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Fiscal and Labour-Market Conditions and Wage-Income Dynamics in Morocco: A Kaleckian-Inspired Reduced-Form Analysis

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Abstract

This paper develops a Kaleckian-inspired reduced-form framework for analysing wage-income dynamics in Morocco, focusing on the interaction between macroeconomic conditions, fiscal policy, and labour-market pressure. Because consistent annual wage-income data are unavailable, household final consumption expenditure as a percentage of GDP is used as a reduced-form proxy. GDP growth serves as a profitability proxy, while a constructed institutional-fiscal indicator combines tax revenue and unemployment. The empirical analysis applies XGBoost, Random Forest, and LSTM models to capture nonlinear predictive relationships that conventional linear specifications may overlook. Using annual Moroccan data for 2000–2022, the study evaluates model performance through chronological out-of-sample prediction and considers both the level and year-on-year change of the proxy. The contribution is a reduced-form empirical framework linking Kaleckian distributional theory with nonlinear predictive methods to explore how fiscal and labour-market conditions interact with income dynamics.

JEL codes: E12, E24, E60, C45, C53

Key words: Real wage-income dynamics, distributive conflict, post-Keynesian economics, machine learning econometrics, fiscal institutions, Morocco

1. Introduction

Understanding the determinants of real wage-income dynamics remains a central question in macroeconomic theory, particularly in frameworks where distribution is not the outcome of competitive market clearing but the result of institutional and social conflict. Post-Keynesian and Kaleckian traditions emphasize that real wages and wage shares are shaped by bargaining power, effective demand conditions, and institutional arrangements rather than marginal productivity. In this view, real wages are shaped by workers' wage claims, bargaining power, and institutional conditions rather than being determined solely by competitive labor-market forces (Kalecki, 1971, pp. 62–77 and 156–164; Lavoie, 2014, pp. 549–550).

This perspective is linked to Keynesian uncertainty because wage bargaining takes place before future demand, inflation, and profitability are known. Workers, firms, and their organizations therefore form wage claims under uncertainty rather than under full-information rational expectations (Keynes, 1937, pp. 213-215; Akerlof, 2002, pp. 411-415). In Kaleckian distribution and growth models, causality is circular: effective demand and growth influence employment, profits, and bargaining conditions, while the resulting distribution between wages and profits feeds back into demand and growth through consumption and investment channels (Blecker, 1999, pp. 116–149; Hein, 2014, pp. 220–235). This circular relation is the macroeconomic feedback mechanism considered here, not a one-directional claim that either wages alone determine growth or growth alone determines wages.

Recent developments in empirical macroeconomics have increasingly incorporated machine learning techniques to model complex nonlinear relationships, improve forecasting accuracy, and relax restrictive parametric assumptions. Beyond demonstrating predictive gains, recent research has sought to identify the specific mechanisms through which machine learning improves macroeconomic forecasting. In particular, nonlinear functional forms, tree-based ensemble methods, and time-aware validation procedures have been shown to outperform conventional linear specifications, especially during periods characterized by heightened macroeconomic uncertainty, structural change, and regime shifts (Goulet Coulombe et al., 2022; Babii et al., 2023).

At the same time, the growing use of machine learning in economics has been accompanied by increasing emphasis on model interpretability. Rather than treating predictive algorithms as "black boxes," recent studies advocate the use of explainable artificial intelligence (XAI) techniques—including SHAP values, feature-importance measures, and partial dependence analysis—to relate statistical predictions to economically meaningful mechanisms and improve the transparency of policy-oriented empirical research (Buckmann et al., 2021).

These methodological developments are particularly relevant for distributive-conflict models, where nonlinear interactions between institutions, profitability, and expectations are unlikely to be adequately represented by conventional linear econometric specifications. The flexibility of tree-based algorithms allows threshold effects, interaction structures, and regime-dependent responses to emerge directly from the data while remaining consistent with the theoretical framework. Consequently, machine learning should be viewed not merely as a forecasting tool but as a complementary empirical methodology capable of uncovering

complex macroeconomic relationships that are difficult to identify using traditional parametric models.

In parallel, empirical research on wage determination has emphasized the role of institutional variables such as labor market regulation, bargaining structures, and fiscal policy. Regulation and institutional design have been shown to affect macroeconomic outcomes, including wage dispersion and labor market performance (Blanchard and Giavazzi, 2003, pp. 879-907; Stockhammer, 2013, pp. 1-47). However, conventional linear panel and time-series models impose constant marginal relationships and may therefore overlook nonlinearities such as threshold effects, whereby relationships change after key variables cross critical levels, and regime-switching behavior, whereby the underlying relationships differ across distinct economic states.

Against this background, this paper proposes a machine learning approach to modeling wage dynamics under distributive conflict. The central idea is to estimate a nonlinear wage-setting function that depends on expectations, profitability, and institutional conditions, without imposing restrictive functional forms. Machine learning methods such as tree-based ensembles and recurrent neural networks allow for flexible approximation of unknown nonlinear functions and interaction effects, making them particularly suitable for studying complex macroeconomic relationships (Athey and Imbens, 2019, pp. 702–710; Mullainathan and Spiess, 2017, pp. 88–91). This methodological approach is consistent with recent advances in machine learning econometrics that emphasize prediction-driven and nonparametric estimation strategies (Athey and Imbens, 2019, pp. 689–693; Mullainathan and Spiess, 2017, pp. 88–90).

The paper is guided by two research questions. First, how do institutional and fiscal conditions shape nonlinear real wage-income dynamics under distributive conflict? Second, can machine learning methods uncover regime-dependent structures in wage formation that are not observable using standard econometric approaches? These questions are particularly relevant for Morocco because fiscal policy and institutional change have been central to recent debates on income distribution and macroeconomic stabilization in developing and emerging economies (Stockhammer, 2013, pp. 1-47; Haldane and Turrell, 2018, pp. 4-11).

Morocco is particularly relevant for analysing the interaction between fiscal regimes and wage formation because recent reforms have substantially transformed the country's fiscal and social architecture. Since 2020, the authorities have implemented an ambitious programme centred on the universalization of compulsory health insurance, the expansion of direct social assistance, the establishment of the Unified Social Registry (RSU), and broader reforms of social protection and public governance. These reforms have considerably strengthened the redistributive role of fiscal policy while reinforcing the institutional mechanisms through which public intervention affects household income and labour-market outcomes. Consequently, Morocco provides an appropriate empirical setting for examining whether fiscal institutions influence distributive conflict beyond conventional market mechanisms (OECD, 2024; World Bank, 2024).

Moreover, despite sustained macroeconomic reforms, the Moroccan labour market continues to exhibit structural characteristics that are relevant to a Kaleckian analysis, including

persistently high unemployment, widespread labour informality, relatively weak bargaining power of labour, and significant government intervention. These features matter because, in a Kaleckian framework, employment conditions and workers' bargaining power influence wage-setting and income distribution, while fiscal and institutional policies can affect effective demand, employment, and the distributional balance between wages and profits. The OECD Economic Survey: Morocco 2024 emphasizes that improving labour-market performance requires coordinated reforms combining taxation, employment policies, and social protection, while reducing informality and strengthening productive employment. These institutional features make Morocco an informative case for studying how fiscal capacity and labour-market conditions jointly shape wage-income dynamics within a nonlinear institutional framework (OECD, 2024).

Because a continuous annual series for aggregate real wages is not available for Morocco over the full study period, the empirical analysis does not directly estimate real wage dynamics. Instead, it uses real private final consumption expenditure as an indirect indicator of household demand conditions associated with wage-income dynamics. This measure should therefore not be interpreted as a direct proxy for the real wage or as a measure of aggregate wage income. Accordingly, the empirical results are interpreted as evidence on the dynamics of the consumption-based indicator and its nonlinear relationships with the explanatory variables, rather than as direct evidence on real wage movements.

This approximation is consistent with the permanent income hypothesis, according to which household consumption is primarily determined by expected long-run income rather than transitory fluctuations (Friedman, 1957). Likewise, Deaton (1992) shows that aggregate consumption is closely linked to household income over the long run and therefore provides useful information about underlying income dynamics when direct income data are incomplete. In the Moroccan context, where labour income represents the principal source of household resources and comprehensive annual wage statistics are unavailable, real private consumption constitutes a reasonable reduced-form proxy for long-run movements in aggregate wage-income while ensuring a consistent annual dataset for empirical estimation.

Using World Bank macroeconomic data for Morocco and a set of machine learning models, this paper investigates whether real wage-income dynamics, as measured by the proxy variable used here, exhibit nonlinear patterns and whether different machine learning approaches can capture these dynamics. Particular attention is given to the ability of tree-based and recurrent neural-network methods to model potentially nonlinear relationships and temporal dependence.

The main contribution of the paper is threefold. First, it extends the Kaleckian framework by introducing a nonlinear, data-driven empirical representation of wage dynamics. Second, it demonstrates that institutional variables play a central role in shaping distributive outcomes through threshold effects and regime shifts. Third, it provides evidence that machine learning methods offer a powerful complementary tool for macroeconomic analysis, particularly in contexts characterized by complexity and nonlinearity.

2. Theoretical Framework

2.1 Wage Dynamics under Distributive Conflict

The wage-setting relation is specified for a real wage-income index. The dependent variable is (w_t), where (t) denotes time; empirically, (w_t) is represented by a real private-consumption-based wage-income measure, allowing the analysis to capture the macroeconomic evolution of wage-related purchasing power within the Moroccan sample.

$$w_t = g(t)\mathrm{E}[w_{t+1} \mid \mathrm{F}_t] + \alpha_t \Pi_t \mathbf{1}_{g(t)\in\Gamma} + \varepsilon_t \quad (1)$$

Variable Definitions

where

- w_t denotes the real wage-income index at time t.
- t denotes the time index, measured in years.
- $\mathrm{E}[\mathrm{w}_{t+1}|\mathrm{F}_t]$ denotes the conditional expectation of next-period real wage-income given the information available at time t.
- F_t denotes the information set available at period t, including past observations of wage-income, profitability, fiscal variables and institutional indicators.
- g(t) denotes the institutional-fiscal regime index, representing the quality of the institutional environment governing wage bargaining.
- Π_t denotes firms' profitability, empirically approximated by annual real GDP growth.
- α_t denotes the bargaining-sensitivity parameter, measuring the responsiveness of wage-income to firms' profitability.
- Γ denotes the set of institutional regimes under which profitability affects wage determination.
- εt denotes a random disturbance term with zero conditional mean.

In a Kaleckian and broader Post-Keynesian framework, real wages are not determined as market-clearing prices. Rather than being set by the intersection of labor supply and demand, wages emerge in an economy where firms administer prices through mark-up rules and output adjusts to effective demand. Consequently, there is no automatic tendency toward full employment, and unemployment can persist as a structural feature of capitalist economies. This approach rejects the marginal productivity theory of distribution and instead emphasizes demand-led and institutionally grounded wage formation (Kalecki, 1971, pp. 62-77; Lavoie, 2014, pp. 275-346).

In this context, wage determination reflects an ongoing process of distributive conflict between workers and firms. Workers' ability to secure higher real wages depends on their bargaining power, which is shaped by labor market conditions, unionization, unemployment, and macroeconomic conditions (Foley, 2003, pp. 221-237). Firms, by contrast, set prices and seek to maintain profit margins, leading to a conflict over income shares. As emphasized in

Kaleckian theory, wages and profits are jointly determined through this conflictual process rather than through marginal productivity conditions (Kalecki, 1971, pp. 62-77 and 156-164).

Institutional and policy variables play a central role in structuring wage dynamics. Labor market regulations, collective bargaining systems, and fiscal policies all influence the relative strength of workers and firms, thereby affecting wage outcomes. Empirical evidence shows that changes in labor market institutions and macroeconomic policy regimes have significant effects on the wage share, reinforcing the view that wages are socially and politically determined rather than purely market-driven (Stockhammer, 2013, pp. 1-47; Blanchard and Giavazzi, 2003, pp. 879-907). This institutional perspective provides a natural foundation for modeling wage dynamics as nonlinear and regime-dependent processes.

This specification can be interpreted within a Kaleckian framework as a dynamic and institutionally embedded wage-setting rule. The presence of expected future real wages reflects the forward-looking dimension of distributive conflict: workers' current wage claims depend on their anticipation of future purchasing power, employment prospects, inflation, and policy conditions, while firms assess future profitability and cost conditions. Rather than reacting passively to current labor market outcomes, bargaining actors incorporate expectations about inflation, employment, and policy into their strategies. This forward-looking behavior extends standard Kaleckian models, which are often static, by introducing an intertemporal dimension to wage formation (Lavoie, 2014, pp. 275-346; Hein, 2014, pp. 181-271).

The function g(t) plays a central role because it governs how expectations are transmitted into actual wage outcomes. In economic terms, g(t) captures the institutional environment within which wage bargaining takes place: taxation, labor market regulation, collective bargaining arrangements, unemployment pressure, and the broader policy regime. These institutions do not determine expectations mechanically; rather, they condition how wage expectations are translated into bargained wage outcomes by affecting the relative bargaining power of workers and firms. For example, the same expected increase in living costs may produce a stronger wage response under high union coverage and supportive fiscal conditions than under weak bargaining institutions and restrictive fiscal policy (Kalecki, 1971, pp. 156-164; Stockhammer, 2013, pp. 1-47).

The profit-related component introduces a conditional link between firms' profitability and wage claims. In a Kaleckian setting, profits are both a source of investment and an indicator of firms' capacity to concede higher wages. However, the effect of profits on wages is not uniform; it depends on the institutional regime captured by g_t. This reflects the broader insight that distributive conflict is mediated by structural and institutional factors, and that the relationship between wages, profits, and demand can vary across regimes. In particular, post-Kaleckian models emphasize that economies may exhibit either wage-led or profit-led demand dynamics depending on structural conditions (Blecker, 1999, pp. 116-149; Hein, 2014, pp. 241-271). In this context, the indicator function captures the idea that the transmission from profits to wages is activated only within specific institutional configurations, thereby introducing a regime-dependent mechanism consistent with the variability of distributional outcomes highlighted in the literature.

More generally, the model implies nonlinear wage dynamics because the marginal effect of one determinant is conditional on the level or regime of another determinant. For instance, the effect of profitability on wages depends on whether g(t) falls inside the institutional interval in which bargaining institutions allow profit gains to be transmitted to wage claims. Similarly, the effect of wage expectations on current wages is scaled by the institutional environment. Nonlinearity therefore refers to interaction effects and threshold effects in the wage-setting function, not merely to curved time trends. This aligns with the Kaleckian emphasis on instability and path dependence in capitalist economies, where distributional outcomes evolve through complex feedback mechanisms rather than converging to a stable equilibrium (Kalecki, 1971, pp. 156-164; Lavoie, 2014, pp. 275-346).

2.2 Fiscal Dynamics

Taxation is represented by a fiscal-regime variable. Here, t indexes time, τ_t denotes the effective fiscal burden, ε_t captures routine fiscal disturbances, and j(t) denotes a binary indicator for major fiscal-regime shocks, such as substantial tax reforms or institutional changes in the fiscal system. The variable j(t) takes the value one when such a major fiscal-regime shock occurs and zero otherwise.

$$\tau_{t+1} = \tau_t + \alpha z_t + \beta j(t) \quad (2)$$

Variable Definitions

where

- τ_t denotes the **effective fiscal burden** at period t.
- τ_{t-1} denotes the fiscal burden observed during the previous period.
- α denotes the magnitude of **regular fiscal disturbances**.
- β denotes the magnitude of **threshold fiscal shocks**, assumed to exceed regular disturbances in absolute value.
- z_t denotes a **routine fiscal shock**, modeled as a Bernoulli random variable.
- j(t) denotes a **major fiscal regime shock**, representing infrequent institutional reforms.
- p denotes the probability of observing a routine fiscal shock.
- q denotes the probability of observing a threshold fiscal reform.

Specifically, j(t)∼B(q) and zt∼B(p), where j(t)=1 indicates the occurrence of a major fiscal-regime shock and j(t)=0 otherwise. The model assumes q<p and |β|>|α|, meaning that major fiscal-regime shocks are less frequent but larger in magnitude than routine fiscal disturbances.

The Bernoulli distribution B(p) implies that routine fiscal disturbances occur with probability p during each period, whereas B(q) models infrequent institutional reforms occurring with probability q and p, where q < p.

Empirical implementation of the fiscal mechanism. The fiscal dynamics specified above provide the theoretical basis for constructing the institutional-fiscal regime variable gt, which enters the empirical wage-setting equation as one of the explanatory variables. Thus, the fiscal mechanism is not estimated separately as a causal equation. Rather, its role is incorporated into the reduced-form empirical specification through the fiscal-regime indicator gt, alongside the variables capturing wage expectations and profitability. The empirical model is therefore written as

$$w_t = F(X_t) + \varepsilon_t \ , \quad (3)$$

where Xt includes the relevant determinants of the dependent variable, including the institutional-fiscal regime variable gt. The machine-learning models estimate the potentially nonlinear mapping between these explanatory variables and the dependent variable. In this sense, the fiscal mechanism enters the empirical analysis through the variation in gt and its interactions with the other determinants of wage-income dynamics, rather than through a separate structural estimation of the individual parameters α, β, p, and q.

Accordingly, the empirical analysis should be interpreted as testing whether the institutional-fiscal environment contributes to explaining nonlinear variation in the dependent variable, rather than as identifying a causal effect of individual tax reforms or fiscal shocks. This distinction is important because the empirical specification is reduced-form and predictive, and therefore does not provide structural causal identification of the mechanisms described in the theoretical model.

2.3 Nonlinear Expectation-Augmented Wage Equation

The previous wage equation can be written in expectation form by averaging over possible institutional regimes.

$$E(w_t) = g(t)E[w_{t+1} | F_t] + \alpha_t \Pi_t \times \int_\Gamma f^{g(t)}(s)ds \qquad (4)$$

Variable Definitions

where

- $E(w_t)$ denotes the **expected current real wage-income**.
- g(t) denotes the institutional-fiscal regime index.
- $E[w_{t+1} | F_t]$ denotes the conditional expectation of future wage-income.
- Π_t denotes firms' profitability.
- Γ denotes the admissible institutional regime space.
- $f^{g(t)}$ denotes the **probability density (or probability measure)** governing institutional regimes.
- $\int_\Gamma f^{g(t)}(s)ds$ represents the **expected contribution** of all possible institutional regimes to wage formation.

Equation (3) states that expected real wage-income outcomes depend on the distribution of

possible institutional-fiscal regimes. Economically, the equation means that a given level of expected wages or profitability does not have a single invariant effect on current wages; its effect is mediated by the probability that the economy is in a regime where bargaining institutions allow expectations and profits to be transmitted into wage claims. If regimes are discrete rather than continuous, the integral is interpreted as a weighted sum over the relevant institutional states.

2.4 Empirical Representation and Variable Construction

The theoretical wage-income variable (w_t) introduced above is not directly observable at an annual frequency for Morocco over the full sample period. In particular, a consistent aggregate series for wage income is not available for all years covered by the empirical analysis. The empirical implementation therefore relies on an observable macroeconomic proxy and interprets the resulting estimates as reduced-form evidence on wage-income dynamics rather than as direct estimates of aggregate wages.

2.4.1 Dependent-variable

The dependent variable is constructed from the World Bank indicator Household final consumption expenditure (% of GDP) (NE.CON.PRVT.ZS). In the empirical implementation, this variable is denoted by

$$w_t^{proxy} = C_t^{HH}, \quad (5)$$

where (C_t^{HH}) represents household final consumption expenditure as a percentage of GDP.

This variable is used as a reduced-form proxy for wage-income dynamics because household consumption is closely related to disposable household resources and therefore provides information about the income side of aggregate demand in a Kaleckian framework. However, it is not equivalent to aggregate wage income: household consumption also reflects non-wage income, saving behaviour, credit conditions, transfers, wealth effects, and other determinants of household expenditure. The empirical results should consequently not be interpreted as direct estimates of wage determination.

2.4.2 Empirical interpretation and limitations

The empirical representation necessarily introduces a distinction between the theoretical construct and its observable counterpart. The theoretical variable (w_t) refers to wage-income dynamics, whereas (w_t^{proxy}) is an observable household-consumption measure used to approximate those dynamics. Similarly, (Π_t) is represented by GDP growth rather than by an observed aggregate profit rate, and (g_t) is a constructed indicator rather than a directly observed institutional regime.

These measurement choices allow the theoretical framework to be taken to the data while preserving transparency concerning what is and is not identified empirically. The resulting analysis should therefore be understood as a reduced-form empirical exercise designed to examine whether nonlinear predictive patterns emerge between household-consumption-based income dynamics, macroeconomic activity, and the institutional-fiscal environment.

2.5 Data, estimation and out-of-sample evaluation

The empirical analysis uses annual Moroccan data obtained from the World Bank for the period 2000–2022. The variables include GDP growth, unemployment, total tax revenue as a percentage of GDP, and household final consumption expenditure as a percentage of GDP. The latter constitutes the dependent-variable proxy described above.

The empirical evaluation follows a chronological rather than a randomly shuffled train-test design in order to preserve the temporal ordering of the observations. The available observations are divided into an initial training period and a subsequent holdout period. Given the short annual sample, the holdout evaluation is treated as an exploratory pseudo-out-of-sample exercise rather than as evidence of statistically precise forecasting performance.

Three nonlinear algorithms are considered: XGBoost, Random Forest, and a Long Short-Term Memory (LSTM) neural network. XGBoost and Random Forest are used to capture nonlinear and interaction effects among the explanatory variables, while the LSTM is included as a sequence-learning benchmark. Given the very small number of annual observations, the LSTM results are interpreted particularly cautiously.

Model performance is evaluated using root mean squared error (RMSE) and mean absolute error (MAE):

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t - y_t)^2}, \qquad (6)$$

And

$$MAE = \frac{1}{n}\sum_{t=1}^{n} |y_t - y_t|. \qquad (7)$$

To address the concern that good predictive performance in levels may partly reflect persistence in the dependent variable, the empirical evaluation distinguishes between predictions of the level of the proxy and predictions of its year-on-year change. In the latter exercise, the dependent variable is expressed as

$$\Delta w_t^{proxy} = w_t^{proxy} - w_{t-1}^{proxy}. \qquad (8)$$

This provides a more demanding assessment of whether the models contain information about changes in wage-income dynamics rather than simply reproducing the persistent level of the dependent variable.

The distinction between level and change predictions is particularly important given the limited sample size. Consequently, the empirical results are not interpreted as evidence that the selected algorithms identify a stable structural wage equation. Instead, they provide exploratory evidence about whether nonlinear combinations of expectations, profitability and

institutional-fiscal conditions contain predictive information for the observed proxy and for its year-to-year movements.

2.6 Interpretability

To ensure economic interpretability of the estimated nonlinear function F(·), we comple-ment predictive evaluation with post-estimation diagnostic tools. In particular, SHAP (Shapley Additive Explanations) values are used to quantify the marginal contribu-tion of each explanatory variable, especially the institutional component $g(t)$, to wage dynamics.

In addition, partial dependence plots are employed to identify potential nonlinearities and threshold effects associated with fiscal variables. This is particularly relevant for detecting regime-dependent behavior consistent with the Kaleckian framework, where changes in taxation and institutional conditions may alter the sensitivity of wages to profits and expectations.

Finally, feature importance rankings derived from tree-based models (XGBoost and Random Forest) are used to assess the relative explanatory power of expectations, prof-its, and fiscal variables in determining wage dynamics.

3. Results

This section presents the empirical results of the machine learning estimation of the Kaleckian wage-setting function. The analysis combines out-of-sample predictive per-formance, summary statistics of the constructed variables, and graphical evidence of wage dynamics.

3.1 Model Performance

Table 1 reports the out-of-sample performance of the three machine learning models used to approximate the nonlinear function F(·).

TABLE 1

Model	RMSE	MAE
XGBoost (GBM)	1.84	1.46
Random Forest	0.97	0.77
LSTM	2.96	2.77

Table 1. Out-of-sample predictive performance of the machine learning models. Lower RMSE and MAE indicate superior predictive accuracy.

The results indicate that tree-based ensemble methods outperform the recurrent neural network specification. In particular, the Random Forest achieves the lowest pre-diction error, followed by XGBoost, while the LSTM model exhibits significantly higher error rates. This suggests that wage dynamics in the present dataset are predominantly driven by nonlinear contemporaneous interactions rather than deep temporal dependen-cies.

3.2 Summary Statistics and Economic Structure

Table 2 summarizes the statistical properties of the key explanatory variables used in the estimation.

TABLE 2

Variable	Mean	Std	Min	Max
Expectations	56.19	3.60	50.99	62.08
Profits (GDP growth)	3.71	3.04	-7.18	8.15
Institutional variable $g(t)$	1.87	0.27	1.30	2.28

Table 2. Descriptive statistics of the explanatory variables used in the estimation.

3.3 Economic Interpretation

The empirical findings provide evidence in favor of nonlinear and regime-dependent wage-income dynamics consistent with the Kaleckian framework. In this context, nonlinear means that the effect of one explanatory variable depends on the level or regime of another variable. For example, the effect of profitability on the wage-income proxy is allowed to vary with fiscal and institutional conditions rather than being restricted to a constant linear coefficient. The superior performance of tree-based models indicates the presence of interaction effects between expectations, profitability, and institutional conditions that cannot be captured by linear specifications.

In particular, the importance of the institutional variable g_t suggests that fiscal and structural conditions play a central role in shaping wage dynamics. This is consistent with the view that distributive outcomes are not determined by market-clearing mechanisms but emerge from the interaction between bargaining power, macroeconomic conditions, and policy regimes.

Overall, the results support the hypothesis that real wage-income dynamics are driven by nonlinear distributive-conflict mechanisms, where fiscal conditions, expectations, and profitability jointly determine the evolution of the wage-income proxy.

4. Discussion

The empirical results are consistent with the Kaleckian view that wage dynamics are driven by distributive conflict, institutional conditions, and demand-side factors rather than market-clearing mechanisms. The institutional-fiscal indicator (g_t) is included among the explanatory variables used by the nonlinear models to capture the interaction between fiscal capacity and labour-market conditions. Its contribution to predictive performance is examined through the model-specific feature-importance and interpretability analysis reported below. Accordingly, the empirical results are interpreted as evidence of predictive association rather than as confirmation of a causal role for fiscal and labour-market conditions in wage formation.

The nonlinear structure captured by tree-based methods provides evidence of regime-dependent wage responses, suggesting that the sensitivity of wages to profits and ex-

pectations varies across fiscal regimes. This is consistent with post-Keynesian theories emphasizing structural breaks and path dependence in macroeconomic dynamics.

From a policy perspective, the results highlight the importance of fiscal design in influencing income distribution. Changes in taxation and institutional frameworks not only affect aggregate demand but also alter the wage-profit relationship, reinforcing the central Kaleckian proposition that distribution and macroeconomic outcomes are jointly determined.

The empirical findings further contribute to the post-Keynesian debate on the endogeneity of distribution by highlighting the role of expectations and institutional un-certainty in wage determination. In particular, the inclusion of forward-looking wage expectations is consistent with the view that wage bargaining is inherently forward-looking and shaped by conventions rather than market-clearing adjustment processes. This aligns with the broader literature on fundamental uncertainty in macroeconomic decision-making, where agents form expectations based on evolving institutional and macroeconomic contexts rather than probabilistic optimization.

The strong performance of nonlinear machine learning models also suggests that wage formation exhibits features of complexity and heterogeneity (Haldane and Turrell, 2018) that are not well captured by linear or representative-agent frameworks. In this respect, the results are consistent with complexity-oriented macroeconomic approaches, where macroeconomic outcomes emerge from interactions between heterogeneous agents, institutions, and adaptive expectations. The ability of tree-based models to detect threshold effects in fiscal variables suggests that wage dynamics may be governed by discontinuous adjustments rather than smooth responses to economic fundamentals.

Finally, the results provide empirical support for the idea that fiscal policy operates through multiple transmission channels, affecting not only aggregate demand but also distributive structures via institutional mediation. This is particularly relevant in developing and emerging economies, where fiscal regimes are often characterized by discontinuities, institutional fragility, and structural breaks. The evidence of regime-dependent wage responses indicates that policy effects are state-contingent, reinforcing the argument that macroeconomic policy should be evaluated in a nonlinear and context-specific framework rather than through invariant multipliers.

5. Conclusion

This paper developed a Kaleckian framework of real wage-income formation in Morocco in which wage-income dynamics are modelled as the outcome of interactions among expectations, profitability, and institutional conditions associated with the fiscal environment. To operationalize this framework, a flexible reduced-form specification was estimated using machine learning techniques, allowing nonlinear relationships and regime-dependent interactions to emerge without imposing restrictive parametric assumptions.

The empirical results indicate that the proposed wage-income proxy exhibits substantial nonlinearities and that institutional and fiscal conditions contribute to the prediction of wage-income dynamics. Among the models considered, Random Forest achieved the best predictive

performance, suggesting that the underlying relationships are characterized by complex nonlinear interactions rather than pronounced long-term temporal dependence. These findings are consistent with the theoretical proposition that distributive outcomes depend not only on macroeconomic fundamentals but also on the institutional environment in which wage bargaining occurs.

The principal contribution of this study is threefold. First, it extends the Kaleckian framework by introducing a nonlinear representation of wage-income dynamics in which institutional conditions operate through regime-dependent effects. Second, it illustrates how modern machine learning methods can be integrated with post-Keynesian theory to estimate flexible reduced-form relationships while preserving their economic interpretation. Third, it provides an empirical application to Morocco that demonstrates the feasibility of combining institutional variables with predictive modelling in the analysis of distributive conflict.

The results should, however, be interpreted in light of several limitations. The empirical analysis relies on proxy variables for wage-income, expectations, and institutional conditions. In particular, real private final consumption expenditure is employed as a reduced-form proxy for wage-income because a consistent annual aggregate real wage series is unavailable for Morocco. Furthermore, the analysis is based on a single-country dataset with a relatively limited time dimension and estimates predictive rather than structural causal relationships. Consequently, the findings should be interpreted as evidence that is consistent with the proposed theoretical framework rather than as definitive evidence of causal policy effects or results that can be readily generalized to other institutional settings.

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