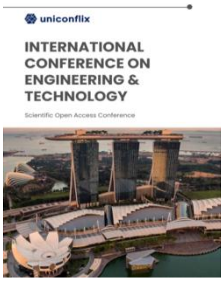

IMPROVING THE METHODOLOGY OF ACCOUNTING FOR THE TECHNOLOGICAL OBSOLESCENCE FACTOR IN THE MANAGEMENT OF INVESTMENT PROJECTS IN THE TEXTILE INDUSTRY

Kurbonov Jasurbek Pozilovich
Dean of the Faculty of Economics
“Alfraganus University” non-state higher education organization, PhD

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ABSTRACT

This thesis scientifically improved the methodology for accounting for technological obsolescence in textile industry investment project management. The study integrated technology monitoring, measurement of obsolescence intensity, adjustment of economic asset life, and reassessment of discounted project value. A decision model based on a composite coefficient, critical threshold, and adjusted NPV was developed. The findings showed that the approach enabled more accurate assessment of technological risks, better timing of modernization, and stronger investment efficiency.

Introduction

The productive value of capital equipment declines for two analytically distinct reasons, and the separation of those reasons forms the starting point of any rigorous methodology of investment project management. Physical deterioration reflects wear, load history and the quality of maintenance, and it is observed directly through technical condition surveys. Technological obsolescence reflects the appearance of newer equipment generations whose productivity, energy intensity, automation level and quality parameters exceed those of installed assets, and it is observed only through comparison with the moving frontier of available technology. Conventional appraisal practice recognises the first process through depreciation schedules and treats the second implicitly, which produces for a machine an accounting life that rarely coincides with its economic life. The distance between these two lives constitutes the methodological problem addressed in the present work.

The textile industry offers a demanding environment for such a distinction. Spinning, weaving, dyeing, finishing and knitting installations operate in continuous regimes, carry a high share of fixed costs in unit cost, and remain exposed to rapid change in fibre processing technology, machine automation, digital process control and energy standards. An investment project in this industry therefore commits capital to a technological position rather than merely to a physical asset, and the durability of that position determines the realised return far more reliably than the nominal service life of the equipment. Treating the technological position as an unmeasured background condition removes from the appraisal precisely the variable that carries the largest part of the risk.

Uzbekistan has placed the sector at the centre of its industrial modernisation agenda, which gives the question direct practical relevance. Presidential Decree No. PF-6 of 16 January 2025 defined the principal target indicators for developing the processing chain in the textile and garment-knitwear industry, setting exports at 4.0 billion US dollars in 2025, 5.0 billion in 2026 and 7.0 billion in 2027, raising exports of finished goods to the markets of the United States and European countries to 500 million US dollars, and increasing the share of finished garment-knitwear products in total exports to 70 per cent [1]. Decree No. PF-2 of 10 January 2023 had earlier established a system of financial and institutional support for cotton-textile clusters and for the reform of the textile and garment-knitwear industry, including concessional working-capital resources for exporting enterprises [2]. Sectoral statistics indicate that in 2024 the industry exported textile products worth approximately 2.87 billion US dollars, with yarn forming 43.2 per cent of the export structure [3], while comparative trade data placed textiles as the second largest export product group of the country, with 3.03 billion US dollars of exports and 1.09 billion US dollars of imports in the same year [4]. Industrial development research has demonstrated that manufacturing carries a strong multiplier effect, since each manufacturing job generates more than two additional jobs elsewhere in the economy, and that industrial firms hold approximately 60 per cent of the green patents registered worldwide [5]. Targets of this scale are attainable when the equipment producing the additional value added remains close to the technological frontier throughout the project horizon.

The aim of the article consists in developing a methodology that incorporates the technological obsolescence factor into the evaluation, monitoring and revision of investment projects in the textile industry, using measurable indicators derived from verified sources rather than from expert impressions.

Literature review

The theoretical foundation for treating obsolescence as an economic variable was laid by vintage capital analysis, in which successive generations of capital embody different states of technology. Research conducted within this tradition demonstrated that capital-embodied technological progress raises the productivity and value of new capital goods while comparatively reducing the production capacity and value of installed goods, and that a shock to the rate of embodied progress does not raise investment as strongly as accelerator reasoning predicts [6]. Surveys of the same literature clarified that the equilibrium lifetime of equipment becomes finite once obsolescence mechanisms enter the model explicitly, and that replacement investment consequently exhibits echo effects rather than a smooth path [7]. The relationship between obsolescence and deterioration was examined from the standpoint of capital aggregation, where the duality condition linking user-cost ratios to relative in-use productive efficiencies supported the argument that both processes enter economic depreciation through a common channel [8].

A second stream approached the question through the timing of irreversible decisions. The exposition of investment under uncertainty established that irreversibility combined with the ability to postpone creates an option value of waiting, which raises the threshold at which committing capital becomes rational [9]. Applied to equipment, the problem of retaining an asset or replacing it with a more advanced technology was formulated with non-stationary technology forecasts, non-stationary revenue functions and explicit salvage values, and an efficient forecast-horizon algorithm was derived for identifying the optimal decision in any period with minimal reliance on forecast data [10]. A related formulation examined the choice between a minor maintenance investment that slows efficiency deterioration and a major replacement investment, expressed the optimal policy as thresholds on long-run prices, and quantified the value of a replacement option embedded in a maintenance option [11]. Extensions incorporating jump processes into the arrival of new technologies produced analytical investment thresholds under shock uncertainty [12], while distributed optimal control treatments derived the optimal economic lifetime of vintage capital in the joint presence of operating costs, technological progress and learning [13].

A third stream originates in valuation practice and supplies the measurement vocabulary. Appraisal methodology distinguishes functional obsolescence arising from excess capital cost, identified through the difference between reproduction cost and replacement cost, from functional obsolescence arising from excess operating cost, identified through the additional labour, energy and material consumed by an older asset relative to a modern equivalent of equal utility [14]. Regulatory guidance for substantiating additional obsolescence requires that claims of technology-based or competition-based value loss rest on the investment, utilisation and replacement patterns of the enterprise itself, and that estimates of remaining economic life be supported by verifiable data [15]. Practitioner literature defines economic obsolescence as the state in which maintaining older equipment costs more than replacing it, and notes the reporting distortion that arises when such assets remain on the books at undepreciated values [16].

Industry-specific research completes the picture. A review of digital technologies in textiles and clothing showed that Industry 4.0 elements, including the Internet of Things, artificial intelligence, computer-aided design and manufacturing systems, digital printing and three-dimensional technologies, changed the precision, waste intensity and energy profile of textile production, and identified investment in skills development as a condition of successful implementation [17]. Work integrating Industry 4.0 with activity-based costing and the theory of constraints in textile manufacturing confirmed that real-time monitoring and smart energy management optimised resource utilisation and profitability, while adoption in textiles proceeded more slowly than in other sectors and required infrastructure investment and qualified personnel [18].

The reviewed sources therefore supply the theory of obsolescence, the theory of optimal timing and the measurement conventions of valuation practice, yet these components are rarely combined into a single operational procedure applicable to textile investment projects. The methodology proposed below addresses that gap.

Methodology

The proposed methodology treats technological obsolescence as a measurable state variable of an investment project rather than as an unquantified risk annotation. It consists of four connected blocks: continuous technology monitoring, quantification of obsolescence intensity, correction of the economic life of the asset, and correction of the discounted value of the project together with an explicit decision rule.

Technology monitoring establishes the reference frontier. For every principal operation of the technological chain - spinning, weaving or knitting, dyeing and finishing, and making-up - a reference machine is identified among the equipment supplied on the market during the evaluation year, and its performance is described by a vector of four parameters: output per machine-hour, specific energy consumption per unit of output, the share of defective output, and labour input per unit of output. The same vector is measured for the installed asset. Reliance on marketed reference equipment, rather than on a hypothetical best available technology, keeps the frontier verifiable and auditable.

Obsolescence intensity is expressed as a normalised composite. For parameter i with weight wi, where the weights sum to unity, the coefficient takes the form:

$$\theta_t = \Sigma_i \, w_i \cdot d_{i,t}, \quad \theta_t \in [0;\ 1] \qquad (1)$$

where di,t denotes the relative distance of the installed asset from the reference machine on parameter i, measured so that a value of zero corresponds to coincidence with the frontier and a value approaching unity corresponds to the maximum divergence recorded in the observation set. The coefficient θt records the technological position of the asset at time t. Weights are assigned from the cost structure of the specific production stage, which makes the indicator sector-specific rather than universal: in energy-intensive dyeing and finishing operations the weight of specific energy consumption exceeds that of labour input, while the reverse relationship holds in making-up.

The obsolescence-adjusted economic life follows from the intensity path. Denoting by Tph the physically attainable service life and by θ* the critical intensity at which the annualised excess operating cost of the installed asset exceeds the annualised cost of its modern equivalent, the effective life is determined as:

$$T = \min\{\, T_{ph};\ \min(\, t : \theta_t \geq \theta * \,)\,\} \qquad (2)$$

The threshold θ* is derived from the excess-operating-cost criterion of appraisal methodology [14] and is substantiated by the utilisation and replacement records of the enterprise itself, as measurement guidance requires [15]. Project value is corrected accordingly. With CFt denoting the cash flow projected under frontier technology, λ the elasticity of cash flow with respect to obsolescence intensity, r the discount rate, I0 the initial outlay and ST the salvage value at the corrected horizon:

$$NPV\theta = \Sigma_t \, CF_t \, (1 - \lambda\, \theta_t)\,(1 + r)^{-t} + S_t\,(1 + r)^{-T} - I_0 \qquad (3)$$

The multiplier (1 − λθt) transfers the technological position of the asset directly into the cash flow, so that a project whose equipment drifts away from the frontier loses value continuously rather than at the moment of a formal revaluation. The elasticity λ is estimated from the observed relationship between the parameter gap and unit cost at the same enterprise, which keeps the coefficient empirical.

The decision rule closes the procedure. Three mutually exclusive alternatives are compared at each review point: full replacement, partial modernisation of the constraining operation, and deferral. Following the reasoning of option-based analysis [9] and of maintenance-replacement threshold models [11], the managerial choice takes the form:

$$V_t = \max\{\, NPV\theta\ (\text{replacement});\ NPV\theta\ (\text{modernisation});\ F(\theta_t)\,\} \qquad (4)$$

where F(θt) denotes the value of waiting when the arrival of a superior technology generation is anticipated within the review interval. Deferral remains admissible only while

$\theta t < \theta^*$, which prevents the option argument from justifying indefinite postponement of modernisation. Data requirements are deliberately restrictive: every element entering expressions (1)-(4) is either measured at the enterprise or taken from published technical documentation and official statistics, and no parameter is introduced by assumption alone. The methodology is therefore reproducible under audit conditions.

Analysis and results

Application of the proposed procedure begins with a structured classification of obsolescence, since a form of value loss that remains unclassified cannot be measured. Table 1 links each form to its economic content, to an observable indicator and to the source establishing the measurement convention.

Table 1. Analytical classification of technological obsolescence in textile production and the corresponding measurable indicators[1]

No.	Form of obsolescence	Economic content	Observable indicator	Source
1	Functional obsolescence from excess capital cost	Reproduction cost of the installed asset exceeds the replacement cost of a modern asset of equal utility	Difference between reproduction cost and replacement cost of the reference machine	[14]
2	Functional obsolescence from excess operating cost	A modern equivalent produces the same output with lower labour, energy and material input	Specific energy consumption and labour input per unit of yarn, fabric or finished item	[14]
3	Obsolescence from overcapacity and inadequacy	Installed capacity or technical parameters no longer match the product range demanded by the market	Share of orders that the installed line cannot execute to the required specification	[15]
4	Economic obsolescence	Maintaining the asset costs more than replacing it, while book value remains undepreciated	Ratio of annual maintenance and repair cost to the annualised cost of the modern equivalent	[16]
5	Obsolescence from capital-embodied technical progress	A newer equipment generation raises the productivity frontier and lowers the relative value of installed vintages	Gap in output per machine-hour and in defect rate against the marketed reference machine	[6]

The classification produces an immediate analytical consequence: four of the five forms are observable from data that textile enterprises already generate for operational purposes. Output per machine-hour, energy consumption per kilogram of yarn or per metre of finished fabric, defect rates and repair expenditure are recorded in routine production and cost

[1] Source: compiled by the author on the basis of sources [6], [14], [15] and [16].

reporting, so the informational cost of introducing the methodology remains low. Only the frontier comparison requires additional information, and that information is available from the technical documentation of equipment manufacturers and from specialised industry exhibitions.

The macroeconomic significance of the correction is visible in the relationship between capital accumulation and productivity. Analysis of the national economy for the period from 2010 to 2022 established that growth relied heavily on capital investment as the primary engine, that this pattern did not generate the expected level of employment, and that reaching upper-middle-income status by 2030 would place total factor productivity at the centre of the agenda, which in turn depends on removing technological constraints [19]. Investment that reproduces an obsolete technological position raises the capital stock without raising productivity, whereas investment placed at the frontier raises both. The obsolescence-adjusted criterion in expression (3) separates the two outcomes at the appraisal stage rather than after commissioning, which is the point at which the separation still carries managerial value.

Sectoral conditions reinforce the argument. Global survey evidence for the textile value chain recorded an average capacity utilisation rate of 75 per cent in September 2024, recovering from 68 per cent in November 2023, with weak demand named as the principal concern by 66 per cent of participants [20]. Under such conditions the marginal contribution of additional physical capacity remains limited, while the marginal contribution of technological upgrading - lower specific energy consumption, higher quality consistency, shorter changeover times, broader product range - remains substantial. The proposed methodology directs investment toward the second channel, because expression (3) penalises cash flows generated from positions distant from the frontier irrespective of the physical volume of capacity installed.

The institutional environment supports this orientation. Industrial development research argues that accelerated catching up requires multiple pathways beyond assembly manufacturing, with emphasis on resource-based processing, innovation, local ownership and strategic positioning within global value chains [21], and the national reform programme has followed a comparable logic, with real gross domestic product growth averaging six per cent annually between 2017 and 2025 and with continuing emphasis on private-sector-led growth and improved conditions for trade, business and investment [22]. An obsolescence-adjusted appraisal methodology operationalises that emphasis at enterprise level, translating a national productivity objective into a decision rule that a project economist applies directly.

Figure 1 presents the resulting procedure as a closed managerial cycle.

1. TECHNOLOGY MONITORING

Identification of the marketed reference machine and measurement

↓

2. OBSOLESCENCE INTENSITY

Calculation of the composite coefficient θt from weighted

↓

3. CORRECTED ECONOMIC LIFE

Determination of the horizon T as the earlier of the physical life

↓

4. ADJUSTED PROJECT VALUE

Discounting of cash flows weighted by the technological position

↓

5. INVESTMENT DECISION

Comparison of replacement, modernisation and deferral;

Figure 1. Managerial cycle of obsolescence-adjusted investment project management in the textile industry[2]

The cycle is closed rather than linear: the decision block returns to technology monitoring, so that the intensity coefficient is recalculated at each review point and the economic life of the asset is re-estimated as the frontier moves. This property distinguishes the proposed methodology from single-point appraisal, in which the obsolescence assumption is fixed at the moment of approval and is never revisited. The practical feasibility of the cycle in textile conditions is supported by evidence that real-time monitoring and digital process control measurably improved resource utilisation and cost management in textile manufacturing [18], which indicates that the data flows the cycle requires are attainable with technologies already present in the industry.

Three results follow from the analysis. The measurement of obsolescence rests on indicators that the enterprise already collects, so the methodology imposes no new reporting burden. The correction enters the value calculation continuously, so the divergence between conventional and adjusted appraisal grows precisely in the projects most exposed to technological change and remains negligible in projects that are not. The decision rule keeps deferral available as a rational alternative while bounding it by the critical threshold, which reconciles the option value of waiting with the modernisation objectives of the sector.

Conclusions and suggestions

[2] Source: compiled by the author on the basis of sources [6], [9], [11], [14] and [15].

The article established that technological obsolescence in the textile industry admits direct measurement and therefore belongs inside the investment appraisal calculation rather than in its qualitative commentary. The separation of obsolescence from physical deterioration allowed the economic life of textile equipment to be defined as the earlier of the physically attainable life and the moment at which obsolescence intensity reaches its critical threshold, which corrects the systematic overstatement of project horizons produced by depreciation-based reasoning. The composite intensity coefficient converted a qualitative judgement into a bounded, weighted and verifiable indicator built from parameters that textile enterprises already record. The adjusted net present value transferred the technological position of the asset into the cash flow continuously, so that value loss appears in the appraisal as it accrues. The decision rule combined replacement, modernisation and deferral within a single comparison while restricting deferral to states in which obsolescence intensity remains below the critical threshold.

The following proposals follow from the results.

First, enterprises implementing modernisation projects should maintain a technological passport for each principal production line, recording the four frontier parameters annually and preserving the comparison base over the full project horizon.

Second, appraisal documentation submitted for concessional financing under the sectoral support instruments [2] should present the obsolescence-adjusted net present value alongside the conventional indicator, since the two diverge precisely in the projects that carry the greatest technological exposure.

Third, sectoral associations should publish an annual reference set of marketed equipment parameters for spinning, weaving, knitting, dyeing and making-up operations, which would lower the cost of frontier identification for small and medium enterprises.

Fourth, financial institutions should treat a documented obsolescence intensity below the critical threshold as a positive covenant condition for modernisation credit, which aligns lending practice with the export and value-added targets established for the industry [1].

Fifth, higher education institutions preparing engineers and economists for the sector should incorporate obsolescence measurement into curricula, since the methodology depends on the joint competence of technologists and financial analysts.

Further research may extend the framework to a portfolio of interconnected production stages, where obsolescence at one stage constrains the realisable return of investment placed at another, and where the optimal sequence of modernisation becomes the central question.

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