

COURSE OUTLINE: BC3411 Lean Operations & Analytics

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|---------------------------|-----------------------------|-----------------|---|
| Academic Year | 2022-2023 | Semester | 1 |
| Course Coordinator | Assoc Prof Rohit Bhatnagar | | |
| Course Code | BC3411 | | |
| Course Title | Lean Operations & Analytics | | |
| Pre-requisites | AB1202 | | |
| No of AUs | 3 | | |
| Contact Hours | 3hr x 13 weeks = 39 | | |
| Proposal Date | 20 Jan 2022 | | |

A) Course Aims

The main objectives of this course are i) to appreciate the key principles/approaches of lean operations including waste elimination, increased speed and response, improved quality, and reduced cost & ii) to gain an understanding of the methodologies, tools, and techniques necessary for analyzing, implementing, managing, and continuously improving operations in both manufacturing and service industries. Topics covered in the course include Toyota Production System, Lean Principles, Value Stream Mapping, Pull Systems, Six Sigma, Lean thinking in manufacturing and service operations, and use of tools like optimization, queuing, simulation, and statistical analyses for modelling and analyzing real life systems. The course will use a mix of lectures, case studies, and problem-solving exercises, to introduce the students to the latest tools, techniques, issues, and strategies in lean operations management. A special focus of the course will be on the operations and technology function in both manufacturing and service sectors. This segment will provide rich opportunities for students to be exposed to challenges in manufacturing and service operations and gain insights through projects.

B) Intended Learning Outcomes (ILO)/Objectives

By the end of this course, you should be able to:

1. *Describe* fundamental issues in lean operations such as reducing waste, inventory and variation and improving responsiveness and quality in the firm's operations (ILO1)
2. *Explain* the key trade-offs necessary for designing, managing, and improving lean operations (ILO2)
3. *Compute* key performance measures related to the trade-offs (ILO3)
4. Relate key performance measures with analysis and comparison of alternate systems to strategic goals of companies (ILO4)

See [Annex F](#) for learning objective taxonomy.

C) Course Content

The course content will have as its backdrop the fundamental concepts and techniques necessary for designing, managing, and improving operations and processes in both manufacturing and service industries by using appropriate lean methodologies. The course adopts a "process management" viewpoint while addressing a variety of strategic and tactical issues. The main topics covered include:

1. Introduction to Lean Operations. Operations Strategy. Real World Applications. Case Study.

2. Process View of Operations and Fundamentals of Process Analysis.
3. Reducing Waste and Improving Quality. Toyota Production System.
4. Reducing Inventory in Operations. Traditional versus Lean Inventory Systems.
5. Improving Responsiveness by reducing lead times. Pull versus Push Systems. Dice Game.
6. Measuring and Reducing Variation in Operations. Lean Six Sigma
7. Global Examples in Lean Excellence.
8. Introduction to Simulation Modelling. Arena Simulation.
9. Simulation Modelling using Arena. Advanced Concepts in Simulation. Statistical Analyses for Steady State Simulation Results.
10. Lean Supply Chains

D) Assessment (includes both continuous and summative assessment)

| Component | ILO Tested | NBS Learning Goal (Refer to Annex E for list) | Weighting | Team/Individual | Assessment Rubrics (Please insert rubrics as Appendix) |
|--|------------------------|--|-----------|--|---|
| 1. Quiz | ILO1, ILO2, ILO3 | Acquisition of knowledge | 20% | Individual | N. A |
| 2. Cases, Games, Littlefield Simulation | ILO1, ILO2, ILO4 | Critical Thinking | 20% | Individual | Critical Thinking Rubric |
| 3. Term Project (written report and in-class presentation) | ILO1, ILO2, ILO3, ILO4 | Problem Solving & Decision Making Oral communication Teamwork and Interpersonal Skills | 40% | Group (70%) Every member is required to present Individual (30%) | Problem Solving and Decision-Making Rubric Oral Communication Mandatory Peer Evaluation # |
| 4. Class Participation | ILO1, ILO2, ILO3 | Oral Communication | 20% | Individual | Class Participation Rubric |
| Total | | | 100% | | |

A mandatory peer evaluation will be done for the Group Project at the end of the course. The peer evaluation forms are given in the Appendix/Outline. The adjustment of project work marks for unequal contributions among members is also described.

E) Formative feedback

You will get feedback on your submissions. The feedback will be both verbal and written.

Feedback is central to the group project. You will be provided feedback on your project proposal to help you identify the strengths and weaknesses of your proposal. During the term, you will be given periodic verbal feedback on your content and analysis so that you are able to continuously improve the quality of your work.

F) Learning and Teaching approach

| Approach | How does this approach support you in achieving the learning outcomes? |
|---------------------|--|
| Seminars | The seminar sessions will have considerable opportunities for interaction and discussion on the conceptual questions raised in the class. This will allow you to think critically and share your ideas with the class. Deep thinking, reviewing materials and clarifying your doubts/questions will provide you a sound platform to do well in the course assessments. |
| In-Class activities | Case studies, exercises, games, and Littlefield Simulation will be discussed in class and after allowing you some time for group discussion, I will call upon individuals to share their analysis. We will also discuss the real-life implications of this analysis. |
| Term Project | The term project is integrative in nature and will encompass all intended learning outcomes (ILO1, ILO2, ILO3 and ILO4). There will be ample opportunities for you to have continuous interaction with me to monitor your progress. I will also provide feedback to enable you to improve the quality of your analysis. |

The teaching approaches described above are strongly aligned to all learning outcomes (please see ILO1, ILO2, ILO3 and ILO4 outlined above).

G) Reading and References

Most of the assigned reading materials and class notes will be provided online on NTULearn (<http://ntulearn.ntu.edu.sg>).

Required

All students will be required to purchase access to Littlefield Simulation Game and the cases used in the course.

There is no prescribed textbook for the course, and we will use several readings and reference materials, which will be incorporated in the class notes.

These references include:

1. An Introduction to Lean Work Design: Fundamentals of Lean Operations Volume I, Lawrence D. Fredendall and Mathias Thurer, 2016, Business Expert Press. (FT1)
2. An Introduction to Lean Work Design: Standard Practices and Tools of Lean, Volume II, Lawrence D. Fredendall and Mathias Thurer, 2016, Business Expert Press. (FT2)

3. Lean Production for Competitive Advantage – A comprehensive guide to Lean Methodologies and Management Practices, John Nicholas, 2011, Productivity Press, NY. (N)
4. Staying Lean – Thriving Not Just Surviving, Peter Hines, Pauline Found, Gary Griffiths, Richard Harrison, 2011, CRC Press, Taylor, and Francis Group. (HFGH)
5. Improving Business Performance with Lean, James R Bradley, 2012, Business Expert Press, NY. (B)
6. Building Lean Supply Chains with the Theory of Constraints, Mandhyam M. Srinivasan, 2012, McGraw-Hill, NY. (MMS)
7. Simulation with Arena, W. David Kelton, Randall P. Sadowski, Nancy B. Zupick, 2015, Sixth Edition, McGraw-Hill. (KSZ)
8. Operations Management, 2nd Edition by Gerard Cachon and Christian Terwiesch, 2020, McGraw-Hill, ISBN: 978-1-260-54761-0 (CT)
9. Operations Management, Eleventh Edition, Lee J Krajewski, Manoj K Malhotra, Larry P Ritzman, 2016, Pearson. (KMR)

H) Course Policies and Student Responsibilities

(1) General

You are expected to complete all assigned pre-class readings and activities, attend all seminar classes punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments, and course related announcements for seminar sessions they have missed. You are expected to participate in all seminar discussions and activities.

(2) Absenteeism

Absence from class without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

If you miss a lecture, you must inform the course instructor via email prior to the start of the class.

I) Academic Integrity

Good academic work depends on honesty and ethical behavior. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honor Code, a set of values shared by the whole university community. Truth, Trust, and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion, and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

J) Course Instructors

| Instructor | Office Location | Phone | Email | Consultation Hours |
|-----------------|-----------------|--------------|------------------------|--------------------------------|
| Rohit Bhatnagar | S3-B2A-21 | 6790623 5 | arbhatnagar@ntu.edu.sg | By prior appointment via email |

K) Planned Weekly Schedule

| Week | Topic | ILO | Readings/ Activities |
|------|---|------------------|--|
| 1 | <i>Lean Strategy</i> Introduction to Lean Operations. Operations Strategy and Role of Lean Thinking | ILO1 | Lecture Notes. FT1, FT2, CT, KMR |
| 2 | <i>Real World Implementation</i> Issues in Operations Strategy Case Analysis: Fabritek Film: Aravind Eye Hospital | ILO1, ILO2, ILO3 | Lecture Notes Case Study Analysis |
| 3 | <i>Process View of Organizations</i> Fundamentals of Process Analysis Product & Process Design Process Analysis Exercises and Mini Cases | ILO1, ILO2, ILO3 | Lecture Notes Exercises |
| 4 | <i>Process View of Organizations (continued)</i> CASE: NATIONAL CRANBERRY COOPERATIVE Exercises and Mini Cases Process of Ongoing Improvement | ILO1, ILO2 | Lecture Notes CT, KMR |
| 5 | <i>Reducing Waste and Improving Quality,</i> Toyota Production System – Prototype for Lean Operations Toyota's Seven Wastes. Kaizen. Exercises/Mini Cases | ILO1, ILO2, ILO3 | Lecture Notes. CT, KMR |
| 6 | <i>Global Examples in Lean Excellence/ Reducing Inventory in Operations</i> CASE: TOYOTA MOTOR COMPANY Introduction to Inventory Management Traditional versus Lean Inventory Systems, Value Stream Mapping | ILO1, ILO2, ILO3 | Lecture Notes MMS Toyota Production System Case Study Analysis |
| 7 | <i>Improving Responsiveness in Operations</i> Pull versus Push Systems <u>Dice Game</u> | ILO1, ILO2, ILO4 | Lecture Notes Exercises |
| 8 | <i>Reducing Variation in Operations</i> Lean Six Sigma Understanding & Measuring Process Variation | ILO1, ILO2, ILO3 | Lecture Notes N, HFGH, B, CT |

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|----|---|------------------------|-----------------------------------|
| | Measuring Process Capability Statistical Process Control Procedures Quiz | | |
| 9 | <i>Introduction to Simulation Modeling</i> Arena Simulation Exercises <u>Electronic Beer Game</u> | ILO3 | Lecture Notes KSZ Exercises |
| 10 | <i>Advanced Concepts in Simulation Modeling</i> Simulating Complex Examples in Arena. Statistical Analyses for Steady State Results <u>Littlefield Simulation Game Briefing</u> | ILO2, ILO3 | Lecture Notes KSZ Exercises |
| 11 | E-Learning: Simulation Based Exercises | ILO1, ILO2, ILO3 | Lecture Notes KSZ |
| 12 | <i>Lean Supply Chains</i> Aligning Supply Chain Incentives <u>Negotiation Game</u> | ILO2, ILO3, ILO4 | Lecture Notes MMS |
| 13 | Term Project Presentations Wrap Up | ILO1, ILO2, ILO3, ILO4 | Presentations |

ANNEX A: ASSESSMENT CRITERIA

| Learning Goal | Course Learning Objective | Assessment Method/Rubric |
|---|--|------------------------------------|
| Acquiring knowledge (AK) | Students should gain knowledge of fundamental concepts and techniques necessary for designing and managing lean operations and knowledge of current issues and strategies for managing global lean operations. | Quiz |
| Problem Solving and Decision Making (PSDM) | Students should be able to develop analytical thinking, problem solving skills, and decision-making skills and apply these to real life situations | Term Project |
| Critical Thinking (CT) | Students should be able to think strategically, and develop ability to analyze business related problems, analyze and evaluate alternative solutions. | Cases/Games/Littlefield Simulation |
| Oral Communication (OC) | The ability to communicate well with others verbally so that it clearly expresses the intended message and is understandable and useful to the receiving party. | Class participation |

1. Quiz

| Learning Goal | Course Learning Objective | Assessment Method |
|---------------------------------|---|---|
| Acquiring knowledge (AK) | Students should gain knowledge of fundamental concepts and techniques necessary for designing and managing lean operations and knowledge of current issues and strategies for managing global lean business operations. | Quiz The quiz contains questions that <ol style="list-style-type: none"> i) test application of fundamental concepts and analysis techniques to specific problems in lean operations ii) test deeper problem solving and analytical thinking skills through more challenging analytical questions and iii) test understanding of current issues and strategies for managing global lean operations posed in a particular, practical lean operations context. |

2. Term Project

| Learning Goal | Course Learning Objective | Assessment Method | Rubric |
|--|---|-------------------|--|
| Problem Solving and Decision Making | Develop analytical thinking, problem solving skills, decision making skills and report writing skills. Develop ability to analyze business related problems and analyze and evaluate alternative solutions. Students are expected to structure business problems as decision models and (where appropriate) solve models using the relevant software and interpret the computer-generated solutions to address key issues | Term Project | Assessment Rubric for Term Project (see below) |

Assessment Rubric for Term Project
 (to assess problem solving and decision making *skills*)

| Traits | Performance Levels | | |
|--|--|---|--|
| | Above Expectations (A+,A,A-) | Met Expectations (B+, B, B-) | Below Expectation (C-F) |
| <u>Group Written Report – 70%</u> | | | |
| Demonstrates logic | Presents and discusses solution(s) in coherent and logical way; flow is effective | Presents and discusses solutions(s) that are mostly correct and demonstrate logical thinking; may miss few steps, or omit a minor point in explanation of rationale for step taken in problem-solving | Steps taken in problem-solving lack logic, and unable to explain rationale for steps taken in problem-solving |
| Identifies alternative options | Identifies a set of feasible options that demonstrates creativity and ability to integrate knowledge | Identifies and discusses a set of feasible alternatives | Does not identify alternatives or discuss |
| Selects an option that is consistent with the evaluation | Strong link between analysis and the option selected | Relatively adequate link between analysis and the option selected | No link or tenuous link between evaluation and option selected |
| Integrates the issues in the project to other business situations, stated or unstated | Appreciates the possible interrelatedness between this situation and others, including those not stated in the scenario | Appreciates the possible interrelatedness between this situation and others stated in the scenario | Does not seem able to appreciate how this situation might be related to others |
| <u>Individual Oral Presentation – 30%</u> | | | |
| Communication Outcome - has a clear message for the audience | Central message is precisely stated; main points are clearly identified | While the central message is stated and the main points are identified, there is some ambiguity about its preciseness | Central message is not explicitly stated in the presentation. Main points are not clearly identified, audience unsure of the direction of the message. |
| Content – Presents relevant information. Supports main points with strong evidence | Content is accurate, thorough, and directly on point; strong support and references are provided. Exhibits depth and insight in content. Effective use of time | While the content is accurate, there are some gaps in providing support and references. Exhibits some insights in content and there is reasonable use of time. | Content is erroneous or irrelevant; references and supporting materials are absent. Lack of depth in content and little insights. Presentation falls |

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| | and stays within time parameters. | | outside set time parameters. |
| Structure - Organizes content coherently. Signals transitions between points | Organizational pattern is clearly and consistently observable and makes the content of the presentation cohesive. | Organizational pattern is somewhat clear with some gaps in consistency. The content of the presentation is largely cohesive. | Organizational pattern (specific introduction and conclusion, sequenced materials within the body, and transitions) is not observable. |
| Verbal - Speaks at appropriate speed and volume. Uses correct grammar and pronunciation | Free of errors in grammar and pronunciation; good choices of word enhance clarity of expression. Vocal delivery is varied and dynamic. Speech rate, volume, and tone facilitate audience comprehension. Minimal gap fillers. | Largely free of errors in grammar and pronunciation with reasonable clarity of expression. Vocal delivery is okay and speech rate, volume, and tone facilitate audience comprehension. | Grammar, pronunciation, and word choice are deficient. Vocal delivery is too soft or too fast to understand; gap-fillers interfere with expression |
| Non-Verbal - Establishes eye contact. Uses gestures and movement to convey energy and confidence | Eye contact, posture, gestures, movement, and facial expressions make the presentation compelling, and speaker appears polished and confident. | Eye contact, posture, gestures, movement, and facial expressions make the presentation good; speaker appears reasonably confident. | Eye contact, posture, gestures, movement, and facial expressions are inappropriate and significantly distracting. |

3. Cases/Games/Littlefield Simulation

| Learning Goal | Course Learning Objective | Assessment Method | Rubric |
|--------------------------|--|---------------------------------------|---|
| Critical Thinking | Develop critical thinking skills. Consider broad perspectives that are important to the analysis of the issue Identify and discuss implications and consequences | Case/Games/ Littlefield Simulation | Assessment Rubric for Cases, Games and Littlefield Simulation (see below) |

Assessment Rubric for Cases/Games/Littlefield Simulation

| Traits | Performance Levels | | |
|---|---|--|---|
| | A+, A, A- (very good) | B+, B, B-(satisfactory) | C - F (unsatisfactory) |
| Identifies and summarizes the issue at hand. | Identifies the main issue and its implicit aspects, addresses their relationships to each other and recognizes nuances of the issue. | While the main issue is identified, some relationships and nuances of the aspects of the main issue are not fully recognized | Does not identify and summarize the issue, is confused or represents the issue inaccurately. |
| Identifies and considers other theoretical perspectives that are important to the analysis of the issue | Addresses perspectives noted previously, and additional diverse perspectives drawn from outside information. Identifies the pros and cons of the salient arguments (reasons and claims). | Deals with multiple perspectives but the pros and cons of key arguments are not addressed | Deals only with a single perspective and fails to discuss other possible perspectives, especially those salient to the issue. Fails to identify or hastily dismisses strong, relevant counterarguments. |
| Identifies and assesses the quality of supporting data/evidence and provides additional data/evidence related to the issue. | Examines the evidence and source of evidence, questions its accuracy, precision, relevance, and completeness. Observes cause and effect and addresses existing or potential consequences. | Examines evidence and observes cause and effect but some aspects of accuracy and completeness are omitted. | Merely repeats information provided, taking it as truth, or denies evidence without adequate justification. Confuses associations and correlations with cause and effect. |
| Identifies and assesses conclusions, implications, and consequences | Identifies and discusses conclusions, implications, and consequences, considering context, assumptions, data, and | While the conclusions, implications, and consequences, are identified and discussed considering | Fails to identify conclusions, implications, and consequences of the issue or the key |

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|--|---|--|---|
| | <p>evidence. Objectively reflects upon own assertions. Draws warranted, judicious, non-fallacious conclusions.</p> | <p>context, assumptions and evidence, some objectivity is missing.</p> | <p>relationships among the various elements such as context, evidence, or assumptions. Regardless of the evidence or reasons, maintains, or defends views based on self-interest or preconceptions.</p> |
|--|---|--|---|

4. Class Participation

Class participation is assessed in every class. Points for class participation will be based on:

- Regular and punctual attendance in class. Being an active listener in class.
- The quality (rather than quantity) of comments offered during case discussions as well as other discussions and in-class exercises,
- The issues and comments that each student offers during a class and sharing of specific experiences from industry that are related to concepts being taught in the class.

Assessment Rubric for Class Participation

| Traits | Performance Levels | | |
|-------------------------------|---|---|---|
| | A+, A & A- (Above Expectations) | B +, B, B- (Met Expectations) | C -F (Below Expectations) |
| Engagement | Engages fully in class | Occasionally engages in distracting activities (e.g., using mobile phone, unnecessary chatting) in class. | Hardly focuses in class (e.g. using mobile phone, unnecessary chatting) |
| Contribution frequency | Speaks up/contributes in all classes | Occasionally speaks up/contributes in class | Does not speak up/contribute in class |
| Contribution quality | Contributions are constructive and insightful | Contributions demonstrate knowledge of subject matter | No contributions/Contributions lack substance |

CONFIDENTIAL PEER EVALUATION FORM FOR TEAM PROJECT

| | |
|--------------------------------|--|
| Member's name: | |
| | |
| Seminar group and team number: | |

Please use the attached Peer Evaluation Rubric to evaluate yourself and your team members on each of the 5 stated attributes (on a scale of 1 to 7). State your ratings for yourself and each of your team members in the table below. For your self-assessment, insert "(Self)" after your name in the table below.

| Index # | Name of team members | 1 - RR | 2 - CM | 3 - CR | 4 - CT | 5 - RS | Average Rating |
|---------|----------------------|--------|--------|--------|--------|--------|----------------|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |

If any of your ratings above is < 4, please provide a brief explanation to justify the ratings.

| Index # | Brief explanation to justify a rating of < 4 |
|---------|--|
| | |
| | |
| | |

You may attach supporting documents (like emails and screen shots), if any, to support your explanations above.

Teamwork & Interpersonal Skills (Peer Evaluation) Rubric
Learning Objective: The ability to work effectively with others in a group setting

| Traits | Performance | |
|--|--|--|
| <u>1. Roles and Responsibility (RR)</u> Behaves professionally by upholding responsibility and assuming accountability for self and others in progressing towards the team's goal. | Scant Unclear about his/her own role; refuses to take a role in the group; insists to work individually and has limited coordination or communication with others. | Substantially Developed Always fulfills responsibilities; performs his/her role within the group with enthusiasm and demonstrates willingness to work collaboratively. |
| | Evaluation: Scant <u>1 2 3 4 5 6 7</u> Substantially Developed | |
| <u>2. Communication (CM)</u> Identifies appropriate mechanisms to coordinate and correspond with team members. | Scant Modes of communication are not appropriate, causing confusion and miscommunication among team members. | Substantially Developed Modes of communication are appropriate, and maintaining timely communication and correspondence with team members. |
| | Evaluation: Scant <u>1 2 3 4 5 6 7</u> Substantially Developed | |
| <u>3. Conflict Resolution (CR)</u> Resolves conflicts using a variety of approaches. | Scant Does not recognize conflicts or is unwilling to resolve conflicts. | Substantially Developed Consistently resolves conflicts through facilitating open discussion and compromise. |
| | Evaluation: Scant <u>1 2 3 4 5 6 7</u> Substantially Developed | |
| <u>4. Contributions (CT)</u> Contributes positive input for the team; effectively utilizes one's knowledge and expertise. | Scant Largely disinterested in working in a group and refuses to participate; observes passively or is unwilling to share information with other team members. | Substantially Developed <u>Actively attends and participates in all activities and provides meaningful contribution in articulating ideas and opinions.</u> |
| | Evaluation: Scant <u>1 2 3 4 5 6 7</u> Substantially Developed | |
| <u>5. Relationship (RS)</u> Maintains cooperative interaction with other team members regardless of individual /cultural differences and respects diverse perspectives. | Scant Rarely listens to others and does not acknowledge the opinions that differ from his/her own. | Substantially Developed Engages in respectful relationships with all other members in the team. Embraces and accepts diverse points of view without prejudice. |
| | Evaluation: Scant <u>1 2 3 4 5 6 7</u> Substantially Developed | |

Adjustment of project work marks for unequal contributions based on peer evaluation scores

| PE Score | % Equivalent | Score Multiplier |
|-----------------|---------------------|-------------------------|
| 0.0 | 0% | 0.50 |
| 0.5 | 7.10% | 0.50 |
| 1.0 | 14.20% | 0.50 |
| 1.5 | 21.40% | 0.55 |
| 2.0 | 28.50% | 0.60 |
| 2.5 | 35.70% | 0.65 |
| 3.0 | 42.80% | 0.70 |
| 3.5 | 50.00% | 0.75 |
| 4.0 | 57.10% | 0.80 |
| 4.5 | 64.20% | 0.85 |
| 5.0 | 71.40% | 0.90 |
| 5.5 | 78.50% | 0.95 |
| 6.0 | 85.70% | 1.00 |
| 6.5 | 92.80% | 1.00 |
| 7.0 | 100.00% | 1.00 |