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Lean Production & Productive Efficiency: New Techniques on Theory and Estimation

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Abstract

As lean production and productive efficiency enhancement becomes an increasingly important issue within Europe and worldwide, policy planning should draw attention towards efficiency estimation and effectiveness attainment. Within this framework, this paper focuses on the efficient resource management, benchmarking the estimated efficiency, through a deterministic analysis. The research is an investigation into prospects of improving productive efficiency in a manufacturing system through productive openness, resource allocation and integration of firm's activities. This paper analyses, through a benchmarking approach, manufacturing investment in selected sectors of production in Europe, creating a spectrum of policy implications.

Keywords: Lean production, Productive Efficiency, Resource Management, Resource Effectiveness

1. Introduction

Productive efficiency is the relationship between what an organization produces and what it could feasibly produce. Efficiency of a production unit represents a comparison between observed and optimal values of its output and input**.** Productive efficiency performance is conventionally judged utilizing the concept of economic efficiency, which is generally assumed to be made up of two components: technical efficiency and allocative efficiency. The former is defined as the capacity and willingness of an economic unit to produce the maximum possible output from a given bundle of inputs and technology level. The latter concept is defined as the ability and willingness of an economic unit to equate its specific marginal value product with its marginal cost. Therefore, productive efficiency represents the estimation of how well a producer uses the available resources to produce outputs from inputs.

In the modern knowledge economy, growth depends extensively on the presence or the formation of a network and environment favorable to innovation, which is based on the endogenous development capabilities. Even though the producer-specific factors are important determinants of innovation activity, technological opportunities and favorable entrepreneurial environment have a positive effect on innovation activity, as well. Combining the production functions in order to create and disseminate innovations leads to improvements in productive efficiency. However, at a given moment of time, when technology and production environment are essentially the same, producers may exhibit different productivity levels due to differences in their productive efficiency. Within growth process, therefore, efficiency of production resources becomes a critical element in growth, through utilizing the available, yet scarce, resources more productively.

However, productivity theory literature has emphasized factors such as productive efficiency, mainly through technological spillovers, increasing returns, learning by doing, und unobserved inputs (e.g., human capital quality), whereas the empirical industrial organization literature has emphasized the degree of openness of countries to imports and industry structure (Koop, 2001). As rigorously described in Kumbhakar and Lovell (2000), productive efficiency represents the degree of success producers achieve in allocating the inputs at their disposal and the outputs they produce, in an effort to meet specific set productive objectives. Thus, in order to measure productive efficiency, it is first necessary to specify producers' objectives and then to quantify their degrees of success.

Figure (1) represents a simple production process. *A* single input *(x)* is used to produce a single output *(y).* The production frontier is *OF* showing the relationship between input and output, namely the maximum output attainable from each input level, regarding the state of technology.

The feasible production set is the set of all input- output combinations which are feasible. It consists of all points between production frontier OF and the x-axis. The production frontier is a graph of maximum feasible output producible given fixed resources. Hence a production frontier envelopes producer output from above. If what a producer actually produces is less than what it could feasibly produce than it will lie below the frontier. The distance by which a producer lies below its production frontier or above its cost frontier is a measure of the producer's inefficiency (Bera and Sharma, 1999). The further below the production frontier a producer lies,

the more inefficient it is. The points along the production frontier define the efficient sub-set of this feasible production set and they show the technically efficient combinations of input and output. On the other hand, the points beneath the production frontier show the non-technically efficient combinations, respectively. In this figure, e.g., point *(A)* is inefficient; points *(B)* and *(C)* are efficient points. The type of efficiency that can be measured using a production frontier is technical efficiency. The level of technical efficiency of a particular producer is characterized by the relationship between observed production and some ideal or potential production. The measurement of producer specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If a producer's actual production point lies on the frontier it is perfectly efficient. If it lies below the frontier then it is technically inefficient, with the ratio of the actual to potential production defining the level of efficiency of the individual producer (Herrero and Pascoe, 2002).

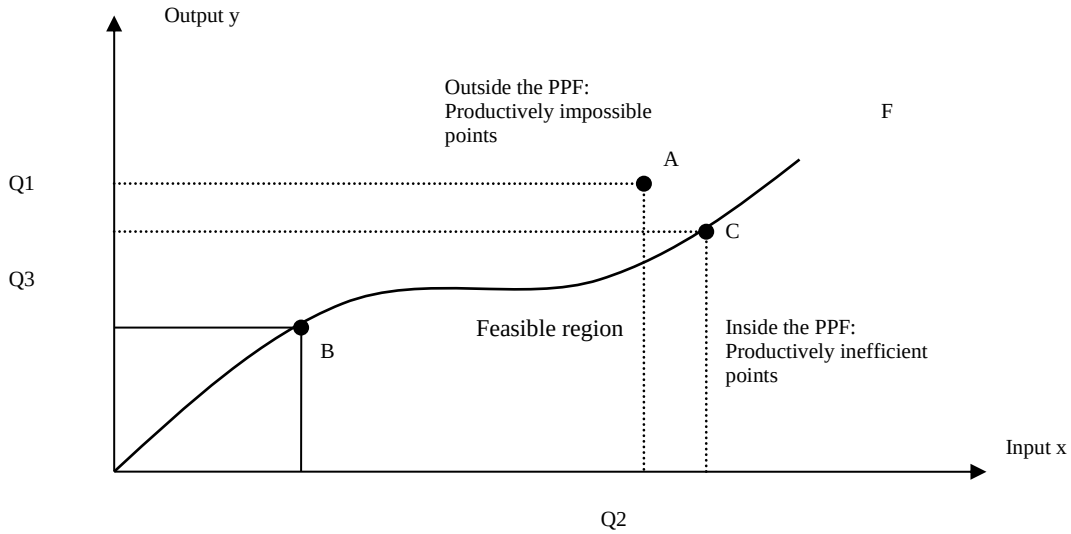

Figure 1. Production frontiers and Technical Efficiency

(Source: Own elaboration)

Technological progress is assumed to push the frontier of potential production upward, while efficiency change will change the capability of productive units to improve production with available inputs and technology.

The difference between actual output and the potential output is generally attributed to a combination of inefficiency and random error (i.e., the stochastic element in production). Methods have been developed to separate out the random component from the efficiency component, so that a more realistic assessment of potential output can be achieved. That is, large levels of output that may have occurred through chance rather than as a consequence of normal practice do not overly influence the estimates. When one considers productivity comparisons through time, an additional source of productivity change, called technical change is possible. This involves advances in technology that may be represented by an upward shift in the production frontier. This is presented in the following figure by the movement of the production frontier from $0F_0$ to $0F_1$ in period 1:

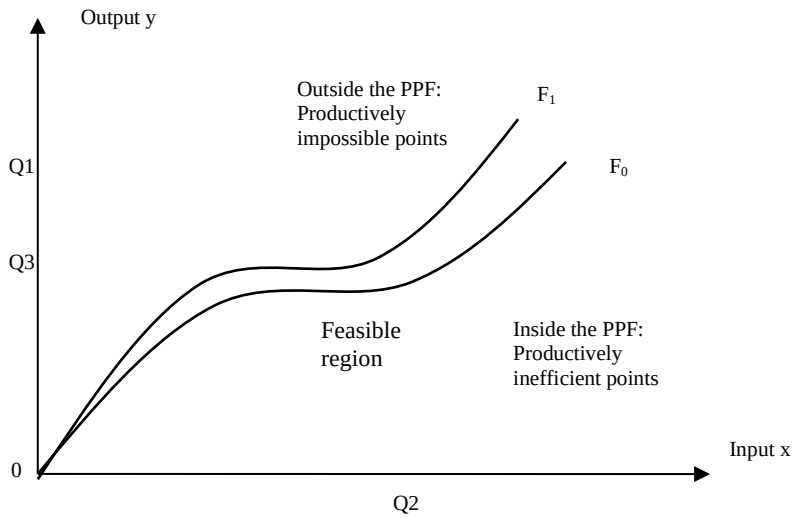

Figure 2. Production frontiers and Efficiency

(Source: Own elaboration)

In period 1, all firms can technically produce more output for each level of input, relative to what was possible in period 0. When we observe that a producer has increased productivity from one period to the next, the improvement need not have been from efficiency improvements alone but may have been due to technical change or the exploitation of scale economies, or from some combination of these three factors (Coelli et al., 2005).

Within this productive efficiency framework, lean production reflects the ability of an organization to use these inputs in optimal proportions, given their respective prices and the production technology. In other words, lean production is concerned with choosing between the different technically efficient combinations of inputs used to produce the maximum possible outputs. Since different combinations of inputs are being used, the choice is based on the relative costs of these different inputs (assuming outputs are held constant).

2. Lean Production

Lean production is a way of managerial strategy which focus on repetitive production systems eliminating all forms of waste in a production process with continuous improvement in technology, materials and inventory management, focusing on (Anttila, et al, 2021, Noto and Cosenz, 2021):

- Accelerating the adaptive process of the industry to the structural changes;
- Developing an environment in the favour of initiative and development of enterprises;
- Encouraging the favourable environment for business cooperation;
- Favouring the industrial potential of the research, technologic development and innovation policies.

Lean manufacturing refers to a business model and associated methods to eliminate non-value–added activities that waste resources for more efficient production and better product quality, resulting from Overproduction, inefficient production methods, long waiting times, unnecessary transportation costs, processing waste, and product defects.

Lean production adjusts product and process design, human capital and organizational elements, as well as manufacturing planning and control. The basic goal of lean production is to provide optimum response to the customer with the highest quality service and lowest possible cost, eliminating disruptions, simplifying production processes, employing flexible systems, reducing times, eliminating waste and reducing inventory levels, with high quality, flexibility and increased productivity **(**vom Brocke et al, 2014**)**.

Lean production acknowledges production process in the most efficient and effective manner, while looking for ways to continuously improving, decreasing cycle time, eliminating sources of waste in a process and, ultimately, increasing productivity.

Today, lean production addresses the need of enterprises to go beyond lean manufacturing to ensure the transformation of the enterprise into lean environment. The new lean methodological approach should focus on:

- Creation of think-tanks (idea pooling)
- Smart and Resilient production
- Green circular economy/ecological impact and recovery
- Block-chain technologies (methodology and applications)
- Interdisciplinary/Inclusive approaches
- Stakeholders: Clusters/Networks
- Ethical Governance (energy, production)

This is to response to the customers and market demands of value creation incorporating sustainability, culture and customisation. A significant change in enterprise performance can come from the adoption of lean thinking throughout the entire product life cycle. The aim is to develop a new model based on lean thinking that will consider entire product life cycle, providing a knowledge-based environment to support value creation to the customers in term of innovation and customisation, quality as well as sustainable and affordable products, providing a lean environment across product life cycle and supply chain, employing:

- Competitive and sustainable manufacturing - Continuous improvement
- Highly capable production systems - Leadership/project management
- Quality improvement - Production flexibility
- Quick adaptation to market needs

- Smooth flow of work - Simple systems that are easy to manage
- Elimination of waste - Little inventory storage
- Manufacturing cells - Cost accounting
- Eliminating anything that does not add value
- Use of product layouts to minimize moving materials and parts

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A shift in focus from waste reduction to value creation will enable manufacturers to quickly respond to market trends for an important boost in competitive position, developing a new model and its associate tools based on lean thinking that consider entire product life cycle, providing a knowledge based user-centric design and development environment to support value creation to the customers in term of innovation and customization, quality as well as sustainable and affordable products.

Lean thinking and applications always have been a continuous improvement effort. Lean product and development need a continuous tracking of production performances in the application of lean thinking, in new product design and development, maximizing customer value representation, ensuring the elimination of harm to its end user and to environment of operation, as well as assuring waste and resources are minimized during manufacturing (Khan, 2013, Khan and Al-Ashaab, 2013, 2021).

Within this framework, the first management challenge concerns the measurement of the readiness level of adoption of lean thinking principles in current industrial practice of product design and development processes by proposing a performance measurement approach that integrates human resources, technology factors and processes of an enterprise. To understand how product and process development is structured and what is needed to streamline the process to maximize value creation constitutes the second challenge, measuring values and estimate the cycle costs, including manufacturing and service components (Salhieh and Abdallah, 2019). A third challenge is to enable manufacturing companies to balance the need to react to value creation opportunities against the efficiencies to deliver them

effectively, this means with the quality demanded, under budget and on time. This is achieved, as any management decision taken based on proven knowledge and experience, to reduce risk and maximize utilization of resources. Lastly, the fourth challenge is to ensure the concurrent generation of lean product and process design as well as, the design of its associated lean manufacturing system that is highly responsive to the changing market requirements and production technologies (Seyyedamiri and Tajrobehkar, 2019).

3. Conclusion – Policy Implications

As it has been asserted above, globalization and worldwide competition has shifted the comparative advantage of corporations and economies towards the factor of efficiency, where entrepreneurship-based enhancement plays a rather important role, as far as the growth, productivity and competitiveness enhancement are concerned. Under this perspective, production policies should focus on creating favourable environment for the co-operation between firms and institutions that support the development and exploitation of knowledge and innovation. Furthermore, policies should promote the entrepreneurial relations between firms and institutions, fostering the development and dissemination of the expertise, the mobility of human and physical capital and the enhancement of the relationships between business and research entities. Specifically, they should encourage actions such as, promoting innovation, technology transfer and interactions between firms and higher education and research institutes, networking and industrial co-operation and support for research and technology supply infrastructure (Sundar, et al, 2014).

Within this framework, the issue of lean production as a mean to enhance productive efficiency is thought to be of particular research interest, explaining the course of productive efficiency and determining factors which might affect it, have been for a long time, and continue to be, one of the most important topics of economic literature (Uhrin, et al, 2017, Wickramasinghe and Wickramasinghe, 2017).

As lean production and productive efficiency enhancement becomes an increasingly important issue within research and business, policy planning should draw attention towards efficiency estimation and effectiveness attainment.

A framework more reliant upon productive efficiency and lean production has become an important policy objective to promote efficiency, effectiveness and competitiveness.

Industries should investigate and act towards identifying, developing and deploying their resources that may influence their technical efficiency, competitiveness and consequently their productivity performance, with better identification and understanding of the key resources, mainly increased knowledge about the impacts of different determining factors on efficiency.

Figure 3. Productive Efficiency Goals

(Source: Own elaboration)

Nowadays, the role of lean production and productive efficiency to the economy is even more important taking into consideration the slowdown in

the world economy, and the effects on the business environment created by the financial crisis. Thus, lean production and productive efficiency have a very important role in creating opportunities making an important contribution to economic growth and development. However, due to their nature, lean production and productive efficiency are characterized by being very heterogeneous since they differ in their endowments of resources, as well as on the risks involved in their productive activities. For this reason, it is of great importance, on the one hand to analyze their efficiency level and potential, in addition, to analyze the factors which determine their efficiency potential.

Knowledge and access to it has become the driving force of productivity, much more than natural resources or the ability to exploit abundant low-cost labor, have become the major determinants of economic competitiveness.

Education, therefore, holds the key to maintaining and strengthening efficiency which in turn inessential for achieving sustained economic development. Moreover, strong emphasis needs to be placed upon the management of the interfaces between human capital policy and other policy realms, such as competition policy, intellectual property rights, standardization, education and training, labor market, employment and social policy, in order to facilitate the creation of a sustainable supply chain management environment, along with fiscal instruments and incentives (Alexiadis, et al, 2011).

Finally, technical progress is another major determinant as new technologies allow the automation of production processes that have led to many new and improved products. allow for better and closer links between firms. and can help improve information flows and organization of production. At the same time, technical progress can be embodied in new equipment and trained workers can only be fully productive if they have the appropriate equipment with which to work. Increases in physical capital are clearly necessary as there are spillovers from capital investment to productivity growth. Thus, it is not appropriate to consider physical capital, human capital and technology as separate factors since their contributions are closely linked. It is the combination of these three factors and the way in which they are organized and managed within the industry that will determine the extent of productivity growth. For sustained output growth, it is also important that a balance between the three main factors be maintained (Korres, et al, 2011).

Moreover, efficiency and policy planning are a major matter which due to the wide interpretations and implications should have a clear mix of principles and priorities, mainly focusing on the effectiveness of the related policies. Infrastructure, innovation and investments should be among the main goals and converting to a new managerial system should include:

- Get top management commitment
- Obtain support of human capital
- Start by trying to reduce setup times
- Gradually convert operations – Reduce gaps
- Meet manufacturing requirements
- Change from traditional thinking and practices and create long term relationships with partners

Much will depend on the capacity of markets to facilitate the reallocation of resources to industries that show rapid productivity growth. However, it is difficult to predict which industries will be the most productive in the future, as technology and innovation trends are inherently difficult to forecast (Kokkinou, 2006 a,b).

This, however, needs to happen not just in central activities where productivity and employment are highest and innovative capacity most developed but throughout the production process, overcoming structural deficiencies and in developing their comparative advantages. This means, among others, that encouraging the development of knowledge-based economic activities and innovation and that particular attention needs to be given to:

- developing new innovation promotion policies which focus much more on the provision of collective business and technology services to groups of firms which can affect their innovative behaviour, rather than direct grants to individual firms which tend only to reduce costs temporarily.
- developing new policies to strengthen the capacity of enterprises to innovate through business networks and clusters and improving their links with the knowledge base, including with universities and research centres.

- encouraging the development of the indigenous Research&Development potential of weaker regions and industries and their capacity to adapt technological advances made elsewhere to local circumstances and needs.
- facilitating access of researchers, businesses and others in less favoured regions to international networks of excellence, sources of new technology and potential R&D partners.

These conditions are largely related to productive and technical efficiency and include, among others, the capacity of a regional economy to generate, diffuse and utilize knowledge and so maintain an effective production system.

As it has already been mentioned, innovation and technology are an important source of competitiveness through facilitating cooperation between the various parties involved in production process. In particular, they can improve collective processes of learning and the creation, transfer and diffusion of knowledge, which are critical for innovation. Such cooperation and the networks that are formed help to translate knowledge into efficiency opportunities. Such actions should extend to all the policy areas relevant for economic, scientific and social development and should ideally establish a long-term policy horizon.

Today, production faces constant changes, complexity, uncertainties, and resource constraints, which result to competing demands with major consequences. Responsive production will adapt to changes, be alert and flexible, empower innovators, value resourcefulness and encourage collaboration. The way out goes through the capacity to react in a timely and effective way to the evolving conditions. Understanding future challenges and issues is important on future developments in manufacturing. Industrial change driven by new technological opportunities will contribute to sustainable growth and improve efficiency.

4. References

Alexiadis, S., Kokkinou, A. and Ladias C. (2011) *Sustainable Growth and Adoption of Innovation*, International Conference on Integrated Information - IC-ININFO, 2011, Kos Island, Greece.

Anttila, T., Oinas, T., & Mustosmäki, A. (2021). Lean in Europe and the USA – A New Dominant Division of Labour? In T. Janoski & D. Lepadatu (Eds.), *The Cambridge International Handbook of Lean Production: Diverging Theories and New Industries around the World* (pp. 423-447). Cambridge: Cambridge University Press. doi:10.1017/9781108333870.018

Bera, A.K. and Sharma, S. C. (1999) Estimating Production Uncertainty in Stochastic Frontier Production Function Models, *Journal of Productivity Analysis*, 12: 187–210.

vom Brocke J., Schmiedel T., Recker J., Trkman P., Mertens W., Viaene S. (2014). Ten principles of good business process management, *Business Process Management Journal*, 20(4), 530–548.

Cagnetti, C., Gallo, T., Silvestri, C., Ruggieri, A. (2021) Lean production and Industry 4.0: Strategy/management or technique/implementation? A systematic literature review,Procedia Computer Science, Volume 180, Pages 404-413, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2021.01.256

Herrero, I. and Pascoe, S. (2002) Estimation of technical efficiency: a review of some of the stochastic frontier and DEA software. *CHEER Virtual Edition*, Volume 15, Issue 1.

Khan, M.S. (2013) A3 thinking approach to support knowledge-driven design, *The International Journal of Advanced Manufacturing Technology*, Vol. 68, Iss. 5, pp. 1371-1386.

Khan, M.S., Al-Ashaab, A. (2013) Towards lean product and process development, *International Journal of Computer Integrated Manufacturing*, 26:12, 1105-1116, DOI: 10.1080/0951192X.2011.608723

Khan, M.S., Al-Ashaab, A. (2021) Towards Lean Product and Process Development. *International Journal of Computer Integrated Manufacturing*, 2011, pp.1. 10.1080/0951192X.2011.608723. hal-00737936

Kokkinou A. (2006b) *Innovation and Productivity: A story of convergence and divergence process in E.U. countries*, 46th European Congress of the Regional Science Association, Volos, Greece, in: Korres, G.M., Tsobanoglou, G.O. and Kokkinou A. (2006) *Technological and*

Industrial Policies in Europe. Lessons for Asia in Measuring the Effects on Growth and Sustainability, Congress on Social, Political and Economic Transition of the Turkic Republics of Caucasus and Central Asia in the 21st Century, Kocaeli University, Turkey.

Kokkinou A. (2006a) *Productivity, Innovation and Regional Growth*, 10th International Conference of the Economic Society of Thessaloniki "The Challenges of a Wider European Union", Thessaloniki, Greece.

Koop, G., and M. Steel (2001) Bayesian Analysis of Stochastic Frontier Models," in *Companion to Theoretical Econometrics*, B. Baltagi, ed., Blackwell Publishers, Oxford, UK.

Korres, G. M., Tsobanoglou, G. O. and Kokkinou, A. (2011) Innovation Geography and Regional Growth in European Union, *SAGE Open* published online 17 June 2011, DOI: 10.1177/2158244011413142, the online version of this article can be found at: http://sgo.sagepub.com/content/early/2011/06/15/2158244011413142

Kumbhakar, S.C., Denny, M. and Fuss, M. (2000) Estimation and decomposition of productivity change when production is not efficient: a panel data approach, *Econometric Reviews*, vol. 19(4): 312-320.

Noto G., Cosenz F. (2021). Introducing a strategic perspective in lean thinking applications through system dynamics modelling: The dynamic value stream map. *Business Process Management Journal*, 27(1), 306–327.

Salhieh L., Abdallah A. A. (2019). A two-way causal chain between lean management practices and lean values. *International Journal of Productivity and Performance Management*, 68(5), 997–1016.

Seyyedamiri N., Tajrobehkar L. (2019). Social content marketing, social media and product development process effectiveness in high-tech companies. *International Journal of Emerging Markets*, 16, 75–91. https://doi.org/10.1108/IJOEM-06-2018-0323

Sundar, R., Balaji, A.N., Satheesh Kumar, R.M. (2014) A Review on Lean Manufacturing Implementation Techniques, *Procedia Engineering*, Volume 97, Pages 1875-1885, ISSN 1877-7058, https://doi.org/10.1016/j.proeng.2014.12.341.

Uhrin Á., Bruque-Cámara S., Moyano-Fuentes J. (2017). Lean production, workforce development and operational performance. *Management Decision*, 55(1), 103–118.

Wickramasinghe G. L. D., Wickramasinghe V. (2017). Implementation of lean production practices and manufacturing performance. *Journal of Manufacturing Technology Management*, 28(4), 531–550.