RESEARCH ARTICLE

A comprehensive study on a warehouse location optimization using mixed integer linear programming

Ngoi Soo Wei

Dr.

School of Computing, Asia Pacific University of Technology and Innovation

Malaysia

Email: ngoosoowei@gmail.com

Ho Ming Kang

Professor

School of Mathematics, Actuarial and Quantitative Studies , Asia Pacific University of Technology and Innovation

Malaysia

Email: homingkang@yandex.com

Doi Serial https://doi.org/10.56334/sei/8.8.11

Keywords warehouse location optimisation, network optimisation, mixed-integer linear programming, visualisation dashboard

Abstract

he purpose of this particular research will be to produce a choice support device with regard to suppliers which are freelancing storage space plus strategies to be able to 3rd party company. The specific device is made having an example within The far east in addition to ruse related to fresh datasets from your producer. An expense style making use of quantity, space for storage price, dealing with cost and even transport costs is utilized within the marketing procedure. Combined Integer Geradlinig Development will be used together with solved which stockroom will be chosen regarding ideal system. The consequence of your choice assistance device is generally an imagine dash to exhibit the particular assessment between current community in addition controlled enhance program as well as the expenses. The outcome demonstrated that this value enhancement will be accomplished using the improve selling price design.

Citation

Ngoi S. W., Ho Ming K. (2025). A comprehensive study on a warehouse location optimization using mixed integer linear programming. *Science Education and Innovations in the Context of Modern Problems*, 8(8), 111-122; doi:10.56352/sei/8.8.11. https://imcra-az.org/archive/375-science-education-and-innovations-in-the-context-of-modern-problems-issue-8-vol-8-2025.html

Received: 09.02.2025 | Accepted: 06.03.2025 | Published: 27.06.2025 (available online)

1.0 .Introduction

Stockroom area optimization is utilized to select the place to create or even rent the particular stockroom using the reason behind reducing the price of transportation in order to clients. In addition , there are several some other unique sectors has its own similarly important reasons such as atmosphere issue simply by loss of co2 release via transport car, or perhaps item top quality just like vaccines inside chilly string and even dairy products merchandise that has restriction upon transfer period. Stockroom program optimization will be section of the optimization with regard to offer cycle system among manufacturer, facilities in addition client areas which often was executed to enhance the specific effectiveness associated with need and provide community substantially. Some cost in many cases are typically the dimensions from the performance from your ideal system.

With regard to producers which have big consumer bottom more than a broad physical area, the particular difficulty related to storage place system will be higher. The in many cases are depending on exterior experts regarding factory area marketing research due to constraint regarding professional understanding plus marketing equipment inside the business. Typical discussion solutions consist of modeling utilizing historic information as well as suggesting perfect method treatment for organization. Nonetheless, you will see space in between best answer by means of specialist as well as the actual performance because of bodily motion involving stockroom place include considerable price in addition to time period. Consultant's suggestion connected with excellent answer may not be extensive as a result of risky enhancements made on distribution community. Because delivery might take two to three many years to attain suitable answer, the answer might not be optimum following this type of any period of time of your time. Therefore, it is very important possess a continuous checking technique around the remedy throughout setup phase, to lessen the specific distance associated with ideal option and even genuine outcome.

You will find restricted research about storage place optimization issue within just production together with manufacturing since the web site place offers reduce flexibility in case in comparison to some other spot marketing problem like position with regard to storage space objective which includes submission center additionally combination middle. The area optimization examine more likely to pay attention to drape plus danger minimization whenever interruption occur in among the creation websites (Afify, Soeanu, in addition to Awasthi, 2020). Occasionally a mixture study regarding safe-keeping area and even internet site place issues may be created for particular explanation. Mother, Li and Liu (2020) analyzed on maximum site linked to each grow and also selection centers related to lead-acid electric batteries business, which usually was executed to handle typically the vehicles inside a shut looped together with concern involving feasible likelihood of dangerous product or service any time event occur. When creating choices in brand new as well as move service is important for people who do buiness growth, reduction will be continual because of the doubt connected with need. Business may also applied to area through the monetary chance point of view, to reduce the most anticipated reduction from your choice upon area (Khorshidi together with Ghezavati, 2019).

Lots of numerical design may be used to solve place associated concern. For instance , within modernizing waste materials administration location-routing issues, multi-objective combined integer nonlinear advancement (MINLP) design is utilized (Rabbani, Heidari plus Yazdanparast, 2019; Asefi, Lim as well as Maghrebi, 2019). Çakmak ainsi que ing (2020) when compared binary Compound Swarm Optimization (BPSO) furthermore binary Integer Advancement (BIP) to select logistic heart spot in Turki. These people used BPSO because meta-heuristic strategy as a result of usefulness in addition to strength solving under the radar several website choice trouble along with the effect demonstrated which will BPSO alternative time period has been more efficient when compared with BIP once the program dimension will get bigger. Anand and Kumar (2017) researched after dependable supply middle position issue with minimization associated with complete faltering expense inside submitting system developed because mixed-integer development (MIP) type along with incredibly complicated restrictions on capability and even client task towards the support, consequently geradlinig growth (LR) method has been incorporated to minimize restriction infractions together with produce the rest towards initial difficulty. An additional analyze carried out by simply Hong ainsi que ing. (2018) created the actual construction issue linked to manufacturers, submitter hub plus merchants having an integer enhancement (IP) unit to lower the entire price of beginning service in addition to travel price among

services. Ish nest optimisation (ACO) formula will be used intended for as a result of many limitations in addition factors to cut back this intricacy in contrast to standard style and even end result demonstrated that this overall performance change is leaner in addition to much better computational period of time too. Nevertheless , ACO formula computational time period is actually lengthy in contrast to additional methods plus its much less utilized for place marketing trouble however read more about automobile redirecting issue in the previous analysis.

With this research, the maker throughout Client concentrated. It is because Consumer the biggest producing country on the planet (WorldBank, 2019), adding to US$ a few. 896 Trillion which is near to 28% related to worldwide developing really worth additional. Because of this, 3PL services within storage area together with travel in addition grew to become an additional flourishing business inside The far east to be able to accommodate the requirement regarding producer to be able to shop plus travelling the particular recycleables, semi-finished, or even completed components of making business. Consequently , the device throughout Customer one of the most intricate on earth also because of the cause, a new maker within The far east that may currently utilized 3PL providers to get storage space in addition to moving so as to clients will be chosen with this research.

Good earlier scientific studies inside of storage facility site search engine optimization, the majority of the research are often choosing a particular area to do since submissions center instead of utilizing the optimization exploration about current facilities. These types of correctly reduce practicability for that existing processing market given that delegate facility support in order to 3PL offers increased versatility as well as more suitable by simply suppliers. The present research primarily minimal while statistical review, however, not since common choice regarding company customers because each one of the consumers may have various degree of numerical information and even well worth acknowledgement around the researching. Therefore, concentrating on the specific 3PL assembly line place, this particular analysis targeted to build up an expense seo version making use of blended integer thready progress (MILP) design intended for manufacturing facility social networking additionally screen present and also best retail method via a visualisation splash.

2.0 Methodology

Your choice assistance device will be built inside a Four-steps strategy because demonstrated within Determine one Very first step will be to get ready the information collected through several sources to become use within modeling plus visualisation. The second stage may be the develop the price optimization style. The 3rd stage may be the software via computational test in to the instance. Last stage will be to design and style an internet dash since deliverable from the choice support device.

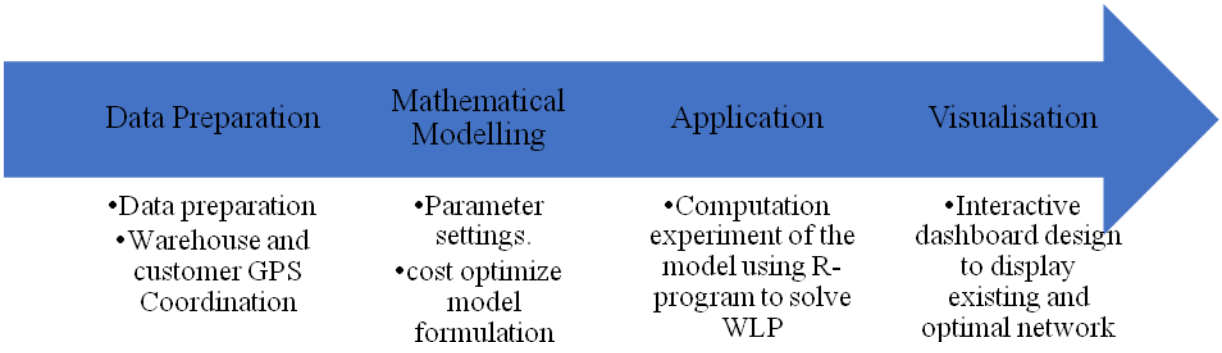


Figure 1: Four-steps Methodology Approach to Construct Decision Support Tool for WLP

2.1 Description of Data

two datasets utilized in this specific research. The far east Stockroom information includes the info associated with seventeen resupply stockroom that will distributing completed items towards clients. The information characteristics within Tiongkok stockroom natural dataset are often explained inside Table one

Table 1: Data attribute and description for China Warehouse data

Data attribute	Description
ERP System	Data source
Site	Manufacturing site
Operation	Type of warehouse
SBU	Business Units related to product
11i Orgn / Plant Code	Warehouse code
Orgn Desc	Warehouse name
ADDRESS (CHINESE)	Warehouse address in Chinese wordings
ADDRESS (ENGLISH)	Warehouse address translated into English
Province	Warehouse located province
PROVINCE CODE	Province code define by manufacturer in ERP system
Region	Region of warehouse located in China
Longitude	Longitude of warehouse location
Latitude	Latitude of warehouse location
s_storage_unitcost	Storage cost per m^3 subject to contract storage space
t_fixed_handling_cost	Warehouse monthly fixed handling cost
u_handling_unitcost	Warehouse unit handling cost subject to volume
v_handling_unitcost	Warehouser unit transportation cost subject to volume

Table 2 shows the minimum and maximum cost value of each group of fixed and variable cost with rounding up value in different unit.

Table 2: Maximum, Minimum, and round up value for group of cost

	s_storage_unitcost	t_fixed_handling_cost	u_handling_unitcost	v_unit_trasnportcost_per_ton
Maximum	125	5200	45	36
Minimum	65	3100	15	8
round up	5	100	5	1

Shipping background dataset could be an additional dataset utilized in this specific research where the info feature will be demonstrated within Desk a few. The particular GPS NAVIGATION dexterity from the client area are produced using the set geocoding totally free web site producer. Geocode. xyz web site is chosen with regard to group code making use of the particular SHIPTO_ADDRESS. Typically the details are taken out as one document as well as the guide Long, plus Lat. are usually mixed in to the delivery historical past dataset.

Table 3: Data attribute and description for Shipment history

Data attribute	Description
FROM_WHSE	Current ship-from-warehouse to respective address
SHIPTO_ADDRESS	Customer address
shippedKG	6 months volume delivered to respective address
Region	Region of warehouse located in China

2.2 Mixed Integer Linear Programming Model

The cost design will be created within numerical functionality to determine the particular enhance system which usually selects upon stockroom selected plus task related to client in order to stockroom. The price design is made along with presumptions underneath:

n The price calculation is founded on six months historic quantity.
n The quantity of facilities is famous in addition choose simply by maker.
n The storage place ability is just not an issue in this instance research.
n The quantity of 1000kg will be consider equal to busy 1 m2 associated with storage space.

This particular expense style will be was executed to solve typically the WLP which will reduce the price inside the submission community. Some we facilities (for i actually sama dengan a single, two, a few, ., m) is intended to be able to function some m clients (for persis oleh one, a couple of, a few, ., n). Your choice factors and they are understood to be binary parameters where is placed as you in case factory we are chosen so as to assist a number of customers and it is arranged because just one only when a customer m will be specified to some stockroom we for all of thier transport.

$$Y_{ij} = \begin{cases} 1, & \text{if customer } j \text{ assigned to warehouser } i \\ 0, & otherwise \end{cases}$$

The parameters used to describe the MILP model are as follows:

f_i Required storage space in m^2

g_j Demand of customer *j* in kilogram

s_i Unit cost of storage per month per m^2 for warehouse *i*

t_i Fixed cost of material handling of warehouse *i* per month

u_i Unit cost of material handling per ton for warehouse *i*

v_{ij} Unit cost for transportation per ton material from warehouse *i* to customer *j*

The particular MILP design is utilized to resolve the price style. Goal functionality will be to reduce the charge, which often symbolize from the complete amount of set associated with storage (storage cost and stuck dealing with cost) plus gadget price (unit managing in addition to transport cost) based on client need quantity.

$$\text{Min } Z = 6\sum_{i=1}^{m} X_i\,(f_i s_i + t_i) + \sum_{i=1}^{m}\sum_{j=1}^{n} Y_{ij}\left(\frac{g_j}{1000}\right)(u_i + v_{ij})$$

Subject to

$$\sum_{i=0}^{m} Y_{ij} = 1 \text{ ,for } \forall\, j$$

$$f_i = \frac{1.5}{6}\sum_{j=1}^{n} \frac{g_j}{1000} Y_{ij}, \qquad \text{for } \forall\, i,j$$

$$Y_{ij} \le X_i \text{ ,for } \forall\, i,j$$

where

f_i integer, $X_i \in (0\,,1)$,for $\forall\, i$ and $Y_{i,j} \in (0\,,1)$,for $\forall\, j$

Since the producer will not desire to repair an area with regard to storage space, the particular space for storage will be contemplating from your point of view associated with dedication related to 30 days share sticking to clients. Generally, typically the dedication will be to keep one to just one. five weeks discuss for every client to be able to demand shipping. As a result, it really is asked for to obtain make use of one 5 a few months regarding common quantity in order to determine the particular safe-keeping space/ plus restriction symbolize typically the pointed out storage space necessity. Space for storage, fi is fixed within an integer because space for storage involving only one can also be equal to profession of just one pallet job. This really is primarily the particular restriction where typically the producer will never permit combining space for storing along with other stockroom customers. Following restriction is to make sure stockroom is chosen with regard to price computation, only if task to be able to a minumum of one consumer. Whenever carrying out stockroom decrease, combination in addition to shifting storage place actually, time in addition

price are usually substantially higher and even needed nicely prepared set up. Producer might select the quantity of facilities to reduce depends upon sources offered by a period. 2 constant figures are usually explained simply by maker because minutes together with maximum to look for the minimal as well as optimum portion connected with storage place lowering from your current amounts of factory.

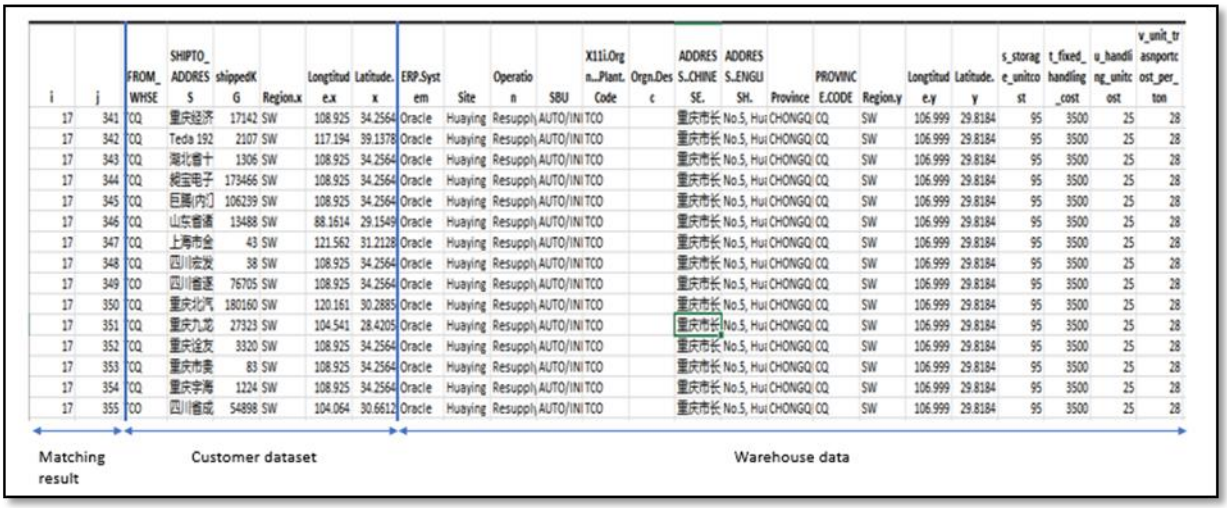
2.3 Visualisation

To build up the particular dash, Energy DRONE desktop computer will be selected because visualisation device in order to the current plus ideal approach to stockroom. Strength DRONE desktop computer is generally an information visualisation gadget which usually completely match the objective of imagining program. The particular became a member of dataset will be kept in the close by pc document, along with the document will be connected since databases for that developed dial.

Since the joined up with dataset offers the info associated with initial storage place, in addition to specified factory, therefore two circulation roadmaps are created to symbolize this current system as well as the ideal community. Set storage space price and even system storage price are often determined with the addition of collection along with formula inside energy DRONE table. An overall total amount of these kinds of expenses will be demonstrated within the dash because current expense in addition optimum price are generally demonstrated in most movement chart. Common type of typically the splash is easy to exhibit the specific decrease regarding method stream together with attainable price preserving. The specific online function to be incorporated in to the splash will be area. Stockroom area will be take advantage of while filtration system to demonstrate the particular chosen region move guide as well as expense whenever required. This particular dial design will certainly assistance your choice producing upon removal involving storage facility additionally streamlining provide technique with regard to The far east client.

3.0 Visualisation of the Optimisation Results

MILP design caters to the information in fact it is found that just one stockroom is chosen with regard to area Eastern, Northeast, Southern plus The west. Task outcome immediately after MILP will be turned into information framework sport stockroom we in the direction of client m inside the exact same location. The outcome within info framework associated with storage place in addition consumer identification next utilized to sign up for the specific desk regarding client files in addition to stockroom information simply by region subsection, subdivision, subgroup, subcategory, subclass with regard to visualisation objective inside energy DRONE. The particular coordinating effect because demonstrated throughout Determine 2 and even becoming a member of the actual Stockroom info as well as Client files. The customer information will be following adjustable l, which often furthermore symbolizing the current factory designated towards clients. Typically the storage place information is usually succeeding varying i actually, that this information get will be addressing the perfect factory picked. The outcomes from then on released right into a document upon nearby pc desktop computer.

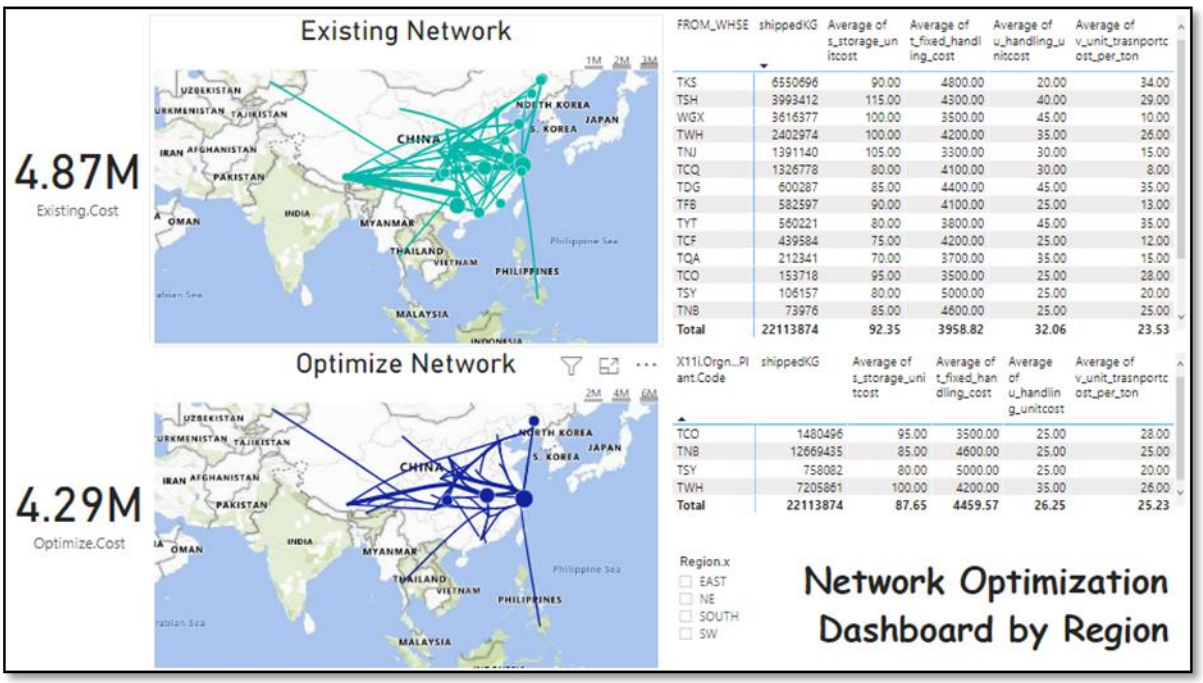


i	j	FROM_WHSE	SHIPTO_ADDRESS	shippedKG	Region.x	Longitude.x	Latitude.x	ERP.System	Site	Operation	SBU	X11i.Org n...Plant.Code	Orgn.Desc	ADDRESS..CHINESE.	ADDRESS..ENGLISH.	Province	PROVINCE.CODE	Region.y	Longitude.y	Latitude.y	s_storage_unitcost	t_fixed_handling_cost	u_handling_unitcost	v_unit_transportcost_per_ton
17	341	CQ	重庆经济	17142	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	342	CQ	Tesla 192	2107	SW	117.194	39.1378	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	343	CQ	湖北普十	1306	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	344	CQ	蛟宝电子	173466	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	345	CQ	巨腾(内门	106239	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	346	CQ	山东睿通	13488	SW	88.1614	29.1549	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	347	CQ	上海市金	43	SW	121.562	31.2128	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	348	CQ	四川宏发	38	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	349	CQ	四川普通	76705	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	350	CQ	重庆北汽	180160	SW	120.161	30.2885	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	351	CQ	重庆九龙	27323	SW	104.541	28.4205	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	352	CQ	重庆迈友	3320	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	353	CQ	重庆市美	83	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	354	CQ	重庆宇海	1224	SW	108.925	34.2564	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28
17	355	CQ	四川普成	54898	SW	104.064	30.6612	Oracle	Huaying	Resupply	AUTO/INI	TCO		重庆市长	No.5, Hui	CHONGQI	CQ	SW	106.999	29.8184	95	3500	25	28

Figure 2: Matching Result and Joined Warehouse and Customer Dataset

The specific file after that used because databases inside energy DRONE with regard to visualisation objective. The particular dash is made to imagine the present plus enhance system of most areas, using the accessibility to seeing the facts simply by region too. Therefore , the first stockroom dataset in addition delivery background dataset furthermore weight to be able to Energy DRONE info with regard to imagining the original community since assessment. Typically the lat. as well as long, through person content are usually along with brand new line because area GPS NAVIGATION for each client every stockroom to become arranged in the source and placement place associated with circulation chart. The particular size from the circulation will be symbolizing from the amount delivered, as well as the real estate is placed regarding source intended for obvious visualisation. The client area is utilized while blocking option, so the current additionally enhance system of each area could be additional seeing when the clients thinking about research regarding particular location simply.

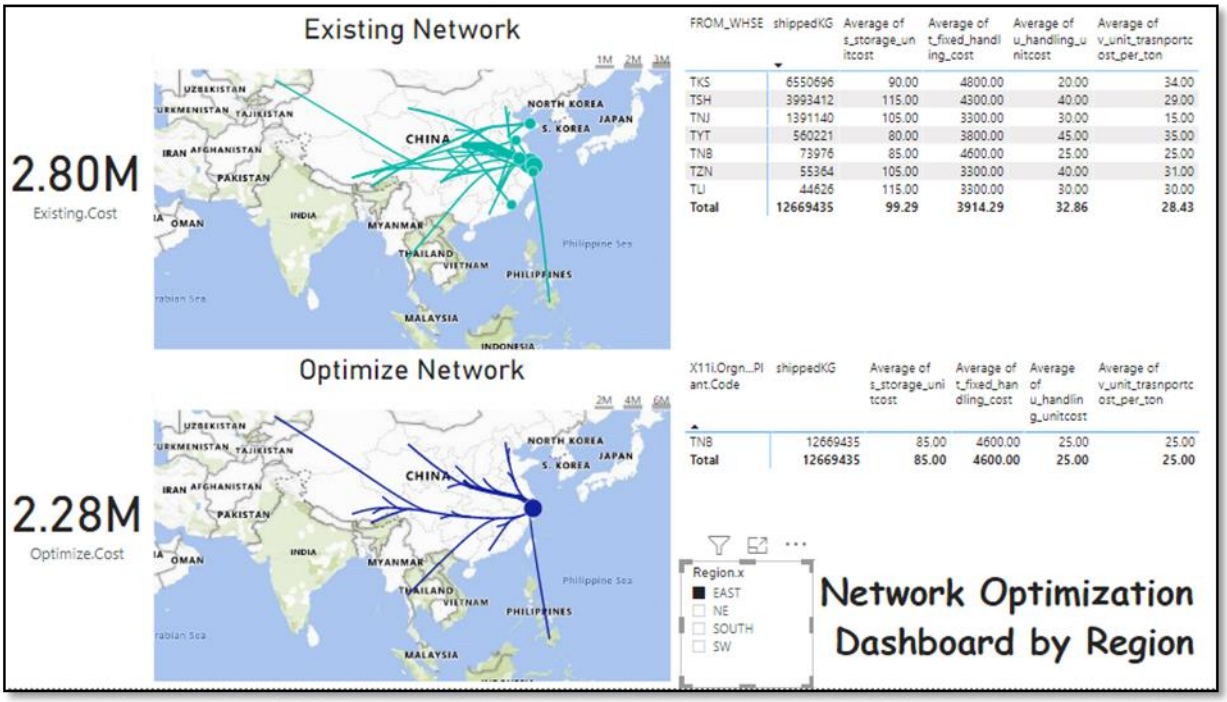
Listed here are the particular splash summary by simply almost all areas through specific locations. Determine a few demonstrated that will complete value is decrease using the improve community for all those parts. Simply by locations, Physique four, Determine five, Number 6 revealed of which Far eastern, Northeast in addition to The southern part of areas are usually showing complete price reduce to get boost program. Just South west location within Shape 7 offers somewhat enhanced within the expense in case combine in to solitary storage place. Therefore , The west area much more affordable with facilities leftover according to present method. Because summary, the specific dash review capable to assistance strategy and also choice upon place to begin typically the combination exercise.



FROM_WHSE	shippedKG	Average of s_storage_unitcost	Average of t_fixed_handling_cost	Average of u_handling_unitcost	Average of v_unit_trasnportcost_per_ton
TKS	6550696	90.00	4800.00	20.00	34.00
TSH	3993412	115.00	4300.00	40.00	29.00
WGX	3616377	100.00	3500.00	45.00	10.00
TWH	2402974	100.00	4200.00	35.00	26.00
TNJ	1391140	105.00	3300.00	30.00	15.00
TCQ	1326778	80.00	4100.00	30.00	8.00
TDG	600287	85.00	4400.00	45.00	35.00
TFB	582597	90.00	4100.00	25.00	13.00
TYT	560221	80.00	3800.00	45.00	35.00
TCF	439584	75.00	4200.00	25.00	12.00
TQA	212341	70.00	3700.00	35.00	15.00
TCO	153718	95.00	3500.00	25.00	28.00
TSY	106157	80.00	5000.00	25.00	20.00
TNB	73976	85.00	4600.00	25.00	25.00
Total	**22113874**	**92.35**	**3958.82**	**32.06**	**23.53**

X11i.Orgn...Plant.Code	shippedKG	Average of s_storage_unitcost	Average of t_fixed_handling_cost	Average of u_handling_unitcost	Average of v_unit_trasnportcost_per_ton
TCO	1480496	95.00	3500.00	25.00	28.00
TNB	12669435	85.00	4600.00	25.00	25.00
TSY	758082	80.00	5000.00	25.00	20.00
TWH	7205861	100.00	4200.00	35.00	26.00
Total	**22113874**	**87.65**	**4459.57**	**26.25**	**25.23**

Figure 3: Dashboard overview for all regions



FROM_WHSE	shippedKG	Average of s_storage_unitcost	Average of t_fixed_handling_cost	Average of u_handling_unitcost	Average of v_unit_trasnportcost_per_ton
TKS	6550696	90.00	4800.00	20.00	34.00
TSH	3993412	115.00	4300.00	40.00	29.00
TNJ	1391140	105.00	3300.00	30.00	15.00
TYT	560221	80.00	3800.00	45.00	35.00
TNB	73976	85.00	4600.00	25.00	25.00
TZN	55364	105.00	3300.00	40.00	31.00
TLI	44626	115.00	3300.00	30.00	30.00
Total	**12669435**	**99.29**	**3914.29**	**32.86**	**28.43**

X11i.Orgn...Plant.Code	shippedKG	Average of s_storage_unitcost	Average of t_fixed_handling_cost	Average of u_handling_unitcost	Average of v_unit_trasnportcost_per_ton
TNB	12669435	85.00	4600.00	25.00	25.00
Total	**12669435**	**85.00**	**4600.00**	**25.00**	**25.00**

Figure 4: Dashboard overview for East region

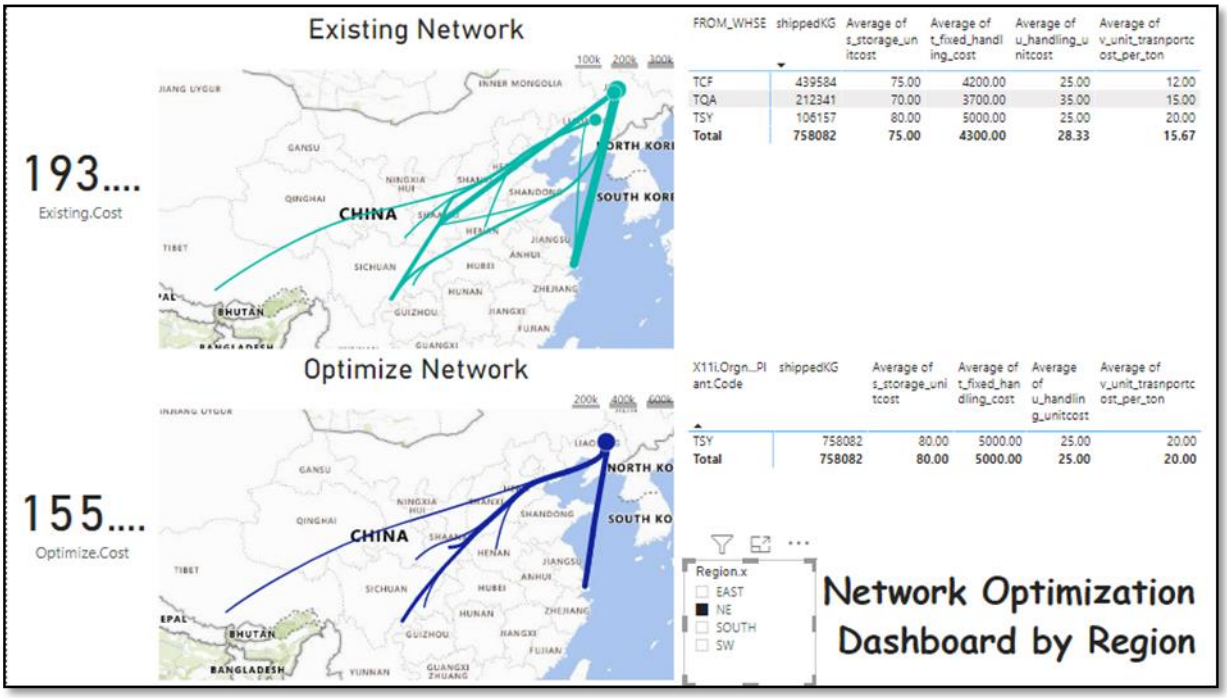


Figure 5: Dashboard overview for Northeast region

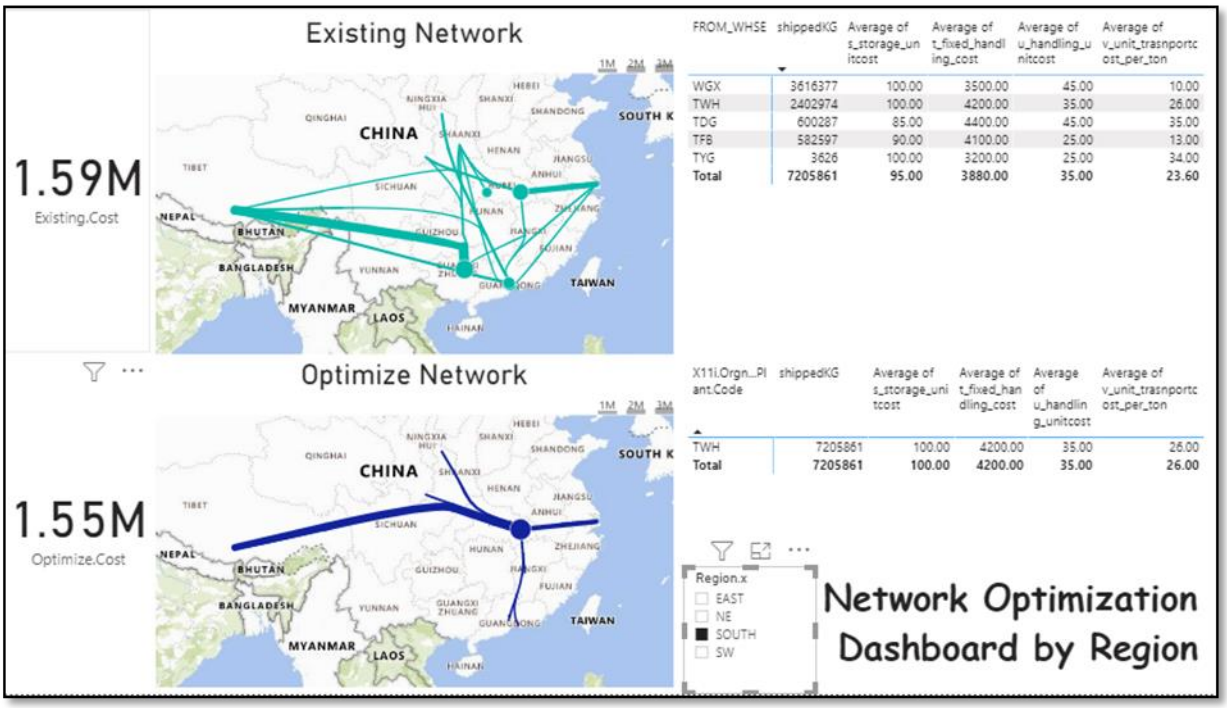
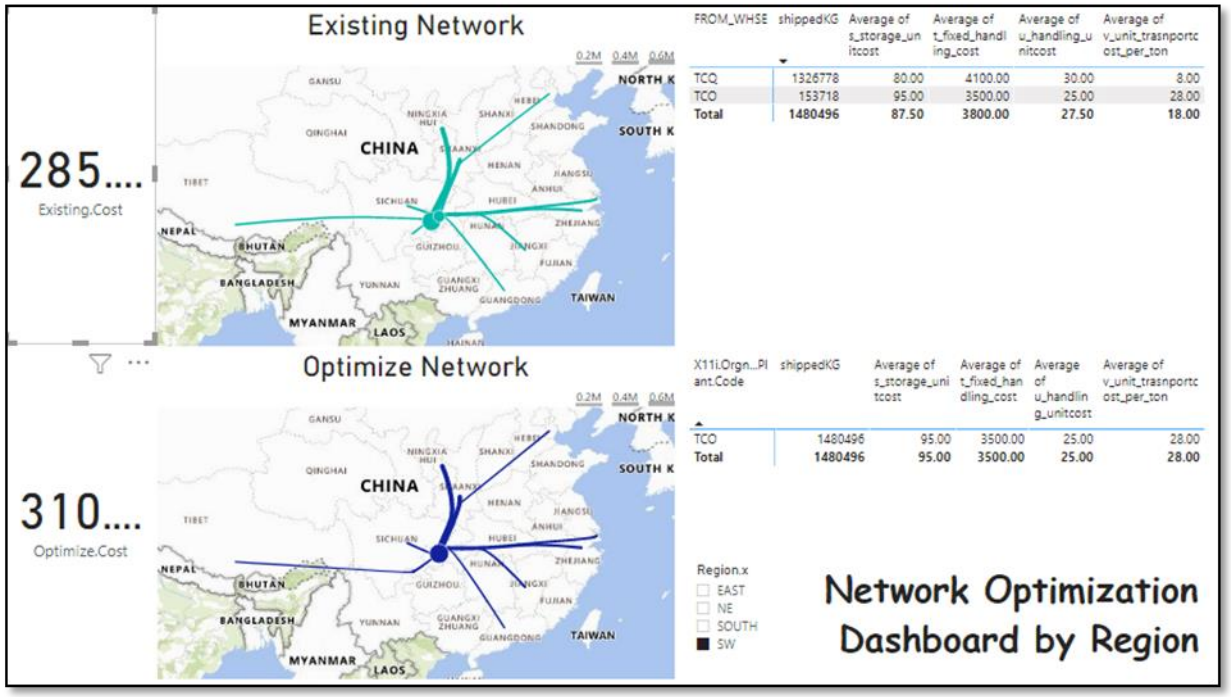


Figure 6: Dashboard overview for South region



FROM_WHSE	shippedKG	Average of s_storage_unitcost	Average of t_fixed_handling_cost	Average of u_handling_unitcost	Average of v_unit_trasnportcost_per_ton
TCQ	1326778	80.00	4100.00	30.00	8.00
TCO	153718	95.00	3500.00	25.00	28.00
Total	**1480496**	**87.50**	**3800.00**	**27.50**	**18.00**

X11i.Orgn...Plant.Code	shippedKG	Average of s_storage_unitcost	Average of t_fixed_handling_cost	Average of u_handling_unitcost	Average of v_unit_trasnportcost_per_ton
TCO	1480496	95.00	3500.00	25.00	28.00
Total	**1480496**	**95.00**	**3500.00**	**25.00**	**28.00**

Figure 7: Dashboard overview for Southwest region

4.0 Conclusion

Stockroom area optimization is usually a good fascinated subject matter within logistic market place plus well-known to be able to producer that take advantage of delegate 3PL companies with regard to storage in addition transport. This particular study evolves a choice support device from the beginning by simply obtaining dataset, building design, server scripting as well as resolving the style making use of software program. The consequence of this particular optimization studies providing an answer which is economical additionally easy to use. They have offered the mention of the organization customers in order to quickly in addition to frequently, uncover the present ideal answer depending on current client foundation and even amount development. Apart from, the cost features together with style with this choice help application has got the flexibility to become additional improve simply by easy personalization inside server scripting process to consider restrictions which will particularly find out merely by various producers. The thought of applying price marketing design is usually the most preferred type for all those companies. Nevertheless , variety plus capability design and style which usually excluding inside the design will also be found out to become a well-known topics that may be a part of long term research. This specific option assistance device will be versatile to modify in to multi-objectives unit as well, if required.

References

1. Afify, B., Soeanu, A., and Awasthi, A (2020). Separation linearisation approach for the capacitated faculty location problem under disruption. Expert Systems with Application. 148. pp. 114187.

2. Anand, R. a. K., V. (2017). Reliable Back-up Facility in Distribution Network. Procedia computer science, 115. pp. 312-321.
3. Asefi, H., Lim, S., Maghrebi, M., and Shahparvari, S (2019). Mathematical modelling and heuristic approaches to the location-routing problem of a cost-effective integrated solid waste management. Annals of Operations Research. 273(1-2). pp. 75-110.
4. Çakmak, E., Önden, İ., Acar, A. Z. and Eldemir, F (2020). Analyzing the location of city logistics centers in Istanbul by integrating Geographic Information Systems with Binary Particle Swarm Optimisation algorithm. Case Studies on Transport Policy, 9(1), pp. 59-67.
5. Hong, J., Diabat, A., Panicker, V. V. and Rajagopalan, S. (2018). A two-stage supply chain problem with fixed costs: An ant colony optimisation approach. International Journal of Production Economics, 204. pp. 214-226.
6. Khorshidi, E. and Ghezavati, V. R. (2019). Application of mathematical modeling value-at-risk (VaR) to optimize decision making in distribution networks. SN Applied Sciences, 1(12). pp. 1671.
7. Ma, H., Li, X. and Liu, Y. (2020). Multi-period multi-scenario optimal design for closed-loop supply chain network of hazardous products with consideration of facility expansion. Soft Computing, 24(4). pp. 2769-2780.
8. Dhanaraj, R. K., Ramakrishnan, V., Poongodi, M., Krishnasamy, L., Hamdi, M., Kotecha, K., & Vijayakumar, V. (2021). Random Forest Bagging and X-Means Clustered Antipattern Detection from SQL Query Log for Accessing Secure Mobile Data. Wireless Communications and Mobile Computing, 2021.
9. Rawal, B. S., Manogaran, G., Poongodi M & Hamdi, M. (2021). Multi-Tier Stack of Block Chain with Proxy Re-Encryption Method Scheme on the Internet of Things Platform. ACM Transactions on Internet Technology (TOIT), 22(2), 1-20.
10. M. M. Kamruzzaman, ""New Opportunities, Challenges, and Applications of Edge-AI for Connected Healthcare in Smart Cities,"" 2021 IEEE Globecom Workshops (GC Wkshps), 2021, pp. 1-6, doi: 10.1109/GCWkshps52748.2021.9682055."
11. Md Selim Hossain, MM Kamruzzaman, Shuvo Sen, Mir Mohammad Azad, Mohammad Sarwar Hossain Mollah, Hexahedron core with sensor based photonic crystal fiber: An approach of design and performance analysis," Sensing and Bio-Sensing Research, 32, 100426
12. Mingju Chen, Xiaofeng Han, Hua Zhang, Guojun Lin, M.M. Kamruzzaman, Quality-guided key frames selection from video stream based on object detection, Journal of Visual Communication and Image Representation, Volume 65, 2019, 102678, ISSN 1047-3203
13. M. M. Kamruzzaman: Performance of Decode and Forward MIMO Relaying using STBC for Wireless Uplink. JNW 9(12): 3200-3206 (2014)
14. M. M. Kamruzzaman, "Performance of Turbo Coded Vertical Bell Laboratories Layered Space Time Multiple Input Multiple Output system," Computer and Information Technology (ICCIT), 2013 16th International Conference on, Khulna, 2014, pp. 455-459.