

**LABOUR AND INDUSTRIAL PRODUCTIVITY IN IMPROVING
ECONOMICAL DEVELOPMENT**

R. Usubamatov, S. Hussain, H. Yee Nean, F. Hamid Mohd and I. Abdul Rahman

School of Manufacturing Eng., PPK Pembuatan, No 16, 18,
Jalan 1, Taman SBRG, Jaya, Fasa 3, University Malaysia Perlis, 02000, Kuala Perlis,
Malaysia

Phone: 604 9852721

ryspek@unimap.edu.my; suhaila@unimap.edu.my; ynheap@unimap.edu.my;

faizalhamid@unimap.edu.my; irfanrahim@unimap.edu.my

ABSTRACT

The growth of economy of country or efficiency of production system depends generally on its level of science, technology and strategic management. For the growth of a country production force that includes production facilities and work force must be developed. Production facilities play a great role in the growth of an economy and society development. To evaluate the right direction of economic development it is necessary to apply complex economic index like labour productivity. Science has created the theory of productivity for labour and facilities. This theory can be used for strategic management to analyse a country or production system regular progress and development of production facilities. The increase of labour productivity depends on increase productivity of facilities and decrease in

quantity of work force. The labour productivity of a system can be expressed as the ratio of quantity of products to quantity of labour expenditure in producing products on yearly basis.

A labour productivity is not a stable magnitude, but varies with time. It grows in the beginning of economical work unit but will reach its limit. Hence, any economical unit provides growth of labour productivity and in future must be replaced by more perfect economical units. The main component of the labour productivity is productivity of industrial machines that used in engineering and technology. Some existing analytical approaches that utilize productivity rate data of industrial machines do not reflect reliable parameters. The productivity of some machines cannot be readily determined. This paper presents a new analytical approach for calculating a productivity rate of some complex design production lines and optimization of its structure by criterion of a maximal productivity rate. The novelty of scientific results is the new mathematical dependency of a productivity rate and optimization of a structure for the complex design industrial machines. The relevant formulas on labour and machine productivity are derived and these formulas can be used to study ways to increase labour productivity.

INTRODUCTION

The growth of economy of any modern country depends generally on its level of science and technology. Pure science without technology does not have influence on the economy of a country. The role of science is to provide directions and methods for development of technology and its practical application. For the growth of economy,

the level of a country production force that includes production facilities and work force must be developed. In such case, it is necessary to have some dependencies in macro, and microeconomics, and tight relationships between them. This approach enables to solve many economical and technical problems and it influence on some initial data of production facilities in macroeconomics results. This is a powerful tool to predict economical development of country and to plan its strategy.

Production facilities play a great role in the growth of country economy and society development. Over the last century there has been a great leap in economy worldwide due to improved production facilities. There is no need to go far in history to understand the development of a country production force. Stages in the development of production facilities and work force can easily be traced by the following criteria or indexes: productivity, reliability, cost, flexibility, quantity and quality of work forces.

All of these indexes are related to the economy of a country. Development of production facilities are concerned with the improvement of one of these indexes like productivity, which decreased the quantity of work forces and worsened other indexes like universality, mobility and price.

To evaluate the right direction of economic development it is necessary to apply complex economic index like labour productivity of a country. For this, science has created the theory of productivity for labour and facilities. The theory can be used to analyse a country regular progress and development of production facilities. The increase of labour productivity of a country creates new production facilities; likewise a decrease in quantity of work force generally decreases the quantity of labour. The

labour productivity of a country can be expressed as the ratio of quantity of common products to quantity of labour expenditure in producing products on yearly basis. Basic theory of index of labour productivity is the growth of labour productivity of a country and it is determined by comparing two variants of economical systems or a country economical unit scale but not absolute size of productivity of labour. Usually, it is used to calculate economical indexes of the same industry.

Production forces of a country are represented by the unit of production facilities and work force that revealed during work processing. Production facilities are divided into two parts, which are work production facilities and work objects. Work production facilities are represented as fixed materialised labour and work objects are represented as current materialised labour that increased on continuous basis proportionally with time and quantity of manufacturing products. A country labour productivity is not a stable magnitude but varies with time. It grows in the beginning of economical work unit but reaches its limit. Hence, any economical unit provides growth of labour productivity and with time must be replaced by more accurate economical units.

Related formula of labour productivity

The theory of labour productivity made it possible to calculate and predict the period of decreasing in productivity, and to show how a better economical unit could support economical growth continuously. With the growth of a country economy, it is possible to reduce social and security problems due to jobs being created and the raise in living standards.

The theory of labour productivity aimed to analyze the natural laws of facility progress and initially natural laws of economic system development. This theory allows us to analyze the factors that influence the labour productivity and efficiency of economic system.

Analysis and evaluation of economic system are impossible without the common criteria of labour productivity. The increasing of labour productivity consisted of the creation of new production facilities (fixed capital), decrease in work force (variable capital), but common quantity of labour is decreasing for production of some init work. Hence, the decreasing of variable capital must be more than increasing of fixed capital for production of one unit of work. It is a base of economical progress and any economical system.

Economic experts give the expression for labour productivity as ratio of results of quantity of products output W to labour expenses T that provided economical system [1, 2]:

$$A = \frac{W}{T} = \frac{Q * N}{T} \quad (1)$$

where $W = Q * N$ products developed according to service years, T - common expenses of labour for developing products, Q - products developed per year, N - system service years, A - (products) / (man-hour) or (products) / \$, or \$ / \$

Because of the fixed capital is realized gradually during years of its service, and then labour productivity must be defined according to the years of its service. Hence, it is easy to come up with average expenditures per year that is commonly being used in practice.

$$T = T_F + N(T_V + T_S)$$

where T_F - fixed capital, T_V - variable or service capital, T_S - salaries and wages of work force

$$A = \frac{QN}{T_F + N(T_V + T_S)} = \frac{Q}{(T_F / N) + T_V + T_S}$$

(2)

It is shown that labour productivity is a variable value and it depends on N years of the system in service and has the following limit:

$$\lim_{N \rightarrow \infty} A = \frac{Q}{T_V + T_S}$$

Figure 1 shows the changes of A , T and Q for work term of economic system and the figure gives the following conclusions:

- Any system provides high rates of growth of labour productivity during work term

$$N_2 > N > N_1$$
- If a work term has $N = 0 - N_1$, then the labour productivity can be less than the present system.
- The labour productivity becomes slower when the work term $N > N_2$. The planned growth in labour productivity rendered higher than what this system provides.
- Any system has utilized old principle must be changed by a new, a more productive and a perfect one.

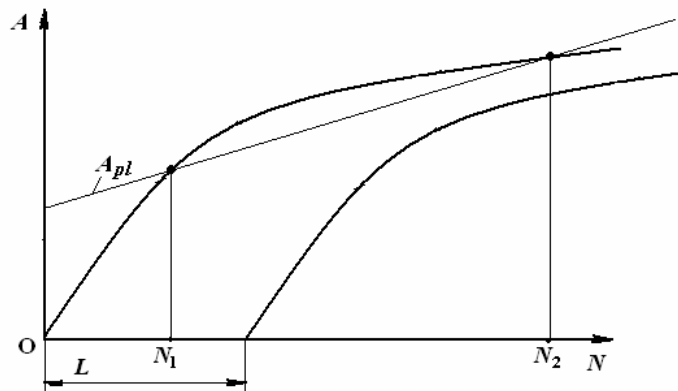


Figure 1: Grow of labour productivity

The components of the labour productivity formula have different influence on the output result.

The study of labour productivity in manufacturing systems shows next result.

1. Increase of machine productivity Q gives 60-70% of labour productivity and economical efficiency of industrial system
2. Decrease the fixed capital T_F and decrease the service capital T_V give 15-20% of labour productivity and economical efficiency as quality of products
3. Decrease the number of employees T_s gives 10-15% of labour productivity and economical efficiency of industrial system
4. Delay of launching industrial system can lead to its ineffectiveness.

Generally, the higher level of facility provided for system will have lesser quantity of work force in economic system yet higher labour productivity. This is historical tendency of industrial development and growth of economics.

The theory of labor productivity enables the designer to analyze different variants of systems, to determine more profitable and perspective benefits from them based on common calculation of all facility data with maximum labor productivity.

As pointed above, the industrial or machine productivity gives most valuable effect and influence for grow of labor productivity. According to these results, manufacturers developed some principles of increase of industrial and labor productivity.

Basic principles to increase industrial or machine productivity

- I. Basic factors of an increase of labor productivity are an increase of machine productivity, quality of output and decrease of all time and financial expenditures.

- II. Tasks of the theory of a labor and a machine productivity are next:
- An analysis of all factors (technology, structure, design, reliability, exploitation), which determine a machine productivity;
 - Development of trends of an increase of a labor and a machine productivity and creation of new perfect machines.
- III The theory of a labor and machine productivity is universal and can be applied to any type of industries (manufacturing, food processing, transport, textile, agriculture etc)

The theory of labor and machine productivity guided by next postulates:

1. Each work requires expenditures of time and labor.
2. Time is considered spent out productively, if it is expended on the basic working processes (forming, machining, controlling, assembling, etc.). All other time is considered as nonproductive time losses (auxiliary, idle times etc).
3. Machine is ideal, if it has high productivity, quality of output and there are no time losses (continuous action machine and perfect reliability).
4. For production of any parts are necessary expenditures of production means, maintenance, and labor force for servicing of them.
5. The development of technology is based on the fact that the specific weight of production means continuously rise, and the expenditures of labor force is lowered with the total decrease of the labor cost, which fall for unit of output.
6. Technological processes should be decomposed into component elements, irrespectively of a labor force.

7. New technology is progressive if labor productivity rises.
8. Automatic machines and automated production lines of any technological processes have united basis of automation, which is expressed in generality of functional mechanisms and control systems, in general laws governing the productivity, reliability, economic effectiveness, in united methods of aggregation, determination of working regimes, evaluating of progressiveness, etc.

Researchers and engineers of complex manufacturing facilities developed many models of production systems, industrial machines for different technological processes and systems of their service, etc. [1-6]. The demand of increasing of labour productivity leads to creation of industrial machines of high output, which based on progressive technology processes. Most high productive industrial machines have complex structure and system service. Experts developed many mathematical methods of calculation and optimise on technical and technological parameters of industrial machines using economical criterion. All these methods used to calculate the productivity rate of industrial machines as main index of microeconomics.

However, many engineering problems in area of calculation of productivity industrial machines are not solved and trustworthy mathematical dependencies are needed due to many restrictions due to real economical environment. For example, it is possible to design highly productive industrial machine, which can produce high quality products, but its price will be very high and hence producing high price of output products. Engineers are required to design industrial machines with consideration of many technical, technological, and economical restrictions. However, designers should have equations to calculate the productivity of new industrial machines. These equations must include all technical and technological parameters that influence on results of calculations. It means that equations should include parameters of

machining regimes, reliability, service system and maintenance, structural and constructional parameters.

Science produced many types of the productivity rate equations of industrial machines. These equations are different in technological processes, types and designs of industrial machines. All of them also include technical and technological restrictions that limit the productivity rate of industrial machines. It is interesting to show the equation of the productivity rate of the complex industrial machine for a section based automated line of serial-parallel structure with limited capacity of buffers to show the complexity of calculation its output. Segmentation of technological process has restriction due to restriction of quality products and productivity rate change. Machining regimes has restriction due to increasing of cutter wears and duration of tool maintaining. Combining of serial and parallel machines into one also will have restriction due to decreasing reliability of automated line that leads to decrease of its productivity rate. In real production condition, the capacity of a buffer system is limited by many factors such as its cost, space and some technical parameters. Real buffer system can compensate only some part of the productivity losses of automated line and each section will have not only its own productivity losses but also uncompensated productivity losses due to the limited capacity of the buffer system located between parallel–serial sections.

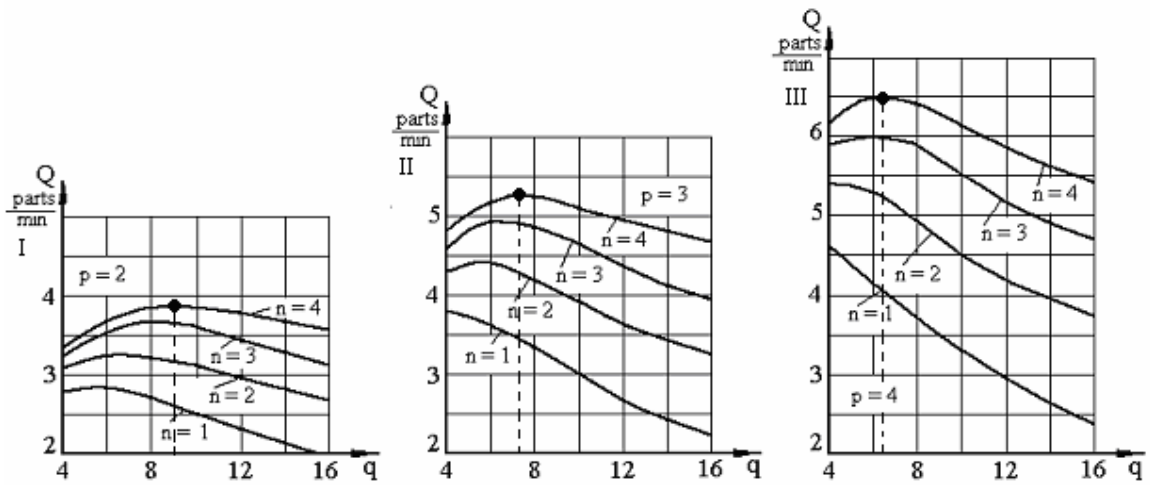
The productivity of a section-based automated production line with limited capacity of buffers has expression below:

$$Q = \frac{p}{\frac{t_m}{q} + t_a + \frac{pq \sum t_e}{n} \left[1 + \frac{2\Delta(1 - \Delta^{n-1})}{1 - \Delta} \right]} \quad (3)$$

where Q is the productivity of automated production line (part/min); t_m is the machining time (min/part); t_a is the auxiliary time (min/part); t_e is the index of productivity loss of single machine tool located in line due to idle time (min/part); q is the quantity of serial machine tools in an automated line; p is quantity of parallel lines; n is the number of parallel–serial sections in a line; Δ is average coefficient of intersectional imposition of productivity losses due to limited capacity of buffers.

Equation (3) has variables t_m , q , p , and n that results on the reliability parameter Σt_e and on the productivity rate Q . In any case, this equation gives some maximum of productivity rate for a section-based automated production line with limited capacity of buffers. This maximum productivity rate is changeable due to change of value of mentioned variables. Fig 2 shows typical diagram of change the productivity rate versus change of some parameters when $\Delta = 0.1$ is the average coefficient of the intersectional imposition of time losses, $t_m = 1$ min/part is the machining time, $t_a = 0.3$ min/part is the auxiliary time, $\sum_1^k t_{ei} = 0.02$ min/part is the productivity losses due to the reliability of stations of an automated production line.

Generally, all types of industrial machines have limited maximum production rate, however all limitations and restrictions due to different reasons should be studied and to be removed. It is possible to do with development of engineering science. In such case, theoretically productivity rate of industrial machines will not have some limit.



C

Figure 2: Productivity increase of the automated line of a parallel-serial structure with n sections and p parallel constructions versus the number of serial stations q .

As mentioned above, the productivity rate Q of industrial machines is most valuable component of equation of labour productivity (2). Substituting of productivity rate equation Q for industrial machines (3) to equation of labour productivity (2) gives solution for calculate the value of labour productivity. The results of such calculation enables to predict grow of labour productivity and predict future change of macroeconomic parameters of economical system. It means that it is possible to begin solve technical and economical at early stages and avoid any types of possible drop of labour productivity.

CONCLUSIONS

Information on labour productivity presented enables the designer to solve strategic economic problem. The formula of labour productivity (2) enables engineers to calculate the production rate to increase labour productivity and to consider each component of economic issue and its influence in general. The equation (3) enables calculation of the productivity of section-based automated lines of a parallel-serial

structure and enables calculation of the optimal number of stations in a section-based automated line by criterion of the maximum productivity rate as well.

Both above formulas give clear answer on the directions of labour productivity enhancement i.e. by increasing the facility productivity system, decreasing the fixed capital, decreasing the expenditures for variable capital, decreasing the quantity of work force and decreasing the terms in bringing a new economical system facilities. The exact initial economic indexes can be predicted by mathematical approaches and to change the terms of any economical and production systems or products in used.

Summary

It is known that labour productivity and productivity of any complex industrial machine depends on a technological process, reliability of units of machine and structure of the machine. Analytical investigations of influence of technological and technical parameters and their results are still not perfect and cannot give reliable dependencies for calculation of labour productivity economical system. The contributions of this paper is in developing of the new approach for calculating of labour productivity and establish relationship between the technical data for the machinery with complex structure and its productivity rate that not solved in economics. This paper developed analytical equations for calculating the labour productivity rate, which includes the equation of productivity rate of complex machinery. Equations include parameters of technological processes, reliability and structure of machinery, and micro economical data of economical system. The equations will be useful in modelling the output of labour productivity and enable calculation of economical and optimal parameters of structure of machinery. Economists, engineers and designers of complex machinery who have industrial

experience can use this developed analytical results in economical system design of the project stage.

Biodata: Dr. R. Usubamatov, Professor in the School of Manufacturing Engineering of University Malaysia Perlis, obtained Professional Engineer Diploma in Mechanical and Manufacturing Engineering from Moscow State Technical University named after Bauman (MSTU), Russia and PhD in Automation of Manufacturing Processes from same MSTU and Doctor of Technical Sciences. He worked in teaching and research positions in a number of universities in Russia, Kyrgyzstan, Kazakhstan, and Malaysia.

REFERENCES

- [1]. Michael Artis and Frederick Nixson, Economics of the European Union, 4th.
Oxford
University Press, Ed. 17 May , 2007, 464 p.
- [2]. Joseph Stiglitz, Jos Antonio Ocampo, Shari Spiegel, Ricardo Ffrench-Davis,
Deepak
Nayyar, Stability with Growth *Macroeconomics, Liberalization and
Development*, Oxford
University Press, Ed. 31 August 2006, 352 p.
- [3]. L.Volchkevich. *Automation of production processes*. "Mashinostroenie ",
Moscow, 2005.

- [4]. Kalpakjian, S. , Schmid, S.R., *Manufacturing Engineering and Technology*,
Prentice Hall
International, 2007.
- [5] Stanley B. Gershwin, “Design and Operation of Manufacturing Systems. The
Control-Point
Policy”, *IIE Transactions*, Volume 32, Number 2, pp. 891-906, October, 2000.
- [6] R. Usubamatov, N. Ismail, and M. Megat, “Productivity of automated lines
divided on
sections”. “*Tehnika mashinostroenia*” #5 (51), pp. 31-34, Moscow, Russia,
2004.
- [7] Glyn Games, ‘*Modern Engineering Mathematics*’. Prentice Hall, 2001.
- [8] Daniel T. Koenig, *Manufacturing Engineering: Principles for Optimization*, 3rd
ed. ASME,
2007-01-30.