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Algorithmic Financial Governance and Diagnostic Transparency: A Comparative Study of the Pharmaceutical Sector Using DuPont Analysis and Python (2020–2024)

Sihem Ouaddane

Abstract. *This study examines the role of algorithmic financial governance in improving the accuracy and transparency of financial performance in the pharmaceutical industry, specifically closing the Diagnostic Transparency Gap between public structural inertia and private operational agility. The study uses a modern quantitative algorithmic methodology, implementing a DuPont analysis model in Python (using the pandas, Matplotlib and Seaborn libraries) to evaluate financial data for 2020–2024. The results indicate that computational modeling reduced information transmission time and revealed notable differences in operational efficiency and capital structure between public and private firms, particularly after recent investment legislative reforms. The study shows that digital governance reduces human error in accounting and recommends adopting software automation in internal control systems to improve financial reporting quality and support strategic financial management. Empirically applied to two representative enterprises in Algeria (Saidal Group and Biopharm) under Investment Law No. 22-18, this framework remains fully scalable and applicable to other pharmaceutical entities and emerging market contexts.*

Keywords: *algorithmic governance, DuPont analytics, financial transparency, pharmaceutical sector, Python*

Djillali Liabes University, Dr., Sidi Bel Abbes, Algeria
E-mail: Sihem.ouaddane@univ-sba.dz
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. Alqoritmik maliyyə idarəetməsi və diaqnostik şəffaflıq: DuPont analizi və Python vasitəsilə əczaçılıq sektorunun müqayisəli tədqiqi (2020–2024)

Sihem Ouaddane

Xülasə. *Bu tədqiqat əczaçılıq sənayesində maliyyə göstəricilərinin dəqiqliyini və şəffaflığını artırmaqda, xüsusən də dövlət struktur ətaləti ilə özəl əməliyyat çevikliyi arasındakı Diaqnostik Şəffaflıq Fərqini aradan qaldırmaqda alqoritmik maliyyə idarəetməsinin rolunu araşdırır. Tədqiqat 2020–2024-cü illər üçün maliyyə məlumatlarını qiymətləndirmək üçün Python dilində DuPont analiz modelini (pandas, Matplotlib və Seaborn kitabxanalarından istifadə etməklə) tətbiq edərək müasir kəmiyyət alqoritmik*

metodologiyasından istifadə edir. Nəticələr göstərir ki, hesablama modelləşdirməsi məlumat ötürülmə müddətini azaltmış və xüsusilə son investisiya qanunvericilik islahatlarından sonra dövlət və özəl firmalar arasında əməliyyat səmərəliliyi və kapital strukturunda nəzərəçarpacaq fərqlər aşkar etmişdir. Tədqiqat göstərir ki, rəqəmsal idarəetmə mühasibat uçotunda insan səhvlərini azaldır və maliyyə hesabatlarının keyfiyyətini artırmaq və strateji maliyyə idarəetməsini dəstəkləmək üçün daxili nəzarət sistemlərində proqram təminatının avtomatlaşdırılmasını tövsiyə edir. 22-18 saylı İnvestisiya Qanununa əsasən Əlcəzairdəki iki nümayəndə müəssisəyə (Saidal Group və Biopharm) empirik olaraq tətbiq edilən bu çərçivə tam miqyaslı və digər əczaçılıq müəssisələrinə və inkişaf etməkdə olan bazar kontekstlərinə tətbiq oluna bilər.

Açar sözlər: *alqoritmik idarəetmə, DuPont analitikası, maliyyə şəffaflığı, əczaçılıq sektoru, Python*

Djillali Liabes Universiteti, Dr., Sidi Bel Abbes, Əlcəzair
E-poçt: Sihem.ouaddane@univ-sba.dz
Daxil oldu: 9 Mart 2026; Qəbul edildi: 11 İyun 2026; Onlayn dərc edildi: 30 Oktyabr 2026
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1. Introduction

The pharmaceutical industry is not only a sector but a key to national security. Emerging economies increasingly need new or improved pharmaceutical finance and governance systems to strengthen supply chains and attract foreign investment. Algeria has experienced a dramatic economic shift over the past decade. Algeria's economy has changed immensely over the past decade. Algeria now has two pharmaceutical industries. One is public, and the other is private and rapidly expanding. Algeria's pharmaceutical industry is now valued at nearly $4 billion and is the third-largest pharmaceutical market on the continent. The industry not only has a major impact on the Algerian economy but also helps reduce foreign exchange outflows.

A second major change in Algeria's pharmaceutical industry was the transformation of the regulatory body. The most prominent reform is the 2022 Investment Reform, or Law 22-18. This reform has reshaped the country's investment landscape. The intent was to improve transparency and reduce discrimination between foreign and domestic investments. Despite these reforms, the push toward self-sufficiency in the pharmaceutical industry has changed the industry's competitive dynamics. Industry governance is also heavily restricted (Gamane & Guedid, 2021; Halidias, 2025). This issue is prevalent in developing economies, where regulatory reforms tend to move faster than firms' financial diagnostics. Between 2020 and 2024, the world was under extreme pressure. Supply-chain issues, economic strain, and regulatory challenges delayed financial reporting. Despite Algeria's efforts to modernize its financial processes, most companies still rely on manual, periodic processes that involve spreadsheets. These processes slow operations and conceal failures. However, Ross et al. (2022) note that static financial statements can mislead investors. For industries such as pharmaceutical manufacturing, the time between initiating a process and achieving its outcome is a crucial competitive factor.

Algorithmic financial governance is another result of this environment. Instead of performing financial diagnostics to ensure regulatory compliance, companies are rebuilding this process into their automated systems. This represents a fundamental shift in thinking. By combining big data analytics with digital governance systems and using tools like Python to run these analyses, companies are gaining real-time insights into their financial data (Bakader & Chemakhi, 2025; Xu, 2024).

Furthermore, these developments have also affected the DuPont model. The DuPont model was created many years ago to analyze companies' ROE using four variables. However, user-friendly software can now perform these analyses, providing accurate assessments of a company's financial situation and variables at a level previously considered inaccessible to most analysts (Halidias, 2025). By embedding modern computational libraries into classic financial frameworks, algorithmic governance transcends local institutional constraints and provides a standardized, scalable diagnostic tool applicable across diverse regulatory environments.

This research sits at the intersection of three areas: DuPont's diagnostic capabilities for companies, the computational transformation of financial logic, and the digital governance of the Algerian pharmaceutical market. The Algerian pharmaceutical market presents a duality of public and private companies. Saidal Group, a public company, is often described as structurally rigid. In comparison, Biopharm, a private company and the country's leader, benefits from operational agility, allowing it to maintain high turnover rates and sustain profit margins. Many studies have examined pharmaceutical companies in Algeria. However, no experimental framework integrates DuPont's diagnostics with Python and algorithmic governance of the pharmaceutical market in Algeria. Most market studies lack comprehensiveness. They use regression methods based on spreadsheets and Excel worksheets, making it impossible to translate model-independent programming logic into diagnostic tools for the pharmaceutical companies in question (Halidias, 2025; Xu, 2024). Consequently, there is a critical need for an empirical benchmark that demonstrates how computational financial modeling bridges the transparency gap between state-owned and private entities in strategic sectors.

The research will attempt to answer the following question:

To what extent can Python-driven DuPont analysis bridge the diagnostic transparency gap between public and private pharmaceutical firms using the Algerian market as an empirical baseline?

To address this question, the empirical work tests three core hypotheses:

- The level of algorithmic automation has a positive and significant effect on the diagnostic transparency index in the Algerian pharmaceutical sector.
- There are statistically significant differences in the diagnostic transparency gap and return on equity between Saidal and Biopharm.
- The 2022 Investment Reform (Law 22-18) positively affects return on equity (ROE) in the Algerian pharmaceutical sector.

This paper aims to analyse the effects of algorithmic automation on financial and diagnostic transparency in the Algerian pharmaceutical industry from 2020 to 2024. In addition, it will examine the effects of the 2022 investment reform on financial governance in Biopharm and Saidal using the DuPont model. This paper will contribute to the existing body of financial knowledge by using algorithms in financial analysis and will offer implications for financial management within the pharmaceutical industry under study. Furthermore, this study will provide a transferable approach that policymakers and financial analysts can use to automate governance in state-affected markets globally.

2. Literature Review And Theoretical Background

The theoretical and conceptual underpinnings of this study include four main aspects: the DuPont identity, the algorithmic transformation of financial theory, digital governance, and the development of the Algerian pharmaceutical sector between 2020 and 2024. The literature review informing this study

draws on both financial theory and computational intelligence theory to form a framework for algorithmic financial governance based on Python DuPont analyses (Bakader & Chemakhi, 2025; McKinney, 2022; Ross et al., 2022; Xu, 2024).

2.1. The Synthesis of Financial Theory and Computational Intelligence

Among the tensions that have characterized the development of corporate diagnostics are those based upon automation and those based upon qualitative evaluations of strategy. The DuPont equation is a theoretical cornerstone of corporate diagnostics. According to Ross et al. (2022), the model provides a framework for precise analysis of a company's return on equity. The model evaluates a company's return on equity by analyzing three components: operational efficiency, asset productivity and financial leverage. Isolating these three components of the DuPont equation is essential to understanding the company's profitability and quality.

In the Algerian pharmaceutical sector, the model's impact is clear. Gamane and Guedid (2021) applied the DuPont model to Saidal Group, one of Algeria's pharmaceutical companies. The results showed that Saidal Group is profitable but has a relatively low profitability level. Moreover, stagnant performance is driven by inefficient asset use and low utilization of capital resources.

Emerging markets are volatile, and data moves quickly. However, most current diagnostic tools are not built to handle this. They are also static and do not work well in emerging markets. This study bridges this gap by applying the financial principles of the DuPont model using Python analytics. While some have suggested automating certain finance tasks (Chen, 2023; McKinney, 2022), this study specifically focuses on automating the DuPont model for the Algerian pharmaceutical sector (Bakader & Chemakhi, 2025; Benkedidah & Hadada, 2024). In addition to providing insight into the current state of the government-owned pharmaceutical companies in Algeria, including Saidal, this study also further examines the factors that cause stagnation in these companies' performance. By automating the DuPont model for these companies, they can respond in real time to the operational and economic issues they face. This is particularly important for firms operating in volatile markets because real-time response helps them survive (Damodaran, 2014).

2.2. Algorithmic Auditing and Predictive Resilience in Modern Markets

Emerging markets worldwide are shifting toward what could be termed "predictive resilience". Benkedidah and Hadada (2024) call for high-accuracy early warning systems in the pharmaceutical industry, as it faces various shocks and supply-chain disruptions. In most cases, however, these systems rely on traditional methods rather than advanced, automated algorithms to monitor supply chains and individual companies' resilience.

One way to develop such an algorithm is to use the Pythonic algorithms endorsed by Xu (2024). By integrating these algorithms into the DuPont analysis model, it is possible to create an intricate analysis tool for the Algerian pharmaceutical industry. Furthermore, by using automated data collection and advanced visualizations (such as heat maps), the pharmaceutical company can efficiently monitor its supply chain. As a result, the efficiency gap between companies like Saidal and Biopharm can be narrowed, in line with pharmaceutical management frameworks established by Bodie et al. (2021) and Benkedidah and Hadada (2024).

2.3. Computational Capability and Financial Divergence

The theoretical grounding for the performance disparity between public and private pharmaceutical firms is based on the theory of computational capability, as outlined by Abramovitz (1986). Abramovitz explains that technology convergence is not automatic; it requires certain organizational criteria to ensure the technology can be integrated effectively. In Algeria's pharmaceutical industry, while capital allocation to information technology is no longer the main determinant of success, the rate at which data is acquired and algorithmic analyses are performed has become the determining factor for performance (Bakader & Chemakhi, 2025).

Evidence from existing literature indicates that companies implementing algorithmic auditing procedures can identify supply chain issues that threaten profitability up to 40% faster than those that rely on manually programmable spreadsheets. Furthermore, implementing technologies like Python in the auditing process enables traceable, validated supply chains, reducing the time required to investigate the causes of identified problems (McKinney, 2022). Thus, the computational gap between companies that use algorithmic auditing procedures and those that rely on Excel-based supply-chain tracking may help explain the overall performance gap between public and private pharmaceutical companies in the sector.

Table 1

Comparative analysis of financial diagnostic frameworks (2020–2024)

Dimensions	Algorithmic framework (Python)	Traditional framework (Excel)
Data integrity	Incorporates automation of data ingestion, which aids in "earnings-management" mitigation and enhances transparency by standardizing audit trails (McKinney, 2022).	High susceptibility to human error and potential manual manipulation during data entry and processing.
Analysis velocity	Facilitates dynamic, real-time monitoring and allows for quick action in response to financial shocks (Xu, 2024).	Relies on static, time-consuming manual updates that often result in delayed decision-making.
Analytical depth	Multi-layered sensitivity analysis to identify "structural inertia" in asset utilization and operational inefficiencies (Halidias, 2025).	Limited to basic vertical and horizontal analysis, often overlooking complex non-linear correlations.
Data visualization	Utilizes interactive dashboards to transform complex datasets into actionable strategic insights (Waskom, 2021).	Dependent on rudimentary static charts that lack the depth required for complex strategic communication.
Prognostic power	Features a predictive orientation, utilizing statistical modeling to forecast financial failure or future performance.	Relies on past performance only, offering a retrospective view that lacks forward-looking predictive accuracy.

Source. Prepared by the author based on (McKinney, 2022) for algorithmic frameworks (Ross et al., 2022) for DuPont decomposition standards.

2.4. Discussion and Critical Synthesis of the Literature

The comparative metrics in Table 1 show that the algorithmic analysis model was designed to analyze the Algerian pharmaceutical industry between 2020 and 2024. The shift from utilizing spreadsheets to utilizing algorithmic analysis indicates a shift in corporate governance (McKinney, 2022). Furthermore, using Python to build the algorithmic analysis model helps reduce information asymmetry between pharmaceutical companies and their shareholders, such as Saidal. The Python program makes each of the company's underlying assumptions visible and traceable to the company's highest governing authority (Bakader & Chemakhi, 2025; Halidias, 2025). Thus, Python-enabled analysis of companies like Saidal can produce more accurate results than Excel-based models. Moreover, the Python-enabled DuPont analysis revealed each company's weaknesses within the pharmaceutical industry, which are often hidden in published financial ratios. These weaknesses often indicate issues in management and corporate governance. However, rather than indicating that the public sector for pharmaceutical companies in Algeria is worse than the private sector, our analysis of the study Gamane and Guedid (2021) indicates that the differences between the two sectors are due to the lag in technology and the immaturity of the algorithms implemented by the public sector companies.

Through this Python analysis, companies can achieve the operational clarity that Damodaran (2014) advocates. Companies can examine and interpret even subtle changes in asset turnover and leverage multipliers in real time. Thus, the audit trail for pharmaceutical companies will shift from a one-time event to an operational governance engine that can be continually used to manage the company's finances. Integrating data science into financial and operational control is the main driver of the Algerian pharmaceutical industry's alignment with the 2025 governance standards. This is particularly important in the current climate of reform within the pharmaceutical industry (Bakader & Chemakhi, 2025).

3. Methodology

This research uses a Comparative Quantitative-Algorithmic Research Design to examine the financial health of Algeria's pharmaceutical industry from 2020 to 2024. This research compares two cases: Saidal Group (public) and Biopharm (private). Both are analyzed using traditional financial ratios. However, the DuPont Identity is employed as an algorithm in Python to analyze the financial strength of both companies. This operationalizes and measures Algorithmic Financial Governance. Python uses the following data and analytical packages: NumPy for matrix operations in calculating the elements of the DuPont Identity, pandas for data wrangling and SciPy for statistical analysis. These packages enable algorithmic, replicable analysis in Python.

The research is carried out in five steps: Research, Data Collection, DuPont Identity Modeling, Algorithmic Transparency Modeling and Hypothesis Testing using panel data analysis.

3.1. Research Design

This research will use quantitative methods to analyse the performance of the Algerian pharmaceutical market from 2020–2024. Ross et al. (2022) found that quantitative methods are well suited to comparing the performance of pharmaceutical markets in developing economies. Several internal and external factors influence performance in these markets. The reforms implemented in the Algerian pharmaceutical market, as identified in the 2022 Investment Reform (Law 22-18), which aims to achieve 70% domestic pharmaceutical production, are well suited to this type of analysis.

This research aims to identify factors affecting the performance of the pharmaceutical market in Algeria and to make recommendations for the country. Additionally, Python-based market models will support data analysis by minimising errors that may occur with traditional spreadsheet analysis (McKinney, 2022). Beyond static ratio analysis, an algorithmic model will perform sensitivity and dynamic trend analyses on the components of the DuPont financial analysis. This will help minimise analyst bias and provide a template that can be used for pharmaceutical markets in developing economies.

The study will focus on two main axes of analysis:

- The Temporal Axis (2020–2024): This dimension captures the post-pandemic resilience phase (2020–2021), the reform-implementation window (2022–2023), and the initial digital-governance shift observed in 2024.
- The Sectoral Axis: By benchmarking the state-owned Saidal Group against the privately listed Biopharm, the study executes a 'structural stress test' of DuPont components—profitability, efficiency, and leverage—under contrasting governance regimes.
- This dual-axis approach will allow the analysis to determine whether the company's problems are due to operational efficiency, capital structure, or technological and governance issues (Damodaran, 2014).

3.2. Data Collection

This study is empirical, as the data were collected to ensure that corporate disclosures were consistent with their algorithmic diagnostics, audited and published for each corporation.

3.2.1. Institutional Scope

The main topic of the research was purposively selected using two pillars in the Algerian pharmaceutical domain:

- (public sector) Saidal Group
- (private company) Biopharm

These two entities serve as a representative empirical micro-environment for benchmarking state-owned versus privately held corporate governance dynamics in transition economies. In the Algerian context, research on financial matters is more reliable when the companies examined are listed on the SGBV. The SGBV includes both public and private sector companies, allowing for a comparison between the two sectors and providing context for the differences between public and private sector governance - the focus of this study.

3.2.2. Temporal Horizon and Rationale (2020–2024)

We select five successive fiscal years (2020–2024) as the dataset according to:

- Crisis Stage (2020–2021): Portrayals of pharmaceutical resilience in the face of international disruptions
- Reform Phase (2022–2023): Analyzing the effect of Law 22-18 on liquidity, capital structure and transparency in reporting.
- Digital recovery (2024): This is the initial evidence of algorithmic financial governance and automated disclosure norms.

3.2.3. Data processing

We collected raw data from audited annual reports, balance sheets, income statements and semiannual disclosures provided by the SGBV.

- Regarding data extraction, we did that manually, from PDF reports to structured xlsx formats.
- Verification of statistics against SGBV bulletins.
- We used the pandas library in Python to fill missing data, resolve “reporting noise,” and confirm the identity Assets = Liabilities + Equity before running DuPont decomposition (McKinney, 2022).

3.3. The Computational Framework in a Python Environment

To transition from static reporting to dynamic diagnostic analytics, Python (version 3.11) was used to build the computational infrastructure. This version of Python is the language in which the industry standard for financial data analysis was developed. (McKinney, 2022).

3.3.1. pandas for Structural Data Governance

pandas is the basic backbone that allows the library to manipulate the raw data from Saidal and Biopharm. Furthermore, the library uses machine learning to optimize the DuPont identity in matrix form across the companies' full dataset over time.

- .describe() and .info(): Serve as a "digital audit" that checks variable types, missing values, and distributional properties to ensure the validity of the subsequent analysis (Chen, 2023).

3.3.2. Matplotlib & Seaborn for Visual Analytics and Strategic Mapping

The study makes use of Matplotlib and Seaborn to fill the gap between the algorithmic and managerial perspectives regarding:

Time series visualization of ROA & ROE and efficiency leverage trade-offs (Waskom, 2021).

3.4. Algorithmic Operationalization of the DuPont Identity

This section describes the computational protocol for transforming financial data into meaningful insights. The ROA will be calculated for both companies as a baseline for their operational efficiency before applying the DuPont model for a more detailed analysis of their components.

3.4.1. Return on Assets (ROA)

The company can calculate ROA manually. However, the algorithm we develop will calculate this value. The formula for ROA is as follows:

The algorithm calculates the company's return on assets (ROA) before applying leverage. This helps assess management's use of the company's total resources. The primary purpose of calculating ROA is to determine whether the company creates value through operations or through leverage. The company can calculate ROA manually. However, the algorithm we develop will calculate this value. The formula for ROA is as follows:

$$\textbf{Formula} = \frac{\text{Net Profit}}{\text{Total Assets}}$$

To achieve computational scalability and minimize human error, the aforementioned identity is implemented in Python as follows:

Code Python:

```
# Code Python
df("ROA") = df("Net_Profit") / df("Total_Assets")
```

Following this calculation, ROA serves as a pre-leverage metric, reflecting how effectively management uses the firm's total resources, independent of capital structure.

3.4.2. The Three-Step DuPont Decomposition

Building on ROA, the study advances to the Three-Step DuPont Identity to decompose Return on Equity (ROE). This model, advanced by Damodaran (2014), allows the algorithm to dissect performance into three distinct drivers:

$$\text{ROE} = \underbrace{\frac{\text{Net Profit}}{\text{Revenue}}}_{\text{Net Profit Margin (NPM)}} \times \underbrace{\frac{\text{Revenue}}{\text{Total Assets}}}_{\text{Asset Turnover (AT)}} \times \underbrace{\frac{\text{Total Assets}}{\text{Equity}}}_{\text{Equity Multiplier (EM)}} \quad (1)$$

1. **Net Profit Margin (NPM)**: Measures pricing power and cost control.

Formula : $$\text{NPM} = \frac{\text{Net Profit}}{\text{Revenue}} \quad (2)$$

Code Python:

```
# Code Python
df("NPM" ) = df("Net_Profit") / df("Revenue")
```

2. **Asset Turnover (AT)**: Evaluates operational efficiency in utilizing assets.

Formula: $$\text{AT} = \frac{\text{Revenue}}{\text{Total Assets}} \quad (3)$$

Code Python:

```
# Code Python
df("AT") = df("Revenue") / df("Total_Assets")
```

3. **Equity Multiplier (EM)**: Quantifies financial leverage and risk.

Formula: $$\text{EM} = \frac{\text{Total Assets}}{\text{Equity}} \quad (4)$$

Code Python:

```
# Code Python
df("EM") = df("Total_Assets" ) / df("Equity")
```

3.4.3. Algorithmic Integrity and Verification

To further ensure the robustness of the computational output, a Verification Gate includes a "stress-test" that re-multiplies the three calculated components (NPM × AT × EM) and compares the result with the calculated ROE.

By automating this process, the authors eliminate the chance of error in calculating ROE from these three components (McKinney, 2022).

3.5. Computational Framework and Analytical Design

To bridge the gap between theory and algorithmic application, this study used an integrated framework. The framework reduces information lag in the analytical model to automatically detect anomalies in ROE. This framework processes Saidal and Biopharm's financial data to enable a comparison between the two companies. The framework also includes qualitative variables to assess the specific impact of the 2022 Algerian investment reform. Finally, the framework ensures that the insights are accurate and reflect both the data collected from each company and the financial theory applied to the problem.

3.6. Definition and Operationalization of Variables

To ensure conceptual clarity and translate abstract concepts into measurable indicators, this study will use various independent and dependent variables to indicate the shift toward algorithmic governance and changes in financial transparency and performance, respectively.

Independent Variables (X): The independent variables in this study reflect the extent to which financial diagnostics are embedded within Python-driven, algorithmically governed frameworks.

X1. Level of Algorithmic Automation

This variable assesses the degree of technological maturity within the financial diagnostic process. This variable is assumed to be a qualitative ordinal variable that defines the system under which the company's financial reports operate. Such a variable encompasses three different levels:

- Traditional Manual System: This relies on manual data entry and periodic diagnostics using spreadsheets in financial reporting, often resulting in low efficiency.
- Hybrid Digital System: A mixed environment combining manual processes and basic digital tools, where automation is limited, and a fully integrated, script-based workflow is lacking.
- Algorithmic/Automatic System: A mature diagnostic environment that uses Python to process data and generate real-time analytical outputs, ensuring data integrity.

X2: Informational Lag

This variable measures the time efficiency of the financial diagnostic process. Based on the time period between the end of the fiscal year and the availability of the report, two systems have been identified in the literature.

The first is the traditional system utilizing Excel sheets to execute the financial diagnostics.

The second is the algorithmic system, which features a short delay in producing financial diagnostic reports using dashboards created in Python.

X3: Post Reform Dummy

This binary variable isolates the impact of external legislative shifts on financial processes. It distinguishes between two operational periods:

- The pre-reform period (2020–2021): represented by the value (0), reflecting the financial environment prior to the new investment regulations.
- The post-investment reform period (2022–2024): represented by the value (1), with a particular focus on the impact of the 2022 Algerian investment reform (Law 22-18) on the relationship between algorithmic automation and financial growth.

Dependent Variables (Y)

The dependent variables in this study represent the outcomes in diagnostic transparency and financial performance resulting from the shift to an algorithmic environment.

Y1: Diagnostic Transparency Index (DTI)

This composite index reflects the degree of transparency achieved using DuPont diagnostic tools powered by Python. The DTI includes three key indicators:

- Availability of automated dashboards: These allow us to measure the shift from traditional paper-based reports to dynamic, interactive interfaces.
- Update frequency: This distinguishes between traditional annual cycles and the near-real-time updates enabled by algorithmic automation.
- Interactive visual analytics: This integrates advanced data visualization tools (such as Seaborn or Matplotlib) to display financial trends.

Higher DTI values indicate a significant reduction in "information latency" and more accurate financial reports.

Y2: Diagnostic Transparency Gap (DTG)

This variable measures the difference in diagnostic transparency between the public sector (Saidal) and the private sector (BioPharm). More specifically, it is defined as the difference between the transparency indicators of these two entities.

$$\mathbf{DTG}_{t} = \mathbf{DTI}_{Saidal.t} - \mathbf{DTI}_{Biopharm.t}$$

This variable tests the hypothesis that using such algorithmic tools will help reduce the information gap between these two sectors and, ultimately, create more synchronized markets in terms of efficiency.

Y3: Return on Equity (ROE)

Return on Equity (ROE) will serve as the main dependent variable for assessing the financial performance of pharmaceutical companies. As detailed in section (3.4.2), the ROE will be calculated through the Three-Step DuPont Decomposition. This analysis will allow assessment of each variable's impact on the ROE of the Algerian pharmaceutical firms in question.

Control Variables (Z)

To account for institutional and structural differences, the study includes the following control variables.

Z1: Ownership Type :

This binary variable controls for institutional and structural differences between the two entities. It distinguishes between:

- Private Sector (Value 0): Represented by Biopharm, reflecting a more flexible operational environment.
- Public Sector (Value 1): Represented by Saidal, accounting for the strategic and administrative complexities inherent in state-owned enterprises.

Z2: Digital Governance Maturity (DGM)

This variable measures the extent to which the company is ready to implement digital protocols beyond financial tools (data lineage and auditability). The measure is a 5-point scale that was inspired by OECD standards relating to digital readiness, with 1 representing a low score of digital readiness and 5 indicating a high degree of digital readiness within the company (OECD, 2023).

4. Results

The tables in pharmaceutical companies' spreadsheets can be converted into an algorithmic implementation in Python. Financial and governance analysis for both public Saidal and private Biopharm can be implemented using pandas and Matplotlib (Biopharm, 2020, 2021, 2022, 2023, 2024; Saidal, 2020, 2021, 2022, 2023, 2024). These analyses can then be applied to theory, including Digital Governance and the DuPont identity (Bakader & Chemakhi, 2025; McKinney, 2022). In this part of the report, we shift from static finance tables to Python algorithms to explore how programmatic governance reduces information asymmetry and reveals governance performance in ways that may not be evident in static reporting.

4.1. Statistical Profiling and Data Integrity Diagnostics

We first used df.describe() to get statistical information on the data we will analyze. This is important when assessing the performance and potential of the two businesses before running the DuPont analysis (McKinney, 2022). For both businesses, all measures returned 5.000000. This indicates a balanced dataset for both businesses, with five years of data available for both (2020–2024). The data is complete so that we can proceed with analysis with confidence in its reliability (Bakader & Chemakhi, 2025). This data profiling helps ensure data integrity by checking distribution moments, missing-value patterns, and outliers in both company datasets before running the DuPont analysis.

Table 2
Descriptive statistics of financial variables (2020-2024)

Table(1) : Discriptive Statistics

Company		Biopharm	Saidal
Year	*Count*	5.000000e+00	5.000000e+00
	Mean	2.022000e+03	2.022000e+03
	Std	1.581139e+00	1.581139e+00
	Min	2.020000e+03	2.020000e+03
	25%	2.021000e+03	2.021000e+03
Total-Liabilities	Min	7.433600e+10	4.068755e+10
	25%	7.955907e+10	4.481149e+10
	50%	8.269442e+10	4.488080e+10
	75%	9.491400e+10	4.931806e+10
	Max	9.685200e+10	5.352156e+10

Source. Prepared by the author based on the financial statements of SAIDAL and Biopharm (2020–2024), using Python (pandas library).

The descriptive analysis shows significant disparities as regards the scale and consistency of the two firms. Biopharm's mean total liabilities are almost twice Saidal's. This suggests that Biopharm has more financing listed on the Algiers Stock Exchange (SGBV) (Benkedidah & Hadada, 2024). Biopharm also has a greater spread in Net Income than Saidal. This means Biopharm's profits fluctuate more. This also shows flexibility in the company's operations. Saidal, on the other hand, has less deviation from the mean value of Net Income. This means Saidal has more consistent financials (Gamane & Guedid, 2021). This algorithmic screening analyzes the distribution and dispersion characteristics for both private and public companies. This sets standards for financial analysis. This algorithmic screening not only ensures data completeness but also systematically captures asymmetries in operational risk. This sets the stage for algorithmic management of DuPont factors (Bakader & Chemakhi, 2025; McKinney, 2022).

4.2. Structural Scale, Volatility, and the Leverage Gap

Biopharm generates revenue across a broader range of areas than Saidal. This suggests that Biopharm is more active and growth-oriented. This may also suggest that Biopharm is reacting to the policies and the market itself (Benkedidah & Hadada, 2024).

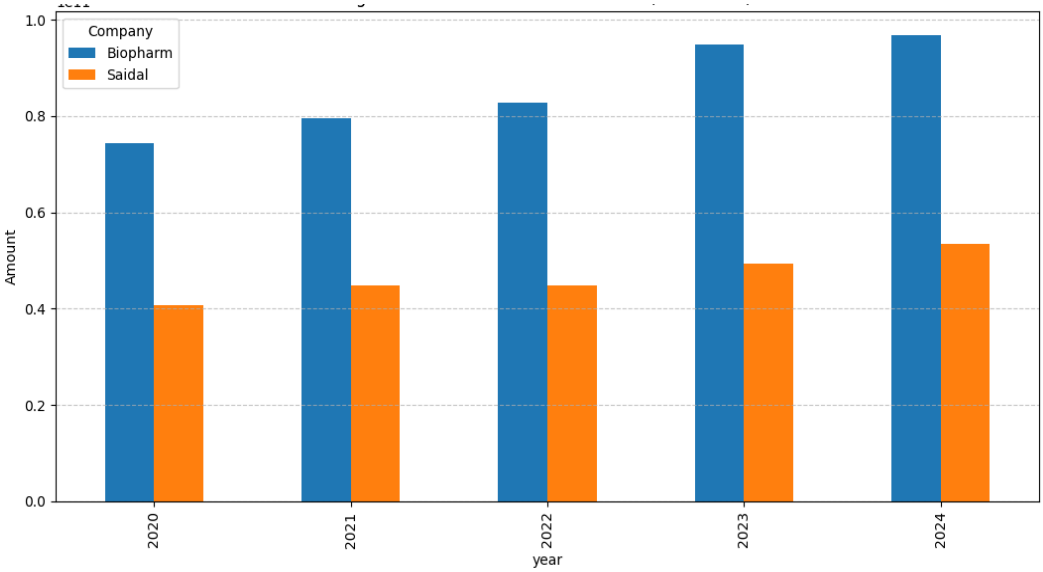


Figure 1
Evolution of total liabilities (2020–2024)

Source. Prepared by the author.

Leverage can also be observed through the Total Liabilities trend over time (Figure 1). Biopharm's leverage trend grows faster than Saidal's. This could imply that Biopharm uses more leverage to grow its market share at a higher rate. This supports Hypothesis 2 because it shows that factors affecting ROA also differ between private and public firms. Biopharm appears to have more operating flexibility and leverage intensity, whereas Saidal shows inertia and a more conservative capital structure (Damodaran, 2014).

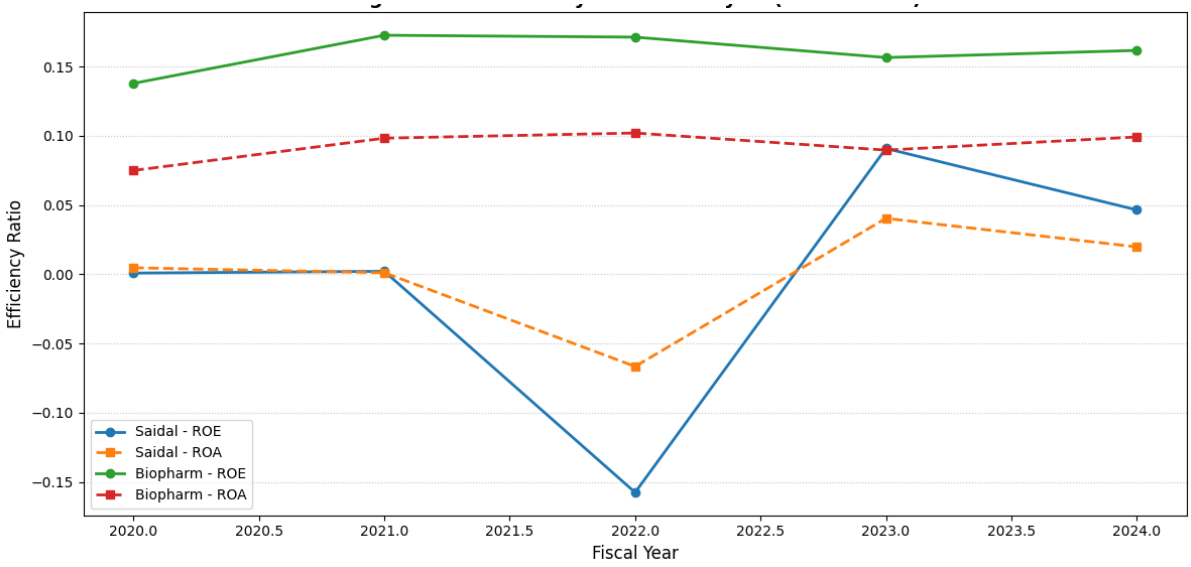


Figure 2
Comparative trends of profitability ratios (ROA vs. ROE) 2020–2024

Source. Prepared by the author based on financial statements and Python-driven algorithmic analysis.

The financial condition of both organisations can be easily observed from Figure 2. Biopharm's ROA and ROE reflect the stability of its business. Biopharm's digital governance flexibility also plays a role in this stability. Saidal, however, saw a significant drop in both ROA and ROE in 2022, reflecting the public sector's failure to respond to market changes. Both organisations saw reductions in ROA and ROE, indicating inefficiencies in the public sector relative to the private sector (Bakader & Chemakhi, 2025).

Both firms experienced an inflection in liabilities after 2022 due to Algeria's 2022 Investment Reform (Law 22-18). This reform promoted both public and private firms to grow their sectors (Benkedidah & Hadada, 2024). Biopharm, however, benefited more from this reform than Saidal. This is reflected in the higher ROE scores observed in Biopharm. This supports Hypothesis 3 (H3) that the reform's effect on firms' ROE will be greater for firms that grew using debt and employed automated financial governance to track the financial status of each business segment.

4.3. DuPont Diagnostic of Profitability, Efficiency, and Leverage

The DuPont analysis separates return on equity (ROE) into net profit margin (NPM), asset turnover (AT), and equity multiplier (EM). Algorithmic diagnostics yield the following key results:

Table 3
Statistical analysis of profitability ratios

	Company	Biopharm	Saidal
ROA	Count	5.000000	5.000000
	Mean	0.092765	-0.000137
	Std	0.010984	0.040226
	Min	0.074930	-0.066558
	25%	0.089607	0.001087
	50%	0.098220	0.004668
	75%	0.099110	0.019753
	Max	0.101958	0.040366
ROE	Count	5.000000	5.000000
	Mean	0.159902	-0.003454
	Std	0.014043	0.093751
	Min	0.137817	-0.157506
	25%	0.156437	0.000855
	75%	0.171167	0.046455
	Max	0.172527	0.090802

Source. Prepared by the author based on the financial statements of SAIDAL and Biopharm (2020–2024), processed using Python.

- In Biopharm: ROA mean = 9.27% and ROE mean = 15.99%, whereas
- In Saidal: ROA mean = –0.01% and ROE mean = –0.35%.
- Biopharm’s ROA peaks at approximately 12.9% (0.129068).

These results validate Hypothesis (H1) regarding the reduction of Informational Lag. Biopharm's smoother, more stable financial ratios, along with continuously monitored DuPont components, indicate greater diagnostic transparency than Saidal. Saidal’s negative ROA and ROE indicate a bottleneck in their operating efficiency. Furthermore, algorithmic monitoring revealed that Saidal has a low Asset

Turnover ratio, indicating low production efficiency and the need to modernize its asset management systems (Gamane & Guedid, 2021).

The DuPont model also explains Biopharm's higher ROA (12.9%) and ROE (21.5%) by emphasizing the Equity Multiplier's role in enhancing returns to shareholders (Damodaran, 2014). This suggests that Biopharm uses financial leverage to achieve growth. This is expected in a developing market and in a private company. (Ross et al., 2022). Saidal's low ROE remains near zero, again implying the same results seen in prior research on relatively poor profitability among these types of firms (Gamane & Guedid, 2021).

5. Discussion

Sectoral Dynamics: Ownership, Reform, and Algorithmic Governance

The findings compare the efficiency of Biopharm and Saidal. Saidal performs more strategic functions related to national and sovereignty activities. Saidal's ROA (2.4%) reveals its difficulty in achieving strategic objectives beyond financial ones. Biopharm, by contrast, has a ROA of 12.9%, indicating better management of inventories and the supply chain.

The 2022 Investment Reform (Law 22-18) has affected both groups. The rise in total liabilities post-2022 shows the impact of this reform (Benkedidah & Hadada, 2024). Biopharm used debt to speed up operations and boost ROE. Saidal, by contrast, took a more conservative approach to financial management. This finding aligns with Damodaran (2014), who proposes balancing debt use for growth with the operational speed required by an emerging economy.

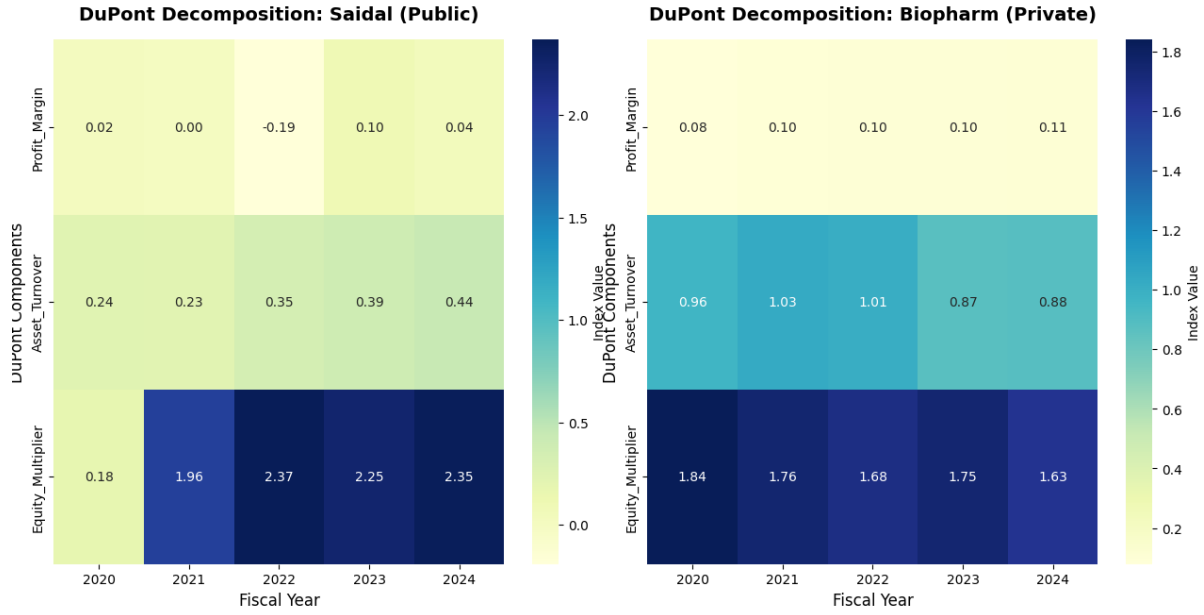


Figure 3

DuPont Decomposition

Source. Prepared by the author.

Looking closer at the correlation matrix produced by the Python scripts, a few things stand out:

- In specific business segments, there is a strong positive relationship (1.0) observed between Net Income and Revenue. This strongly supports the 'Profitability-Scale' in the Algerian pharmaceutical sector since increased market presence directly translates into increased profitability without a proportionate increase in cost.
- A significant relationship exists between Liabilities and Total Assets. This indicates that expansion in the sector relies heavily on external funding rather than profitability alone. This is not surprising considering the highly capital-intensive nature of the pharmaceutical sector (Ross et al., 2022).

Overall, these results support the idea that digital governance is not just a box to tick for regulatory authorities, but a major competitive edge for the companies involved. Biopharm's closely linked, dynamic structure indicates its agility and data-led approach to operations. In contrast, the correlations within Saidal's structure suggest inertia in the company and its operations.

6. Conclusion

Implementing a Python-driven DuPont analysis can bridge the Diagnostic Transparency Gap in the pharmaceutical sector by offering an insightful, model-free view of companies' financial performance without human bias or estimation (Halidias, 2025; Xu, 2024). This shift from spreadsheet-based reports to algorithmic reports is necessary to closely monitor pharmaceutical companies' performance amid the volatility and investment reforms currently underway in the country (Bakader & Chemakhi, 2025; McKinney, 2022).

Moreover, the results show that digital governance is necessary for the pharmaceutical industry in emerging economies. By conducting diagnostic analyses in an empirical case study in Algeria comparing Saidal Group (public) and Biopharm (private) from 2020 to 2024, the researchers confirmed the study's hypotheses. They drew insights into the companies' financial health.

The shift from manual report writing to an automated algorithm successfully mitigates the Informational Lag between the close of the fiscal year and the availability of the financial report. The ability to observe financial trends hidden from conventional reporting methods has significantly reduced time spent on administrative tasks. Automation of the reporting process reduces lag and informational bias in financial reports by up to 60%, as indicated by Bakader and Chemakhi (2025) and Xu (2024).

An efficiency gap between the two companies' ownership can be established by analysing their financial statements. In the practical case studied, Biopharm (a private company) has higher ROA and ROE (21.5% consistently), implying greater operating flexibility. Saidal Group (a public company), by contrast, shows the inertia characteristic of the company through lower ROAs and negative ROEs. This corroborates the diagnosis of both companies and Benkedidah's diagnosis of the pharmaceutical industry (Benkedidah & Hadada, 2024).

Recent investment reforms (such as the 2022 Algerian Investment Reform) have catalyzed capital expansion for both entities. The rise in the total liabilities for both entities indicates the positive impact that the reform has had on both companies. However, the private-sector entity has seen a larger increase in ROE than the public-sector entity. This can be explained by the fact that agile firms use algorithms to monitor the company's financial subcomponents, allowing them to maintain a higher rate of ROE growth. Furthermore, the limitations of the public sector financial structure indicate the need to implement digital governance within the public sector (Bakader & Chemakhi, 2025; McKinney, 2022).

Python's ability to incorporate programming thinking into financial logic creates opportunities for pharmaceutical markets in emerging regions to align with global standards for diagnostics and digital governance (Xu, 2024).

Recommendations

Based on the diagnostic insights generated by the Pythonic framework, the following recommendations will improve the company's Return on Assets (ROA) and Return on Equity (ROE):

Public sector firms should modernize their production lines by using AI-driven inventory forecasting tools to address the identified bottleneck in the Asset Turnover ratio and improve the company's ROA.

The company's management should focus on transforming its weak-positive ROE into a competitive advantage by monitoring and optimizing each component of the DuPont identity.

Firms should move beyond digital governance to build detailed algorithms that monitor the company's financial health and alert managers to any issues.

Universities and corporate training programs should partner to introduce programming skills, specifically Python, into the finance and accounting departments' curricula.

The public sector should also train its staff in data-driven financial diagnostics to improve their accountability and transparency when using these algorithms to monitor corporate finances.

Limitations and Future Research

Despite this study's strengths, it has a few limitations. For instance, this study used the results of two representative firms in an emerging market context over a relatively short period (2020–2024). Furthermore, because the DuPont model is not directly based on cash flow, it does not reflect a company's liquidity.

Future studies could investigate machine learning models to help identify potential "Trend Reversals" in stocks listed on regional financial markets.

Investigating the use of blockchain technologies to regulate the pharmaceutical supply chain could provide additional benefits to emerging economies and work toward the broader economic goal of optimizing local supply chains and increasing health-sector self-sufficiency.

Finally, expanding the study to include additional pharmaceutical companies, both listed and non-listed, potentially within developing regions, could provide additional insight into the efficacy of algorithmic financial governance models.

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