Productivity Study of the Non-Resource Sector in Papua New Guinea, 2001-2024

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Executive Summary

Why this study matters.

This study presents the first comprehensive analysis of productivity growth in Papua New Guinea's (PNG) formal non-resource economy. Labour productivity, the amount of output produced per worker, is the single most important driver of long-term improvements in living standards, real wage growth, and national competitiveness. Yet until now, PNG has lacked reliable, sector-specific productivity estimates to inform wage-setting and economic policy.

What is productivity and how does it relate to wages?

When workers become more productive (through better skills and education, technology, business organisation, or improved capital deepening) they can produce more output in the same amount of time. Over the long run, this allows real wages (wages adjusted for inflation) to rise sustainably. If wages grow faster than productivity, businesses may struggle to keep up, potentially resulting in job losses or higher prices. If productivity improves but wages do not, workers are left behind. Linking wages to productivity is therefore key to inclusive and sustainable growth.

A non-technical explanation of how we measure productivity.

Standard methods for calculating productivity based on sectoral output and hours worked are difficult to apply in PNG due to weak or nonexistent data. To overcome this, we use the "wage-as-a-window" approach. Intuitively, in competitive labour markets, growth in wages tends to reflect growth in productivity, all else equal. Using a large administrative dataset of formal sector wages, we develop a novel technical approach that, after controlling for worker, firm and sectoral characteristics, and external factors (such as real exchange rate and terms of trade shocks) isolates the fraction of wage growth over time that is driven by productivity growth. We apply this estimation technique to the non-resource economy, generating a productivity-growth series for the agriculture, industry, and services sectors.

What we find.

We estimate that **productivity in the non-resource formal economy grew at an average of 1.5% per annum (p.a.) from 2001 to 2024**. This is decomposed into the following sectoral growth rates:

- **Services sector:** Productivity grew at an average of **1.9% p.a.** from 2001 to 2018. Projections show it slowed modestly to 1.45% p.a. from 2019 to 2024 due to a more difficult business environment. The services sectors remain the most dynamic part of PNG's economy.
- **Industry sector:** Productivity grew at an average of **1.46% p.a.** over 2001 to 2018, and over 2019 to 2024 projections show it maintained this growth. Despite challenges, the sector has shown consistent productivity gains.
- **Agriculture sector:** Productivity has **stagnated** in the agricultural sector. Growth has averaged around zero, with no statistically significant improvement over the last two decades. This highlights structural barriers to progress in the agricultural sector.

The sectoral results reveal a dual economy.

The services and industrial sectors had positive productivity growth, while agricultural growth was stagnant. Without policy reforms to turnaround agricultural productivity, agriculture workers risk missing out on the benefits of higher productivity growth.

Why does industry trail services? Contrary to international experience, PNG's services sector has outpaced industry in productivity growth. This divergence likely reflects structural constraints rather than differences in underlying potential. These include:

- *Infrastructure and business environment constraints.* Industrial activities are differentially exposed to chronic infrastructure impediments, such as unreliable electricity, high transport costs, inefficient ports, and weak domestic transport links, as well as broader business impediments like foreign exchange shortages and regulatory delays.

- *Skills shortages.* Limited vocational pipelines leave plants short of technicians and supervisors, keeping capacity utilisation below potential.
- *Technology transfer advantage in services.* Many service businesses can import turnkey software and managerial know-how, options that are less applicable to firms in industry.

Tackling these bottlenecks could allow industry productivity to catch up and exceed service-sector gains.

The role of the business environment.

To better understand more recent trends, we construct a Business Difficulty Index using data from the Westpac Business Advantage PNG 2025 CEO100 Survey 2025. The index captures the severity of business constraints across areas such as access to foreign exchange, unreliable utilities, regulatory uncertainty, skills shortages and law and order. Since 2019, business conditions have worsened significantly. We use the BDI to adjust our projections over 2019-2024, finding that these constraints have slowed productivity growth since 2019.

Policy implications.

Our results point to a number of actionable policy implications, summarized below:

- **Minimum wage setting:** Productivity growth provides a solid benchmark for sustainable wage increases. If real wages grow in line with productivity, business competitiveness is maintained and workers can share in their productivity gains. Our estimate of 1.5% annual productivity growth offers reference point for minimum wage growth.
  - With agricultural productivity growth near zero, agriculture firms may struggle to absorb minimum wage increases linked to economy-wide productivity growth. In such circumstances, mechanisms like the *Agriculture Sector Partial Payment* and the *Exemption for Incapacity to Pay* provide safeguards for firms under financial stress.
- **Agricultural Reform:** Stagnant agricultural productivity growth suggest agriculture work-

ers are being left behind and points to deeper structural issues, such as weak infrastructure, a lack of investment, low technology adoption, and poor market access. Policy reforms are needed to lift incomes and close the gap with other sectors.

- **Improve the business climate:** Productivity in all sectors is being held back by difficult business operating conditions.The marked deterioration in business conditions since 2019 is an early warning sign. If left unaddressed, this deterioration may continue to erode the productivity gains that PNG's more dynamic sectors have worked hard to build. Improving forex access, unreliable utilities, regulatory uncertainty, skills shortages and law and order is necessary if PNG is to unlock faster productivity growth.
- **Establish a PNG Productivity Commission:** Drawing on international models, such as Australia's Productivity Commission, we recommend establishing an independent body to monitor productivity trends, identify bottlenecks, and advise government on reform priorities.

Conclusion.

This study equips PNG with the tools and evidence to link wages and productivity with a data-driven approach. It provides the technical foundation to align minimum wage policy with economic fundamentals and also offers a roadmap for broader reform.

A non-technical guide to reading this study

First, read the **Executive Summary**, which provides a clear overview of the study's purpose, approach, key findings, and policy implications. Then go to **Appendix A.6: Summary of the Productivity Study**, which gives an intuitive description and explanation of the entire study. Once you've done this, go to **Section 3.1: What is Labour Productivity?** for a plain-language explanation of what productivity means and why it matters for wages and economic growth. Next, read **Section 3.2: Measuring Labour Productivity in the Existing Literature**, which explains how productivity is usually measured and why this is difficult in PNG's context. Read selectively here. Follow with **Section 7: Discussion and Policy Implications**, which draws out the meaning of the results and discusses what they imply for minimum wage policy, structural reform, and national productivity strategy. If you are feeling adventurous, you could try **Section 6: Results**, again read selectively. For a discussion of "What is Regression" visit **Appendix A.4**. Finally, read **Section 8: Conclusion**.

1 Introduction

Productivity growth is the cornerstone of long-term economic progress. It drives improvements in living standards, wage growth and business competitiveness. In high-income and developing economies alike, the relationship between productivity and real wages has been widely studied and is increasingly central to policy debates around labour markets, growth strategy, and minimum wage setting.

In Papua New Guinea (PNG), there has been little, if any, empirical analysis of productivity trends at the economy-wide or sectoral levels. Although macroeconomic aggregates, such as GDP and employment, are regularly published, comparable measures of sectoral productivity across agriculture, industry, and services are absent.[1] This gap in the evidence base constrains the ability of policymakers to design effective wage policies, shape industrial strategy or design reforms to improve competitiveness.

This study addresses that gap. To our knowledge, it represents the first comprehensive and empirically grounded study of productivity growth in PNG's formal non-resource sector. Using a rich panel dataset and a novel wage-based methodology, we estimate sectoral productivity trends over the period 2001–2018 (the period for which we have underlying data) and generate a projection of productivity changes from 2019-2024. The analysis draws on a "wage-as-a-window" approach that links real wage growth, conditional on individual, firm, and macroeconomic characteristics, to underlying labour productivity trends. This method is well suited to data-sparse environments such as PNG, where standard output-per-worker measures are unavailable or unreliable.

Our contribution is methodological as well as empirical. We adapt and extend wage-based methods of productivity estimation to the unique context of a small, resource-rich, data-sparse developing economy. This includes a novel two-stage estimation method that integrates macroeconomic

[1] These sectors are defined by aggregating divisions in the PNG Standard Industrial Classification (PNGSIC–2000) into the three categories noted here. The full mapping of PNGSIC divisions to these sectors is provided in Appendix A.7.

shocks and firm–worker level heterogeneity, and an adjustment for worsening business conditions.

By anchoring productivity estimates in both observed real wages and macroeconomic variables (notably, the real exchange rate and terms of trade), this study offers a technically robust framework for evaluating productivity across time and sectors. In doing so, it contributes new evidence to PNG's wage-setting discussions and broader debates around inclusive growth, competitiveness, and private sector development.

Beyond its technical contributions, the study offers a practical tool for public policy: a sector-by-sector benchmark for average productivity growth, including adjustments for recent deteriorating business conditions captured through the Business Difficulty Index (BDI). These benchmarks can inform minimum wage decisions and guide national productivity-enhancing reforms. They also provide the empirical foundation for recommending institutional innovations, such as the creation of a PNG Productivity Commission, that could support sustained improvements in efficiency and inclusive growth over the coming decades.

2 Study Objectives

The primary objective of this study is to measure labour productivity growth across the non-resource sectors of Papua New Guinea's formal economy over the past 24 years. Specifically, the study develops and applies an empirical methodology suited to data-sparse environments that can be used for future productivity analysis in PNG and comparable environments.

Given the limitations of conventional output-based productivity measures in PNG, the study adopts a`wage-as-a-window" approach that uses real wage movements, after controlling for worker, firm, sectoral, and macroeconomic factors, as a measure for underlying productivity growth. This allows us to infer productivity trends from observed wages while filtering out wage dynamics driven by external shocks and individual, firm and sectoral factors.

The specific objectives of the study are as follows:

1. Develop and implement a robust empirical methodology for estimating productivity in data-limited environments using a wage-based proxy framework.
2. Estimate sector-specific labour productivity growth over the historical period 2001–2018 using real wage panel data, controlling for individual, firm, sectoral, and macroeconomic factors.
3. Decompose changes in wages into components driven by productivity growth, real exchange rate movements, and changes in the terms of trade.
4. Forecast productivity growth for 2019–2024 using macroeconomic projections and the estimated model.
5. Adjust forecasted productivity trends to account for the post-2018 deterioration in the business environment using a Business Difficulty Index (BDI) constructed from PNG CEO survey data.
6. Compare productivity performance across PNG's non-resource sectors (agriculture, industry, and services) and identify structural divergences in growth.
7. Provide evidence-based insights to inform national policy debates on business competitiveness, labour market regulation, and inclusive growth.

3 Background and Existing Literature

Below we offer an overview of the economics of labour productivity and a review of how the existing literature measures productivity in similar settings.

3.1 What is Labour Productivity?

Labour productivity is a fundamental measure of economic performance. At its core, it captures how efficiently labour inputs, typically hours worked or number of workers, are converted into output. It is most commonly defined as:

$$\text{Labour Productivity} = \frac{\text{Output}}{\text{Labour Input}} \tag{1}$$

Labour productivity growth reflects improvements in the amount of output that can be produced by each worker. This can occur through a variety of mechanisms: better technology, improved skills and education (human capital), better management, increased investment in equipment and infrastructure (capital deepening), or through reallocation of labour toward more productive firms (see Appendix A.2).

In the context of a developing and resource-dependent economy like PNG, labour productivity is particularly important. Increasing labour productivity is one of the few ways to sustainably raise real incomes, improve competitiveness, and achieve broad-based economic growth. Changes in labour productivity over time can also reveal broader structural trends and be a guide for policies to improve sectoral and overall productivity growth.

3.2 Relationship of our approach to the existing literature

There are myriad challenges associated with measuring worker productivity, particularly in developing countries like PNG. The conventional or standard method of calculating worker productivity is to divide an index of real output by an index of hours worked by all persons involved in the production process, including employees, proprietors, and unpaid family workers (U.S. Bureau of Labour Statistics, 2007).[2]

Formally:

$$\text{Labour Productivity Index} = \frac{\text{Index of Real Output}}{\text{Index of Hours Worked}} \tag{2}$$

[2]A more comprehensive measure is total factor productivity (TFP), which estimates how efficiently both labour and capital are used in production. TFP is typically derived as a residual, that is, the portion of output growth that cannot be explained by increases in labour and capital inputs. These measures have been extensively used in growth accounting exercises (Solow, 1957; Jorgenson et al., 2005; Feenstra et al., 2015) and are the foundation of productivity statistics compiled by international organisations such as the OECD and World Bank.

However, this method relies critically on the availability of accurate and reliable measures of both output and hours worked, ideally disaggregated at sectoral levels. In PNG, comprehensive data on either sectoral output or labour hours is unavailable. This creates significant measurement limitations, especially if one's objective is to measure productivity growth across sectors and over time.

In such cases, researchers often turn to observed wage patterns to infer productivity changes. The underlying intuition is that in competitive labour markets, workers are paid roughly in line with the value of their output. If wages rise after controlling for structural factors, this can indicate that productivity is increasing. This approach, what we refer to as the "wage-as-a-window" method, is widely used in practice. For instance, in development and labour economics, researchers use trends in real wages to assess sectoral productivity dynamics where formal output data are lacking (Gindling and Terrell, 2005; Grimm et al., 2011). A recent Australian Government Productivity Commission Report, *Productivity growth and wages – a forensic look*, notes that long-term real wage growth is predominantly driven by labour productivity growth (Productivity Commission, 2023).

A closely related study is Blunch and Davies (2025), which provides the first systematic analysis of real wage growth in PNG's formal private sector over the period 1999–2018. Using a rich panel dataset of superannuation records, their findings reveal that real wages in PNG have broadly followed the country's boom-bust macroeconomic cycles and diverged significantly across sectors and genders. Importantly, Blunch and Davies (2025) demonstrate that conditional real wage growth is driven by both labour productivity and movements in the real exchange rate.[3] This insight provides the empirical foundation for the approach adopted in our study.[4] Our work thus builds on and complements Blunch and Davies (2025).

[3]The conditional real wage variable is the time fixed effect in their main regression specification. As Blunch and Davies (2025) note, the time trend coefficient yields an estimate of productivity growth, aligning with Productivity Commission (2023). However, in RRDCs with high import dependence, this measure is not fully satisfactory given the susceptibility of the economy to terms of trade shocks and movements in the real exchange rate.

[4]Blunch and Davies (2025) carry out the first stage of our regression-based approach, outlined in section 5.2.1.

The relationship between real wage growth and productivity growth may be affected by cyclical or institutional factors. Changes in the bargain between employers and workers (e.g. sectoral concentration) and macroeconomic shocks (e.g. changes in the real exchange rate) can cause real wage growth to diverge from productivity growth. These fluctuations may result in wage growth either lagging behind or overshooting productivity gains.

If one can control for these short-term factors, specifically bargaining power dynamics and macroeconomic shocks, real wage trends offer an accurate proxy for measuring trends in labour productivity. This approach is particularly relevant in data-sparse environments like PNG, where real wage data (from payroll taxes or superannuation contributions) may be more readily available and reliable than detailed input-output data.

In this study, we adopt this approach by estimating productivity trends in PNG's non-resource sectors using real wage data, adjusted for individual, firm and sectoral characteristics and macroeconomic conditions. This method allows us to extract an accurate measure of underlying labour productivity growth, despite the data limitations faced in the PNG context.

4 Data

This study draws on several complementary data sources to measure and analyse productivity trends and business conditions in PNG from 2001 to 2024.

4.1 Conditional Real Wage Data

The Conditional Real Wage (CRW) data comes from the analysis and results presented in Blunch and Davies (2025). It is based on detailed administrative records of matched employer and employee superannuation contributions in the private formal sector in PNG. Using these data from Nasfund (the largest private-sector superannuation fund in PNG), the authors created a panel of annual wages for employees over the period 2000 to 2018.[5]

The CRW series spans from 2000 to 2018. Given that the CRW is constructed from a regression in which the dependent variable is the *log of real wages*, the CRW values are expressed in log-points.[6] Taking first differences of CRW over time yields an approximation of the growth rate of CRW.

The analysis is conducted separately for three broad sectors: *Agriculture*, *Industry*, and *Services*. These sectors are defined by aggregating divisions in the Papua New Guinea Standard Industrial Classification (PNGSIC–2000) into the three categories used in this study. The full mapping of PNGSIC divisions to these sectors is provided in Appendix A.7.

4.2 Macroeconomic Indicators

We incorporate two key macroeconomic variables as controls in the regression-based productivity estimation and one of these two in the theory-based productivity estimation:

- **Real Exchange Rate (RER):** The RER data are sourced from the PNG Economic Database, (`https://pngeconomic.devpolicy.org/`). This index captures PNG's price competitiveness relative to its trading partners. Any other noted macroeconomic variables are also accessed from this source.
- **Terms of Trade (TOT):** We construct a barter terms of trade index using IMF commodity price series. The export price index is built from individual commodity export prices weighted by their share in PNG's total commodity exports (rolling weights). The import price index uses commodity import prices weighted by the ratio of imports to GDP. The final TOT index is the ratio of these two indices.

[5]The regression analysis in Blunch and Davies (2025) was completed in 2021, after which the authors did not retain access to the NASFUND database. This study relies on results from Blunch and Davies (2025): see stage 1 of the regression-based approach in Section 5.2.

[6]See Section 5.2.1 for an elaboration on the regression approach in Blunch and Davies (2025).

4.3 Business Difficulty Index

The BDI is derived from the Westpac Business Advantage PNG 2025 CEO100 Survey (Westpac IQ, 2025) conducted annually from 2012 to 2025. We digitize and compile responses related to six impediments to doing business and create a composite index following the methodology developed in Section 4.3.1 of this study. The BDI captures perceptions of business constraints and provides an empirical proxy for non-price factors affecting productivity and firm performance. We describe the construction and trends in the BDI data in more detail below.

4.3.1 Construction of the Business Difficulty Index (BDI), 2019-2024

We construct a composite measure from the Westpac Business Advantage PNG 2025 CEO100 Survey (Westpac IQ, 2025). It aggregates the perceived severity (rated from 1 to 5, where 5 represents the highest difficulty) of the six most consistently cited business impediments:

1. Foreign exchange availability
2. Unreliable utilities
3. Lack of government capacity
4. Regulatory uncertainty
5. Shortage of expertise and skills
6. Security and law and order

The index is calculated as the arithmetic mean of the scores for these six impediments for each year. This structure maintains comparability and interpretability by preserving the original scale used by survey respondents.

4.3.2 Trends Over Time

Figure 1 shows the evolution of the BDI together with each of its six component impediments. The dashed red line indicates the fitted linear trend for 2019–2024. Between 2012 and 2025, the BDI has fluctuated between 3.4 and 4.3, generally reflecting a challenging operating environment. However, conditions have deteriorated sharply in recent years. Since 2019, the index has shown a consistent upward trajectory, peaking in 2024 at the highest level recorded in the series and remaining elevated in 2025.

Figure 1 shows the evolution of the BDI together with each of its six component impediments. The dashed red line indicates the fitted linear trend for 2019–2024.

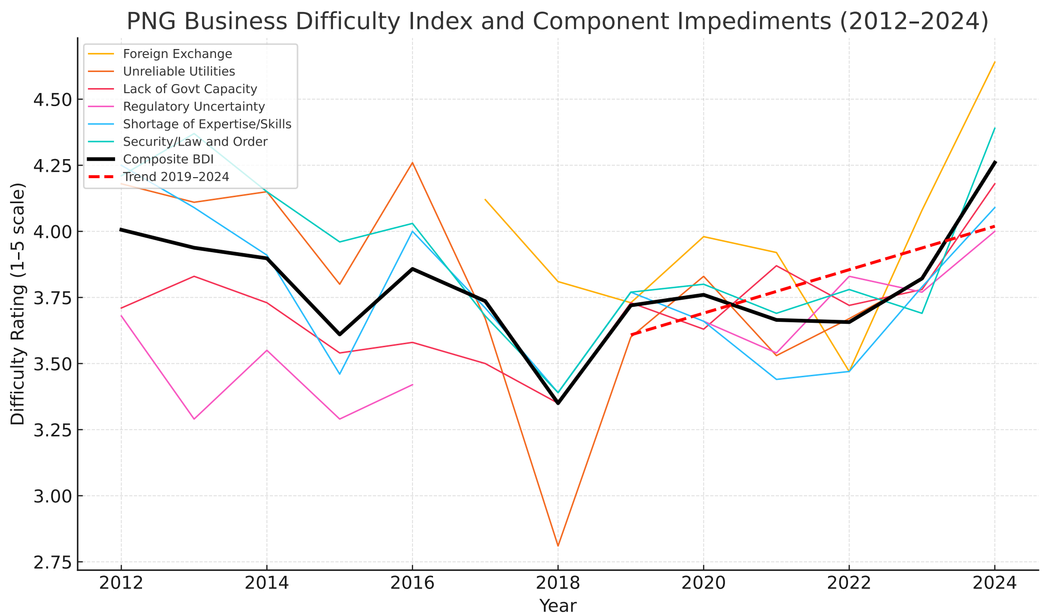

Figure 1: Evolution of the Business Difficulty Index and its six component impediments, 2012–2024. The dashed red line is the fitted linear trend for 2019–2024.

A linear regression over the period 2019-2025 confirms a statistically significant upward trend in business difficulty. The estimated slope is 0.076 per annum (p.a.), indicating that the BDI has increased by nearly half a point over six years. The R-squared is 0.53, meaning that over half the variation in the index is explained by the time trend. Importantly, the p-value of 0.063 suggests the trend is statistically significant at the 10% level, providing credible evidence that business conditions have structurally worsened in recent years.

This deterioration has been driven by worsening access to foreign exchange, persistent weaknesses in utilities and infrastructure, and growing concerns around public sector performance. The convergence of multiple constraints has compounded the burden on firms, with perceived difficulty escalating across all six core dimensions.

In the next section, we outline how we leverage the datasets described above to measure productivity growth in PNG.

5 Methodology

We adopt a two-pronged approach to estimate labour productivity growth in PNG over the period 2001-2018. The first approach is a structural, theory-based method that relates real wage growth to productivity using a stylized macroeconomic identity. The second is an empirical approach using individual-level administrative data on wages coupled with macroeconomic indicators to estimate productivity trends, after controlling for individual, firm, and macroeconomic factors.

5.1 Theory-Based Approach to estimating Productivity Growth

The structural approach follows Carlin and Soskice (2014) and is formalised in Blunch and Davies (2025). It begins from an equation that links real wage growth to changes in productivity and other structural variables given by:

$$\widehat{(W/P)}_t = \widehat{(1-\mu_t)} + \widehat{\text{RER}}_t + \widehat{A}_t + \theta_K\,\widehat{K}_t + \theta_H\,\widehat{H}_t + \theta_L\,\widehat{L}_t \tag{3}$$

where μ is the marginal cost mark-up, $\widehat{A}$ is productivity growth, and the θ terms are elasticities of the marginal product of labour with respect to capital (K), human capital (H), and labour (L). The $\widehat{\ }$ notation indicates percentage growth in a variable.

In our data-driven approach described in detail in Section 6.2.1 below, individual and firm fixed effects, and controls for market concentration absorb the effects of K, H, and μ. This allows us to simplify equation (3) to:

$$(\widehat{W/P})_t = \widehat{\text{RER}}_t + \widehat{A}_t \tag{4}$$

Thus, $\widehat{W/P}$ is interpreted as the conditional real wage and productivity growth is obtained as the residual:

$$\widehat{A}_t = (\widehat{W/P})_t - \widehat{\text{RER}}_t \tag{5}$$

This approach serves as a benchmark for the empirical strategy.

5.1.1 Calculating Average Productivty Growth

To calculate average productivity growth over a time period T, we compute the time average of the annual differences:

$$\bar{A} = \frac{1}{T}\sum_{t=1}^{T}(\widehat{CRW}_t - \widehat{\text{RER}}_t) \tag{6}$$

This average provides a benchmark estimate of underlying productivity growth over the selected time horizon.

5.2 Regression-based Approach to Estimating Productivity: 2000-2018

The goal of our empirical strategy is to use observed wages to infer productivity. We achieve this in two stages.

5.2.1 Stage 1: Estimating the Conditional Real Wage (CRW)

In the first stage (taken from Blunch and Davies (2025), we leverage administrative data from NASFUND on the wages of roughly 200,000 workers from 2000-2018 to estimate the following individual-level regression:

$$\log(w_{it}) = X'_{it}\beta + \delta HHI_{st} + \alpha_i + \gamma_j + \lambda_t + \varepsilon_{it} \tag{7}$$

where w_{it} is the wage for individual i in year t. X'_{it} is a vector of observable worker characteristics including age, gender, and years of experience. The parameter β is a vector of regression coefficients associated with the characteristics in X'_{it}. HHI_{st} is the Herfindahl-Hirschman Index of sectoral concentration for sector s and year t.[7] The parameter δ is the association between HHI and wages.

We also employ a rich set of fixed effects. α_i represents the individual fixed effect which captures any unobserved time-invariant characteristics of individual i that may affect i's wage such as inherent skills and ability, education[8], long-term preferences for work, and others. Intuitively, the individual fixed effect nets out from the wage any person-specific characteristics that are captured in i's wage.

Similarly, we include firm-level fixed effects, represented by γ_j. This fixed effect accounts for any firm-specific characteristics that are unobserved in data, but could affect wages. Examples include: firm culture, compensation norms, and efficiency. Intuitively, the firm fixed effects account for inherent firm characteristics, and nets those out from the wage.

Finally, we include a set of 20 year fixed effects, represented by λ_t. These fixed effects account for any economy-wide shocks and changes over time that apply to the economy as a whole such as: commodity price shocks, booms and busts, etc. Intuitively, this nets out any common shock that might impact a worker's wage.

The resulting set of estimated λ_t fixed effect coefficients can be interpreted as the conditional real wage (CRW). The values of the CRW estimated in Stage 1 are used in the productivity calculations

[7] For further discussion on the calculation of the HHI, see Blunch and Davies (2025).
[8] In PNG it is safe to assume education is time-invariant.

in Stage 2.[9] Other studies that have used a similar approach have used λ_t as direct estimates of productivity. However, in the PNG context (a small open economy and a resource-rich developing country), divergence between movements in the CRW and productivity can be driven by movement in the real exchange rate (RER) and the terms of trade (TOT). So, in order to precisely estimate the productivity growth, we need to account for these variables in Stage 2 of our data-driven approach. This will allow us to improve our estimation of the true productivity growth over the period of study.

5.2.2 Stage 2: Estimating Productivity Growth

We regress the year-on-year change in CRW obtained in Stage 1 on macroeconomic controls using the following regression equation:

$$\Delta\text{CRW}_t = \alpha + \beta_1\Delta\text{RER}_t + \beta_2\Delta\text{RER}_{t-1} + \beta_3\Delta\text{TOT}_t + \epsilon_t \tag{8}$$

where ΔCRW_t is the change in the estimated CRW in year t (using the values of λ_t estimated in Stage 1). ΔRER_t is the change in the (log) real exchange rate in year t, taken from the PNG Economic Database. The parameter β_1 is the estimated association between the change in the real exchange rate and the change in the CRW. ΔRER_{t-1} is the change in the lagged (log) real exchange rate in year t. The parameter β_2 is the estimated association between the change in the lagged real exchange rate and the change in the CRW. ΔTOT_t is the change in the (log) terms of trade in year t. β_3 is the estimated association between the change in the terms of trade and the CRW. The residual after accounting for time-varying macroeconomic conditions, ϵ_t, represents annual variation in CRW. By controlling for the change in RER and TOT, epsilon is assumed to be idiosyncratic.

The coefficient of interest in this equation is α, which should be interpreted as the average labour productivity growth over time. Intuitively, α is the average growth rate of labour productivity after accounting for the movements in the real exchange rate (RER) and terms of trade (TOT). Note that

[9] For more detail see Blunch and Davies (2025).

it is also possible to recover an estimate of the year-specific productivity by adding α and ϵ_t.

Overall, the second stage of our estimation strategy enables us to isolate productivity growth from wage growth because we have controlled for real exchange rate (RER) and terms-of-trade (TOT) shocks. This will return a more precisely-estimated measure of productivity growth in the PNG context, relative to using a conventional approach used in other settings. Finally, because we are looking at average productivity growth over an 18 year period, which includes periods of both boom and bust, the net impact of omitted cyclical factors is likely to average out, reducing their bias on the estimated long-run productivity trend captured by the constant term α.[10]

Summary: The combination of these two approaches (the theoretical/structural approach and the empirical regression approach) offer complementary analyses of the changes in productivity over time. Where the two approaches yield similar results, they provide a robustness test for our productivity estimates. Where they diverge, the gap helps inform our interpretation of unobserved factors, such as institutional frictions or data limitations.

5.3 Forecasting Productivity: 2019-2024

Once we have estimated productivity growth for the observable years 2001–2018, we can use our estimates from the regressions above to forecast productivity growth for 2019–2024, where data is unavailable. To do this, we use both the regression-based and theory-based approaches in sequence. Intuitively, we use projected values of ΔCRW for 2019-2024 in combination with theoretical identity equation (5) to back out productivity growth for 2019-2024.

5.3.1 Step 1: Forecasting CRW for 2019-2024

We use regression equation (7) above to calculate a predicted value of ΔCRW for 2019-2024:

$$\Delta\widehat{\mathrm{CRW}}_t = \alpha + \beta_1 \Delta\mathrm{RER}_t + \beta_2 \Delta\mathrm{RER}_{t-1} + \beta_3 \Delta\mathrm{TOT}_t \tag{9}$$

[10]See Section A.5 for more details of PNG's economic conditions over 1999–2024.

where ΔRER_t and ΔTOT_t are the observed values from 2019 to 2024. We utilize the regression coefficients obtained in Stage 2 above to calculate an estimate of $\Delta \widehat{\text{CRW}}_t$ for each year.

5.3.2 Step 2: Inferring Productivity for 2019-2024

We then use the theory-based identity given by theoretical equation (5) above, and repeated here below using estimated-value notation:

$$\widehat{A}_t = \Delta \widehat{\text{CRW}}_t - \Delta \text{RER}_t \tag{10}$$

to infer productivity growth by accounting for the actual changes in the observed real exchange rate.

5.3.3 Step 3: Adjusting for Business Difficulty

The CRW regression that underlies the baseline forecast is estimated on 2001-2018 data, so its constant term, α, already embeds the *average* level of business difficulty over that period (with year-to-year deviations reflected in the residuals). When we estimate ΔCRW for 2019-2024 as described in Section 5.3.1, we implicitly impose that firms continue to face that same operating environment. However, in the following, we show evidence that the difficulty of doing business increased after 2018. In this section, we define and create the BDI based on the data from this survey, showing that the index rose significantly after 2018. Without a separate correction for this change, the forecast therefore assumes the 2001-2018 business difficulty level and risks overstating productivity growth in a climate that became markedly more challenging.

How we adjust for business difficulty:

1. Measure the long-run benchmark. The average BDI over 2012–2018, denoted $\overline{\text{BDI}}_{12\text{–}18}$, is considered the baseline operating environment.

2. Estimate the sensitivity of productivity to difficulty. For 2012–2018 we regress each sector's

productivity growth, $\widehat{A}_{it}$, on the log-deviation of the BDI from the benchmark:

$$\widehat{A}_{it} = \gamma_i + \beta_i \Big[\ln\big(\text{BDI}_t\big) - \ln\big(\overline{\text{BDI}}_{12\text{–}18}\big) \Big] + u_{it}. \tag{11}$$

The coefficient β_i tells us how many percentage points sector i's productivity growth changes when the business climate is tougher than the 2012–2018 average.

3. Apply the business difficulty elasticity of productivity to the forecast years.[11] For each forecast year $t = 2019, \ldots, 2024$ we compute the same log-deviation of the BDI and adjust the baseline productivity forecast:

$$A_{it}^{\text{adjusted}} = A_{it}^{\text{base}} + \beta_i \Big[\ln\big(\text{BDI}_t\big) - \ln\big(\overline{\text{BDI}}_{12\text{–}18}\big) \Big]. \tag{12}$$

When the BDI returns to its long-run mean the adjustment term vanishes; when difficulty rises persistently above the benchmark, the forecast is reduced in proportion to β_i.

Summary

The three-step procedure described above combines macro projections, structural wage–productivity theory, and an adjustment for the business environment. The first two steps generate baseline forecasts anchored in observable exchange rate and terms-of-trade trends and the historical CRW relationship; the third step tempers those forecasts by the extent to which current business cost conditions deviate from the previous norm. By taking this approach, the projections remain firmly grounded in economic theory and empirical macro relationships while still capturing the practical reality that firms operate in a business climate that can shift over time, which is especially important in the context of PNG.

[11] The business difficulty elasticity of productivity is interpreted as the percentage decrease in productivity for each one percent increase in business difficulty.

6 Results

Below, we present the results separately by sector for the services, industry, and agriculture sectors, ordered by growth rates. For each sector, we first present results on the change in the CRW for the historical (2000-2018) period following the method outlined in sections 5.1 and 5.2 and next we present the results for the forecast of productivity growth for the years 2019-2024 following the method outlined section 5.3.

6.1 Services Sector

Table 1 presents the regression results for the change in the CRW in the services sector in PNG from 2000 to 2018. The results for the services sector indicate that changes in the CRW are driven by both contemporaneous and lagged movements in the real exchange rate, and by the terms of trade. The estimated effect of the lagged real exchange rate is statistically significant at the 5% level, suggesting a delayed pass-through of exchange-rate shocks into wage dynamics. The terms-of-trade coefficient is significant at the 10% level. The coefficient of interest, $\hat{\alpha} = 0.0231$, implies an average annual productivity growth of 2.31% over 2001-2018.

Table 1: OLS Results for Services Sector, 2001-2018: $\Delta CRW_t^{\text{services}}$

Variable	**Coefficient**	**Standard Error**	**p-Value**
Constant ($\hat{\alpha}$)	0.023	0.012	0.081
ΔRER_t	0.158	0.136	0.264
ΔRER_{t-1}	0.294	0.130	0.040
ΔTOT_t	0.169	0.088	0.074
R^2	0.381		
Observations	18		

Using the theory-based approach, equation (6) determines that the average theory-based productivity growth rate in the services sector is 1.48%.[12]

Since the services sector produces some non-traded goods, to assess the robustness of the findings above, we augmented the baseline specification with several variables. These variables are intended to capture non-resource sector economic activity. We included, in sequence, the non-resource GDP growth and non-resource sector labour force growth. Both variables return the expected signs, however, the associations are statistically insignificant and have negligible impact on the ΔRER and ΔTOT coefficients. Second, we introduced a set of year indicators for the PNG LNG investment phase (2009-2012) to test for a structural break associated with the construction boom. The LNG indicators were individually and jointly insignificant, indicating no discrete shift in CRW behaviour during that period. Because these additional regressors neither improve overall fit nor alter the inference on the main drivers, they are omitted from the preferred specification.

Next, we turn to our forecast of productivity growth in the services sector for the years 2019 to 2024. We apply the approach described in Section 5.3: first, we generate a theory-based productivity forecast, which combines actual movements in the real exchange rate (RER) and the terms of trade (TOT) with estimated coefficients from the CRW regression from Table 1, then we incorporate changes in the post-2018 business climate as measured by the BDI described in Section 5.3.3. These results are presented in Table 2.

The theory-based forecast predicts an average annual productivity growth over 2019-2024 of 1.61%. When adjusted for elevated business difficulty over 2019-2024, the average annual BDI-adjusted productivity growth falls to 1.45%. This illustrates the drag on productivity from the deteriorating operating environment during this period.

For the services sector, the estimated business difficulty elasticity of productivity is $\hat{\beta}_s = -0.142$, suggesting that a 10% increase in business difficulty relative to the 2012-2018 average reduces productivity growth by approximately 1.4 percentage points. We use this estimate to calibrate the effect of the deterioration in business conditions on projected productivity over 2019-2024 to

[12] Computed from year-by-year data on CRW and RER for the services sector.

temper the effect presented in column 1 and instead offer a more realistic estimate in column 2.

Table 2: Average Services Sector Productivity Growth, 2019–2024

	Theory-Based	**BDI-Adjusted**
Average annual growth (2019–2024)	1.61%	1.45%
Business difficulty elasticity of productivity: $\hat{\beta}_s = -0.142$		

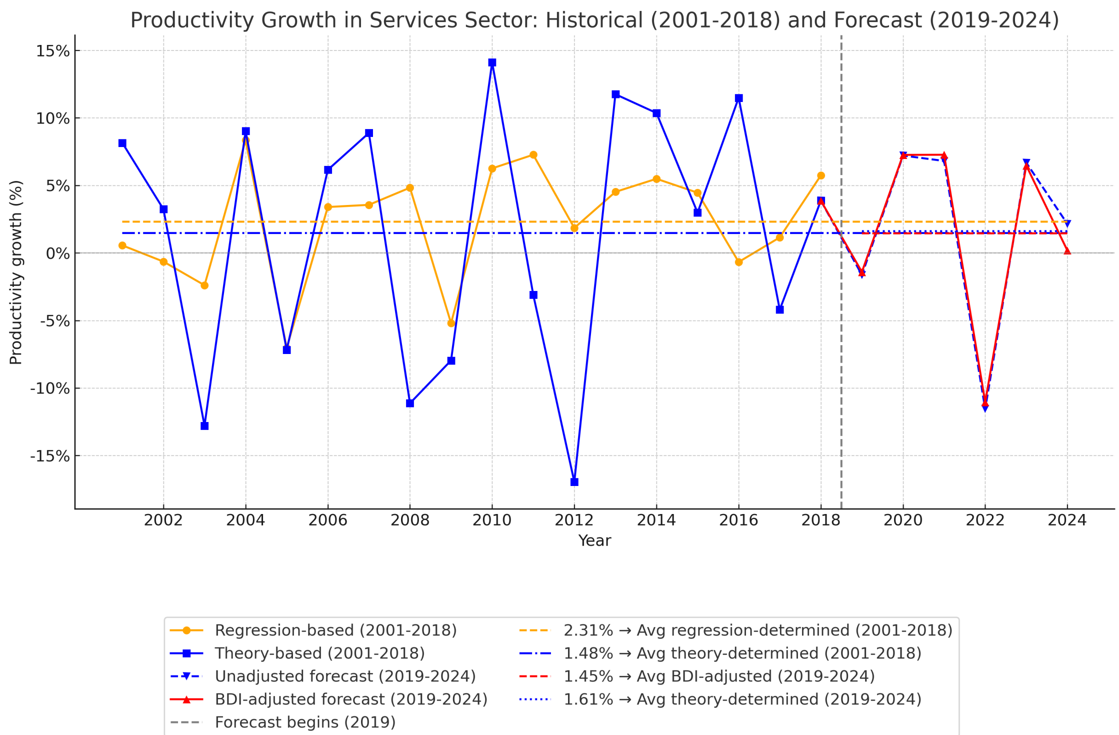

Figure 2: Theory-determined vs. Regression-determined Productivity in Services Sector (2001–2024)

Figure 2 offers a visual summary of the main findings in the services sector.[13] It presents the evolution of labour productivity in services from 2001 to 2024. It distinguishes between three key series: first, the regression-determined productivity is shown in orange; second, the theory-based productivity estimated by calculating equation (6) is shown in blue; and third, the BDI-adjusted forecast is shown in red.

[13] The productivity growth values are summarized in Table 11.

The historical period (2001–2018) is contains both the regression and theory-based estimates, which track each other somewhat closely, however the amplitude of the theory-based estimates is larger than the regression-based estimates. The forecast period begins in 2019, indicated by the vertical dashed line. The theory-based forecast (shown in blue with triangle markers) shows unadjusted productivity growth averaging 1.61% p.a., under the assumption that macroeconomic relationships and business conditions remain similar to the pre-2019 period. In contrast, the BDI-adjusted forecast (the red line with diamond markers) accounts for the deterioration in the business climate. Using the estimated business difficulty elasticity of productivity of $\hat{\beta}_s = -0.1415$, the adjustment lowers productivity forecasts in years where the BDI exceeds its 2012-2018 benchmark. The resulting series highlights how sustained increases in business difficulty have dampened productivity growth. Together, these trajectories provide both a central projection and a downside scenario for assessing productivity trends in the services sector.

6.2 Industry Sector

Table 3 reports the regression results for the change in the CRW in the industry sector. The results indicate that industry CRW growth is significantly influenced by movements in both the real exchange rate and the terms of trade. The coefficient on the contemporaneous and lagged real exchange rate are both statistically significant at the 10 % level. The effect of the terms-of-trade, ΔTOT_t, is statistically significant at the 5 % level, highlighting a strong positive relationship between commodity-price shifts and productivity in the industrial sector. The coefficient of interest, $\hat{\alpha} = 0.0130$, implies an average annual productivity growth rate of 1.3% over from 2001 to 2018.

Table 3: OLS Results for Industry Sector, 2001-2018: $\Delta CRW_t^{\text{industry}}$

Variable	Coefficient	Standard Error	p-Value
Constant ($\hat{\alpha}$)	0.0130	0.006	0.049
ΔRER_t	0.4060	0.210	0.074
ΔRER_{t-1}	0.4171	0.202	0.058
ΔTOT_t	0.3182	0.136	0.035
R^2	0.436		
Observations	18		

As a robustness cheque, we augmented the regression by including growth in non-resource GDP, growth in the non-resource labour force, and a set of LNG construction-phase indicators (2009–2012). None of these additional regressors were statistically significant, and their inclusion left the main exchange-rate and terms-of-trade coefficients relatively unchanged.

Using the theory-based approach, and specifically equation (6), the average annual productivity growth in the industry sector between 2001 and 2018 is estimated at 1.61%.[14] This is slightly higher than the regression-based average. These two approaches offer complementary perspectives on underlying productivity performance during the 2001-2018 period.

Next, we forecast productivity in the industry sector for the years 2019 to 2024. We apply the same two-pronged forecasting framework described in 5.3 based on the CRW model presented earlier. The results are presented in Table 4. The theory-based forecast shows sustained productivity performance over 2019-2024, with a average growth rate of 1.71% p.a.. When adjusted for the increase in business difficulty, the forecast average growth falls to 1.46% p.a., highlighting the effect of the deterioration in the business environment on the industry sector. For the industry sector, the estimated business difficulty elasticity of productivity is $\hat{\beta}_i = -0.2481$, indicating that a

[14]Computed from year-by-year data on CRW and RER for the industry sector using $\widehat{A}_t = \Delta CRW_t^{\text{industry}} - \Delta RER_t$.

10% increase in business difficulty relative to the 2012-2018 average reduces productivity growth by approximately 2.5 percentage points.

Table 4: Average Industry Productivity Growth, 2019–2024

	Theory-Based	**BDI-Adjusted**
Average annual growth (2019–2024)	1.71%	1.46%
Business difficulty elasticity productivity:		$\hat{\beta}_i = -0.2481$

Figure 3 offers a graph summarizing the three key series for the industry sector. It presents the evolution of labour productivity in the industry sector from 2001 to 2024. The historical period (2001-2018) shows both the regression and theory-based estimates, which generally align in trend but diverge in certain years due to differing sensitivities to exchange rate and terms-of-trade shocks. The theory-based forecast projects consistent growth, averaging just over 1.7% p.a. from 2019 to 2024, assuming that the structural relationships and business environment remain consistent with the pre-2019 period. In contrast, the BDI-adjusted forecast incorporates the impact of the business climate. Using the estimated elasticity of $\hat{\beta}_i = -0.2481$, the adjustment lowers productivity forecasts in years where the BDI exceeds its 2012-2018 benchmark, and raises them slightly when the BDI is below it. The resulting red trajectory reveals both downside risk from deteriorating business conditions, particularly evident in 2024, and some mild upward corrections in other years. The average BDI-adjusted forecast over 2019-2024 is 1.46%, which is identical to the average over 2001-2018. See Table 12 for a more detailed results table corresponding to Figure 3.

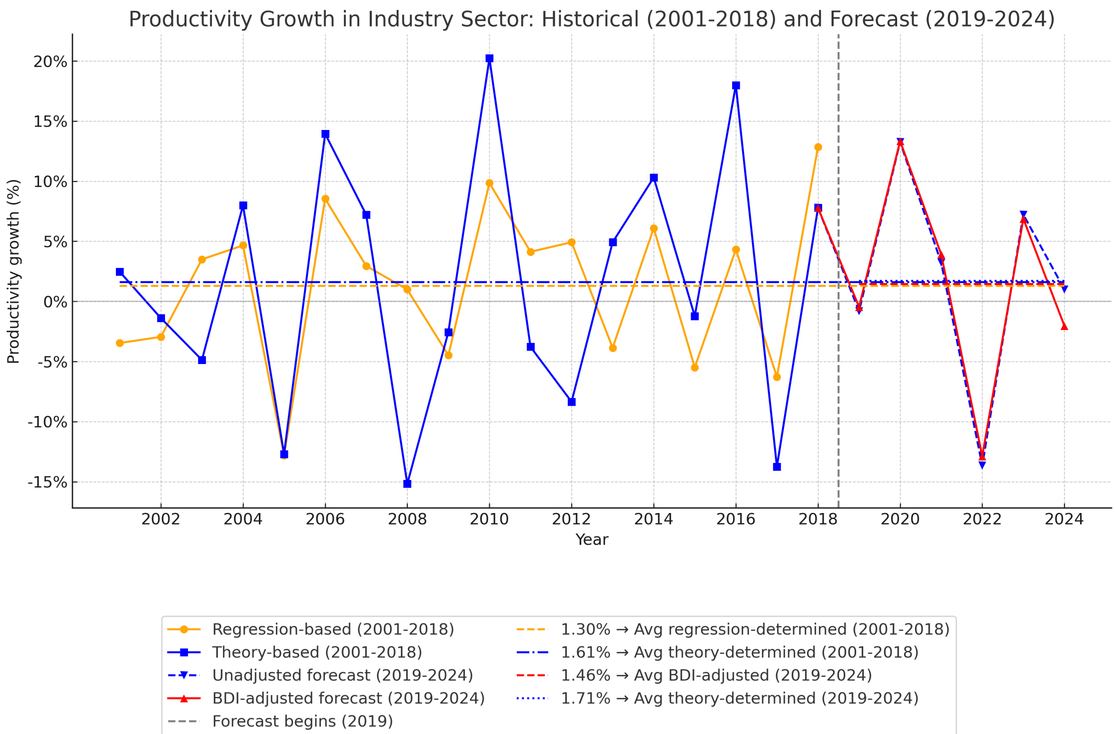

Figure 3: Theory-determined vs. Regression-determined Productivity in Industry Sector (2001-2024)

6.3 Agriculture Sector

Table 5 reports the regression results for the change in the CRW in the agriculture sector. The results indicate that macroeconomic factors explain only a modest share of conditional real wage movements. Neither contemporaneous nor lagged changes in the real exchange rate are statistically significant, whereas the terms-of-trade variable is significant at the 5 % level. The coefficient of interest, $\hat{\alpha} = 0.0059$, is near zero and statistically insignificant, suggesting no evidence that average annual productivity growth in agriculture differs from zero.

Table 5: OLS Regression for Agriculture Sector, 2001-2018: $\Delta CRW_t^{\text{agriculture}}$

Variable	**Coefficient**	**Std. Error**	***p*-Value**
Constant ($\hat{\alpha}$)	0.0060	0.0199	0.772
ΔRER_t	0.1593	0.2205	0.482
ΔRER_{t-1}	0.1388	0.2113	0.522
ΔTOT_t	0.3539	0.1424	0.026
R^2	0.314		
Observations	18		

Using the theory-based approach, the average annual productivity growth in agriculture between 2001 and 2018 is estimated at -0.22%.[15]

Since the two estimates are near zero and opposite in sign, and the regression-based estimate is insignificant, suggesting no robust trend, we assign agriculture a productivity growth rate of 0% p.a.

Table 6 presents the productivity projections for 2019–2024 following the two-step framework outlined in Section 5.3 and uses an estimated business difficulty elasticity of productivity of $\hat{\beta}_a = -0.1097$ for agriculture. Hence, a 10% rise in business difficulty relative to the 2012–2018 norm reduces forecast productivity growth by roughly 1.1 percentage points. The theory-based average productivity growth forecast from 2019 to 2024 is 0.12%. The BDI-adjusted average productivity growth is 0.01%. Overall, the BDI-adjusted path underscores the downside risk posed by a deteriorating operating environment.

[15]Computed from year-by-year data on CRW and RER using $\widehat{A}_t = \Delta CRW_t^{\text{agriculture}} - \Delta RER_t$.

Table 6: Average Agriculture-Sector Productivity Growth, 2019–2024

	Theory-Based	BDI-Adjusted
Average annual growth (2019–2024)	0.12%	0.01%
Business difficulty elasticity of productivity: $\hat{\beta}_a = -0.1097$		

Figure 4 presents a figure to summarize the evolution of the three key series in the agriculture sector from 2001 to 2024 and Table 13 presents the detailed numerical results.

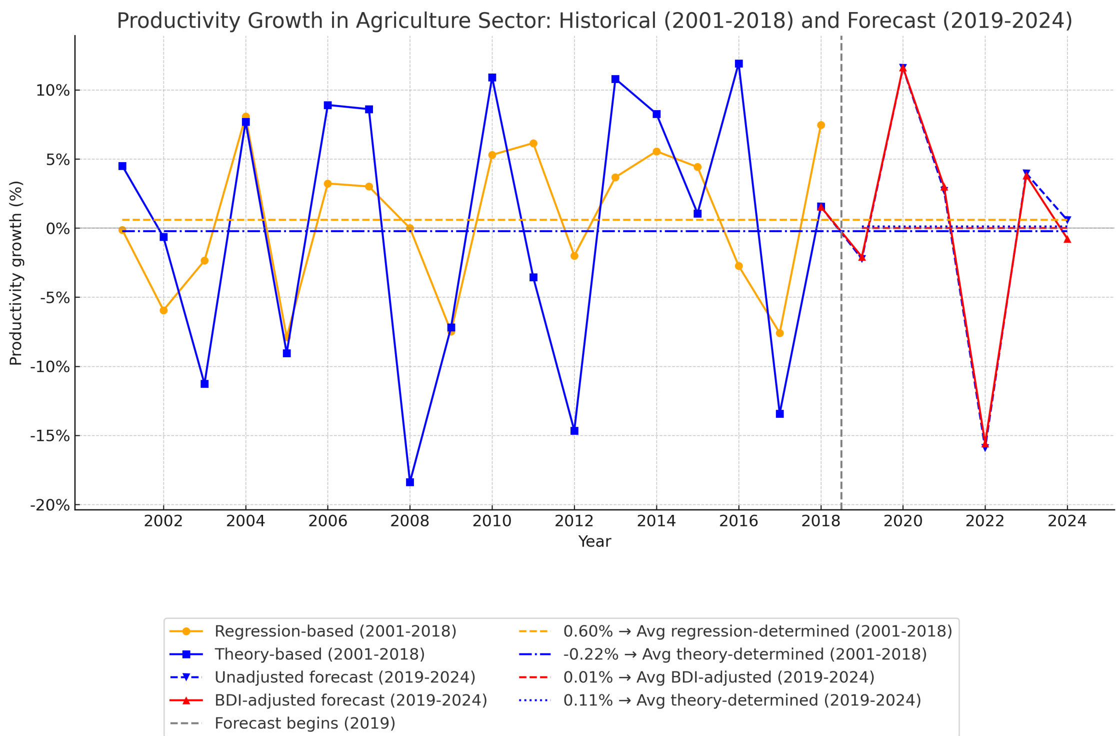

Figure 4: Theory-determined vs. Regression-determined Productivity in Industry Sector (2001-2024)

The regression and theory-based estimates generally follow similar patterns over time, although again the theory-based series shows greater year-to-year volatility. Agriculture has experienced no clear positive trend growth in productivity over the historical period.

In the forecast period from 2019 onward, the theory-based projection shows minimal productivity growth, while the BDI-adjusted forecast incorporates the adverse effect of worsening business conditions. Applying the estimated business difficulty elasticity of productivity of $\hat{\beta}_a = -0.1415$, the forecast is adjusted downward in years where the BDI exceeds its 2012–2018 baseline. The result is a projected productivity path that remains flat.

Together, these trajectories underscore the stagnation of agricultural productivity in PNG. The BDI-adjusted series highlights the sensitivity of agricultural productivity to business conditions, and further the importance of broader business climate reforms to revitalize productivity growth in agriculture.

6.4 Aggregate Productivity in the Non-Resource Sector

To construct a measure of productivity growth in PNG's non-resource sector, we estimate average annual productivity growth for each major sector, agriculture, industry, and services, using two empirical approaches: a regression-based method and a theory-based method, as outlined in the analysis above. To mitigate the methodological limitations of either approach, we take the simple average of the two estimates for each sector. The resulting sectoral productivity growth rates are summarized in Table 7.

This averaging yields a balanced and robust estimate that reflects both macroeconomic responsiveness and underlying productivity trends. The regression-based approach identifies systematic relationships between real wages and macroeconomic variables, allowing us to control for external shocks. The theory-based approach, on the other hand, strips out real exchange rate effects to isolate underlying productivity trends.

Table 7: Sectoral Productivity Growth Estimates, 2001-2018 (% p.a.)

Sector	Regression-based	Theory-based	Average
Agriculture	0.60	-0.22	0.19
Industry	1.30	1.61	1.46
Services	2.31	1.48	1.90

For the purposes of calculating the non-resource productivity average, we assign agriculture a productivity growth rate of 0% p.a. This is justified on the basis that there is no robust trend in agriculture productivity growth as discussed in 6.3.

Table 8 summarizes the average forecast annual productivity growth rates for the period 2019-2024 across the services, industry, and agriculture sectors, both adjusted and BDI-adjusted.

Table 8: Forecast Productivity Growth by Sector, 2019-2024 (% p.a.)

Sector	Projected (Unadjusted)	BDI-Adjusted
Agriculture	0.12%	0.01%
Industry	1.71%	1.46%
Services	1.61%	1.45%

In the services sector, projected productivity growth is 1.61% p.a. under baseline conditions and 1.45% when adjusted for the post-2018 deterioration in the business environment. In industry, the projected productivity growth is slightly higher at 1.71% unadjusted, though the BDI-adjusted figure drops to 1.46%. Projected agricultural productivity remains near zero, with the projected growth rate under baseline conditions at just 0.12%, falling to 0.01%) after accounting for increased business difficulty.

We now combine our average results over 2001-2018 and our projected-adjusted results over 2019-2024 into one table. We compute a weighted average productivity growth for each sector over the full 2001-2024 period, weighting the historical (2001-2018) and projected (2019-2024) growth rates according to their relative duration (the historic period being 18 out of 24 years and the forecast period being 6 out of 24):

$$\textit{Full Period Average} = \frac{18}{24}\textit{Historical} + \frac{6}{24}\textit{BDI-adjusted Projected} \tag{13}$$

Table 9: Average Annual Productivity Growth by Sector (% p.a.), 2001-2024

Sector	**2001-2018**	**2019-2024 (BDI-adjusted)**	**Weighted Average (2001-2024)**
Agriculture	0.00	0.00	0.00
Industry	1.46	1.46	1.46
Services	1.90	1.48	1.80

To calculate overall productivity growth for the non-resource economy, we use sectoral labour shares as weights. These are taken from Blunch and Davies (2021), who provide descriptive statistics on the composition of PNG's formal labour market between 1999 and 2018. The labour shares are presented in Table 10.

Table 10: Sectoral Shares of Labour Force (%)

Sector	**Labour Share (%)**
Agriculture	10.7
Industry	21.5
Services	67.8

Using these shares and the sectoral productivity growth estimates, we compute the labour-weighted average productivity growth for the non-resource sector as:

$$\textit{Productivity Growth}_{2001\text{–}2024} = 0.678 \cdot 1.80 + 0.215 \cdot 1.46 + 0.107 \cdot 0.00 = \boxed{1.53\% \text{ p.a.}} \quad (14)$$

Our analysis determines that average annual productivity growth in the formal non-resource sector over the 2001-2024 period is approximately 1.5% p.a. This composite estimate reflects productivity estimates based on both historical data (2001-2018) and projections over 2019-2024, while accounting for the differing economic weights of each sector in the formal non-resource economy.

7 Discussion and Policy Implications

This study, a first of its kind in PNG, provides a detailed analysis of labour productivity trends in PNG's formal non-resource economy. Using both regression-based and theory-based approaches, we estimate sector-level productivity growth for the period 2001-2018 and project productivity growth from 2019-2024 adjusting for worsening business conditions.

Over the historical period 2001-2018, the services sector recorded the highest average annual productivity growth at 1.90%, followed by industry at 1.46%. In contrast, agriculture experienced no growth, with estimates from both approaches small in magnitude and opposite in sign. This stark sectoral divergence points to significant differences in opportunities for productivity growth across sectors.

The fact that productivity growth in services exceeds that in industry runs counter to the Baumol cost-disease hypothesis, which posits that services should lag behind manufactures in productivity performance (Baumol and Bowen, 1966). Similar evidence for PNG is reported in Blunch and Davies (2025), who also find that service-sector productivity has matched or outpaced industrial productivity despite the canonical expectation to the contrary.

Several structural factors may explain why labour productivity growth in PNG's industry (manufacturing and other tradables) has lagged behind that of services. First, industrial activities are more exposed to the country's chronic infrastructure bottlenecks: unreliable electricity, high transport costs, and patchy logistics networks. Second, manufacturing firms face persistent skills shortages and weak vocational training pipelines. With experienced technicians and supervisors in short supply, industrial plants often operate below full capacity, which depresses measured productivity. Third, the productivity differential also reflects the uneven impact of business impediments across sectors. Unreliable power supply, inefficient and costly port operations, foreign exchange shortages, and weak domestic transport links tend to impose greater constraints on industrial firms, which are more dependent on physical inputs, uninterrupted production, and export logistics. And, finally, services firms are often better able to adapt to the local business environment. Many can import turnkey technology and managerial expertise from abroad, a flexibility that is more limited in the manufacturing sector.

Forecasts for 2019-2024 indicate a modest slowdown in productivity growth. When adjusted for elevated business difficulty using the BDI, projected productivity growth falls to 1.45% p.a. from 1.61% p.a for services, to 1.46% p.a. from 1.71% p.a. for industry, and to 0.01% from 0.12% for agriculture.

Combining historical and projected performance for each sector using time-weighted averages, we calculate productivity growth for the formal non-resource economy at around 1.5% p.a. This measure provides a meaningful benchmark for wage policy discussions and minimum wage setting, especially in the context of balancing business competitiveness with real wage growth.

The results align broadly with international findings on the link between productivity and wages. For instance, the Australian Productivity Commission has demonstrated that long-term real wage growth is typically driven by productivity growth (Productivity Commission, 2023). Our findings reinforce this relationship in the PNG context: sectors with higher productivity growth (e.g. services and industry) also experienced greater real wage gains over the sample period (see Blunch and Davies, 2025).

7.1 Policy Implications

The analysis points to several key policy implications:

- **Minimum wage alignment:** With estimated average productivity growth of 1.5% p.a. in the formal non-resource economy, increases of the minimum wage consistent with this growth rate can preserve employment incentives and business competitiveness.
  - A caveat to this recommendation is the agriculture sector, which has recorded zero productivity growth over the past two decades. Agricultural firms may find it difficult to absorb minimum wage increases calibrated to average productivity growth in the broader economy. In such cases, special provisions such as the *Agriculture Sector Partial Payment* mechanism and the *Exemption on Incapacity to Pay* offer safeguards and allow businesses under financial stress to seek relief.
- **Structural reform in agriculture:** The stagnation in agricultural productivity highlights the need for targeted reforms to raise efficiency in this sector. Without such reform, the sector risks falling further behind.
- **Business environment sensitivity:** The impact of deteriorating business conditions shows that even sectors with historically strong performance can experience productivity slowdowns (e.g. services.) Policies that address regulatory uncertainty, access to foreign exchange, and infrastructure reliability are essential to reduce these impediments moving forward.
- **The case for a Productivity Commission:** Given that productivity is a primary engine of long-run economic growth, real income gains, and international competitiveness, this study reinforces the fundamental importance of productivity. As highlighted by international experience and analytical frameworks (such as those of the Australian Productivity Commission), sustained improvements in living standards are only possible through rising productivity. In the context of PNG, where data constraints and institutional fragmentation often limit ef-

fective policy design, we recommend the establishment of a national Productivity Commission. Such an institution could play a critical role in diagnosing productivity bottlenecks, coordinating cross-sectoral reforms, and advising government on regulatory and investment priorities to raise productivity growth across both the formal and informal economies. The evidence presented in this study provides a strong empirical foundation for that agenda.

8 Conclusion

This study provides the first comprehensive and empirically grounded analysis of labour productivity in PNG's formal non-resource economy. Using a robust two-stage methodology, anchored in panel regression estimates and supported by a theory-based framework, we estimate sectoral productivity growth over the period 2001–2018 and project performance over 2019-2024, adjusting for worsening business conditions via the Business Difficulty Index.

Our findings reveal strong and sustained productivity growth in the services and industry sectors, but long-run stagnation in agriculture. When weighted by labour force composition, we estimate average productivity growth of 1.53% p.a. in the non-resource formal sector over the 2001–2024 period. This estimate provides a rigorous and policy-relevant benchmark for policy and minimum wage adjustments.

The close empirical alignment between productivity and conditional real wages underscores the validity of the "wage-as-a-window methodology" for productivity measurement in data-sparse settings. It also strengthens the case for using productivity growth as a guiding anchor in wage-setting institutions, including the Minimum Wage Board.

A Appendix

A.1 Summary of Wage Study by Blunch and Davies

A 2025 study by Blunch and Davies, *Real Wage Growth in Papua New Guinea Over Three Decades*, provides a comprehensive empirical analysis of real wage dynamics in PNG, based on a novel longitudinal dataset of formally employed private sector workers covering the period 1999 to 2018. The data, derived from Nasfund (the largest private-sector superannuation fund in PNG), offers near-complete coverage of the formal private workforce over two decades. This allows the authors to undertake fixed effects panel regressions that account for individual-level heterogeneity, including time-invariant characteristics such as education, gender, and sectoral affiliation, while isolating the impact of time-varying macroeconomic and sectoral factors on real wage growth.

A central finding of the study is that conditional real wage growth (i.e., wage growth after controlling for observable and unobservable individual and firm traits) differs significantly by sector. Mining emerges as the leading sector, with real wage growth averaging between 5.4% and 5.9% annually. Industry and services also record solid real wage growth (around 3.2% to 3.5%), while the agriculture sector significantly lags behind, with annual growth of just 2.2%. These patterns suggest structural disparities in productivity across sectors.

These findings form the empirical foundation for the sectoral regressions presented in this study. We use Blunch and Davies (2025) as a baseline. Their micro-level fixed effects regressions control for individual and firm characteristics, isolating the influence of macroeconomic and sectoral shocks on wages. Building on this, our analysis seeks to explain the variation in CRW using macroeconomic regressors, specifically changes in the real exchange rate (RER), terms of trade (TOT), and their lags, at the sector level.

The sectoral sensitivity to macroeconomic shocks identified by Blunch and Davies directly informs both our choice of explanatory variables and how we interpret the results. For example, they find a strong correlation between RER and real wages in the services and industry sectors is reflected in our regressions. In contrast, the weak responsiveness of agricultural wages to macro shocks in their study aligns with our finding that RER and TOT have limited explanatory power in that sector.

The study also highlights the close co-movement between real wages and the real exchange rate (RER), especially in tradable sectors, both through their theoretical framework (discussed below), and also empirical work (see Blunch and Davies (2025), Figure 3, Cumulative growth in conditional real wages in agriculture, industry and services and the real exchange rate, 1999–2018).

The theoretical framework in Blunch and Davies (2025) formalizes this interpretation by deriving an expression for real wage growth in a small open economy. In their model, the growth rate of the real wage is shown to depend on both changes in the real exchange rate and improvements in productivity. When firm and individual characteristics are controlled for, changes in the conditional real wage can therefore be interpreted as reflecting the combined effects of productivity growth and RER movements. See the Appendix A.3 for a descriptive and discussion on the theory-based approach to determining productivity.

A.2 Determinants of Labour Productivity Growth

Labour productivity can be understood more formally through the lens of production theory. A useful and widely used representation of the production process is the Cobb-Douglas production function, which can be extended to include human capital. In this formulation, output Y is a function of capital K, labour L, average human capital per worker H, and total factor productivity A:

$$Y = AK^{\alpha}(HL)^{1-\alpha} \tag{15}$$

where:

- Y is total output (e.g. GDP or value added),

- K is the capital input,
- L is the quantity of labour (number of workers),
- H is average human capital per worker (reflecting education, skills, and health),
- A captures total factor productivity (TFP), which reflects technological progress, institutional quality, and other factors not directly measured by capital, labour, or human capital,
- $\alpha \in (0, 1)$ is the factor share of capital, and $1 - \alpha$ is the combined factor share of human capital and labour.

Labour productivity is defined as output per unit of labour:

$$\frac{Y}{L} = A \left(\frac{K}{L} \right)^{\alpha} H^{1-\alpha} \tag{16}$$

This expression reveals three key drivers of labour productivity:

- **Capital deepening:** An increase in the capital-to-labour ratio $\left(\frac{K}{L}\right)$ raises labour productivity, holding other factors constant.
- **Human capital accumulation:** Improvements in the education and skill level of the workforce (higher H) raise labour productivity independently of changes in capital or labour quantity.
- **Total Factor Productivity (TFP):** Improvements in A—such as better technology, organisational improvements, and institutional efficiency—raise productivity independently of factor inputs.

This formulative shows that productivity growth is determined capital accumulation, human capital formation, and TFP growth. We formally show this in the next section.

A.2.1 Change in Labour Productivity

We now examine how labour productivity changes over time in this extended framework. Starting with the production function:

$$Y_t = A_t K_t^{\alpha} (H_t L_t)^{1-\alpha} \tag{17}$$

Labour productivity at time t is given by:

$$\frac{Y_t}{L_t} = A_t \left(\frac{K_t}{L_t}\right)^{\alpha} H_t^{1-\alpha} \tag{18}$$

Taking logs and differencing over time yields the growth rate of labour productivity:

$$\Delta \ln \left(\frac{Y_t}{L_t}\right) = \Delta \ln A_t + \alpha \, \Delta \ln \left(\frac{K_t}{L_t}\right) + (1-\alpha) \, \Delta \ln H_t \tag{19}$$

This decomposition shows that labour productivity growth consists of:

- **TFP growth** ($\Delta \ln A_t$): reflecting improvements in efficiency, institutions, or innovation.
- **Capital deepening** ($\alpha \, \Delta \ln(K_t/L_t)$): increases in physical capital per worker.
- **Human capital accumulation** ($(1-\alpha) \, \Delta \ln H_t$): increases in education and skills per worker.

In summary:

$$\text{Labour Productivity Growth} = \text{TFP Growth} + \alpha \times \text{Capital Deepening} + (1-\alpha) \times \text{Human Capital Growth} \tag{20}$$

This decomposition is particularly useful for analysing the sources of productivity growth in developing economies. It shows that even if physical capital accumulation is limited, improvements in human capital or TFP can still drive productivity gains. In the case of PNG, where physical capital may be concentrated in resource sectors and TFP growth may be hindered by weak institutions, investing in education, skills, and workforce training offers a viable pathway for broad-based productivity growth in the non-resource economy.

A.3 Theory-based Approach to the determination of labour productivity

Following Carlin and Soskice (2014), the real wage, W/P, in a small open economy is determined by the interaction between wage-setters (workers, unions) and price-setters (firms), and is given by:

$$\frac{W}{P} = (1-\mu) \cdot \frac{\text{MPL}}{1-\phi\left(1-\frac{1}{\eta}\right)} \tag{21}$$

where μ is the firms' mark-up on marginal cost, and the marginal product of labour (MPL) is determined by the underlying production function:

$$Y = AF(K, H, L) \tag{22}$$

Here, A is the technology parameter, K and H are physical and human capital, and L is labour. The denominator term in equation (1) accounts for the influence of movements in import prices, and is dependent on the share of the consumption bundle that is imported, ϕ, and the real exchange rate, $\eta = \frac{P}{eP*}$.

In a small open economy like PNG, ϕ is large, so this import channel is a key determinant of the real wage. The percentage change in the real wage is then given by:

$$\widehat{W/P} = \widehat{(1-\mu)} + \widehat{\eta} + \widehat{\text{MPL}} = \widehat{(1-\mu)} + \widehat{\eta} + \widehat{A} + \theta_K\widehat{K} + \theta_H\widehat{H} + \theta_L\widehat{L} \tag{23}$$

with factor elasticities:

$$\theta_K = \frac{KF_{LK}}{F_L}, \tag{24}$$

$$\theta_H = \frac{HF_{LH}}{F_L}, \tag{25}$$

$$\theta_L = \frac{LF_{LL}}{F_L}. \tag{26}$$

The unique structure of our panel dataset allows us to estimate the conditioned growth in the real wage with considerable granularity. Since we observe nearly the entire population of private sector workers, we can calculate labour shares by firm and construct a labour-share-based Herfindahl-Hirschman Index (HHI) of concentration at the sector or economy-wide level.

Proposition 1. ***Proposition 1.*** *The sectoral mark-up, μ, is proportional to the Herfindahl-Hirschman index, H, with the coefficient of proportionality being the inverse of the price elasticity of sectoral demand, $1/\varepsilon$, where*

$$\mu = \frac{\Pi}{pQ} = \frac{1}{\varepsilon}\sum_{i=1}^{n}\alpha_i^2 = \frac{1}{\varepsilon}H$$

Intuition: Proposition 1 states that when industries are more concentrated—meaning fewer, larger firms dominate—a higher mark-up over marginal cost is sustained. This happens because with fewer competitors, each firm's pricing power increases, especially when consumers are less responsive to price changes (i.e., low elasticity of demand). Thus, tracking the HHI gives us a sector-specific proxy for firms' mark-ups, allowing us to control for $\widehat{(1-\mu)}$ in our regression framework Blunch and Davies (2025)

Given that we have a panel structure, the inclusion of individual employee fixed effects, firm fixed effects, and time fixed effects allows us to control for time-invariant characteristics at the worker, firm, and temporal levels. The individual fixed effects account for innate ability, education, and motivation. Firm fixed effects capture persistent firm-level productivity drivers such as technology, capital intensity, and management quality. Time fixed effects absorb macroeconomic and institutional changes common to all workers. Since most PNGns do not pursue further education once employed, H varies little over time. We also observe workforce tenure, which serves as a proxy for workplace learning-by-doing.

Consequently, the conditional real wage primarily captures changes in productivity and changes in the real exchange rate:

$$\widehat{W/P} = \widehat{\eta} + \widehat{A} \tag{27}$$

In our empirical analysis, we estimate this conditional wage growth. In our theory-based productivity analysis, once we control for changes in the real exchange rate, what remains is a direct estimate of productivity growth:

$$(\widehat{W^*)}/P = \widehat{A} \tag{28}$$

where $(\widehat{W^*)}/P$ is the conditional real wage controlling for the real exchange rate. This forms our measure of labour productivity.

A.4 What is Regression?

Regression is a statistical method that helps us understand how one variable is related to others. At its core, it answers questions like: *If one thing changes, holding all other things constant, what do we expect to happen to our variable of interest?* For example, in this study, we want to understand how the conditional real wage responds to changes in external conditions like the real exchange rate and terms of trade. Regression allows us to isolate the effect of each independent variable—such as the real exchange rate or terms of trade—on the dependent variable, in this case the conditional real wage (CRW).

A.5 Economic Conditions in PNG, 1999-2024

PNG is classified as a small, resource-rich developing country. Its exports are dominated by extractive commodities, including gold, copper, oil, and liquefied natural gas (LNG), as well as primary products such as palm oil, coffee, and timber. This structure makes the economy highly susceptible to external commodity price shocks, resulting in recurrent boom–bust cycles driven by shifts in the terms of trade and the timing of large resource project investments.

The resource sector contributes a large but variable share of GDP, ranging between 13% and 34% of total output during the study period, depending on commodity prices and the development stages of major resource projects. As a result, PNG's overall macroeconomic performance often masks significant divergence between the resource and non-resource sectors. While the resource sector tends to expand sharply during commodity booms and project construction phases, the non-resource economy, including agriculture, manufacturing, and services, has historically experienced slower and more volatile growth.

A.5.1 Economic Conditions: 1999–2018

Despite episodes of strong resource-sector growth, the broader non-resource economy has been characterised by persistent constraints and underperformance. Weak infrastructure, unreliable utilities, forex rationing, and governance challenges have contributed to sluggish growth in formal employment and limited spillovers from resource activity. This dualistic structure has reinforced wage stagnation outside of mining and constrained inclusive development.

We divide the 1999–2018 period into three sub-periods that reflect distinct macroeconomic regimes, bust, boom, and bust, linked to both commodity cycles and major project phases.

A.5.2 1999-2002: Drought, Crisis, and Contraction

This period was marked by the aftershocks of the 1995–1997 El Niño-induced drought, weak governance, and persistently low commodity prices. Economic growth was anaemic, and real wages stagnated. The formal private sector contracted reflecting a general downturn in domestic demand and macroeconomic stress.

A.5.3 2003-2013: Commodity Boom and LNG Investment Surge

Global commodity prices surged in the early 2000s, fuelling a decade of robust growth in PNG. This phase was briefly interrupted by the 2009 Global Financial Crisis, but a large domestic fiscal stimulus cushioned the impact. The investment phase of the PNG LNG project (2010–2013) drove construction activity and non-resource growth, boosting formal employment and wages across sectors. This period represents the most sustained expansion in the modern PNG economy.

A.5.4 2014-2018: Non-Resource Recession amid Export Boom

Although the PNG LNG project began exporting in 2014, the impact on the broader economy was muted. The resource sector experienced a short-lived boom, but commodity prices fell sharply in 2015, and the domestic economy entered a period of stagnation. Foreign exchange shortages emerged as a key constraint, with rationing suppressing imports and constraining business activity in the non-resource sector. Real wages plateaued, and the formal labour force began to decline, reflecting weak private investment and subdued demand.

A.6 Summary of the Productivity Study

1. Why Productivity Matters

Productivity growth, the ability to produce more with the same amount of work, is the single most important driver of long-term wage growth and rising living standards. If each worker can generate more output over time, businesses can afford to pay higher wages and families can improve their quality of life.

In high-income countries, like Australia, productivity and real wages tend to move closely together. When productivity rises, wages usually follow. However, in PNG, we've never had a clear picture of productivity performance across sectors like agriculture, services, and industry. This study is the first to fill that gap.

2. A First for PNG

To our knowledge, this is the first comprehensive study of productivity trends in PNG's formal non-resource economy. It covers the years 2001 to 2024 and provides detailed productivity growth estimates for the agriculture, services, and industry sectors.

What makes this study possible is a novel method that uses changes in wages, specifically, "real wages" (wages adjusted for inflation), to infer changes in productivity over time. In places like PNG, we lack good data on how much is produced by each sector or how much labour is used to produce it. But, in this case, we have had access to excellent wage data in the past. By carefully analysing wages while controlling for factors like exchange rates and commodity prices, we can uncover how much of wage growth is actually driven by improved productivity.

3. Measuring Productivity Using Wages

The key idea behind the study is simple and intuitive: in the long run, wages and productivity tend to move together. If workers are becoming more productive, perhaps by using better tools, gaining experience or education, or working in better-managed firms, they will tend to earn more.

This connection between productivity and wages lets us use real wage trends as a window into productivity. But we also need to adjust for things that can affect wages without changing productivity, like changes in the cost of imports due to flucuations in the value of the exchange rate or changes in foreign prices, or the prices of PNG's key exports and imports (terms of trade).

This study uses two methods:

- A **theory-based method** that uses economic theoretical modelling to back out productivity from wage and exchange rate data.

- A **regression-based method** that statistically separates the effects of different macroeconomic factors on wages.

When both methods tell a similar story, we can be more confident in the results.

4. Sectoral Findings: Services Lead, Agriculture Lags

Here's what we find when we apply these methods to PNG's three major non-resource sectors:

- **Services** (e.g., finance, transport, communications, retail): *Strongest performer*. Productivity grew by about **1.9% p.a.** between 2001 and 2018. Even in recent years, under more difficult business conditions, productivity has continued to grow, though more slowly.
- **Industry** (e.g., manufacturing, construction): *Steady performance*. Productivity grew by **1.46% p.a.**, with a relatively stable trend across the full period.
- **Agriculture**: *Weak performance*. Productivity showed **no growth** over the past two decades. The two methods used in this study gave small with opposites signs (one positive, the other negative) and any recent gains have been undermined by worsening business conditions.

These trends are important because different sectors employ different proportions of PNG's formal workforce. The services sector, for instance, employs more than two-thirds of all formal private sector workers.

5. Business Conditions Matter

One major innovation in this study is adjusting productivity forecasts to reflect changing business conditions. The study constructs a **Business Difficulty Index (BDI)** that tracks how hard it is to operate a business in PNG.

This index shows that conditions worsened significantly after 2018. Firms have faced greater difficulties with foreign exchange access, infrastructure, regulation, law and order, and skills shortages. These challenges weigh on productivity growth.

By adjusting productivity growth forecasts using this index, the study provides a more realistic picture of productivity performance over the forecast period, 2019-2024. For example, in services and industry, unadjusted productivity forecasts were higher than they likely should be. Once we account for the tougher business environment, the outlook becomes more modest.

6. Overall Result: A Productivity Benchmark for PNG

Combining historical results and forecasts, and weighting them by sector size, the study estimates that PNG's **formal non-resource sector productivity has grown by about 1.5% p.a.** on average over the 2001-2024 period.

This figure is an important result. It provides a solid, evidence-based benchmark for policymaking, especially for discussions around real wage growth and minimum wage adjustments.

7. Policy Implications

The findings of the study lead to four major takeaways for policy:

- **Minimum Wage Setting:** Future minimum wage increases should align with productivity growth. Since productivity in the formal non-resource sector has grown at about 1.5% p.a., wages can rise at this pace without harming employment or competitiveness of businesses.
  - With agricultural productivity growth near zero, firms in the sector may find it difficult to absorb minimum wage increases aligned with broader economy-wide trends. Mechanisms such as the *Agriculture Sector Partial Payment* and the *Exemption for Incapacity to Pay* provide safeguards for firms under financial stress.
- **Agricultural Reform:** Agriculture employs a large share of PNG's total workforce, even though this study focuses on the formal sector. The stagnation in agricultural productivity points to deeper structural issues, such as a lack of investment, poor infrastrucutre, low technology adoption, and poor market access, that require policy attention.
- **Improving the Business Environment:** Productivity in all sectors is being held back by

difficult operating conditions. Fixing forex access, infrastructure reliability, and government capacity is essential if PNG is to unlock faster productivity growth.

- **A Case for a Productivity Commission:** Many countries have independent institutions that monitor productivity and advise on reforms. PNG should consider creating a **Productivity Commission** to help diagnose bottlenecks and propose solutions across government and industry.

8. Final Thoughts

This study is both a technical contribution and a practical policy tool. It gives PNG, for the first time, a reliable, sector-by-sector picture of productivity performance, and it does so using methods that are feasible and replicable in a data-limited environment.

As PNG looks to raise living standards, diversify its economy, and build resilience, productivity will need to be at the heart of the strategy. This study provides a foundation for that conversation.

A.7 Sub-Sector Composition of Agriculture, Industry, and Services

The classification of sub-sectors follows the Papua New Guinea Standard Industrial Classification (PNGSIC–2000). For the purposes of this study, all economic activities are grouped into three broad sectors: *Agriculture*, *Industry*, and *Services*, as detailed below.

Agriculture

- **Agriculture, hunting and related service activities:** cultivation of cereals, vegetables, flowers, fruits, nuts, beverage crops, spices, tobacco, rubber, oil palm, peanuts, pyrethrum, sugar cane, other crops; farming of animals (cattle, pigs, poultry, bees, crocodiles, silk worms, others); mixed farming; agricultural services; hunting, trapping and game propagation; subsistence activities.

- **Forestry and logging:** planting and conservation of forests; gathering of minor forest products; logging and related services.

- **Fishing and aquaculture:** marine and inland fishing; collection of aquatic products (shellfish, corals, sea cucumbers, etc.); fish farming and farming of other aquatic life.

Industry

- **Mining and quarrying:** coal, oil and gas extraction; uranium and thorium ores; metal mining (iron, copper, gold, other non-ferrous); other mining and quarrying (stone, sand, clay, chemicals, salt, etc.).
- **Manufacturing:** food and beverages; tobacco; textiles; apparel; leather goods; wood products; paper and printing; petroleum products; chemicals; rubber and plastics; non-metallic mineral products; basic and fabricated metals; machinery and equipment; electronics; transport equipment; furniture; miscellaneous manufacturing; recycling.
- **Electricity, gas and water supply:** electricity generation and distribution; gas manufacture and distribution; water collection, purification, and distribution.
- **Construction:** site preparation; building construction; installation and completion activities; building maintenance; heavy construction (roads, dams, bridges, irrigation, sports facilities).

Services

- **Wholesale and retail trade; repair of motor vehicles and motorcycles.**
- **Hotels and restaurants.**
- **Transport, storage and communications:** land, water, and air transport; transport support services; postal and courier services; telecommunications.
- **Financial intermediation:** banking; insurance and pension funding; auxiliary financial services.

- **Real estate, renting and business activities:** real estate; machinery and equipment rental; computer services; research and development; legal, accounting, consulting, advertising, recruitment, cleaning, packaging.
- **Other community, social and personal services:** waste management; membership organisations; recreation, cultural and sporting activities; personal services.
- **Private households with employed persons.**

A.8 Tables: Labour Productivity Growth Estimates: Historical and Forecast

A.8.1 Services

Appendix Table 11: Services Sector Productivity Growth Estimates and Forecasts (2001-2024)

Year	Regression-Based	Theory-Based	Projected (Unadjusted)	BDI-Adjusted
2001	0.0056	0.0815		
2002	-0.0064	0.0324		
2003	-0.0239	-0.1279		
2004	0.0835	0.0902		
2005	-0.0703	-0.0718		
2006	0.0340	0.0615		
2007	0.0356	0.0888		
2008	0.0483	-0.1113		
2009	-0.0520	-0.0796		
2010	0.0626	0.1412		
2011	0.0727	-0.0309		
2012	0.0185	-0.1695		
2013	0.0452	0.1175		
2014	0.0549	0.1036		
2015	0.0446	0.0298		
2016	-0.0067	0.1149		
2017	0.0115	-0.0420		
2018	0.0574	0.0387		
2019			-0.0163	-0.0141
2020			0.0721	0.0726
2021			0.0681	0.0727
2022			-0.1155	-0.1105
2023			0.0668	0.0647

A.8.2 Industry

Appendix Table 12: Industry Sector Productivity Growth Estimates and Forecasts (2001-2024)

Year	Regression-Based	Theory-Based	Projected (Unadjusted)	BDI-Adjusted
2001	-0.0346	0.0246		
2002	-0.0295	-0.0139		
2003	0.0350	-0.0487		
2004	0.0466	0.0799		
2005	-0.1282	-0.1271		
2006	0.0854	0.1395		
2007	0.0295	0.0721		
2008	0.0099	-0.1518		
2009	-0.0448	-0.0256		
2010	0.0985	0.2023		
2011	0.0413	-0.0378		
2012	0.0492	-0.0835		
2013	-0.0386	0.0492		
2014	0.0609	0.1031		
2015	-0.0549	-0.0123		
2016	0.0432	0.1799		
2017	-0.0629	-0.1375		
2018	0.1285	0.0778		
2019			-0.0080	-0.0046
2020			0.1327	0.1334
2021			0.0322	0.0392
2022			-0.1365	-0.1289
2023			0.0722	0.0688
2024			0.0100	-0.0203

A.8.3 Agriculture

Appendix Table 13: Agriculture Sector Productivity Growth Estimates and Forecasts (2001-2024)

Year	Regression-Based	Theory-Based	Projected (Unadjusted)	BDI-Adjusted
2001	-0.0014	0.0450		
2002	-0.0594	-0.0064		
2003	-0.0235	-0.1127		
2004	0.0809	0.0770		
2005	-0.0789	-0.0904		
2006	0.0323	0.0891		
2007	0.0301	0.0861		
2008	0.0000	-0.1838		
2009	-0.0748	-0.0719		
2010	0.0530	0.1092		
2011	0.0615	-0.0355		
2012	-0.0199	-0.1465		
2013	0.0368	0.1080		
2014	0.0556	0.0827		
2015	0.0442	0.0106		
2016	-0.0273	0.1192		
2017	-0.0759	-0.1342		
2018	0.0746	0.0155		
2019			-0.0223	-0.0208
2020			0.1160	0.1163
2021			0.0270	0.0301
2022			-0.1592	-0.1558
2023			0.0396	0.0381
2024			0.0058	-0.0076

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