DHL Supply Chain
Case Study Report

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Executive Summary

This report details data, methods, and recommendations provided for DHL Supply Chain to help manage its global operations and achieve its overall goals.

After developing the excel model for the original CNY 3 billion budget assignment, we generated the optimal solution which spent nearly CYN 3 billion yet saved roughly CYN 14,000. The solution subcontracts and ships all required units of LCD 32” and LCD 42” to meet demand while satisfying constraints.

Next, we created other models to compare the impact of an increased budget of CNY 3.3 billion, with the original budget, and with various carbon emission reduction rates of 10%, 20%, and 30%. The increased budget shows promise for decreased emission goals, but is insignificant when compared to the original budget because their optimal solutions are nearly identical.

If DHL operates at 90% of the total carbon emissions, the total cost would be CNY 3.033 billion and with a surplus of CNY 267 million. With carbon emissions of 80%, the total cost would be around CNY 3.047 billion and the remaining budget would be CNY 253 million. With carbon emissions reduced to 70%, the total cost would be around CNY 3.061 billion leaving a budget surplus of CNY 238 million. The total cost to increase emission reduction from 0-30% would be CNY 61.5 million.

Using this information, Deutsche Post DHL’s carbon efficiency goal, which calls for a 30% reduction in total emissions, is both a feasible and a profitable plan.

Background on DHL Supply Chain

DHL Supply Chain is a company which mass produces consumer electronics for sale all around the world. The DHL has stated on its website, “We recognize environmental protection as our responsibility as well as a business opportunity.”

Yee Hwai, a member of the solutions team at DHL Supply Chain, has encountered the issue of excessive carbon dioxide emission from their logististics and transportation sectors. With Deutsche Post DHL being the parent firm, and the first logistics company to set a carbon emission reduction goal of 30% compared to previous years, it was important for Hwai to formulate the most cost effective and least emitting carbon dioxide routes for all transportation modes.

Hwai’s objective is to subcontract and ship all required demands of LCD 32” and LCD 42” TV sets through subcontracting various specific original design manufacturers (ODM) from Taiwan and China, while meeting the demand of 920,000 units of LCD42” and 530,000 units of LCD32”. Hwai also has an allocated a budget of CNY 3 billion and a goal of emitting the least amount of carbon dioxide through their transportation modes for the first model. (See Exhibit 1) For the second model, Hwai increased the budget by 10% to CNY 3.3 billion as a response to anticipate tax incentives from the government and a potential increase in brand value. (See Exhibit 4) With the new budget, he hoped to potentially find a possible reduction of CO2 emissions.

Methodology

To formulate the model for this problem, we used linear programming to optimize the available resources, meet demand, reduce pollution emission, and decrease production and transportation costs. Our decision variables are to determine how many units of LCD 42" and LCD 32" TV sets to subcontract from a specific ODM through a total of seven different types of transportation modes divided into four categories; air, road, rail, and water, while staying within the CNY 3 billion budget. (See Exhibit 1)

We chose linear programming because the method is used to achieve the best possible outcome, including minimizing production costs and maximizing profit, for a mathematical model whose requirements are represented by linear relationships. The objective of DHL Supply Chain is to reduce total cost and models constraints show working linear relationships.

Some of the ways we used linear programming to optimize for the decision variables is by including the parameters and inputs provided to ensure the optimization of all resources and transportation modes. Below we've included the shipping cost per a LCD TV through each transportation mode in CNY currency. (Blue describes the ODMs that are are capable of producing LCD 32" and LCD 42", while the orange depicts the firms only able to produce LCD 42".)

Shipping Cost/unit CNY						
Regular Air	Air Express	Road	Road LTL	Road-	Rail	Water
1,062.60	1,168.86	102.01	86.07	79.70	70.13	51.00
1,912.68	2,103.95	116.89	95.63	93.51	95.63	44.63
1,416.80	1,558.48	136.01	114.76	106.26	93.51	68.01
2,550.24	2,805.26	155.85	127.51	124.68	127.51	59.51
2,266.88	2,493.57	155.85	127.51	124.68	127.51	72.26
1,416.80	1,558.48	136.01	116.18	114.76	93.51	68.01
X	X	212.52	198.35	191.27	X	X
2,975.28	3,258.64	X	X	X	X	75.09
2,266.88	2,479.40	155.85	127.51	121.84	128.93	60.92

Along with the data provided above, we were also given the total emission produced for each ton being shipped via the four different categories of transportation modes. As for the minimum capacity to be shipped for LCD 32" and LCD 42", each transportation category has a minimum requirement that also must be met, air being 53,000 units, road and rail being 79,500 units each, and no minimum is requirement of units for water transportation. Data shown below.

	Transportation Modes j						
	Regular Air	Air Express	Road	Road LTL	Road-Network	Rail	Water
Co2 Emission in Kg/Ton: Kim Shipped	1.44	1.44	0.0613	0.0613	0.0613	0.0285	0.007
Min Capacity to be shipped for LCD32"	53000		79500			79500	0
Min Capacity to be shipped for LCD42"	46000		92000			138000	0

As for our objective function within our linear programming model, we've decided that it is best to optimize the minimization of our transportation costs per each unit shipped through its various shipping methods and also the production cost per each unit produced at various ODM with varying production costs. The data to the bottom left, provides information on the production cost at each ODM. While the data to the bottom right provides information of the total production and transportation cost at each individual ODM.

Product - ODM i	TV Unit Production Cost CNY
LCD32" - ODM1	1,818.00
LCD32" - ODM2	1,996.40
LCD42" - ODM1	1,983.40
LCD42" - ODM2	2,254.00
LCD42" - ODM3	2,582.40
LCD42" - ODM4	1,976.10
LCD42" - ODM5	2,711.30
LCD42" - ODM6	2,704.80
LCD42" - ODM7	2,125.20

	Production Cost	Shipping Cost
LCD32" - ODM1	963540000	84448541.1
LCD32" - ODM2	0	0
LCD42" - ODM1	634688000	27831619.2
LCD42" - ODM2	0	0
LCD42" - ODM3	0	0
LCD42" - ODM4	1185660000	103817436.8
LCD42" - ODM5	0	0
LCD42" - ODM6	0	0
LCD42" - ODM7	0	0
Total Cost	$ 2,999,985,597.10	

As for the restrictions and constraints for this model, it includes production capacity, budget capacity, the minimum required units for each transportation modes, the demand requirement, the non-negativity, and integrality variables. The first constraint, would be the production capacity, if we were to produce at any manufacturing ODM, regardless of LCD 32" or LCD 42, the minimum requirement for a business partnership to existing would be 200,000 units at any available ODM.

Along with the minimum requirement of production, there is also a maximum production of the 32" and 42" LCD TVs capping at a total of 600,000 units at any available ODM facility. However, if a specific facility is not utilized, then it is canceled out using the binary variable and that specific ODM doesn't have to meet any minimum or maximum production capacity.

The next constraint would be the budget constraint. We are expected to remain within the budget of CNY 3 billion, while meeting all other requirements. Next, we have the minimum requirement of units to be shipped via air, road, and rail. The minimum requirement of units to be transported through air is a total of 46,000 units for LCD 42" and 53,000 for LCD 32". The minimum requirement of units to be shipped via road would be a total of 92,000 for LCD 42" and 79,500 for LCD 32". The minimum requirement of units to be shipped via rail is 138,000 units for LCD 42" and 79,500 units for LCD 32".

While meeting all these current constraints, we must also meet the units demanded for each type of LCD TV, LCD 42" demanding 920,000 units total and LCD 32" requiring a total of 530,000 units. Our last two constraints would be the integrality

and the non-negativity constraint. Units are to be shipped as whole products and our units are to be positive integers only. We felt that a linear programming model is the best method to utilize optimization for all these variables because we are able to manipulate variables and constraints to abide to the given parameters and while to satisfy current demand.

Model Analysis and Findings

As a team, we developed a linear programming model for the first standard model, optimizing for shipping and production cost only, we've discovered that the ODM 1 and ODM 4 were the only facilities that were utilized. We've also noticed that ODM 1 will be producing the majority of the demanded LCD 42" and LCD 32" TVs and also transmitting these products through various air, rail, road and water transportation. While ODM 4 is only transporting these TVs via water modes.

Based on our models success with the 3 billion budget, we wanted to see if an increase in the budget would affect our optimal solution. When we compared budgets of CNY 3 billion and CNY 3.3 billion; the outcome for both was virtually the same. With the 3 billion budget, we contracted work from ODM 1 and ODM 4 to meet demand and we saw a budget surplus of roughly CNY 14,000. With the CNY 3.3 billion budget, we got almost identical production results with a budget surplus of a little over CNY 300 million. The only difference between the models was the ODM changes for units shipped by rail and units shipped by water. (See Exhibit 2 & 3) With the CNY 3 billion budget

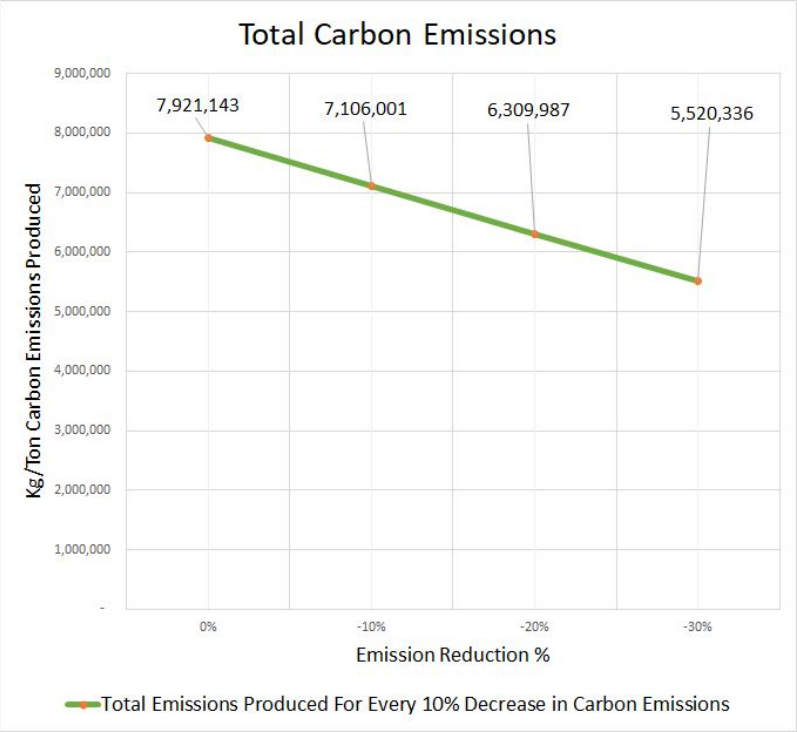
We found that instead of spending the increase budget, the company would be saving the 10% increase provided in funds and they would be operating at the same level of the CNY 3 billion.(See Exhibit 4) The lack of change in ODM selection, transportation modes used, and budget use told our team that the increase in budget is insignificant when operating under the original parameters and constraints. The calculated budget comparison ensured that the optimal solution was the best outcome possible for DHL Supply Chain's problem.

Taking Carbon Emissions into Consideration

After we completed the original model and testing of the optimal solution for the CNY 3 billion budget assignment, we decided to take our research further by exploring the increased budget and the effects of new constraints created to decrease the supply chains total carbon emissions. If the company makes efforts for carbon emission reduction, it will be eligible for tax incentives which could translate to a 10% increase in total budget.

As mentioned in the DHL background, the company is aware of the pollution created from operations and they have started setting carbon efficiency goals for the future. To help DHL reach their goals for both reduced emissions and minimized costs, we decided to manipulate the model and compare the results of our total emission, by creating a three models that illustrates the difference in total emission reductions of 10%, 20%, and 30%. (See Exhibit 5)

Total carbon emissions calculated for each reduction rate can be seen below.

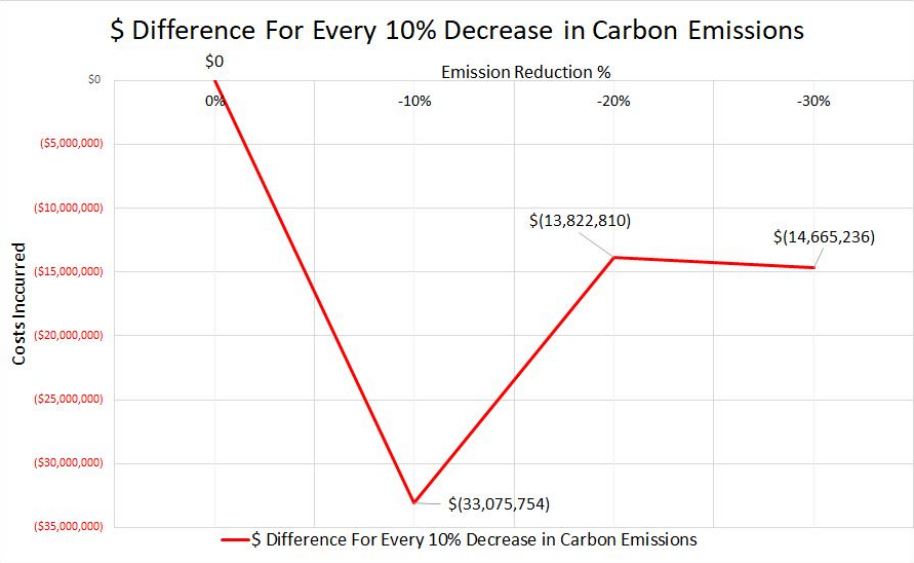


The change from no reduction to 30% reduction would result in over 2 million kg/ton carbon emissions being saved from entering the atmosphere.

When comparing all the optimal solution given for each emission rate, we can see that ODMs 1, 2, 4, and 7, are selected every time.(See Exhibit 6) We call also see that the only transportation modes not selected are Air-Express and Road.

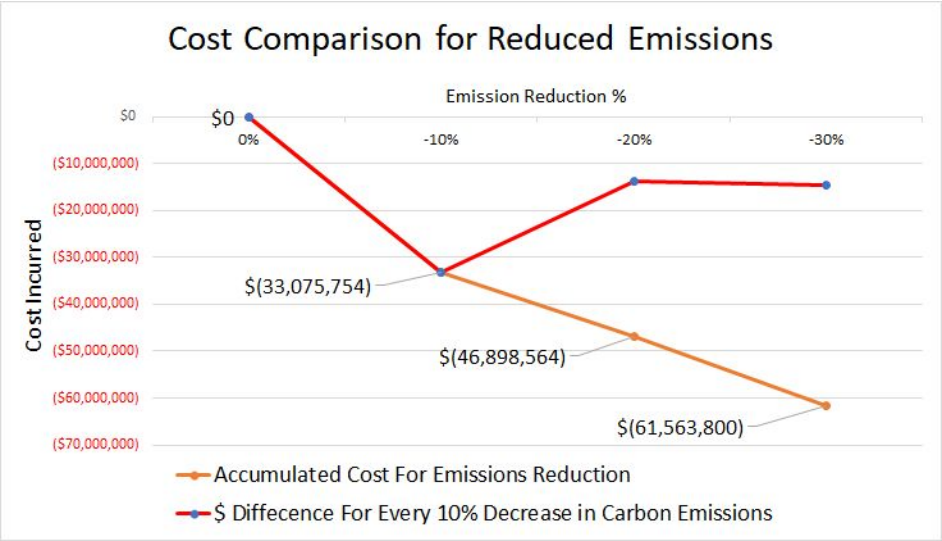
When comparing the emission reduction rates, operating at 90% of the total carbon emissions, the total cost would be CNY 3.033 billion and with a surplus of CNY 267 million. When operating with 80% of the total emissions, the total cost would be around CNY 3.047 billion and the remaining budget would be CNY 253 million. With carbon emissions reduced to 70%, the total cost would be around CNY 3.061 billion leaving a budget surplus of CNY 238 million. (See Exhibit 7 & 8)

The cost incurred from operating at each emission reduction can be seen below.



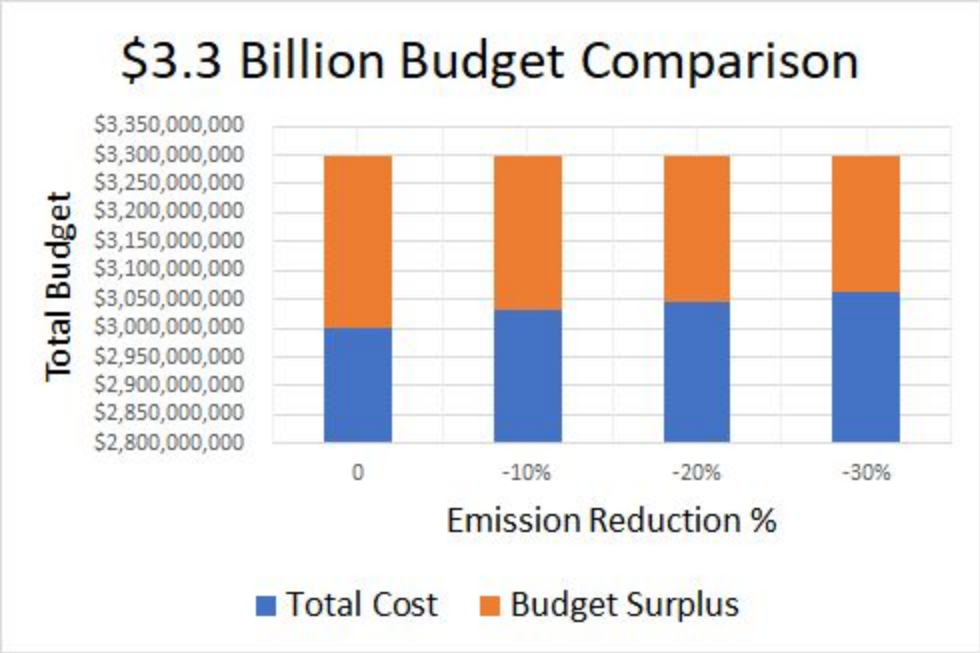
Overall we can see that going from no reduction to 10% reduction is the most expensive first step in the right direction towards limited carbon emissions. For 20% and 30% reduction, the costs are almost the same. The larger expense from -10% emissions could result because changing the whole supply chains operations can be expensive but once the changes are made it won't be as expensive.

The total accumulated cost to decrease emissions from 0-30% would be CNY 61.5 million. We created a cost comparison to visualize the cost for emissions.



When comparing price per emissions change with accumulated total cost we can see that going green is expensive but the overall price for 30% reduced emissions is minimal in comparison to our over total budget. The total price to achieve reduction goals only accounts for 2% of the total budget of CNY 3.3 billion.

When comparing the budget with the budget surplus from no emissions ranging to 30% reduction in emissions, we can see the the change in budget is very small.



In conclusion, to meet our goal of reducing the amount of emission produced through the various transportation modes, we'll change the shipping methods primarily from ODM 1 and 4 to ODM 1,4, and 7. With the additional ODM transportation, we'll be decreasing our total emissions by 17.5M Kg/Ton. With the investment of only an additional CNY 61.5M, we'll be able to acquire the additional tax incentives leaving us with roughly CNY 240 million remaining.

Conclusion

The Supply Chain Champions were selected to assist the DHL Supply Chain in curating the most cost-effective transportation route through 7 different modes, organized into four different categories; air, road, rail, and water. With Deutsche Post DHL being the parent firm and the first to set a carbon emission reduction goal of 30%, it was also important that we formulated the perfect model which will also take into consideration of the amount of carbon dioxide emitted, while meeting all the required demand of each LCD 32" and LCD 42". Our standard model has suggested that the majority of production is to be subcontracted through ODM 1 and 4, while meeting all the various required restrictions of budget restrictions to the minimum and maximum production capacity.

After completing the original model, we've decided to manipulate the data and change the budget to fit the tax incentive provided by the government. With the changed budget, we flucated the total amount of carbon dioxide emitted ranging from a total of 70%, 80%, and 90%, which we then all compared to the original model producing emission at 100%. We have come to the conclusion that the task to reduce emissions and remain within all restricted guidelines is feasible.

Recommendations for the Future

With Deutsche Post DHL being focused on reaching their carbon efficiency goal and the reduction of their total emissions by 30% compared to previous years, we've concluded that the best results will come from the reduction of 30% emission. The 30% reduction of emission will not only benefit the environment but also increase the value of their LCD TVs, resulted from greater customer awareness which can potentially increase future budget value. With greater customer awareness of DHL's ability to work towards sustainability, people are more inclined to purchase products from companies who are honorable and it'll position the brand as a charitable philanthropist, highlighting the shipping company in a more positive spotlight.

Appendix

Exhibit 1: Mathematical Formulation

Objective Function:
Minimize ΣΣCijXij + ΣΣCijYij + Σpi + ΣXij + ΣYij

Set I = ODM n = 7
SetJ = Transportation modes m = 7

Parameters:
Kj: Max possible capacity by transportation mode j
Oj: Minimum possible capacity by transportation mode j
Ki: Maximum possible production at ODM i
Oi: Minimum possible production at ODM i
Pi: Cost ot produce 1 unit at ODM i
Dj: Minimum units demanded of 32" by transportation mode j
Bj: Minimum units demanded of 42" by transportation mode j
Cij: Cost of shipping 1 unit from ODM I through transportation mode j

Decision Variables
Xij: Units of 42" to produce at ODM I and shipped by transportation mode j
Yij: Units of 32" to produce at ODM I and shipped by transportation mode j
Wi: 1 = Subcontract at ODM I, 0 = Otherwise

Constraints:	
Budget Constraint:	**Production Capacity:**
Xij + Yij ≤ 3 Billion CNY	Xij - 200,000*Wi ≤ 0
	Yij - 200,000*Wi ≤ 0
Demand Constraint:	Xij - 600,000*Wi ≤ 0
ΣXij-Dj=0 j =1-7	Yij - 600,000*Wi ≤ 0
ΣYij-Bj=0 j =1-7	
Non-negativity:	**Integrelity:**
Xij, Yij, Wi ≥ 0	Xij, Yij, Wi = integer

Minimum Units Transportation Mode:		
	LCD 32	LCD 42
Air:	Xi-53,000 ≥ 0	Xi-46,000 ≥ 0
Rail:	Xi-79,500 ≥ 0	Xi-92,000 ≥ 0
Road:	Xi-79,500 ≥ 0	Xi-138,000 ≥ 0

Exhibit 2: 100% Emission with a CNY 3B Budget

Product - ODM i	Regular Air	Air Express	Road	Road LTL	Road-Network	Rail	Water
LCD32" - ODM1	53,000.00	0.00	0.00	0.00	79,500.00	79,500.00	318,000.00
LCD32" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM1	46,000.00	0.00	0.00	0.00	92,000.00	138,000.00	44,000.00
LCD42" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM4	0.00	0.00	0.00	0.00	0.00	0.00	600,000.00
LCD42" - ODM5	0	0	0.00	0.00	0.00	0	0
LCD42" - ODM6	0.00	0.00	0	0	0	0	0.00
LCD42" - ODM7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total units shipped	99,000.00	0.00	0.00	0.00	171,500.00	217,500.00	962,000.00

Exhibit 3: 100% Emission with a CNY 3.3B Budget

Product - ODM i	Regular Air	Air Express	Road	Road LTL	Road-Network	Rail	Water
LCD32" - ODM1	53,000.00	0.00	0.00	0.00	79,500.00	79,500.00	318,000.00
LCD32" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM1	46,000.00	0.00	0.00	0.00	92,000.00	0.00	182,000.00
LCD42" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM4	0.00	0.00	0.00	0.00	0.00	138,000.00	462,000.00
LCD42" - ODM5	0	0	0.00	0.00	0.00	0	0
LCD42" - ODM6	0.00	0.00	0	0	0	0	0.00
LCD42" - ODM7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total units shipped	99,000.00	0.00	0.00	0.00	171,500.00	217,500.00	962,000.00

Exhibit 4: Comparison of CNY 3B and CNY 3.3B Budget without Emission change

OBJECTIVE FUNCTION		
	Production Cost	Shipping Cost
LCD32" - ODM1	963540000	84448541.1
LCD32" - ODM2	0	0
LCD42" - ODM1	634688000	90845216
LCD42" - ODM2	0	0
LCD42" - ODM3	0	0
LCD42" - ODM4	1185660000	40803840
LCD42" - ODM5	0	0
LCD42" - ODM6	0	0
LCD42" - ODM7	0	0
Total Cost	$ 2,999,985,597.10	

Budget constraint		
$ (14,403)	<=	0

OBJECTIVE FUNCTION		
	Production Cost	Shipping Cost
LCD32" - ODM1	963540000	84448541.1
LCD32" - ODM2	0	0
LCD42" - ODM1	634688000	87325884.8
LCD42" - ODM2	0	0
LCD42" - ODM3	0	0
LCD42" - ODM4	1185660000	44323171.2
LCD42" - ODM5	0	0
LCD42" - ODM6	0	0
LCD42" - ODM7	0	0
Total Cost	$ 2,999,985,597.10	

Budget constraint		
$ (300,014,403)	<=	0

Exhibit 5: Comparison of total emissions when reducing emissions by 10%, 20%, and 30%

-10% Total Emissions	-20% Total Emissions	-30% Total Emissions
Emissions Constraint	Emissions Constraint	Emissions Constraint
Total Emissions	Total Emissions	Total Emissions
3545820.808	3545820.808	3545820.808
0	0	0
121898.3615	77312.31325	77309.31719
0	0	0
0	0	0
3318145.223	2196703.497	1037042.647
0	0	0
0	0	0
120136.4552	490149.9923	860163.5295
7106000.848	6309986.611	5520336.302
≤	≤	≤
7150059.931	6355608.827	5561157.724

Exhibit 6: The optimal solution when reducing emissions by 10%, 20%, and 30%

i	Regular Air	Air Express	Road	Road LTL	Road-Network	Rail	Water
LCD32" - ODM1	53,000.00	0.00	0.00	0.00	79,500.00	79,500.00	318,000.00
LCD32" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM1	0.00	0.00	0.00	0.00	24.00	0.00	315,399.00
LCD42" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM4	41,422.00	0.00	0.00	0.00	91,976.00	138,000.00	133,179.00
LCD42" - ODM5	0	0	0.00	0.00	0.00	0	0
LCD42" - ODM6	0.00	0.00	0	0	0	0	0.00
LCD42" - ODM7	4,578.00	0.00	0.00	0.00	0.00	0.00	195,422.00
Total units shippec	99,000.00	0.00	0.00	0.00	171,500.00	217,500.00	962,000.00

-10% Carbon Emissions

i	Regular Air	Air Express	Road	Road LTL	Road-Network	Rail	Water
LCD32" - ODM1	53,000.00	0.00	0.00	0.00	79,500.00	79,500.00	318,000.00
LCD32" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM1	0.00	0.00	0.00	19.00	3.00	0.00	199,978.00
LCD42" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM4	24,313.00	0.00	0.00	0.00	91,978.00	138,000.00	265,709.00
LCD42" - ODM5	0	0	0.00	0.00	0.00	0	0
LCD42" - ODM6	0.00	0.00	0	0	0	0	0.00
LCD42" - ODM7	21,687.00	0.00	0.00	0.00	0.00	0.00	178,313.00
Total units shippec	99,000.00	0.00	0.00	19.00	171,481.00	217,500.00	962,000.00

-20% Carbon Emissions

i	Regular Air	Air Express	Road	Road LTL	Road-Network	Rail	Water
LCD32" - ODM1	53,000.00	0.00	0.00	0.00	79,500.00	79,500.00	318,000.00
LCD32" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM1	0.00	0.00	0.00	20.00	1.00	0.00	199,979.00
LCD42" - ODM2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCD42" - ODM4	7,204.00	0.00	0.00	0.00	91,979.00	138,000.00	282,817.00
LCD42" - ODM5	0	0	0.00	0.00	0.00	0	0
LCD42" - ODM6	0.00	0.00	0	0	0	0	0.00
LCD42" - ODM7	38,796.00	0.00	0.00	0.00	0.00	0.00	161,204.00
Total units shippec	99,000.00	0.00	0.00	20.00	171,480.00	217,500.00	962,000.00

-30% Carbon Emissions

Exhibit 7: Budget surplus resulting from operations

Budget Surplus Resulting From Operations

	Budget constraint		
-10%	$ (266,938,649)	<=	0
-20%	$ (253,115,839)	<=	0
-30%	$ (238,450,603)	<=	0

Exhibit 8: Comparison of total budget spent for each reduction rate

Total Cost From Reduced Emisisions

OBJECTIVE FUNCTION		
	Production Cost	Shipping Cost
LCD32" - ODM1	963540000	84448541.1
LCD32" - ODM2	0	0
LCD42" - ODM1	625609978.2	21451700.79
LCD42" - ODM2	0	0
LCD42" - ODM3	0	0
LCD42" - ODM4	799484609.7	91203167.69
LCD42" - ODM5	0	0
LCD42" - ODM6	0	0
LCD42" - ODM7	425040000	22283353.89
Total Cost	$ 3,033,061,351.37	-10%

OBJECTIVE FUNCTION		
	Production Cost	Shipping Cost
LCD32" - ODM1	963540000	84448541.1
LCD32" - ODM2	0	0
LCD42" - ODM1	396680000	13602283.09
LCD42" - ODM2	0	0
LCD42" - ODM3	0	0
LCD42" - ODM4	1027572000	75976254.2
LCD42" - ODM5	0	0
LCD42" - ODM6	0	0
LCD42" - ODM7	425040000	60025082.47
Total Cost	$ 3,046,884,160.87	-20%

OBJECTIVE FUNCTION		
	Production Cost	Shipping Cost
LCD32" - ODM1	963540000	84448541.1
LCD32" - ODM2	0	0
LCD42" - ODM1	396680000	13602253.34
LCD42" - ODM2	0	0
LCD42" - ODM3	0	0
LCD42" - ODM4	1027572000	52899791.25
LCD42" - ODM5	0	0
LCD42" - ODM6	0	0
LCD42" - ODM7	425040000	97766811.05
Total Cost	$ 3,061,549,396.74	-30%