

FRI-2G.404-1-EM2-01

DEFINING AND MEASURING PRODUCTIVITY

Assoc. Prof. Aleksandar Kosuliev, PhD

Department of Economics and International Relations,
"Angel Kanchev" University of Ruse
E-mail: akosuliev@uni-ruse.bg

Viktor Merdzhanov, PhD Student

Department of Economics and International Relations,
"Angel Kanchev" University of Ruse
E-mail: vmerdzhanov@uni-ruse.bg

***Abstract:** Productivity is commonly defined as the ratio of output to input, but it is a multidimensional construct influenced by unit selection, analytical level, and market context. It is related to other concepts including technical efficiency, allocative efficiency, value added, and profitability. Key complexities arise from aggregation problems across heterogeneous inputs and outputs. Some of these are resolved with the use of monetary rather than physical measures, but this does not resolve all issues. Productivity manifests differently across operational, firm, sectoral, and national levels. Its measurement, while useful for benchmarking, cannot independently identify causal factors driving performance improvements.*

***Keywords:** productivity, efficiency, labour, capital, production, value added*

INTRODUCTION

Productivity is an important concept in Economics. Adam Smith saw it as the foundation of economic prosperity. Neoclassical economists built their theory of distribution on the marginal productivity of the factors of production. Knowing what productivity is and how to measure it is crucial for improving performance. This knowledge is a prerequisite for identifying the sources of productivity gains. If we don't know what they are, we can't optimize the production process systematically. Productivity also has motivational aspects that relate to the contribution of those involved and their corresponding rewards. Thus, it is of interest to academics, policy makers, and managers.

Productivity initially appears to be a straightforward construct, but a closer examination reveals its multidimensional nature. It is usually defined as the relation between output and input (Björkman, 1992; Tangen, 2002). The higher the ratio is, the more productive we are. We can become more productive if we increase the output, keeping the input constant. Alternatively, we can keep the output constant, while the input decreases.

There are layers of complexity behind this simple definition, related to the choice of units; the level of analysis; internal and external drivers of productivity; supply side and demand side factors; complementarity and substitutability of the inputs. For analytical purposes these can be examined separately, but in practice they are often interwoven and manifested together.

EXPOSITION

Productivity and Other Concepts

Defining productivity as the relation of output to input is very similar to the concept of *technical efficiency* (see Black et al., 2009). If inputs are given, what is the maximum we can get from them?

However, in many cases inputs are not just given. We may have at our disposal a set, from which we can select different inputs and combine them in various ways. It makes no sense to persevere in finding the optimal way to produce output Q from input F_1 , if we can get the same

quantity of output Q from input F_2 (or a combination F_1 and F_2) more easily. This begs the question what “easily” means? It could mean using less effort, time, money, or anything we consider important, grouped under the umbrella term “costs”. Different inputs are non-homogeneous by definition and non-homogeneous entities can’t be directly compared. We need a common denominator for the inputs when more than one type of input is or can be involved. Combining the inputs in a way that minimizes the costs of production gives us *cost efficiency*.

There is no reward in producing in a technically efficient or a cost-efficient way, if the output doesn’t cater to anyone’s needs. *Allocative efficiency* entails the choice of the most appropriate output. Goods can be quantitatively and qualitatively different, and the common numeraire in the absence of an objective way to measure utility would be to use money. If markets function competitively and without distortions, relative prices reflect marginal valuations. Thus, money serves as a practical proxy for welfare comparisons.

Once money is adopted as a unit of measure (for both inputs and outputs), we get two additional concepts that resemble productivity. These are value added (Coates, 1980) and profitability (Tangen, 2002). Both compare output (as monetary units) to input (as monetary units). But unlike productivity, this comparison is through subtraction, not ratio. Profitability is more limited, as it exists only at the level of the firm. Value added penetrates multiple levels - from within firm operations to the national economy. Value is added by all factors of production, whereas profitability counts only the contribution of capital or the entrepreneur. Other things being equal, when productivity goes up, so does value added.

Inputs, outputs, and units

In theory we could have single-input - single-output production; single-input - multiple-output production; multiple-input - single-output production, multiple-input - multiple-output production. And “what counts as input” or “what counts as output” is conceptually prior to the question of what units we use to measure either of them. In practice, the analysis gets complicated from the start because single-input - single-output production hardly exists. Depending on the analytical perspective, “input” can mean very different things. Except for maybe the provision of some idiosyncratic services, almost all productive activities require capital, even if only in its simplest form. The single-input assumption is short-run and conditional. It can be analytically useful as a modelling abstraction if we have no choice regarding the use or the availability of certain resources. Say that we want to build a stone wall and we have fixed endowment of stones and a fixed technique to stack them (e.g. like Lego blocks) at a certain location. We can treat stones as a constraint, not an input, as they are not a choice variable. Output will depend on the amount of labour applied and the skill and effort of the worker(s). Production will then be a single variable input activity, conditional on fixed inputs.

Even under these limited conditions the choice of units will be open to interpretation as the results of labour combine multiple elements such as time, effort, skill, and risk exposure, which may be interchangeable to one degree or another. Breaking down conceptually labour units to homogenous entities, we can choose to measure inputs as time spent working or as metabolic energy expended, but as they are inversely related, we will get ambivalent results regarding productivity. In terms of energy, we might do better if effort intensity is decreased, but this will increase hours worked and vice versa. Further complications arise from intertemporal trade-offs, as raising short-run productivity may lower future productivity due to fatigue or injury. Even in the simplest scenario of a single-input - single-output activity the use of physical units to measure productivity is questionable as in the example above we will have to decide on the importance of effort and time and to find a way to put valuation to them.

This takes us to the more complicated cases of either multiple inputs or multiple outputs, or both, where the problem of aggregation becomes clearer. Physical productivity becomes input-specific (output-specific in the case of joint production) as we may have labour productivity, capital productivity, energy productivity or materials productivity, and they will not necessarily

be aligned. Changes in the quantity used of one factor may affect some of the other indicators. For example, capital deepening can lead to the conclusion that labour productivity has increased. There is no one measure of "true" productivity, as all the factors matter. We have to weigh inputs and use value, but productivity then becomes monetary, not physical. Monetary productivity measurements have the advantage of solving the aggregation problem across heterogeneous inputs and outputs. These also allow for quality adjustments, which again requires prices, not physical quantities.

While the use of money solves one problem, it creates another. Once productivity goes beyond the physical, its conceptualization and measurement become dependent not only on technical efficiency, but also on supply and demand conditions, price elasticities, market structure and power, the temporal consistency of the numeraire, and other external to the production process factors.

When supply is elastic and demand is inelastic, physical and monetary productivity can diverge. Gains in technical efficiency will result in a supply curve shift downward and to the right, and equilibrium adjustment will be the result of price reductions, rather than quantity expansion. Despite higher physical productivity, value added per unit will fall, given the new market valuation. This is not problematic per se, as we have established above that allocative efficiency should be considered, too. But given this divergence, we should have clear criteria for what matters more in the context – physical or monetary productivity.

Changes in demand and supply that alter the valuation of outputs or inputs can be short-lived in nature and may not warrant reallocation of resources or changes in the mode of production. Nor should the observed change in productivity be attributed to changes in technical efficiency. Demand constraints and capacity utilization are important considerations here. When demand declines, companies with a lot of fixed capital and skilled employees often hesitate to adjust capital or labour in response to what they anticipate will be a temporary disruption. As a result, measured productivity will decline even if technical efficiency remains unchanged. Variable capital utilization and labour effort are a possible explanation for the procyclical character of productivity. Changes in the latter may reflect demand fluctuations, not efficiency (Burnside et al., 1993; Basu & Fernald, 2001).

Demand side considerations and capacity utilization deserve special attention in the case of service sector productivity. Services are immaterial, they can't be stored, and their provision involves the interaction of both the producer and the consumer in getting the desired result. They are consumed during or immediately after production, and are not an entity, but a change of condition or state (Gadrey, 2000). Clients are both input and output. They are simultaneously the object of transformation (e.g. being advised, educated, entertained) and provide time, information and effort to make the change happen. Standard productivity logic does not apply in full, because inputs and outputs are no longer separable and productivity can't be defined independently of demand. The labour intensity of services and the impossibility to store them makes service productivity very sensitive to constraints on the demand side and to utilization rates on the supply side, complicating its measurement and interpretation. Productivity gains are frequently assessed in terms of quality enhancements rather than by the volume of work completed (Rutkauskas & Paulavičienė, 2005).

Monetary and physical productivity can be misaligned and will diverge for a number of reasons. This will happen when competition is imperfect, and firms exercise market power. Monopolies on the final goods market can charge prices above the marginal revenue, the markup (the ratio of price to marginal cost) being a measure of their market power. Monopsonies can pay below the marginal product for inputs (markdowns), which also contributes to higher monetary productivity (Syverson, 2011).

Temporal and spatial factors also influence how inputs and outputs are valued. Because production and market exchange occur over time, inflation can create discrepancies. When inputs

are purchased earlier at lower prices, monetary productivity may rise even if physical output per unit of input remains constant. Geographic location similarly affects productivity measurement through the broader productivity environment. A unit of production may maintain identical physical productivity while experiencing changes in monetary value simply by relocating to a different city or state, where market conditions and relative valuations differ (Kosuliev, 2019). The latter also shows why, when discussing productivity, the level of analysis is important.

Levels of analysis

The transformation of inputs into outputs can be examined from different points of view:

the operational level of tasks and processes;

the level of the individual firm;

the sectoral or industry level;

the aggregate level of the national economy.

At each level, productivity will have a specific meaning and measurement approach. What is more, the different levels are not merely nested in each other and the changes on one level are not necessarily transposed to other levels in the same way or direction.

On the operational level we are mostly concerned with technical efficiency as we transform inputs to outputs in the most basic form possible. The task is given and it needs to be optimized using better technology or organization of the production process (e.g. by overcoming production bottlenecks or the introduction of automation). On this level, productivity can be measured in physical units and (other things being equal) improvements here will usually lead to improvements on other levels. However, there are exceptions, as operational productivity does not guarantee that the product will sell. Optimal capacity utilization from the operational perspective may lead to inventory hoarding.

On the level of the individual firm the operational processes are integrated with view of getting better results, which are not limited to the physical dimension but receive market valuation. Technical efficiency, cost efficiency, and allocative efficiency interact in a way that requires monetary units for the expression and measurement of productivity. The latter can be improved not only by task optimization, but also by task creation, task outsourcing, the introduction of new roles in production, changing the scale of operations, or changing the output mix altogether. The time dimension is important, as resource intensive activities may fail to show results in the short term (e.g. research and development or business restructuring) and initially may seem like a drag on the firm. The contradictions with other levels can be observed in the case of negative externalities (where the firm decreases costs at the expense of losses of productivity for third parties). A firm can also increase its market share through superior marketing, even if it is technically less efficient than its competitors in the conduct of their operations, which would lead to fall in allocative efficiency on the sectoral level.

The sectoral level analyses the productivity of all firms in an industry. Streamlining or optimizing processes within firms can improve productivity in the sector, as well as spillover effects and agglomeration externalities. But productivity is also a dynamic result of the movement of resources between firms. To a large extent productivity in the sector increases not because each and every firm is doing better, but because inefficient firms go out of business. There is a redistribution of market share from low productive to high productive firms, which raises aggregate sector productivity.

The importance of allocative efficiency grows as we get to the level of the national economy. A significant part of productivity gains can be explained by the reallocation of resources (Baqae & Farhi, 2020). Aggregate productivity will improve if the economy moves labour and capital from low value-added activities to activities with higher value added, even if there is no productivity growth within sectors (McMillan et al., 2014). But this structural transformation also has the potential to increase productivity within sectors due to input and

output linkages and cross-sectoral spillovers (e.g. IT innovations introduced in banking services). And due to the Baumol effect we can register higher monetary productivity in some sectors, even if physical productivity there has not changed (Baumol & Bowen, 1965). In addition, aggregate productivity involves the management of positive and negative externalities, apart from improving technical and allocative efficiency.

CONCLUSION

Productivity appears to be a simple concept, for which a deeper examination reveals not only a complex and layered nature, but also essential contradictions. They can be resolved only in a contextual framework, not at the ontological level. Productivity is not intrinsic. It depends on the result and the goal of the activity, what is considered an input, which inputs are fixed and which are allowed to vary. In a market economy at the level of the firm and above, productivity reflects both efficiency and market valuation.

Essentialist ambiguities aside, the concept is operationalized in a pragmatic benchmarking instrument, used to measure change over time or to make comparisons across productive entities. However, when this instrument is given too much credit and the results are uncritically accepted, this can compromise both practical decision-making and scholarly conclusions. The fact that the transformation to a practical toolkit obfuscates unresolved conceptual issues should not be neglected.

While the measurement of productivity is an important step towards decisions that lead to performance improvements, it is only important as long as we measure the proper inputs, the proper outputs, and the right processes. Even then, productivity measurement is just an element of accounting and aggregation. It doesn't provide explanations. Identifying the sources of productivity is primarily a managerial and organizational problem, not something that productivity statistics can do on their own. They don't tell us which activities matter most, where are the bottlenecks, who contributes what, and what should be changed to get better results. At best, they give a summary of performance but don't identify causal relationships. The latter is as much an art, as a science.

ACKNOWLEDGMENTS

This research was conducted within the framework of project 2025-BM-01 "Transformation of Socio-Economic Systems through Integration and Digitalization", supported by the Scientific Research Fund of the University of Ruse "Angel Kanchev".

REFERENCES

- Baqae, D. R. & Farhi, E. (2020). Productivity and misallocation in general equilibrium. *National Bureau of Economic Research Working Paper No. 24007*. <https://doi.org/10.3386/w24007>
- Baumol, W. J., & Bowen, W. G. (1965). On the Performing Arts: The Anatomy of Their Economic Problems. *The American Economic Review*, 55(1/2), 495–502. <http://www.jstor.org/stable/1816292>
- Basu, S., & Fernald, J. G. (2001). Why is productivity procyclical? Why do we care? In C. R. Hulten, E. R. Dean, & M. J. Harper (Eds.), *New developments in productivity analysis* (pp. 225–296). University of Chicago Press.
- Björkman, M. (1992). What is Productivity?. *IFAC Proceedings Volumes*, 25(8), 203-210.
- Black, J., Hashimzade, N., & Myles, G. (Eds.). (2009). *Technical efficiency*. In *A Dictionary of Economics (3rd ed.)*. Oxford University Press. <https://doi.org/10.1093/acref/9780199237043.001.0001>

- Burnside, C., Eichenbaum, M., & Rebelo, S. (1993). Labor hoarding and the business cycle. *Journal of Political Economy*, 101(2), 245-273.
- Coates, J. B. (1980). Productivity: What is it?. *Long Range Planning*, 13(4), 90-97.
- Gadrey, J. (2000). The characterization of goods and services: An alternative approach. *Review of Income and Wealth*, 46(3), 369–387. <https://doi.org/10.1111/j.1475-4991.2000.tb00848.x>
- Kosuliev, A. (2019). Are employees paid their marginal product? Analysis of wage setting practices from Bulgaria. *58th Annual scientific conference of University of Ruse and Union of Scientists, Bulgaria*. Reports Awarded with "Best Paper" Crystal Prize'19, pp. 66-71. <https://conf.uni-ruse.bg/bg/docs/cp19/bp/bp-8.pdf>
- McMillan, M., Rodrik, D., & Verduzco-Gallo, Í. (2014). Globalization, Structural Change, and Productivity Growth, with an Update on Africa. *World Development*, 63, 11–32. <https://doi.org/10.1016/j.worlddev.2013.10.012>
- Rutkauskas, J., & Paulavičienė, E. (2005). Concept of productivity in service sector. *Engineering Economics*, 43(3), 35-41.
- Syverson, C. (2011). What determines productivity?. *Journal of Economic literature*, 49(2), 326-365.
- Syverson, C. (2025). Markups and Markdowns. *Annual Review of Economics*, 17(1), 57–76. <https://doi.org/10.1146/annurev-economics-081624-080143>
- Tangen, S. (2002). Understanding the concept of productivity. In *Proceedings of the 7th Asia-Pacific Industrial Engineering and Management Systems Conference*, Taipei (pp. 18-20).
- Van den Bosch, J., & Vanormelingen, S. (2023). Productivity growth over the business cycle: cleansing effects of recessions. *Small Business Economics*, 60(2), 639-657.