Chapter 2
Discrete Science and Knowledge Form

Abstract This chapter introduces two knowledge forms, namely Matsui's form and Chameleon's criteria in the discrete world, and lays the basis for the physics and economics of management. The former is Matsui's (1977) equation ($W = ZL$) and its circumference in the cyclic view. This form includes the generalized EOQ formula in 1913, Little's formula in 1961, and Ohm's law in physics. The latter is Muda's form, which represents new criteria for the economic efficiency vs. 'muda' (loss) problem and control in the limited-cycle view. These relative criteria control are applicable to the standard vs. allowance time in time study as well as to inventory control, marginal profit and financial problems in enterprises.

2.1 Matsui's Form of the Discrete World

2.1.1 Introduction

The real world has many 3M&I systems (human, materials/machine, money, and information), which are in any one of three states at a certain time: moving, stationary, or a mixed process in the 3M&I-Time system. In the traffic world, these are referred to as busy, idle, and progressive states, respectively.

We first explore telephone traffic [4], and then develop the problem and analysis of queueing theory. However, the study of 3M&I-Time system has a wide area of applications beyond queueing theory, which are used in relation to physics, management, and economics [7, 17]. (see Appendix A in [17], too)

Matsui started this step as a linear relationship of delay and overflow [16, 22], and recently developed it into the $W = ZL$ form [19], namely an intelligence (nature) on cyclic views in a discrete world. This also represents an extension of Little's formula [13] and Matsui's equation (Appendix A) [16, 17] to the notion of lot size (EOQ) [5].

On the 50th anniversary of his 1961 formula, Little [14] expressed certain controversial views about the formula. Matsui's system of equations [19] and

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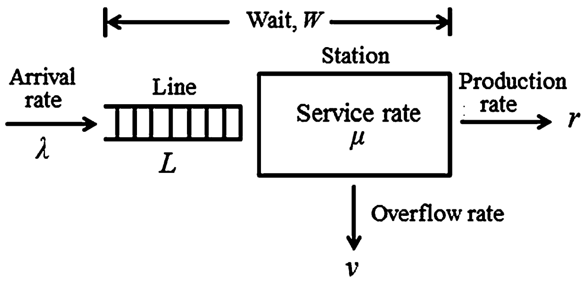


Fig. 2.1 A general queueing system

Takagi's views [26] on the formula have also appeared recently. It is noted here that Little's formula may have originated from the EOQ formula, used since 1913.

This chapter discusses Matsui's version of the $W = ZL$ formula beyond traditional queueing theory settings, drawing on the knowledge resources of physics, management, and economics. Then, the cycle value, Z, can be expressed as not only the mean time but also the mean value or amount per unit cycle.

2.1.2 *The Queueing System*

2.1.2.1 The General Queueing System

Traditionally, the queueing system consists of a service station, the inflow (arrival), and the outflow (departure). This general queueing system includes an overflow, which is just another outflow, and is an extended type of the traditional queueing system, as shown in Fig. 2.1.

In the steady state, network flow is represented by three variables: the arrival rate λ, the production rate r, and the overflow rate v. That is, the following input–output relationship (balancing) holds:

$$\lambda = r + v \tag{2.1}$$

The service rate, μ, is traditionally assumed to be stable, $\mu > \lambda$, but this constraint is omitted here.

In the general queueing system, the number of customers (amount in the time-space system), L, and waiting time (time in the time-space system), W, are related and are given by Little's formula [6] as follows:

$$rW = L, \qquad r < \mu, \tag{2.2}$$

where $r = \lambda - v$. This relationship is seen on a busy cycle $(0, \gamma)$ in Fig. 2.2.

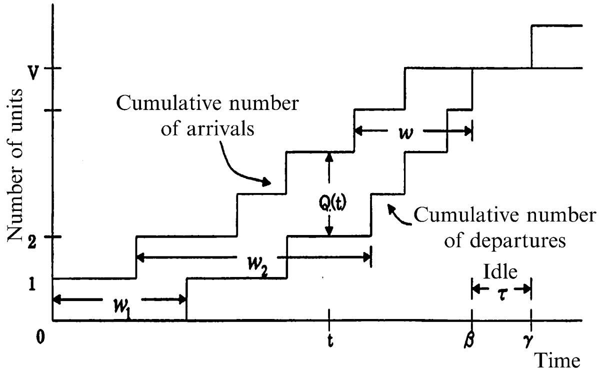


Fig. 2.2 An example of a busy cycle and $\lambda_0 W = L$

2.1.2.2 Queueing Formula for Overflow

The overflow problem of the system was systematically treated in a 1979 study of a conveyor-serviced production station (CSPS) [16]. In 1976–1977, Matsui [16, 22] demonstrated a linear relationship between delay time (time in the time-space system), D, and the number of overflows (amount in the time-space system), η, per unit produced (production cycle). That is,

$$\lambda D = 1 - \rho + \eta, \qquad \lambda > 0 \tag{2.3}$$

where $\rho(=\lambda/\mu)$ is the traffic intensity.

This relation is also seen in the counter model [10], which is called Muda's formula herein. Figure 2.3 shows a numerical example of the CSPS model [16, 22] for Poisson arrival ($\lambda = 1$), Erlang service, and the operating policy SRP(c).

Equation (2.3) is equivalent to the following input–output relationship:

$$\lambda Z = M = 1 + \eta, \qquad \lambda > 0, \tag{2.4}$$

where cycle time, Z, is $Z = X(1/\mu) + D$, and M is the output per production cycle.

2.1.3 *Matsui's Form: W = ZL*

2.1.3.1 Matsui's Equation and Form

Now, let us replace the arrival rate λ with cycle time Z. Then, Matsui's equation [15, 16, 21] is originated in 1977 and given as follows:

$$W = ZL, \qquad \lambda > 0, \tag{2.5}$$

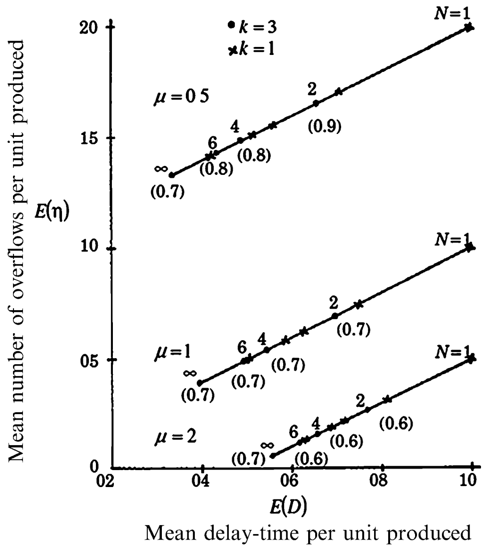


Fig. 2.3 Linear relationship between $E(D)$ and $E(\eta)$: $\lambda = 1$, Erlangian phase, $k = 1, 3$, (time ranges)

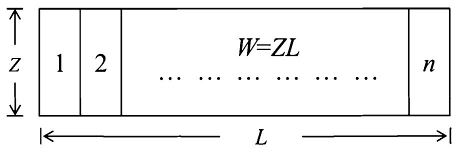


Fig. 2.4 Outline of workload (W) and balancing: Line type

where $Z = 1/\lambda$. This equation shows that waiting time (value), W, is the product of cycle time (unit), Z, and the number of customers (amount), L, in the system.

From (2.4) and (2.5), the following relationship is also obtained:

$$\lambda W = ML, \text{for any } \lambda > 0 \tag{2.6}$$

Little's formula holds when $M = 1$ ($\eta = 0$), but not when $M > 1$ ($\eta \neq 0$).

Now, it is noted that when the arrival rate r is replaced by cycle time $Z(=1/r)$, Matsui's equation is similar to Little's formula. The only important difference is in the dimensions of Little's formula in the traffic world and of Matsui's equation in the square world (the rectangle in Fig. 2.4). Thus, Little's formula may be derived from Matsui's equation, but the inverse is not true.

Additionally, Matsui's equation shows the principle of system balancing in the assembly line type of manufacturing, where workload, W, is supposed to be the total area of rectangles in a line of the n-division of work by the number of stations, L. Z refers to cycle time in Fig. 2.4.

This problem is discussed in more detail in Chap. 6.

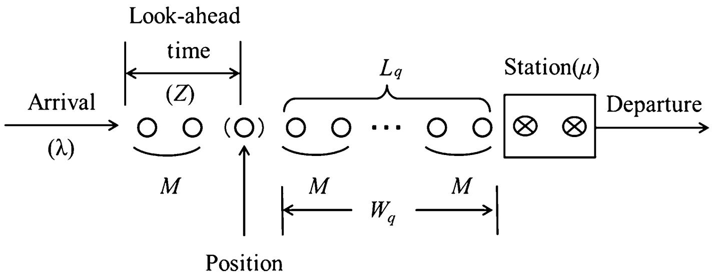


Fig. 2.5 A variant of Matsui's equation: $M(=\lambda Z) = 2$

2.1.3.2 Issues Concerning $M(=\lambda Z) = 2$

A variant of Matsui's equation provides interesting practical applications. Figure 2.5 shows an example of a queueing system with a control variable (look-back time, Z). This is useful for estimating waiting time W_q from a paired number of arrivals, λZ and L_q, in the look-ahead (Z) and look-back, respectively, at the waiting position in Z.

Thus, instead of Eq. (2.6), waiting time W_q is given by

$$\lambda W_q = ZL_q, \qquad \lambda > 0 \tag{2.7}$$

The $M(=\lambda Z) = 2$ case is presented in Fig. 2.5.

Here, the relationship between the arrival rate and cycle time is as follows:

$$\lambda = \begin{cases} 1, & Z = 2: \quad cycle\ \ amount\ \ (M) \\ 2, & Z = 1: \quad cycle\ \ time\ \ (Z) \end{cases} \tag{2.8}$$

Waiting time in Fig. 2.5, then, is $W_q = 5$. This is another example of the relationship between Little's formula and Matsui's equation.

2.1.4 *Views on Z: Value*

2.1.4.1 Matsui's Form: EOQ Type

Next, we discuss a form of discrete intelligence, $W(Q) = Z(Q) \times L(Q)$, which is an extension of Matsui's equation to the lot-size problem (EOQ formula) in Fig. 2.6. From Fig. 2.6, this version can be obtained from Matsui's lot-size (EOQ) equation by using the classic inequality of addition and multiplication.

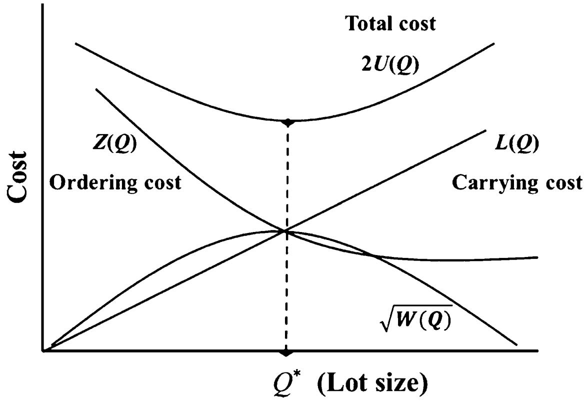


Fig. 2.6 Matsui's equation vs. EOQ formula in the lot type of manufacturing: $Q \leftrightarrow \lambda(=1/Z)$

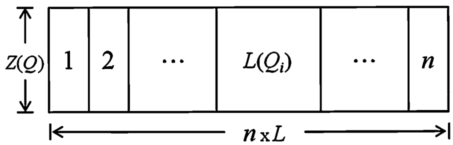


Fig. 2.7 Outline of workload (W) and balancing: Lot type

That is, when $Q \leftrightarrow \lambda(=1/Z)$, the following result holds in Matsui's equation:

$$U(Q) = \{Z(Q) + L(Q)\}/2 > \sqrt{Z(Q)L(Q)} = \sqrt{W(Q)}. \tag{2.9}$$

Thus, Little's formula may have originated from the EOQ formula, used since 1913, and this equality condition corresponds to Nash's solution in the pair game $(\sqrt{Z(Q) \times L(Q)}, \quad (Z(Q) + L(Q))/2)$.

From (2.9), $Z = L$ ($=W$) at equality. Then, the left-hand side provides the minimization of the consumer's risk per unit (cost), while the right-hand side provides the maximization of the producer's risk per cycle (cost).

In addition, Matsui's equation shows the principle of system balancing in the lot type of manufacturing, where total cost, W, is supposed to be the total area in a hypothetical line passing through rectangles 1 to n in Fig. 2.7, each representing a demand period of orders [17, 18].

The Ford-like method would be near to $Q(n) \to \infty$, the Toyota-like method would be near to $Q(n) \to 1$, and the EOQ-like method would provide the maximization of W (producer's risks) when EOQ is economic.

In the near future, this could be expected to become a lot-sizing problem similar to dynamic programming [9].

Table 2.1 The physics view of Matsui's equation

	Traditional areas		
Physics	Physics	MS/OR	Discrete world
Law	Ohm's law	Little's law	Matsui's equation
	$V = IR$	$\lambda W = L$	$W = ZL$
	(I: interest)	(λ: arrival rate)	(Z: cycle time)
Efficiency	System resistance	System reliability	System rate
	$R_I = \sum R_i$	$R_I = \prod R_i$	$r_I = \lambda \prod P_i$
	$R_{II} = 1/(\sum G_i)$	$R_{II} = 1\text{-}\prod R_i$	$r_{II} = \lambda\text{-}\prod(1\text{-}P_i)$

Table 2.2 Matsui's equation from an economics viewpoint

	Traditional area		
Economics	Physics	MS/OR	Discrete world
Profit	Profitization	Throughput	Traffic accounting
	? (unknown)	$EN = \min EN_i$	$EN = ER\text{-}EC$
		$(EC = \sum EC_i)$	$(D = Z\text{-}X)$
Assets	Energy	Real option	Workload/work-in progress
	$Pt(=IV_t)$	Process assets	$W = ZL$
			(Z: Revenue)

2.1.4.2 The Physics and Economics Views

We can now review and rediscover Matsui's form in the wider context of physics and economics.

(a) The physics view and related issues
Table 2.1 is prepared from a physics viewpoint. From Table 2.1, Matsui's equation is similar to Newton's law and Ohm's law, $V = IR$, where V, I, and R correspond to W (condenser), Z (current), and L (register), respectively, in a quantum (circuit). In an efficient system, a dual relationship would generally be seen in a series vs. parallel type configuration, but the arrival (failure) rate may be due to the unreliability of the MS/OR methods used.

(b) Economics view and related issues
Table 2.2 is prepared from an economics viewpoint. From Table 2.2, cycle time Z corresponds to revenue, ER, in Chap. 3, and this is related to traffic accounting [15] as follows:

$$Z(ER) = X(EC) + D(EN), \tag{2.10}$$

where EC is operating cost and EN profit.

In addition, let Z and L correspond to revenue and lead-time, respectively, and W be assets-in-progress. Then, Matsui's form can be seen as the principal law in matrix accounting [28] (see Sect. 5.2), as follows:

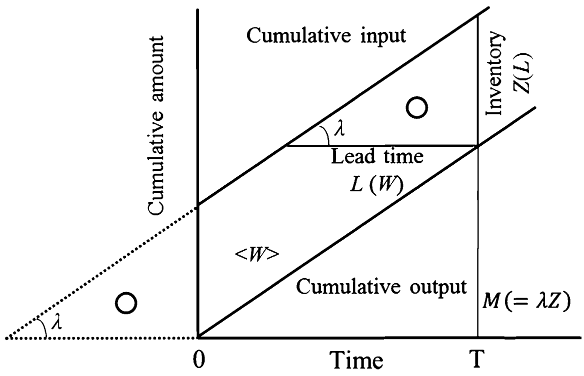


Fig. 2.8 Progressive chart and lead-time formula: Matsui's (vs. Little's) version

$$W(\text{expense}) = Z(\text{cost}) \times L(\text{amount}) \tag{2.11}$$

or

$$W(\text{sales}) = Z(\text{price}) \times L(\text{amount}). \tag{2.12}$$

Alternatively, W could correspond to manufacturing workload (labor force), the process assets in the real option, or energy (power) in physics.

2.1.5 Matsui's Form in the Progressive State

Matsui's equation is similar to the traditional progressive curve tool used in industrial engineering. The progressive curve tool is an input–output approach to a service station (process), and it consists of two cumulative input and output curves [20, 23]. The medium approach and control originate in this tool.

(a) Progressive inventory/control

The progressive curve tool is popular in production control (see Sect. 4.1). In the progressive curve, the differences between the two cumulative values of inflow and outflow represent the stock in height, L, and lead-time, W. It is well known that Little's formula holds when the arrival rate (the λ angle in Fig. 2.8) is set equal to λ_0.

For the practical application of Matsui's equation in the Japanese system of Kaizen, the time required (lead-time), L, is estimated as follows:

$$(\text{Time required}, L) = (\text{Cumulative inventory}, W)/(\text{Cumulative output}, M(= \lambda Z)). \tag{2.13}$$

Here, L and W correspond to the length and square of the width of the rectangle, respectively (see Fig. 2.8).

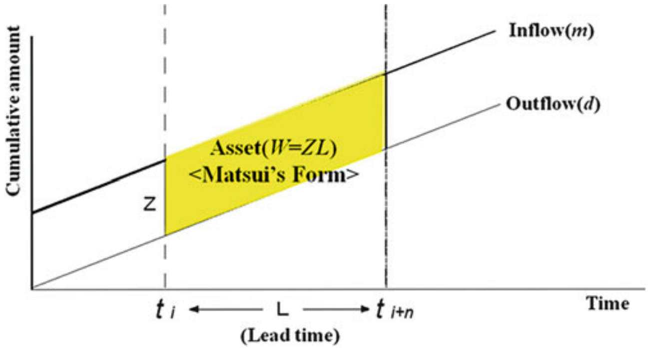


Fig. 2.9 Assets: The rectangle (*square*) in the cumulative curve

Under the parallel cumulative input and output condition in Fig. 2.8, this geometric proof is easily ascertained by finding the congruence of the parallelogram from the congruence of the triangles with the circle mark. Equation (2.13) is useful for industry and society to obtain inventory turns (or the turnover ratio), the number of days spent in hospital, and so on.

(b) Progressive assets/control
Matsui’s equation is also available for the control of workload and management of assets in an enterprise or in economic theory [17, 20, 21]. W now corresponds this to the assets-in-progress described in Sect. 4.2. Figure 2.9 shows the developmental type of a progressive curve in the rectangle (square). The progressive curve in the rectangle (square) is discussed further in Sect. 4.2 in regard to inventory. In Sect. 5.2, a dual relationship is found in the progressive type (a) vs. (b) in $W = ZL$.

2.2 Efficiency vs. “Muda”: Chameleon’s Criteria

2.2.1 Introduction

Since Taylor [27], waste has become a central issue in the economics of factories, enterprises, and entire communities, and the modern world still needs Kaizen, the continuous improvement program, for economic development. However, Taylor’s theory of scientific management faces criticism today, more than 100 years after its introduction [3]. This criticism relates to the scientific approach to the problem of waste—“muda” (loss) in Japanese.

This section considers an economic or harmonized efficiency vs. muda problem in society and discusses the new (post-Taylor) Chameleon’s criteria in relation to the newsvendor or medium method [12]. These criteria are first applied to the problems of economic profit vs. fixed cost and economic investment vs. consumption.

Next, traffic accounting [25] is introduced and developed to include accountability and controllability issues. This medium approach to these new criteria, a type of stochastic control (ODICS in Chap. 4), is then related to the balance between nature and the arts (the beautiful harmony of physics with the heart) for a human or for society as a whole (medium control).

Finally, we note that these new criteria could be applied to the social balancing of a limited cycle by using the network flow method [6, 9, 17]. This would provide a social balance to the input–output analysis of inter-enterprise relationships in the economic society [12].

In addition, it is shown that these criteria are similar to the redundancy constraints in information theory [1] and may be regarded as a version of Smith's invisible hand [24]. Another version of the invisible hand [25] is the so-called demand speed, and is utilized in Chap. 6 [17, 18]. For these Chameleon's criteria, the so-called medium would become the break-even point in the unlimited cycle, and thus, it may be here named Matsui's point.

2.2.2 A Classic View

2.2.2.1 Problem of Efficiency

The following formulae represent popular efficiency measures in enterprises:

$$(\text{Production rate}, r) = 1/\{(\text{Processing time}, X) + (\text{Idle time}, D)\} \tag{2.14}$$

$$(\text{Utilization rate}, B) = (\text{Processing time}, X)/\{(\text{Processing time}, X) + (\text{Idle time}, D)\} \tag{2.15}$$

We note from the above that the production rate, r, is the inverse of cycle time $Z(=X+D)$ in Matsui's form (Sect. 2.1.5) and that utilization is similar to the busy rate, B.

Traditionally, these efficiencies are increased by reducing the following:

$$\text{Processing time } (X) \quad \text{and/or} \quad \text{Idle time } (D) \tag{2.16}$$

These times are reduced by increasing the strength of labor and labor intensity, respectively. Traditional industrial engineering techniques generally target the latter (muda) rather than the former.

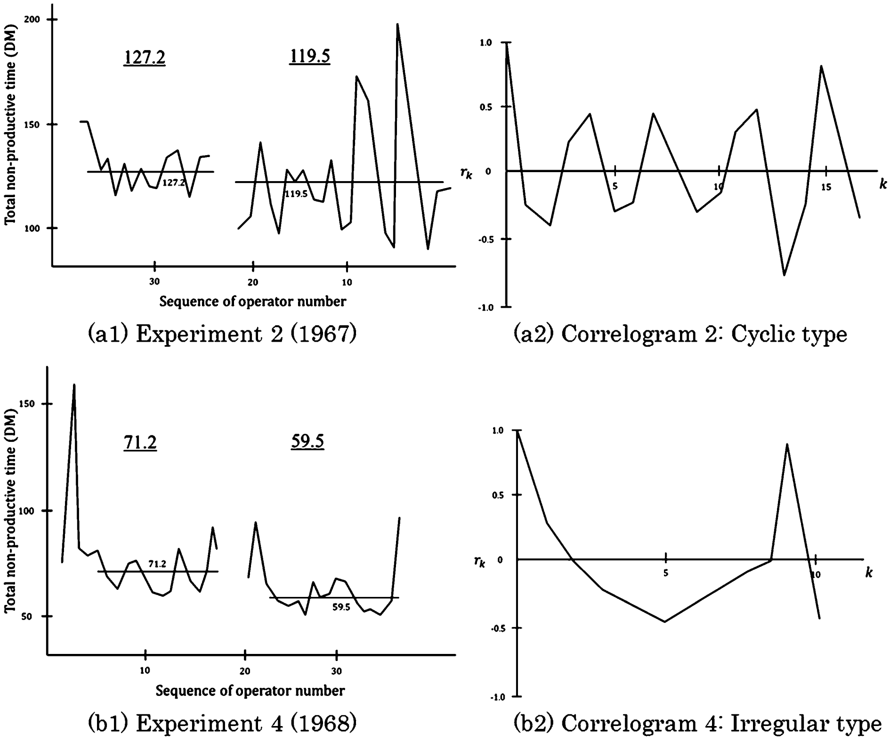


Fig. 2.10 A classic example of non-productive time behaviors [8]

2.2.2.2 A Classic Trial for Muda

Surprisingly, the nature of this muda was previously unknown. However, an exceptional classic example (see Fig. 2.10) is provided in the statistical study of non-productive time by Isotani and Matsui [8].

In this example, two fluctuating and two regular non-productive time behaviors during some pegboard work are observed and analyzed with a stopwatch. The results show a large reduction in the mean of total non-productive time per operator. In addition, the two correlograms of the autocorrelation coefficient r_k, $k = 1,2,\ldots$, show a largely different pattern of regular cyclicity between the former and latter halves.

Table 2.3 Sources and problems of muda (risk)

Sources of muda		Related problems
Human/Machine	Body	Allowance (safety)
	System	Balancing (coordination)
Money (cost)	Fixed cost	Design (space)
	Variable cost	Operation (time)
Money (profit)	Equipment/Investment	Risk appetite (return)
	Inventory/Stock	Buffer appetite (stock)
Information	Data/Document	Uncertainty (redundancy)
	Process	Modeling (likelihood)

2.2.3 Problem of Efficiency vs. Muda

2.2.3.1 A Post-Taylor Problem

Taylor's theory of scientific management has been criticized on several grounds. One criticism relates to setting a time standard based on a time study, as follows [2]:

$$(\text{Standard time}, X) = (\text{Normal time}, Y) + (\text{Allowance time}, A), \qquad (2.17)$$

where normal time is based on the best worker's method and the allowance is usually set to a predetermined time.

Taylor introduced a fair day's work based on this physical or absolute management criterion. In this chapter, the allowance in (1) is referred to as "muda"—the gap between normal time and the allowance; the problem here concerns not the relative but rather the absolute or physical setting. Some typical examples of the problem, generalized to the wider world, are shown in Table 2.3.

We regard muda to be a relative loss (risk) because the viable speeds of demand and supply are not absolute but rather relative to the environment. Therefore, we propose adopting Chameleon's criteria in the post-Taylor era by using the newsvendor or medium approach rather than the statistical (mean) method [29]. In this context, the reader should note the distinction between physical (absolute) and economic (harmonized) efficiency, each reflecting a different type of muda.

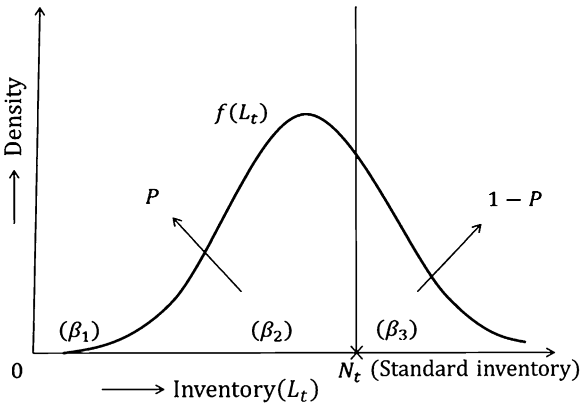
2.2.3.2 Introduction to Chameleon's Criteria

The chameleon criterion is introduced as a solution to the standard newsvendor problem [29] in Fig. 2.11. For simplicity, let us treat this inventory case, and consider the total penalty function in Sect. 4.1 as follows:

$$C(N_t) = \beta_1 N_t + \beta_2 (N_t - L_t)^+ + \beta_3 (L_t - N_t)^+, \qquad (2.18)$$

in which L_t is the inventory level at time t, N_t is the standard inventory at time t, and $(a)^+ = \max(a,0)$.

Fig. 2.11 Newsvendor model with penalties (β_i)



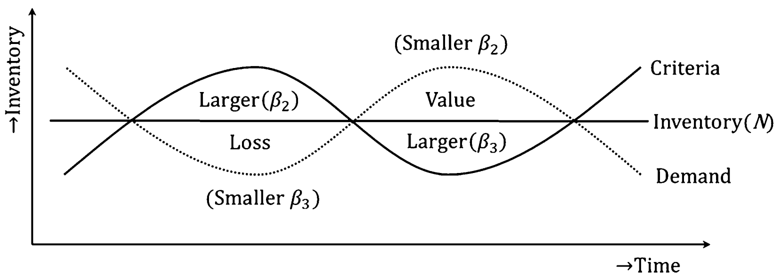


Fig. 2.12 Criterion behavior and balancing

Then, the optimal inventory is given by the minimization of the total penalty function based on the derivative or differential method. That is, the optimal condition is analytically given as follows:

$$F\left(N_t^*\right) = (\beta_3 - \beta_1)/(\beta_2 + \beta_3) = \overline{\beta}, \quad 0 < \overline{\beta} < 1. \tag{2.19}$$

This solution, $N_t^*\left(\overline{\beta}\right)$, is relatively determined and called the chameleon criterion. Moreover, it can be easily translated to the negative entropy (information amount) and redundancy (constraints) in cybernetics. In demand and supply series, these criteria would cyclically show the dual wave behavior of β_2 and β_3 as in Fig. 2.12.

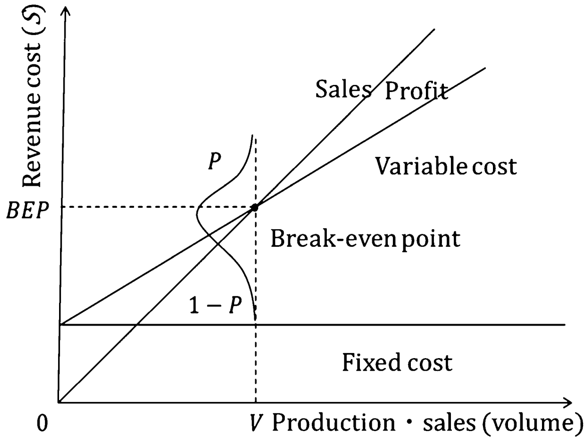


Fig. 2.13 Break-even chart and MP (marginal profit)

2.2.4 *Economic Efficiency vs. Muda*

2.2.4.1 Microeconomics View

Break-even analysis is a popular management accounting technique for analyzing the efficiency of an enterprise (see Fig. 2.13). This method can be used in traffic accounting as well (see Sect. 3.1).

In Fig. 2.13, marginal profit (*MP*) consists of profit (which is related to efficiency) and fixed cost (which concerns muda).

The break-even point (*V*) is generally given as follows:

$$\text{BEP } (V) = \text{Fixed cost } (EC^{+}) + \text{Marginal profit } (MP). \tag{2.20}$$

This leads to the following equation:

$$\text{BEP } \langle \text{amount } L \rangle \times \text{MP } \langle \text{money } Z \rangle = \text{Fixed cost } \langle \text{expense } W \rangle, \tag{2.21}$$

which is included in a class of Matsui's equation: $W = ZL$ [16, 17].

Now, let us consider the problem of MP. If probability P represents the distribution function of sales, S_t, at time t, the penalty function of MP would be given by the newsvendor method:

$$C(MP) = \beta_1(MP) + \beta_2(MP - St)^{+} + \beta_3(St - MP)^{+} \tag{2.22}$$

where β_i, $i = 1, 2, 3$, are gap penalties.

From (2.22), Chameleon's criteria (2.19) can be obtained as an economic efficiency vs. muda condition: $F(MP) = \overline{\beta}\ \left(0 < \overline{\beta} < 1\right)$. These criteria provide an alternative to the economic solution of the break-even point.

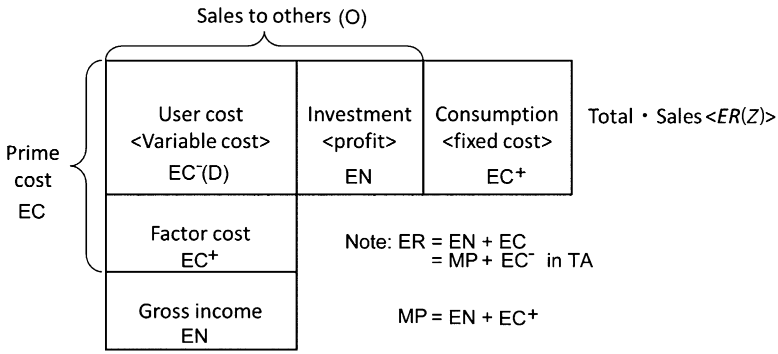


Fig. 2.14 Input–output (ER) and income (MP) chart according to Keynesian economics and traffic accounting (TA)

Table 2.4 Chameleon's criteria in economics

Sales/income (*ER*)	Holding (β_1)	$MP > ER$ (β_2)	$MP < ER$ (β_3)
Microeconomics	MP	Profit (loss)	Variable cost
Macroeconomics	Marginal investment	Investment (savings)	User cost

2.2.4.2 Macroeconomics View

In Chap. 6, we focus on the macroeconomics of the invisible hand that balance demand and supply and introduce the Keynesian input–output analysis of inter-enterprise relationships [11]. Figure 2.14 shows family or enterprise income (*MP*) in the input–output table.

Recent topics relate to the assignment of resources to investment (which is related to efficiency) and consumption (which concerns muda). This solution could become an assignment problem based on Chameleon's criteria. Table 2.4 summarizes Chameleon's criteria and their penalties from micro- and macroeconomics perspectives.

2.2.5 Developments in Macroeconomics

2.2.5.1 Measurability of the Criteria

For the break-even analysis, the newsvendor model is converted into a traffic accounting framework (Fig. 2.15). This allows us to measure Chameleon's criteria for the break-even point.

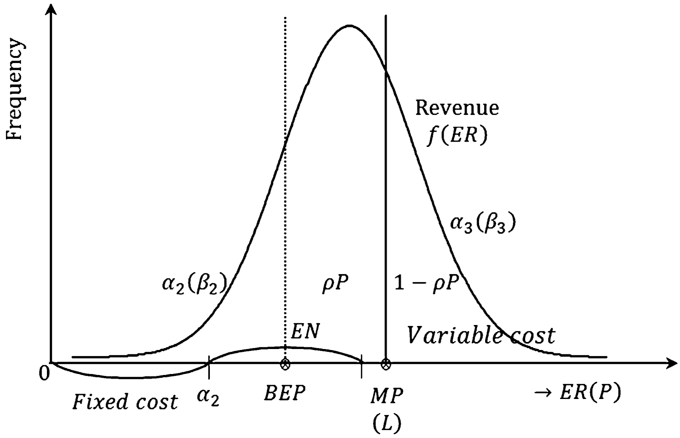


Fig. 2.15 Newsvendor-like traffic accounting model ($\alpha_2 < \alpha_3$)

Then, the cost (penalty) function is as follows:

$$C(MP) = \beta_1 MP + \beta_2(ER - MP)^+ + \beta_3(MP - ER)^+ \tag{2.23}$$

$$\rightarrow \alpha_1 MP + \alpha_2 \rho P + \alpha_3(1 - \rho P), \tag{2.24}$$

where $MP \rightarrow L$, $\beta_i(i = 1, 2, 3) \rightarrow \alpha_i$, and

$$MP = \begin{cases} \alpha_2 + EN, & \alpha_2 < \alpha_3 \\ \alpha_3 + EN, & \alpha_2 > \alpha_3 \end{cases} \tag{2.25}$$

From (2.24), Chameleon's criteria are obtained as follows for traffic accounting:

$$F(MP^*) = (\alpha_3 - \alpha_1)/(\alpha_2 + \alpha_3) = \overline{\beta}, 0 < \overline{\beta} < 1 \tag{2.26}$$

where $F(*)$ is the distribution function of revenue (ER).

In addition, ER corresponds to cycle time Z in Sect. 2.1. From (Sect. 2.1.4), it is clear that

$$\lambda ER = M = 1 + \eta \tag{2.27}$$

where $p(=1/\lambda)$ is the sales price and $\eta = \rho B$ [17]. That is, ER can be easily estimated from $\eta = \rho B$ as follows:

$$ER = p(1 + \rho B). \tag{2.28}$$

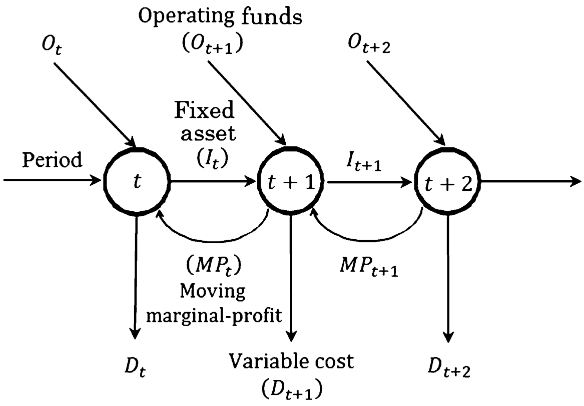


Fig. 2.16 Accounting flow of an enterprise in period t

2.2.5.2 Controllability of the Criteria

Next, a viable Chameleon's criteria operation based on break-even point processes is expected to become reality in the future by using the progressive control method [20, 23]. (See the inventory case in Chap. 4, for example.) Figure 2.16 shows a network representation of a viable dynamic operation.

From the translation of the inventory case [23], the fundamental equation becomes (see Fig. 2.16):

$$\begin{aligned}\text{Next input } (O) = \text{Next outflow } (D) &+ \text{Moving standard inventory } (MI)\\ &+ \text{Present inventory } (I)\end{aligned} \tag{2.29}$$

$$\begin{aligned}\rightarrow \text{Next operating funds } (O) = \text{Next variable cost } (D)&\\ + \text{Moving marginal profit } (MP)&\\ - \text{Present fixed assets } (I)&\end{aligned} \tag{2.30}$$

This treatment would be effective for the real-time management and balancing of enterprises [21], and it allows us to derive operable methods such as dynamic programming [9]. This problem would also be related to the concept of material flow cost accounting (MFCA) presented in Sect. 3.2.

By changing Eq. (2.30), the optimal condition is given from the classic inequality as follows:

$$(O+I)/2 = (MP+D)/2 \geq \sqrt{MP \times D}. \tag{2.31}$$

Then, the optimal property is O = I = MP = D(=W) at equality.

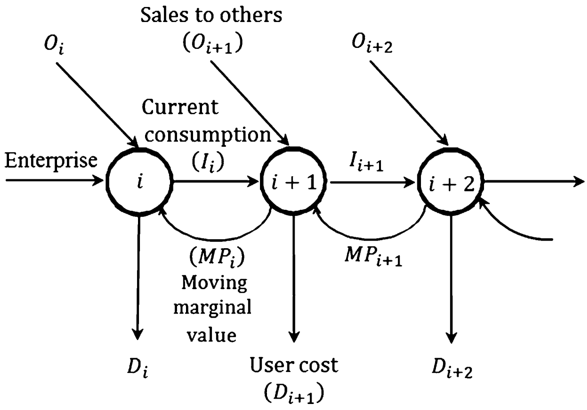


Fig. 2.17 Network flow of enterprises (i) in domestic income

2.2.6 *Further Developments*

2.2.6.1 Types of Macroeconomics

In Keynesian economics, accountability and controllability are similar to the break-even analysis case. Then, the penalty function of domestic income consists of C (MP) in (2.24), in which α_2, EN, and MP correspond to consumption, investment, and marginal value (consumption plus investment), respectively. This shows the measurability of the criteria.

In addition, the operation control of individual bodies (families or enterprises) would become possible through the following equation (see also Figs. 2.14 and 2.17):

$$\begin{aligned}\text{Sales to others } (O) = &\ \text{User cost } (D) + \text{Moving marginal value } (MP)\\ &- \text{Present consumption } (I)\end{aligned} \tag{2.32}$$

This, in turn, would allow for controllability (operability) in the inter-body balancing problem in a dynamic market or country (GDP). Although this is a difficult problem in regard to further inter-enterprise input–output analysis, it would be solvable and operable by using a solution method such as dynamic programming [9].

2.2.6.2 New Formula for Standard Time

Following these new criteria, a new standard time formula can now be considered. Let us denote traditional standard time, X, by (Y + A) in (2.17). So-called cycle time, Z, is then denoted by (X + D) as follows:

$$Z = Y + D + A. \tag{2.33}$$

Thus, this penalty function in the newsvendor model would be similar to that in Eq. (2.22) if the new standard time corresponds to MP. In Eq. (2.22), MP may correspond to the following:

$$MP = \begin{cases} Y + A, & \beta_2 < \beta_3 \\ D + A, & \beta_2 > \beta_3 \end{cases} \tag{2.34}$$

In the future, this new economic efficiency vs. muda method might also be available for the achievement of work/life balance as part of balancing theory. This extended theory may even provide a new basis for productivity issues in advanced societies.

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