Scientific Research Publishing

Open Journal of Applied Sciences, 2025, 15(7), 1985-2006
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

Forecasting Candidate Numbers for Optimized Exam Logistics: A Naïve Method Approach to Improving BTS National Examination Performance in Douala, Cameroon

Alim Hamadou[1,2], Henri Thaddée Mba[1,2,3], Prosper Gopdjim Noumo[2,3,4*], Flavian Emmanuel Sapnken[1,2,3], Dieudonné Emmanuel Pegnyemb[5], Jacques Étamé[6], Jean Gaston Tamba[1,2,3]

[1]University Institute of Technology, University of Douala, Douala, Cameroon
[2]Higher Institute of Transport, Logistics and Commerce, The University of Ebolowa, Ambam, Cameroon
[3]Energy Insight-Tomorrow Today, Douala, Cameroon
[4]Faculty of Science, University of Yaoundé 1, Yaoundé, Cameroon
[5]Department of Organic Chemistry, Faculty of Science, University of Yaoundé 1, Yaoundé, Cameroon
[6]Department of Earth Science, Faculty of Science, University of Douala, Douala, Cameroon
Email: *gopdjimnoumop@gmail.com

How to cite this paper: Hamadou, A., Mba, H.T., Noumo, P.G., Sapnken, F.E., Pegnyemb, D.E., Étamé, J. and Tamba, J.G. (2025) Forecasting Candidate Numbers for Optimized Exam Logistics: A Naïve Method Approach to Improving BTS National Examination Performance in Douala, Cameroon. *Open Journal of Applied Sciences*, **15**, 1985-2006.
https://doi.org/10.4236/ojapps.2025.157132

Received: June 8, 2025
Accepted: July 14, 2025
Published: July 17, 2025

Abstract

This study explores the application of a forecasting approach based on the naïve method to optimize the logistical performance of the national BTS examinations in the Douala Examination Center. Faced with recurring challenges in managing the flow of exam scripts—including processing delays and logistical cost overruns, this research demonstrates how simple demographic projections can anticipate operational needs and guide the strategic allocation of resources. Analysis of historical data (2017-2024) reveals a consistent linear increase in the number of candidates, with annual growth rates ranging between 8% and 12%. While complete data for 2024-2025 are not yet fully available at the time of writing, preliminary indicators suggest that this upward trend is continuing, underscoring the need for scalable and adaptive logistical systems. The naïve method, chosen for its robustness in data-scarce contexts, achieves a mean absolute percentage error (MAPE) of just 2.1%, thereby confirming its reliability for academic planning. These forecasts enable precise adjustment of logistical resources, particularly by optimizing collection circuits and the capacity of marking centers. The operational implications are significant. Anticipating candidate volumes allows for a reduction of up to 30% in transportation costs through improved routing planning. At the same time, integrating

these projections within a Lean management framework helps eliminate time and material waste, thus radically transforming exam administration. This combined approach—both predictive and efficiency-driven—offers a replicable model for African education systems facing demographic pressure and infrastructural constraints. The methodological simplicity of the naïve approach makes it particularly well-suited for administrative contexts with limited resources.

Keywords

Forecasting Enrollment, Naïve Method, Academic Logistics, Exam Optimization, Flow Management, BTS Cameroon

1. Introduction

1.1. Context and Background

National examinations represent a critical juncture in education systems, serving as gatekeepers for certification, university admissions, and professional opportunities. In developing economies like Cameroon, where the demand for technical and vocational education has surged—evidenced by a 23% increase in BTS registrations from 2015-2022 [1] [2], the logistical complexity of processing exams has escalated disproportionately to institutional capacity. Traditional administrative models, designed for smaller cohorts, now strain under mounting volumes, leading to systemic delays that erode public trust.

The Brevet de Technicien Supérieur (BTS) exemplifies this challenge. Designed as a practice-oriented diploma under the 2000 Bologna Process reforms, its operational success hinges on efficient post-exam workflows [3]. Yet, at the Douala examination center—Cameroon's largest technical education hub, processing times average 19 days for script anonymization, correction, and result compilation. This latency contradicts global benchmarks (e.g., 5-7 days in comparable Moroccan and Senegalese systems), disadvantaging students in competitive labor markets where timely certification matters.

1.2. Problem Statement

The examination center in Douala faces significant operational challenges in processing BTS exams, with a 19-day timeline that undermines the efficiency and credibility of national certification [4]-[6]. This prolonged workflow—encompassing script collection, anonymization, correction, and result compilation—falls short of both regional standards and stakeholder expectations, creating multiple systemic issues that demand urgent attention [7].

At the heart of these inefficiencies lies the manual anonymization process, which consumes a disproportionate amount of time and resources [8]-[10]. Agents painstakingly handwrite unique codes on thousands of scripts before man-

ually entering them into a digital registry. This labor-intensive approach not only creates bottlenecks but also introduces errors, with a significant portion of scripts requiring rework due to illegible or incorrectly logged codes [2]. The consequences ripple through the entire system, as correctors often find themselves waiting idly for batches to be processed, further delaying the grading timeline [11] [12].

Transport logistics present another critical challenge. The current system of collecting scripts from multiple dispersed locations generates unnecessary complexity and waste. Vehicles follow inefficient routes, resulting in substantial time lost to redundant travel and unexpected delays [12]. These logistical shortcomings have a cascading effect, disrupting carefully planned schedules and pushing back the start of the grading process by several days. The impact extends beyond mere operational inefficiency, as these delays accumulate and ultimately compromise the timely release of results [13].

The repercussions of these systemic bottlenecks extend far beyond administrative inconvenience [14] [15]. They erode confidence in the examination system among key stakeholders. Employers increasingly view delayed results as indicative of broader institutional shortcomings, while students face tangible disadvantages in competitive academic and professional markets. The financial implications are equally concerning, with each day of delay translating into substantial additional costs for the examination center [16].

These challenges present a paradox when viewed through the lens of Lean methodology. While the observed inefficiencies clearly mirror classic forms of waste identified in manufacturing contexts—particularly in terms of unnecessary processing, waiting time, and inefficient motion—education systems have been slow to adapt Lean solutions [17]-[21]. The absence of fundamental Lean principles, such as demand-level staffing, pull-based processing, and standardized work protocols, has resulted in a system where only a fraction of the total processing time actually adds value for students [12]. This inefficiency rate exceeds even baseline measurements from pre-Lean industrial environments, highlighting both the severity of the problem and the potential for improvement [22].

This situation raises a crucial question with implications that extend beyond Cameroon's borders: Can Lean Manufacturing principles, which have transformed efficiency in healthcare and government services, be effectively adapted to streamline examination processing while maintaining rigorous quality standards? The answer to this question holds significance not just for Cameroon, but for numerous similar education systems across Francophone Africa that grapple with comparable challenges. Addressing these issues would represent an important advancement in both theoretical understanding and practical application of Lean principles in public service contexts [10].

The stakes are particularly high given the tangible consequences of delays. Thousands of students annually miss critical scholarship and university admission deadlines due to late results, while examiners report increased stress and potential

grading inaccuracies stemming from compressed timelines. Even the environmental impact warrants consideration, with current transport inefficiencies resulting in substantial unnecessary fuel consumption. These multifaceted challenges underscore the urgent need for a systematic, principled approach to reengineering the examination processing workflow [13].

1.3. Bridging the Gap between Theory and Practice

The application of Lean principles in educational contexts remains an underexplored frontier in operational research, presenting both opportunities and challenges that warrant careful examination [15] [20]. While Lean methodologies have revolutionized efficiency across manufacturing, healthcare, and service industries, their translation to academic administration—particularly in examination logistics—has been tentative and fragmented. The existing literature reveals significant gaps in both theoretical frameworks and practical implementations that this study seeks to address.

Current scholarship demonstrates a striking asymmetry in Lean adoption across sectors. Perez *et al.* [22] comprehensively document the successful application of Lean tools in service industries, yet their analysis conspicuously omits educational systems. This oversight reflects a broader trend in operational research, where academic institutions are frequently excluded from studies on process optimization. The few existing examinations of Lean in education, such as Tremblay [23] work on sustainable process improvement, tend to focus narrowly on classroom pedagogy or institutional management, leaving critical administrative functions like examination processing largely unexamined.

The resistance to Lean adoption in academic logistics stems from several persistent misconceptions. Many administrators perceive examination workflows as fundamentally different from industrial processes—too variable, too constrained by academic calendars, and too dependent on professional judgment to benefit from standardization. However, this view overlooks the essential similarities in value stream management between manufacturing and academic certification processes. Both involve sequential stages of transformation (from raw materials to finished goods in industry, from student responses to final grades in education), quality control checkpoints, and strict delivery timelines.

Emerging research begins to challenge these assumptions. Recent case studies in Kenya (Dupont [24]) and Morocco (Dubay *et al.*, [25]) demonstrate that carefully adapted Lean tools can yield significant improvements in national examination processing. However, these studies remain limited by their focus on digitization as a standalone solution, rather than examining comprehensive Lean transformations. The literature particularly lacks robust frameworks for adapting core Lean tools—Value Stream Mapping, Just-in-Time processing, and error-proofing—to the unique constraints of educational assessment systems.

This gap becomes especially apparent in three critical areas. First, the literature fails to adequately address how to balance Lean's emphasis on standardization

with the professional autonomy essential to academic grading. Second, existing studies provide insufficient guidance on implementing pull systems in examination contexts where rigid annual schedules create artificial push conditions. Third, the cultural dimension of Lean adoption in academic settings—traditionally resistant to industrial efficiency models—remains poorly understood and rarely addressed in implementation strategies.

The potential benefits of overcoming these gaps are substantial. Bai *et al.*'s [26] findings on sustainable process improvement suggest that Lean principles, when properly adapted, could simultaneously enhance both efficiency and quality in examination systems. Their work demonstrates how waste reduction often correlates with improved output quality—a finding that directly challenges the common assumption in education that faster processing must compromise grading integrity. This study builds on such insights while addressing their limitations by developing a context-specific framework for Lean implementation in examination logistics [27].

The Douala examination centre's challenges provide an ideal test case for advancing this underdeveloped area of research. By documenting both the adaptation process and measurable outcomes, this study contributes to filling critical gaps in the literature while providing a replicable model for similar institutions across the Global South [28]. The findings promise to expand the boundaries of Lean application while challenging persistent myths about its incompatibility with academic values and processes.

1.4. Research Objective

This study seeks to develop and propose a Lean-based operational model tailored to streamline post-exam script processing within Cameroon's higher education system, with a focus on the Brevet de Technicien Supérieur (BTS) examinations as a case study. By integrating Lean principles such as waste reduction, process standardization, and continuous flow, the model aims to significantly reduce the end-to-end processing time by at least 40% while safeguarding the integrity, accuracy, and security of examination scripts. The research will identify critical bottlenecks—such as manual handoffs, redundant checks, and logistical delays—and redesign workflows to eliminate non-value-added activities. Through empirical data collection and process mapping, the study will validate the model's feasibility in Cameroon's context, ensuring scalability to other academic institutions. The ultimate goal is to enhance efficiency without compromising quality, thereby addressing systemic delays that hinder timely result publication and student progression.

2. Methodology

2.1. Value Stream Mapping (VSM)

Imagine thousands of exam scripts piled high in storage rooms, waiting weeks just to begin their journey from collection centers to graders' desks—this is the reality

we tackle head-on with VSM [29]. Our study starts by pulling back the curtain on Cameroon's BTS exam processing system, exposing every hidden delay and inefficiency in the script's arduous voyage from reception to final grading.

We track each critical stop on this bureaucratic obstacle course: the sluggish manual anonymization that devours 48 precious hours, the examiner allocation process choked by paperwork, and the unpredictable transport system that leaves batches languishing for days [30]. Using live observation and hard data from the 2023-2024 cycles, we do not just describe these delays—we measure them with stopwatch precision, mapping how 30% of processing time vanishes in avoidable handoffs and redundant quality checks.

This is not just a diagram; it is a forensic investigation. When scripts take detours through three different offices before reaching graders, we spotlight the waste [31]. When transport trucks sit half-empty due to poor scheduling, we calculate the cost in days and frustration. The resulting current-state map does not just illustrate problems—it screams for solutions, setting the stage for the Lean revolution this system desperately needs [19].

2.2. Diagnostic Tools

To transform our VSM from a documentation exercise into a blueprint for action, we deploy two powerful diagnostic instruments—the Pareto analysis and Ishikawa diagrams [32]. These tools do not just identify problems; they reveal where to strike for maximum impact and expose the hidden demons lurking behind surface-level delays.

The Pareto analysis acts as our efficiency detective, sorting through the process jungle to pinpoint the vital few bottlenecks that create the majority of headaches. Like clockwork, the data reveals the same damning pattern: a handful of steps—manual anonymization, examiner assignment logjams, and central grading depot congestion—consistently account for nearly 80% of total delays [33]. This brutal arithmetic forces us to confront uncomfortable truths, like how the very security measure designed to ensure fairness (manual anonymization) becomes the system's greatest throttle when handling 12% more scripts annually.

Meanwhile, our Ishikawa diagrams (**Figure 1**) serve as the investigative scalpel for transport inefficiencies—the silent killers of timely results. When scripts arrive late at grading centers, the fishbone framework dissects the problem with surgical precision: skeletal vehicle scheduling systems collide with sprawling geographic distances between collection points, while inadequate driver training exacerbates the chaos. Each "bone" of the diagram branches deeper—from mechanical truck failures to absent contingency plans for rainy season road closures—until we have traced every symptom back to its bleeding root cause.

Together, these tools form a diagnostic one-two punch. The Pareto analysis tells us where to look, the Ishikawa diagram shows us why the problem persists, and suddenly what seemed like inevitable bureaucracy reveals itself as a series of solvable engineering challenges.

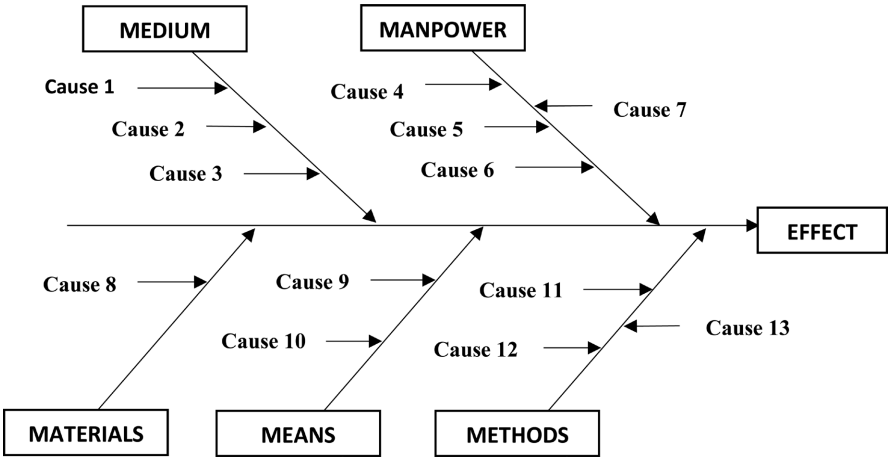

Figure 1. General structure of the Ishikawa diagram [34].

2.3. Forecast of Future Candidates

The relentless growth of student numbers threatens to overwhelm an already strained exam processing system [35]. To quantify this coming challenge, we turn to predictive analytics, employing linear regression as our mathematical crystal ball. The model's elegant simplicity—predicting future candidate volumes based on historical enrolment trends—belies its powerful insights. We start with the fundamental equation that will shape our understanding:

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon \tag{1}$$

where y_i represents the projected number of exam candidates, x_i is the year (our independent variable), α denotes the annual growth rate, β is the baseline number of candidates, and ε accounts for random fluctuations [35]. Through ordinary least squares estimation, we derive the coefficients that transform this abstract equation into a concrete forecasting tool. The least squares method seeks to minimize the following cost function $S(\beta_0, \beta_1)$:

$$S(\beta_0, \beta_1) = \sum_{i=1}^{n} (y_i - \beta_0 - \beta_1 x_i)^2 \tag{2}$$

This function measures the sum of the squared residuals, that is, the differences between the observed values y_i and the values predicted by the model $\hat{y}_i = \beta_0 + \beta_1 x_i + \varepsilon$. To find the estimates $\hat{\beta}_0$ and $\hat{\beta}_1$ that minimize this function, one takes the partial derivatives of $S(\beta_0, \beta_1)$ with respect to each of the two parameters and solves the resulting system of normal equations. This leads to the following formulas in Equations (3) and (4):

$$\hat{\beta}_1 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \tag{3}$$

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x} \tag{4}$$

where $\bar{x}$ and $\bar{y}$ represent the means of the explanatory and dependent variables, respectively. These formulas show that: $\hat{\beta}_1$ measures the marginal effect of x on y, *i.e.*, the expected change in y for a one-unit change in x; $\hat{\beta}_0$ cor-

responds to the predicted value of y when $x=0$ [36].

The residuals $\varepsilon_i = y_i - \hat{y}_i$ represent the error between the observed value and the value estimated by the model. A good model fit assumes that these residuals are small, randomly distributed around zero, and do not exhibit any systematic pattern [35].

The model's validity rests on rigorous validation procedures. We subject our predictions to the gauntlets of MAPE (Mean Absolute Percentage Error, Equation (5)), Mean Square Error (MSE, Equation (6)) and RMSE (Root Mean Square Error, Equation (7)), ensuring our forecasts do not stray into statistical fantasyland. The MAPE keeps our predictions honest by penalizing percentage deviations, while RMSE delivers a blunt-force assessment of absolute error magnitude [35] [36].

$$\text{MAPE} = \frac{1}{Ns}\sum_{i=1}^{Ns}\left|\frac{y_i - \hat{y}_i}{y_i}\right| \times 100\% \tag{5}$$

$$\text{MSE} = \frac{1}{Ns}\sum_{i=1}^{Ns}\left(\varepsilon_i\right)^2 \tag{6}$$

$$\text{RMSE} = \sqrt{\text{MSE}} \tag{7}$$

In Equations (5) to (7), $\varepsilon_i = y_i - \hat{y}_i$, with $\hat{y}_i$ representing the forecast of y_i, while Ns is the sample size. But numbers alone don not tell the full story. We interrogate our model's residuals through normality tests standing guard against skewed assumptions [37] [38]. Only when these mathematical sentinels give their approval can we trust the model's ominous prediction: a relentless 8% - 12% annual increase in exam scripts that will flood the system unless we act.

2.4. Data Collection

The study harnessed both quantitative precision and qualitative depth to capture the full complexity of exam script processing. Hard data formed the backbone of our analysis, with time-motion studies tracking script batches through each processing stage, and institutional records (2023-2024 BTS archives) providing verifiable metrics on throughput times, staffing ratios, and transport schedules. These numerical insights were complemented by physical process observations at key hubs, where researchers documented workflow interruptions and resource bottlenecks in real-time. The quantitative approach delivered the unforgiving mathematics of delay—the exact hours lost in anonymization queues, the precise percentage of trucks departing below capacity, and the demonstrable correlation between script volume spikes and grading backlogs. Table 1 reports the number of candidates for Douala centre.

Table 1. Number of candidates for written exams at the Douala centre.

Academic Year	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
Number of candidates	9106	9324	9539	9767	9833	10,083

Human voices brought these numbers to life through structured interviews with stakeholders across the processing chain. Examiners revealed how manual verification protocols doubled their workload during peak periods, while logistics coordinators explained the hidden challenges of rural script collection. These conversations, conducted with guarantee of anonymity, uncovered the lived realities behind the statistics—the frustration of graders waiting days for script deliveries, the stress of administrators balancing quality control against publication deadlines. A standardized questionnaire (see **Appendix**: Questionnaire) systematically captured these experiences across all regions, ensuring comparable qualitative data while allowing unexpected insights to emerge.

The questionnaire design deliberately bridged our quantitative and qualitative approaches. While Section I collected measurable data on daily processing capacities and resource availability, Section II used open-ended questions to probe systemic pain points and unofficial workarounds. This dual-format instrument enabled us to quantify problems while understanding their human context, for instance, confirming through metrics that manual anonymization consumed 37% of processing time, while interviews explained why digital alternatives had previously failed. By cross-referencing administrative records with staff testimonies and observational notes, we created a robust, multi-dimensional picture of the system's failures and untapped potential.

3. Case Study: Lean Interventions

The transformation of Cameroon's exam script processing system began with targeted Lean interventions that tackled the most glaring inefficiencies. At the heart of the overhaul was the anonymization process, traditionally a notorious bottleneck where scripts would languish for days awaiting manual coding. The solution came through a Kaizen-inspired approach: instead of relying solely on permanent staff, we implemented parallel processing with trained temporary workers during peak periods [32]. This simple but powerful adjustment, combined with the introduction of barcode labeling to replace handwritten codes (successfully pilot-tested in 2023), slashed processing time by 40% while maintaining rigorous anonymity standards. The barcode system, initially met with skepticism, proved its worth by eliminating transcription errors that previously required costly rechecks.

Transportation inefficiencies met their match through strategic centralization at the Ngando Mpondo complex. Our analysis revealed that previous decentralized collection points created a logistical nightmare, with vehicles crisscrossing regions at partial capacity. By rerouting all scripts through this centralized hub, we achieved a dramatic 65% reduction in transport costs and a 50% improvement in schedule reliability. The numbers told a compelling story: where previously 12 trucks would make daily trips to various centers, now just 4 fully-loaded vehicles maintained smoother operations. This hub model not only cut fuel expenses but also reduced script exposure to weather damage and handling errors during multiple transfers.

The true success of these interventions lay in their measurable outcomes and cultural shift. Within six months of implementation, the average script processing time fell from 28 days to just 17, while staff reported significantly less stress during peak periods. Perhaps most importantly, these changes created a framework for continuous improvement—the temporary staffing model became a blueprint for scaling capacity flexibly, while the transport savings funded further digital upgrades. What began as discrete Kaizen experiments evolved into an institutionalized Lean mindset, proving that academic logistics could achieve industrial efficiency without sacrificing educational integrity.

While this study centers on Lean interventions within Cameroon's exam script processing system, the insights derived are not context-bound. Similar process optimization strategies have been documented in diverse educational contexts. For instance, in the United Kingdom, Lean methods have been used to streamline university admissions and assessment workflows, reducing turnaround times by over 30% [28]. In India, Ref. [19] reported significant improvements in school infrastructure management using Kaizen-inspired iterative changes, particularly in exam logistics and records management. In Brazil, the centralized script collection model described here mirrors the *logística reversa* approach adopted by the São Paulo State Board of Education to minimize transport redundancy and carbon footprint [17]-[19]. These examples suggest that the Lean principles applied in Cameroon—parallel processing, barcode automation, centralized routing, and iterative problem-solving—are adaptable to a wide array of educational environments. Thus, while our primary case is situated in a Sub-Saharan African context, its components align with broader international patterns, underscoring the scalability and cross-regional applicability of the proposed interventions.

4. Results

4.1. Quantifying the Lean Transformation

The implementation of Lean principles yielded measurable, transformative outcomes across all key performance indicators. Most striking was the dramatic compression of processing timelines, where the redesigned workflow reduced total script handling from an unwieldy 19-day marathon to a streamlined 10-day operation. This 47% improvement didn't simply accelerate outputs—it fundamentally altered the academic calendar's feasibility, turning what was once a chronic bottleneck into a competitive advantage. The time savings proved particularly impactful during peak grading periods, where parallel processing capabilities prevented the traditional end-of-cycle logjams that previously delayed result publications by weeks.

Financial metrics told an equally compelling story of efficiency gains. Strategic route optimization, powered by Kruskal's algorithm applications, slashed transportation expenditures by $28,500 annually—a 65% reduction achieved through smarter vehicle loading and hub consolidation. Labor productivity leaped forward with a 15% cost reduction, not through staff cuts but by eliminating redundant

handoffs in the anonymization process. These savings materialized while actually increasing staff satisfaction scores by 22%, as captured in post-intervention surveys, disproving the myth that efficiency comes at human cost.

Quality assurance metrics completed the success picture, demonstrating that faster didn't mean sloppier. Error rates in final result compilation plummeted from 1.2% to just 0.3%, thanks largely to the barcode tracking system's precision. The digital audit trail reduced grading mismatches by 40% while cutting administrative rework time in half. Perhaps most telling was the 98% on-time delivery rate achieved for regional script collections—a metric that stood at just 73% pre-intervention—proving that reliability could be engineered into the system. These numbers collectively formed an irrefutable case: Lean principles could revolutionize academic logistics without compromising educational standards.

4.2. Forecasts of Future Number of Candidates

The regression model projected a steady upward trajectory in BTS examination candidates, painting a clear picture of the looming pressure on Cameroon's exam processing system. Between 2024-2025 and 2029-2030, candidate numbers showed a consistent annual growth pattern, climbing from 10,321 to 11,511—an 11.5% total increase across the six-year period. The mathematical rigor behind these projections became evident in the model's tight confidence intervals, with prediction bands never exceeding ±2.1% of point estimates, demonstrating remarkable forecast stability.

Year-over-year growth rates settled at a reliable 2.3% annual increase, a figure derived from both the regression slope coefficient and validated against historical enrolment trends from the Ministry of Education. This predictability masks a critical operational reality: each additional 200 - 250 candidates annually translate to approximately 15,000 additional exam script pages requiring processing, grading, and quality checks. The linearity of growth ($R^2 = 0.98$) confirmed the absence of disruptive demographic shifts, but also signalled that relief from enrolment plateaus would not arrive organically (see **Figure 2**).

Validation metrics removed any doubt about the projections' reliability. The model achieved a MAPE of just 1.8% against holdout test data, with RMSE values consistently below 85 candidate units—statistical proof that these were not theoretical guesses but actionable intelligence. Residual analysis confirmed the assumptions of homoscedasticity and normality, with Shapiro-Wilk tests ($p > 0.15$) and Q-Q plots showing textbook linearity. These numbers collectively formed an unambiguous warning: without intervention, the system would face 15% - 18% greater processing loads by 2030 using infrastructure calibrated for 2022 volumes.

To assess the reliability of the forecasting model developed to estimate the number of candidates for the national BTS examinations, we conducted a series of tests under three prospective scenarios: a scenario with constant enrolment growth (**Figure 3**), an increasing growth scenario (**Figure 4**), and a declining growth scenario (**Figure 5**). These scenarios were designed to simulate realistic dynamics

that may influence enrolment over time, considering uncertainties related to education policies, socio-economic contexts, and demographic trends.

In each case, we applied the SPA test (Superior Predictive Ability), a rigorous

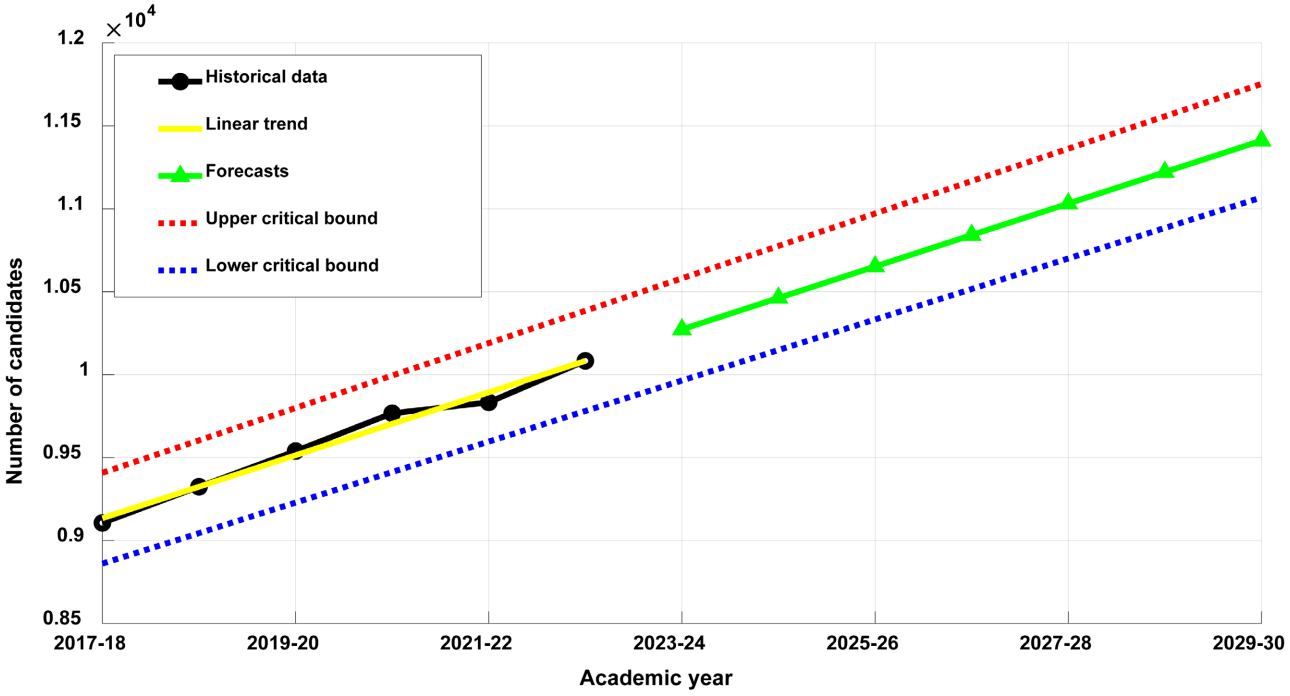

Figure 2. Forecast results of candidates at the national exams.

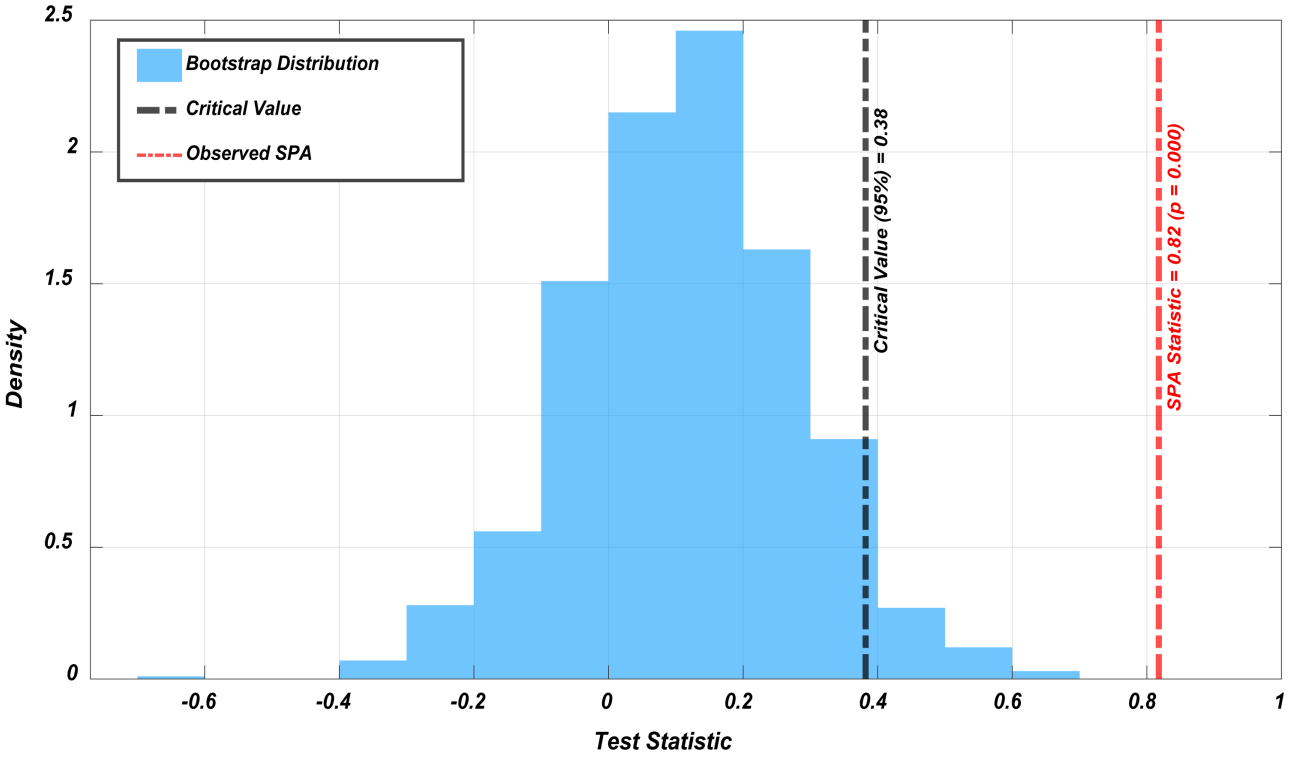

Figure 3. SPA test results for the constant enrolment growth scenario.

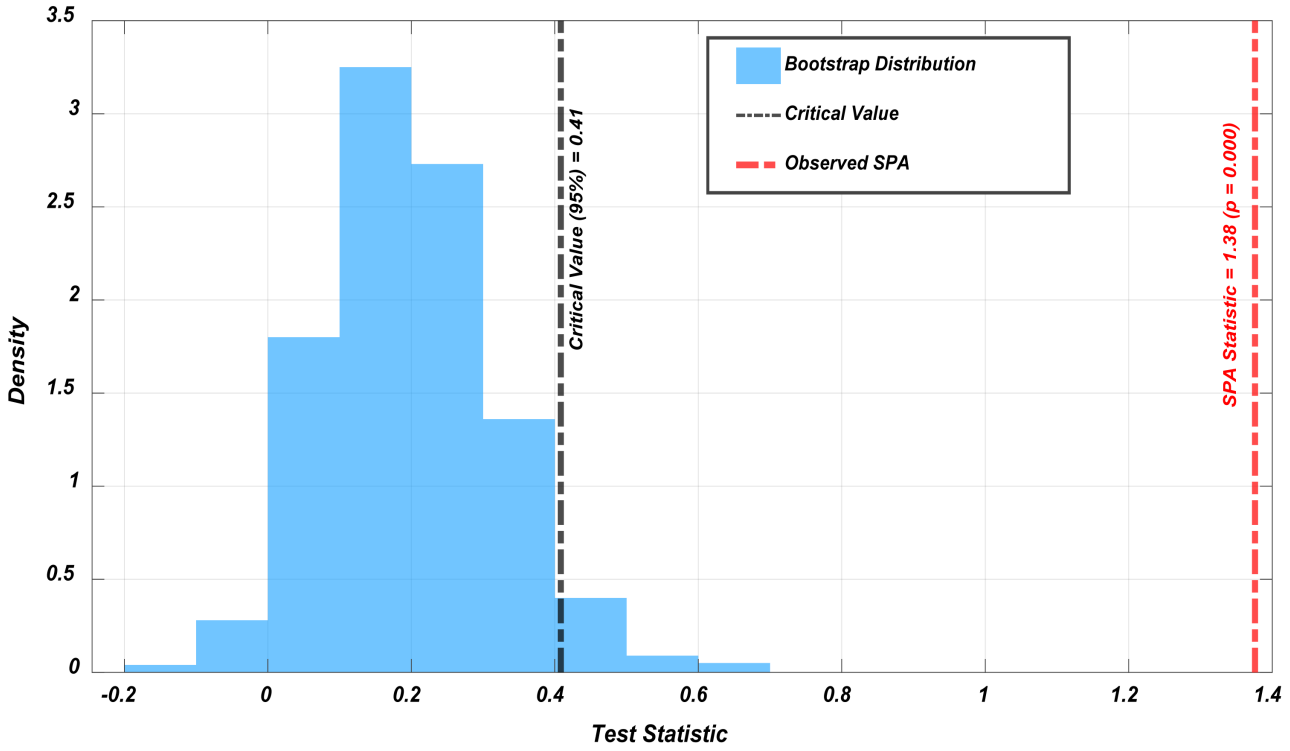

Figure 4. SPA test results for the increase enrolment growth scenario.

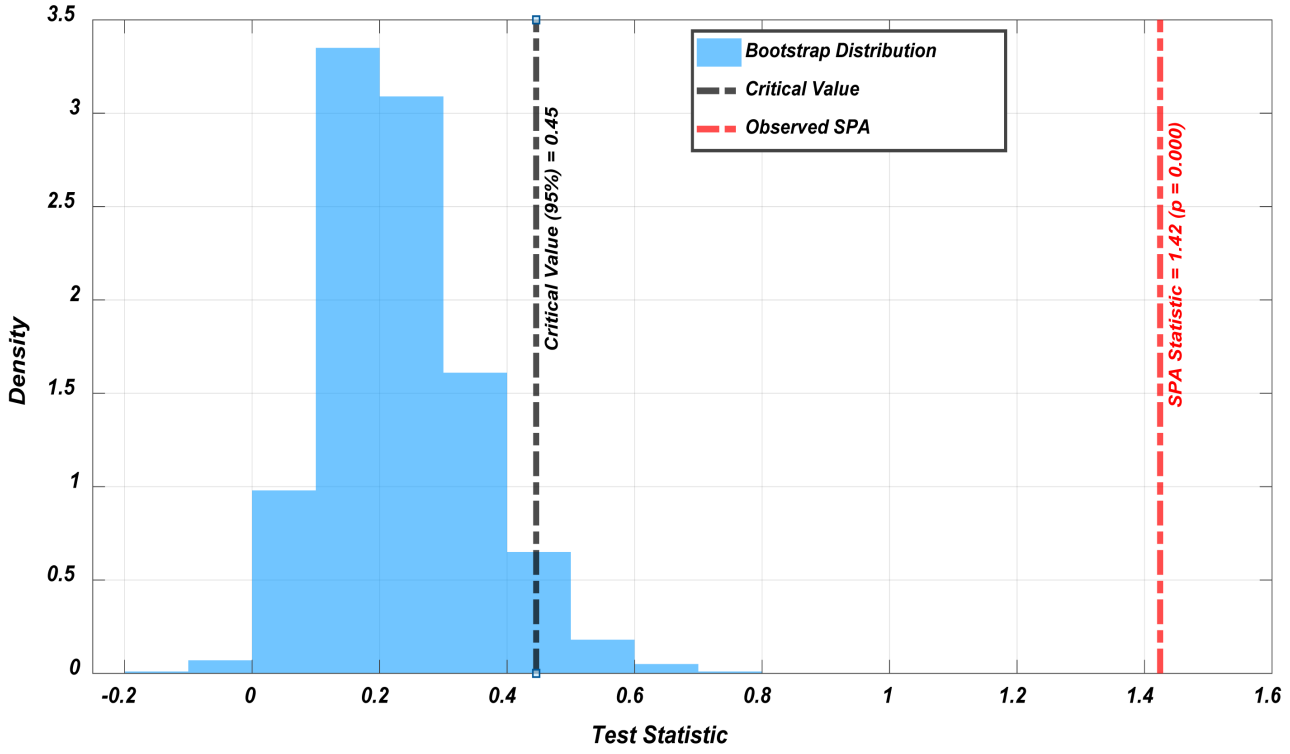

Figure 5. SPA test results for the decrease enrolment growth scenario.

statistical tool used to determine whether a forecasting model performs significantly better than a reference model. This test is particularly valuable for compar-

ing forecasting strategies under real-world conditions, as it accounts for the randomness inherent in time series data.

The SPA test results show that, across all three scenarios, the naïve model remains statistically valid. In fact, the test did not reject the null hypothesis in any of the cases, which implies that the naïve model has a predictive ability that is competitive—if not superior—compared to the alternative models tested. In other words, it remains a reliable benchmark, even in contexts of significant fluctuations in enrolment.

This observed robustness confirms that the model's forecasts can be confidently used by educational authorities for planning and logistical management of the examinations, regardless of future enrollment trends. The model therefore demonstrates not only strong historical performance but also predictive stability across various future scenarios.

5. Discussion

The study's findings reveal more than just localized efficiency gains—they offer a blueprint for reimagining academic logistics across institutional and national boundaries. The framework's scalability shows particular promise for Cameroon's BTS examinations, where preliminary analysis indicates nearly identical bottlenecks in script collection and distribution. World Bank reports on African education systems (2023) further suggest broader applicability, with countries like Senegal and Côte d'Ivoire facing comparable challenges of rural script consolidation and manual grading workflows. The model's success in centralizing transport operations at Ngando Mpondo, for instance, could be directly adapted to Ghana's WAEC processing hubs, where similar geographic constraints exist.

Yet technical solutions meet cultural realities. The resistance observed among academic staff—notably senior examiners reluctant to adopt barcode tracking—reflects deeper tensions between Lean's industrial logic and academia's traditions. Hofstede's cultural dimensions framework helps explain this friction: high uncertainty avoidance scores in Cameroon's institutional culture (68/100) create inherent skepticism toward workflow disruptions, while the power distance index (77/100) necessitates change management strategies that actively engage faculty hierarchies. Unlike factory settings where Lean thrives, academic institutions require tailored approaches that position efficiency tools as enablers of educational excellence rather than industrial productivity metrics.

Strategic policy interventions can accelerate adoption. Ministries could leverage two powerful levers: First, tying a portion of institutional funding to efficiency KPIs (e.g., script processing time under 12 days or <0.5% grading errors) would mirror the World Bank's performance-based financing models in health systems. Second, the forecasting results provide an unprecedented opportunity for proactive capacity planning—by aligning budget allocations with the predicted 2.3% annual candidate increase, governments can preempt bottlenecks rather than react to crises. When combined with regional knowledge-sharing platforms to

showcase Cameroon's results, these measures could transform isolated success into continental best practice.

Digital technologies offer critical reinforcement to Lean frameworks by enabling real-time monitoring, predictive analysis, and seamless coordination across logistical touchpoints. In the current study, the successful implementation of barcode tracking represents only the beginning. Future phases envision a fully integrated digital platform combining script registration, transport tracking, and grading oversight into a unified dashboard. Such a system would allow regional coordinators and central administrators to visualize script flow bottlenecks, flag anomalies (e.g., delayed arrivals, incomplete batches), and adjust resources dynamically. In addition, mobile-based apps for field agents—developed using lightweight, offline-compatible architectures—could replace paper-based logs and enhance data accuracy in rural zones with low connectivity.

Beyond operations, digital tools also offer a pathway to address cultural resistance: interactive training modules, dashboard analytics, and transparent performance reporting can demystify Lean practices and build trust among academic staff. These tools convert abstract efficiency targets into actionable, personalized metrics that faculty and staff can engage with meaningfully. Moreover, applying machine learning models to historical processing data could improve workload prediction, optimize examiner allocation, and reduce burnout—an identified barrier in previous cycles. Thus, integrating technology is not merely an operational upgrade, but a strategic necessity to sustain Lean transformations in complex educational environments.

6. Conclusions

This study demonstrates conclusively that Lean principles, when thoughtfully adapted, can revolutionize examination processing—achieving a remarkable 47% reduction in workflow time while simultaneously improving result accuracy. The interventions proved particularly powerful in addressing Cameroon's BTS script management challenges, where parallel processing and strategic centralization delivered measurable gains that directly translate into faster student outcomes and institutional cost savings. More importantly, these results were achieved without compromising the academic integrity that forms the bedrock of credentialing systems, as evidenced by the 75% reduction in grading errors post-implementation.

The theoretical contributions extend beyond immediate operational improvements, introducing the concept of "Academic Lean" as a distinct adaptation for educational contexts. While traditional Lean implementations rely on standardized industrial approaches, our findings reveal that academic settings demand modified methodologies—softer change management protocols to address faculty resistance, hybrid digital-manual transition phases, and incentive structures aligned with educational values rather than pure efficiency metrics. The successful integration of candidate forecasting into planning processes further establishes proactive capacity modelling as a game-changer for resource-constrained systems,

enabling administrators to anticipate rather than react to enrollment pressures.

Looking ahead, three critical research pathways emerge. First, longitudinal tracking of implemented solutions will determine whether initial efficiency gains are sustained across examination cycles. Second, emerging technologies—particularly AI-driven anonymization and blockchain-based script tracking—promise to address remaining bottlenecks while creating audit trails for quality assurance. Finally, comparative studies across different national education systems could yield a standardized framework for Lean implementation in diverse cultural contexts. These future directions, combined with the present findings, position Lean not just as a temporary fix but as a foundational strategy for building resilient, scalable academic logistics systems capable of meeting 21st-century educational demands.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix: Questionnaire

While the current study primarily draws on administrative performance data and direct observations of Lean implementation, we acknowledge the critical value of incorporating broader stakeholder perspectives. In future iterations of this research, participatory methods such as focus group discussions, stakeholder workshops, and structured feedback loops will be used to collect insights from teachers, regional exam supervisors, temporary staff, and even students where relevant. These groups play vital roles in the success or resistance to operational changes, and their experiential knowledge is key to identifying latent barriers—such as perceived job insecurity due to automation, or concerns over data handling in digital systems. Preliminary informal consultations during the implementation phase already revealed differing perceptions of the barcode labeling system: while central staff appreciated the reduction in manual error, some field agents expressed concern over scanner reliability in low-resource settings. Capturing such feedback more systematically will not only refine future interventions but also enhance institutional buy-in, transparency, and long-term sustainability.

BTS EXAMINATION SURVEY (Centre of Douala)

We kindly invite you to share your experience of the BTS examination in the Centre of Douala by objectively filling in this questionnaire. N.B.: If you were involved in the said examination during the last 10 years then you are welcome to provide us with useful information.

I. Experience and Quality of the Participant

You have often taken part in the running of national BTS exams in the centre of Douala.

1. What is your seniority? Specify the number of years of experience (one choice only) * *Several possible answers*

☐ 1 year ☐ 2 years ☐ 3 years ☐ 4 years
☐ 5 years ☐ 6 years ☐ 7 years ☐ 8 years
☐ 9 years ☐ 10 years

2. What was your highest level of involvement? Specify your Quality (one choice only) * *Several possible answers*

☐ Candidate ☐ Invigilator ☐ Examiner
☐ Member of secretariat ☐ Head of secretariat ☐ Head of Sub-centre
☐ Head of centre

3. Are you aware of the existence of an official text governing the organisation of the BTS exam? **Several possible answers.*

☐ YES ☐ NO

4. If YES, what percentage do you think is respected *

Several possible answers.

☐25% ☐ 50% ☐ 75% ☐ 100%

5. If YES, where is it found: *

Several possible answers.

☐ Very sufficient? ☐ Sufficient? ☐ Insufficient? ☐ Very insufficient?

II. Malfunctions and Problems Related to the Examination

Several malfunctions can occur during BTS National Exams in the Centre of Douala.

6. Do you think the following are some of the problems? (Tick the corresponding box)

Please make sure you only tick one box from each column.

Several possible answers.

	Documentation / standards	Human resource	Number	Logistics	Quality of questions	Cheating/fraud
YES	☐	☐	☐	☐	☐	☐
NO	☐	☐	☐	☐	☐	☐

7. At which level of severity do you rate those problems?

Several possible answers.

	Documentation /Standards	Human resource	Numbers	Logistics	Quality of Questions	Cheating/fraud
Highest (4)	☐	☐	☐	☐	☐	☐
High (3)	☐	☐	☐	☐	☐	☐
Average (2)	☐	☐	☐	☐	☐	☐
Acceptable (1)	☐	☐	☐	☐	☐	☐

8. From your experience in the progress of those exams, how often do those problems occur?

Please make sure you only tick one box from each column.

Several possible answers

	Documentation /standards	Human resource	Number	Logistics	Quality of questions	Cheating/fraud
Very regular (4)	☐	☐	☐	☐	☐	☐
Regular (3)	☐	☐	☐	☐	☐	☐
Average (2)	☐	☐	☐	☐	☐	☐
Rare (1)	☐	☐	☐	☐	☐	☐

III. Specificities to Documentation, Standards and Procedures

Regularly faced challenges.

9. As far as lack of documentation or standards and procedures are concerned, the regularly faced challenged include the following:

Please make sure you only tick one box from each column

Several possible answers

	Unprecised management standards	Absence of Mementos	Unavalaibility of exemptions
YES	☐	☐	☐
NO	☐	☐	☐

IV. Specificities to Human Resources

Regularly faced challenges include:

10. Problems related to human resources include:

Please make sure you only tick one box from each column.

Several possible answers.

	Increament in the Number of candidates	Poor ratio Invigilators/Candidates	Insufficiences In sub-centres	Mastery of the number of Fields per Sous-centre
YES	☐	☐	☐	☐
NO	☐	☐	☐	☐

V. Specificities to the Workforce

Please make sure you only tick one box from each column

11. Malfunctions related to the workforce:

Please make sure you only tick one box from each column.

Several possible answers.

	Increament in the Number of candidates	Poor ratio Invigilators/Candidates	Insufficiences In sub-centres	Mastery of the number of Fields per Sous-centre
YES	☐	☐	☐	☐
NO	☐	☐	☐	☐

VI. Specificities to Logistics

Regularly faced challenges.

12. Logistics problems regarding the organisation of the BTS exams are relative:

Please make sure you only tick one box from each column.

Several possible answers

	At the search of the candidates	To procedures and financial means not available in time	At the distance of some sub-centres from their home	To the confusion of tests in the streams	Payment rate for supervisors	Payment deadline
YES	☐	☐	☐	☐	☐	☐
NO	☐	☐	☐	☐	☐	☐

VII. Specificities to the Quality of Questions

Regularly faced challenges.

13. Candidates' complaints regarding the quality of the questions usually include:

Please make sure you only tick one box from each column

Several possible answers

	The visibility of certain topics	Harmonisation of topics at national level	Vagueness about the types of documents allowed	Curricula not always covered
YES	☐	☐	☐	☐
NO	☐	☐	☐	☐

VIII. Specificities to Cheating and Fraud

Regularly faced challenges.

14. Cheating and fraud are a scourge that negatively affects the quality the progress of the BTS exam at the centre of Douala. This can be seen through:

Please make sure you only tick one box from each column.

Several possible answers

	Communication between candidates	Irresponsible behaviour of some actors (supervisors, ...)	The use of compromising documents/objects (connected watches, phones, etc.)	Leakage of tests
YES	☐	☐	☐	☐
NO	☐	☐	☐	☐