APPLICATION OF LAFFER CURVES IN THE CONTEXT OF CONFORMITY ASSESSMENT MODULES FOR THE MACHINERY SECTOR

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Abstract: *The paper presents the application concept of the Laffer curve to optimizing conformity assessment processes in the machinery sector. Originally used in fiscal economics, the Laffer curve can be adapted to analyze the relationship between the intensity/frequency of conformity assessments and the resulting compliance levels. The key idea of the paper is that an optimal level of assessment exists that maximizes compliance while minimizing excessive quality costs. The paper presents how assessment for machinery manufacture is carried out through various conformity assessment modules, each with different requirements in terms of documentation, testing, and involvement of third-party bodies. When applying the Laffer curve principles, it can be helpful for enterprise management to identify the right balance between regulatory rigor of conformity assessment and economic pragmatism, avoiding situations where over-investment in compliance compromises the competitiveness of the enterprise without proportional safety or other benefits. We suggest that the Laffer curve can provide an important conceptual framework for optimizing conformity assessment processes, aiming to find the optimal balance where compliance costs are minimized while maintaining an adequate level of product safety and quality.*

Keywords: *Laffer curve, conformity, assessment modules, machinery*

1. Introduction

Several models are used in economic theory that propose various optimization models. One of these models is the Laffer curve, which presents the theoretical relationship established between tax rates and the resulting government revenues. This curve suggests that there is an optimal level of taxation that maximizes revenues, and any deviation from this level can lead to a decrease in revenues. If taxes are too low, less is collected, and if they are too high, economic activity is reduced or may lead to increased tax evasion. Presented as a concave curve, the Laffer curve revealed an optimal point of the tax rate that maximizes tax revenues. Beyond this point, increasing the tax rate can lead to a decrease in revenues, because economic activity is discouraged [1].

Similarly, the curve can be conceptually adapted in various contexts to analyze the effectiveness of policies or processes [1]. In the context of product conformity assessment, we can assume that there is an optimal level of intensity or frequency of assessments that maximizes compliance, and beyond this level, the effects may become counterproductive. Applying the principles of the Laffer curve to product conformity assessment modules may provide a framework for optimizing process efficiency and achieving a more effective balance between regulatory effort and compliance outcomes.

In the context of product conformity assessment, for the application of the Laffer curve, an analogy can be made between:

- "Taxation" → Complexity and resources of conformity assessment. If product compliance costs become excessive (too high a "tax rate"), firms could be discouraged from investing in product compliance or even from operating in certain sectors, leading to a lower overall level of compliance and, consequently, a decrease in revenues.
- "Tax revenue obtained by the state" → economic efficiency obtained from product sales.

2. Conformity assessment modules and risks

Product conformity is a key principle within the European Union single market, aiming to ensure that products marketed comply with the safety, health, environmental protection, and performance standards set at the European level [2]. The instrument used to ensure that a product complies with the relevant regulatory requirements in ensuring product conformity is the CE marking. The responsibility for applying the CE marking lies with the economic operators who ensure the implementation of the conformity assessment process. This process is carried out according to assessment modules, established by legal regulations: European decisions, directives, and regulations. The conformity assessment modules through which the marking application can be ensured represent, in fact, different procedures through which it can be demonstrated that a product complies with the legal requirements [3].

Machinery safety is a critical area where excessive or insufficient assessment can lead to inefficiencies, increased risks, or reduced compliance. The choice of the conformity assessment method is made depending on the nature of the product, the degree of risk it involves, and its complexity [4]. In Table 1, the main differences between the conformity assessment modules are presented.

When we look at the effort to implement a conformity module, we see that some issues for resource analysis must be referred to the effort to make independent verification, to create the necessary documentation, and responsibilities, which sometimes involve a third-party (notification body).

The assessment of the types of conformity modules and risks requires high resources, and in the context of establishing the necessary resources, costs increase with the requirements regarding the appeal for quality system certification, the involvement of specialists in risk assessment, and the involvement of testing laboratories or notified conformity assessment bodies [5].

The evaluation of machine-type products can be carried out based on conformity assessment modules under European legislation. Directive 2006/42/EC plays a crucial role in ensuring machinery safety in the EU while promoting market integration [6]. The directive establishes essential health and safety requirements that manufacturers must adhere to when designing and constructing machinery. These requirements cover aspects such as risk assessment, ergonomic design, electrical safety, and emergency stop mechanisms. The Machinery Directive 2006/42/EC mandates that manufacturers perform a risk assessment during the design and construction phases of machinery.

In addition to choosing the module, manufacturers must comply with: risk assessment; safe design steps (elimination of risks by design); protective measures (loading, blockages, emergency stop systems); and preparation of mandatory documentation [7]. The ISO 12100 standard establishes the basic terminology, principles, and methodology for achieving safety in the design of machinery, defines the principles of risk assessment and risk reduction, helping designers achieve this goal. Compliance with EN ISO 12100:2010 conferred a "presumption of conformity" with the essential health and safety requirements.

Table 1. *The main differences between the conformity assessment modules*

Cod	Module name	Responsibility	Need independent verification	Necessary documentation	Applicability
A	Internal production evaluation	Manufacturer	No	Technical file	Low-risk products
A1	Internal assessment + random testing	Manufacturer	No (requires testing)	Technical file + test report	Slightly increased risk products
A2	Internal assessment + type examination	Manufacturer + Notified body (examination)	Partial (type examination)	Technical file + examination report	Moderate risk products
B	EU type examination	Notified body	Yes (initial assessment)	EU examination certificate	Combined with modules C, D, E, F
C	EU type conformity	Manufacturer	No (based on mode B)	Declaration of performance and conformity	Mass-produced products
C1	Product verification	Manufacturer + Notified body (test)	Yes (random checks)	Technical file + verification report	High-risk products
C2	Periodic product review	Manufacturer + Notified body	Yes (tests and inspections)	Technical file + examination report	Complex products, high risk
D	Production quality assurance	Manufacturer (quality system)	Yes (quality system audit)	Quality system certificate	Mass production
D1	Production quality assurance (without module B)	Manufacturer + Notified body	Yes (quality system assessment)	Quality system certificate	Special cases
E	Product quality assurance	Manufacturer (control final)	Yes (quality system audit)	Quality system certificate	Mass production
E1	EU final examination	Notified body	Yes (final check)	Declaration of performance and conformity	Critical products
F	Product verification	Notified body	Yes (tests on each product)	Declaration of performance and conformity	Unitary production, high risk
F1	Verification based on type examination	Notified body	Yes (tests + examination)	Declaration of performance and conformity	Customized products
G	Unitary verification	Notified body	Yes (tests on product)	Declaration of performance and conformity	Unit production, high risk
H	Full quality check	Manufacturer (quality system) + Notified body	Yes (audit + tests)	Quality system certificate	Complex products, high risk
H1	Full review + quality management	Manufacturer + Notified body	Yes (extensive assessment)	Quality system certificate	Medical, aeronautical products

The correlation between the necessary resources and these additional requirements imposes a new assessment of the costs necessary to carry out these activities. This assessment must follow a structured and iterative methodology, as outlined in ISO 12100, which specifies the principles for identifying all potential hazards and evaluating the associated risks. The aim of ISO 12010 is to optimize machinery design to minimize risk while maintaining functionality and usability, and requires trade-offs between safety measures and other design considerations, such as cost, efficiency, and user experience. Over-engineering for safety might make machinery impractical or prohibitively expensive. The design of the machine involves increasing the safety measures, but this does not always result in proportional reductions in risk and an increase in security for the operator. Diminishing returns may occur, where additional safety features yield minimal improvements in safety, logically and effectively. So, it should be an optimal balance between two competing factors, safety/cost.

All these activities regarding the choice of conformity module and evaluating the hazards and risks involve resources that can be transformed into conformity costs. If compliance costs become excessive, the manufacturers may be discouraged from investing in compliance, which could lead to a lower overall level of compliance and possibly a significant reduction of their market and, consequently, a decrease in their revenues. This requires optimization of compliance costs such as: design & development costs, testing & certification costs, administrative, documentation and risk assessment costs, implementation of compliance processes costs, ongoing compliance, testing & validation costs, certification costs, cost of non-compliance, and indirect & opportunity costs.

3. The Laffer curve in the management of conformity

The Laffer curve, used in fiscal economics, presents the relationship between the level of taxation and tax revenues and indicates the existence of an optimal taxation point [8]. Although the Laffer curve originates from the field of taxes and levies, it offers complementary insights into how compliance assessment systems can be designed and managed effectively and warns of the risk of imposing disproportionate requirements. Stimulating economic activity by producers to obtain increased financial benefits requires reducing compliance costs, and this approach could encourage more organizations to adhere to standards and regulations. However, reducing compliance costs should not compromise product quality and assessment effectiveness. Applying the Laffer curve in the context of choosing one of the compliance assessment modules requires economic thinking about optimizing the costs and benefits of compliance.

In the field of assessing the conformity of products to make them available on the market, "tax levies" could be interpreted as the total resources of compliance that an organization must pay. The resources allocated to meet compliance requirements include: information, time, personnel, technology investments, costs, etc. The costs associated with product compliance refer to all the expenses a company incurs to ensure that its products meet regulatory, safety, and quality standards required by law or market expectations [9].

When product compliance is analyzed, it is observed that, in addition to resources, several factors influence it, among which we can list: a series of internal factors, such as organizational culture and risk awareness, but also a series of external factors, such as competitive pressure and the application of regulations.

The suitable economic efficiency can be translated into financial benefits and other forms. In the context of product conformity assessment, "other benefits" can include: ensuring product safety, complying with consumer protection requirements, reducing environmental impact, strengthening the brand and image of the product on the market, reducing risks, building trust in

products, etc., benefits that are more difficult to quantify directly.

The Laffer curve principle can be applied to identify the optimal level of assessment that maximizes the efficiency of conformity assessment processes from design to product selling. Based on established economic assumptions regarding economic efficiency, it can be shown that too high a level of assessment can lead to additional costs and delays, while too low a level can compromise the quality and safety of products and, respectively, reduce sales on the market. Thus, the requirement arises to identify an optimal balance that can ensure that conformity assessment processes are efficient and effective, and therefore performant. To reduce the conformity costs, the following should be taken into account:

- Simplifying assessment procedures: identifying ways to make assessment processes more efficient and less costly.
- Using IT technology: creating digital platforms, using tools that provide automation, and implementing AI, tools that can reduce the resources needed for assessment and monitoring.
- Risk-based approach: increasing the resilience of the processes, identifying processes and their activities with the highest exposure to hazards and risks.
- Incentives for compliance: reducing the frequency/intensity of quality inspections/controls and internal quality audits for processes where the principle of continuous improvement operates, and focusing assessment resources to reduce costs.

The Laffer curve provides valuable elements for the design of compliance assessment modules by establishing a balance between regulation and compliance. Using this model helps balance regulatory rigor with economic pragmatism.

The logic of the Laffer curve can be applied in compliance assessment regulations through accountability, validation of compliance (internal or external), and differentiated use of risk-based assessment modules. When applying Laffer curve principles in the context of compliance assessment modules for the machinery sector, it provides a pragmatic approach to optimizing resources and maximizing results. The application of Laffer curves in conformity assessment involves identifying an optimal level of assessment intensity that maximizes compliance while minimizing costs and adverse effects.

The Laffer curve expresses the central idea of the balance between effort, costs, and outcome - conformity. In assessing compliance costs, using such a conceptual framework helps the managers of an enterprise to understand that neither excess nor lack of control is efficient – the optimal solution lies in identifying a strategically balanced level of investment. Figure 1 represents the Laffer curve in safety vs costs of compliance coordinates. The X-axis represents increasing levels of safety, and the Y-axis represents the costs of compliance with maintaining that level of safety.

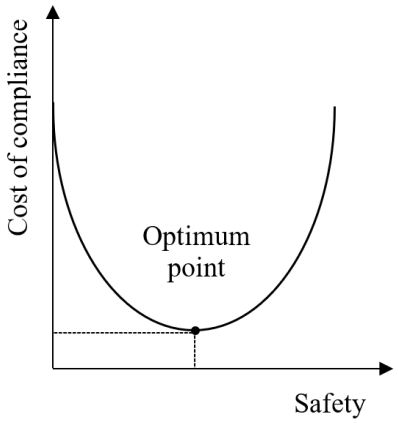

Figure 1. Laffer Curve - safety vs costs of compliance

At a conceptual level, for the application of the Laffer Curve principles, regarding the design of machines, it can be argued that there is an optimal point regarding the aspects related to the "cost of compliance vs. safety", aiming to obtain the maximization of the "benefits of compliance". Compared to this optimal point, if the aim is to reduce the resources (cost) related to compliance, the risk assessment could be superficial, and the safety measures established would be insufficient, leading to an increased risk of accidents and low benefits of compliance. If the company

excessively increases the resources (costs) to ensure safety measures that do not bring a significant improvement in compliance, respectively, the level of safety or other benefits, this additional investment could affect competitiveness without obtaining a proportional return in terms of safety or benefits. Additional investments in compliance can become inefficient and costly, and in this respect, there is an optimal level of investment in compliance (prevention and assessment) that minimizes the total cost. The Laffer model aims to optimize the outcome according to a strategic decision (regulation vs. level of compliance spending). When used in machine design, the standard ISO 12100 and Laffer model seeks an optimal level of safety measures and conformance that reduces risk, without making machinery impractical or excessively costly.

4. Conclusions

Although there is no direct link between the Laffer Curve and the ISO 12100:2010 standard, a conceptual correlation can be associated with the idea of finding an optimal point of compliance cost that maximizes the benefits of compliance in terms of machine safety and economic advantages and ensuring the balance between the costs of implementing safety standards (thus achieving compliance) and the economic benefits they bring.

Ideally, machine manufacturers should seek a level of investment in implementing ISO 12100 that ensures an adequate level of safety and maximizes the benefits of compliance (risk reduction, good reputation, market access, and economic profit) without imposing excessive costs that could negatively affect the firm's economic viability.

The use of optimization principles, such as those inspired by the Laffer Curve, to Conformity Assessment Modules for machinery safety involves finding the right balance between ensuring safety and avoiding unnecessary resources.

Applying a Laffer-like framework to machinery safety means balancing compliance costs with safety outcomes.

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