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TEACHING BRIEF

Supply Chain Performance Analysis of Dow Jones Industrial Average Indexed Firms and Top 50 Supply Chain Firms

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ABSTRACT

Operations and Supply Chain Management (OSCM) courses may cover supply chain strategies, supply chain classification, and supply chain performance. Familiarity with various manufacturing and logistics firms would help students to better understand such topics. Information on the Dow Jones Industrial Average indexed firms and top 50 supply chain firms by Gartner is easily accessible and typically covers a variety of industries from chemical, food/beverage, high-tech to retail, to name a few. Instructors of OSCM courses can take advantage of this kind of information to discuss industry characteristics and supply chain classification. We present how to collect financial data, calculate supply chain metrics (e.g., inventory turns, profit margin, and cash-to-cash cycle) by building a spreadsheet model and creating an earns-turns matrix, which prescribes supply chain classification. We also show how to analyze supply chain performance and describe industry characteristics based on the earns-turns matrix. We provide vital questions and takeaways for instructors to lead and wrap-up discussions. Students claim that they appreciated learning about industry characteristics and different supply chain strategies through the earns-turns matrix analysis.

Subject Areas: Dow Jones Industrial Average Indexed Firms, Earn-Turns Matrix, Industry Characteristics, Lean Supply Chain, Profitable Supply Chain, Supply Chain Classification, and Top 50 Supply Chain Firms.

INTRODUCTION

Operations and Supply Chain Management (OSCM) courses typically cover operations and supply chain strategies, demand management, sales and operations planning, production planning and scheduling, inventory control, material/capacity requirement planning, and so forth. Quantitative approaches such as linear regression or linear programming have been used to address such topics. Accounting concepts also help students understand value chain activities

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across the supply chain, which deals with the flow of product/service, information, and funds. An income statement reflects primary and supportive activities across the value chain (see the detailed description in the third section). However, integration among supply chain and accounting, cost structure of different industries, and supply chain classification and strategy based on financial ratios have rarely been discussed, to the best of our knowledge, in OSCM courses or textbooks. Recently, a few textbooks have placed emphasis on the interface between OSCM and accounting/finance (Cachon & Terwiesch 2004, Chopra & Meindl 2014).

Most business-school students in OSCM classes have basic accounting knowledge, as they are typically required to take basic accounting courses at the sophomore level and OSCM courses at the junior or senior level. All students in our OSCM classes had basic accounting knowledge, even though the accounting course is not a prerequisite. Students in OSCM courses should be able to interpret financial statements analysis. Notably, inventory-related measures such as inventory turnover (ITR) and days of supply (DOS) are essential in OSCM courses. However, we have experienced that few students have been able to adequately relate basic accounting concepts to supply chain activities or to compute supply chain metrics such as ITR.

Students in OSCM classes are expected to compare and contrast a variety of firms to understand operations and supply chain strategies or supply chain classification. The Dow Jones Industrial Average (DJIA) indexed firms and top 50 supply chain firms by Gartner, Inc. are good candidates for multifirm analysis. The benefits of the multifirm study and a single-firm study vary. A study on the single-firm benefits in-depth understanding of a specific operation or industry. The multifirm study provides students with higher-level understandings of industries, industry characteristics, different supply chain strategies in the same industry, and so forth. Each industry has a unique cost structure as well. Financial ratio analysis, DuPont analysis, and other analyses lead students to appreciate the cost structure of each firm and supply chain classification. This teaching brief shows how to analyze different industries using supply chain metrics.

This teaching brief is designed for instructors of OSCM courses to equip students with good senses of integration between OSCM and accounting/finance. The first pedagogical goal of the teaching brief is for students to be able to take advantage of accounting information to generate supply chain metrics such as ITR, DOS, profit margin (PM), and return on assets (ROA). The second goal is to provide a hands-on mechanism for students to compute supply chain metrics and to explore the relationships through a spreadsheet model. Instructors may provide students with a spreadsheet template to collect necessary accounting information such as revenue, cost of goods sold (CGS), and inventory. The last, but not the least, goal is for students to be able to evaluate the relationship between supply chain metrics and supply chain strategies and to describe industry characteristics. The teaching brief covers a variety of areas: supply chain metrics, cost structure, industry characteristics, and supply chain strategy.

The teaching brief is organized as follows. The second section introduces the DJIA firms and top 50 supply chain firms. The third section explains basic accounting principles and procedures. The fourth section provides instructors with

concepts of supply chain classifications. The fifth section describes the tasks to be accomplished in the class, demonstrates how to calculate supply chain metrics using MS-Excel or Google Sheets, and provides instructors with the discussion points and critical takeaways for wrap-ups. The sixth section discusses the effectiveness of the teaching brief. Finally, the seventh section concludes this teaching brief.

DOW JONES INDUSTRIAL AVERAGE INDEXED FIRMS AND TOP 50 SUPPLY CHAIN FIRMS

The DJIA firms consist of the 30 largest public firms listed on the New York Stock Exchange or NASDAQ of the United States. The DJIA firms represent a variety of industries such as consumer electronics, aerospace/defense, chemical, food/beverage, high-tech, biopharmaceutical, software, apparel, consumer goods, retail, to name a few (http://www.djindexes.com). Financial institutions are not taken into account because they do not make or deliver tangible products to customers. Note that the index has been influenced by not only corporate and economic reports, but also by domestic and foreign political events as well as by natural disasters.

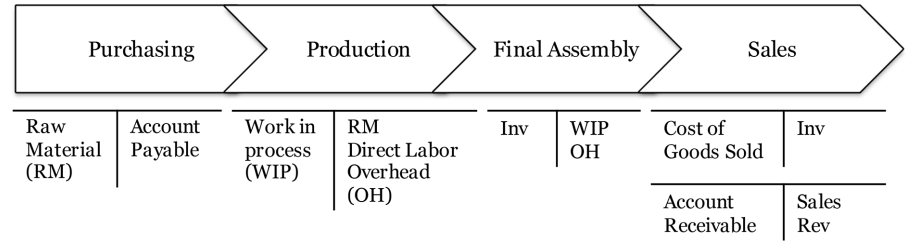
Gartner evaluates supply chain firms and ranks top 50 supply chain firms every year (https://www.gartner.com/technology/supply-chain/top25.jsp). Around 20 firms out of top 50 are foreign (e.g., Toyota Motors, Samsung Electronics, Unilever), and the other 20 firms (e.g., Apple, Intel, Amazon) are DJIA firms. Hence, we add around 10 firms (e.g., Gap, Northrop Grumman, Amgen) to the list of our interest. (See the appendix for the detailed listing.) The DJIA and top supply chain firms have individually appeared in top peer-reviewed journals (e.g., *Decision Sciences Journal of Innovative Education*, *Interfaces*, *INFORMS Transactions on Education*, and *Journal of Business Research*) because the DJIA firms are representative of the U.S. economy, and top supply chain firms adopt advanced technologies and/or innovative business processes (or practices) to make significant gains in the supply chain domain.

Supply chain performance analysis of various firms from different industries can be a good starting point to understand the differences among industries and supply chain strategies because the DJIA and top supply chain firms could be good representatives from each industry. We recommend that students in OSCM courses analyze supply chain performance of the DJIA and top supply chain firms, i.e., how well they operate compared to their competitors or other industries.

BASIC ACCOUNTING PRINCIPLES

Instructors need to review two basic financial statements—the balance sheet and the income statement. A balance sheet reports the financial position using asset, liability, and equity accounts. Asset accounts represent economic resources that can contribute to generating earnings across the value chain. Liability accounts are used to express financing activities from outside sources (i.e., creditors), whereas equity accounts show financing activities from owners (or shareholders).

Figure 1: Accounting procedures have been prescribed across primary activities of the value chain (Porter 1998) from purchasing, manufacturing, and final assembly to sales.



The basic accounting equation of assets = liabilities + equity manifests that all kinds of economic resources (i.e., assets) have been obtained through either outsourced (i.e., liabilities) or in-sourced finance (i.e., equities). The double-entry booking procedure keeps a record of debit and credit accounts at the same time, holding to the basic accounting equation. Traditionally a T-account may be used to explain accounting procedures as shown in Figure 1. Note that recent accounting textbooks write two lines of debit and credit rather than the T-account approach.

Take a look at purchasing and sales transactions based on the double-entry booking shown in Figure 1. All inventory-related accounts (e.g., raw material, work-in-process, and finished goods), which are from the balance sheet, increase in value and are debited for purchasing or manufacturing transactions; whereas inventory decreases in value and hence is credited for sales (i.e., outgoing) transactions. Two income statement accounts, CGS and revenue, reflect outgoing flow rates. CGS is the flow rate at cost, and revenue is the flow rate at the selling price, respectively.

Account payable turnover (APT) and its related flow time (i.e., account payable days) take into account average AP and ending CGS together, assuming that the inflow rate is the same as the outflow rate (i.e., CGS) according to Little's law (Hopp & Spearman 2000). ITR and its flow time (inventory days or DOS) take into account average inventory and ending CGS together. ITR is the number of times that an inventory cycles during a fiscal year (Blackstone Jr. 2013). In other words, ITR and DOS can answer the following questions, respectively: 1) How many times does a firm supply inventory to satisfy an annual demand? And 2) How many days does the firm keep inventory during one cycle (Cachon & Terwiesch 2004, Chopra & Meindl 2014)? High ITR cannot guarantee the profitability of the firm. All the more, ITR seems to have a negative relationship with profitability (Gaur, Fisher, & Raman 2005, Gaur & Kesavan 2009). Account receivable turnover (ART) and its flow time (i.e., AR days) take into account average AR and ending revenue together. ART is the number of collection cycles during a fiscal year. AR days indicates how long it takes for a sales department to collect cash after sales (Cachon & Terwiesch 2004, Chopra & Meindl 2014).

Similarly, asset turnover (AST) can be computed by dividing revenue by average asset.

With turnovers, students can compute its related average flow times such as inventory days (i.e., from purchase to sell-out), collection cycle (i.e., from the sales to the collection), and payment cycle (i.e., from purchase to payout). Cash-to-cash cycle (CCC) is the difference between cash inflow, which is the sum of inventory days and collection cycle, and cash outflow, which is payment cycle (Chopra & Meindl 2014). Note that turnover is a measure of operational excellence, PM a measure of profitability, and CCC a measure of liquidity, respectively.

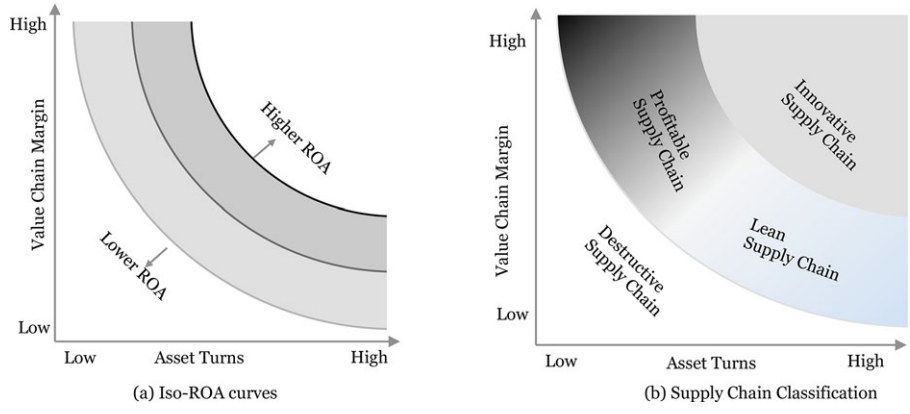
An income statement reports operating results of a firm during a fiscal period, i.e., a variety of earning (or profitability) measures. The first type of earning is revenue from customers. Gross profit, the difference between revenue and CGS, reflects net earning from primary activities because CGS, a product cost, is directly related to primary activities across the supply chain. PM is the ratio of gross profit to revenue. Note that students typically misunderstand the difference between PM and markup, which is the ratio of gross profit to CGS. Operating income, the difference among gross profit and selling and general administrative (SGA), depreciation expense, and other expenses, is related to both primary and supportive activities because SGA is a period cost and related to supportive activities. However, operating income takes into account depreciation expense, which is non-cash-related, and does not consider R&D expense, which is related to a critical supportive activity. Instructors may introduce a new concept of earning. Value chain income, the difference between gross profit and SGA and less R&D expense, is a proper earning that reflects both primary and supportive activities across the value chain. Value chain margin (VCM) is the ratio of value chain income to revenue (Choi 2016).

ROA or return on equity (ROE) can be used to compare different size firms. The DuPont analysis incorporates profitability (e.g., VCM or PM) and turnover (e.g., AST or ITR) to calculate ROA (Subramanyam 2014).

SUPPLY CHAIN CLASSIFICATIONS

A traditional supply chain classification is related to manufacturing strategy and its related plant layout (Hayes & Wheelwright 1979). Make-to-stock (MTS), assemble-to-order (ATO), and make-to-order (MTO) are major manufacturing strategies. MTS strategy covers customer lead time from delivery to shipment, ATO from final assembly to shipment, and MTO from raw material to shipment, respectively. An extreme case of MTO is engineer-to-order, covering from design to shipment. An MTS strategy would allow limited variations of customer order and implement product-focused layout (e.g., continuous shop) to keep resources highly utilized, whereas an MTO strategy allows customers to place individualized orders and requires a process-focused layout (e.g., job shop) to keep extra capacity. Instructors can give a guiding example of a particular industry. For example, local pizza restaurants would adopt an MTO strategy, pizza delivery chains (e.g., Domino) an ATO strategy, and frozen pizza firms (e.g., DiGiorno) an MTS strategy, respectively.

Figure 2: (a) Shows an earns-turns matrix with different ROA values. (b) Depicts a supply chain classification based upon the earns-turns matrix with ROA values.



Fisher (1997) classifies two different types of products—functional and innovative. The functional products have the following characteristics: predictable demand pattern, low contribution margin, low product variety, low stock-outs, and so forth. The functional products require an efficient supply chain in which firms can maintain a high utilization rate, generate high turnovers, and select cost or quality as their competitive advantages. The innovative products require a responsive supply chain in which firms can respond quickly to unpredictable demand, deploy excess buffer capacity, and select speed, flexibility, or quality as their competitive advantages. Chopra and Meindl (2014) adopt Fisher's (1997) classification in their textbook. Examples of the responsive and efficient supply chains have been verified through qualitative factors such as implied uncertainty or product variety, which cannot be obtained easily from publicly available data.

Robeson and Copacino (1994) classify products into the winner, traffic-builder, sleeper, and loser with a quadrant scheme. An earns-turns matrix by Robeson and Copacino (1994) use a two-dimensional space with ITR on the x-axis and PM on the y-axis. Another earns-turns analysis can be addressed by decomposition of ROA, which is based on DuPont analysis. Including ROA into Robeson and Copacino (1994), a cursive quadrant scheme can be used, as shown in Figure 2. Two or more firms may have the same or close ROA value (say, iso-ROA), but VCM and AST may be different. For example, considering ROA $= .1$, we may have a variety of combinations such as (AST, VCM) $= (1, .1)$, $(2, .05)$, $(5, .02)$, $(10, .01)$, and so forth. The former firms (i.e., firms with lower AST and higher VCM) concentrate on profitability; the latter ones focus on operational excellence. One of the iso-ROA firms might have higher VCM and lower turns; the other firm(s) might have lower VCM and operate efficiently (i.e., higher turns). The innovative supply chain (Figure 2, upper right) generates higher PM and

operates very efficiently. The profitable supply chain (Figure 2, upper left) keeps higher PM and operates less efficiently; in other words, ITR is lower. The lean (or efficient) supply chain (Figure 2, lower right) operates very efficiently, but its PM is lower. The destructive supply chain (Figure 2, lower left) has lower PM products and operates less efficiently. The earn-turns analysis in the fifth section shows distinct characteristics of each industry. For example, biopharmaceutical, high-tech, and chemical firms keep higher PM, and ITR is lower; whereas retail firms (e.g., discount, department) achieve lower PM, and ITR is higher.

TASKS TO BE ACCOMPLISHED IN THE CLASSROOM

Instructors typically have three main tasks to be accomplished in the classroom: (1) theoretical discussions, (2) data collection and analysis, and (3) discussions on cost structure and supply chain classification. Instructors are provided general guidelines for each main task in the next subsections.

Theoretical Discussions

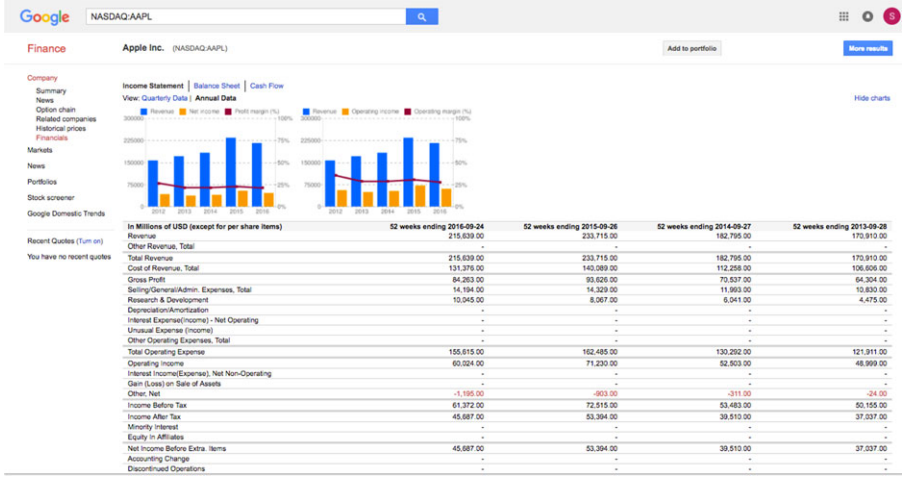
Instructors need to lead theoretical discussions on supply chain classification and industry characteristics using the contents of the third and fourth sections. Instructors need to explain the basic accounting principles across all supply chain activities for students to be able to relate financial analysis to operational excellence. Instructors also must present the three different approaches (discussed in the fourth section) to supply chain classification. Instructors need to revisit supply chain classification in detail for the wrap-up. With analysis of the DJIA and top supply chain firms, instructors can lead to more in-depth discussions.

Data Collection and Analysis

It is recommended that all activities related to data collection be done by group. The recommended group size is four or five students, and instructors may assign eight to 10 firms to each group. Instructors may mix different industries for each group, e.g., one from retail, one from traditional manufacturing, one from high-tech, one from biopharmaceutical, one from consumer packaged goods, one from chemical, one from basic material processing, and one from food chain. Each student will be responsible for two or more firms, and he/she would introduce the assigned firms to the group members during the discussion.

Students would be asked to collect key accounting data to calculate supply chain metrics from EDGAR (Electronic Data Gathering, Analysis, and Retrieval system) or elsewhere. Instructors need to show how to set up a spreadsheet, how to obtain accounting data, and how to set up formulae for supply chain metrics. Students are recommended to access Google Finance (www.google.com/finance) or Yahoo Finance (http://finance.yahoo.com) as shown in Figure 3. Students can find any U.S. public firm by searching its full name, short name, or stock symbol. Google Finance and Yahoo Finance provide four-year or four-quarter financial information such as income statements, balance sheets, and cash flow.

Figure 3: Students can collect financial data of all DJIA and top supply chain firms from either Google Finance (http://www.google.com/finance) or Yahoo Finance (http://finance.yahoo.com).



Instructors need to exercise caution because students may make errors to copy quarterly data instead of annual data. It is typically difficult to access to non-U.S. firms such as Toyota Motors, Samsung Electronics, and Unilever at Google Finance.

Figure 4 shows how to build-up all formulae of supply chain metrics. First, students need to copy and paste necessary accounting data such as revenue, cost of revenue (or CGS), SGA, and R&D from the income statement and AR, inventory, AP, and total assets from the balance sheet. Students may be asked to complete formulae of PM, ITR, and others in MS-Excel or Google Sheets, as shown Figure 4. Otherwise, instructors should provide a template sheet with formulae, and all students can save time and concentrate on the discussions. Each student should complete one firm on one sheet, of which the spreadsheet name is a stock symbol code. If all sheets have the same format, instructors can easily integrate them. Column A contains account or metric names; column B shows labels and formulae with labels; columns C through F are copied values of accounts or computed values of metrics for the recent four years, respectively. For the calculated values, we show exact formulae using cell references (Figure 4). Note that students will often be interested in numbers-in-and-numbers-out rather than the concept or semantics of supply chain metrics. Instructors should emphasize that the spreadsheet modeling is not only a computational tool but also an exploratory one.

Once the students complete data collection and metric calculation for all assigned firms, they have to collect all relevant information from one consolidated

Figure 4: Students can copy and paste data from any source such as Google Finance or Yahoo Finance to a spreadsheet. Students need to input not all data, but inventory, AR, AP, revenue, CGS, SGA, and R&D. All other data such as gross profit, operating income, and turns and flow times, can be set up to calculate supply chain metrics.

	A	B	C	D	E	F
1	Account		2016	2015	2014	2013
2	Account Receivable	(A)	29,299.00	30,343.00	27,219.00	20,641.00
3	Inventory	(B)	2,132.00	2,349.00	2,111.00	1,764.00
4	Total Current Assets	(C)	106,869.00	89,378.00	68,531.00	73,286.00
5	Total Assets	(D)	321,686.00	290,345.00	231,839.00	207,000.00
6	Account Payables	(E)	37,294.00	35,490.00	30,196.00	22,367.00
7	Total Liabilities	(F)	193,437.00	170,990.00	120,292.00	83,451.00
8	Total Equity	(G)=(D)-(F)	=C5-C7			
9	Revenue	(H)	215,639.00	233,715.00	182,795.00	170,910.00
10	Cost of Revenue	(I)	131,376.00	140,089.00	112,258.00	106,606.00
11	Selling/General/Admin Expenses	(J)	14,194.00	14,329.00	11,993.00	10,830.00
12	R&D	(K)	10,045.00	8,067.00	6,041.00	4,475.00
13	Gross Profit	(L)=(H)-(I)	=C9-C10			
14	Operating Income	(M)=(H)-(I)-(J)	=C9-C10-C11			
15	Value Chain Income	(N)=(H)-(I)-(J)-(K)	=C9-C10-C11-C12			
16	Profit Margin	(O)=(L)/(H)	=C13/C9			
17	Value Chain Margin	(P)=(N)/(H)	=C15/C9			
18	Inventory Turnover	(R)=(I)/average of (B)	=C10/AVERAGE(C3:D3)			
19	Inventory days	(S)=365/(R)	=365/C18			
20	Account Receivable Turnover	(T)=(H)/average of (A)	=C9/AVERAGE(C2:D2)			
21	AR days	(U)=365/(T)	=365/C20			
22	Account Payable Turnover	(V)=(I)/average of (E)	=C10/AVERAGE(C3:D3)			
23	AP days	(W)=365/(V)	=365/C22			
24	Cash-to-Cash Cycle	(X)=(S)+(U)-(W)	=C19+C21-C23			
25	ROA=Value Chain Income/Total Assets	(Y)=(N)/average of (D)	=C17/AVERAGE(C5:D5)			
26	Asset Turnover	(Z)=(H)/average of (D)	=C9/AVERAGE(C5:D5)			

and comprehensive sheet. Figure 5 shows an example of a collective spreadsheet, which includes all supply chain metrics of all firms. All information on this sheet is linked to each firm's sheet. With the consolidated sheet, it is easy to compare all DJIA and top supply chain firms. Instructors can quickly figure out any extraordinary or odd values for a firm (e.g., even smaller ITR in the same industry) through the collective sheet in Figure 5 when a student would make errors to copy and paste wrong data. Instructors generate Figure 6 to show different cost structure. Students can draw a scatter chart with AST and VCM (or ITR and PM), as shown in Figure 7.

Discussion Points on DJIA and Top Supply Chain Firms

If all students complete copying data and filling formulae, each group should generate an earns-turns matrix with AST verus VCM (or ITR vs. PM). Instructors can provide students with a list of questions that students may discuss. Candidate questions are as follows:

1. Which industries (or firms) spend high in R&D expenditure?
2. Which industries (or firms) keep high PM?

3. Is there any relationship between R&D expenditure and PM?
4. Which industries (or firms) spend more in CGS than PM?
5. Which firms have higher ROA? Who are ROA-frontiers in the earns-turns matrix?
6. Is there any relationship between VCM and AST?
7. Is there any relationship between PM and ITR for those firms that deliver goods?
8. Which industries (or firms) belong to the profitable supply chain?
9. Which industries (or firms) belong to the efficient supply chain?

Each student should explain the industry features of the assigned firm(s) and point out the location of each firm on the earns-turns matrix. With the earns-turns matrix and cost structure, students could start in-depth and productive discussions. Students will appreciate industry characteristics by answering the above questions. Instructors need to collect all spreadsheets and generate another earns-turns matrix with all firms. Instructors are recommended to create a scatter chart using a statistical tool such as R or JMP because it is difficult to add labels on the scatterplot using MS-Excel. See the Appendix for the detail R code and Graph Builder of JMP how to generate a scatterplot (Figure 7). Instructors can wrap-up the discussion by focusing on the earns-turns matrix. Instructors may raise questions and students can respond to all questions by observing the earns-turns matrix.

Figure 5: Instructors can collect all firms' performance analysis on one spreadsheet. With collective data, it is easy to create an earns-turns matrix. In addition, instructors provide a dashboard for cost structure and two earns-turns matrices on the collective sheet.

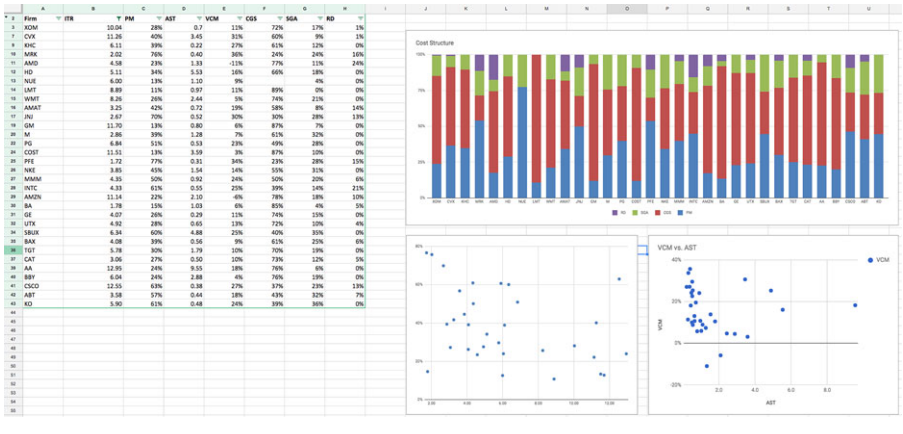
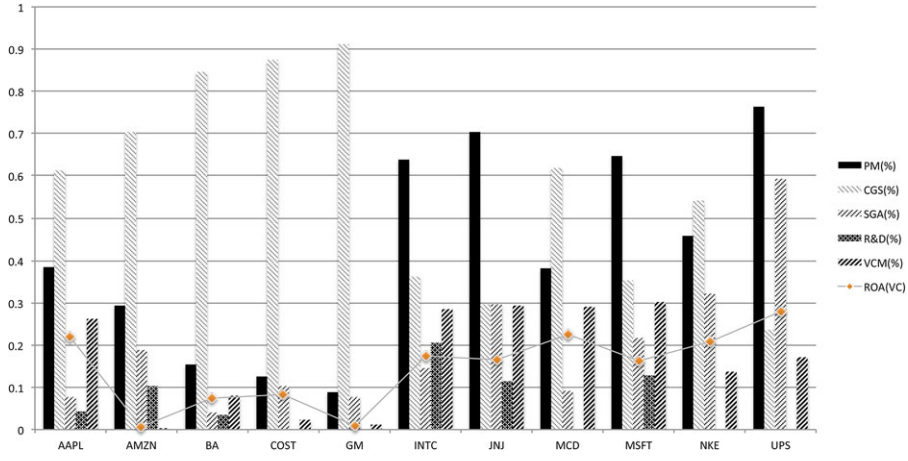


Figure 6: Cost structure of different DJIA and top supply chain firms. AAPL is for Apple; AMZN for Amazon; BA for Boeing; COST for Costco; GM for General Motors; INTC for Intel; JNJ for Johnson & Johnson; MCD for McDonald; MSFT for Microsoft; NKE for Nike; UPS for UPS, respectively.

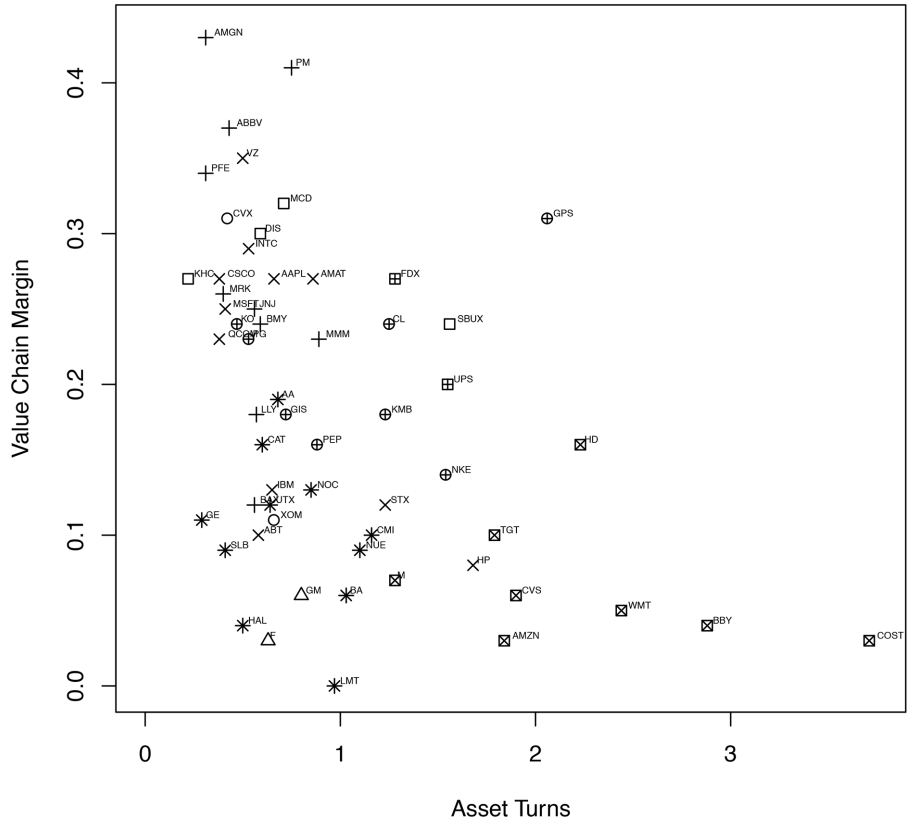


Key Takeaways from the Discussions

Instructors need to point out critical takeaways from supply chain metrics of all DJIA and top supply chain firms because each group has limited information of its assigned firms (around 10). Students can obtain access to the cost structure analysis shown in Figure 5 or 6. The stacked bar chart in Figure 6 shows that the relationship between R&D expenditure and PM is positive; in other words, the more spending in R&D, the higher PM. Note that there are exceptions such as Amazon and AMD. High-tech (e.g., Intel), biopharmaceutical (e.g., Pfizer), and chemical firms (e.g., Johnson and Johnson) spend more in R&D and build up a high barrier for competitors not to be able to enter into the game. With this, instructors need to relate the earns-turns matrix shown in Figure 7. High-tech, biopharmaceutical, and chemical firms are located in left-top (i.e., profitable supply chain). This discussion would answer questions 1–3, and 8.

Another critical clue is about comparisons between CGS and PM. Retail and traditional industries spend more in CGS than PM. Retail firms are leaner than high-tech, biopharmaceutical, and chemical firms (Figure 7, bottom right). Retail firms add markup, not value, to their products and deliver finished goods and services from manufacturing firms to customers. Logistics service providers merely transport finished goods. Logistics service providers make higher ROA than retail firms, as shown in Figure 7. Traditional manufacturing firms make lower ROA than other industries, as shown in Figure 7. This discussion would answer questions 4, 5, and 9.

Figure 7: An earns-turns matrix with AST and VCM of the DJIA and top supply chain firms. For manufacturing and retail firms, ITR and PM would be used. ⊠ represents retail firms; ∗ traditional manufacturing firms such as basic materials, defense, and machinery; + chemical or biopharmaceutical; × high-tech; □ food chain and entertainment; ⊕ consumer goods; ⊞ logistics service providers; ◯ oil and gas; △ automotive, respectively. All stock symbols are listed in appendix.



With the above two discussions, students were able to identify three categories: profitable, lean, and destructive supply chains. The majority of firms belong to either a profitable or lean supply chain. In other words, VCM (PM) and AST (ITR) have negative relations. This classification is relative, depending upon the compared industries (or firms). For example, retail firms are lean compared with high-tech firms. Some retail firms (e.g., Macy's, Home Depot) are more profitable than other retail firms (e.g., Costco, Walmart). This discussion would answer questions 6–9.

EVIDENCE OF EFFECTIVENESS AND ASSESSMENT OF LEARNING OBJECTIVES

Feedback from students has been strongly positive. Application of accounting procedures to supply chain performance analysis appears to be something new to students irrespective of their prior knowledge level of accounting. Students believed that the application of accounting principles should be discussed in OSCM discipline rather than just in the accounting discipline. Students appreciated the opportunity to work on the interdisciplinary approach between OSCM and accounting/finance. Several questions are typically asked to assure the pedagogical learning objectives described in the first section. Around one-third students received 90% or better scores from the associated exam; around 90% students received 80% or better scores. Sample questions are as follows:

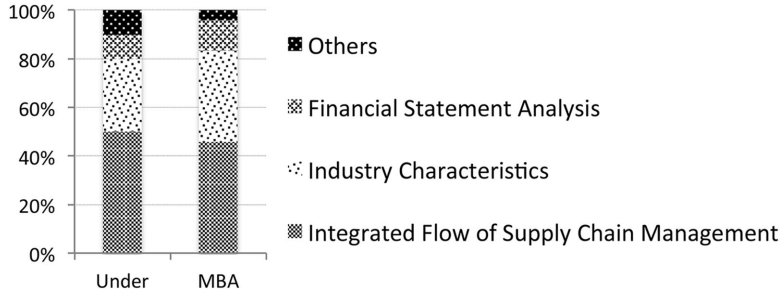
1. Given the financial data, compute the inventory turns (or inventory days).
2. Given the financial data, calculate the AR turns (or collection cycle).
3. Given the financial data, calculate the AP turns (or payment cycle).
4. Given the financial data, calculate the cash-to-cash cycle in days.
5. ROE is larger than ROA, provided that asset, liability, and equity are positive. (T/F)
6. Retail firms are lean whereas high-tech firms are profitable. (T/F)
7. Costco is lean whereas Macy's is profitable. (T/F)

OSCM classes have been taught over five years since 2012, i.e., five semesters at the undergraduate level and six semesters at the MBA level, respectively. Surveys were conducted at the undergraduate and MBA levels after the first adoption of supply chain performance analysis of the DJIA and top 50 supply chain firms to assess the learning objectives and to evaluate the effectiveness of our new approach. There were 12 respondents from the undergraduate classes and 13 respondents from the MBA classes, respectively. Because class sizes were small, the respondent rates are reasonably good. The three major questions for the survey of the learning effectiveness are as follows:

Q1) What do you think about the topic of supply chain performance analysis?
   a. It is a must-learn.
   b. It is a generally good topic.
   c. It is not necessary to learn about it.

Q2) What did you learn from the topic of supply chain performance analysis?
   a. Integrated flow of supply chain management.
   b. Industry characteristics.
   c. Financial statement analysis.
   d. Others

Figure 8: Survey results for the question of major lessons learned from the topic, Q2.



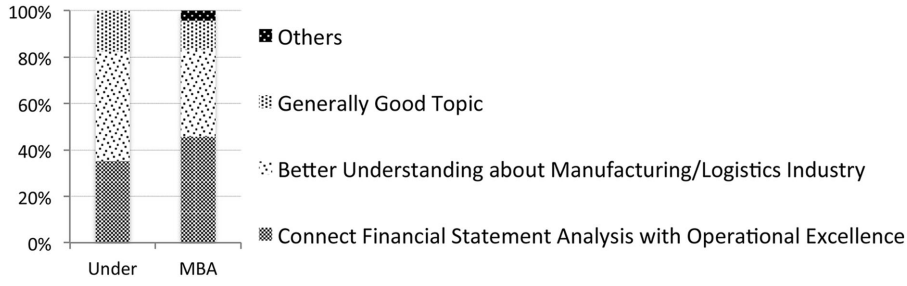
Q3) How would the lessons learned from the topic improve your professional knowledge and/or skills?
   a. Will be able to connect financial statement analysis with operational excellence.
   b. Will be able to better understand about manufacturing and/or logistics industry.
   c. It is a generally good topic.
   d. Others.

Sixty percent of MBA students responded that the topic is a must-learn, whereas 40% of undergraduate students responded in the same way, according to the responses to Q1, a multiple-choice question. All MBA students were working professionals and better realized that the topic would be important in practice. We conclude that MBA students valued the topic more than undergraduate students did because of their professional experience. Instructors need to expand on the importance of supply chain performance analysis. Supply chain professionals must understand basic accounting principles because all transactions across operations have been recorded in the financial statements such as income statement and balance sheet. Understanding accounting terminologies will assist supply chain professionals to make better decisions and efficiently perform (Leon 2015).

Major lessons learned, according to the responses to Q2, a multiple-answer question, are the integrated flow of supply chain management and industry characteristics, as shown in Figure 8. Financial statement analysis follows. These top two lessons, accounting for 80% of the responses, are our primary teaching objectives. MBA and undergraduate students did not show a big difference for Q2.

The results of Q3, a multiple-answer question, show that students would be able to connect financial statement with operational excellence and that

Figure 9: Survey results for the question of major lessons learned for the future career, Q3.



understanding of the industry characteristics would help their professional knowledge and skills in their future career (Figure 9).

We believe that students were able to grab the ideas of supply chain strategy and industry characteristics because of the interdisciplinary approach. Students also felt self-achievement by contributing to the class activity. Students actively participated in discussions because they were dedicated to at least one industry and one firm.

CONCLUDING REMARKS

OSCM courses require an interdisciplinary approach because operations and supply chain activities affect and are affected by other disciplines. OSCM deals with all resources of the firm. Henceforth, OSCM courses would be a petit-capstone course. Instructors need to encourage students to remind their prior knowledge and experience from other areas to dive into OSCM classes. Especially, accounting/finance plays a crucial role in interpreting operational excellence.

Students can learn many different perspectives from supply chain performance analysis of the DJIA and top supply chain firms. Students have to refresh their knowledge of accounting to calculate supply chain metrics. Students agreed that supply chain performance analysis is beyond an accounting class. Supply chain performance analysis provides a high-level understanding of OSCM and requires broad prior knowledge. In addition, one undergraduate student was mentored to research the high-tech industry using supply chain performance analysis (Lindenmuth 2018). Instructors can improve students' research experience through supply chain performance analysis.

Through this approach, students can obtain a good understanding across different areas such as supply chain strategy, accounting, and spreadsheet modeling. Note that students tend to value spreadsheet modeling more than conceptual topics. Instructors need to keep the balance among concept, discussion, and technical tasks, which are not the end, but a tool.

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APPENDIX

A. List of Firms To Be Analyzed

B. R Code to Generate a Scatterplot with Stock Symbols

Instructors are provided with detail steps to generate charts as follows.

Initialization. Open R and invoke `calibrate` library.

Table 1: Dow Jones Industrial Average Firms and Top 50 Supply Chain Firms.

Industry	Firm Name (Stock Symbol)	DJIA	Top SC	Industry	Firm Name (Stock Symbol)	DJIA	Top SC
Biopharmaceutical	Pfizer (PFE)	Y	N	Retailer	Home Depot (HD)	Y	Y
or Chemical	Johnson & Johnson (JNJ)	Y	Y		Target (TGT)	Y	N
	Merck & Co (MRK)	Y	Y		Amazon (AMZN)	Y	Y
	Abbott Lab (ABT)	Y	N		Best Buy (BBY)	Y	Y
	3 M (MMM)	Y	Y		Wal-Mart (WMT)	Y	Y
	Amgen (AMGN)	N	Y		Costco Wholesale (COST)	Y	Y
	AbbVie (ABBV)	N	Y				
	Dupont (DFT)	Y	Y				
	CVS Health (CVS)	N	Y				
Logistics	United Parcel Service (UPS)	Y	Y	Oil& Gas	Exxon Mobil (XOM)	Y	N
service provider	FedEx (FDX)	Y	N		Chevron (CVX)	Y	N
					Tesco (TESO)	N	Y
Food & Beverage	Coca-Cola (KO)	Y	Y	Consumer	Nike (NIKE)	Y	Y
	McDonald (MCD)	Y	Y	package goods	Gap (GPS)	N	Y
	Starbucks (SBX)	Y	Y		Colgate-Palmolive (CL)	N	Y
	Kraft (KRFT)	Y	Y		Kimberly Clark (KMB)	N	Y
	Pepsico (PEP)	N	Y		Proctor & Gamble (PG)	Y	Y
Traditional	General Electric (GE)	Y	N	High-tech	Oracle (ORCL)	Y	N
manufacturer	Caterpillar (CAT)	Y	Y		Microsoft (MSFT)	Y	N
	Alcoa (AA)	Y	N		Google (GOOG)	Y	N
	Boeing (BA)	Y	N		IBM (IBM)	Y	N
	Lockheed Martin (LMT)	Y	Y		Advanced Micro Devices (AMD)	Y	N
	General Motors (GM)	Y	N		Cisco (CSCO)	N	Y
	Nucor (NUE)	Y	N		Intel (INTC)	Y	Y
	Northdrop Grumman (NOC)	N	Y		HP (HPQ)	N	Y
	Halliburton (HAL)	N	Y		Seagate Technology (STX)	N	Y
	Cummins (CMI)	N	Y		Qualcomm (QCOM)	N	Y
	Emerson Electric (EMR)	N	Y		Applied Materials (AMAT)	Y	N
					Apple (AAPL)	Y	Y
					Verizon (VZ)	T	N

1. Highlight six columns (`Code`, `AssetTurns`, `VCMargin`, `ITR`, `PM`, and `sub`) with header from the collective spreadsheet. `Firm` is firm's symbol; `AssetTurns` asset turns; `VCMargin` value chain margin; `ITR` inventory turns; `PM` profit margin; `sub` industry classification, respectively.
2. In R window, use the following code to store data in `scp` vector:`scp = read.table(pipe(''pbpaste''), header=T)`
3. Make sure that you have proper data using `display` command in R window.
4. If data are properly uploaded, use the following code to create a scatter chart. Firms in the same industry will appear with the same pitch in the plot, if `pch` option is used for industry classification using Sub column. Instructors may add the labels and the title using `textxy` as follows:

   ```
   plot(scp$ITR, scp$PM, pch=scp$Sub)
   textxy(scp$ITR, scp$PM, scp$Code, cex = 0.5)
   ```

   Instructors may use VCM for y-axis and AST for x-axis using the following code for the DJIA and top supply chain firms, because their cost structures are different.

   ```
   plot(scp$AssetTurns, scp$VCMargin, pch=scp$Sub)
   textxy(scp$AssetTurns, scp$VCMargin, scp$Code,
   cex = 0.5)
   ```

5. Make sure that the scatterplot is proper. Instructors may save the plot in pdf format using the following code. `pdf` command must appear before `plot` command and instructors must close the pdf file using `dev.off()` command.

   ```
   pdf(''EarnsTurns.pdf'')
   plot(scp$ITR, scp$PM, xlab=''Inventory
   Turnover'', ylab=''Profit Margin'',
   xlim=c(0, max(scp$ITR)*1.05),
   ylim=c(0,max(scp$PM)*1.05), pch=scp$Sub)
   textxy(scp$ITR, scp$PM, scp$Code, cex = 0.5)
   dev.off()
   ```

C. How to Generate a Scatterplot Using JMP

Figure 10: Scatterplot by Graph Builder in JMP. Add labels for both row and column. Open Graph Builder, put AST on *x*-axis and VCM on *y*-axis. Choose ScatterPlot.

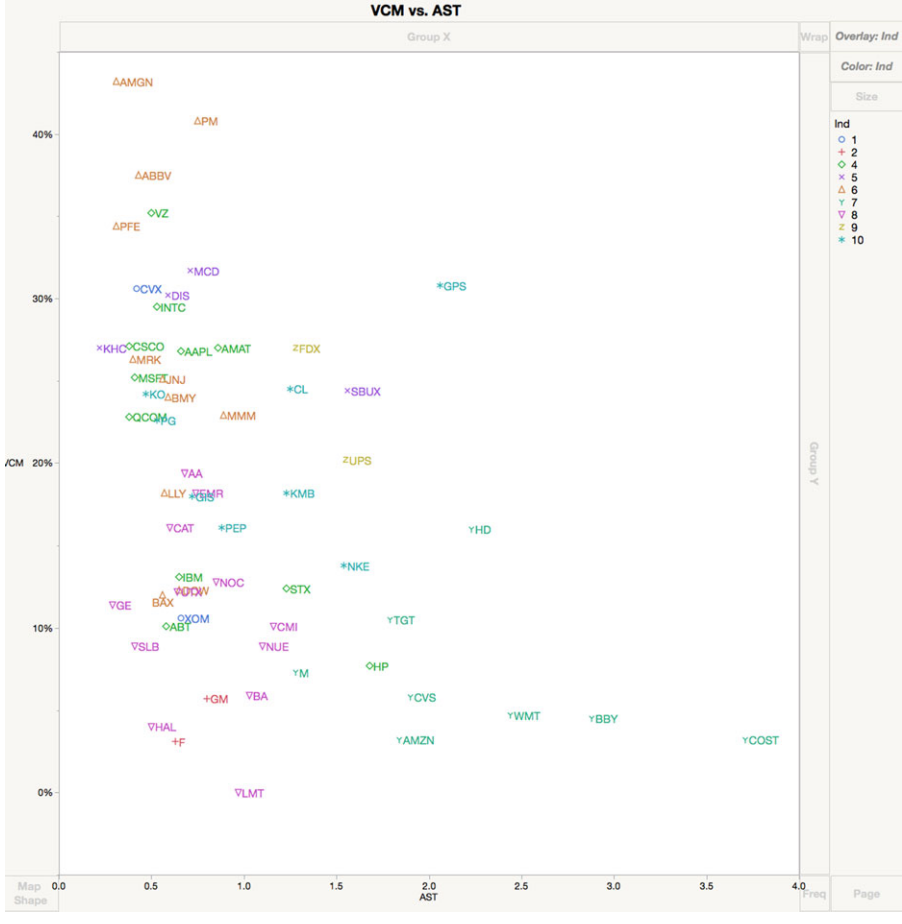
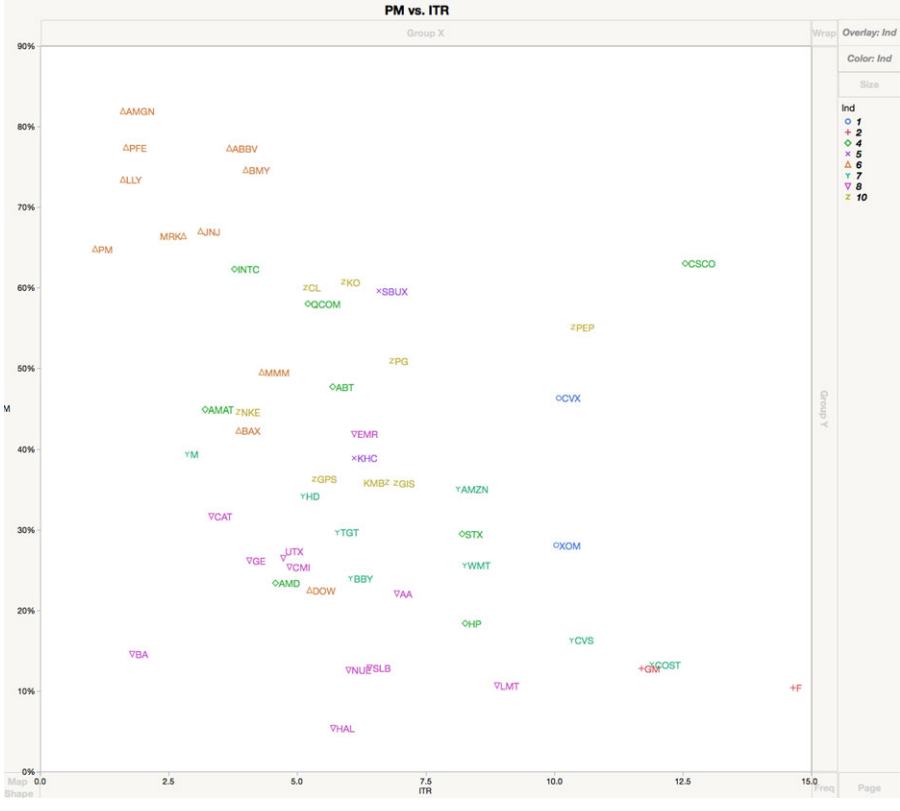


Figure 11: Scatterplot by Graph Builder in JMP. Add labels for both row and column. Open Graph Builder, put ITR on *x*-axis and PM on *y*-axis. Choose ScatterPlot.



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