Welcome to the Webinar

Labor Strategy Optimization for the Professional Services Industry

Speaker Introduction

- **Dr. Haitao Li**
  - Professor of Supply Chain & Analytics at the University of Missouri- St. Louis
  - Ph.D. in Operations Management from the University of Mississippi, USA
  - Over ten years of research experience in optimization modeling, algorithm design and their applications in scheduling, resource allocation and supply chain configuration

Speaker Introduction

- **Dr. Cipriano Santos**

  - Sr. Technical Content Manager at Gurobi
  - Worked at Hewlett-Packard Enterprise for 23 years
    - Retired as Distinguished Technologist
  - Developed and implemented several decision support tools for Product Life-cycle Management, Customer Relationship Management, Large Data Centers Computing Resources Allocation, Professional Services Workforce Planning, Airline Dispatcher Workload Distribution Optimization, and Operating Room Planning & Scheduling
  - Holds a Bachelor’s Degree in Applied Mathematics from the University of Mexico (UNAM), and a Master’s and PhD degrees in Operations Research from the University of Waterloo, Canada

Agenda

- Motivation and business setting of strategic workforce planning at a Professional Services firm
- Problem description and spreadsheet approach
- Optimization model formulations and solutions methods
- Business impact and managerial insights
- Lessons learned and best practices in developing and deploying an optimization application

Motivation and business setting of strategic workforce planning

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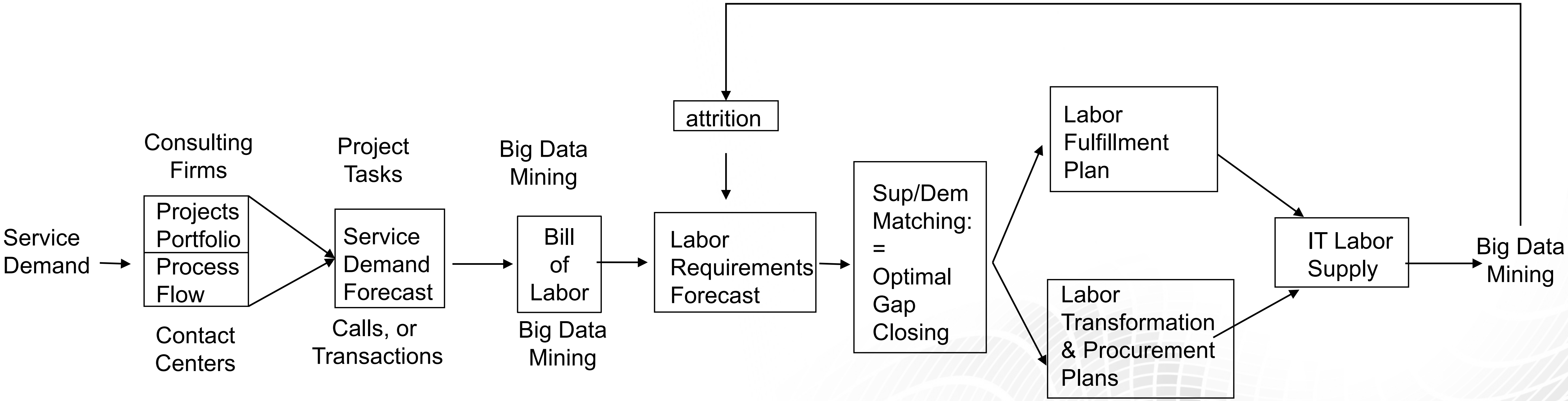
Workforce planning in the professional services industry

- People are the most important asset in the knowledge economy, particularly in the professional services industry.
- Large professional services companies employ thousands of professionals to deliver a wide variety of services (jobs), making labor the industry's highest expense.
- Workforce resource supply-demand matching is challenging when considering thousands of employees, with thousands of skills to be "optimally" mapped to thousands of services (jobs).
- The manual spreadsheet-driven approaches used in most companies cannot be sustained if we want to "optimize" both the workforce and the financial growth of the industry.

Workforce planning process flow



Problem statement

- Workforce planning objectives at professional services companies
  - Increase (billable) utilization of workforce resources
  - Reduce overall labor costs
  - Properly match service (job) requirements with labor resources' capabilities and availability

- The fundamental problem of workforce planning is to match labor resources
  - with the right skills,
  - for the right job,
  - at the right time,
  - at the right location,
  - at the right cost.

Hierarchical Workforce Planning Components

- Strategy model (Labor Strategy Optimization)
  - Given a forecast revenue of a service offering, determine budgets for these strategies to maximize total gross margins:
    - location: onshore/offshore
    - labor mix: internal/contingent workforce, agency labor
    - labor transformation: training/re-skilling, hiring/layoffs, promotions/demotions
- Tactical model
  - For the above strategy budgets, select and schedule a portfolio of projects that optimizes the trade-offs of conflicting objectives while considering budgets, labor resources, and other constraints.
  - This model determines the labor resource requirements to fill the jobs of selected projects.
- Operational model
  - Given the above resource requirements, determine “best” resources (by name) available to fill the requirements of jobs for the selected projects in the optimal portfolio.
- Execution
  - Track execution and provide feedback loops to Operational/Tactical/Strategy models.

Description of the labor strategy

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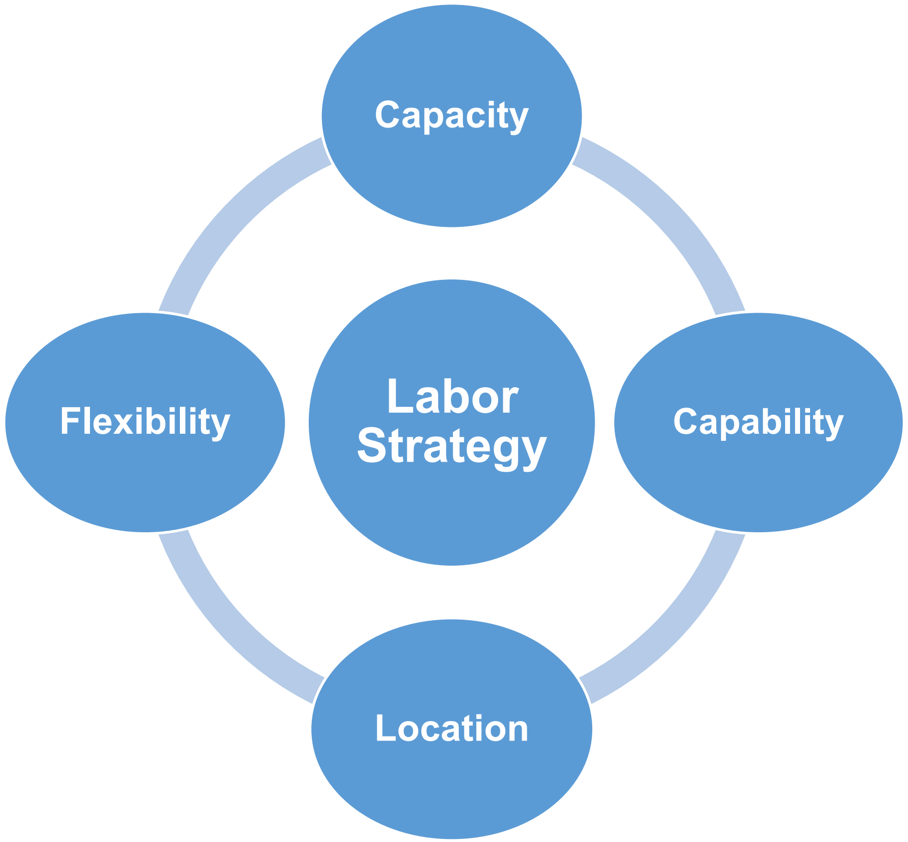
Challenges of strategic workforce planning

- Complexity of Service Transformation and Delivery
  - From early demand signal, to labor requirements, to allocation of labor resources, to delivery
- Heterogeneous Demand of Projects/Tasks:
  - Skill requirements, proficiency/experience level
- Heterogeneous Supply of Workforce Resources:
  - Skill, pay rate, productivity, organization, geographical location
- Flexible Source of Labor: internal workforce, contractors, third-party partners, onshore, offshore
- The need for cross-training and labor transformation
- Decentralized Staffing Decision with Visibility and Accessibility of Centralized Global Resource Pool

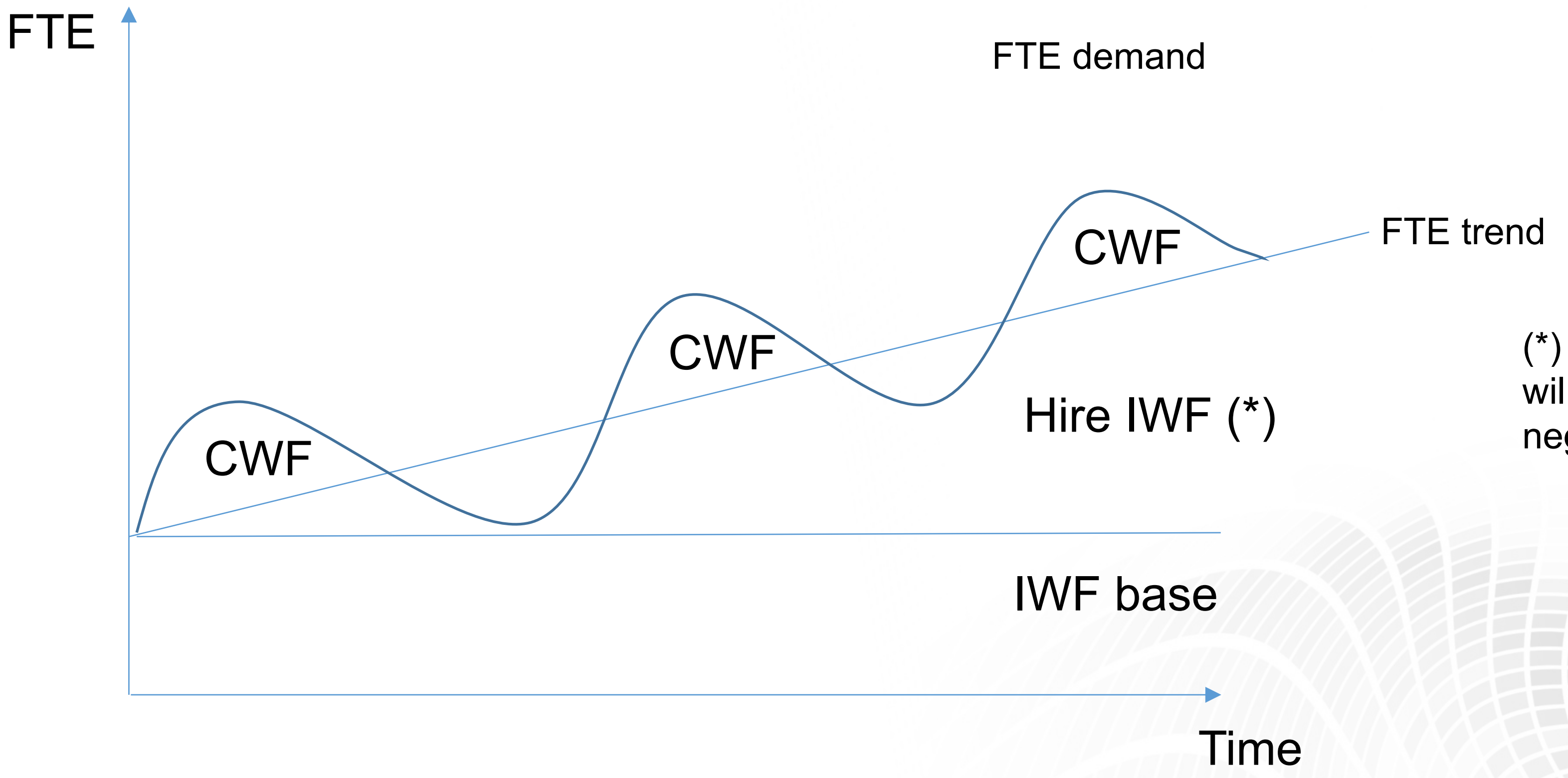
Labor strategy defined



- Capacity:
  - Level and amount of manpower measured in FTE (full time equivalent)
- Capability:
  - Capabilities and roles of each individual
- Location:
  - Onshore/offshore
- Workforce Flexibility:
  - Internal and external workforce

Idea behind IWF and CWF strategy

Assume demand of low priority projects, or projects requiring non-critical skills, is allocated to 3PP



(*) Professional services firms will lay-off IWF if trend slope is negative.

Strategic workforce planning spreadsheet approach

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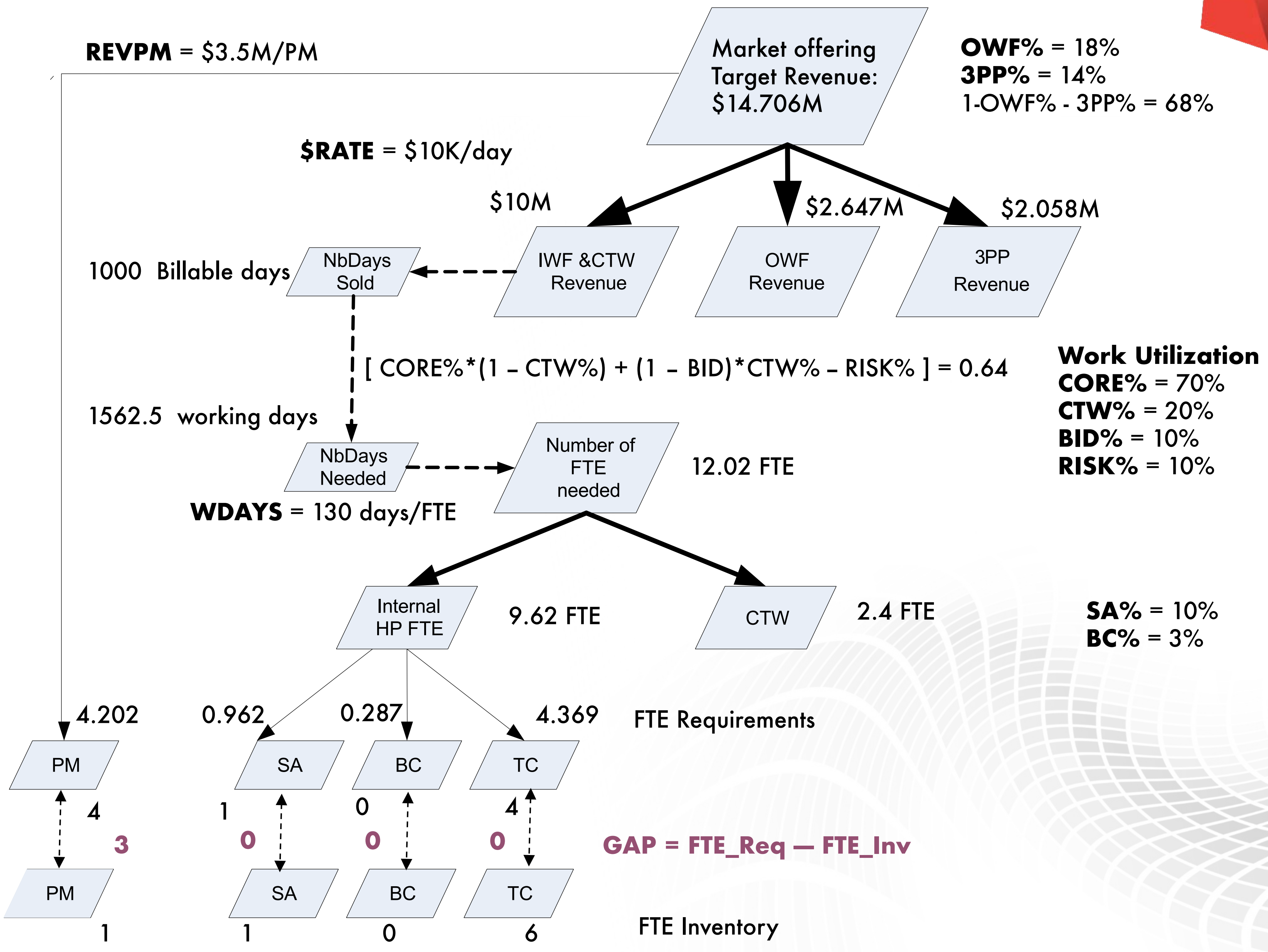
Introduction to spreadsheet approach of former HP C&I

- HP C&I offered services (market offerings) all over the world.
  - There were four major regions,
    - NA –North America, EMEA –Europe, Middle East, and Africa, AP –Asia Pacific, and LA –Latin America.
  - Market offerings included:
    - application solutions (APS), enterprise integration services (ENI), financial services (FS), manufacturing services (MFG), network services (NSP), etc.
- Labor strategy planning was done every six months, considering a single planning period.
- Four sources of labor were considered:
  - IWF, CWF, OWF (offshore workforce), and 3PP
- Four roles and capabilities were considered:
  - PM: project manager
  - SA: solution architect
  - BC: business consultant
  - TC: technical consultant

Introduction to spreadsheet approach of former HP C&I

- Input parameters of spreadsheet approach:
  - WDAYS: workdays during planning horizon (six months)
  - OWF%: percentage of revenue allocated to offshore workforce (India)
  - 3PP%: percentage of revenue allocated to third-party partners (Softtek)
  - $RATE: consulting fee/day
  - REVPM: revenue value per PM
  - CORE%: productivity of IWF – internal workforce. It is the percentage of time the FTE generates revenue.
  - CTW%: percentage of contingent workforce in the total workforce mix (IWF + CWF)
    - Assume productivity of CWF is 100%
  - BID%: percentage of time that workforce spends on biding
  - RISK%: percentage of deliverable time not billable due to project disruption
  - SA%: percentage of total FTE requirements needed for solutions architects
  - BC%: percentage of total FTE requirements needed for business consultants

Spreadsheet approach for labor strategic planning



Limitations of a spreadsheet-based approach

- A cost-accounting approach with no optimization capability
  - Missed opportunity to maximize total gross margins for all market offerings
  - Missed opportunity to increase resource utilization by training and re-skilling
- Manually adjust revenue allocation and labor sourcing decisions, in a trial-and-error fashion
- Time-consuming!

Optimization model formulations and solution methods

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Labor strategy optimization (LSO)

- A Prescriptive (Optimization) Methodology and Tool for the **Strategic Level** Workforce Optimization of a PSO
- LSO Provides Decision-Support for a PSO's Workforce Decisions in Four Integrated Dimensions:
  - Capacity Strategy: **How many FTEs are needed?**
  - Capability Strategy: **What kind of mix of skills/roles will the firm need?**
  - Location Strategy: **Where to source the labor?**
  - Flexibility Strategy: **How to achieve flexibility by using external workforce?**
- **Data-Driven** Decision-Support

High-level sketch of LSO

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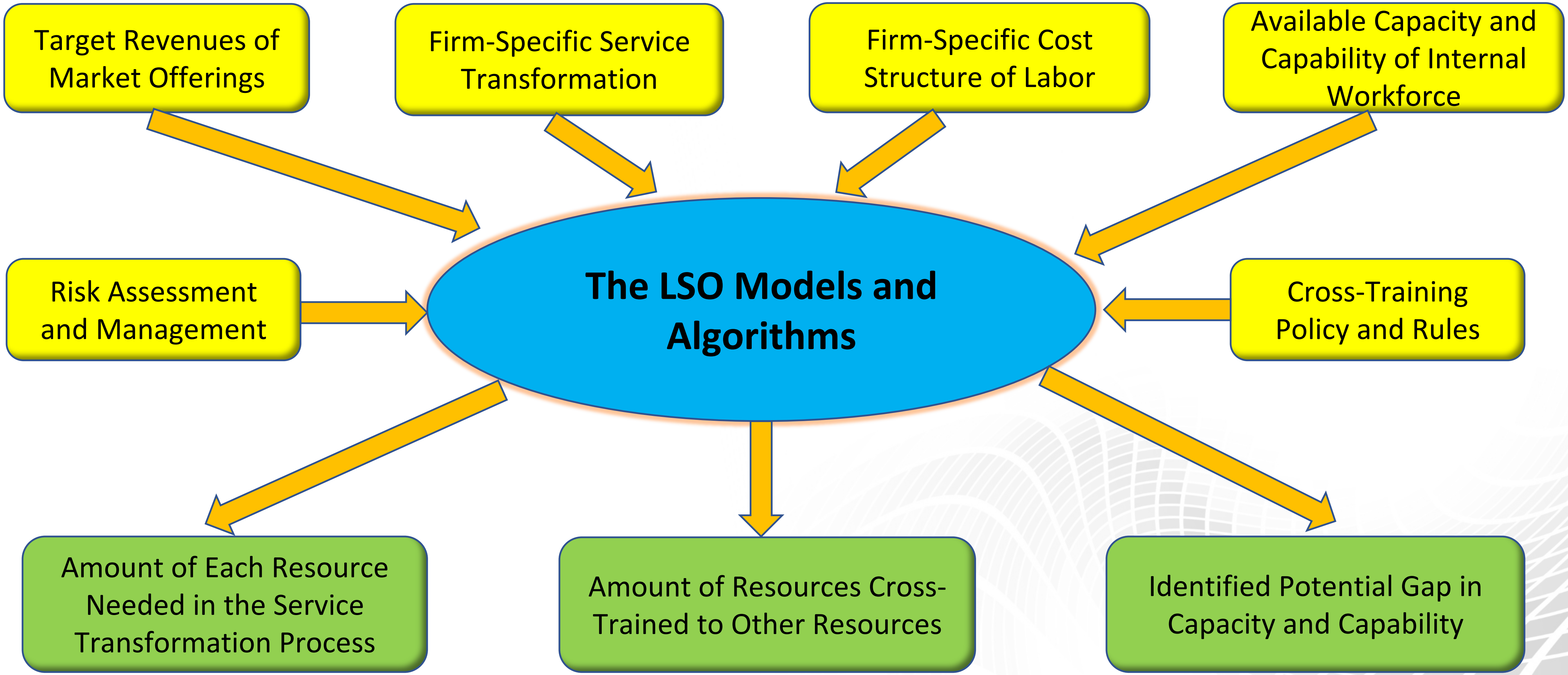


Modeling the key components of LSO

- Bill-of-Labor (BOL)
- Modeling Cross-Training
- Modeling Supply Side Risk and Uncertainty

Introduction to Bill-of-Labor (BOL)

- Analogous to the well-known Bill-of-Materials (BOM) in manufacturing
- Describes the firm-dependent service transformation and delivery
- **A hierarchy of labor resources as inputs**
- **The generated revenues as outputs**
- It includes the **dependent demand of labor resources** as building blocks

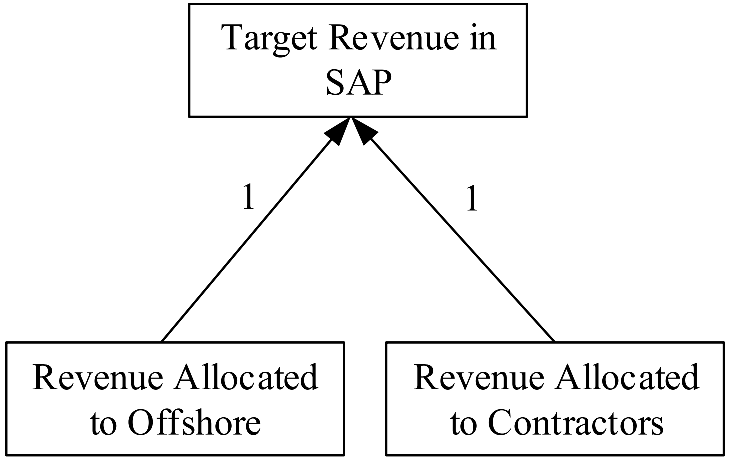
Key data needed for BOL

- τ: the discounted internal rate of an employee, i.e. the revenue generated by an internal FTE per day. (**$RATE**)
- η: the number of working days in the planning horizon. (**WDAYS**)
- λ_i: risk of an offshore resource of role i as percentage of deliverable time that is not billable due to project disruption caused by time zone difference, lack of communication, etc. (**RISK%**)
- μ_i: the commitment rate of FTE of role i as the percentage of time the FTE generates revenue. It can be calculated as the average number of hours billed divided by the total number of hours worked. (**CORE%**)
- φ_{ij}: is the efficiency of training measured as percentage of time needed to transform FTE of role i to j

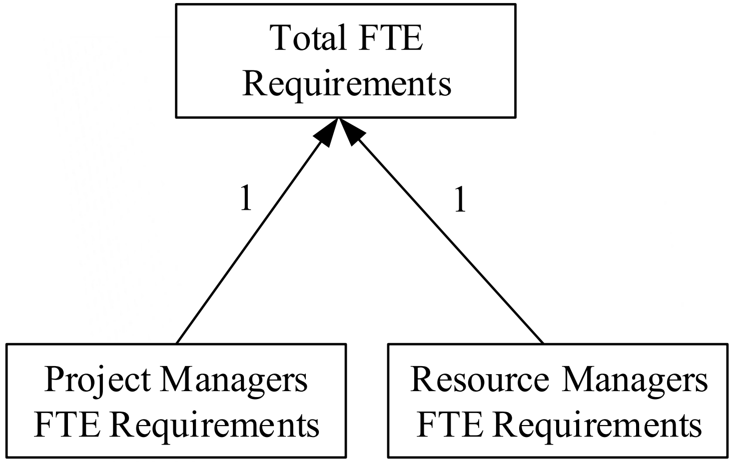
Demand dependency modeled as a multiplier $h_{ij}(\cdot)$

Involved Parameters	Functional Form	Interpretation
-	1	Modeling revenue and FTE allocation
τ, η	$\tau\eta$	Revenue generated by one internal FTE
τ, η, λ_i	$\tau\eta(1-\lambda_i)$	Revenue generated by an offshore FTE
μ_i	μ_i	Commitment rate of an FTE
φ_{ij}	$1-\varphi_{ij}$	Efficiency of training

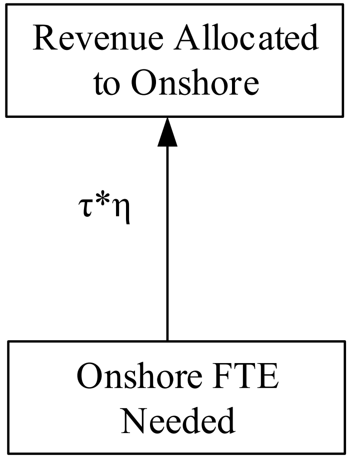
Examples of demand dependencies in BOL



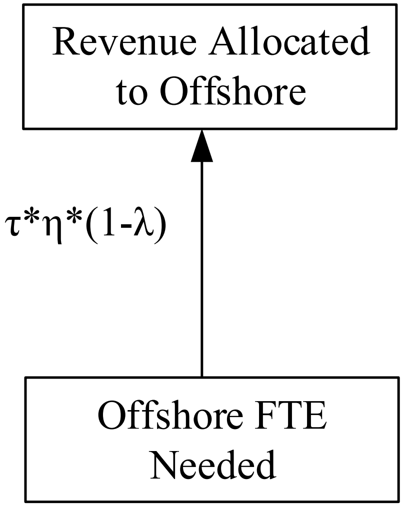
(a) Modeling revenue allocation



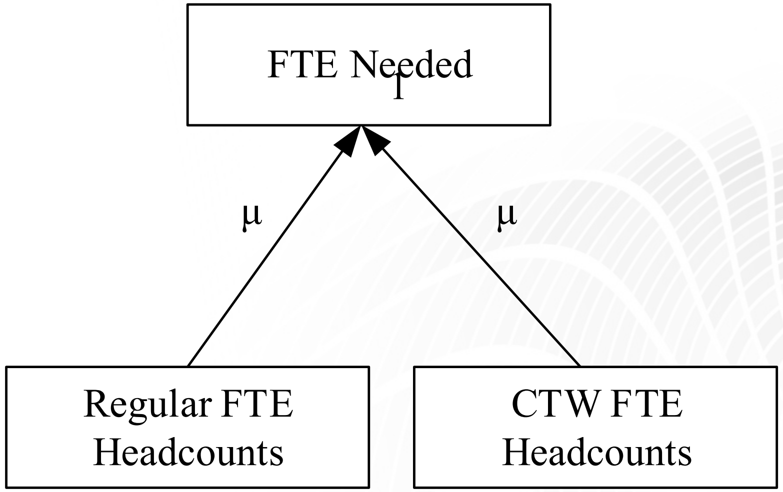
(b) Modeling FTE composition



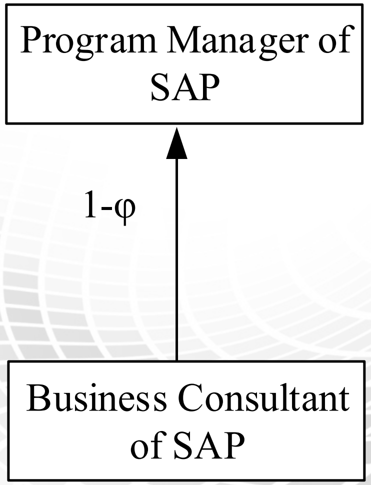
(c) Modeling productivity



(d) Modeling offshore risks

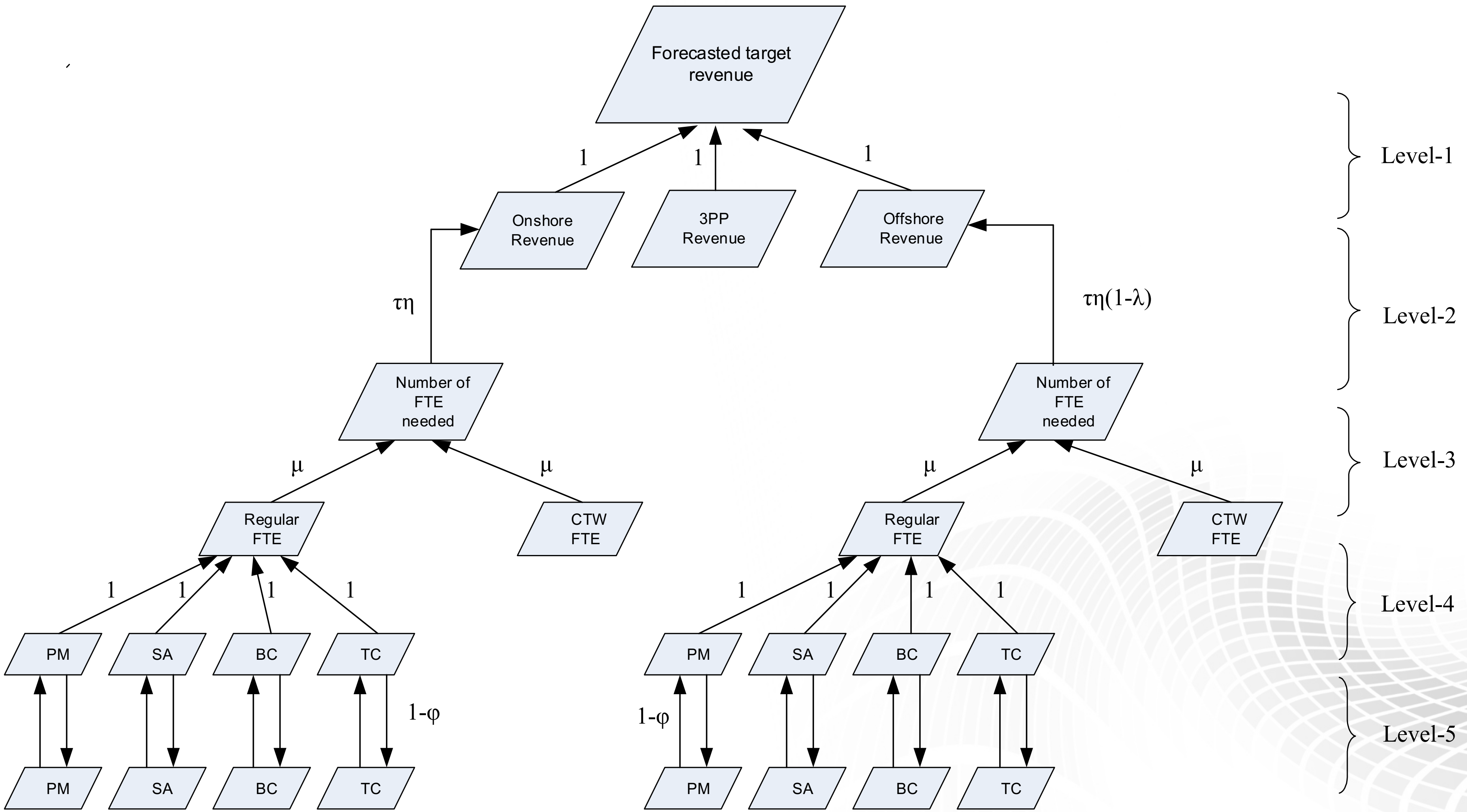


(e) Modeling workforce efficiency

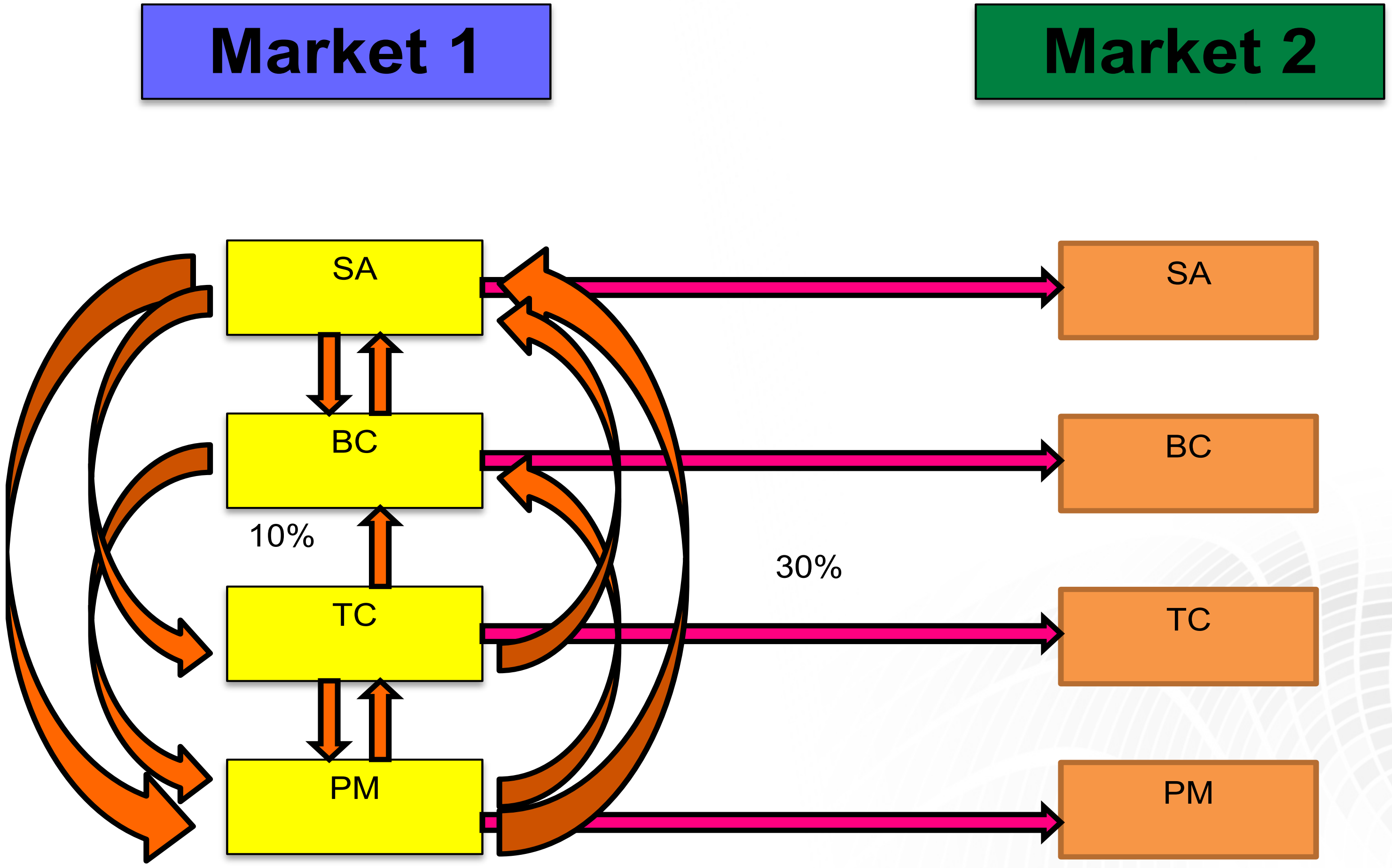


(f) Modeling workforce transformation

An example of BOL



Modeling cross-training



SA: Solution architect
BC: Business consultant
TC: Technical consultant
PM: Program manager

Modeling supply side risk and uncertainty in BOL

- Unlike the product structure in a manufacturing BOM, which is often stable and deterministic, the structure of a BOL may involve uncertainty
- This unique feature of BOL is due to the intrinsic nature of service transformation: high degree of customization and the underlying learning effect
- One way to model this uncertainty is to treat some parameters in the demand-dependency function $h_{ij}(\cdot)$ as stochastic random parameters
- For instance, the commitment rate μ of an FTE and the offshore risk factor λ might be uncertain, but may follow various probability distribution based on historical data or expert experience

Deterministic MILP model: sets and parameters

V^{M}: set of marketing offerings

V^{I}: set of internally-owned resource/labor

V^{O}: set of outsourced resource/labor

V: set of all nodes in a BOL, i.e. $V = V^{\mathrm{O}} \cup V^{\mathrm{I}} \cup V^{\mathrm{M}}$ where set of nodes do not overlap.

A: set of arcs in a BOL, representing the demand-dependency of resource/labor

T: set of arcs in a BOL that are eligible for training

R_i: target revenue of market offering $i \in V^{\mathrm{M}}$

ρ_i: cost ratio of outsourcing to external source $i \in V^{\mathrm{O}}$. It is the ratio between the payment to i and the revenue generated by i.

c_i: cost per day per internally-owned resource $i \in V^{\mathrm{I}}$. For a regular FTE, it is the salary; for a CTW FTE, it refers to the payment to the CTW.

I_i: available inventory of internally-owned resource $i \in V^{\mathrm{I}}$.

$h_{ij}(\cdot)$: the outflow multiplier of node i going into node j for each arc $(i, j) \in A$. $h_{ij}(\cdot)$ is a generic form to include some specific functional forms that involve the commitment rate μ, risk of resource λ and others as special cases.

Deterministic MIP model: decision variables

$x_i \geq 0$: Amount of resource $i \in V$. Note that x_i is defined in a generic way for all nodes in the node set V. Depending on the specific attribute of i, x_i may carry different meaning and measure. For instance, for i being a predecessor of a market offering node $j \in V^{\mathrm{M}}$, x_i means the breakdown of revenue (in \$) to i; while for $i \in V^{\mathrm{I}}$ being an internal workforce, x_i refers to the FTE headcount.

$y_{ij} \geq 0$: FTE amount of resource used for training from resource type i to resource type j for an eligible

training pair $(i, j) \in T$

$\gamma_i \geq 0$: idled FTE amount of internally-owned resource type $i \in V^{\mathrm{I}}$

$$\varepsilon_i = \begin{cases} 1 \text{ if the idled internally} - \text{owned resource type } i \in V^{\mathrm{I}} \text{ can be positive } (\gamma_i > 0) \\ 0 \text{ otherwise} \end{cases}$$

$$\delta_{ij} = \begin{cases} 1 \text{ if the training from resource } i \text{ to resource } j \text{ can be positive for } (i,j) \in T \; \left(y_{ij} > 0\right) \\ 0 \text{ otherwise} \end{cases}$$

Deterministic MILP model: objective function

$$\text{Max} \quad \sum_{i:(i,j)\in A, j\in V^{\mathrm{M}}} x_i - \sum_{i\in V^{\mathrm{O}}} \rho_i x_i - \sum_{i\in V^{\mathrm{I}}} \eta c_i x_i - \sum_{(i,j)\in T} \eta c_i \varphi_{ij} y_{ij} - \sum_{i\in V^{\mathrm{I}}} \eta c_i \gamma_i \qquad (2)$$

Deterministic MILP model: constraints

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Subject to:

$$\sum_{j:(j,i)\in A} x_j \leq R_i \qquad \forall i \in V^{\mathrm{M}} \qquad (3)$$

$$x_j = \sum_{i:(i,j)\in A} h_{ij}(\cdot) x_i \qquad \forall j \in V \backslash V^{\mathrm{M}} \qquad (4)$$

$$x_i = I_i - \sum_{j:(i,j)\in T} y_{ij} + \sum_{j:(j,i)\in T} (1 - \varphi_{ji}) y_{ji} - \gamma_i \qquad \forall i \in V^{\mathrm{I}} \qquad (5)$$

$$\gamma_i \leq I_i \cdot \varepsilon_i \qquad \forall i \in V^{\mathrm{I}} \qquad (6)$$

$$y_{ij} \leq I_i \cdot \delta_{ij} \qquad \forall (i,j) \in T \qquad (7)$$

$$\varepsilon_i + \delta_{ij} \leq 1 \qquad \forall (i,j) \in T \qquad (8)$$

$$x_i \geq 0,\ y_{ij} \geq 0,\ \gamma_i \geq 0,\ \varepsilon_i \in \{0,1\},\ \delta_{ij} \in \{0,1\} \qquad (9)$$

The two-stage stochastic programming model

Random Parameters

$\tilde{\mu}_i$: commitment rate of a resource $i \in V^{\mathrm{I}}$

$\tilde{\lambda}_i$: risk of offshore operations of a resource $i \in V^{\mathrm{I}}$

$\tilde{h}_{ij}(\cdot)$: a function of random parameters

Let Ω be the set of sample space, and $W^{\omega} = \{\mu_i^{\omega}, \lambda_i^{\omega} : \forall i \in V^{\mathrm{I}}\}$ be a set of realization of the random parameter set $\widetilde{W} = \{\tilde{\mu}_i, \tilde{\lambda}_i : \forall i \in V^{\mathrm{I}}\}$, where $\omega \in \Omega$. We assume that $\widetilde{W}$ follow a discrete distribution with a finite number of scenarios, with p^{ω} being the probability of scenario ω, i.e. $Prob\left(\widetilde{W} = W^{\omega}\right) = p^{\omega}$, and satisfying $\sum_{\omega \in \Omega} p^{\omega} = 1, p^{\omega} \geq 0 \ \forall \ \omega \in \Omega$. Associated with each W^{ω} is weight function $h_{ij}^{\omega}(\cdot)$.

Decision variables

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First-Stage Decision Variables

$z_j \geq 0$: target revenue allocated to a predecessor j of a market offering node, i.e. $j \in P$.

Second-Stage Decision Variables

For each scenario $\omega \in \Omega$, we define the following second-stage decision variables:

$x_i^\omega \geq 0$: FTE amount of resource type i which is not a market offering node or a predecessor of a market offering node, i.e. $i \in V \backslash V^{\mathrm{M}} \backslash P$

$y_{ij}^\omega \geq 0$: FTE amount of resource used for training from resource type i to resource type j for an eligible training pair of $(i, j) \in T$

$\gamma_i^\omega \geq 0$: idle FTE amount of internally-owned resource $i \in V^{\mathrm{I}}$

$$\varepsilon_i^\omega = \begin{cases} 1 \text{ if the idled internally} - \text{owned resource } i \in V^{\mathrm{I}} \text{ can be positive at scenario } \omega \in \ \Omega \ (\gamma_i^\omega > 0) \\ 0 \text{ otherwise} \end{cases}$$

$$\delta_{ij}^\omega = \begin{cases} 1 \text{ if the training from resource } i \text{ to resource } j \text{ can be positive for } (i, j) \in T \text{ at scenario } \omega \in \ \Omega \ (y_{ij}^\omega > 0) \\ 0 \text{ otherwise} \end{cases}$$

Objective function and constraints

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$$\text{Max} \quad \sum_{i\in P} z_i - \sum_{\omega\in\Omega} p^\omega \left(\sum_{i\in V^O} \rho_i x_i^\omega + \sum_{i\in V^I} \eta c_i x_i^\omega + \sum_{(i,j)\in T} \eta c_i \varphi_{ij} y_{ij}^\omega + \sum_{i\in V^I} \eta c_i \gamma_{ij}^\omega \right) \qquad (10)$$

Subject to:

$$\textstyle\sum_{j\in P_i} z_j \le R_i \qquad \forall i \in V^M \qquad (11)$$

$$x_j^\omega = \textstyle\sum_{i:(i,j)\in A} h_{ij}^\omega(\cdot) x_i^\omega \qquad \forall j \in V \backslash V^M \backslash P, \omega \in \Omega \qquad (12)$$

$$x_i^\omega = I_i - \textstyle\sum_{j:(i,j)\in T} y_{ij}^\omega + \sum_{j:(j,i)\in T} (1-\varphi_{ij}) y_{ji}^\omega - \gamma_i^\omega \qquad \forall i \in V^I, \omega \in \Omega \qquad (13)$$

$$\gamma_i^\omega \le I_i \cdot \varepsilon_i^\omega \qquad \forall i \in V^I, \omega \in \Omega \qquad (14)$$

$$y_{ij}^\omega \le I_i \cdot \delta_{ij}^\omega \qquad \forall (i,j) \in T, \omega \in \Omega \qquad (15)$$

$$\varepsilon_i^\omega + \delta_{ij}^\omega \le 1 \qquad \forall (i,j) \in T, \omega \in \Omega \qquad (16)$$

$$x_i^\omega \ge 0,\ y_{ij}^\omega \ge 0,\ \gamma_i^\omega \ge 0,\ \varepsilon_i^\omega \in \{0,1\},\ \delta_{ij}^\omega \in \{0,1\} \qquad (17)$$

Business impact and managerial insights

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A case study

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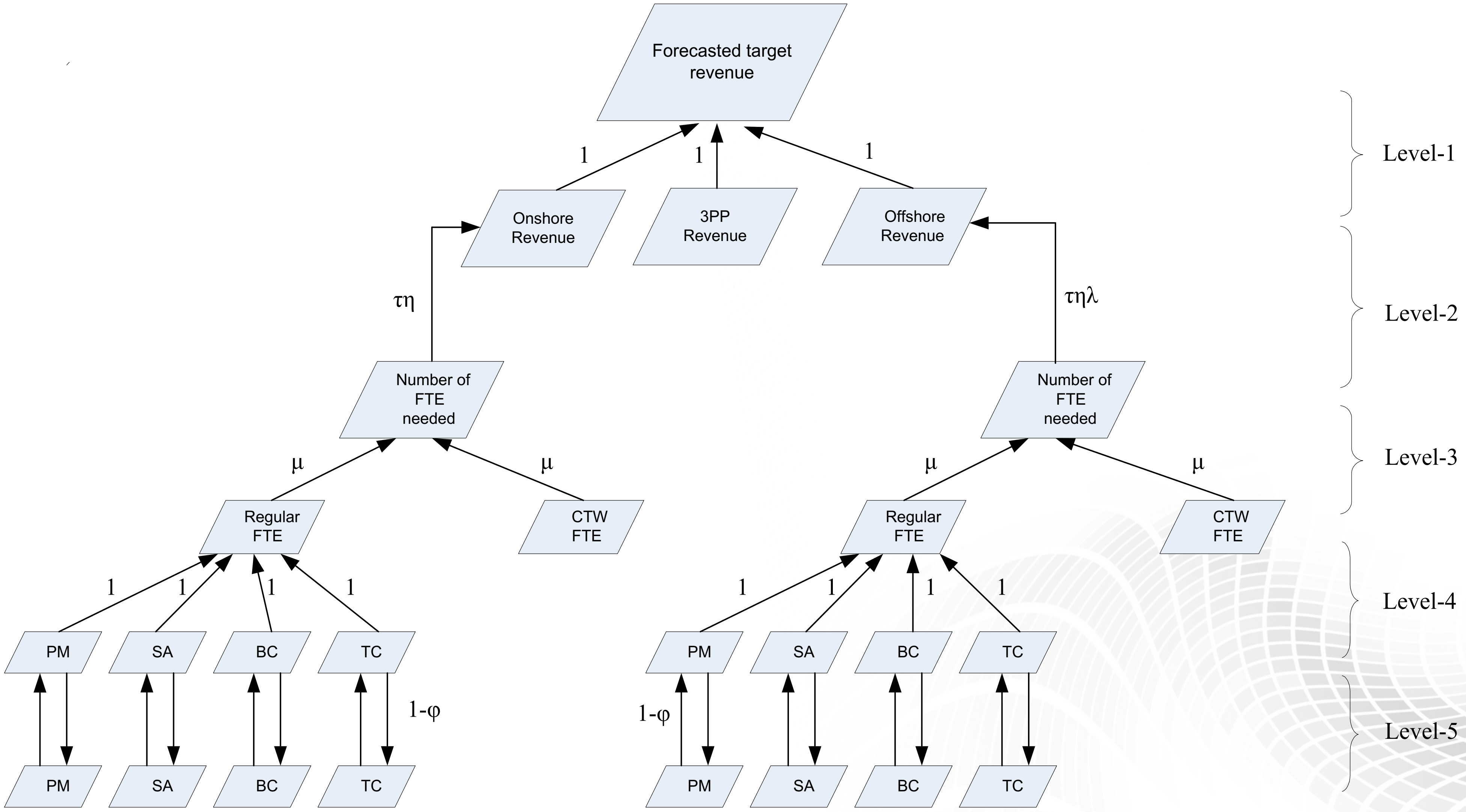
Market offering	Description	Forecasted Revenue
APS	Application solutions	$347,712,130
ENI	Enterprise integration services	$921,068,469
FS	Financial services	$58,845,227
MFG	Manufacturing services	$70,821,142
NSP	Network services	$330,549,579
PS	Border, trade and protection	$142,005,182
RPO	Custom consulting	$75,536,111
	Total	$1,946,537,840

The data in this Case Study includes real-business scenarios, but has been masked to protect proprietary information.

BOL in one-market offering



Capacity of internal workforce by market offering, role and location

Market Offering	Onshore SA	Onshore BC	Onshore TC	Onshore PM	Offshore SA	Offshore BC	Offshore TC	Offshore PM
APS	34	0	124	19	41	0	149	0
ENI	24	9	413	7	29	11	496	0
FS	0	5	0	16	0	6	0	0
MFG	2	5	3	11	2	6	4	0
NSP	32	2	78	12	38	2	94	0
PS	3	7	5	14	4	8	6	0
RPO	0	2	7	5	0	2	8	0

Similarity coefficient for cross-training

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Mk Offering	APS	ENI	FS	MFG	NSP	PS	RPO
APS	-	0	40%	40%	0	30%	0
ENI	0	-	0	0	60%	50%	0
FS	0	0	-	0	0	0	20%
MFG	20%	0	0	-	0	0	30%
NSP	0	40%	0	0	-	0	0
PS	0	30%	0	0	0	-	0
RPO	0	0	40%	20%	0	0	-

Roles	TC	SA	BC	PM
TC	-	50%	0	30%
SA	70%	-	50%	60%
BC	30%	50%	-	50%
PM	10%	20%	50%	-

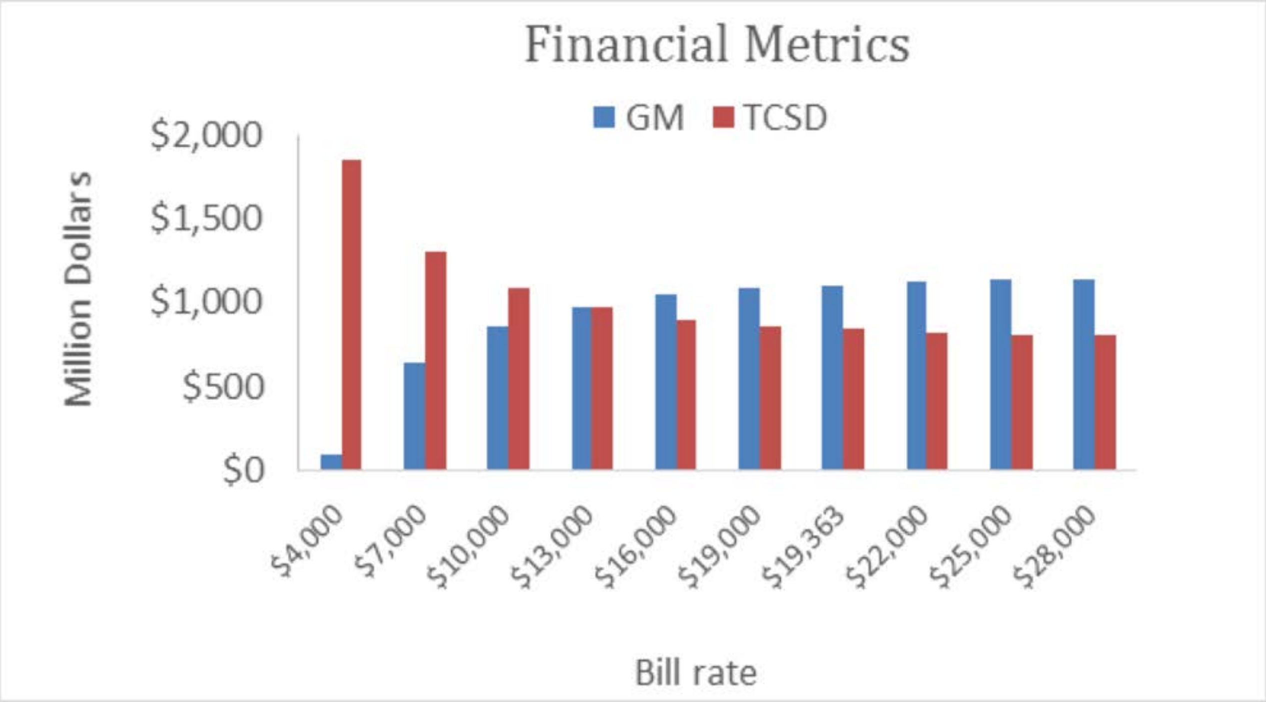
Case study results

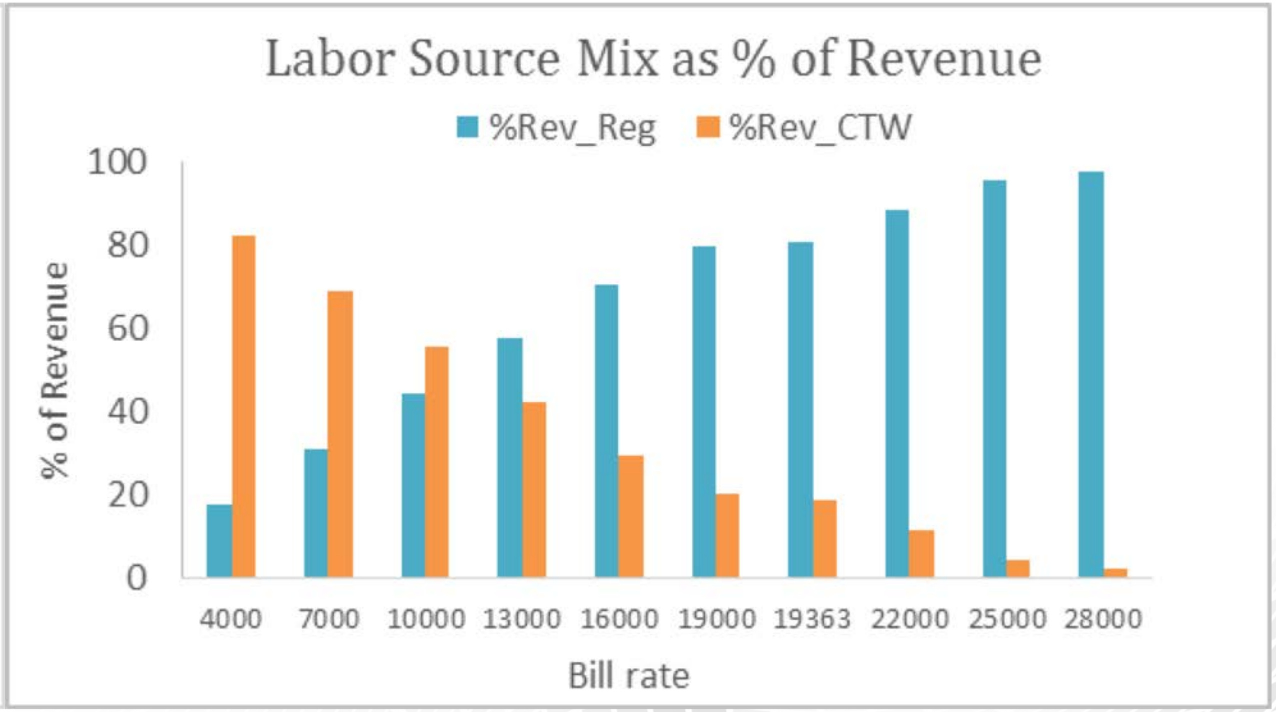
		Spreadsheet	*Restricted LSO*	*LSO*
Financial Performance		81%	92%	100%
Gross Margin	Onshore	28%	34%	34%
	Offshore	65%	59%	66%
	3PP	7%	7%	-
Total FTE Requirements		1681	1630	1713
Number of FTEs	Onshore-Regular	28%	40%	38%
	Onshore-CTW	2%	0.1%	0.1%
	Offshore-Regular	66%	50.9%	50%
	Offshore-CTW	4%	9%	11.9%

Business Impacts

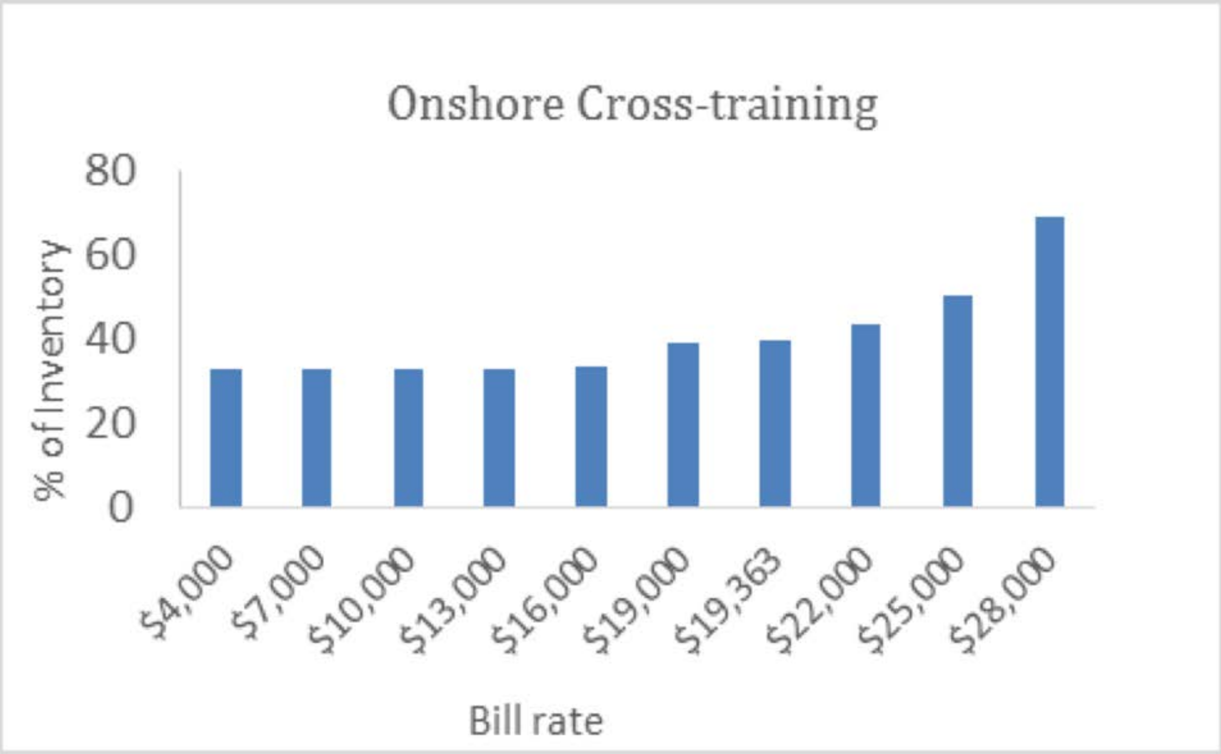
- The optimal LSO solution generates a **higher gross margin**:
  - 9% more than the restricted LSO
  - 23% more than the spreadsheet solution
- The LSO solution provides an **optimal labor mix,** different from the other two (heuristic) solutions:
  - does not use 3PP
  - provides higher Offshore CTW percentage
- Additional insights can be obtained through sensitivity analysis on some key parameters
- Complete computational results are available in our paper:
  - ***Optimizing the Labor Strategy of a Professional Service Firm*** (2018), by H. Li, C. A. Santos, A. Fuciec, T. Gonzalez, S. Jain, C. Marquez, C. Mejia, A. Zhang.

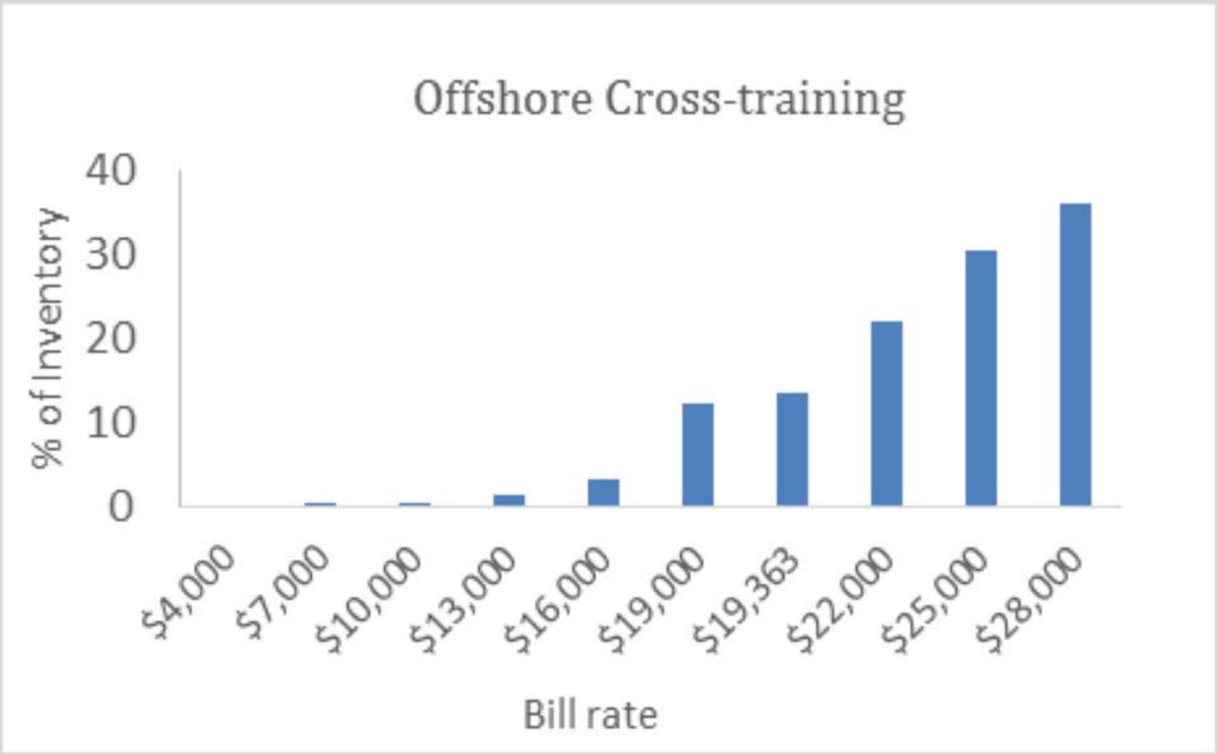
Impact of bill rate on overall LSO solution



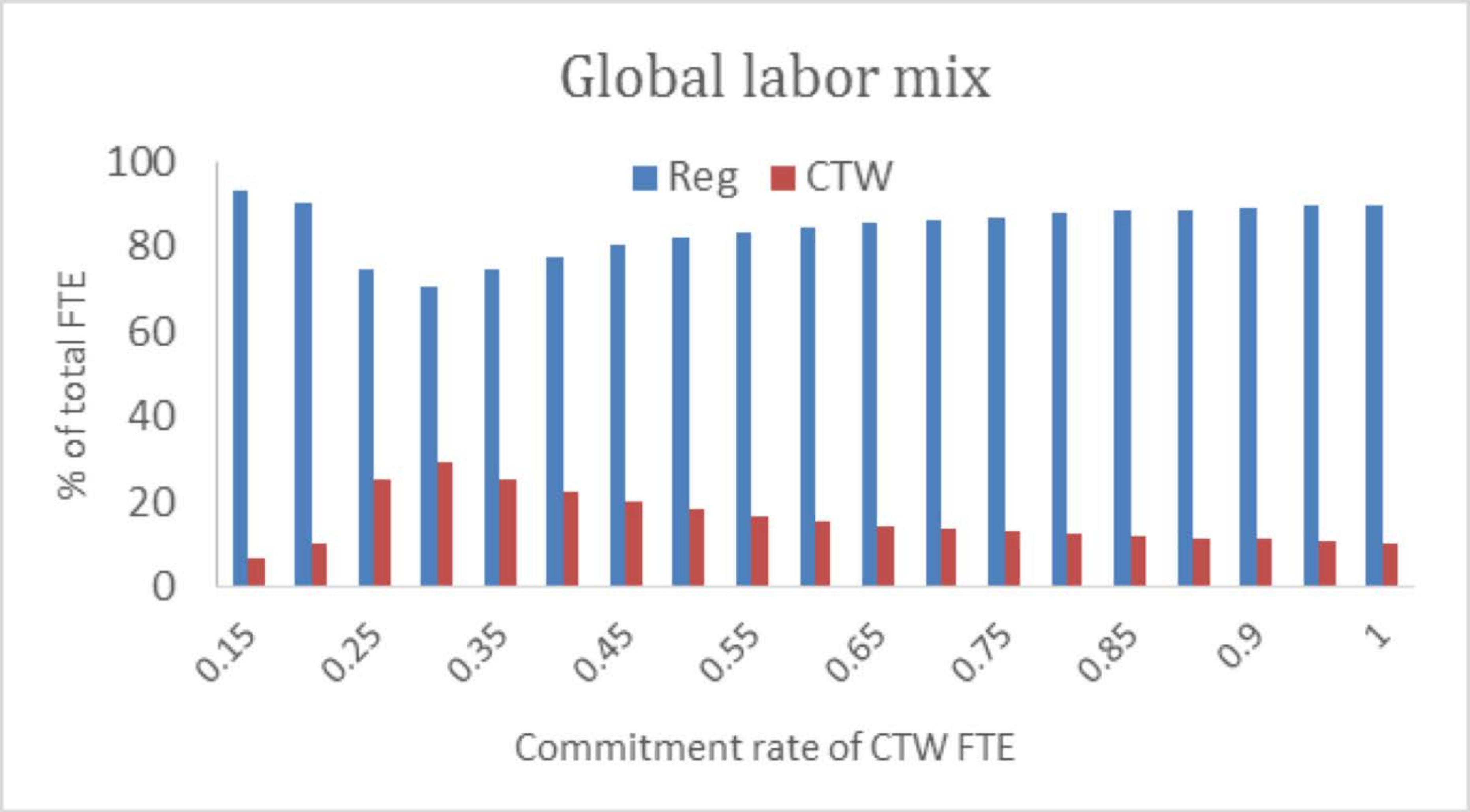


Impact of bill rate on cross-training

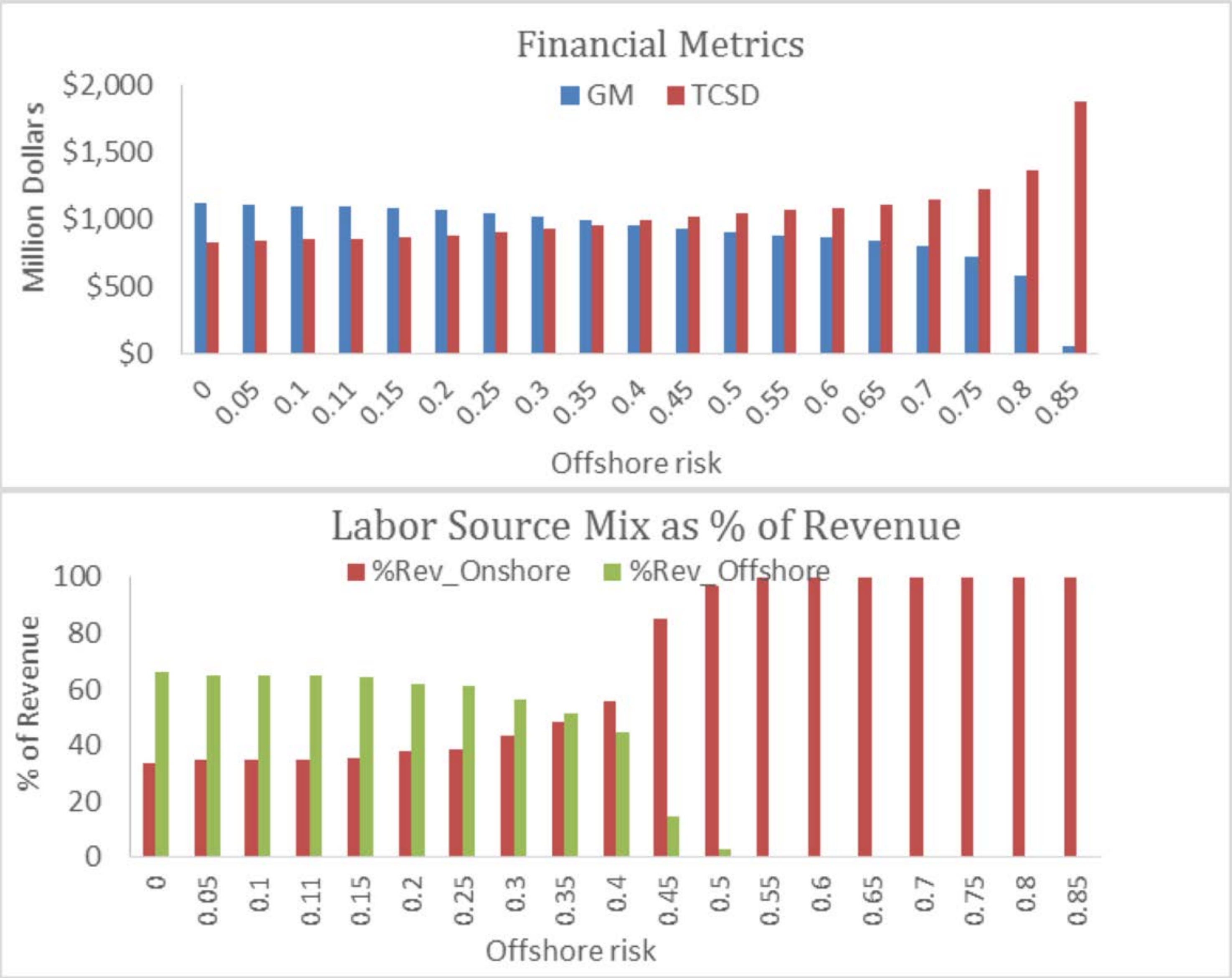




Impact of commitment rate of CTW FTE



Impact of offshore risk



Lessons learned and best practices

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Lesson 1:

- Mathematical modeling is an iterative process
- Follow a prototyping process where you:
  - Gather business requirements
  - Define data requirements
  - Build the appropriate optimization model
  - Build a prototype solution tool where you can show output reports and do what-if scenario analysis
  - Ask the decision maker: is the solution implementable?
    - If no, go back to previous steps as appropriate
    - If yes, transfer prototype to business until it is stable, no bugs. Then transfer to IT organization for long term first level support

Lesson 2:

- Not transferring your prototype solution to an IT organization for productization means death of your application in the long-term.
  - The systems generating data for your application will be upgraded and evolve
  - If your prototype solution has not been transferred to IT, your application won't be in IT dev roadmaps
  - Your application won't receive the required data, and your end user won't be able to use it

Lesson 3:

- Evangelize mathematical optimization at your company
  - Your company has many optimization problems - maximization of operational efficiency at various business functions and business units
    - Identifying an optimization problem is non-trivial
    - Requires an optimization expert and a subject matter expert (SME)
  - Educate business people and top executives about the money they are leaving on the table, due to not utilizing mathematical optimization
  - Organize seminars, tech fairs, advertise your success with mathematical optimization, show what is possible when mathematical optimization is implemented