Exploiting Concealed Hospital Capacities - A Focus Workflow Improvement Approach

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ABSTRACT
*In view of the increasing demand for healthcare services, the rapid increase in medical cost with limited growth of budgets and shortage of medical professionals, hospital executives are facing much pressure to improve productivity (productivity = Output / Input). Enormous efforts have been spent in improving productivity by reducing the input (i.e. cost reduction and efficiency) under the slogan of "**do more with less**". However, little contribution has make to the global hospital performance in terms of Length of Stay; stress experienced by staff is a common concern; and capacity is already perceived to be short, suggesting that available capacity is not used to its fullest potential. The research in this paper customizes the five focus steps of TOC, into an improvement framework for enhancing hospital capacity. Using this framework, ten research projects have been conducted in a variety of care systems in four hospitals. The care systems discussed in this paper covers the operating theatre, emergency room, wards' length of stay, surgery ward discharge, scarce resource utilisation (Tomotherapy machine) and between hospital transfer services. Results are encouraging and were verified in practice.*

Keywords: Theory of Constraints (TOC), 5 Focus Steps, Hospital Capacity, Patient Flow.

1. Current Issues of Healthcare Services

Healthcare systems in most countries allow more people to receive healthcare services at considerably less cost. However, there are concerns about the sustainability of health systems (Knight, 2003). Despite the relatively high proportion of governmental budgets spent on healthcare services, healthcare providers are still faced with the challenge of dealing with massive increases in Healthcare costs in real terms and as a percentage of their gross national products. (Knight, 2014a; Ronen, et al., 2006).

Accountability necessitates that the existing resources within the healthcare System are best employed before investing in additional capacity (Chan, 2016). As highlighted in 2016-2017 Annual Plan of the Hong Kong Hospital Authority (HA), there is a need to increase throughput with available resources in health systems (HA Annual Plan 2016 - 2017). This may be the goal of all hospitals over the world.

2. What is TOC?

TOC is a relatively new management theory that emphasizes the importance of improving system performance through a smarter utilization of existing resources, especially by exploiting the constraint, before increasing the system's capacity. (Goldratt and Cox, 2003). The principal tenet of TOC is that any system has at least one constraint that limits its performance. Since a system can at best perform only as well as its constraints, TOC emphasizes that improving constraint performance directly results in enhancing total system performance (Dettmer, 1998; Goldratt, 1990b, 1998).

Therefore TOC seems to be a natural fit for the resource-constrained health systems and in fact some of its tools and concepts have been applied to this setting (Knight, 2003; Ronen et al. 2006; Sadat et al. 2012). However, there are only few reported applications of TOC and inadequate customization with regards to various specialties in hospitals (Gupta and Kline, 2008; Mabin & Balderstone, 2000; Ritson and Waterfield, 2005).

3. Application of Five Focus Steps (5FS) in Healthcare Services

The five focusing steps (5FS) originally suggested by Goldratt (1988; 1990b) are the central working tenet of TOC. The 5FS evolved into what is now referred to as the Process Of On Going Improvement (POOGI) (Dettmer, 1997; Goldratt, 2003; Watson et al. 2007). The five steps of POOGI are illustrated in the following diagram:

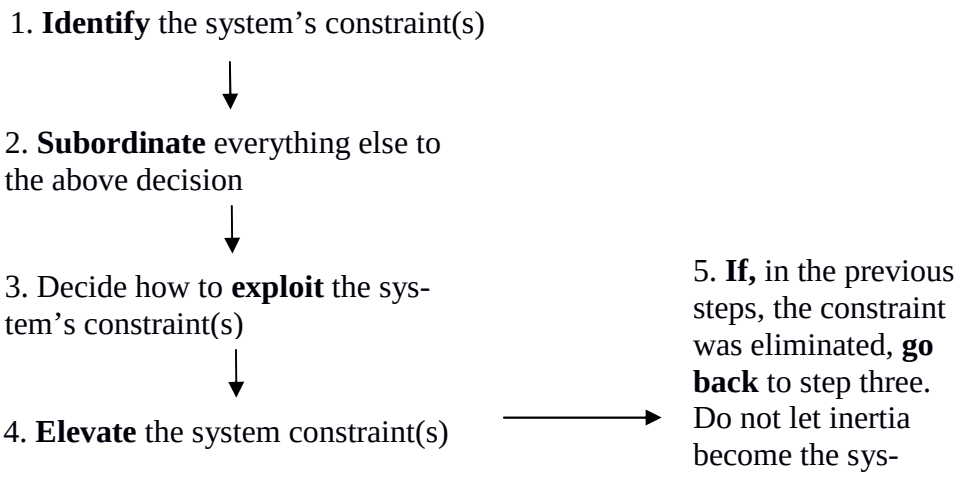


Figure 1. The Process of Ongoing Improvement (POOGI)

Step 1: Identify the Constraint
The first step of Goldratt's Five Focus Steps (5FS) is to identify the system's constraint. This means determining what limits the system from achieving a higher level of performance relative to its goal. One approach to identify the constraint is to perform a load analysis; examining the capacity utilization of the system's resources in order to identify a possible constraint (Goldratt, 2003; Ronen et al. 2006).

Step 2: Exploit the Constraint
Exploiting the constraint means making the most of current resources by maximizing the performance of the constraint (Goldratt, 1999). This entails eliminating policy and dummy constraints, and ensuring that the throughput governing resource constraint is utilized to its full potential (Goldratt, 2001).

Step 3: Subordinate Everything Else to the Above Decision
Once the constraint has been determined, a policy for managing the noncritical resources, the non-constraints, is needed. 'Subordinating everything else to the above decision' means managing the non-constraints around the constraint. The non-constraints should serve the constraint, ensuring that the constraint's capacity is exploited to its maximum at all times (Goldratt and Goldratt, 2003).

Step 4: Elevate the Constraint
To elevate the constraint means increasing its capacity in order to improve the throughput of the entire system (Goldratt, 2003; Ronen et al. 2006). Step 4 typically involves increasing capacity through investment (Goldratt, 1990b; Reid 2007), such as acquiring additional equipment or manpower or offloading the constraint by transferring work from the constraint to non-constraints when possible.

Step 5: If, the constraint was eliminated, go back to step three. Do not let inertia become the system's constraint.
This final step makes the 5FS a process of ongoing improvement. Since a system is always subject to at least one constraint, if a constraint has been broken, a new constraint must have emerged somewhere else in the system. Therefore we should return to step one and repeat the process, to avoid organizational inertia becoming the constraint (Goldratt 1990b).

4. Development of the Focus Workflow Improvement Framework

4.1. Introduction

The basis for TOC methodologies, the Five Focusing Steps (5FS) framework is very useful in identifying the most critical area for rapid improvement to obtain dramatic results (Goldratt, 1990a). This critical area is the constraint within the system and using the appropriate Lean and Six Sigma tools, improving this critical area will improve flow hence improving hospital capacity (Ronen and Pass, 2010).

4.2 Development of the New Improvement Framework

4.2.1 Comparison of the Three Frameworks of Focus Steps

Due to the pragmatic nature of this study, this research studied Goldratt and Ronen's focus step framework and modify it into an improvement framework suitable for hospital services. The name of the modified framework is "Focus Workflow Improvement Framework (FWI)" which emphases the importance of taking holistic view in order to identify systemic improvement. The comparison of the three methods with reasons for change is shown in the following table:

1	**Identify** the System Constraint.	Define the system's **goal**	**Identify** the constraint	In Healthcare services, the constraint may or may not be the System Constraint.
2	Decide how to **exploit** the System Constraint.	Determine proper, global and simple performance measures	**Evaluate** the problem	Understand the current status before setting targets
3	**Subordinate** everything else to the above decision.	**Identify** the system constraint(s)	Set improvement **targets**	Target should be in agreement with the common goal: treat more patients, better and quicker
4	**Elevate** the System Constraint.	Decide how to **exploit** the System Constraint(s)	**Exploit and elevate** the constraint	Both can be undertaken simultaneously
5	If in the previous steps a constraint has been broken, **go back** to Step 1, but do not let inertia cause a System Constraint.	**Subordinate** everything else to the above decision	**Confirm Results**	Ensure results are valid and all improvements are toward achieving the system goal
6		**Elevate** the System Constraint(s)	**Retain Performance**	Ensure measures are in place to sustain the gain.
7		**If,** in the previous steps, the constraint was eliminated, **go back** to step three. Do not let inertia become the System Constraint	**Identify next constraint**, go back to step 1	Same as Goldratt's Step 5

Table 1. Comparison of TOC Focus Step Frameworks

4.2.2. The Proposed Focus Workflow Improvement Framework (FWI)

The proposed Focus Workflow Improvement Framework (FWI) has been adopted in this research and was used in the 10 improvement projects. Results of these projects prove that FWI provides satisfactory solutions that bring about significant and rather rapid results as discussed latter in this Paper.

The seven steps in FWI are:

1. **F**ind the Constraint
2. **E**valuate the problem
3. **S**et improvement targets
4. **E**xploit and elevate the constraint
5. **C**onfirm Results
6. **R**etain Performance
7. **I**dentify next constraint, go back to step 1.

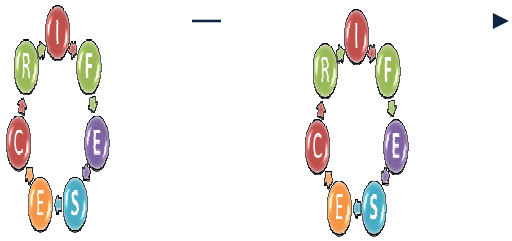
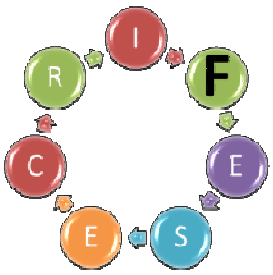


Figure 2 The HIF's Improvement Cycle

4.3 The FWI in Practice

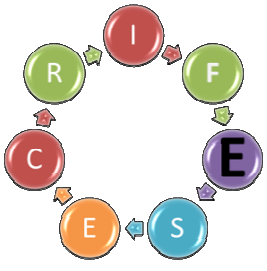
4.3.1 Step 1: Find the System's Constraint



In a complex healthcare system, there are two types of most crucial constraints: the patient flow and scarce resources. The first type of constraint is simply the smooth flow of patient among specialties in the patient journey. The latter is usually referred to the most expensive resource: human, machine, or physical space. For example, in a small clinic the constraint is usually the physician. In a hospital system, it could be the operating room, recovery room, emergency room, or MRI machine.

A high-level Value Stream Map (VSM) can help clarify the key obstruction or constraint to the flow of patients and information. An example of current state VSM is provided in Figures. 3, which show the patient discharge process. The constraint location in the discharge process is preparation of discharge documentation (Extracted from case no.2).

4.3.2 Step 2: Evaluate the Problem



The data collection is performed in this step. The first stage is to draw the Value Stream Map (VSM) to elaborate and analyze the process flow using a set of standard symbols. The VSM provides an overview of the process under study. Process attributes such as cycle time, uptime of machines, number of shifts, number of operators, number of patients waiting, etc. are collected from the process. Relevant statistic and metrics are posted on the appropriate steps of the VSM as illustrated in Figure 3 (from case no. 2).

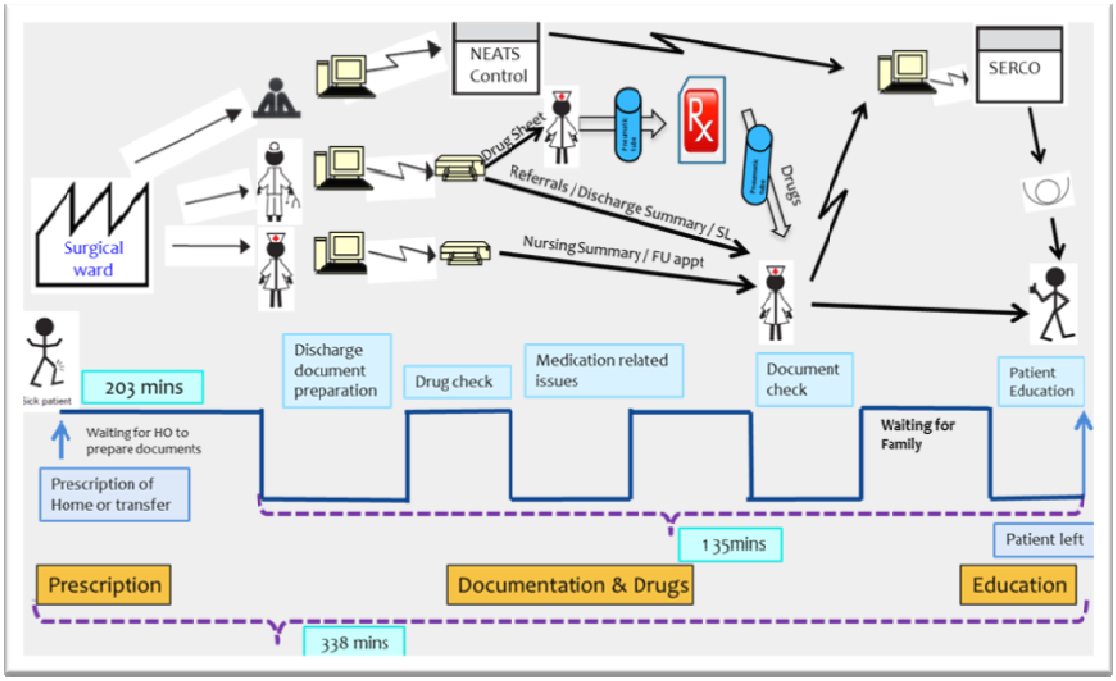
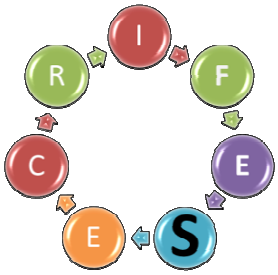


Figure 3. The Value Stream Map for the Discharge Process

The analysis of the current state identifies the constraint of the process, for example in Figure 3, the constraint is preparation of the discharge documentation, which takes 203 minutes of the 338 minutes for the whole process. Reduce the discharge document preparation time will shorten the length of stay (LOS) and increase bed availability and hence ward capacity for admitting more patients.

4.3.3. Step 3: Set improvement targets



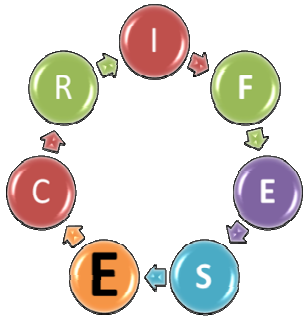
The goal of the hospital is of the utmost importance and should guide every decision and action in the hospital. For this research, the goal of hospital services is defined as "to treat more patients, better and quicker". However, the goals of each of the processes to be improved have to be aligned with the overall healthcare system in the larger context. For example, the constraint of a surgery process may be the OT room itself, but in some hospitals, the constraint may be the bed availability in the recovery room. The system goal is to increase the number of operating procedures, which in turn meets the overall goal of treating more patients.

In Case No. 4, "Portering in Radiology", the project improvement target is to reduce the patient waiting time for a porter. The real contribution of the project is to shorten the patient length of stay and therefore more beds can be available to house an additional 201 admissions per year. The calculation is illustrated in the following table:

Table 2. Increase Admission Capacity

		Remarks
Patient hours saved per case (hr)	2	
No. of plain X-ray cases per year	10,400	
Projected patient hours saved per year	20,800	= 2*10,400
Average patient LOS in AHNH (day)	4.3	
Additional in-patient admission capacity per year	**201**	= 20,800/(4.3*24)

4.3.4 Step 4: Exploit and Elevate the Constraint



In a situation of shortage of resources (human or material), the inclination is to solve the shortage by seeking additional personnel or by acquiring additional equipment. The step of exploiting and utilizing the constraint means that much more can be done with existing resources, that is, extract significant additional output by elevating the constraint resource. According to Goldratt's five focus steps, the decision on whether to increase resources should be postponed until after the improvement potential of the current constraint is fully exploited (Goldratt, 2001).

4.3.4.1 Exploit the Constrain

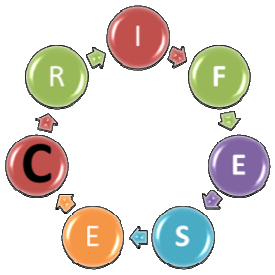
Improvement through exploitation can be achieved relatively fast and is, therefore, the most realistic improvement for the short term. Ronen et al. (2006) has shown that *"in every system it is possible to extract more by better system management and by focusing on existing constraints. Exploitation is performed on two dimensions: efficiency and Effectiveness. In parallel, we must break Policy and Dummy Constraints"*.

1. *Efficiency: Increasing constraint utilization to as close as possible to 100 Percent.*
2. *Effectiveness: Because the constraint cannot supply the entire demand, one must decide on the product or service mix of the constraint.*

4.3.4.2 Elevate the Constraint

The previous steps of management by constraints dealt with increasing the output of a given system, without any changes in the system itself. Elevation is a structural change in the system to increase the effective capacity of the constraint. Increasing this capacity will increase the throughput of the whole system. Elevating and breaking the constraint can be achieved in two ways:

4.3.5 Step 5: Confirm Results



There are two essential elements in this step: ensure results break the dummy and policy constraints and results must be validated with statistical evidence. Details are discussed in the following paragraphs.

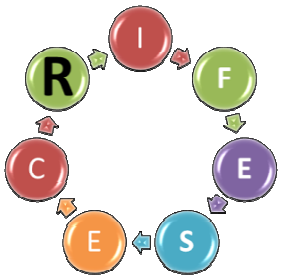
4.3.5.1 Ensure Results Break the Dummy and Policy Constraints

The improvement results must ensure that constraints be exploited efficiently and effectively. Dummy and Policy Constraints must be broken. The Dummy Constraint of the cleaning person in the OT can be immediately remedied by hiring additional personnel. Policy Constraints are a bit more difficult to deal with. For example, overtime work can be eliminated by a policy that differentiates between the work center that is the constraint and other work centers. This allows the manager to provide the overtime budget only for the constraint department.

4.3.5.2 Validate Results with Statistic Tests

Results from these cases broke the Dummy or Policy Constraints, validated by statistical tests and triangulated by actual performance.

4.3.6 Step 6: Retain the Performance



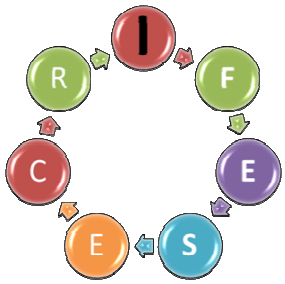
Once the constraint is identified and improved, there is a need to create a policy for managing and operating the constraint and noncritical resources. The noncritical resources must be available to assist system constraints, especially at peak times. For example:

1. In a hospital OT, the constraint could be the anesthetists, nurses, or the OT capacity. Management must identify the constraint and subordinate all others to serve and assist the constraint to ensure it functions efficiently.
2. In maintenance, priority should be given to the constraint equipment.

When the constraint equipment fails, the relevant maintenance people should drop all other tasks and assist in fixing the constraint equipment because it stops all system output.

1. If efficient use of scarce lab equipment calls for batches of a hundred specimens at a time, then all wards and logistics should subordinate to this constraint, even if they prefer preparing smaller batches.

4.3.7 Step 7: Identify the Next Constraint, go back to step 1



If a constraint is eliminated, then return to step 1 to identify the next constraint. This is a programme of on-going improvement (POOGI) suggested by Goldratt (2003) as there is always a constraint (constraints) in a system. The task is to identify constraints, manage them, eliminate them, and face a new constraint that may appear elsewhere. By moving from constraint to constraint, system output increases.

5. Results of FWI Application in Hospitals

The research applies the customized focus steps – the Focus Workflow Improvement Framework, FWI (Figure 5) as the improvement framework in 10 different functional areas of four different hospitals. The purpose of is to achieve the research objective of this study. The section demonstrates how the FWI is used to achieve this goal.

5.1 Unveil Concealed Capacities

The FWI allows significantly improved performance of A&ED, OT rooms, In-patient beds and scarce resources in a relatively short time with existing resources as illustrated in various cases in Table 3. These ten research projects, conducted in four hospitals, have provided empirical evidences for improving productivity while sustaining, even improving quality, without the need to increase spending. Details are in the following table:

Table 3. Project Results on Capacity Enhancement

No.		
1	Workflow of Operation Theater Turn-around	Increased 16.5% of OT capacity was expected.
2	Patient Discharge Workflow in Department of Surgery	An estimated 3.6% additional patients can be accommodated
3	Journey of Patients with Upper Gastro-intestinal bleeding	Reduced 477 patients using PWH A&E service and endoscopy ward in two years.

4	Setup Time of Total Knee Replacement	The OT could complete 4 major operations instead of 3 major and one minor operations
5	Portering Services in AHNH Radiology	Increased in-patient capacity by 201 patients per year
6	Patient Discharge Process	Provided 5 in-patient beds each in 8 medical wards before 2 pm in match with admission needs of patient at the A&E department.
7	Discharge Medication Flow in Department of Surgery	An estimated 3.8% additional patients can be accommodated
8	Discharge Medication Process	Reduced the time collecting medications from 416 minutes for eight wards to 103 minutes, thus reduces LOS of 4.07% in-patient beds
9	Reduction of Operation theaters Turnaround Time	Increased the no. of surgery operation by 17% .
10	Capacity of the Tomotherapy machine	An increase of 38.9% capacity has been achieved.

5.2 Financial Contributions

To demonstrate the impact of these results in financial terms, a very rough estimation of financial values is made. The purpose is to provide the contributors with monitory values of their contribution, which is an important factor of recognition.

Table 4 Financial Values of Projects

	Research Projects	**Estimated Financial Benefits (HK$M)**
1	Workflow of Operation Theater Turnaround	148.5
2	Patient Discharge Workflow in Department of Surgery	20.7
3	Journey of Patients with Upper Gastrointestinal bleeding	4.6
4	Setup Time of Total Knee Replacement	2.6
5	Portering Services in AHNH Radiology	2.4
6	Patient Discharge Process	3.0
7	Discharge Medication Flow in Department of Surgery	3.4
8	Discharge Medication Process	14.8
9	Reduction of Operation theaters Turnaround Time	204.0
10	Capacity of the Tomotherapy machine	95.0
	Total:	**HK$ 413 m or US$53 m**

The financial values are significant and all projects were completed within 6 month. FWI which evolved from the five focus steps (5FS) invented by Godratt's (Goldratt, 1990b) is to identify the system's constraint that limits the system from achieving higher level of performance. In hospital context, it means "to treat more patients better and sooner". The results proved that Goldratt's 5FS of TOC are very useful in identifying the most critical area(s) for rapid improvement to obtain dramatic results.

6. Conclusion

Application of the Theory of Constraints is the most advanced management theory today. (Cox & Schleier, 2010). It includes focusing steps that significantly increase system throughput within a short time by focusing on constraints. The method allows significantly improved performance of A&ED, OT rooms, In-patient beds and scarce resources in a relatively short time with existing resources as illustrated in various cases in this paper. The cases used a customized FWI framework modified from the original 5FS (Goldratt, 2001) and the 7FS proposed by Ronen et al. (2006), which proved to be more appropriate to tackle hospital improvements in the Hong Kong environment. Results of these cases are validated by triangulation with direct observation, statistical test and actual performance.

To conclude, the empirical evidence suggests that the FWI method provides an effective framework to exploit the concealed capacities in hospital services. This approach seems to be generic to many hospital systems. The ongoing challenge in relation to enhancing capacity without sacrificing safety and cost is to understand what changes need to be made to existing structures, work processes and culture in order to improve the process flow through the holistic hospital system.

Research suggests that there are five key principles:

1. Consider the system holistically, focus on system constraint.
2. Problems need assessment with real-time data.
3. Adapt appropriate improvement tools, such as tools in Lean and Six Sigma methodologies.
4. Account for practicalities.
5. Staff engagement is central to success.

Focusing on these core principles is likely to support improvement better and there is great potential in using the FWI in other hospitals

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Authors' Backgrounds

Dr. Sebastian Chan is General Manager of the SBTI-HK Ltd and the General Manger of the Six Sigma Institute. Dr. Chan has 12 years' experience in management consultancy. He has served wide spectrum of clients, covering serving, manufacturing and public sectors. His project with East New Territory Cluster of Hospitals of Hong Kong has won the 1st Class Award of Lean Management grated by the Association of Quality, China. He is a registered Lean Specialist, a Register Master Black Belt and an International Certified Theory of Constraints Practitioner. He is also received the Major Contributors' Award for the 10-year Six Sigma Journey in China granted by the National Six Sigma Promotion and Management Council.

Dr. Y.K. Chan has over 30 years working experience in engineering and management positions in both Manufacturing and servicing industries. He has rich consultancy experience in the field of strategy operations management, quality management, team and motivation, leadership and strategic management. Dr. Chan was the Chairman and President of the Hong Kong Quality management for 10 years and currently the Chairman of the Six Sigma Institute. He was also a Standing Director of the China Association for Quality as well as a Central Member of the National Six Sigma Promotion and Management Council.