IEOR 4615: Service Engineering
Spring 2015, First Class: January 20

- **Professor: Ward Whitt**
  - **801D Schapiro (CEPSR)**
  - **EMAIL: ww2040@columbia.edu**
  - http://www.columbia.edu/~ww2040

- **Teaching Assistant: Ni Ma (doctoral student)**
  - **345 Mudd**
  - **EMAIL: nm2692@columbia.edu**

Course Focus

- **Service Systems (Staffing, Allocation of Resources)**
  - Telephone Call Centers
  - Hospitals
- **Stochastic Queueing Models**
  - Build on IEOR 3106/4106 (Prerequisite!)
- **Data and Statistics**
  - Data Repository and Analysis Tools from Service Engineering Course, by Avishai Mandelbaum, the Technion, http://iew3.technion.ac.il/serveng/
  - Build on IEOR 3600 (elementary Statistics)
  - Data Analysis (Excel)

IEOR 4615: Service Engineering
Spring 2015, Ward Whitt
Logistics

- **Lectures** Tu&Th, 4:10-5:25pm,
- **Courseworks** and **course webpage**: www.columbia.edu/~ww2040/4615S14/IEOR4615S14.html
- Homework done in 3-person **teams**
- **Recitations** and **Homework**, Fridays
  - Posted on **Courseworks**
  - Homework assigned and turned in on Fridays
  - Show how to use Excel plus tools and data from the Mandelbaum repository
- **Midterm Exam**, but **no final exam.**

Today's OUTLINE

1. **Sample Problems**
2. **Brief Discussion of the Data**
    1. Data Repository and Analysis Tools from Service Engineering Course, by Avishai Mandelbaum, the Technion, http://iew3.technion.ac.il/serveng/
    2. Sample plots
3. **Psychology of Waiting (Maister paper)**
4. **Overview of Services (Fitzsimmons, Ch. 1-3)**
    1. Role of Services in the Economy
    2. The Nature of Services
    3. Service Strategy

(NEXT CLASS: Queueing Models)

1. Sample Problems

from upcoming classes

Averages: Little's Law ($L = \lambda W$)

- A hospital emergency room (ER) is organized so that all patients register through an initial check-in process. At his/her turn, each patient is seen by a doctor and then exits the process, either with a prescription or with admission to the hospital.

- Currently, 50 people per hour arrive at the ER, 10% of whom are admitted to the hospital. On average, 30 people are waiting to be registered and 40 are registered and waiting to see a doctor. The registration process takes, on average, 2 minutes per patient. Among patients who receive prescriptions, average time spent with a doctor is 5 minutes. Among those admitted to the hospital, average time is 30 minutes.

- **Q1:** On average, how long does a patient stay in the ER?
- **Q2:** On average, how many patients are being examined by doctors?
- **Q3:** On average, how many patients are in the ER?

Staffing

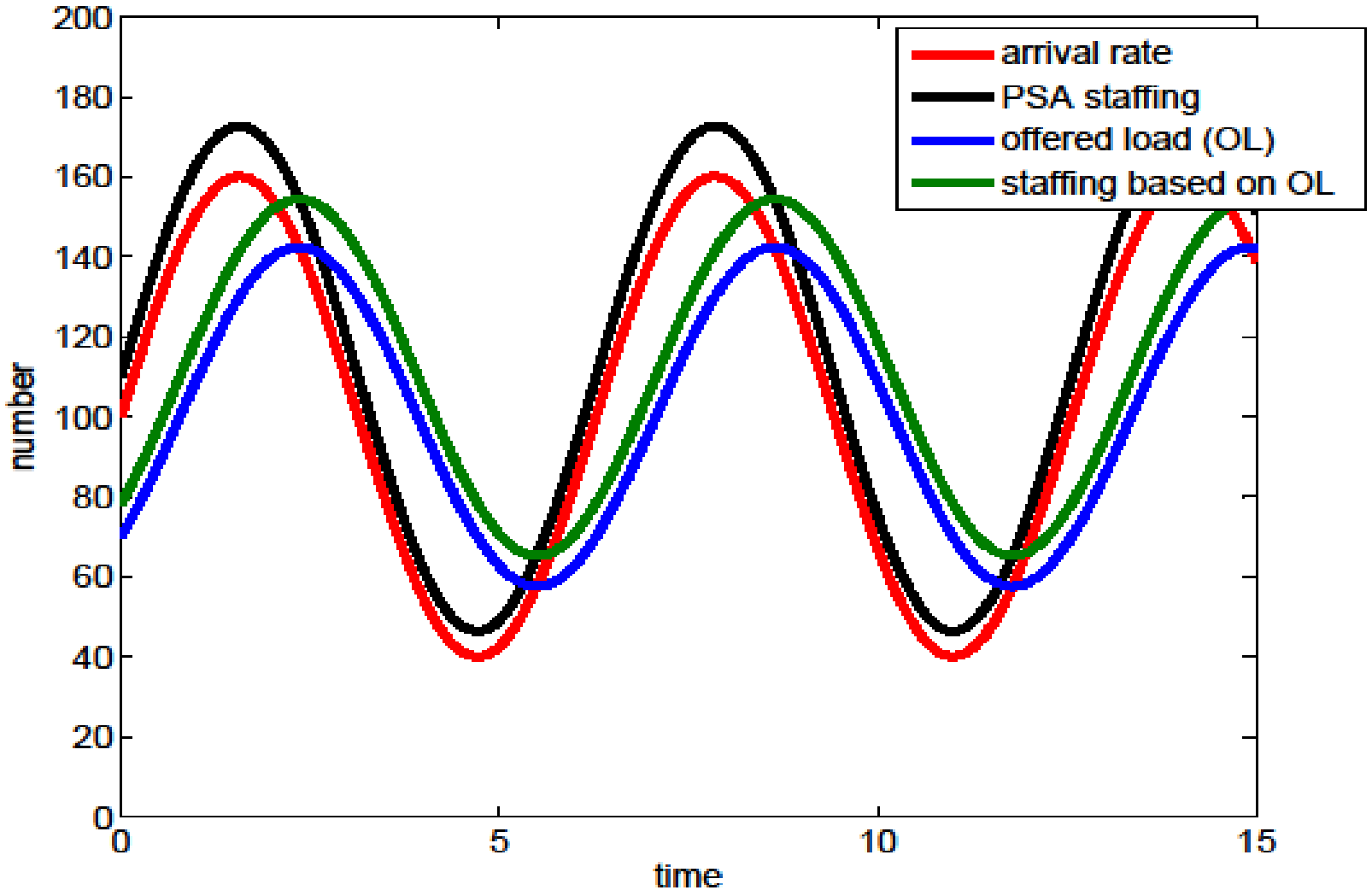
Business Case: H&S Schlock
Service Center to Help Prepare tax Returns

- arrival rate = 100 per hour
- expected service time = 1 hour
- ***How many service representatives are needed?***

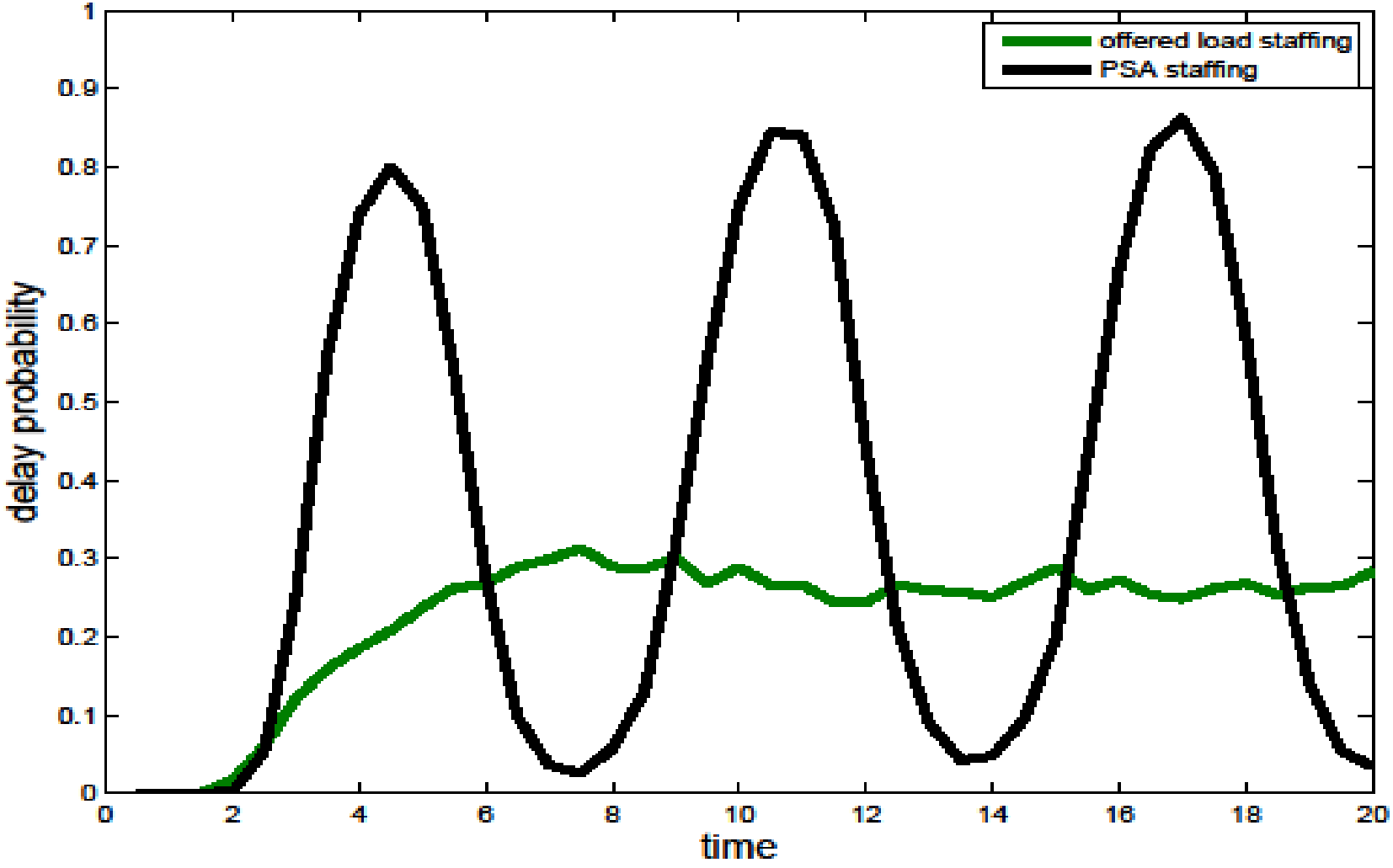
Time-Varying Arrival Rate

- Long-run average arrival rate = 100 per hour
- Now $\lambda(t) = 100 + 60 \sin(t)$ (**new!!**)
- expected service time = 1 hour
- Want to stabilize performance at similar level
- $P(Wait > 0) \leq 0.20$
- How many service representatives are needed at each time now?

Staffing by PSA and TVOL



Simulation Comparison: PSA versus TVOL



2. Discussion of Data

The Importance of Data and Measurements

- Lord Kelvin: ``We can not understand (manage) that which we can not **measure** (quantify).“
- Robert Herman (``Father" of Transportation Science): Far too little reliance on **Data**, the language of nature, in formulating models for the systems of the deepest importance to human beings, namely those in which we are actors.
- Empirical ``Axiom“: The **Data** One Needs is Never There For One To Use (Always Problems with Historical Data)
- Columbia Institute for **Data** Science and Engineering

Project DataMOCCA/SEEStat

Avishai Mandelbaum, the Technion

- Data MOdels for Call Center Analysis
- Service Enterprise Engineering Statistics
- Project Partners: Technion, Wharton, Companies
- Goal: Designing and Implementing a (universal) data-base/data-repository and interface for storing, retrieving, analyzing and displaying Call-by-Call-based data/information
- Enables the Study of:
  - Customers: Wait Time, Abandonment, Retrials
  - Service Providers/Agents: Service Duration, Activity Profile
  - Managers/System: Loads, Queue Lengths, Trends

SEEStat

- **System Components:**
  - Cleaned data: operational histories of individual calls - export, import
  - Daily / monthly / yearly reports and flow-charts for a complete operational view
  - Graphs and tables
    - in customized resolutions (month, days, hours, minutes, seconds)
    - for a variety of (pre-designed) operational measures (arrival rates, abandonment counts, service- and wait-time distribution, utilization profiles,…), and for new user-defined measures

- Currently Four **Databases** (some public, some for research):
  - **US Bank** (220/40M calls, 1000 agents, 2.5 years).
  - **Israeli Telecom** (800 agents, 3.5 years; 55GB; ongoing).
  - **Israeli Bank** (500 agents, 1.5 years; ongoing).
  - **Hospital** (from 7 hospitals, 1-4 years, different levels of information)

What do you see?

Need to have expectations

Experience and Models Help Greatly

Common Call Center Reports from Automatic Call Distributor (ACD)

Command Center Intraday Report

Updated Through: All Day

Date 06/13 - Tue		Recvd	Answ	Abn %	ASA	AHT	Occ %	On Prod%	On Prod FTE	Sch Open FTE	Sch Avai %
Total:		129,960	126,321	2.8%	31	318	90.9%	88.4%	1531.7	1585.0	96.6%
INQ	Charlotte	20,577	19,860	3.5%	30	307	95.1%	85.4%	222.7	234.6	95.0%
INQ	Columbus MCSC	7,973	7,773	2.5%	36	314	94.9%	89.8%	89.2	94.5	94.4%
INQ	Phoenix	17,102	16,757	2.0%	31	298	92.7%	91.8%	187.3	194.8	96.2%
INQ	Scranton	1,257	1,254	0.2%	6	515	78.6%	28.9%	28.5	35.1	81.2%
INQ	Tampa	9,174	8,859	3.4%	42	366	91.5%	93.6%	123.1	125.9	97.8%
CEN	Bourbonnais	6,070	5,937	2.2%	33	362	86.7%	90.2%	86.0	88.4	97.3%
CEN	Bristol	10,667	10,505	1.5%	25	355	95.1%	93.1%	136.3	139.6	97.6%
CEN	Columbus Claims	5,258	5,153	2.0%	27	293	86.7%	89.8%	60.5	62.2	97.3%
STH	Atlanta	7,514	7,338	2.3%	40	318	82.1%	89.5%	98.6	99.8	98.8%
STH	Sherman	19,669	18,833	4.3%	46	252	93.8%	90.6%	175.5	174.9	100.4%
STH	Wilmington	10,422	9,888	5.1%	21	285	89.9%	92.1%	108.7	114.6	94.8%
WST	Visalia	14,277	14,164	0.8%	10	382	87.2%	85.0%	215.2	220.6	97.6%

12 CC's

(Charlotte)

6/13/00 - Tue

[redacted] - Center

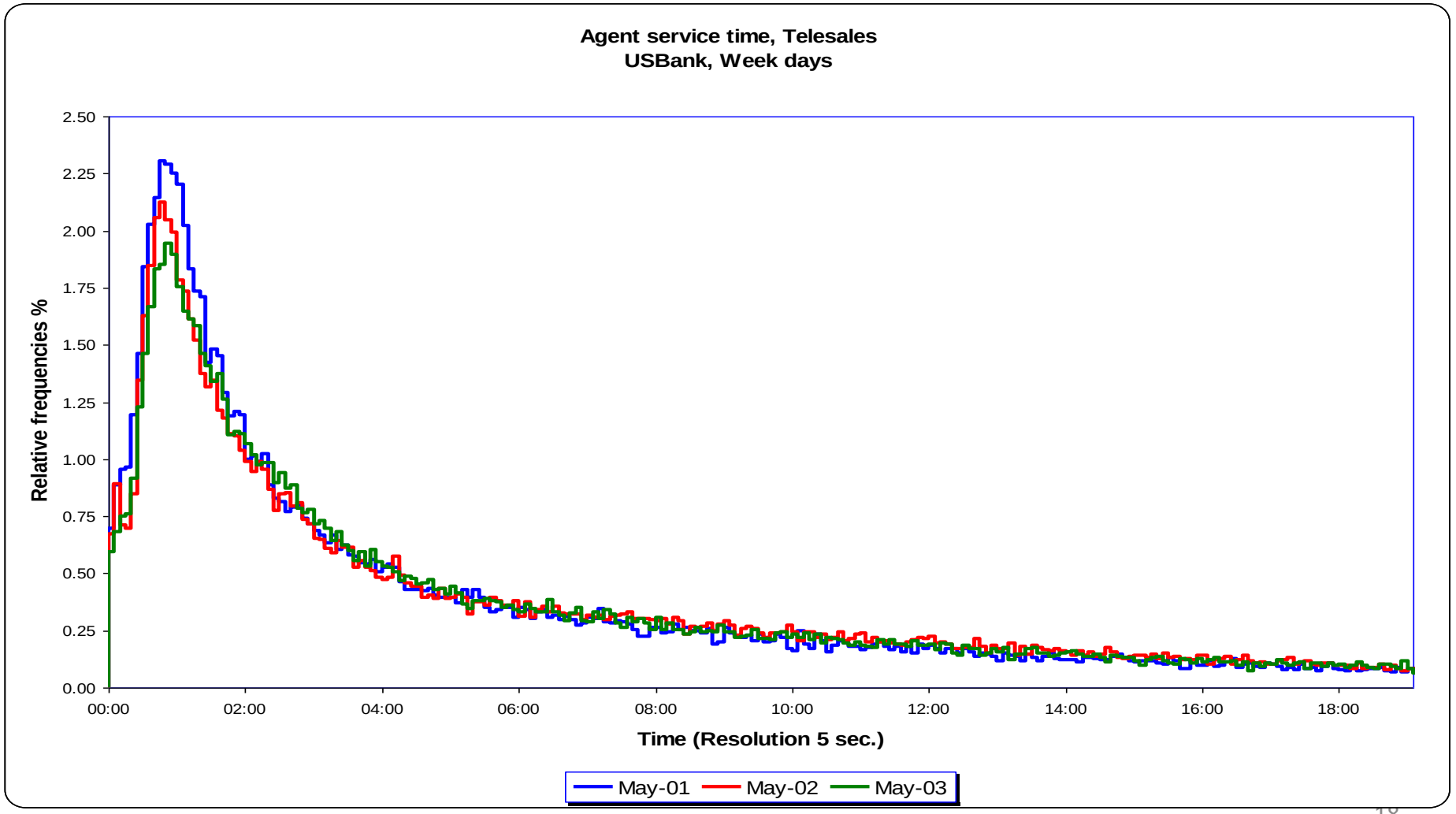
Time	Recvd	Answ	Abn %	ASA	AHT	Occ %	On Prod%	On Prod FTE	Sch Open FTE	Sch Avail %
0	20,577	19,860	3.5%	30	307	95.1%	85.4%	222.7	234.6	95.0%
8:00	332	308	7.2%	27	302	87.1%	79.5%	59.3	66.9	88.5%
8:30	653	615	5.8%	58	293	96.1%	81.1%	104.1	111.7	93.2%
9:00	866	796	8.1%	63	308	97.1%	84.7%	140.4	145.3	96.6%
9:30	1,152	1,138	1.2%	28	303	90.8%	81.6%	211.1	221.3	95.4%
10:00	1,330	1,286	3.3%	22	307	98.4%	84.3%	223.1	229.0	97.4%
10:30	1,364	1,338	1.9%	33	296	99.0%	84.1%	222.5	227.9	97.6%
11:00	1,380	1,280	7.2%	34	306	98.2%	84.0%	222.0	223.9	99.2%
11:30	1,272	1,247	2.0%	44	298	94.6%	82.8%	218.0	233.2	93.5%
12:00	1,179	1,177	0.2%	1	306	91.6%	88.6%	218.3	222.5	98.1%
12:30	1,174	1,160	1.2%	10	302	95.5%	93.6%	203.8	209.8	97.1%
13:00	1,018	999	1.9%	9	314	95.4%	91.2%	182.9	187.0	97.8%
13:30	1,061	961	9.4%	67	306	100.0%	88.9%	163.4	182.5	89.5%
14:00	1,173	1,082	7.8%	78	313	99.5%	85.7%	188.9	213.0	88.7%
14:30	1,212	1,179	2.7%	23	304	96.6%	86.0%	206.1	220.9	93.3%

Call Center Measurements: Call-by-Call Data

vru+line	call_id	customer_id	priority	type	date	vru_entry	vru_exit	vru_time	q_start	q_exit	q_time	outcome	ser_start	ser_exit	ser_time	server
AA0101	44749	27644400	2	PS	990901	11:45:33	11:45:39	6	11:45:39	11:46:58	79	AGENT	11:46:57	11:51:00	243	DORIT
AA0101	44750	12887816	1	PS	990905	14:49:00	14:49:06	6	14:49:06	14:53:00	234	AGENT	14:52:59	14:54:29	90	ROTH
AA0101	44967	58660291	2	PS	990905	14:58:42	14:58:48	6	14:58:48	15:02:31	223	AGENT	15:02:31	15:04:10	99	ROTH
AA0101	44968	0	0	NW	990905	15:10:17	15:10:26	9	15:10:26	15:13:19	173	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44969	63193346	2	PS	990905	15:22:07	15:22:13	6	15:22:13	15:23:21	68	AGENT	15:23:20	15:25:25	125	STEREN
AA0101	44970	0	0	NW	990905	15:31:33	15:31:47	14	00:00:00	00:00:00	0	AGENT	15:31:45	15:34:16	151	STEREN
AA0101	44971	41630443	2	PS	990905	15:37:29	15:37:34	5	15:37:34	15:38:20	46	AGENT	15:38:18	15:40:56	158	TOVA
AA0101	44972	64185333	2	PS	990905	15:44:32	15:44:37	5	15:44:37	15:47:57	200	AGENT	15:47:56	15:49:02	66	TOVA
AA0101	44973	3.06E+08	1	PS	990905	15:53:05	15:53:11	6	15:53:11	15:56:39	208	AGENT	15:56:38	15:56:47	9	MORIAH
AA0101	44974	74780917	2	NE	990905	15:59:34	15:59:40	6	15:59:40	16:02:33	173	AGENT	16:02:33	16:26:04	1411	ELI
AA0101	44975	55920755	2	PS	990905	16:07:46	16:07:51	5	16:07:51	16:08:01	10	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44976	0	0	NW	990905	16:11:38	16:11:48	10	16:11:48	16:11:50	2	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44977	33689787	2	PS	990905	16:14:27	16:14:33	6	16:14:33	16:14:54	21	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44978	23817067	2	PS	990905	16:19:11	16:19:17	6	16:19:17	16:19:39	22	AGENT	16:19:38	16:21:57	139	TOVA
AA0101	44764	0	0	PS	990901	15:03:26	15:03:36	10	00:00:00	00:00:00	0	AGENT	15:03:35	15:06:36	181	ZOHARI
AA0101	44765	25219700	2	PS	990901	15:14:46	15:14:51	5	15:14:51	15:15:10	19	AGENT	15:15:09	15:17:00	111	SHARON
AA0101	44766	0	0	PS	990901	15:25:48	15:26:00	12	00:00:00	00:00:00	0	AGENT	15:25:59	15:28:15	136	ANAT
AA0101	44767	58859752	2	PS	990901	15:34:57	15:35:03	6	15:35:03	15:35:14	11	AGENT	15:35:13	15:35:15	2	MORIAH
AA0101	44768	0	0	PS	990901	15:46:30	15:46:39	9	00:00:00	00:00:00	0	AGENT	15:46:38	15:51:51	313	ANAT
AA0101	44769	78191137	2	PS	990901	15:56:03	15:56:09	6	15:56:09	15:56:28	19	AGENT	15:56:28	15:59:02	154	MORIAH
AA0101	44770	0	0	PS	990901	16:14:31	16:14:46	15	00:00:00	00:00:00	0	AGENT	16:14:44	16:16:02	78	BENSION
AA0101	44771	0	0	PS	990901	16:38:59	16:39:12	13	00:00:00	00:00:00	0	AGENT	16:39:11	16:43:35	264	VICKY
AA0101	44772	0	0	PS	990901	16:51:40	16:51:50	10	00:00:00	00:00:00	0	AGENT	16:51:49	16:53:52	123	ANAT
AA0101	44773	0	0	PS	990901	17:02:19	17:02:28	9	00:00:00	00:00:00	0	AGENT	17:02:28	17:07:42	314	VICKY

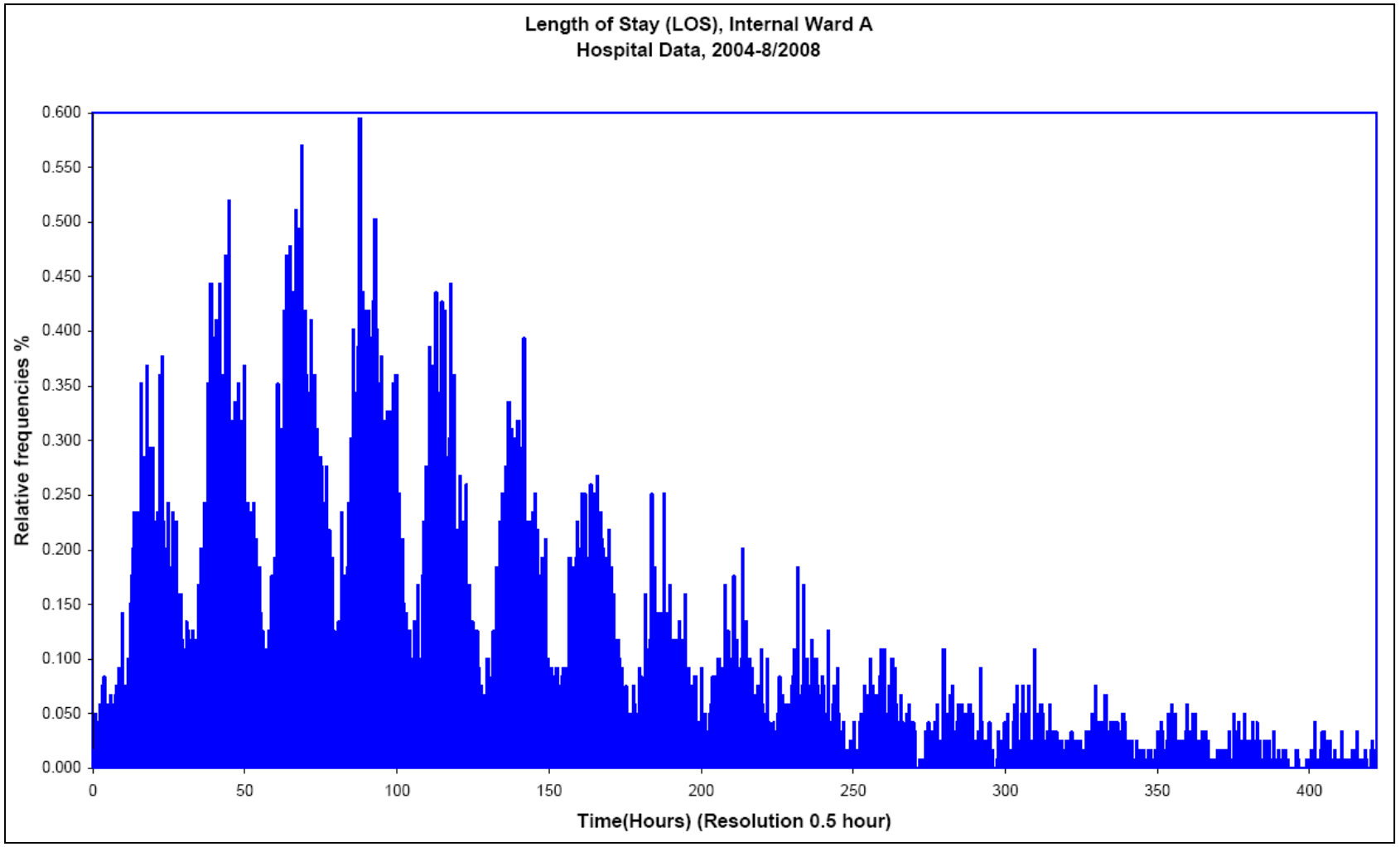
Empirical Distribution (Histogram) of Service Times

US Bank: Three Days in May 2001



Empirical Distribution (Histogram) of Response Times

Israeli Hospital: Length of Stay in 2008



3. The Psychology of Waiting

"The Psychology of Waiting Lines"

By David Maister

pp. 113-123 in ***The Service Encounter***,
J. A. Czepiel, M. R. Solomon and F. C. Surpenant (editors), D. C. Heath&Co., 1985.

Paper posted

How Does a Customer Feel About Waiting?

- "Waiting is frustrating, demoralizing, agonizing, aggravating, annoying, time consuming and incredibly expensive."
- "Products are consumed, Services are experienced' (Levitt)

- Maister proposes **testable propositions**.

•Customer **perceptions** are important! Psychology is important.
•Queue management is ***NOT*** all models!

The First and Second Laws of Service

- **S = P – E**
  - Satisfaction
  - Perception
  - Expectation
    - Mirrors at hotel elevators
    - Restaurant promised waiting times

- **It's hard to play catch up ball.**
  - Halo effect created by early stages of any service encounter
    - Waiter: "If they sit down in a good mood, it is easy to keep them happy. If they sit down disgruntled, it is almost impossible to turn them around. They are looking to find fault and criticize."
  - Money, time and attention spend on improving the early stages of service are most rewarding

Propositions about the Psychology of Waiting

- ***Occupied time*** feels shorter than unoccupied time.
  - Hand out menus in restaurants, turn waiting area into bar. Sport team playing highlights of previous game. "Put me back so-and-so is about to score."
- People want to ***get started***.
  - Hand out menus in restaurants; first contact most important: preprocess waits are perceived as longer.
- ***Anxiety*** makes waits seem longer.
  - Have we been forgotten? Did we choose the wrong line?
  - Attendant at airport: "Don't worry folks, you will all get on.
- ***Uncertain waits*** are longer than known, finite waits.
  - Appointment syndrome; subway announcement system

Propositions about the Psychology of Waiting

- ***Unexplained waits*** are longer than explained waits.
  - Doctor's receptionist: "an emergency has taken place;" airplane pilot: on-board announcements
  - Waiting in ignorance creates a sense of powerlessness
- ***Unfair waits*** are longer than equitable waits.
  - Agitation in wait for crowded subways; issuing number at deli counter
- The more ***valuable the service***, the longer the customer will wait.
  - Post-process waits (hotel checkout, get off landed flight)
- ***Solo waits*** feel longer than group waits.
  - Line might turn into service encounter(amusement parks)

4. A Book on Service Management

(a broad view from a management perspective)

Service Management

Operations, Strategy and Information Technology

James A. Fitzsimmons
and Mona J. Fitzsimmons

Fourth Edition, 2004, McGraw Hill, Irwin

***Book** on Reserve in Engineering Library:*

Book chapters posted

Broad View, Gives Perspective

Book Contents

Book Contents *continued*

Part Three: Managing Service Operations

10 Managing Supply and Demand (IEOR 4601)

11. Managing Waiting Lines

12. Managing Service Supply Relationships

13. Managing Facilitating Goods

14. Managing Projects

Part Four: Toward World-Class Service

15. Productivity and Quality Improvement

16. Growth and Globalization of Services

Part Five

17. Forecasting Demand for Services

18. Queueing Models and Capacity Planning

Appendices

Chapter 1

Definition

- A **service** is a ***time-perishable***, ***intangible*** experience performed by a customer acting in the role of co-producer. (p.4)
- ***Not*** a good or product

Distinctive Characteristics of Services (Ch. 2)

1. Customer **participates** in service process (not like making cars)
2. Created and consumed **simultaneously** (Inability to inventory)
3. A service is a **perishable** quantity (e.g., hotel room for a night)
4. Services are ideas and concepts, so **intangible**; products are things.
5. Properties 1 and 4 lead to **heterogeneity**

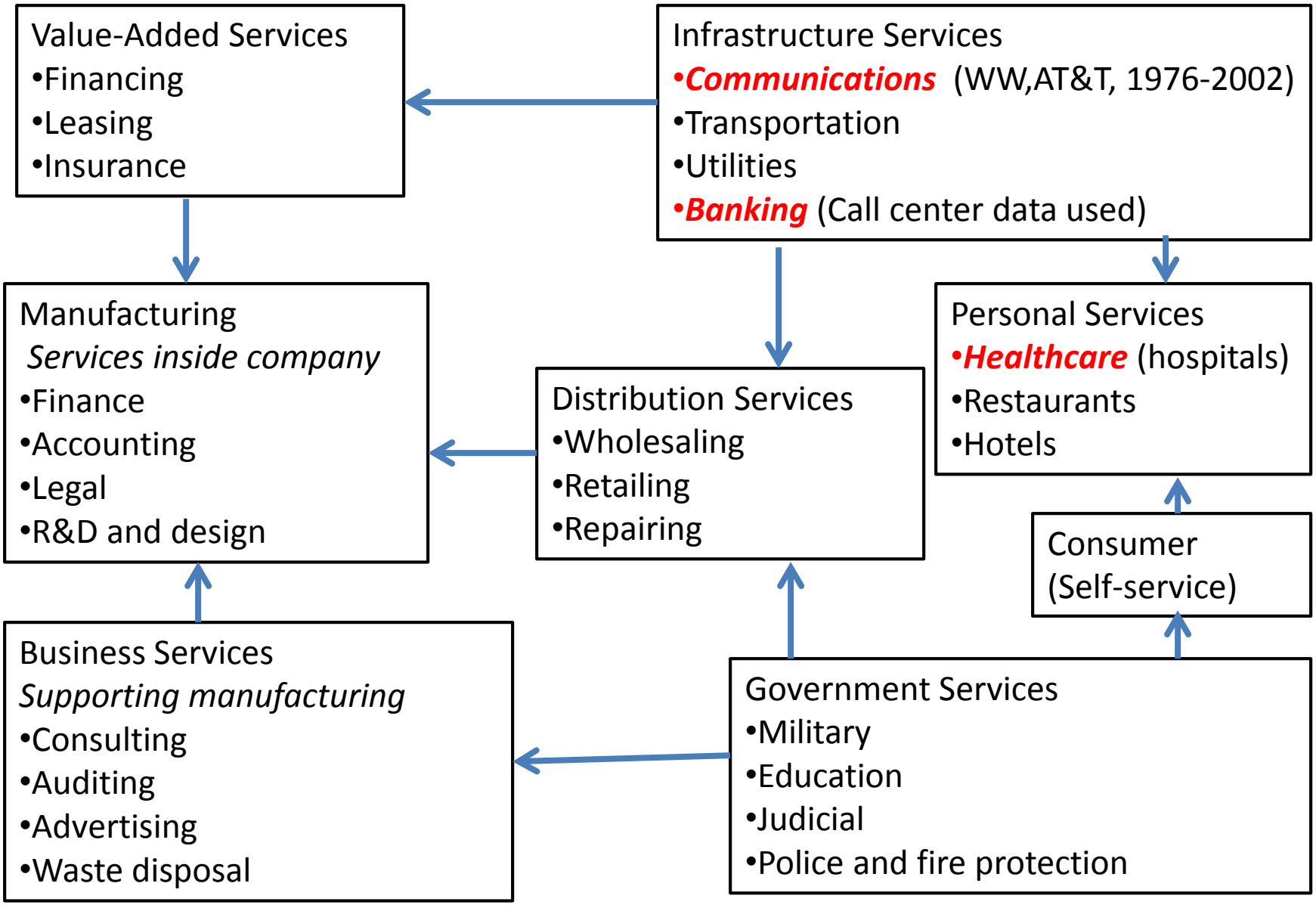
Services *versus* Products

Traditional Industrial Engineering

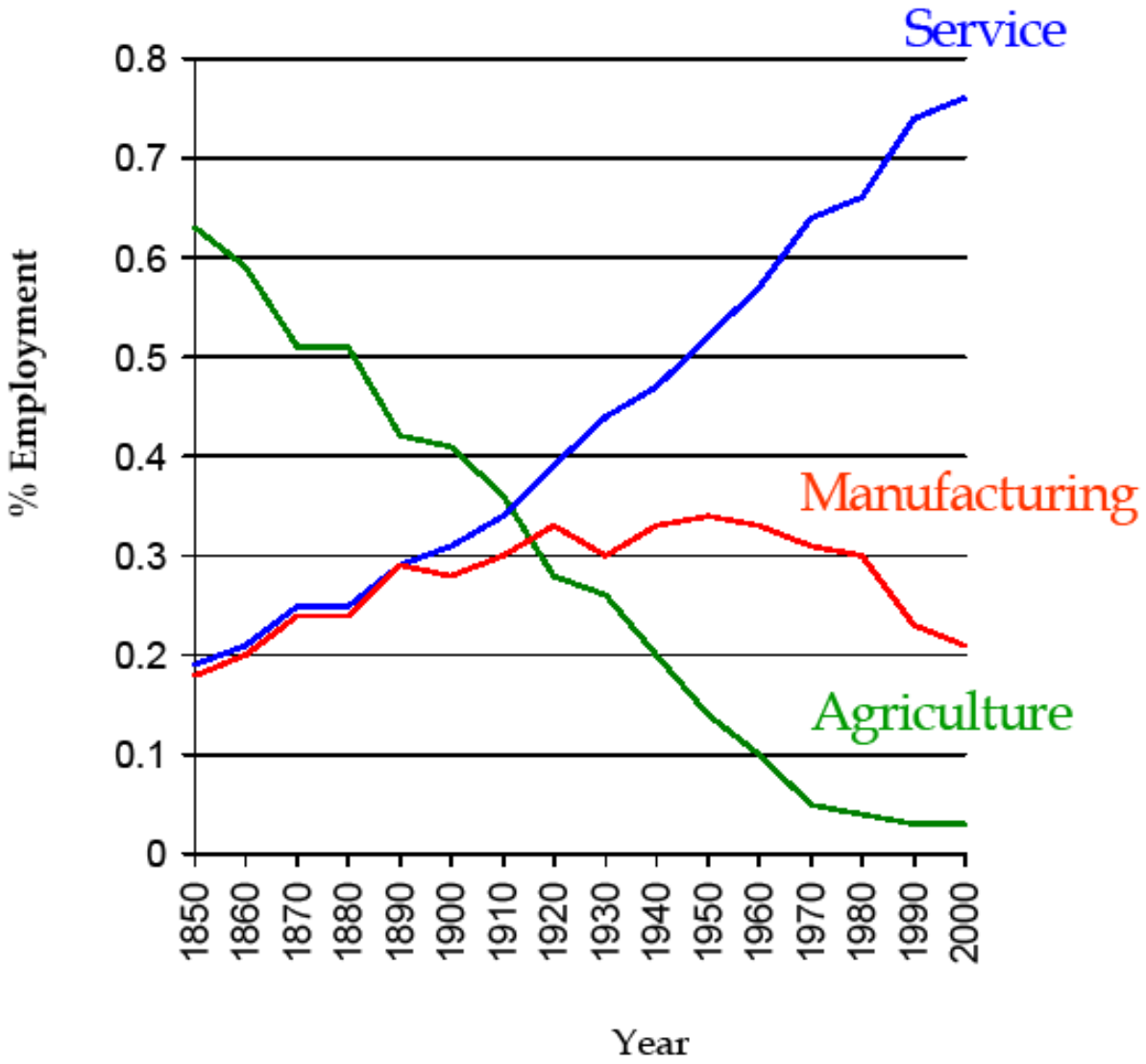
- IEOR 3402: Production Inventory Planning and Control
- IEOR 4000: Production Management
- *IEOR 4001: Design & Mgt. of Prod. and Service Systems*
- IEME 4310: The Manufacturing Enterprise
- IEOR 4405: Production Scheduling
- *IEOR 4412: Quality Control and Management*
- *IEOR 4520: Applied Systems Engineering*
- *IEOR 4601: Dynamic Pricing and Revenue Management*

(***Italics***: Applies to **Both**)
Significant commonality; significant differences

Role of Services in an Economy (p. 5)



Historical Trend in United States



Chapter 2

Service Classification

- Concepts of service management should be applicable to all service organizations. (p.18)
  - For example, hospital administrators could learn from restaurants and hotels.
- But services are ***not*** all the same:

The Service Process Matrix (Fig 2.1)

Degree of interaction and customization

Degree of Labor Intensity*	Low	High
Low	*Service factory:* •Airlines •Trucking •Hotels •Resorts	*Service shop:* •Hospitals •Auto repair •Other repair services
High	*Mass service:* •Retailing •Wholesaling •Schools •Retail commercial banking	*Professional service:* •Physicians •Lawyers •Accountants •Architects

*Ratio of labor cost to capital cost

Nature of the Service Act (Fig 2.3)

Direct recipient of the service

Nature of the service act	People	Things
Tangible actions	*Services directed at people's bodies:* •Healthcare •Passenger transportation •Beauty salons •Exercise clinics •Restaurants	*Services directed at goods:* •Freight transportation •Repair and maintenance •Laundry and dry cleaning •Veterinary care
Intangible actions	*Services directed at people's minds:* •Education •Broadcasting •Information services •Theaters •Museums	*Services directed at intangible assets:* •Banking •Legal services •Accounting •Securities •Insurance

Thinking creatively about the service may identify more convenient forms of delivery; e.g., lectures available on line.

Service-to-Customer Relationship (Fig 2.4)

Type of relationship between service organization and its customers

Nature of the service delivery	"Membership" Relationship	No formal relationship
Continuous Delivery of service	•Insurance •Telephone subscription •Electric utility •Banking	•Radio station •Police protection •Lighthouse •Public highway
Discrete Transactions	•Long distance phone calls •Theater series tickets •Transit pass •Wholesale buying club •Airline frequent flyer	•Toll Highway •Pay phone •Movie theater •Public transportation •Restaurant

Services have the opportunity to build long-term relationships.

Customization and Judgment (Fig 2.5)

Extent of customization permitted by service

Extent to which service personnel exercise judgment in providing service	High	Low
High	Surgery Taxi Service Gourmet restaurant	Education (large classes) Preventive health programs Family restaurant
Low	Telephone service Hotel services Retail banking Cafeteria	Public transportation Movie theater Spectator sports Institutional food service

An opportunity exists to tailor the service to the needs of the customer.

Nature of Demand and Supply (Fig 2.6)

Extent of demand fluctuations over time

Extent which supply is constrained	Wide	Narrow
Peak demand can be met without major delay	•Electricity •Telephone •Hospital maternity unit •Police emergencies	•Insurance •Legal services •Banking •Laundry and dry cleaning
Peak demand often exceeds capacity	•Tax preparation •Passenger transportation •Hotels and motels	•Fast-food restaurant •Movie theater •Gas station

Managing supply is a major focus of the course.

Method of Service Delivery (Fig 2.7)

Availability of service outlets (Location)

Nature of interaction	Single site	Multiple sites
Customer travels to service firm	•Theater •barbershop	•Bus service •Fast-food chain
Service provider travels to customer	•Pest control service •Taxi	•Mail delivery •AAA emergency repairs
At arm's length	•Credit card company •Local TV station	•National TV network •Telephone company

Chapter 3

- Competition
- Service Strategy
- Information (& Inf. Technology)

F. X. Frei, P. T. Harker, L. W. Hunter, ***Innovation in Retail Banking***, Report from Financial Institutions Center, Wharton, 1998. (Reading in homework 1)

Competitive Service Strategies (Ch 3)

- Cost Leadership
  - Seek low-cost customers
  - Standardize a custom service
  - Reducing personal element in service delivery
  - Reducing network costs
  - Taking service operations offline
- Differentiation (uniqueness to win customer loyalty)
  - Making the intangible tangible
  - Customizing the standard product
  - Reducing perceived risk
  - Extra personnel training
  - Controlling quality
- Focus (serving a particular target market)

The Strategic Service Vision (Tab 3.1)

Target Market Segments		Service Concept		Operating Strategy		Service Delivery System
Common characteristics of important market segments? How to segment market? Importance and needs of segments? How well being met?	How well is the service concept positioned in relation to customer needs and competitor offerings?	Important elements of the service? How should these elements be perceived? How do customers perceive the service concept? How affect design, delivery?	Cost benefit analysis	Important elements of the strategy? On which will most effort be concentrated? Where will investments be made? How to control quality and cost Expected results?	Does the service delivery system support the operating strategy?	Key features of service delivery system? Role of people, technology, equipment, layout, procedures? What capacity is provided? Evaluate success in ensuring quality, differentiating service from competitors and providing barrier to entry by competitors?

Strategic Service Vision of **Southwest Airlines** at startup (1967-71)

- Target market segments
  - Intrastate (Dallas, Houston, San Antonio, about 250 miles) business travelers with carry-on luggage who currently drive by auto or are frustrated by poor service of other airlines
- Service concept
  - On-time performance and frequent departures are critical and meals are unnecessary on short flights (less than one hour)
- Operating strategy
  - Fast airport gate turnaround to make productive use of expensive aircraft and have frequent departures
- Service delivery system
  - Cabin crew with interpersonal skills to create “fun” atmosphere; no assigned seating; rely on carry-on luggage.

Competitive Environment of Services (Ch 3)

- Low barrier to entry
- Limited opportunities for economy of scale
- Erratic fluctuations in time of demand
- No size advantage in dealing with suppliers
- Product substitution
- Customer loyalty to other firms
- Exit barriers for other firms

References

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