Implementing Digital Procurement in Construction Industry

Clarinda Joanne Ellorin Igros, Klint Allen A. Mariñas, Michael N. Young, and Yogi Tri Prasetyo
School of Industrial Engineering and Engineering Management
Mapúa University
658 Muralla St., Intramuros, Manila 1002, Philippines
cjmellorinigros@mymail.mapua.edu.ph, kaamarinas@mapua.edu.ph, mnyoung@mapua.edu.ph, ytprasetyo@mapua.edu.ph

Klint Allen A. Mariñas and Yung-Tsan Jou
Department of Industrial and Systems Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
klintallen2011@gmail.com, ytjou@cycu.edu.tw

Reny Nadlifatin
Department of Information Systems,
Institut Teknologi Sepuluh November, Kampus ITS Sukolilo,
Surabaya 60111, Indonesia
reny.nadlifatin@gmail.com

Abstract

Digital Transformation is considered to be one of the most significant advancements that happened in technology development. Intelligent systems and strategic enhancements are continuously improved as time goes by. Most industries use Digital Technologies as it is proven to provide an advantage in terms of productivity, communication, and efficiency. Digital Procurement is one of the most common uses of digital advancement in the construction industry. It demonstrates capabilities to automate systems that will reduce supplier risks and avoid supply chain disruptions. Digitizing the procurement process proves to increase effectiveness and reduce construction costs. The study's objective is to demonstrate the advantages of digital procurement in the construction industry. Four phases of the digital procurement model were established including the identification of the scope of procurement study, identifying applicable technologies, implementation, and warehousing and distribution. Cross Docking is implemented to strategize materials dealt with in the central warehouse logistically. The current study can be a basis for other companies planning to implement procurement digitization.

Keywords

Digital Transformation, Digital Procurement, Construction Industry, Cross Docking

1. Introduction

Digital Transformation is defined as a process of using digital technologies to improve business models, strategies, and procedures. (*What Is Digital Transformation - Salesforce*, n.d.) The integration of various innovative technologies is essential in developing work organizations that bring value-added services to their customers. (*What Is Digital Transformation? | The Enterprisers Project*, n.d.)

Several industries have already adopted incorporating digital technology into their business structure. One of the most promising sectors that benefit from the expanded output of technology is the construction industry. As of early 2022, the global construction industry shows a favorable economic outlook as the construction forecast displays a growth of 4.6%. Though labor and skill shortage are expected, innovation, research, and development will help in boosting the construction industry's reputation. (*Global Construction Outlook 2022*, n.d.)

Construction Software is expected to be greatly utilized to boost the market growth. As seen in Figure 1, Construction Management Software trends to increase towards 2026. (*Construction Management Software Size to Grow by USD 1.13 Bn| Increasing Requirements for Large-Scale Project Management to Boost Market Growth| Technavio*, n.d.)

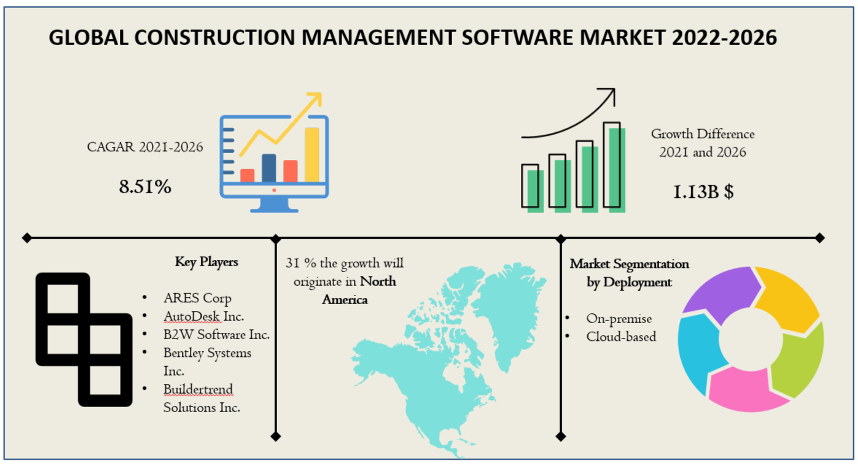

Figure 1. Construction Software Market 2022-2026

The digitalization roadmap for the Philippine construction industry is estimated to increase business productivity by the year 2030. Action plans include institutionalizing technologies and promoting digital transformation through incentives for digital transformation that can be applied using Building Information Modeling, Research & Development, and upgrades in facilities. (*Digital Roadmap Eyes P130B Gains – Daily Tribune*, n.d.)

It is necessary that construction companies develop competence and be able to adapt with continuous shifting market situation s (Uusitalo & Lavikka, 2021). The study will provide solutions to how the construction industry will fully utilize the advantages of digital procurement. What are the available technologies that will help improve supply chain management as businesses are gearing towards technological advancements?

2. Related Literature

Digitalization is highly regarded in the construction industry. According to McKinsey Global Institute, it is estimated that 57 trillion US Dollars will be spent on infrastructure by the year 2030; this is an enormous opportunity for digital transformation in the construction business. (Prebanić & Vukomanović, 2021)

According to Park, Lee, et al., Technical Risk Analysis is essential in engineering projects. Several proposed cost-saving approaches can be utilized by construction projects to reduce risks associated with project delays. Risk studies during the bidding stage of the procurement process will entail more profound systematic decision-making skills since critical factors are considered to expand the performance of digital information systems. (Park et al., 2021)

One of the latest applications developed to improve processes in the construction industry is Building Information Modeling (BIM). It has already been a conventional way of project construction due to its internet platform. Engineering Procurement Construction (EPC) can be consolidated and aligned with the details generated from BIM. Data sharing improves the efficiency and quality of project development. The BIM roadmap is based on digitization that utilizes cloud technology and the internet of things. Implementation of BIM shows progress in design, procurement, construction, and maintenance. (Jiang et al., 2021)

The selection of construction products is crucial since it determines the project cost and other fundamental designs and systems to be implemented in the project. Based on the journal of Barbini, Malacarne, et al.; digital evaluations in the procurement stage using BIM showed an increase in productivity and sustainability. A higher number of data can also be considered due to the cloud-based model of the software. (Barbini et al., 2020) The study of Hallikas, et. al presented those operational and dynamic analytics confirms positive outcomes of digital procurement capabilities in supply chain performance. It highlights the importance of gathering data thru digitalized process and data utilization improves the operational performance of an organization (Hallikas et al., 2021).

Algorithmic models developed by Choi, et. al, can be implemented to automatically extract and analyze contract risks when implementing EPC contracts. The system integrator can easily identify project characteristics and the frequency results can be visualized and be used by project implementors (Choi et al., 2021). Key Performance Indicators projects can also be linked with the EPC of the projects. It is significant to calculate and prioritize the different weight impacts of all reruns and delays in schedule. Managing the EPC will result lead to proper planning of resources and will effectively enhance the project's performance (Habibi et al., 2019).

Implementation of digitalized processes improves the quality and enhance the company's operation performance. Technologies such as Building Information Management, Cloud-based computing, augmented and visual reality are being used to modernized and influence the stability of the construction industry (Alaloul et al., 2020).s

3. Methodology

Material demand in the construction industry influences the project completion date. Resource management must be aligned with the work availability processes (Subramani & Prabhu, 2018). Thus, procurement is an essential process in any business structure. It involves comprehensive selection and shortlisting of accredited suppliers. It requires a thorough review and analysis of the supply chain to plan the finances and establish inventory control properly.

Accuracy, scheduling, budget allocation, and product quality must simultaneously comply with the guidelines set by the company to ensure smooth workflow. 87% of construction professionals believe that having a reliable procurement process will entail a higher project success rate. (*Procurement in Construction - How to Control Procurement Process*, n.d.) The Construction Procurement process shall be transparent, competitive and cost-efficient to ensure value for money. Capturing procurement activities can be challenging since it involves large volume of required data. Thus, traditional procurement process shall be mitigated by presenting applicable digital technologies (Perera et al., 2021).

The study will focus on using digital procurement of 4 residential buildings of ABC Company. It will demonstrate the process and benefits of digital procurement in the construction industry.

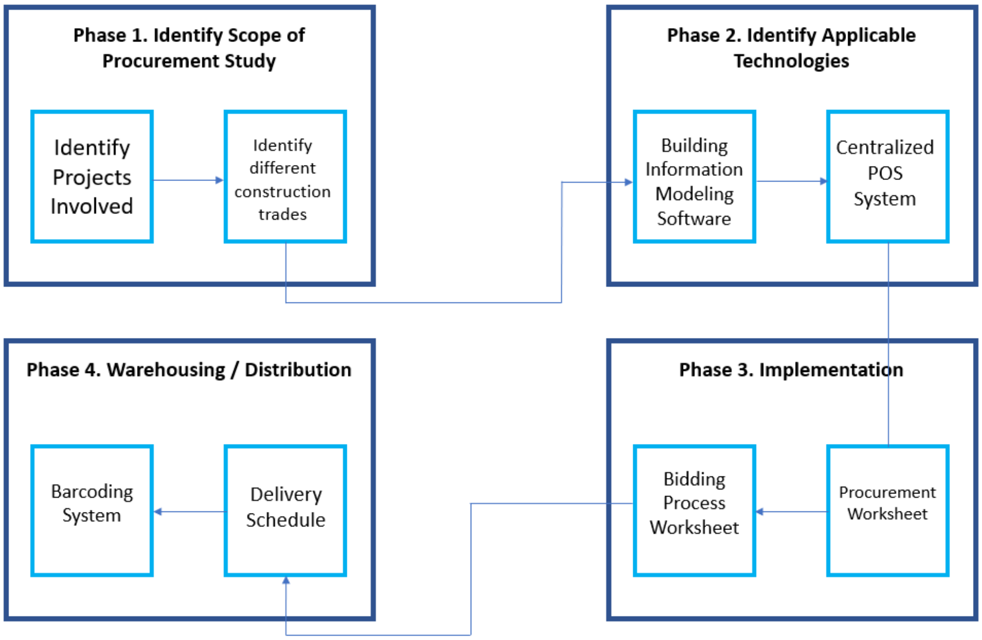

Figure 2. Conceptual Framework

Phase 1 of the journal deals with identifying the scope of the procurement study. Projects involved will be identified, and different construction trades will be classified. The study utilized 4 high-rise projects of ABC company and will focus on electro-mechanical trades to provide appropriate solutions in digital procurement.

Once the scope is identified, Phase 2 of the study will identify the different technologies available to enhance digital construction procurement further. Two of the emerging technologies that will be applied are Building Information Modeling Software (BIM) and Centralized Point of Sale System (POS). BIM Software shall be used to generate the list of required resources and its corresponding quantities needed for the project, while the POS System will be used for the procurement of the said materials and equipment.

Phase 3 emphasizes the different methodologies for implementing the proposed technologies. Different worksheets shall be generated to implement the digital procurement process properly. The worksheets will be essential to the POS system.

Once the worksheets are available and ready for implementation, listed supplies and materials shall be integrated with the POS system. Phase 4 will focus on implementing the barcoding system, which shall be aligned with the delivery schedule.

3.1 Implementation

The study considered four (4) high-rise projects of ABC company. Equipment and materials needed for Electro-mechanical trades such as *Electrical, Fire Protection, Mechanical / Ventilation, and Plumbing & Sanitary* works shall be considered in the digital procurement solutions. Using Building Information Modeling software, material list and specifications can be extracted from the model. Data from BIM can be integrated with the POS system. Figure 2 shows the sample interface in the extraction of materials in the BIM model for Electrical Works

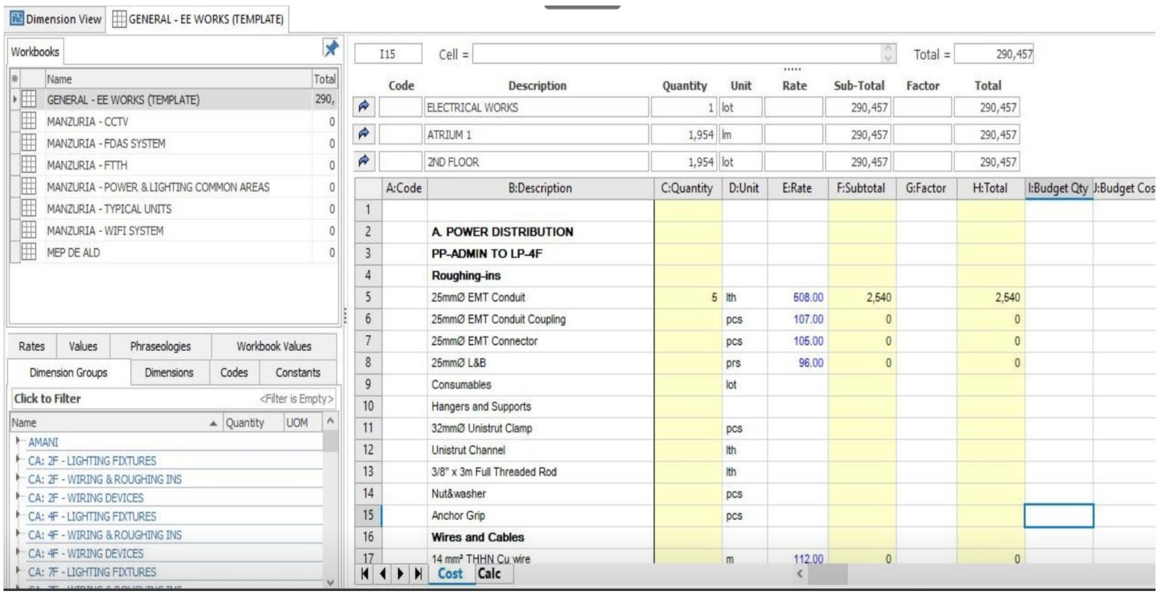

Figure 3. Electrical Material List (BIM Model)

The Procurement team will then use generated data from the BIM software to tabulate all necessary equipment and materials needed for the project. This will be encoded in the POS system to ensure that all essential supplies will be ordered and delivered to designated project sites.

Delivery of materials and equipment will be based on the assigned construction schedule. The project's timetable will determine the "just in time" distribution of supplies to ensure proper warehousing and material allocation. This strategy will also generate savings since resources will be purchased in bulk to get the most cost-efficient proposal from suppliers and subcontractors.

Shared Managed Inventory will also be implemented through the POS System. Subcontractors and suppliers can verify the status of all resources to ensure sufficient stocks, manage inventory, and timely delivery of materials to project sites.

4. Results and Discussion

Data from the BIM software will be aligned with the construction schedule to designate materials delivery properly. Tables 1 to 12 shows the monthly distribution of materials per scope of work. The tabulated data refers to the monthly requirement of each project per type of material. The data will be used by the procurement team to identify the delivery schedule as well as material allocation per project. The data is generated based from the quantity extraction of BIM models.

Table 1. Material Delivery Schedule for Electrical Works (January)

Scope of Works	Materials	JANUARY				
		Project A	Project B	Project C	Project D	SUBTOTAL
Electrical Works	20mmØ EMT Pipe Compression Type	3		3	2	8
	20mmØ EMT Compression Type Connector	6		6	3	15
	20mmØ Locknut Locknut and Bushing	6	3	6	5	20

	25mmØ EMT Pipe Compression Type	1	1	2	1	5
	25mmØ EMT Compression Type Connector		1		1	2
	25mmØ Locknut Locknut and Bushing		1	1	1	3
	32mmØ PVC Pipe	3	1	4	2	10
	32mmØ PVC Adapter and Locknut Locknut	1		1		2
	25mmØ PVC Pipe	38	12	35	25	110
	25mmØ PVC Adapter and Locknut Locknut	5		6		11
	25mmØ Locknut Locknut and Bushing			1		1
	20mmØ Locknut Locknut and Bushing	5				5
	Nylon Rope (for cable pulling) 200 meters			4	1	5
	Square Box Ga. 18	1			1	2
	22 mm² Al-THHN/THWN	20	6	19	27	72
	14 mm² Al-THHN/THWN	298	86	252		636
	8 mm² Al-THHN/THWN	160	40	135	101	436

Table 2. Material Delivery Schedule for Electrical Works (February)

Scope of Works	Materials	FEBRUARY				
		Project A	**Project B**	**Project C**	**Project D**	**SUBTOTAL**
Electrical Works	20mmØ EMT Pipe Compression Type	1	2	2	2	7
	20mmØ EMT Compression Type Connector	3	4	8	5	20
	20mmØ Locknut Locknut and Bushing	2	3	6	3	14
	25mmØ EMT Pipe Compression Type				1	1
	25mmØ EMT Compression Type Connector				1	1
	25mmØ Locknut Locknut and Bushing	1		1	1	3
	32mmØ PVC Pipe	1	2		2	5
	32mmØ PVC Adapter and Locknut Locknut			1	1	2
	25mmØ PVC Pipe	17	24	47	27	115
	25mmØ PVC Adapter and Locknut Locknut	3	3	8		14
	25mmØ Locknut Locknut and Bushing		1	1		2
	20mmØ Locknut Locknut and Bushing	3	2	8		13
	Nylon Rope (for cable pulling) 200 meters	1	1			2
	Square Box Ga. 18	1	1			2
	22 mm² Al-THHN/THWN	9	12	25		46
	14 mm² Al-THHN/THWN	110	172	333	376	991
	8 mm² Al-THHN/THWN	56	80	178	100	414

Table 3. Material Delivery Schedule for Electrical Works (March)

Scope of Works	Materials	MARCH				
		Project A	Project B	Project C	Project D	SUBTOTAL
Electrical Works	20mmØ EMT Pipe Compression Type	1	2	3	2	8
	20mmØ EMT Compression Type Connector	2	4	4	6	16
	20mmØ Locknut Locknut and Bushing	3		6	6	15
	25mmØ EMT Pipe Compression Type					0
	25mmØ EMT Compression Type Connector	1		2		3
	25mmØ Locknut Locknut and Bushing					0
	32mmØ PVC Pipe	1		4	2	7
	32mmØ PVC Adapter and Locknut Locknut		1		1	2
	25mmØ PVC Pipe	17	24	34	35	110
	25mmØ PVC Adapter and Locknut Locknut	3	3	4	14	24
	25mmØ Locknut Locknut and Bushing	1			2	3
	20mmØ Locknut Locknut and Bushing	3	2	10	14	29
	Nylon Rope (for cable pulling) 200 meters	1			2	3
	Square Box Ga. 18			4	2	6
	22 mm² Al-THHN/THWN	9	12	17	19	57
	14 mm² Al-THHN/THWN	115	172	252	252	791
	8 mm² Al-THHN/THWN	64	78	135	135	412

Table 4. Material Delivery Schedule for Fire Protection Works (January)

Scope of Works	Materials	JANUARY				
		Project A	Project B	Project C	Project D	SUBTOTAL
Fire Protection Works	BI Pipes 150 mmø	465	314	364	183	1326
	BI Pipes 100 mmø	204	131	155	78	568
	BI Pipes 75 mmø	5500	3,600	4200	2100	15400
	BI Pipes 65 mmø	169	114	135	68	486
	BI Pipes 50 mmø	3801	2,495	2910	1455	10661
	BI Pipes 40 mmø	3805	2,596	3027	1513	10941
	BI Pipes 32 mmø	2222	1,586	1850	924	6582
	BI Pipes 25 mmø	11000	7,157	8349	4175	30681
	single jacket fire hose	56	40	48	24	168
	Sprinkler, Upright	112	80	93		285
	Sprinkler, Extended Sidewall (K=8.1)	666	396	467		1529
	Sprinkler, Standard Sidewall (K=5.6)	2914	2,095	2448	1224	8681
	Sprinkler, Pendent	3000		2165	1083	6248

	10 lbs PFE FE 36	112		95	46	253
	10 lbs PFE Dry Chem	852	2,614		306	3772

Table 5. Material Delivery Schedule for Fire Protection Works (February)

Scope of Works	**Materials**	**FEBRUARY**				
		Project A	**Project B**	**Project C**	**Project D**	**SUBTOTAL**
Fire Protection Works	BI Pipes 150 mmø	204	627	488	183	1502
	BI Pipes 100 mmø	80	266	206	78	630
	BI Pipes 75 mmø	2000	7200	5600	2100	16900
	BI Pipes 65 mmø	77	231	180	66	554
	BI Pipes 50 mmø	1539	4987	3880	1455	11861
	BI Pipes 40 mmø	1762	5190	4038	1515	12505
	BI Pipes 32 mmø	1082	3172	2466	925	7645
	BI Pipes 25 mmø	4200	14313	11132	4175	33820
	single jacket fire hose	23	81	61	24	189
	Sprinkler, Upright	67	162	126	157	512
	Sprinkler, Extended Sidewall (K=8.1)	222	1602	622	777	3223
	Sprinkler, Standard Sidewall (K=5.6)	1600		3264	1224	6088
	Sprinkler, Pendent	1100	5570	2886	1083	10639
	10 lbs PFE FE 36	55		126	48	229
	10 lbs PFE Dry Chem	300		1424	304	2028

Table 6. Material Delivery Schedule for Fire Protection Works (March)

cope of Works	**Materials**	**MARCH**				
		Project A	**Project B**	**Project C**	**Project D**	**SUBTOTAL**
Fire Protection Works	BI Pipes 150 mmø	201	625	366	243	1435
	BI Pipes 100 mmø	84	266	155	102	607
	BI Pipes 75 mmø	2500	7200	4200	2800	16700
	BI Pipes 65 mmø	74	231	133	90	528
	BI Pipes 50 mmø	1588	4989	2910	1940	11427
	BI Pipes 40 mmø	1643	5192	3029	2019	11883
	BI Pipes 32 mmø	1100	3170	1850	1234	7354
	BI Pipes 25 mmø	4678	14311	8349	5565	32903
	single jacket fire hose	33	81	48	31	193
	Sprinkler, Upright	45	162	95		302
	Sprinkler, Extended Sidewall (K=8.1)	222		465		687
	Sprinkler, Standard Sidewall (K=5.6)	1314	8396	2448	1632	13790
	Sprinkler, Pendent	1054	3,708	2165	1442	8369
	10 lbs PFE FE 36	57	404	93	63	617
	10 lbs PFE Dry Chem	300		609	407	1316

Table 7. Material Delivery Schedule for Plumbing Works (January)

Scope of Works	Materials	JANUARY				
		Project A	Project B	Project C	Project D	SUBTOTAL
Plumbing Works	GI Pipes 100 mm ø x 6m	28		19	3	50
	GI Pipes 75 mm ø x 6m	149	25	207	18	399
	GI Pipes 50 mm ø x 6m	55	9	43	7	114
	GI Pipes 40 mm ø x 6m	249	40	193	30	512
	GI Pipes 25 mm ø x 6m	28		21	4	53
	PPR Pipes 32 mm ø x 4m	1		2		3
	PPR Pipes 25 mm ø x 4m		1	1		2
	PPR Pipes 20 mm ø x 4m	350	48		36	434
	PPR Pipes 15 mm ø x 4m	4450	756		567	5773

Table 8. Material Delivery Schedule for Plumbing Works (February)

Scope of Works	Materials	FEBRUARY				
		Project A	Project B	Project C	Project D	SUBTOTAL
Plumbing Works	GI Pipes 100 mm ø x 6m	10	20	25	3	58
	GI Pipes 75 mm ø x 6m	60	48	180	18	306
	GI Pipes 50 mm ø x 6m	33	18	58	7	116
	GI Pipes 40 mm ø x 6m	100	80	260	30	470
	GI Pipes 25 mm ø x 6m	16	9	29	4	58
	PPR Pipes 32 mm ø x 4m					0
	PPR Pipes 25 mm ø x 4m			1		1
	PPR Pipes 20 mm ø x 4m	128	96		36	260
	PPR Pipes 15 mm ø x 4m	2000	1512	12285	567	16364

Table 9. Material Delivery Schedule for Plumbing Works (March)

Scope of Works	Materials	MARCH				
		Project A	Project B	Project C	Project D	SUBTOTAL
Plumbing Works	GI Pipes 100 mm ø x 6m	10		19	4	33
	GI Pipes 75 mm ø x 6m	88	46		24	158
	GI Pipes 50 mm ø x 6m	22	17	42	8	89
	GI Pipes 40 mm ø x 6m	149	80	195	40	464
	GI Pipes 25 mm ø x 6m	11	13	22	3	49
	PPR Pipes 32 mm ø x 4m		1		1	2
	PPR Pipes 25 mm ø x 4m	1			1	2
	PPR Pipes 20 mm ø x 4m	120	96	778	48	1042
	PPR Pipes 15 mm ø x 4m	3000	1512		756	5268

Table 10. Material Delivery Schedule for Ventilation Works (January)

Scope of Works	Materials	JANUARY				
		Project A	Project B	Project C	Project D	SUBTOTAL
Ventilation Works	PVC Pipe 75mmØ x 3m Series "600"	1308	576			1884
	PVC Pipe 100mmØ x 3m Series "600"	10	3	3		16
	PVC Pipe 150mmØ x 3m Series "1000"	4	3	3	6	16
	GI Fittings 150 x 100 mm (Vertical)	682	301	287	655	1925
	GI Fittings 150 x 100 mm (Horizontal)	1309	576	550	1257	3692
	GI Fittings 250 x 150 mm (Vertical)	1				1
	GI Fittings 250 x 150 mm (Horizontal)	1	2			3
	Broan FA C020PH		325	310	700	1335
	GF-1 & GF-2 (GF Female & Male Toilet)					0
	RD-1 & RD-2 (RD Female & Male Toilet)		1	1		2
	B1-1 Personnel Locker T&B	1	1	1		3
	B1-2 PMO Pantry		1			1
	B1-3 PMO T&B		1			1
	B1-4 Convenience Store Storage Room			1	2	3
	B1-5 PMO Storage Room			1	2	3

Table 11. Material Delivery Schedule for Ventilation Works (February)

Scope of Works	Materials	FEBRUARY				
		Project A	Project B	Project C	Project D	SUBTOTAL
Ventilation Works	PVC Pipe 75mmØ x 3m Series "600"	800	1152	1833	2513	6298
	PVC Pipe 100mmØ x 3m Series "600"		3	3	9	15
	PVC Pipe 150mmØ x 3m Series "1000"	4	10	4	6	24
	GI Fittings 150 x 100 mm (Vertical)	682	1200	382	655	2919
	GI Fittings 150 x 100 mm (Horizontal)		1152	733	1257	3142
	GI Fittings 250 x 150 mm (Vertical)	1		1	2	4
	GI Fittings 250 x 150 mm (Horizontal)			1		1
	Broan FA C020PH	1000			715	1715
	GF-1 & GF-2 (GF Female & Male Toilet)	3	2	2	5	12
	RD-1 & RD-2 (RD Female & Male Toilet)		2	1	4	7
	B1-1 Personnel Locker T&B		1		2	3
	B1-2 PMO Pantry	1			1	2
	B1-3 PMO T&B			1	1	2

	B1-4 Convenience Store Storage Room		1			1
	B1-5 PMO Storage Room		1			1

Table 12. Material Delivery Schedule for Ventilation Works (March)

Scope of Works	Materials	MARCH				
		Project A	Project B	Project C	Project D	SUBTOTAL
Ventilation Works	PVC Pipe 75mmØ x 3m Series "600"	510	1152		1676	3338
	PVC Pipe 100mmØ x 3m Series "600"		5	1	7	13
	PVC Pipe 150mmØ x 3m Series "1000"	3		1	6	10
	GI Fittings 150 x 100 mm (Vertical)			286	873	1159
	GI Fittings 150 x 100 mm (Horizontal)	1309	1152	550	1675	4686
	GI Fittings 250 x 150 mm (Vertical)		3	1	2	6
	GI Fittings 250 x 150 mm (Horizontal)				2	2
	Broan FA C020PH	474	1297	722	944	3437
	GF-1 & GF-2 (GF Female & Male Toilet)		2	1		3
	RD-1 & RD-2 (RD Female & Male Toilet)	2				2
	B1-1 Personnel Locker T&B					0
	B1-2 PMO Pantry		1	1	1	3
	B1-3 PMO T&B	1	1		1	3
	B1-4 Convenience Store Storage Room	1	1			2
	B1-5 PMO Storage Room	1	1			2

Since the delivery schedule for all construction resources were already identified, it is easier for the procurement department to handle material distribution properly. As seen in Figure 4, the project requirement per material per quarter (January-March) is illustrated. Cross Docking can be implemented easily to strategize materials dealt within the central warehouse logistically. Materials unloaded in the warehouse will be sorted according to the project's needs and schedules.

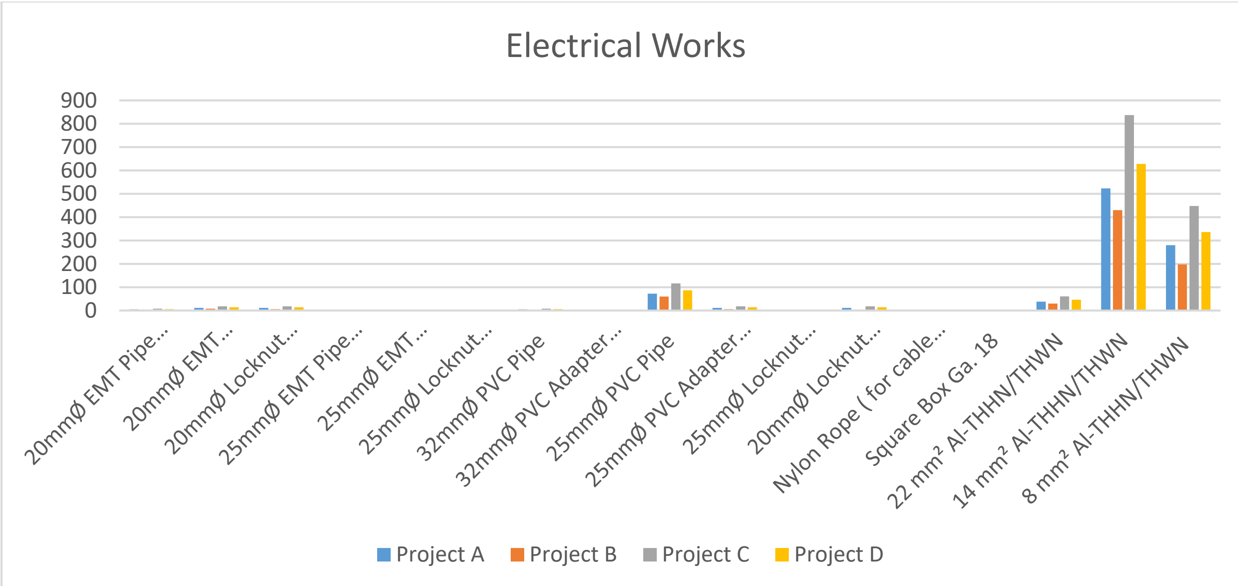

Figure 4. Electrical Works Project Requirement Material List Distribution

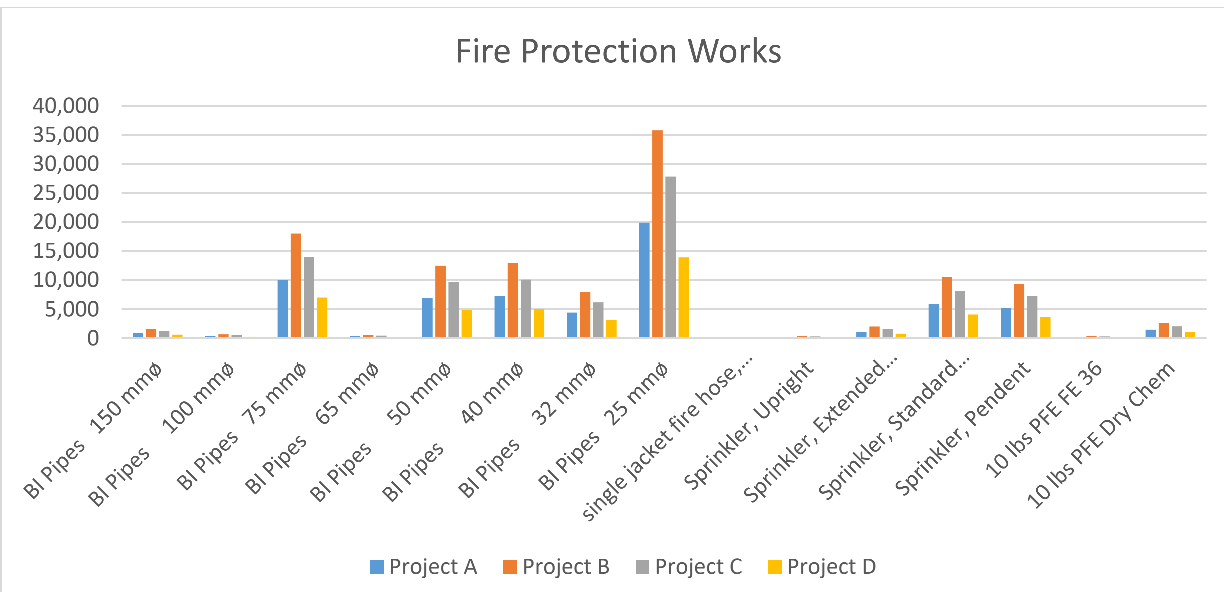

Figure 5. Fire Protection Works Project Requirement Material List Distribution

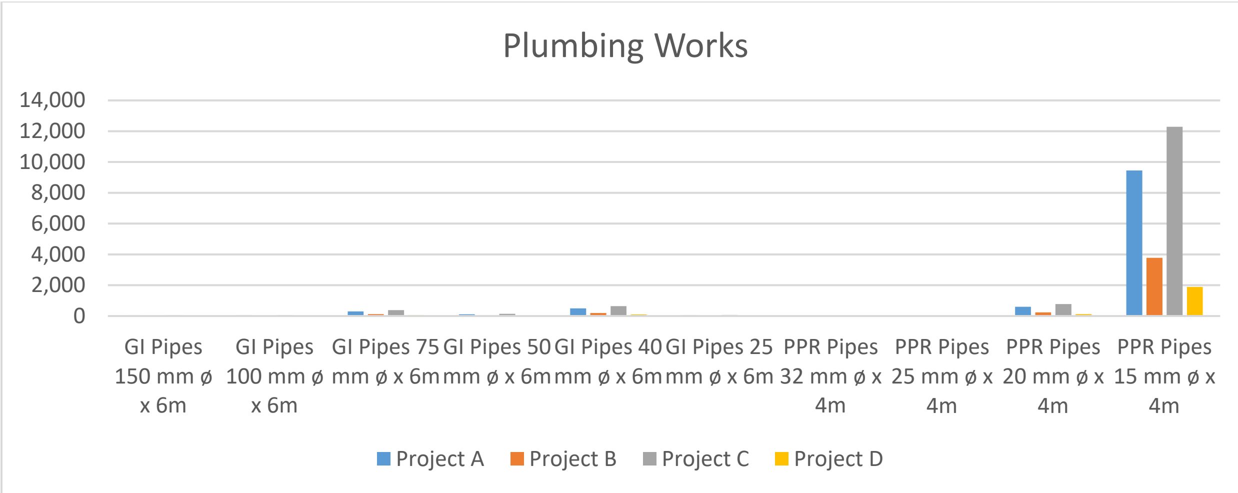

Figure 6. Plumbing Works Project Requirement Material List Distribution

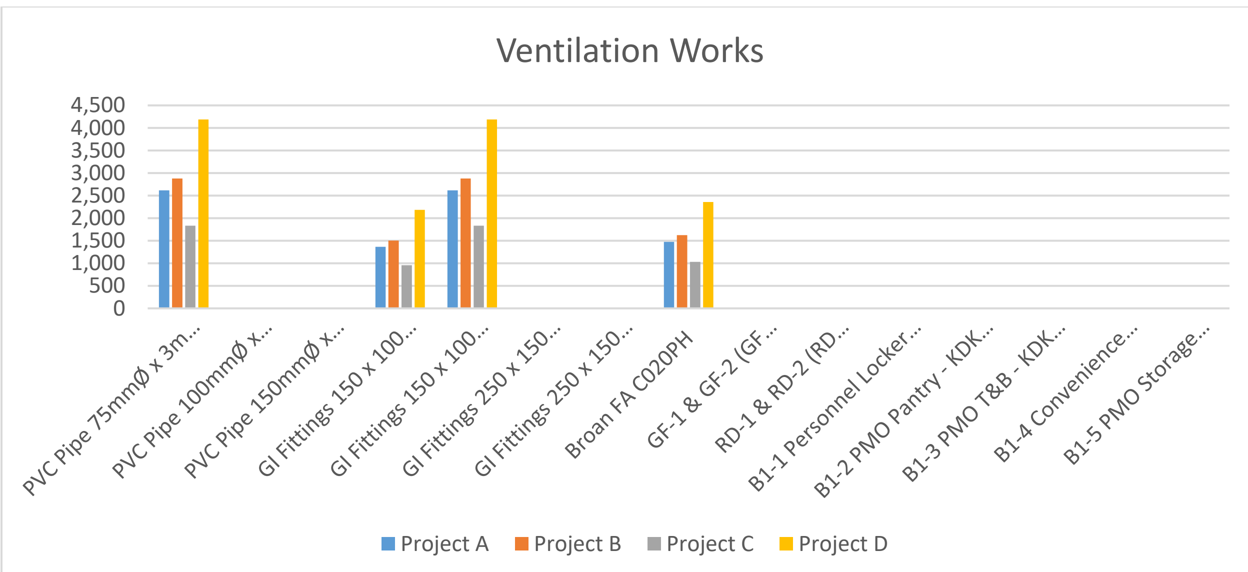

Figure 7. Plumbing Works Project Requirement Material List Distribution

In scenarios where there are changes in material specifications and quantities, another implemented strategy by the procurement team is Backhauling. It is agreed among all suppliers that excess materials can be returned or replaced when necessary.

5. Conclusion

Digital Procurement plays a vital role in the Construction Industry as it aligns the inventory and construction schedule. Forecasting of materials not only ensures timely delivery of materials, but proper planning can lead to project savings. Companies that can maximize the benefits of digitalization will have a significant advantage over businesses that do not take full advantage of the technology.

6. Recommendation

Supply Chain Management is an integrated approach to planning and forecasting inventory and sales to cross-check data across suppliers and required demand. Technology is a vital aspect of analyzing trends and properly tracking resources' movement. This will result in a more cost-efficient distribution model to manage logistics and warehousing. The construction industry greatly benefited from digitization since collating necessary information is more accessible thru technology. Digital strategies are implemented to ensure a more effective supply chain implementation.

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Biography

Clarinda Joanne Ellorin Igros is currently a master's student at Mapua University taking a Master of Science in Engineering Management. She has taken her bachelor's degree in Electrical Engineering at Mapua Institute of Technology in 2009. And currently working as Electrical Engineer in a leading construction company in the Philippines.

Klint Allen A. Mariñas is a Ph.D. student at the Industrial and Systems Engineering Department, Chung Yuan Christian University in Taiwan. He earned his bachelor's degree in Industrial Engineering at Adamson University, Manila, Philippines, and his master's in Industrial Engineering degree at Mapua University, Manila, Philippines. He previously worked as a process engineer in a plastic manufacturing company in the Philippines for three years and eventually took his graduate studies focusing on production planning, human factors, ergonomics, and quality engineering. He is currently under the CIM and Smart Manufacturing laboratory working on ergonomics and production improvement studies.

Michael N. Young is an associate professor in the School of Industrial Engineering and Engineering Management at Mapúa University. He earned his B.S. Industrial Engineering & B.S. Engineering Management from Mapúa Institute of Technology (Philippines) and M.S. & Ph.D. in Industrial and Systems Engineering from Chung Yuan Christian University (Taiwan). His research interests include portfolio optimization and financial engineering.

Yogi Tri Prasetyo is an associate professor in the School of Industrial Engineering and Engineering Management, Mapua University, Philippines. He received a B.Eng. in industrial engineering from Universitas Indonesia (2013). He also studied at Waseda University Japan during his junior year (2011-2012) as an undergraduate exchange student. He received an MBA (2015) and a Ph.D. (2019) from the Department of Industrial Management National Taiwan University of Science and Technology (NTUST), with a concentration in human factors and ergonomics. Dr.Prasetyo has a wide range of research interest including color optimization of military camouflage, human-computer interaction particularly related to eye movement, strategic product design, accident analysis, and usability.

Reny Nadlifatin is a Lecturer in the Department of Information System, Institut Teknologi Sepuluh Nopember (ITS_, Surabaya. She obtained a double degree in Master of IT and Master of Business Administration from ITS and National Taiwan University of Science and Technology (NTUST). Meanwhile, she obtained doctoral degrees from the National Taiwan University of Science and Technology (NTUST).

Yung-Tsan Jou received his Ph.D. degree in Integrated (ME, ISE) engineering from Ohio University, Athens, OH, in 2003. He is an Associate Professor of Industrial and Systems Engineering at Chung Yuan Christian University, Taiwan. His research has made contributions in green design, human–system interface design, senior assistive devices, and usability or quality evaluation by using virtual reality tools, smart manufacturing, machine learning, and data analysis.