced with different factor intensities parallel to cost-minimising capital-labour ratio. These two countries have identical quality of endowments but differ in terms of quantity e.g. labour and land. Countries have identical productive methods and exhibit constant returns to scale. Under Heckscher-Ohlin-Samuelson, transport expenses are removed, there is free trade, and there is perfect competition in consumption (Malan et al., 2015, Steedman and Metcalfe, 1979). According to the Heckscher-Ohlin-Samuelson framework, a country specialises in producing and exporting goods that intensively use its abundant factor (Steedman and Metcalfe, 1979) -labour for China and India or capital for Brazil, Russia, and South Africa (Chatterjee and Naka, 2022). It can be concluded that trade exacerbates the income disparities between labour and capital, which is crucial when analysing income disparities in countries with different factor endowments.

2.5. Stolper-Samuelson theory

The Stolper-Samuelson model is modelled after the price movements of goods and factor gains, alongside the Heckscher-Ohlin framework considering high-tech and factor gains (Malan et al., 2015, Edwards and Behar, 2006). The Stolper-Samuelson theorem describes how price shocks impact labour markets when resources shift towards high-tech sectors with skilled and knowledgeable labour, and away labour-intensive sectors that require low to unskilled labour. The aftermath is a reduction in the price of labour-intensive goods and wages directed to these workers, compared capital-intensive sectors. Ultimately, trade openness exacerbates wage disparities and the cost of skill focused goods in developed economies but mitigates the wage

gap in developing economies by increasing labour-intensive goods and giving unskilled workers more job opportunities (Malan et al., 2015).

While recognising that rapid trade liberalisation and import surges can cause labour market dislocations, the connection between trade and employment cannot be correctly examined independently of overall demand, such as consumer expenditure, investments, and government policies. Additionally, the impacts of global financial markets, such as exchange rates and interest rates, extend this to the impact of technological change, which is also part of the globalisation process associated with information-communication technologies and innovative machinery in firms, which can explain labour market problems (Akyuz et al., 2002). Technological change in an industry is profitable at initial input prices and fixed product prices. In response, all producers expand production in that sector. Hence, national relative labour demand upsurges for the factor used intensively in that sector. With fixed labour supply, relative wages adapt under the circumstances, until the profit opportunities are fully diminished due to market competition (Tregenna, 2009).

Furthermore, institutions characterised by rapid capital accumulation, trade and technological innovation can strengthen economic growth and the aspects that describe economic growth, namely, increased work opportunities, efficiency in product output and living standards. In a situation of slow capital accumulation and weak economic growth, an incline of trade and technical progress exacerbates unemployment and income inequality. This is illustrated by studying the increase of employment in industrial countries, i.e., the United States, despite a widening trade deficit with emerging economies and the widespread of information and communication technologies. Technology outlines how trade components produce commodities, and the type of goods produced, exported, and imported by countries will depend on input resources, specifically labour and capital (Akyuz et al., 2002).

According to Saylor Academy (2024), in countries labour-abundant countries (India and China), trade will increase wages by increasing the demand for labour-intensive

goods and, in turn, labour share of income. Trade liberalisation improves profits on capital invested in capital-abundant countries, including Brazil, Russia, and South Africa. Hence labour share of income decreases as capital gains outperform wage growth. Therefore, trade can exacerbate income inequality depending on a country's factor endowment.

2.6. Labour share theory

The labour share of income is the portion of domestic income directed to labour, represented as a portion of wages in overall output. The labour share is impacted by employment levels together with wages paid to workers, the innovation of technology, the elasticities of substitution between labour and capital, and market structures, including the presence of unions and a competitive market. Perspectives from David Ricardo, Karl Marx, and modern investigations integrating international trade and technology innovations, help explain labour share, its theoretical foundations, and its distribution across economies.

In the David Ricardian framework, wages were determined by the supply price of labour, while employment levels relied on the available capital. Labour share is a variable influenced by capital and current economic conditions. Hence, shifts in capital accumulation and economic conditions cause labour share to vary over time. David Ricardo highlighted how technological advancements improve productivity yet benefit primarily capital owners rather than workers, and favours rents and profits (Schneider, 2011, Blaug, 1997). In the Karl Marx framework, wages were set at subsistence levels, with the supply of labour exceeding the demand at existing wage rates, decreasing labour share over time. Increased output would be seen through increased capital efficiency per worker, while wages stagnated unless altered through bargaining power. If wages increased with output per worker, then labour share could stabilise rather than increase (Schneider, 2011)

2.7. Labour share in the context of trade and technology

Comparative advantage justifies how countries that specialise in manufacturing, have a lower opportunity cost through outsourcing. However, as trade integrates economies, labour-abundant countries may initially experience wage and share increases due to labour demand shifts towards labour-intensive goods. As economies adopt capital-intensive technologies, labour share may decline, depicting less reliance on physical labour (Dean et al., 2020, Krugman et al., 2018).

The Heckscher-Ohlin model further links trade to factor endowments of countries' predicting that labour-abundant countries gain more from trade through increased demand for labour-intensive goods. Similarly, capital-abundant countries experience increased wage disparities as profits accrue to capital owners due to international. Furthermore, technological innovation allows capital-intensive production even in labour-abundant economies, complicating the technology dynamics (Chatterjee and Naka, 2022, Karabarbounis and Neiman, 2014).

The Stolper-Samuelson theorem takes a closer look at the of trade openness together with its impact on factors of production returns. International trade increases the relative cost of goods produced by a country's abundant factors, leading to increased wages and a possible increase in labour share for labour-abundant countries. With technology adoption in capital-intensive economies, low-skilled labour is less required. Consequently, international trade and technology innovations extend opportunities for skilled labour while reducing labour and wage share for low-skilled labour (Malan et al., 2015).

2.8. Empirical review of labour share

The global adjusted labour share income of 2004 - 2017 displayed a substantial downward trend, temporarily inverting during the financial crisis of 2008 - 2009, demonstrating countercyclical behaviour (International Labor Office, 2019). For example, the labour share of income falls by more than 3% in Mexico. On the contrary, Brazil saw an upward trend in labour share. (Stockhammer, 2015). Asia experienced

a significant countercyclical decline in labour share, mainly determined by India's labour share pattern. Africa has experienced a steady increase in income since 2010 (International Labor Office, 2019).

2.9. International trade and labour share

In emerging countries, international trade impacts expose opportunities facing labour markets; as diverse as they are, policymakers and academics need to pursue sustainable and more inclusive economic growth and development. Investing in human capital (people's skills, knowledge, and abilities) is vital to sustainable development and decreasing wage differentials. There is a need for a skilled labour force to successfully make use of these resources for sustainable economic growth (Altiner and Toktaş, 2017). Education plays an essential role as more educated workers have a higher labour wage share, and education drives the employees' wages towards marginal productivity from the skills they supply and competition between potential employers (Daudey and Decreuse, 2006). In globalised markets, skilled labour gains more in wage benefits; in Stockhammer (2015), there was an overall negative relationship between wage share changes and technology in developing economies.

In a theoretical sphere, Brock and Dobbelaere (2006) state that globalisation affects labour share income distribution during the workers' bargaining process. A close relationship between the modern globalisation process, the divergence in bargaining power, and greater flexibility of capital has been detected by Akyuz et al. (2002). The correlation between labour share and trade openness in the BRICS countries highlights the intricacies of open economies, trade liberalisation, technological innovation, and global market dynamics. Trade liberalisation and the influx of foreign direct investment inflows pose challenges to reduced bargaining power. Studies have found a statistically significant negative correlation between labour share of income and FDI inflows. This relationship may be attributed to the volatility of capital inflows, where the more investment a country receives, the more negatively impacted bargaining power (Guerriero and Sen, 2012, Vijaya and Kaltani, 2007). Conversely, a

positive relationship was found by Brock and Dobbelaere (2006) between technology advancements and workers' bargaining power (Brock and Dobbelaere, 2006).

2.10. Empirical evidence

This empirical review examines how international trade and technological innovation impact labour share, focusing on BRICS countries. The empirical review integrates key economic frameworks, including the Heckscher-Ohlin-Samuelson and Stolper-Samuelson frameworks related contexts, to demonstrate how globalisation and technological progress interact with factor endowments, thus influencing income distribution and labour market outcomes.

2.11. International trade and labour share

Empirical research emphasises an intricate relationship between trade and labour share, often modelled by a country's factor endowments and economic openness. According to Roser and Cuaresma (2016), imports from low-wage developing countries increase income inequality in developed countries by reducing wages for low-skilled workers. Their analysis showed that trade liberalisation leads to a 1% expansion in trade openness and a 0.013% rise in the Gini index. This relationship is more robust in low-cost import sectors, strengthening competition for low-skilled labour.

Goldberg and Pavcnik (2007) examined the after-effects of tariff reductions in developing countries including Mexico and Brazil; while substantial tariff reductions were in Colombia, a 37% reduction in tariffs lead to a 4% decrease in manufacturing income. Their study highlighted that the most extensive tariff cuts were from low-skilled labour sectors, intensifying income disparities. Technological innovations in the BRICS bloc, primarily India and China, have transformed sectors towards more capital-intensive, high-technology production (International Labour Organization, 2024, Karabarbounis and Neiman, 2014).

2.12. Technological innovation and labour dynamics

Technological innovation is another disparity factor, as it benefits skilled labour while displacing low-skilled labour. A panel data BRICS study by Biyase et al. (2023) from 1990 - 2017 found that technological innovation, while beneficial for productivity, tended to exacerbate income inequality. Over the study period, technological innovation had a trend of aggravating income inequality observed. The study revealed that technological innovation is increasing in Brazil, China, and India. Contrarily, the technological innovation trend in South Africa and Russia declined in the 1990s, then a multifarious pattern.

Technological innovation was positive and statistically significant, suggesting it widens the inequality gap in BRICS countries. With the panel dynamic least squares (PDLS) model, the researchers identified a positive relationship between technological innovation and inequality, as technological advancements reduced demand for low-skilled labour and benefited capital-intensive industries. Mnif (2016) and Roser and Cuaresma (2016) echo this, emphasising that skill-biased technological change underpins disparities, mainly in increased technology economies. These two studies found that the gains of technological progress, including digitisation innovation, contributed to increasing income disparities in emerging countries between skilled and unskilled labour in emerging economies. Some countries observe disparity due to technological advancements, while other countries may experience income inequality from their financial progress, current income distribution, and economic structures.

In the Stolper-Samuelson theorem, technological advancements and trade liberalisation should raise wages in labour for labour-abundant countries. However, digitisation and automation have diminished these gains by distributing them mainly to skilled workers while reducing their share of income and labour's bargaining power. Likewise, in their study of 89 developed and developing countries, using a panel dataset from 1970 - 2009, Guerriero and Sen (2012) detected that while patent applications correlated with labour share and efficiency, automation yielded a contrasting effect. Technological mechanisation often shifts labour demand for labour-intensive industries, reallocating income away from previously labour-abundant

sectors towards capital holders. In BRICS countries such as China and India, technological innovations have transformed sectors from labour-intensive manufacturing to more capital-intensive, high-tech production, transforming the labour market and mostly excluding low-skilled workers from productivity gains (International Labour Organization, 2024). The variation in effects gives policymakers a need to consider country-specific circumstances when addressing the after-effects of technological advancements on disparity.

The International Monetary Fund (2007) underscored that information and communication technologies enhance skilled labour while replacing and unskilled labour, which exacerbates disparities. Roser and Cuaresma (2016) added that technological innovations reduce education's ability to lessen the inequality gap as productivity gains increase disproportionately to skilled labour in technologically advanced economies.

2.13. Combined effects and policy implications

The convergence of trade, technological innovation, and FDI inflows creates an exciting outlook for the impact of the labour market in BRICS countries. Trade liberalisation creates specialisation opportunities, generating efficiency gains that increase the labour share of income. Increased trade openness can reinforce the demand for labour in export-oriented, competitive, and capital-intensive (more automation, digitisation and technology-based) industries while putting downward pressure on low-wage import competition industries (Choi et al., 2023, Goldberg and Pavcnik, 2007). The Stolper-Samuelson theorem supports these findings by indicating that trade liberalisation increases wage disparities through favouring skilled labour evidently in BRICS countries such as in South Africa, capital-oriented industries including mining and energy disproportionately benefit from trade, reducing the labour share (Choi et al., 2023, Guerriero and Sen, 2012, Goldberg and Pavcnik, 2007). To address the impact of international trade on labour share and wage disparities, policymakers in the BRICS countries can invest in education and training programs to enhance workers' skills. Furthermore, social protection institutions should be implemented to support workers negatively impacted by international trade, and

promote inclusive growth policies that prioritise reducing wage disparities, and ensuring fair labour practices, as highlighted by Choi et al. (2023). The researchers suggest comprehensive social protections are essential to support workers displaced by trade and technological shifts.

In conclusion, the empirical findings indicate that globalisation and technological progress can increase economic output while challenging income distribution stability in emerging economies. The combination of quantitative and qualitative methods allowed for a comprehensive investigation of the interaction between trade trends, factor endowments, and technological progress. Policies prioritising comprehensive growth and equitable productivity gains with fair labour systems are required. Key variables provided a deeper understanding of how these variables mould labour share of income and trade dynamics, highlighting the importance of considering technological factors alongside traditional economic variables in trade theory and policy formulation.

3. Methodology

This chapter will display the methodologies used to reach the aim of the study. The study runs a static panel regression across 31 years from 1991 – 2022. The study runs a random effects estimation along with a generalised methods moments regression. Static panel analysis for estimating random effects is chosen as the study focuses on the differences between countries over a specified period. The static panel model captures this cross-sectional variation more successfully. The study uses a dynamic panel model for lag effects or temporal relationships between labour share and trade liberalisation in the generalised methods of moments estimation

3.1. Correlations matrix

The correlation matrix displays correlation coefficients between all the pairs of the variables used in this study. The matrix displays the correlation of variables in a table. The insights from the correlation matrix are vital for understanding how trade policies and technological progress impact labour markets, informing policy frameworks and recommendations for encouraging equitable income distribution and sustainable and inclusive growth (Pedace, 2013).

3.2. VIF results

The variance inflation factor (VIF) detects multicollinearity among the variables. Multicollinearity arises when the independent variables are highly correlated. When there is multicollinearity, the distorted coefficients reduce the reliability of the models. This study used the VIF to ensure that multicollinearity does not compromise the reliability and integrity of the study, enabling more accurate interpretations of the relationships that measure labour share, trade openness, and technology advancements (Pedace, 2013).

3.3. Hausman test

The Hausman test inspects the variations in the fixed effects and random effects estimations, to determine which estimation, between the abovementioned, is

appropriate for the study. The null hypothesis of the Hausman test implies that the random effects model holds and is preferred for efficiency; despite that both the random and fixed effects models produce the same estimated parameters. The alternative hypothesis implies that the random effects assumptions do not hold; therefore, the fixed effects estimates are preferred and will be consistent.

3.4. Random effects model

The Hausman test tested the random effects estimation against the fixed effects estimation and concluded the random effects model as the appropriate model for this study. Using a random effects model on a balanced panel data analysis assist in addressing the research question on the impact of trade openness, and technological advancement on labour share. The random effects model enables the model to capture between-country variation, hence analysing how international trade and technology impact labour share across the BRICS bloc. By including country-specific random effects, individual-level variation is preserved together with the degrees of freedom, thus generalising the results (Pedace, 2013).

3.5. Generalised methods of moments

The generalised methods moments regression is a robust estimation tool used in panel data analysis to address possible autocorrelation, heteroscedasticity, and endogeneity by incorporating instruments from lagged variables. The generalised methods moments technique ensures that parameter estimates are consistent and unbiased even when independent variables correlate with the error term. This study uses generalised methods moments to investigate the link between trade openness, technological advancements, and labour share across the BRICS countries (Zsohar, 2012).

3.6. Durbin (score) chi-squared and Wu-Hausman test.

The Durbin (score) chi-squared test is a test for endogeneity. This study will use this test to detect if there is endogeneity in the trade and technology variables for the generalised methods moments model. The null hypothesis states that the variables

are exogenous. The Wu-Hausman test for endogeneity compares the results from an OLS estimation with results from an estimation with instrumental variables (Pedace, 2013).

The proposed empirical random effects model is as follows:

$$LS_{it} = \beta_0 + Trade_{it}\beta_1 + Technology_{it}\beta_2 + \Sigma_k \delta_k X_{ikt} + u_t + \alpha_t + \varepsilon_{it} \quad (1)$$

The i subscript captures the country, and the t subscript represents the time. LS is the labour share, and a β_0 intercept has been included. *Trade and technology* represent trade openness and technological advancements as the variables of interest. The X_k represents control variables used in the estimations. At the same time, $u_t \; and \; \alpha_t$ are the error terms that capture the time-invariant (year effect) and the country-invariant (country random effect), while the ε_{it} error term is the white noise element. The other explanatory variables include income per capita, investment share, education, and trade regulations.

Furthermore, the total population used as a proxy for the market size of the economy is included as another control variable, which can affect trade through economies of scale, by lowering the average cost of production per unit. Therefore, making the good more competitive in the global scale. Due to possible biases in the estimations of the effects of trade from more significant economies engaging in more trade than smaller economies. Thus, the standard model to be estimated is:

$$LS_{it} = \beta_0 + Trade_{it}\beta_1 + Technology_{it}\beta_2 + Ln(GDP)_{it}\beta_3 + Trade.reg_{it}\beta_5 + Investments_{it}\beta_6 - Education_{it}B_7 + Ln(population)_{it}\beta_8 + u_t + \alpha_t + \varepsilon_{it} \quad (2)$$

3.7. Data

This study is based on yearly aggregate data from five countries, Brazil, Russia, India, China, and South Africa (BRICS), forming an balanced panel over 31 years from 1991 - 2022.

The data used in this study is guided by the variables used in the Guerriero and Sen (2012) study. International trade is measured as total trade as a percentage of Gross Domestic Product (GDP) and FDI (net inflows and net outflows as a percentage of GDP). KOF Index of Globalisation as a measure of trade regulations. The natural logarithm of the total population is used as a proxy for the market size of the economy. Technological progress is measured through the patent's variable. The level of investment, GDP per capita, and the mean schooling years in the population aged 25+ are used in the study.

The population and GDP per capita data were transformed into log forms for several reasons. 1) using log form transforms this variable's relationship with the dependent variable into a linear relationship to make interpreting the results more straightforward. 2) Log variables can be interpreted as percentages (elasticities) to display a percentage correlation between the dependent and independent variables. 3) Using the log of the variables adjusts the skewness of the data, bringing the data closer together to improve statistical tests and reliability. 4)The forms of the variables assist in stabilising the residuals' variances to address the heteroscedasticity issue in the regressions (Andy, 2019).

3.8. Variables

The labour share of income, as the dependent variable, measures the national income allocated to workers. The Labour share variable is extensively used in empirical literature (Stockhammer, 2015, Guerriero and Sen, 2012) to analyse the impacts of globalisation, economic structures, and policy implementations. The trade openness variable is a key component of globalisation, and a key driver of economic integration for the BRICS economies, with other countries. The notion of trade liberalisation

shifting the demand for capital and labour through trade benefits aligns with the Heckscher-Ohlin and Stolper-Samuelson frameworks, and trade captures its impact on labour share, similarly in studies such as Roser and Cuaresma (2016) and Goldberg and Pavcnik (2007). Patents proxy technological advancements and reflect the impacts of skill-biased technological shifts on labour share, as seen in Mnif (2016) and Karabarbounis and Neiman (2014). Foreign direct investment (FDI) and investment share as a percentage of GDP represent globalisation's financial component and capital accumulation and their role in economic expansion. FDI inflows and outflows represent the dual role of recipients and investors in the BRICS countries. This approach aligns with that of Dünhaupt (2016) and Guerriero and Sen (2012).

GDP per capita as a proxy of living standards and economic structural shifts in the BRICS countries, reflects the economic development and expansion as both Biyase et al. (2023) and Stockhammer (2015) emphasise its relevance in justifying income inequality and production changes. Trade Regulations as an index for the role of policy implementations and their impacts on trade liberalisation and labour share measures the rigidity or permissiveness of policies and how trade regulations influence factor allocation (Anjum and Perviz, 2016). Education levels are crucial for determining labour force outcomes as they indicate human capital and quality of skills development. Studies show that education is likely to impact labour share by modifying the skill structure of the labour force (Altiner and Toktaş, 2017, Daudey and Decreuse, 2006). Population is a proxy for labour force size as larger populations may increase trade and production, thus impacting labour share.

This chapter detailed the approaches used to accomplish the study's objectives through a static panel regression using 31 years from 1991 - 2022. The study aims to identify the impact of trade openness and technology advancement on labour share in the BRICS bloc. The random effects model addresses unobserved heterogeneity and controls for time-invariant features within the country data. Including time dummy variables assists in accounting for macroeconomic shocks and ensuring that trends are controlled adequately in these BRICS countries. Furthermore, the inclusion of a 2009 - 2022-year dummy variable accounts for structural changes associated with the

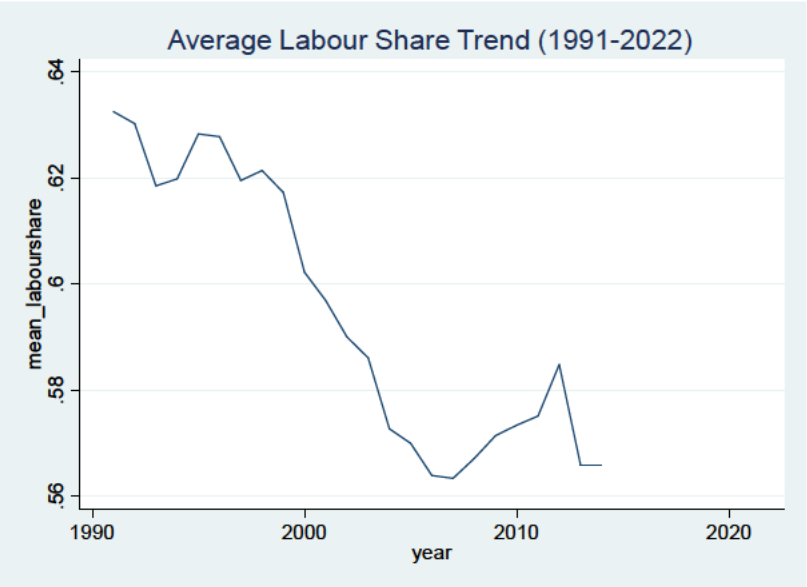
official formation of the BRICS bloc. This approach highlights how labour share related differently to the independent variables prior to and post-2009, reflecting shifts in trade policies, collaborative initiatives, and economic integration.

The empirical model, inspired by Guerriero and Sen (2012), includes explanatory variables such as labour share, trade, education, and trade regulations. Control variables such as total population and GDP per capita are included to capture the broader economic effects. The Hausman test determines which model is more appropriate between fixed and random effects. The significant results from the Hausman test confirmed the need for a random effects approach, ensuring that the estimates are consistent and reliable. The data used in the study is sourced from five BRICS countries, including the critical variables addressed, skewness, and heteroscedasticity, interpreting the results more precise and statistically robust.

4. Results

This chapter will provide and discuss the outcomes of the study's estimations. The results cover five countries (Brazil, Russia, India, China, and South Africa) as emerging economies and low-medium and medium-high-income earning countries from 1991 - 2022. The data used in the study presents medium- long-term evidence of substantial variability in factor shares over time.

4.1. Figure 1: Average Values of Labour Share from 1991 - 2022



Source: own calculations

Figure 1 depicts the mean labour share over time in between 1991 - 2022. The International Labour Organization (2024), Stockhammer (2015), and Guerriero and Sen (2012) share the same sentiments and highlight the systemic global reduction in labour share for Brazil, Russia, India, China and South Africa. Here, the effects of globalisation are pronounced. The labour share trend aligns with the Ricardian and Heckscher-Ohlin frameworks that forecast that as economies adopt capital-intensive technologies and are open to international trade, the relative income to labour ratio decreases, especially for low-skilled labour. Krugman et al. (2018) and Chatterjee and Naka (2022) echo that globalisation, through competition, often reallocates resources towards capital-intensive industries, driving labour share of income down and reducing labour share.

Appendix A displays the variables, labour share, trade, and patents. Observing the variables of interest; labour share, trade, and patents, there has yet to be a clear-cut trend over the years. Each country displays a different trend. Table 1 and table 2 present the summary statistics for all the variables used in the study before and after their transformations. The tables show the average mean of labour share for all BRICS countries during 1991 - 2022. The summary statistics provide a high-level yet comprehensive view of the dataset. In table 1, the labour share variable establishes an average of 0.5943376, with a standard deviation of 0.076325, indicating some variability. The variability in labour share trends indicates the diverse resource endowments and economic structures within the BRICS countries. FDI inflows display an average mean of 2.097527, with a standard deviation of 1.590665, indicating some variability. Trade displays an average of 41.41676, with a standard deviation of 14.59798, indicating considerable variation in trade activities. Patents display an average of 89669.97 with a standard deviation of 278792.7, indicating high variability. GDP per capita averages 5362.491 with a standard deviation of 3015.221, a high degree of variability. Investment share has an average mean of 24.9694 and a standard deviation of 10.51381, which shows considerable variability. Education has an average mean of 7.650194 and a standard deviation of 2.804414, which shows some variability.

4.2. Levin-Lin-Chu (LLC) and Augmented Dickey-Fuller (ADF) tests for stationarity

The tables in appendix A displays the results of the Levin-Lin-Chu (LLC) and Augmented Dickey-Fuller (ADF) tests for stationarity, conducted post and prior differencing for the dependent and independent variables. Stationarity of variables is essential for time series analysis such that mean and variance remain constant over the periods for consistent econometric modelling. Table 2 (LLC test) indicated that labour share, log of GDP per capita, investment share, labour regulations, and education were already stationary, as their p-values were below the significance level of 0.05. However, trade, FDI inflows, FDI outflows, trade regulations, log population, and patents were not stationary.

Based on the LLC and ADF tests, the variables that required differencing to achieve stationarity were trade, FDI inflows, FDI outflows, trade regulations, log population, and patents. Differencing assists the model to retain its robustness. After the first differencing (D), *log population* and *patents* remained non-stationary and required a second differencing. The two variables were stationary after the second difference (D2) between the LLC and ADF tests.

The summary statistics in table 2 from Appendix A show that the labour share variable establishes an average of-0.0021471, with a standard deviation of 0.0132488, indicating little variability. The variability in labour share trends indicates the diverse resource endowments and economic structures within the BRICS countries. FDI inflows display an average mean of 0.0111338, with a standard deviation of 0.8120768, indicating some variability. Trade displays an average of 0.7532607, with a standard deviation of 8.665912, indicating considerable variation in trade activities. Patents display an average of 600.8333 with a standard deviation of 38939.35, indicating substantial variability. GDP per capita averages 0.0311188 with a standard deviation of 0.0458475, a low degree of variability. Investment share has an average mean of 24.72841 and a standard deviation of 10.88902, which shows considerable variability. Education has an average mean of 7.7019 and a standard deviation of 2.806118, which shows some variability. After the transformation of the variable, variability in most of the variables is lost.

4.3. Table 1: Hausman Test Outcomes

Test statistic	Value	p-value	Decision
Chi-squared	3.47	0.9016	The null hypothesis is not rejected.

Since the p-value is 0.9016, more significant than the commonly used significance level of 5%, therefore the null hypothesis is accepted meaning the random effects model is better suited for the estimations in this study.

4.4. Table 2: Correlation matrix

	D_labour share	D_trade	D_FDI Inflows	D_FDI outflows	D_trade regulations	D2_log population	D2_patents	D_log GDP per capita	Investment share	Education
D_labour share	1.0000									
D_trade	-0.1115	1.0000								
D_FDI Inflows	-0.1371	0.0591	1.0000							
D_FDI outflows	-0.0796	0.0762	0.0834	1.0000						
D_trade regulations	-0.0270	-0.2071	-0.1238	-0.0549	1.0000					
D2_log population	0.0214	0.0395	-0.1577	-0.0566	-0.0141	1.0000				
D2_patents	-0.0045	-0.0043	0.0385	0.0344	-0.0917	-0.0085	1.0000			
D_log GDP per capita	-0.0664	0.3201	0.1878	0.1187	-0.1142	-0.1538	-0.0179			

Investment share	-0.0350	0.1567	-0.0005	-0.0323	-0.0858	-0.0758	0.0230	0.6511	1.0000	
Education	0.6095	-0.1417	-0.0161	-0.0531	-0.0368	0.0460	-0.0085	-0.3102	-0.4090	1.0000

Source: Own calculations

In this correlation matrix, the labour share variable is the dependent variable. education and labour share are Positively correlated (0.6095), suggesting that a higher labour share value is associated with higher education levels. Furthermore, there is a weak negative correlation with D.fdiinflows (-0.1371), D_trade (-0.1115), and D.fdioutflows (-0.0796), indicating that the listed variables have a minimal direct impact on labour share. D_trade negatively correlates with trade regulations (-0.2071), suggesting that increased and stricter trade barriers could decrease trade quantities. D_trade has a positive but weak correlation with D_log GDP per capita (0.3201), signalling that those countries with a higher GDP per capita could experience increased international trade. Investment share and D_log GDP per capita have a strong positive correlation (0.6511), which can be attributed to increased investment levels expanding economic growth. Conversely, investment share has a negative and weak correlation with education (-0.4090), highlighting the nuanced complexities in these BRICS countries. D2.log_population and D2_patents have weak correlations with most other variables, meaning minimal impact from these variables.

4.5. Table 3: Random effects models

Dep var: D_Labour Share	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
D_trade	-.0002514 (.0002102)	-.0002546 (.0002121)	-.0002444 (.0001981)	-.0002526 (.0002122)	-.0002592 (.0002154)	-.0002825 (.0001964)	-.0002876 (.0002174)
D2_patents		-1.41e-09 (4.29e-09)	-1.59e-09 (4.33e-09)	-6.21e-10 (4.71e-09)	-5.39e-10 (4.77e-09)	-1.95e-09 (5.15e-09)	6.41e-10 (5.49e-09)
D_log GDP per capita			-.0012788 (.008153)	.0166499 *** (.0100628)	.0177451 (.014321)	.0166439 (.0143885)	.0338301 (.0241536)
Investment share				-.0001012 *** (.0000605)	.017723 (.0143581)	-.0001193 (.0001245)	-.0001753 (.000156)
Education					-.0001169 (.0001264)	-.0001243 (.0005046)	-.0001533 (.0005298)
D_trade regulations					-.0001008 (.0005149)	-.0001402 (.0002076)	-.0001983 (.0002171)
D_FDI inflows							-.0022753 (.0016843)

D_FDI outflows							-.0005789 (.0003485)
D2_log_population	.2378602 (.3153338)	.2479543 (.3205419)	.2184272 (.3139837)	.2473286 (.3238644)	.2584189 (.3352067)	.2548625 (.3390772)	.1357464 (.3584345)
Year dummy 2009 - 2022	.0037323 (.0031145)	.0037144 (.003134)	.0037334 (.0031321)	.0045073 *** (.0027142)	.004524 (.0027118)	.0042832 (.0024883)	.0042067 *** (.0024772)
Cons	-.0037468 (.0026425)	-.0037554 (.0026324)	-.0036876 (.0027188)	-.0018996 (.0034302)	-.0010189 (.0078446)	-.0007033 (.0077782)	.0003855 (.008584)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	150	150	150	150	150	150	150
R-squared (overall)	0.0320	0.0320	0.0320	0.0349	0.0351	0.0369	0.0583
Asterisks: significance level	* = 0.05	** = 0.01	*** = 0.1				

Table 3 shows the random effects of robust standard error estimation results using aggregated annual data for all countries. Columns show how progressively variables are included in the following order: column 1: trade openness and log of population, column 2: Patents, column 3 GDP per capita, 4: investment share, column 5: education levels, column 6: trade regulations, and column 7: FDI inflows and FDI outflows. A population log variable and a year dummy variable were added to the regression as control variables across all the specifications. The 2009 - 2022-year dummy variable was added to capture labour share dynamics post-2009. The results of the random effects model show that the impact the explanatory variables have on labour share is minimal.

Trade openness (D_trade) is consistently negative and statistically insignificant across all models, suggesting that changes in trade do minimally and negatively impact labour share in this study. Similarly, Goldberg and Pavcnik (2007) found that trade reduced labour share by shifting production towards capital-intensive sectors. While the correlation between labour share and trade openness appears as nuanced, the Stolper-Samuelson theorem also supports the results of this study through the notion that the gains of trade openness are increased for abundant production factors -capital in the BRICS countries- to the disadvantage of labour, thus creating more income inequality. Similarly, the outcomes are consistent with Dünhaupt's (2016) findings that international trade weakens the bargaining power of labourers through shifting production towards capital-intensive systems. The results of D_trade in this study suggest that changes in trade openness adequately explain the changes in labour share. Stockhammer's (2015) findings also revealed that globalisation had a minimal direct impact on labour share and was not statistically significant in some contexts.

Similarly, patents (D2_patents) which measure technological advancements, switch between weak positive and weak negative coefficients in the estimations, are inconsistent and statistically insignificant. This finding suggests that technological progress does not correlate clearly with labour share in this study. In the literature and empirical evidence review, technological innovations are vital to skill bias by disproportionately favouring skilled labour and reducing labour share for lower-skilled

labour in developing countries (Stockhammer, 2015, Guerriero and Sen, 2012). The results for D2_patents partially coincide with these findings through small alternating (negative and positive) coefficients. Moreover, findings suggest that technological advancements have a direct impact on labour share and might be mediated by other explanatory variables. Hosanna (2023) and Mnif (2016) asserted that although technological advancement streamlined productivity, it benefits capital-centred sectors. This dynamic is evident in the BRICS countries where skill-biased technological change is prominent in China and India from automation and digitisation substituting low-skilled jobs and increasing demand for skilled labour. The observed weak relationship in this study may also reflect fluctuations in the quality and magnitude of technological adoption across the BRICS countries, as noted by the International Labour Organization (2024).

Economic growth, used as a proxy for GDP per capita (D_log_gdppercapita), shows a positive coefficient in models 4, 5, 6, and 7, plus statistical significance in model 4. According to these findings, there is generally positive evidence of economic growth that directly impacts the distribution of labour income. Furthermore, Investment share (INVS) is only negative and statistically significant in model 4, suggesting a minimal impact on labour share and a complex outcome of capital accumulation in the BRICS countries. Education's (EDUC) coefficients are not statistically significant, suggesting that these explanatory variables minimally impact labour share and skills development in the form of education, leading to a decline in labour share. This outcome could explain that higher education shifts towards capital-intensive production technologies, reducing the demand for physical labour relative to technology.

Furthermore, the literature and empirical review highlight higher education levels as a critical determinant of labour share and productivity (Altiner and Toktaş, 2017, Daudey and Decreuse, 2006). The results do not emphasise quality over quantity in educational development. Biyase et al. (2023) found that an increase in GDP per capita exacerbates inequality, whereas Stockhammer (2015) found that economic growth, including increases in GDP per capita, has varying effects on wages across regions. Therefore, economic growth alone does not directly impact the income

distribution toward labour. Accompanying policies and structural frameworks need to be incorporated.

Trade regulations (D_traderegulations), FDI inflows (D_fdiinflows), and FDI outflows (D_fdioutflows) all have negative coefficients and are not statistically significant, suggesting minimal direct impact and movements on labour income distribution. Similarly, Goldberg and Pavcnik (2007) found that trade barriers negatively impacted low-skilled labour, particularly in labour-abundant countries. Likewise, Dünhaupt (2016) and Guerriero and Sen (2012) also find that FDI negatively impacts labour share by shifting production towards capital-intensive methods, thus weakening labourers' bargaining power. Population (D2_log_population) consistently shows positive coefficients yet is not statistically significant.

The low overall R-squared values, ranging from 0.0320 to 0.0583 across all seven models, imply that for this study, the explanatory variables only justify a small portion of the changes in labour share. This result suggests that the models require further modification to capture the intricacies of labour share dynamics.

4.6. Table 4: Endogeneity test for trade and patents

Durbin (score) chi2(2)	.016 (p = 0.9920)
Wu-Hausman F (2,140)	.007725 (p = 0.9923)

The p-value (0.9920) of the Durbin (score) test indicates that the null hypothesis is accepted; meaning, there is no evidence that the variables D_trade and D2_patents are endogenous. The p-value (0.9923) of the Wu-Hausman test also indicates that the null hypothesis is accepted; meaning there is no evidence of endogeneity in the OLS model that tests for endogeneity. Therefore, the generalised methods moments model is appropriate.

4.7. Table 5: Generalised methods moments results

Variable	Coefficient	Robust standard errors	P-value
Lagged dependent variable (D_labourshareL1.)	2.818108	2.86807	0.326
D_log_trade	-.0121107	.0171402	0.480
D2_patents	-2.30e-06	2.03e-06	0.258
Year dummy 2009 - 2022	.0514834	.0963586	0.593
Cons	-.0163672	.034628	0.636

The generalised methods moments results in table 5 reveal that the lagged dependent variable (L.D_labourshare) does not significantly impact current labour share. It is positive and is statistically insignificant (2.818108, p = 0.326). This revelation applies to trade openness (D_log_trade) and technological progress proxied by patent proxies (D2_patents). The effects of trade and patents remain statistically insignificant (p = 0.480 and 0.258), prompting the idea that such relationships rely on other variables that tackle the scopes of the degree of economic openness or labour market policies, to mention a few. The 2009 dummy variable reveals a weak positive relationship with labour share, highlighting the complex and nuanced relationship labour share has post-2009 due to unobserved factors such as labour policies, trade policies, and structural frameworks. For this study, these variables do not have a significant direct impact on labour share. As previous research has found complexities in linking trade openness, technological progress, and wage distribution in aggregated analyses across multiple countries, the BRICS countries highlight heterogeneous impacts, which may be weakened in aggregated models.

In conclusion, the results indicate various relationships between trade openness and labour share in the BRICS bloc. The link between trade liberalisation and labour share could reveal a complex outcome for labour share with increased liberalisation. The

findings of this study draw attention to the need for critical reflection on trade, strengthening labour market institutions, and implementing social protections and technological integration policies to address their impact on income distribution in the BRICS countries and safeguard workers' rights, as Choi et al. (2023) suggested. Trade liberalisation policies should uplift low-skilled workers through skills development programs (International Monetary Fund, 2007, Akyuz et al., 2002).

5. Conclusion

This study uses the BRICS country's (Brazil, Russia, India, China, and South Africa) dataset of the labour share, trade openness, and technological advancements from 1991 - 2022. The study set out the following questions: How did trade openness affect the labour share of income in the BRICS countries? How do technological advancements impact the BRICS countries' economic growth and labour market outcomes? What is the significant association between technological innovation and changes in labour shares across the BRICS countries? Over the past 31 years, there seems to be a general average decline in the labour share for the BRICS countries. Furthermore, the relationship between trade openness, technological advancements, and labour share within the BRICS countries is intricate.

Trade theory and labour frameworks provide a foundation for understanding how trade openness and income distribution relate to one another. According to the frameworks, countries will export goods with a comparative advantage in producing them efficiently with their factors of production, leading to shifts in the factor demands. Specialisation can influence the labour share of income, representing a share of national income assigned to labour. Increased trade liberalisation can reallocate resources that could benefit capital-intensive industries in emerging markets such as the BRICS countries. According to the Stolper-Samuelson theorem, this phenomenon could decrease labour share in a more capital-intensive economy. Guerriero and Sen (2012) found that labour share reduces over time, which is consistent with the theory in the study's findings.

The study examines the effects of globalisation and technological advancement on the labour share. Robust error terms method is implemented across the different estimations contrasting the anticipated positive role in Guerriero and Sen (2012) observed between trade openness and labour share. Trade openness is found to have negative minimal impact on the labour share in the BRICS data sample. The findings emphasise the importance of improving living standards, equal income distribution, employment, and output growth. Similarly, technology proxied by patents switches

from weak negative to weak positive in model 7, suggesting that technological progress does not have a clear correlation with labour share.

Moreover, FDI inflows and outflows have a weak negative relationship with labour share in the BRICS countries. To address the negative relationship between labour share and FDI inflows, governments may investigate frameworks that promote labour rights to protect workers' rights and equal income distribution, technology adoption to boost productivity, and investment in education and training programs for skills development. Labour market reforms are also needed for institutions and workers. The positive relationship between investment and labour share suggests that the BRICS countries should encourage collaboration between foreign investors, knowledge sharing, and technology transfers. The generalised methods of moments did not produce any statistically significant results for the relationship of labour share related to trade openness and technological progress.

This study is essential as it highlights the critical role of trade and technology in influencing labour market outcomes and income distribution, which are pivotal to economic policy frameworks. The BRICS countries, representing a significant portion of emerging economies and the global population, serve as a good case study to analyse global economic trends that influence labour share and income inequality. Policymakers and investors in the BRICS countries stand to benefit meaningfully from this research. The results of this study can inform targeted policies designed to mitigate the adverse effects of trade and technological advancements on labour markets. For example, investments in education and career training can uplift and enhance the workforce to adapt to globalisation and technological progress changes. These initiatives are essential for wage disparity reductions and promoting holistic economic expansion.

5.1. Recommendations

Policymakers should emphasise sectors that generate substantial employment and invest in infrastructure to support these industries, thus promoting sustainable

economic development. As established, financial depth substantially impacts technological advancement and income distribution. Therefore, policies should reinforce financial institutions and encourage financial inclusion, essential in fostering an equitable growth environment. Trade has a negative relationship with labour share, and to mitigate this, governments need to address income inequalities and encourage skills development initiatives, especially for low-skilled workers. Also, establish frameworks that protect workers and industries displaced due to international trade.

With patents as a proxy for technology, having some positive relationships with labour share, governments can leverage this correlation through skills development for labour, facilitate transfers of technology plus, a collaboration with unions and businesses for fair negotiations for the integration of automation and making sure the benefits are shared equally among the people. Investment shares have a positive relationship with labour shares; therefore, the BRICS countries should capitalise on it by encouraging collaboration between foreign investors, technology transfers, and knowledge sharing. To address the negative relationship between labour share and FDI inflows, governments may investigate frameworks that promote labour rights to protect workers' rights and equal income distribution—technology adoption to boost productivity and investment in education and training programs for skills development. Labour market reforms are also needed.

5.2. Future research

This study highlights a few areas that need to be considered for further investigation. Research and development (R&D) as a proxy of technological progress and labour regulations were initially considered due to theoretical and empirical relevance, and for their impacts on labour share dynamics. However, they were excluded from the final analysis due to stationarity and multicollinearity issues. Future research should reintroduce these variables and use alternative econometric techniques. Future research may consider a more extensive sample period and larger sample size with a more refined dataset to comprehensively explore trade liberalisation, technology innovation, and labour share. Additionally, despite efforts to ensure relevance and stationarity, the statistical insignificance of most of the results in the random estimation

model and generalised methods moments estimations emphasises the intricacies of investigating labour share dynamics in the BRICS countries. Future studies should explore alternate estimation tools to capture the nuanced relationships between trade liberalisation, technology, and labour share.

In conclusion, this study provides an essential investigation of the interaction between international trade, technology, and labour share in the BRICS countries. The insights are invaluable for economists, policymakers, and researchers devoted to understanding and addressing the intricacies of globalisation and its impact on labour markets. By implementing the recommended policies, the BRICS countries can better navigate the adversaries of economic integration and technological adoption, eventually attaining sustainable and inclusive economic development.

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	Appendix A	
	Description of the data	
Variable name	Variable Description	Source
Labour share	The labour share as a percentage of GDP represents the combined compensation of wages and social protection transfers concerning GDP. It offers insights into the share of output, revealing what portion is allocated as remuneration to employees, in contrast to the share directed towards capital within the production process during a specified time frame.	United Nations Economic Commission for Europe Available at Homepage | UNECE
Openness	Trade, measured as a percentage of GDP, is the sum of exports and imports of goods and services from 1970 to 2022.	World Development Indicators, The World Bank Available at World Development Indicators | DataBank (worldbank.org)
KOF Globalisation index	KOF Index of Globalisation ranges from 0 to 100 and encompasses three principal dimensions of globalisation: economic, social, and political integration. This index is based on data from 203 countries in 1970-2020.	2022 KOF Globalisation Index Available at Indicators – KOF Swiss Economic

		Institute | ETH Zurich
Trade regulations	The 2022 KOF Globalisation Index from 1970-2020 includes a sub-index specifically focused on trade regulations, which falls under the economic globalisation dimension of assessment. The index has a numerical range of 0 to 100 and is constructed based on several factors. These factors include the prevalence of non-tariff trade barriers, the expenses associated with compliance for importing and exporting, the income generated from trade taxes as a percentage of total revenue (with an inversion applied), and the unweighted average of tariff rates. It also considers the count of bilateral and multilateral free trade agreements.	2022 KOF Globalisation Index Gwartney et al. (2022) Available at Indicators – KOF Swiss Economic Institute | ETH Zurich
FDI inflows	The weighted average of net Foreign Direct Investment inflows as a percentage of GDP, with observations from 1970-2022.	World Development Indicators, The World Bank Available at World Development Indicators | DataBank (worldbank.org)
Population	Total population in thousands, from 1970-2022.	World Development Indicators, The World Bank Available at World Development

		Indicators | DataBank (worldbank.org)
GDP per capita	That GDP per capita is presented in constant 2015 U.S. dollars from 1970-2022. It is obtained by dividing the GDP by the midyear population. GDP, in turn, is the cumulation of the gross value added by all domestic producers within the economy, including any product taxes but excluding any subsidies not accounted for in the product value. The calculation of GDP does not factor in deductions for asset depreciation or for the depletion and degradation of natural resources.	World Development Indicators, The World Bank Available at World Development Indicators | DataBank (worldbank.org)
Schooling	The mean years of schooling of the population aged 25 and above serve as a critical metric to reflect the education within society. The data encompasses information on educational attainment for 157 countries, with data available at 5-year intervals from 1990 to 2021. The data is sourced from official statistical agencies. For the most accurate estimate possible, national values from the UNDP-Human Development Index (HDI) database were incorporated, with subnational values adjusted by interpolating in a manner that ensures their population-weighted average for a given year aligns with the national UNDP value for that same year.	Global Lab Data Available at Global Data Lab - Innovative Instruments for Turning Data into Knowledge

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Labour share	120	0.5943376	0.076325	0.4706959	0.7575438
Trade	160	41.41676	14.59798	22.10598	65.97452
Fdi inflows	159	2.097527	1.590665	-1.787319	9.703406
Fdioutflows	159	0.8208017	0.9306678	-2.595241	3.773507
Trade regulations	150	46.61606	12.64601	16.14955	74.41499
Log_population	160	19.07206	1.282216	16.97115	20.7115
Patents	154	89669.97	278792.7	138	1426644
Log_gdppercapita	160	5362.491	3015.221	582.8982	11560.33
Investment share	159	24.96194	10.51381	-10.18	47.029
education	155	7.650194	2.804414	2.885	12.77

Table 2: Summary Statistics 2

Variable	Observations	Mean	Std. Dev.	Min	Max
D.Labourshare	155	-0.0021471	0.0132488	-0.1003959	0.060208
D_Trade	120	0.7532607	8.665912	-41.87862	84.32036
D.FDI Inflows	160	0.0111338	0.8120768	-4.172066	3.195035
D.FDI outflows	159	0.0378786	1.394119	-7.437948	8.769351
D.Trade regulations	159	0.9316719	4.142609	-13.35778	23.9839
D2.Log_ population	150	-0.0003454	0.0022527	-0..0150032	0.0110245
D2.Patents	154	600.8333	38939.35	-298353	251496
D.Log GDP per capita	160	0.0311188	0.0458475	-0..1579866	0.1278286
Investment share	159	24.72841	10.88902	-12.403	47.029
Education	155	7.7019	2.806118	2.885	12.77

Table 3: Levin-Lin-Chu (LLC)

Variable	LLC Test Statistic	LLC p-value	LLC Test Statistic (First Difference)	LLC p-value (First Difference)	LLC Test Statistic (Second Difference)	LLC p-value (Second Difference)
Labour share	-2.4877	0.0064	-5.8350	0.0000		
Trade	-1.4210	0.0777	-1.5472	0.0609		
FDI inflows	-1.2081	0.1135	-4.2962	0.0000		
FDI outflows	-1.0669	0.1430	-7.6209	0.0000		
Trade regulations	-0.8076	0.2097	-5.4618	0.0000		
Log Population	-0.8937	0.1857	2.9723	0.9985	-3.1295	0.0009
Patents	5.1913	1.0000	-0.1686	0.4331	-6.8810	0.0000
Log GDP per capita	-2.0250	0.0214	-2.6515	0.0040		
Investment share	-2.7646	0.0028				
Education	-3.6727	0.0001				

Table 4: Augmented Dickey-Fuller Test

Variable	Lags(1) p-values	Lags(2) p-values	Lags(3) p-values
Labour share	P: 0.1444 Z: 0.0993 L*: 1102 Pm: 0.1480	P: 0.1450 Z: 0.1724 L*: 0.1589 Pm: 0.1488	P: 0.2433 Z: 0.2635 L*: 0.2649 Pm: 0.2760
Trade	P: 0.0002 Z: 0.0660 L*: 0.0036 Pm: 0.0000	P: 0.7204 Z: 0.6455 L*: 0.6473 Pm: 0.7450	P: 0.7343 Z: 0.5868 L*: 0.5833 Pm: 0.7555
FDI inflows	P: 0.1196 Z: 0.0710 L*: 0.0802 Pm: 1156	P: 0.2068 Z: 0.1128 L*: 0.1315 Pm: 0.2296	P: 0.2220 Z: 0.1459 L*: 0.1565 Pm: 0.2490
FDI outflows	P: 0.1728 Z: 0.0867 L*: 0.1053 Pm: 0.1853	P: 03172 Z: 0.2776 L*: 0.2942 Pm: 0.3655	P: 0.3960 Z: 0.3528 L*: 0.3544 Pm: 0.4536
Trade regulations	P: 0.8618 Z: 0.7256 L*: 0.7051 Pm: 0.8474	P: 0.7978 Z: 0.8451 L*: 0.8549 Pm: 0.8019	P: 0.7669 Z: 0.8531 L*: 0.8618 Pm: 0.7796
Log Population	P: 0.0187 Z: 0.0354 L*: 0.0350 Pm: 0.0055	P: 0.0395 Z: 0.1221 L*: 0.0894 Pm: 0.0214	P: 0.0739 Z: 0.1457 L*: 0.1332 Pm: 0.0582
Patents	P: 0.3024 Z: 0.5128 L*: 0.3010 Pm: 0.3481	P: 0.8138 Z: 0.7173 L*: 0.7440 Pm: 0.8134	P: 0.8399 Z: 0.9797 L*: 0.9902 Pm: 0.8319

Log GDP per capita	P: 0.8236 Z: 0.7832 L*: 0.7819 Pm: 0.8204	P: 0.8904 Z: 0.8229 L*: 0.8088 Pm: 0.8677	P: 0.8398 Z: 0.8013 L*: 0.7916 Pm: 0.8319
Investment share	P: 0.0026 Z: 0.0069 L*: 0.0030 Pm: 0.0001	P: 0.0000 Z: 0.0006 L*: 0.0000 Pm: 0.0000	P: 0.1421 Z: 0.1137 L*: 0.1137 Pm: 0.1449
Education	P: 0.1422 Z: 0.1520 L*: 0.1557 Pm: 0.1451	P: 0.1476 Z: 0.2251 L*: 0.2305 Pm: 0.1521	P: 0.0806 Z: 0.2282 L*: 0.2138 Pm: 0.0663

Table 5: Augmented Dickey-Fuller Test (First Difference)

Variable	Lags (1) p-values (Differenced)	Lags (2) p-values (Differenced)	Lags (3) p-values (Differenced)
Labour share	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0001 Z: 0.0001 L*: 0.0001 Pm: 0.0000	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000
Trade	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0001 Z: 0.0001 L*: 0.0001 Pm: 0.0001	P: 0.9416 Z: 0.9974 L*: 0.9983 Pm: 0.9056
FDI inflows	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0000 Z: 0.000 L*: 0.0000 Pm: 0.0000	P: 0.0005 Z: 0.0002 L*: 0.0004 Pm: 0.0000
FDI outflows	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0000 Z: 0.000 L*: 0.0000 Pm: 0.0000	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.000
Trade regulations	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0000 Z: 0.000 L*: 0.0000 Pm: 0.0000	P: 0.0080 Z: 0.0019 L*: 0.0041 Pm: 0.0010
Log Population	P: 0.7165 Z: 0.8687 L*: 0.8987 Pm: 0.7421	P: 0.9897 Z: 0.9886 L*: 0.9889 Pm: 0.9515	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000
Patents	P: 0.0121 Z: 0.0427 L*: 0.0267 Pm: 0.0023	P: 0.0184 Z: 0.1383 L*: 0.1111 Pm: 0.0054	P: 0.2203 Z: 0.7271 L*: 0.7168 Pm: 0.2468

Log GDP per capita	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0088 Z: 0.0044 L*: 0.0061 Pm: 0.0012	P: 0.1093 Z: 0.0703 L*: 0.0793 Pm: 0.1023

Table 6: Augmented Dickey-Fuller Test (Second Difference)

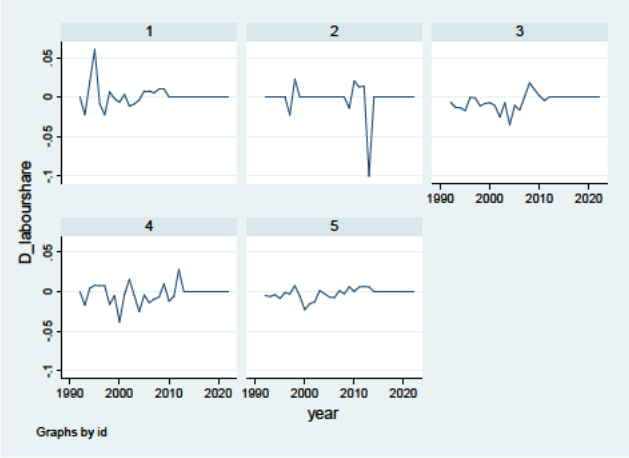
Variables	Lags (1) p-values (Second difference)	Lags (2) p-values (Second difference)	Lags (3) p-values (Second difference)
Log Population	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0817 Z: 0.1440 L*: 0.1373 Pm: 0.0676	P: 0.0014 Z: 0.0013 L*: 0.0017 Pm: 0.0000
Patents	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000	P: 0.0000 Z: 0.0000 L*: 0.0000 Pm: 0.0000

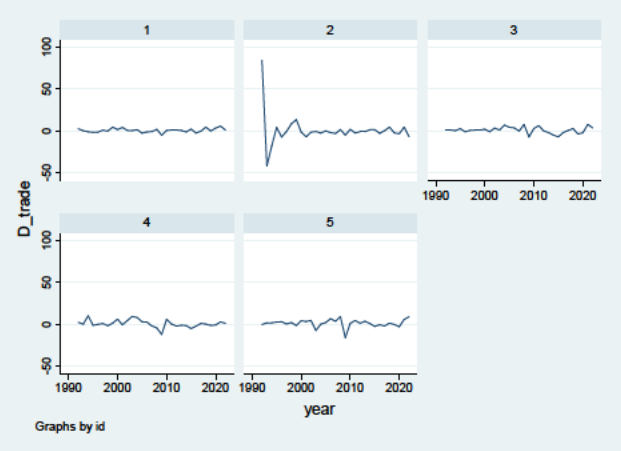
Table 7: Variance Inflation Factor (VIF)

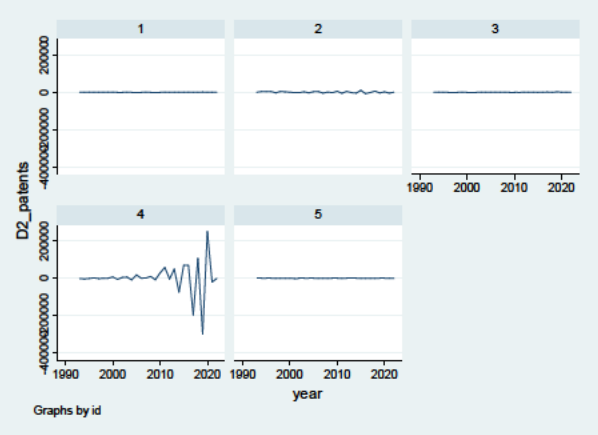
Variable	VIF
D_Trade	1.18
D_FDI Inflows	1.10
D_FDI outflows	1.05
D_Trade regulations	1.08
D2_Log population	1.05
D2_Patents	1.01
D_Log GDP per capita	2.10
Investment share	2.02
Education	1.23
Mean VIF	1.31

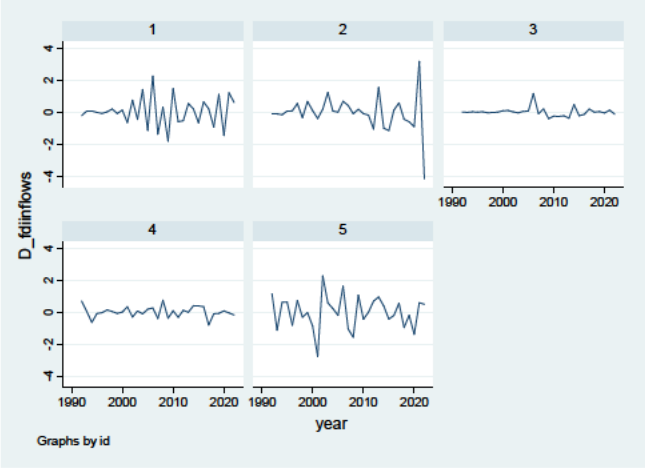
Appendix B

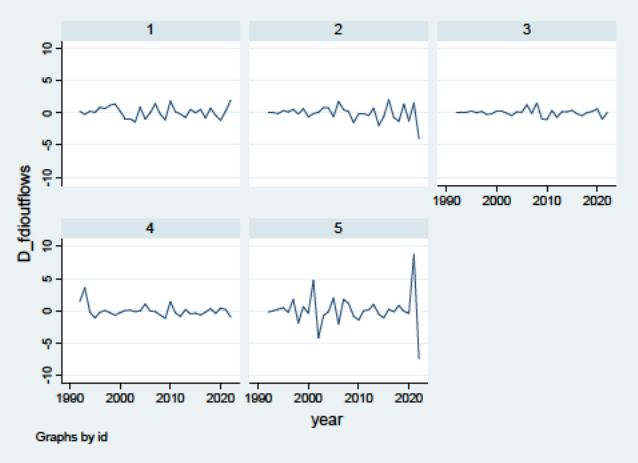
Graph variables

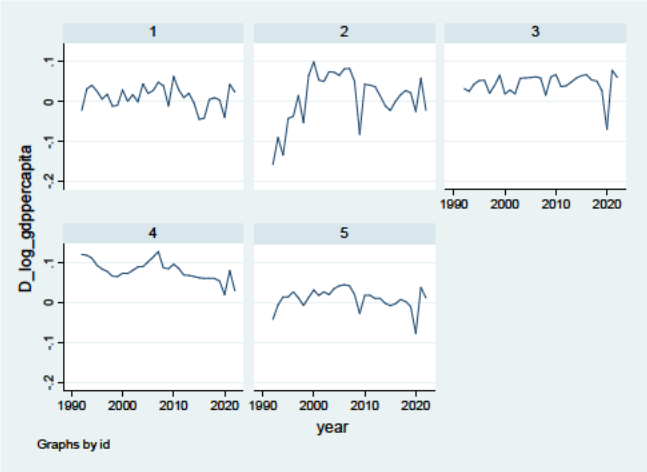











1
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2000
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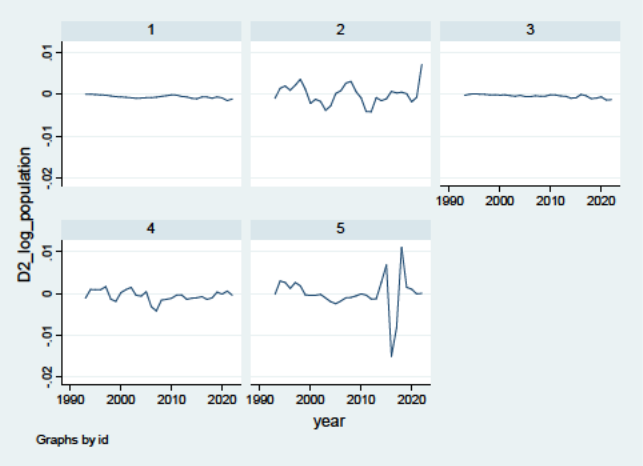
2020
year
Graphs by id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D2_log_population
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-.01
-.02
1990
2000
2010
2020
year
Graphs by id

Table 8: Diagnostics for generalised methods moments model

Diagnostic Test	Test statistic	P-value	Interpretation
Hansen J-Test (overidentification)	0.00	1.000	No overidentification
AR(2) Test (autocorrelation)	0.98	0.326	-
Number of instruments	45	-	-
Groups	5	-	-
Number of observations	150	-	-