Erken Apparel

Group 3

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Erken Apparel Introduction

We are working with Erkan Apparel International to develop a transhipment model to minimize the cost of all their shipments to meet the demand of leather jackets according to the distribution centers, and their given resource constraints.

- **Erkan Apparel is contracted with a U.S wholesale retail clothing distributor for leather jackets, where they distribute them to various store chains.**

The distribution sites and their demand which needs to be fulfilled:

Distribution Center	Goatskin Jackets	Lambskin Jackets
Indiana	1000	780
North Carolina	1400	950
Pennsylvania	1600	1150

- **Erken has Tanning Factories and Manufacturing Plants in Europe and South America.**

Each tanning factory has the following supply:

Tanning Factory	Goatskin Supply(lb).	Lambskin Supply (lb)
Mende	4000	4400
Foggia	3700	5300
Saragosa	6500	4650
Feira	5100	6850
El Tigre	3600	5700

Each Manufacturing plant has the following capacity:

Plant	Capacity (lb.)
Madrid	7800
Naples	5700
Limoges	8200
São Paulo	7600
Caracas	6800

- **The leather is tanned in Europe and then shipped to South America for manufacturing.**

The cost of tanning, shipping and producing the leather jacket at each plant are as follows ($/lb.):

PLANT

Tanning Factory	Madrid	Naples	Limoges	São Paulo	Caracas
Mende	$24	$22	$16	$21	$23
Foggia	31	17	22	19	22
Saragosa	18	25	28	23	25
Feira	-	-	-	16	18
El Tigre	-	-	-	14	15

- 37.5% of the goatskin leather and 50% of the lambskin leather is waste

The cost of shipping the leather from the European plants to the South American Ports ($/lb.):

	Ports		
Plant	Lisbon	Marseilles	Caracas
Madrid	.75	1.05	-
Naples	3.45	1.35	-
Limoges	2.25	.60	-
São Paulo	-	-	1.15
Caracas	-	-	.20
CAPACITY	8000	5500	9000

- Once produced the goatskin jacket weighs 3 pounds and the lambskin jacket weighs 2.5 pounds.

- **Once produced they leave the ports of South America to enter U.S ports**

Port	New Orleans	Jacksonville	Savannah
Lisbon	2.35	1.90	1.80
Marseilles	3.10	2.40	2.00
Caracas	1.95	2.15	2.40
CAPACITY	8000	5200	7500

The cost of the shipment to the U.S ports from South America ($/lb.)

Distribution Center

Costs from port to distribution Center ($/lb.)

U.S Port	Indiana	North Carolina	Pennsylvania
New Orleans	.65	.52	.87
Jacksonville	.43	.41	.65
Savannah	.38	.34	.50

How we went about solving the problem:

Objective Function:

Minimize - Z = 24Xmm + 22Xmn + 16Xml + 21Xms + 23Xmc + 31Xfm + 17Xfn + 22Xfl + 19Xfs + 22Xfc + 18Xsm + 25Xsn + 28Xsl + 23Xss + 25Xsc + 16XFeS + 18XFeC + 14Xes + 15Xec

Here are the constraints:

Xmm + Xmn + Xml + Xms + Xmc <= 4000
Xfm + Xfn + Xfl + Xfs + Xfc <= 3700
Xsm + Xsn + Xsl + Xss + Xsc <= 6500
XFeS + XFeC <= 5100
Xes + Xec <= 3600
Xmm + Xfm + Xsm <= 7800
Xmn + Xfn + Xsn <= 5700
Xml + Xfl + Xsl <= 8200
Xms + Xfs + Xss + XFeS + Xes <= 7600
Xmc + Xfc + Xsc + XFeC + Xec <= 6800
Xmm + Xmn + Xml + Xms + Xmc + Xfm + Xfn + Xfl + Xfs +
Xfc + Xsm + Xsn + Xsl + Xss + Xsc + XFeS + XFeC + Xes + Xec = 19200

Xij= quantities moved between the various locations

How we went about solving the problem

First we had to identify the direction of the products/production, from where to where these plants, ports, and cities were going

TANNING FACTORIES → MANUFACTURING PLANTS

(On the side are the supplies of available leather from each tanning facility)

TO PORTS → FROM MFG PLANTS

FROM PORTS (EUROPE & SA) → U.S. PORTS

TO DISTRIBUTION CENTERS → FROM PORTS

From Tanning Factories to Manufacturing Plants	Madrid ($/lb)	Naples (/lb)	Limoges ($/lb)	Sao Paulo ($	Caracas ($/lb)
Mende	$24	$22	$16	$21	$23
Foggia	$31	$17	$22	$19	$22
Saragosa	$18	$25	$28	$23	$25
Feira	1.00E+07	1.00E+07	1.00E+07	$16	$18
El Tigre	1.00E+07	1.00E+07	1.00E+07	$14	$15
Processing Capacity (lb)	7,800	5,700	8,200	7,600	6,800

Tanning	Goatskin Supply	Lambskin Leather Supply
Mende	4000	4400
Foggia	3700	5300
Saragosa	6500	4650
Feira	5100	6850
El Tigre	3600	5700

Mende	4000	4400
Foggia	3700	5300
Saragosa	6500	4650
Feira	5100	6850
El Tigre	3600	5700

To Ports/From mfg plants	Madrid ($/lb)	Naples (/lb)	Limoges ($/lb)	Sao Paulo ($	Caracas ($/lb)	Capacity
Lisbon ($/lb)	0.75	3.45	2.25	1.00E+07	1.00E+07	8000
Marseilles ($/lb)	1.05	1.35	0.6	1.00E+07	1.00E+07	5500
Caracas ($/lb)	1.00E+07	1.00E+07	1.00E+07	1.15	0.2	9000

From Ports in Europe and SA to US Ports	New Orleans	Jacksonville	Savannah
Lisbon	2.35	1.9	1.8
Marseilles	3.1	2.4	2
Caracas	1.95	2.15	2.4
Capacity	8000	5,200	7,500

To Distribution Centers/ From Ports	New Orleans	Jacksonville	Savannah	Demand	Goatskin Jackets	Lambskin Jackets
Ohio ($/lb)	0.65	0.43	0.38	Ohio	1000	780
Tennessee ($/lb)	0.52	0.41	0.34	Tennessee	1400	950
New York ($/lb)	0.87	0.65	0.5	New York	1600	1150
				Weight	3	2.5
				Wastage	37.50%	50%

From Tanning Factories to Manufacturing Plants

We then set up constraints for each direction of the products:

From Tanning Factories to Manufacturing Plants								
Goatskin Leather	**Madrid ($/lb)**	**Naples ($/lb)**	**Limoges ($/lb)**	**Sao Paulo ($/lb)**	**Caracas ($/lb)**			
Mende	0	0	3800	0	0	=SUM(B30:F30)		
Foggia	0	1858	0	0	0	=SUM(B31:F31)		
Saragosa	6768	0	0	0	0	=SUM(B32:F32)		
Feira	0	0	0	2905	0	=SUM(B33:F33)		
El Tigre	0	0	0	0	3600	=SUM(B34:F34)		
	=SUM(B30:B34)	=SUM(C30:C34)	=SUM(D30:D34)	=SUM(E30:E34)	=SUM(F30:F34)	=SUM(B35:F35)		
Lambskin Leather								
Mende	0	0	4400	0	0	=SUM(B37:F37)		
Foggia	0	1342	0	0	0	=SUM(B38:F38)		
Saragosa	1032	0	0	0	0	=SUM(B39:F39)		
Feira	0	0	0	1898	0	=SUM(B40:F40)		
El Tigre	0	0	0	2260	3200	=SUM(B41:F41)		
	=SUM(B37:B41)	=SUM(C37:C41)	=SUM(D37:D41)	=SUM(E37:E41)	=SUM(F37:F41)			
Total Capacity Used	**=SUM(B35,B42)**	**=SUM(C35,C42)**	**=SUM(D35,D42)**	**=SUM(E35,E42)**	**=SUM(F35,F42)**			
Number of Jackets Produced								
Goatskin Jackets	=ROUND(B35*(1-$F$26)/$	=ROUND(C35*(1-$F$26)/$	=ROUND(D35*(1-$F$26)/$F	=ROUND(E35*(1-$F$26)/$F$25,(	=ROUND(F35*(1-$F$26)/$F$25,(			
Lambskin Jackets	=ROUND(B42*(1-$G$26)/$	=ROUND(C42*(1-$G$26)/$	=ROUND(D42*(1-$G$26)/$(	=ROUND(E42*(1-$G$26)/$G$25	=ROUND(F42*(1-$G$26)/$G$25			
To Ports / From mfg Plants								
Goatskin Jackets Shipped	Madrid	Naples	Limoges	Sao Paulo	Caracas	Total Jackets	Weight of Jackets (lb)	Total Capacity Used (lb)
Lisbon	1421	0	79	0	0	=SUM(B51:F51)	=G51*3	=H51+H58
Marseilles	0	387	713	0	0	=SUM(B52:F52)	=G52*3	=H52+H59
Caracas	0	0	0	650	750	=SUM(B53:F53)	=G53*3	=H53+H60
Total Jackets	=SUM(B51:B53)	=SUM(C51:C53)	=SUM(D51:D53)	=SUM(E51:E53)	=SUM(F51:F53)			
Weight of Jackets (lb)	=B54*$F$25	=C54*$F$25	=D54*$F$25	=E54*$F$25	=F54*$F$25			
Lambskin Jackets Shipped	Madrid	Naples	Limoges	Sao Paulo	Caracas			
Lisbon	193	268	0	0	0	=SUM(B58:F58)	1153	
Marseilles	0	0	880	0	0	=SUM(B59:F59)	2200	
Caracas	0	0	0	899	640	=SUM(B60:F60)	3847	
Total Jackets	=SUM(B58:B60)	=SUM(C58:C60)	=SUM(D58:D60)	=SUM(E58:E60)	=SUM(F58:F60)			
Weight of Jackets	=B61*$G$25	=C61*$G$25	=D61*$G$25	=E61*$G$25	=F61*$G$25			
From Ports in Europe and SA to US Ports								
Goatskin Jackets Shipped	New Orleans	Jacksonville	Savannah	Total Jackets				
Lisbon	0	933	500	1433				
Marseilles	0	0	1100	1100				
Caracas	1400	0	0	1400				
Total Jackets	=SUM(B66:B68)	=SUM(C66:C68)	=SUM(D66:D68)					

From Ports in Europe and SA to US Ports							
Goatskin Jackets Shipped	New Orleans	Jacksonville	Savannah	Total Jackets			
Lisbon	0	933	500	1433			
Marseilles	0	0	1100	1100			
Caracas	1400	0	0	1400			
Total Jackets	=SUM(B66:B68)	=SUM(C66:C68)	=SUM(D66:D68)				
Lambskin Jackets Shipped	New Orleans	Jacksonville	Savannah				
Lisbon	0	328	200	=SUM(B72:D72)			
Marseilles	0	0	880	=SUM(B73:D73)			
Caracas	1017	522	0	=SUM(B74:D74)			
Total Jackets	=SUM(B72:B74)	=SUM(C72:C74)	=SUM(D72:D74)		**From Tanning Factories to**		
					Goatskin Leather	=SUMPRODUCT(B30:F34,$B$2:$F$6)	
Total Capacity Used (lb)	=B69*$F$25+B75*$G$25	=C69*$F$25+C75*$G$25	=D69*$F$25+D75*$G$25		Lambskin Leather	=SUMPRODUCT(B37:F41,$B$2:$F$6)	
					To Ports / from mfg plants	=SUMPRODUCT(B51:F53,$B$11:$F$13)*F25	
To Distribution Centers/ From Ports					Goatskin Jackets	=SUMPRODUCT(B58:F60,$B$11:$F$13)*G25	
Goatskin Jackets Shipped	New Orleans	Jacksonville	Savannah	Total Jackets	Lambskin Jackets		
Indiana	0	1000	0	=SUM(B82:D82)			
North Carolina	1400	0	0	=SUM(B83:D83)	**From Ports in Europe and S**		
Pennsylvania	0	0	1600	=SUM(B84:D84)	Goatskin Jackets	=SUMPRODUCT(B66:D68,$B$16:$D$18)*$F	
Total Jackets	=SUM(B82:B84)	=SUM(C82:C84)	=SUM(D82:D84)		Lambskin Jackets	=SUMPRODUCT(B72:D74,$B$16:$D$18)*$G	
Lambskin Jackets Shipped	New Orleans	Jacksonville	Savannah		**To Distribution Centers / Fr**		
Indiana	0	780	0	=SUM(B88:D88)	Goatskin Jackets	=SUMPRODUCT(B82:D84,$B$22:$D$24)*$F	
North Carolina	950	0	0	=SUM(B89:D89)	Lambskin Jackets	=SUMPRODUCT(B88:D90,$B$22:$D$24)*$C	
Pennsylvania	0	70	1080	=SUM(B90:D90)			
Total Jackets	=SUM(B88:B90)	=SUM(C88:C90)	=SUM(D88:D90)		Total Cost	=SUM(176:189)	<-- Ob
Total Capacity Used (lb)	=B85*$F$25+B91*$G$25	=C85*$F$25+C91*$G$25	=D85*$F$25+D91*$G$25				

$$Z = 24Xmm + 22Xmn + 16Xml + 21Xms + 23Xmc + 31Xfm + 17Xfn + 22Xfl + 19Xfs + 22Xfc + 18Xsm + 25Xsn + 28Xsl + 23Xss + 25Xsc + 16XFeS + 18XFeC + 14Xes + 15Xec$$

Approaches to solve problem (in mathematical equation)

Approach 1: Using least amount of factories with highest supplies

Distribution Center	Goatskin Jackets	Lambskin Jackets
Indiana	1000	780
North Carolina	1400	950
Pennsylvania	1600	1150
Totals	4000	2880

Total lbs needed (without waste) to waste		
12,000 lbs goat	Assume 37.5% waste for goat	= 20,000 lbs
7,200 lbs lamb	Assume 50% waste for lamb	= 14,400 lbs

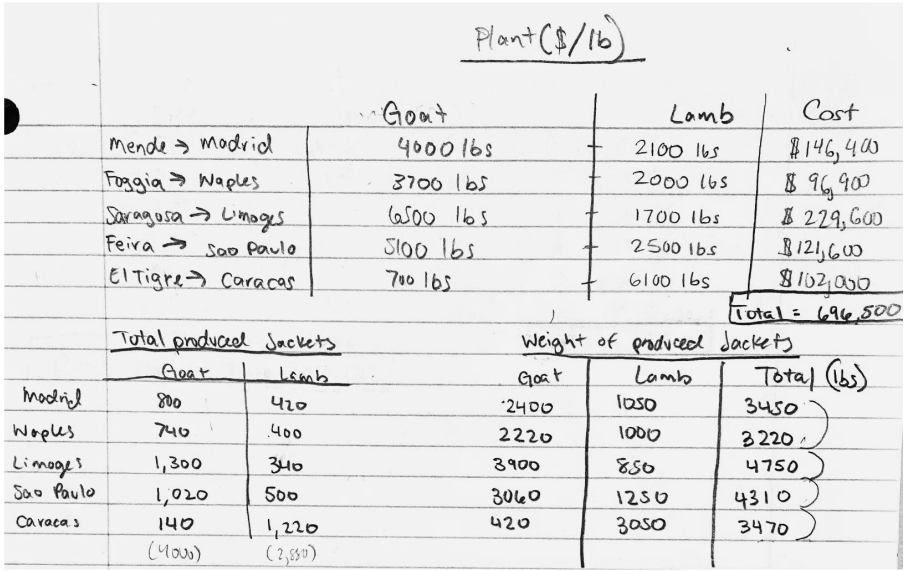
Tanning Cities	Using all 5 Tanning Facilities Supply (goat)	Using 3 Tanning Facilities Supply (lamb)
Mende	4000 lbs	-
Foggia	3700 lbs	-
Saragosa	6500 lbs	1850 lbs
Feira	5700 lbs	6850 lbs
El Tigre	700 lbs	5700 lbs

Tanning Cities	Total lbs (goat + lamb) per city
Mende	4,000 lbs
Foggia	3,700 lbs
Saragosa	8,350 lbs
Feira	11,950 lbs
El Tigre	6,400 lbs

Manufacturing Cities	Plants (Capacity)
Madrid	7,800 lbs
Naples	4,000 lbs
Limoges	8,200 lbs
São Paulo	7,600 lbs
Caracas	6,800 lbs

Approaches to solve problem (in mathematical equation)

Approach 2: Particular route using all factories/facilities/ports



Plant ($/lb)

	Goat		Lamb	Cost
Mende → Madrid	4000 lbs	+	2100 lbs	$146,400
Foggia → Naples	3700 lbs	+	2000 lbs	$96,900
Saragosa → Limoges	6500 lbs	+	1700 lbs	$229,600
Feira → Sao Paulo	5100 lbs	+	2500 lbs	$121,600
El Tigre → Caracas	700 lbs	+	6100 lbs	$162,000

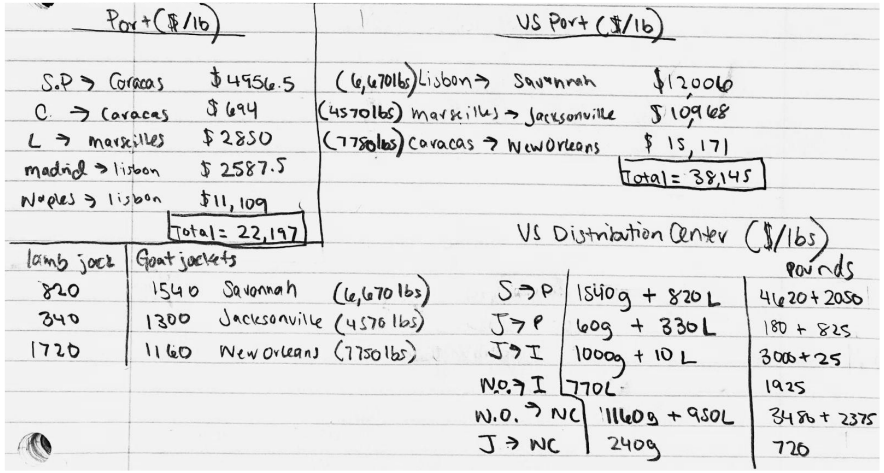
Total = 696,500

Total produced Jackets

	Goat	Lamb
Madrid	800	420
Naples	740	400
Limoges	1,300	340
Sao Paulo	1,020	500
Caracas	140	1,220
	(4000)	(2,880)

Weight of produced Jackets

	Goat	Lamb	Total (lbs)
Madrid	2400	1050	3450
Naples	2220	1000	3220
Limoges	3900	850	4750
Sao Paulo	3060	1250	4310
Caracas	420	3050	3470



Port ($/lb)

S.P → Caracas	$4956.5	
C. → Caracas	$694	
L → Marseilles	$2850	
Madrid → Lisbon	$2587.5	
Naples → Lisbon	$11,109	

Total = 22,197

US Port ($/lb)

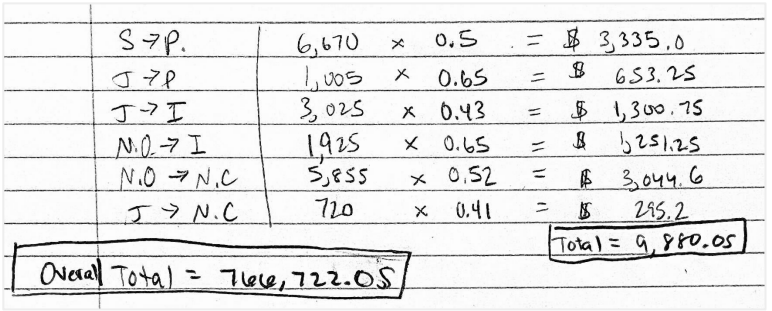
(6,670lbs) Lisbon →	Savannah	$12006
(4570lbs) Marseilles →	Jacksonville	$109,68
(7750lbs) Caracas →	New Orleans	$ 15,171

Total = 38,145

lamb jack	Goat jackets	
820	1540	Savannah (6,670 lbs)
340	1300	Jacksonville (4570 lbs)
1720	1160	New Orleans (7750 lbs)

US Distribution Center ($/lbs)

		pounds
S → P	1540g + 820L	4620 + 2050
J → P	60g + 330L	180 + 825
J → I	1000g + 10L	3000 + 25
N.O. → I	770L	1925
W.O. → NC	1160g + 950L	3480 + 2375
J → NC	240g	720



S → P.	6,670	×	0.5	= $ 3,335.0
J → P	1,005	×	0.65	= $ 653.25
J → I	3,025	×	0.43	= $ 1,300.75
N.O → I	1,925	×	0.65	= $ 1251.25
N.O → N.C	5,855	×	0.52	= $ 3,044.6
J → N.C	720	×	0.41	= $ 295.2

Total = 9,880.05

Overall Total = 7696,722.05

Pros and cons of approaches

Approach 1	
Pros	Cons
- Attempt to use less facilities, thus less resources - Easy method	- Was unable to obtain feasible solution, let alone optimal solution

Approach 2	
Pros	Cons
- Met demand for goat and lambskin jackets - Reached feasible solution	- Not able to obtain optimal solution - Multiple trips for last ports to distribution centers

The Outcomes

From Tanning Factories to Manufacturing Plants			
Goatskin Leather	$	314,690.00	
Lambskin Leather	$	221,798.00	
To Ports / from mfg plants		$9,274	
Goatskin Jackets		$6,898	
Lambskin Jackets			
From Ports in Europe and SA to US Ports			
Goatskin Jackets		$22,808	
Lambskin Jackets		$14,622	
To Distribution Centers / From Ports			
Goatskin Jackets		$5,874	
Lambskin Jackets		$3,537	
Total Cost	$	599,500.73	<-- Objective Function

The Outcomes

From Tanning Factories to Manufacturing Plants						
Goatskin Leather	**Madrid ($/lb)**	**Naples ($/lb)**	**Limoges ($/lb)**	**Sao Paulo ($/lb)**	**Caracas ($/lb)**	
Mende	0	0	3800	0	0	3800
Foggia	0	1858	0	0	0	1858
Saragosa	6768	0	0	0	0	6768
Feira	0	0	0	2905	0	2905
El Tigre	0	0	0	0	3600	3600
	6768	1858	3800	2905	3600	18931
Lambskin Leather						
Mende	0	0	4400	0	0	4400
Foggia	0	1342	0	0	0	1342
Saragosa	1032	0	0	0	0	1032
Feira	0	0	0	1898	0	1898
El Tigre	0	0	0	2260	3200	5460
	1032	1342	4400	4158	3200	
Total Capacity Used	**7800**	**3200**	**8200**	**7063**	**6800**	
Number of Jackets Produced						
Goatskin Jackets	1410	387	792	605	750	
Lambskin Jackets	206	268	880	832	640	

Our starting points are Mende, Foggia, Saragosa, Fiera, and El Tigre where the supply of goatskin and lambskin leather resides awaiting departure to the manufacturing plants of Madrid, Naples, Limoges, São Paulo, and Caracas where the jackets will be assembled.

49	**To Ports / From mfg Plants**								
50	**Goatskin Jackets Shipped**	Madrid	Naples	Limoges	Sao Paulo	Caracas	Total Jackets	Weight of Jackets (lb)	Total Capacity Used (lb)
51	Lisbon	1421	0	79	0	0	1500	4500	5653
52	Marseilles	0	387	713	0	0	1100	3300	5500
53	Caracas	0	0	0	650	750	1400	4200	8047
54	**Total Jackets**	1421	387	792	650	750			
55	**Weight of Jackets (lb)**	4263	1161	2376	1950	2250			
56									
57	**Lambskin Jackets Shipped**	Madrid	Naples	Limoges	Sao Paulo	Caracas			
58	Lisbon	193	268	0	0	0	461	1153	
59	Marseilles	0	0	880	0	0	880	2200	
60	Caracas	0	0	0	899	640	1539	3847	
61	**Total Jackets**	193	268	880	899	640			
62	**Weight of Jackets**	482.5	670	2200	2247.5	1600			

- We now move from the manufacturing plants to the South American ports of Lisbon, Marseilles and Caracas where we can see the total amount of jackets that are sent from each plant highlighted vertically under total jackets and horizontally highlighted to show the amount of jackets received by each European port.

- Moving to the next step in the process we now see the jackets move from the European and South American ports to the US ports.
- Here the horizontally highlighted boxes for goatskin and lambskin jackets shipped show the amount of jackets received by each american port
- We also see on the very bottom the total capacity in pounds of the product used

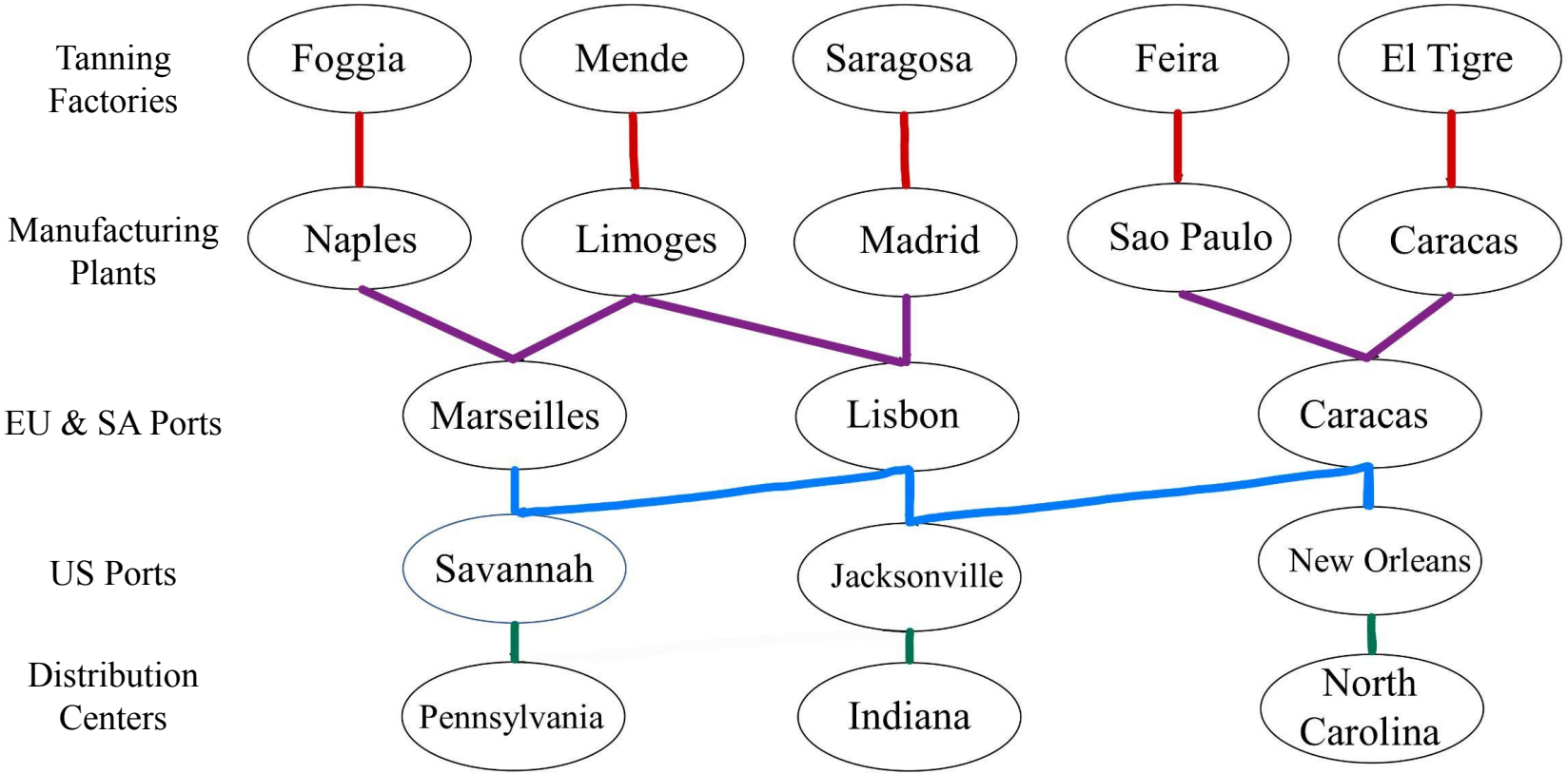
From Ports in Europe and SA to US Ports				
Goatskin Jackets Shipped	New Orleans	Jacksonville	Savannah	Total Jackets
Lisbon	0	933	500	1433
Marseilles	0	0	1100	1100
Caracas	1400	0	0	1400
Total Jackets	1400	933	1600	
Lambskin Jackets Shipped	New Orleans	Jacksonville	Savannah	
Lisbon	0	328	200	528
Marseilles	0	0	880	880
Caracas	1017	522	0	1539
Total Jackets	1017	850	1080	
Total Capacity Used (lb)	6742.5	4924	7500	

- The final step in this process is the move from the american ports to the distribution centers of Indiana, North Carolina, and Pennsylvania
- Here we see vertically the total jackets that were received by the distribution centers
- Horizontally we see the total jackets that were sent from the American ports
- And once again we can see the total capacity in pounds of the products transported

To Distribution Centers/ From Ports				
Goatskin Jackets Shipped	New Orleans	Jacksonville	Savannah	Total Jackets
Indiana	0	1000	0	1000
North Carolina	1400	0	0	1400
Pennsylvania	0	0	1600	1600
Total Jackets	1400	1000	1600	
Lambskin Jackets Shipped	New Orleans	Jacksonville	Savannah	
Indiana	0	780	0	780
North Carolina	950	0	0	950
Pennsylvania	0	70	1080	1150
Total Jackets	950	850	1080	
Total Capacity Used (lb)	6575	5125	7500	

Future Work

- Erken Apparel should continue shipping leather jackets through these routes to maintain minimal costs.
- For Goatskin Leather Jackets:



Future Work

- For Lambskin Jackets: