Increasing Labor Efficiency and Reducing Construction Costs for a Real Estate & Home Building Firm

A Supply Chain Management DMAIC Process Improvement Project

Sam Deery-Schmitt, Syracuse University, MS Applied Data Science Program. MBC 638 — Data Analysis & Decision Making

Key Dates —>	Team Launch 4/12/21	Define 4/14/21	Measure 4/29/21	Analyze 5/17/21	Improve 5/31/21	Control Ongoing

DEFINE

➢Stakeholders suspect, but have not measured, significant supply chain inefficiency: employees frequently leaving job sites purchase supplies and materials in-person, which incurs additional labor costs and increases time to complete construction

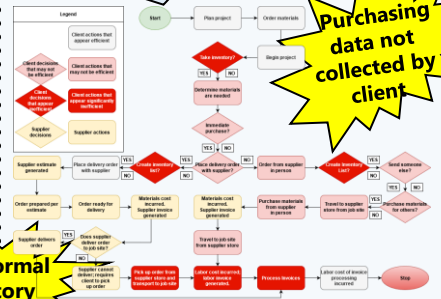
➢Because client works with 100+ suppliers, we target largest supplier

➢An initial systematic random sample of 176 invoices (n=18), representing one month of purchases, leads to the conclusion that 72% of these purchases were done in-person, with an estimated weekly labor cost of $1,794

Initial SQL: 0.77

MEASURE

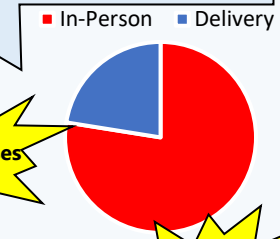
Conversations with stakeholders and supplier elucidate process



Purchasing data not collected by client

No formal inventory mgmt.

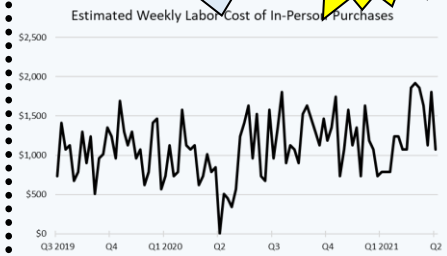
7 quarters of client accounting records cross-referenced with supplier invoices reveal order type for 2031 purchases



78% purchases in-person

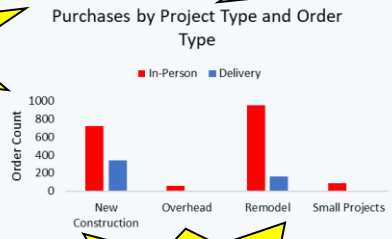
Inefficiency quantified

Average cost: $1100/week

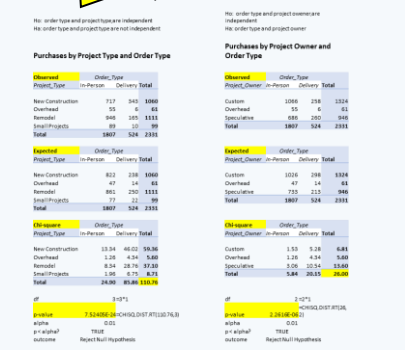


ANALYZE

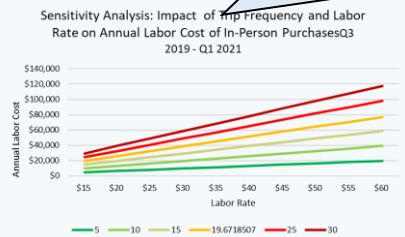
Remodels appear to be most inefficient project type



Hypothesis tests confirms findings! p < 0.01



Forecast predicts significant cost-savings if trip frequency and labor rate are reduced even marginally



IMPROVE

Top 5 Recommendations to Client:

➢Collect order type data and continue to measure process

➢Ensure all employees feel invested in changing the long-established practice

➢Study most inefficient projects, custom remodels, and most efficient projects, speculative new construction

➢Bundle in-person purchases together

Final SQL: 0.83

Explanation: improvements not implemented at scale

CONTROL

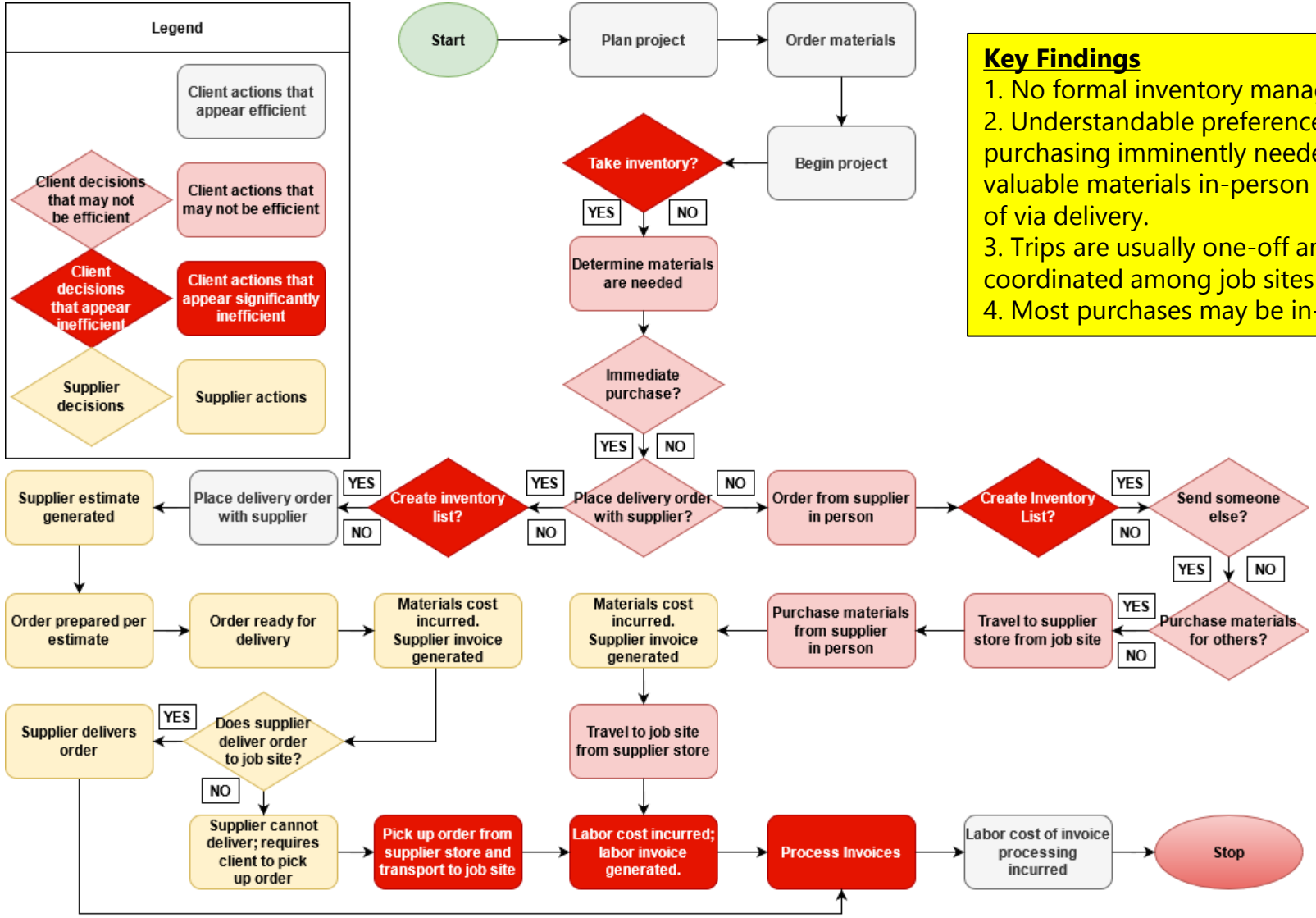
➢Monitor process and incrementally implement improvements

➢Implementing and iteratively improving an inventory management system will be critical to securing long-term improvements

➢Incorporate company-wide feedback to ensure all stakeholders remain committed to maintaining change

BUSINESS CASE: Previously unmeasured supply chain inefficiency calculated to cost client $57,000 annually

Process Map



Key Findings

1. No formal inventory management.
2. Understandable preference to purchasing imminently needed or valuable materials in-person instead of via delivery.
3. Trips are usually one-off and not coordinated among job sites
4. Most purchases may be in-person.

ANALYSIS

After speaking with stakeholders, I learned how the supply chain works. New construction is generally better planned than a remodel. Materials are ordered in advance in both cases. Once a project begins, to keep clutter and waste to a minimum, contractors prefer not to have a significant amount of extra material on-site, and when new materials are needed, the minimum amount estimated to complete a given task is purchased. There is no formal inventory management process, and usually items that are needed are purchased right away by someone at the job site. There are good reasons for making in-person purchases, such as quality control, and length delivery windows (days).

DMAIC Goals

- Discern key decision points during the purchasing process
- Measure the process in order to quantity both the in-person and delivery purchasing patterns from largest supplier, and how these trends vary with time and by project
    - Process has not previously been measured: order type is not recorded during invoice processing
- Make evidence-based recommendations to stakeholders based on granular analysis in order to improve process
- Reduce frequency of weekly in-person purchases by 20%
- Maintain efficiency gains in the long-term during control phase

Initial Estimate

Based on a simple random sample (n=20) of 1 month of data, 179 invoices, we estimate that more than 70% of purchases are in-person; some in the sample were for as few as $20 of materials, which is problematic because we calculated a labor cost of $56 for a 1-hour trip.

Most purchases may be in-person, and the labor cost of obtaining materials in-person may, in many cases, exceed the cost of materials.

Estimated weekly labor cost of purchasing materials from largest supplier in-person: $1,794

Operational Definitions

Performance Measure	Data Type (on disk)	Data Type (statistics)	Operational Definition	Notes
Project Number	Integer	Discrete	Client-assigned numeric job identifier	
Project Name	Character	Discrete	Client-assigned character job identifier	Usually last name of customer or street name of project.
Project Owner	Character	Discrete	Party that finances construction, and owns the land and home built on the land	Project owner can be either the client (a speculative project) or customer of client (a custom project)
Project Type	Character	Discrete	Designates nature of construction; project types include new construction, remodels, small projects, and overhead.	An example of a small project would be building a garage. The overhead category exists to classify invoices that are purchases that are not for any specific project, and are therefore billed to the client as overhead.
Invoice Number	Integar	Discrete	Supplier-assigned numeric purchase order identifier for in-person purchases or delivered goods	An invoice, with a unique invoice number, is issued upon purchase of goods in-person or upon delivery of shipped goods
Quote Number	Integar	Discrete	Supplier-assigned numeric purchase order identifier for shipped goods	A quote, with a quote number ,is issued when an order for delivery is placed, and subsequently a separate invoice with a unique, unrelated invoice number is issued upon arrival of the shipped goods. For the purposes of tracking order placement, quote numbers were incorporated into the data set for shipped orders, and invoice numbers were used for in-person purchases. This is because the arrival of goods, and therefore the invoice date, does not accurately reflect when the order was placed
Invoice Date	Datetime	Both	Date of in-person purchase for in-person purchases, or date of delivery for shipped goods.	
Quote Date	Datetime	Both	Date that delivery order was placed.	
Order Description	Character	Discrete	Client's characterization of the items purchased for the given invoice.	Does not always contain 100% of the purchase.
Order Amount (Client)	Numeric	Continuous	The amount the client paid for the given invoice.	
Order Amount (Supplier)	Numeric	Continuous	The amount the client was billed for the given invoice.	There is an important distinction here that caused a significant headache when merging the two datasets. The amount on the quotes for delivery orders often was different than the amount paid for the order. Sometimes quoted orders were split up into multiple invoices, delivered on the same day or different days.
Order Type	Character	Discrete	Characterization of type of purchase	Either POS for in-person purchases or SHIPPED for deliveries.

Data Measurement Plan

Performance Measure	Data Type (on disk)	Data Type (statistics)	Data Source	Data Location	Data Collection Methods	Responsible Parties	Collection Dates	Target Sample Size
Project Number	Integer	Discrete	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Project Name	Character	Discrete	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Project Owner	Character	Discrete	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Project Type	Character	Discrete	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Invoice Number	Integar	Discrete	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Quote Number	Integar	Discrete	Supplier's Records of Client's Purchase Invoices	Supplier Portal	Download 2019 Q1 - 2021 Q1 records by job site and order type (Excel) and aggregate	SDS, Supplier	4/29 – 5/16	NA; taking every record
Invoice Date	Datetime	Both	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Ship Date	Datetime	Both	Supplier's Records of Client's Purchase Invoices	Supplier Portal	Download 2019 Q1 - 2021 Q1 records by job site and order type (excel) and aggregate	SDS, Supplier	4/29 – 5/16	NA; taking every record
Order Description	Character	Discrete	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Order Amount (Client)	Numeric	Continuous	Client's Internal Accounting Records	Client Database	Query database, aggregate 2019 Q1 - 2021 Q1 Records	SDS, Client	4/29 – 5/16	NA; taking every record
Order Amount (Supplier)	Numeric	Continuous	Supplier's Records of Client's Purchase Invoices	Supplier Portal	Download 2019 Q1 - 2021 Q1 records by job site and order type (excel) and aggregate	SDS, Client	4/29 – 5/16	NA; taking every record
Order Type	Character	Discrete	Both Client's Internal Accounting Records and Supplier's Records of Client's Purchase Invoices	SDS Computer	Match Client and Supplier records to determine order type using invoice number and quote number, invoice date and ship date, order amount (client) and order amount (supplier)	SDS	4/29 – 5/16	NA; taking every record

Data Collection, Cleaning, and Validation Methods

Goal: using 8 quarters of financial records, determine which purchases were in-person from supplier, and which were delivery
Obstacle: client accounting database excluded this information; delivery is free, so accountant did not record this information
Solution: access supplier records, which include purchase type, and cross-reference with client records
Additional Obstacles: supplier records are accessed via an online portal in fragments and required significant cleaning and munging; client records contained errors (never financial; only mistyped invoice numbers) and required cleaning and munging

Methods

Query client database to collect internal accounting data on invoices paid between Q2 2019 and Q1 2021

- Clean data set, resolving errors in data types and adding additional fields including project name, project owner, and project type

Access supplier portal and retrieve invoices

- Automated retrieval process, including downloading invoices by purchase type and job site, aggregating all downloaded files and subsequently aggregating all supplier data into one table

Systematically match client invoice data with supplier invoice data

- Matched by price, price with tax – it turns out the shipped orders did not have tax included on the supplier estimate – as well as order date, project name – which differed in both systems – and resolved unmatched client records manually by further investigating idiosyncrasies in the data
    - Learned that deliveries were often split up into multiple deliveries, so client invoices wouldn't match a supplier quote
    - Learned the supplier database, which I accessed through an online portal, had been reset just before the start of Q3 2019 when the supplier was acquired by the current ownership; had to throw out Q2 2019 of client data
    - Further eliminated client records for credits and rebates, and kept a thorough, automatically updating log of data changes
- Manually checked remaining unknowns with pdfs of invoices to resolve any discrepancies

Successfully determined exact order type of 2,229/2,331 invoices and estimated order type of final 2 based on price

Measurement Error Analysis

- Possible sources of error: mistyped invoice/quote numbers on the client end and the supplier end
  - Client manually entering data; this did happen. Supplier seems to automate the process; this did not happen
  - When I was done, I saw no instances of an unknown supplier record. If I had seen unknown supplier and unknown client records, I would have some uncertainty.
  - The two unknown client records are likely to be purchases from another supplier, but it can't be ruled out that they are from this supplier
- Errors in the code I wrote to match client and supplier records
  - I iteratively corrected over time and used so many different fields that I am confident I eliminated this source of error.
  - I cross-referenced any unknowns I could not eliminate with my code by manually checking the pdfs of the invoices and quotes
- In summary, there were external sources of measurement error (client and supplier mismanaging data) and internal sources of measurement error (my own misinterpretation of data) but I am confident that I effectively eliminated this error

Sigma Quality Level Calculations

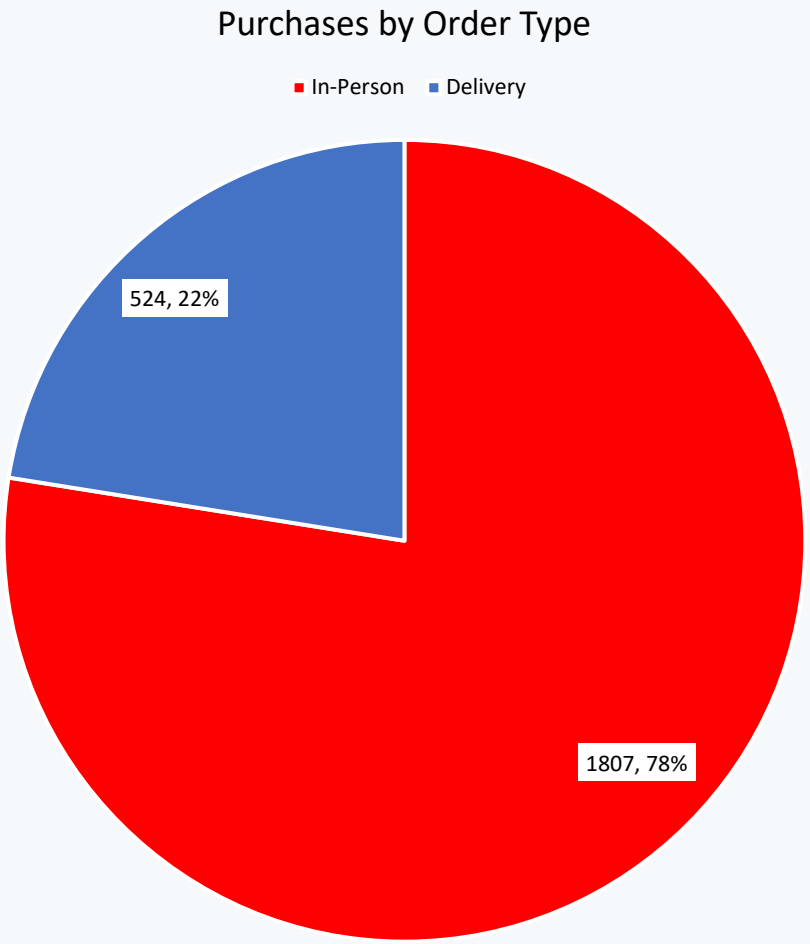
Sigma Quality Level: Before	
1. Definition of unit:	
Unit Definition:	1 week
2. Defect opportunities per unit:	
Defect 1	Average spending less than $112/in-person purchase in a week (twice the labor cost of an in-person purchase)
Defect 2	More than 7 in-person purchases in a week
D =	2
3. Units produced per timeframe:	
timeframe:	92 weeks
U =	92
4. Total possible defects per timeframe:	
D × U =	184
5. Total actual defects:	
Defect 1	51
Defect 2	90
A =	141
6. Defect-per-opportunity rate:	
A ÷ DU = DPO =	0.766304348
7. Defects per million opportunities (DPMO):	
DPO × 1,000,000 =	766,304.35
8. SQL value:	
SQL = NORM.S.INV(1-DPMO/1000000) + 1.5	0.77

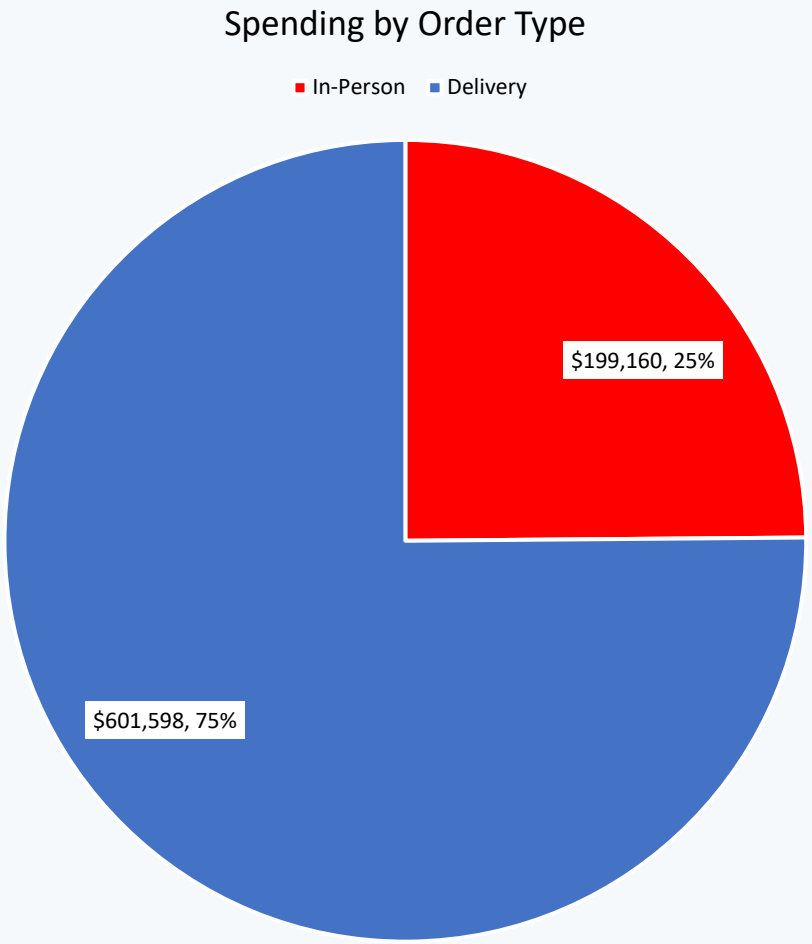
Sigma Quality Level: After	
1. Definition of unit:	
Unit Definition:	1 week
2. Defect opportunities per unit:	
Defect 1	Average spending less than $112/in-person purchase in a week (twice the labor cost of an in-person purchase)
Defect 2	More than 7 in-person purchases in a
D =	2
3. Units produced per timeframe:	
timeframe:	2 weeks
U =	2
4. Total possible defects per timeframe:	
D × U =	4
5. Total actual defects:	
Defect 1	1
Defect 2	2
A =	3
6. Defect-per-opportunity rate:	
A ÷ DU = DPO =	0.75
7. Defects per million opportunities (DPMO):	
DPO × 1,000,000 =	750,000.00
8. SQL value:	
SQL = NORM.S.INV(1-DPMO/1000000) + 1.5	0.83

ANALYSIS

There was not a significant change in S.Q.L. after the Improve Phase. The biggest driver: improvements were not implemented company-wide. Ongoing efforts are underway to implement improvements and SQL will be periodically recalculated.

What proportion of purchases are in-person?
What proportion of spending is in-person?

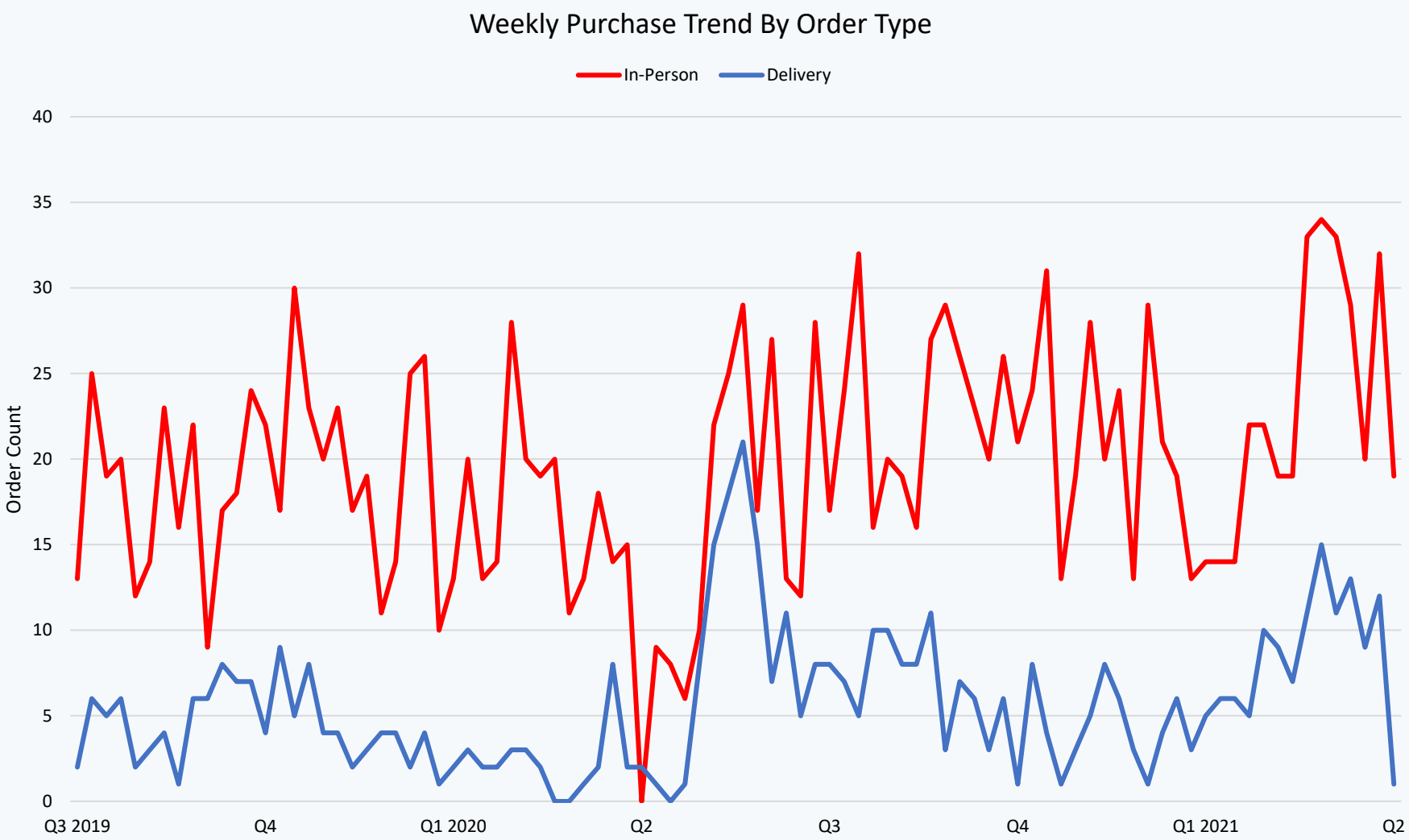




ANALYSIS

This was the first set of charts I made upon completely cleaning my data set, and they offer a stark conclusion: the problem is even bigger than we had thought. A huge majority of the client's purchases were done in-person, while only comprising a quarter of the overall spending for this time period. This indicates frequent, low-spending trips to the supplier's store may be common.

How does purchasing behavior vary over time?



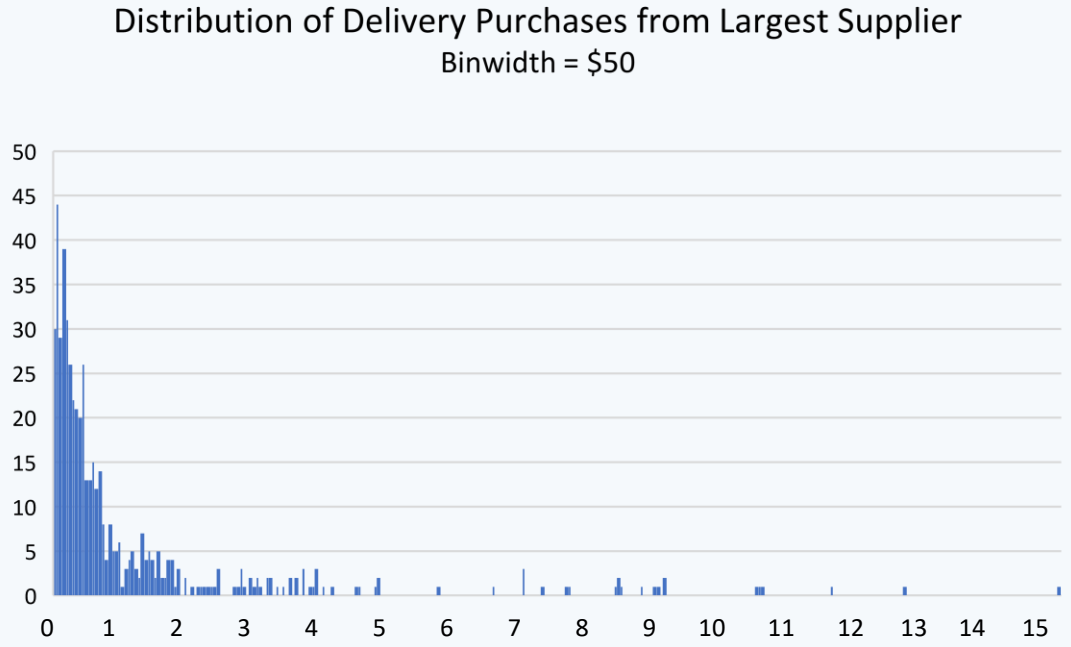
ANALYSIS

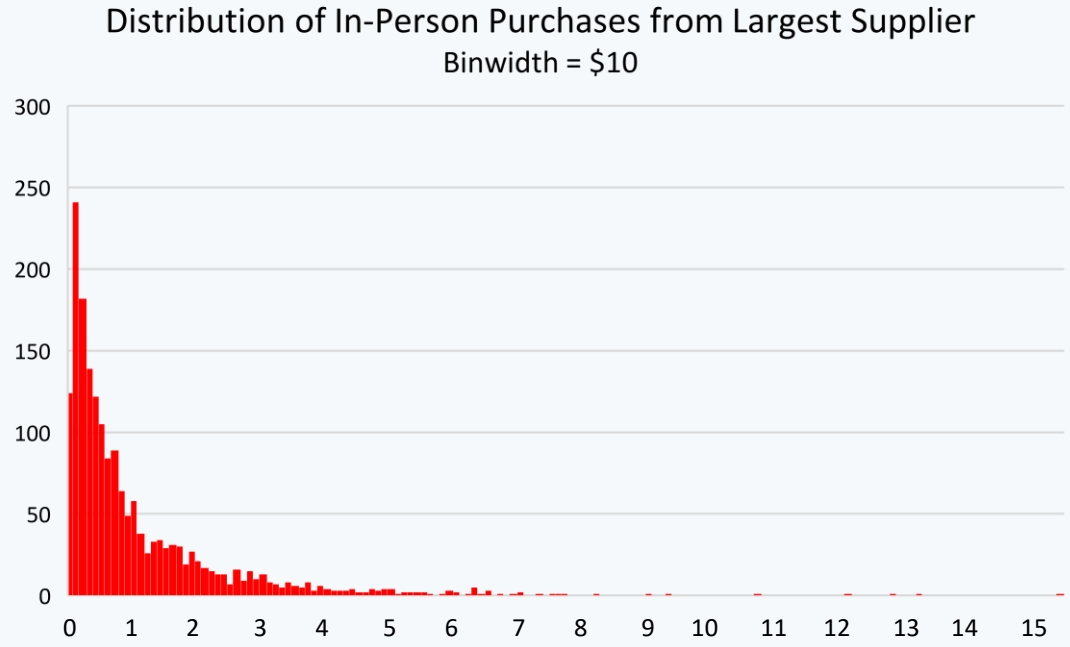
This was another question I wanted to answer immediately. There is always a clear gap between in-person and delivery purchases, with a notable plummet during the onset of the global pandemic. The momentary spike in weekly deliveries once the company started doing construction again quickly subsides. In-person purchases appear to be trending up.

Weekly Average
19.67 In-Person Purchases

How is order type distributed?

Spending Descriptive Statistics								
Purchase Type	Min	Q1	Median	Q3	Max	Percentile of Mean	Mean	Std Dev
In-Person	$0.85	$25	$60	$141	$1,548	57%	$110	$1,055
Delivery	$0.27	$183	$446	$1,133	$15,344	75%	$1,148	$2,013

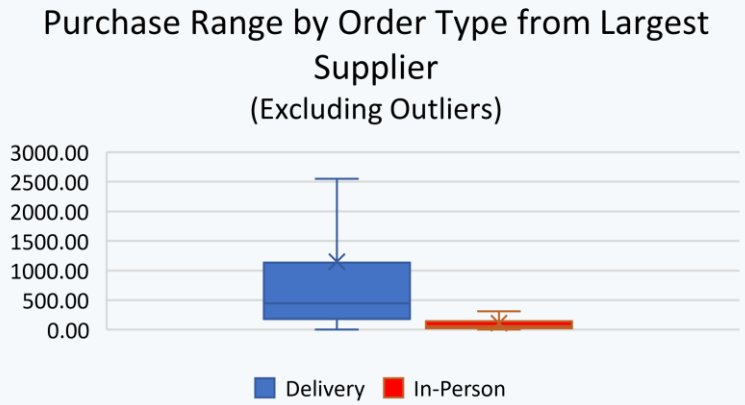


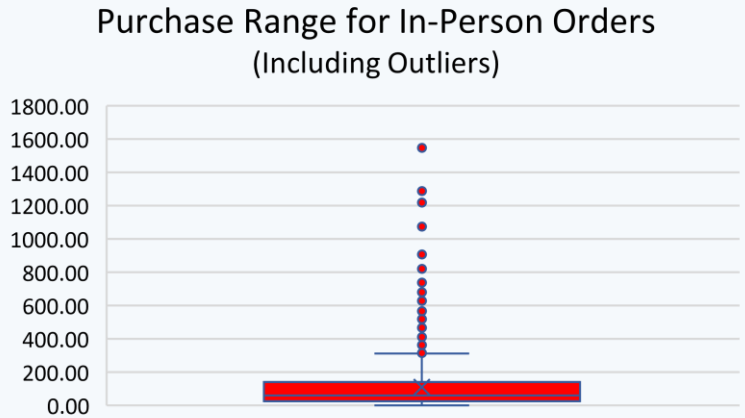


ANALYSIS

Now I can better understand the purchasing behavior of the client's management and employees. Both distributions are skewed heavily to the right, indicating the occasional expensive purchases, as seen on the histograms, inflate the mean, making median a better measure of center. Most purchases that are done in-person are for small amounts, relatively speaking. The third quartile of the in-person purchases fits neatly inside the first quartile of delivery purchases.

What can we learn from taking a closer look at these distributions?

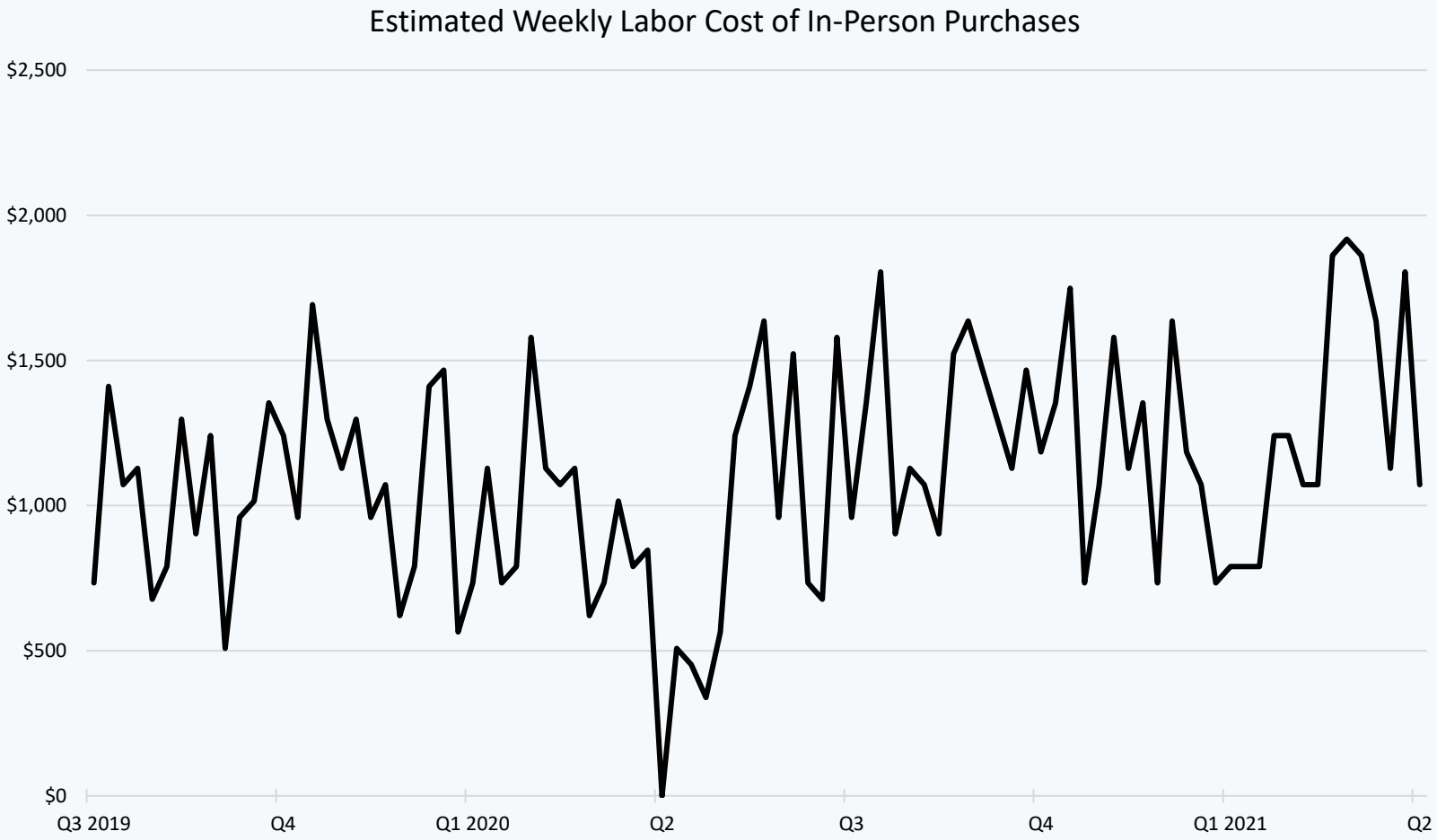




ANALYSIS

The side-by-side boxplots allow for comparisons that the individual histograms do not, and summarize the descriptive statistics table nicely. Comparing the two boxplots for in-person orders, we can see the outsize effect this outliers have on the mean, and how tight the range is for in-person purchases.

How much does the inefficiency cost the client?



ANALYSIS

Now that I thoroughly understood the basic summary statistics of order type, I could finally answer this question. I decided that modeling the estimated cost for the time period I analyzed on a weekly basis was a logical way to break up the data because we want to address this problem in terms of purchases and spending per week.

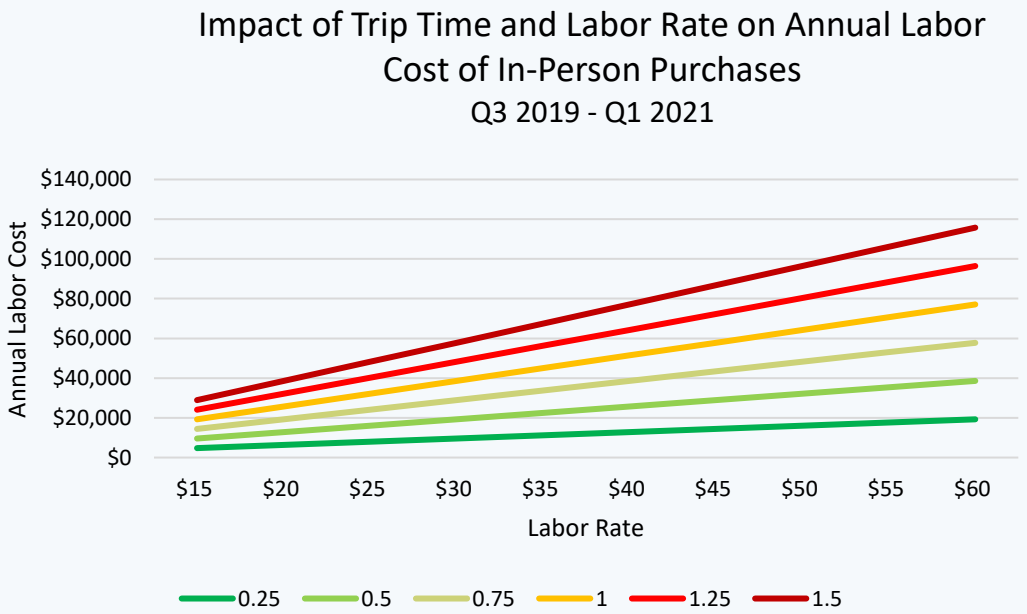
Weekly Average
$1,100 labor cost

How I estimated the cost of the inefficiency:

Trips/Week =	19.6719	Time to Purchase (Hrs)					
Annual Labor Cost =	$57,860	0.25	0.5	0.75	1	1.25	1.5
Labor Rate	$15	$4,822	$9,643	$14,465	$19,287	$24,108	$28,930
	$20	$6,429	$12,858	$19,287	$25,715	$32,144	$38,573
	$25	$8,036	$16,072	$24,108	$32,144	$40,180	$48,216
	$30	$9,643	$19,287	$28,930	$38,573	$48,216	$57,860
	$35	$11,251	$22,501	$33,752	$45,002	$56,253	$67,503
	$40	$12,858	$25,715	$38,573	$51,431	$64,289	$77,146
	$45	$14,465	$28,930	$43,395	$57,860	$72,325	$86,790
	$50	$16,072	$32,144	$48,216	$64,289	$80,361	$96,433
	$55	$17,679	$35,359	$53,038	$70,718	$88,397	$106,076
	$60	$19,287	$38,573	$57,860	$77,146	$96,433	$115,720

Calculations

In-Person Purchases	1807
Time Period Start	6/27/2019
Time Period Stop	3/31/2021
True Trips/Week	19.6718507
Labor Rate	$45.00
Billed Labor Rate	$56.41
Time to Purchase (hrs)	1
Trips/Week	19.6718507
Annual Cost	$57,860



ANALYSIS

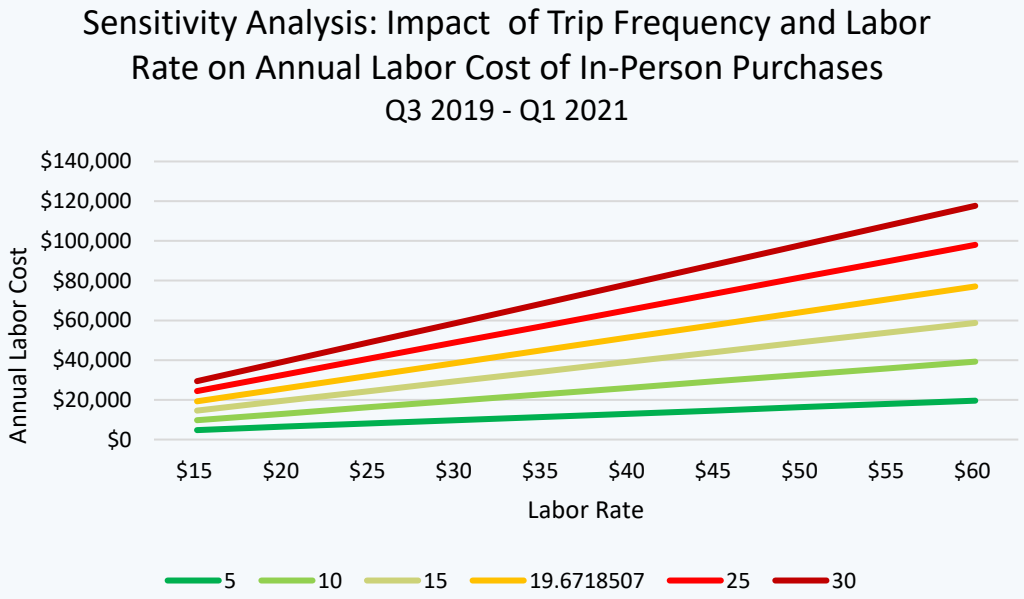
By performing a sensitivity analysis to estimate trip time and labor cost, I projected the annual labor cost. Our best estimate was 1 hour for a trip and $45/hr as a standard labor rate, which amounts to $57,860 annually, or $1,112/week. This table and graph allowed me to clearly communicate my findings, and a potential range of estimated labor costs, with the client.

How much could we reduce this inefficiency cost if we decrease in-person purchase frequency and labor rate for trips to supplier?

Time to Purchase (Hrs)	1	Trips/Week					
Annual Labor Cost	$57,860	5	10	15	19.6719	25	30
Labor Rate	$15	$4,902	$9,804	$14,706	$19,287	$24,510	$29,412
	$20	$6,536	$13,072	$19,608	$25,715	$32,681	$39,217
	$25	$8,170	$16,340	$24,510	$32,144	$40,851	$49,021
	$30	$9,804	$19,608	$29,412	$38,573	$49,021	$58,825
	$35	$11,438	$22,876	$34,315	$45,002	$57,191	$68,629
	$40	$13,072	$26,144	$39,217	$51,431	$65,361	$78,433
	$45	$14,706	$29,412	$44,119	$57,860	$73,531	$88,237
	$50	$16,340	$32,681	$49,021	$64,289	$81,701	$98,042
	$55	$17,974	$35,949	$53,923	$70,718	$89,871	$107,846
	$60	$19,608	$39,217	$58,825	$77,146	$98,042	$117,650

Calculations

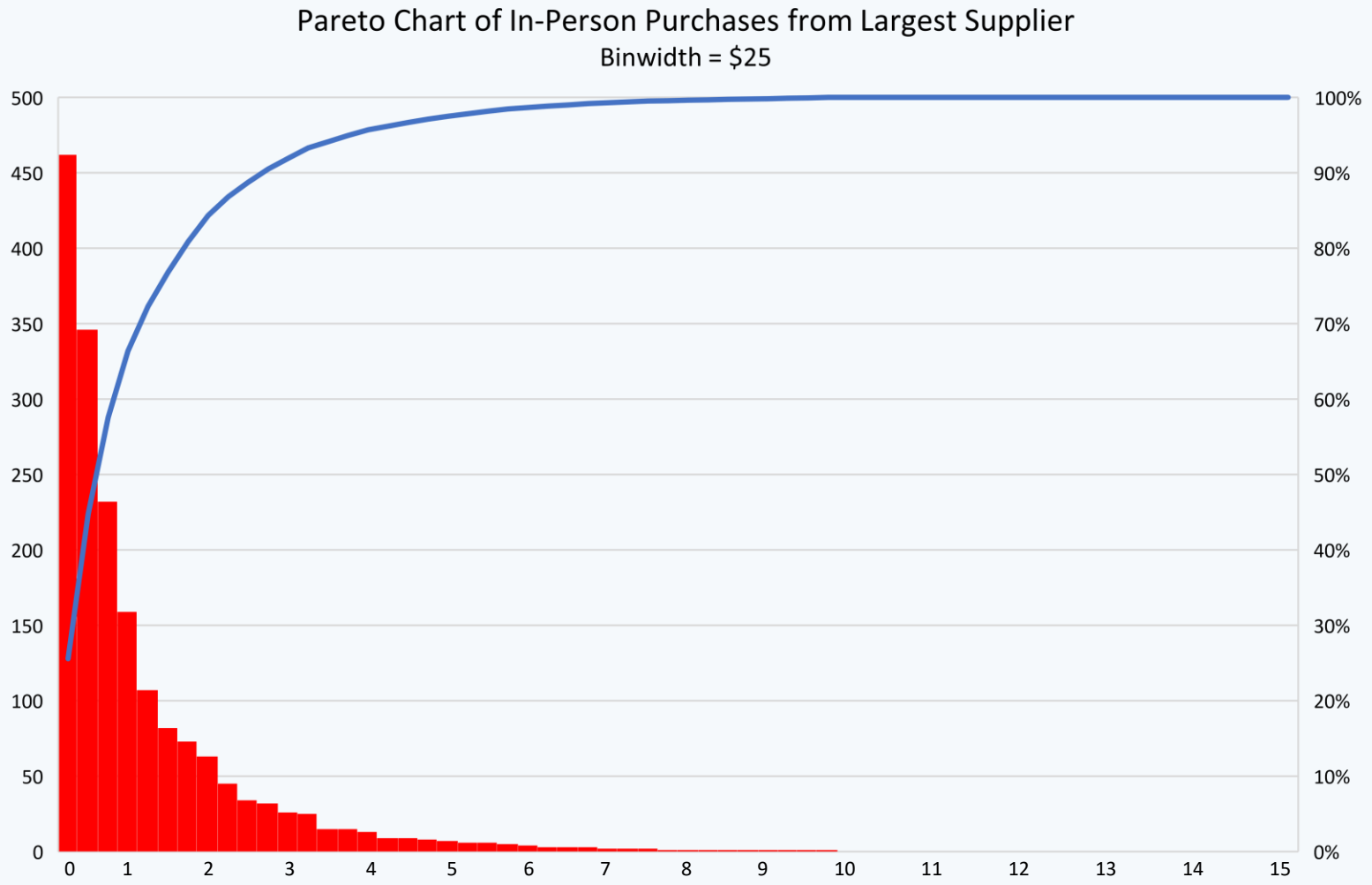
In-Person Purchases	1807
Time Period Start	6/27/2019
Time Period Stop	3/31/2021
True Trips/Week	19.6718507
Labor Rate	$45.00
Billed Labor Rate	$56.41
Time to Purchase (hrs)	1
Trips/Week	19.6718507
Annual Cost	$57,860



ANALYSIS

This sensitivity analysis allowed us to have constructive conversations about the concrete impact of setting specific goals for reducing trips/week. A 25% reduction leads to a $13,000 savings at a labor rate of $45/hr, and reducing the labor rate for purchasing materials to $20/hr reduces the annual cost to less than $20,000 at 15 trips/week!

What should we target as a minimum-spending threshold for future in-person purchases?

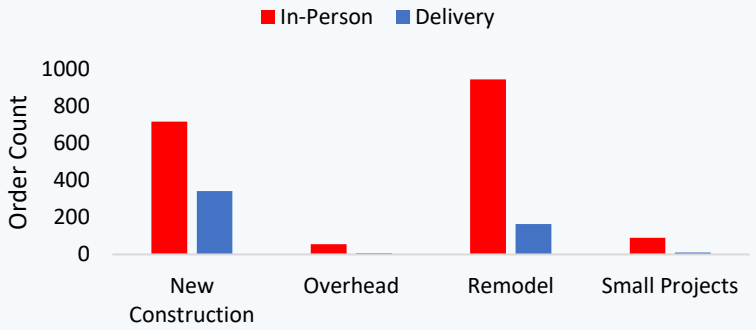


ANALYSIS

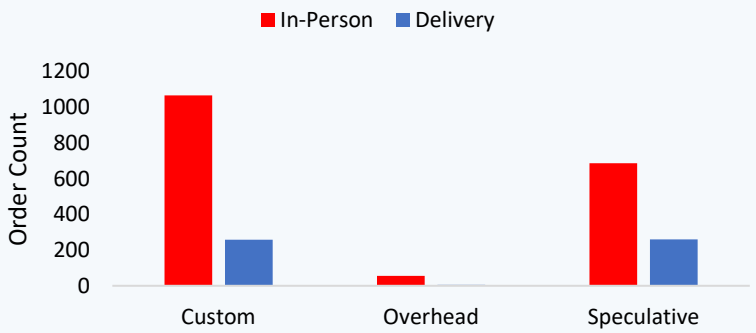
With this analysis I could hone in on this critical number, which appears to be near the inflection point on the curve for in-person purchases: more than 70% of in-person purchases are for $125 or less. Interestingly, this is approximately double our "typical" purchase (the median is $60). One way to put it would be doubling the goods purchased in a typical trip would reduce labor costs by at least 35%; if 70% of trips are for $125, then by combining trips, we will at least halve the number of these trips taken by combining them into one.

How does purchasing vary by project?

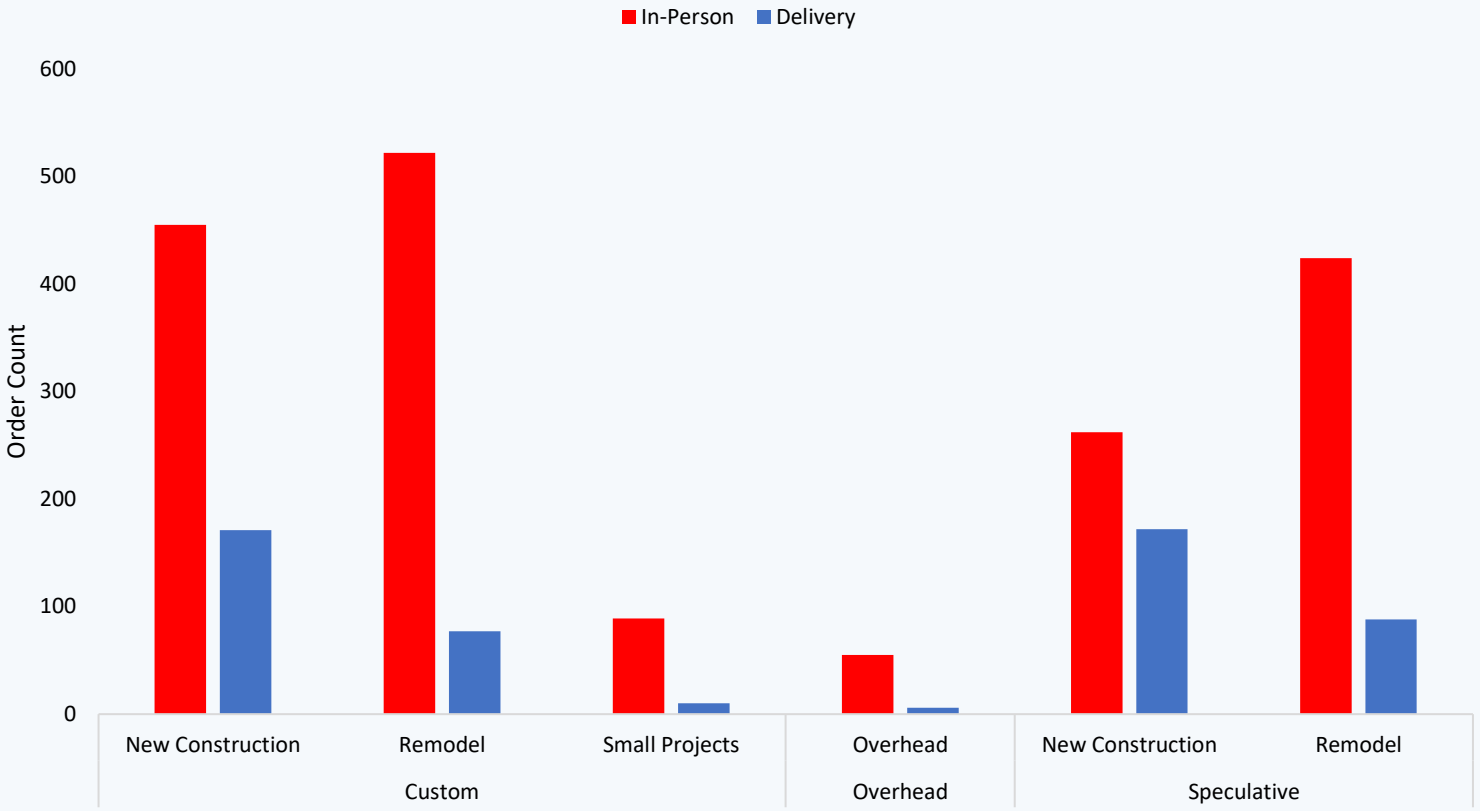
Purchases by Project Type and Order Type



Purchases by Project Owner and Order Type



Purchases by Project Owner, Project Type, and Order Type



ANALYSIS

This analysis led to some very interesting improvement insights. Looking at the data in this way help me understand what types of projects are driving the in-person spending trend. The Chief offender appears to be custom remodels. Some chi-square tests helped affirm that there are real differences here.

Are the observed differences among projects significant?

Ho: order type and project type are independent

Ha: order type and project type are not independent

Purchases by Project Type and Order Type

Observed	*Order_Type*		
Project_Type	In-Person	Delivery	**Total**
New Construction	717	343	**1060**
Overhead	55	6	**61**
Remodel	946	165	**1111**
Small Projects	89	10	**99**
Total	**1807**	**524**	**2331**

Expected	*Order_Type*		
Project_Type	In-Person	Delivery	**Total**
New Construction	822	238	**1060**
Overhead	47	14	**61**
Remodel	861	250	**1111**
Small Projects	77	22	**99**
Total	**1807**	**524**	**2331**

Chi-square	*Order_Type*		
Project_Type	In-Person	Delivery	**Total**
New Construction	13.34	46.02	**59.36**
Overhead	1.26	4.34	**5.60**
Remodel	8.34	28.76	**37.10**
Small Projects	1.96	6.75	**8.71**
Total	**24.90**	**85.86**	**110.76**

df	3	=3*1
p-value	7.52405E-24	=CHISQ.DIST.RT(110.76,3)
alpha	0.01	
p < alpha?	TRUE	
outcome	Reject Null Hypothesis	

Ho: order type and project owener are independent

Ha: order type and project owner

Purchases by Project Owner and Order Type

Observed	*Order_Type*		
Project_Owner	*In-Person*	*Delivery*	**Total**
Custom	1066	258	1324
Overhead	55	6	61
Speculative	686	260	946
Total	**1807**	**524**	**2331**

Expected	*Order_Type*		
Project_Owner	*In-Person*	*Delivery*	**Total**
Custom	1026	298	**1324**
Overhead	47	14	**61**
Speculative	733	213	**946**
Total	**1807**	**524**	**2331**

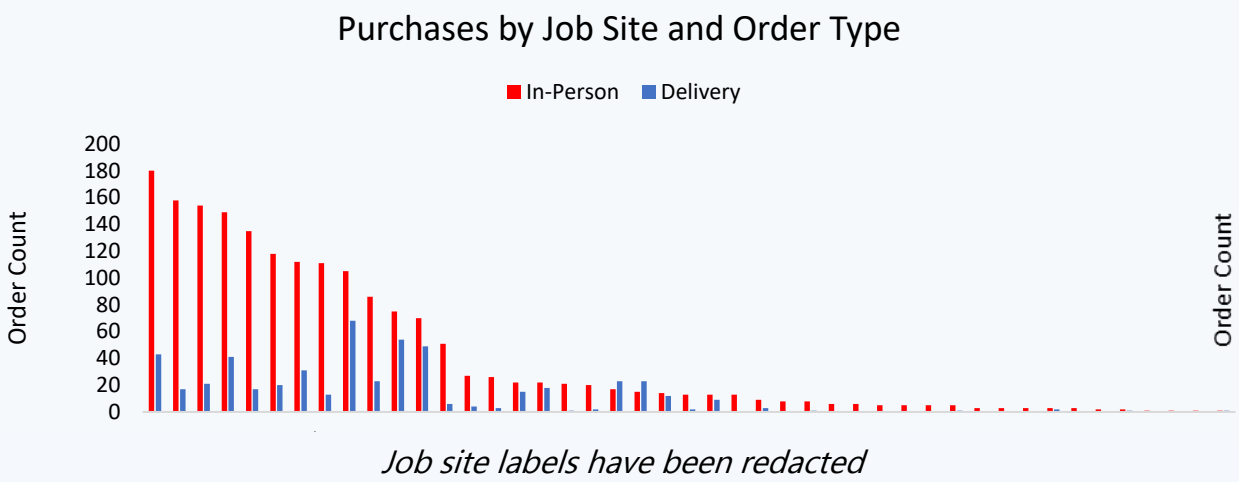
Chi-square	*Order_Type*		
Project_Owner	*In-Person*	*Delivery*	**Total**
Custom	1.53	5.28	**6.81**
Overhead	1.26	4.34	**5.60**
Speculative	3.06	10.54	**13.60**
Total	**5.84**	**20.15**	**26.00**

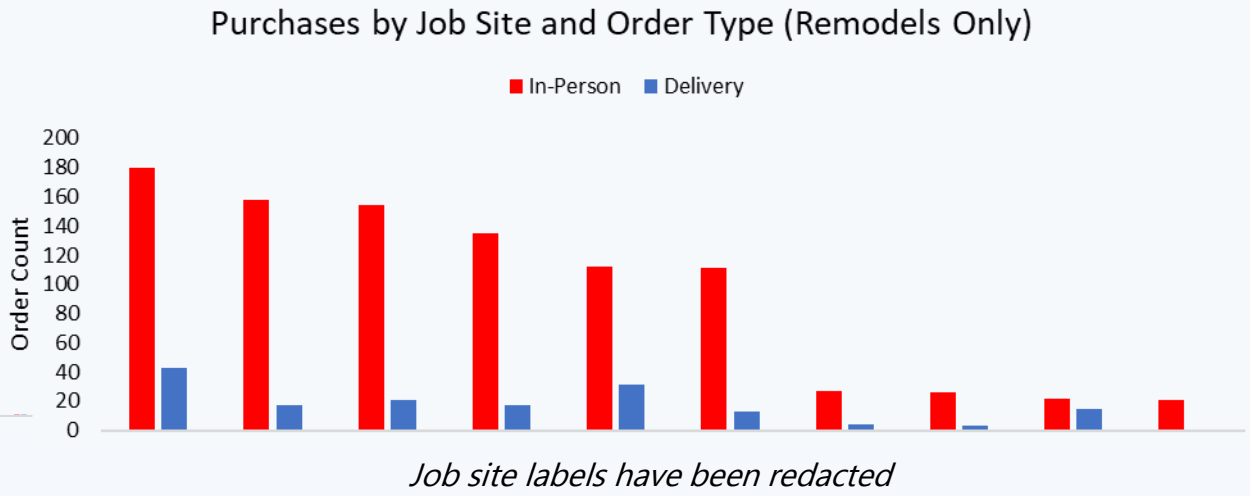
df	2	=2*1
p-value	2.2616E-06	=CHISQ.DIST.RT(26,2)
alpha	0.01	
p < alpha?	TRUE	
outcome	Reject Null Hypothesis	

ANALYSIS

A chi-square hypothesis tests yield p-values that are essentially zero. I am 99% confident that project type has an influence on order type, and I am 99% confident that project owner has an influence on order type. Remodel projects, particularly custom remodels, should be thoroughly examined as they also have the greatest number of in-person purchases.

What does a granular view of purchasing trends look like? Which projects can we learn the most from about improving this process?





ANALYSIS

On the left we have all projects, and on the right we have only remodels. 6 of the 9 projects with more than 100 in-person purchases are remodels. Now that I know that sites by name, I refer the projects to the client so we can learn more from the supervisors about what factors may have led to these purchasing patterns.

Improve Phase

Suggestions to Stakeholders:

Collect the order type data from invoices when reconciling invoices paid
- Will make measuring, and therefore, improving, the process significantly easier by eliminating the need for the type of complex validation with the supplier's invoice data that I performed

Involve the entire company, from entry-level laborers to senior site managers in improving this process
- Without full support of the employees making the actual purchase decisions, this long-established practice is unlikely to change
- As already evidenced, they offer valuable insight into the process, such as the fact the in-person-purchasing is necessary or preferred for certain order types including purchasing smaller quantities of lumber, where performing quality control is essential

Study the most inefficient and efficient projects
- 6 of the 9 most inefficient projects were custom remodels
  - *redacted and *redacted in particular can be used as case studies that senior leaders, management, and employees can learn valuable lessons from
- The most efficient remodel was a *redacted, a speculate project
  - Similarly, analyzing how this project was managed may yield actionable insights

** identifying information redacted*

Suggestions to Stakeholders, cont.

Bundle in-person trips together
- 40% of in-person purchases are for materials that cost less than or the same as the labor cost of purchasing them ($56)
- 50% of in-person purchases are for $60 or less
- 70% of in-person purchases are for $125 or less
- Planning ahead and purchasing these items will reduce unnecessary trips

Hire an entry-level laborer whose duties include fulfilling orders for different projects
- This way one person can coordinate purchases among project sites
- This person could be instructed what to buy for each site, then make regularly occurring trips to purchase necessary in-person items and distribute among jobs sites accordingly
- This way, a more senior carpenter isn't removed from a job site, minimizing cost and increasing time spent working on projects

Implement an inventory-management system
- This could be as basic as using a cloud-based notes app to keep a running list of what each site needs
- Perform regular inventory checks on each site to determine what supplies may needed and what may need to be purchased soon

Order more items through delivery
- Not all items are ideal to order through delivery, but the most commonly purchased items could be purchased on a regular basis for delivery instead of shipment, thus further eliminating unnecessary trips

Primary reason for lack of SQL change:

Longer timeframe needed to change this long-established, company-wide practice
- In 1 month, it was difficult to implement any of these suggestions company-wide
- Current process is fragmented and requires coordination to improve
- Before we can reduce the number of trips, all employees need to feel invested in changing the process

Control Phase

- By collecting purchase type data, monitoring the process will be significantly easier by continuing to employee the previously used tools as well as a control chart
- We will be able to directly measure the success of any changes in the process by looking at the number and proportion of in-person vs delivery purchases, as well as the associated spending
- Implementing and iteratively improving an inventory management system will be critical to securing long-term improvements
- Regularly collecting feedback from carpenters and other employees in one-on-ones and surveys will also be critical
  - We can learn what they feel is helping them, what they feel isn't helping them, and make continual adjustments
  - If everyone is a partner in improving this process, we should be able to maintain improvements for the long-term
- The control phase summary will be updated periodically as the process continues to be monitored and improvements are implemented

Bottom Line: "What gets measured gets done."
Continuing to measure this process will offer previously unavailable insight that will enable stakeholders to make evidence-based supply-chain management decisions.

Conclusion

Although the process has not improved yet, by measuring and analyzing the process, I have offered my stakeholders a granular view of the issue and quantified the cost of this specific supply chain inefficiency. In addition, by determining that custom remodels contribute most significantly to the issue, we can concentrate on learning from issues that arose at the most inefficient projects in order to avoid or lessen the impact of similar issues in the future. Over the next several quarters, by working with all levels of the client's employees, we can implement the improvements that everyone agrees will make the biggest impact and iteratively reduce unnecessary labor costs while increasing labor efficiency. In the long-term, developing an inventory management system and continuing to incorporate employee feedback will control the process and ensure these inefficiencies do not persist.

This is an ongoing project, and as the process improves, this slide deck will be updated to reflect new progress and findings.

If you've made it this far, thank you for reading. I welcome any questions or feedback: spdeerys@syr.edu