WFP Supply Chain Capacity in Ethiopia:

An Analysis of its Sufficiency, Constraints & Impact

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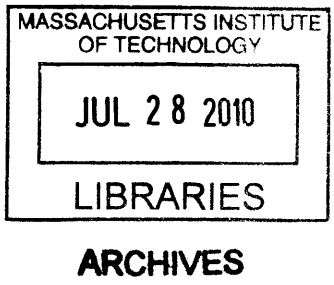

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ABSTRACT

The WFP's transport of food aid to Ethiopia's landlocked population is constrained by supply chain bottlenecks at the port, and limited availability of trucks for inland transport. How can the WFP supply chain be optimized to effectively operate within the given constraints? First, we assess Ethiopia's current food transport capacity – a critical factor for the WFP's ability to deliver humanitarian food aid. Specifically, we review the current and forecasted movement of goods, gather and analyze information on transport capacity versus demand, and address the impact of government policies and regulations on the road transport sector. As a result, our research helps the WFP in analyzing quantitative and qualitative factors used in selecting routes and mitigating port bottleneck issues. The results of our study may be used by the WFP and other humanitarian organizations which aid distressed populations.

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1 Introduction

The delivery of commercial and humanitarian goods is dependent upon a country's available capacity to transport these goods to the population. For a land-locked country like Ethiopia in need of humanitarian aid, sufficient transport capacity and an efficient transport system are especially critical. The World Food Programme (WFP) and other humanitarian agencies utilize Ethiopia's existing infrastructure of transport to deliver food aid through both secure and insecure regions, and as a result, are often faced with augmented transport capacity issues.

This thesis will explore the extent to which Ethiopia's shipping and ground transport capacity is sufficient to address the country's commercial and humanitarian needs. Next, it will define the relationship between this transport capacity and the timely delivery of food aid and the cost efficiency of operations for WFP.

We review the current and forecasted movement of goods, gather and analyze information on transport capacity versus demand, and assess the impact of government policies and regulations on the road transport sector. The Ethiopian Government and WFP will use the results of this study to enhance their understanding of transportation and to identify any potential gaps in the logistics process impacting the capacity for transport of commercial and humanitarian freight in Ethiopia.

In this introductory section, we set the groundwork for understanding the extent of the WFP's involvement in Ethiopia food aid efforts, describe the WFP's organizational structure and provide a brief background on Ethiopia's history and geographic issues. The information in this introductory section provides the basis for

understanding the Methods and Analysis sections, which describe our study of trucking transport capacity, route selection and port congestion.

1.1 The World Food Programme in Ethiopia

As the world's largest humanitarian agency fighting hunger worldwide, the United Nations' World Food Programme (WFP) distributes food aid to over 100 million people and moves on average 3.5 million tonnes of food per year around the world. In Ethiopia, the WFP's work is complicated by geographic limitations, political conflicts, natural disasters, and poor infrastructure. Ranked 171 out of 182 countries on the Human Development Index, Ethiopia is one of the poorest countries in the world. According to their website, the WFP assisted nearly ten million people within the total estimated population of 80 million in Ethiopia in 2009. Of this ten million served by the WFP, 6.2 million people received emergency food assistance due to the recurrent drought. (WFP, 2010) In 2003 – 2007, there was no emergency food aid delivered by the WFP but in 2008, 74,000mt (equivalent to 11% of all 2008 WFP food aid) was of the emergency nature.

Given Ethiopia's needs, the WFP is continuously searching for improved efficient methods of transporting and distributing food (i.e. optimizing existing port capacity for alleviating ship unloading bottlenecks and truck capacity for overland transport). Within the past two years, Ethiopia's increasing need for support is stretching the capacity of the supply chain. Per conversations with the WFP Ethiopia logistics department, the food requirements in 2010 are projected to be 870,000mt with total USD requirements of $646 million and total planned beneficiaries of 9.4 million people. This increased demand for

food aid in Ethiopia comes at a time when government and commercial cargo imports have greatly increased through the Djibouti port, further exacerbating the bottlenecks for food transportation into the country. As a result, WFP began utilizing two additional ports in Sudan (North-west) and Berbera (South-east) in May 2010 as alternate supply routes to reach the landlocked population. In 2009, the WFP transported 86% of its food aid through Djibouti, 14% through Berbera and 10% through Sudan. This decision has alleviated the bottlenecks at Djibouti, and the WFP continues to examine ways to mitigate port congestion, as well as transport and storage capacity issues in Ethiopia.

1.2 WFP Organization

The WFP is organized such that WFP Logistics is headquartered in Rome, Italy. The department, headed by Martin Ohlsen, coordinates with the WFP Country Offices in Ethiopia, most notably the Addis Ababa office, to execute shipping procedures from other countries into the three ports in which Ethiopia receives food aid: Sudan, Berbera and Djibouti. The responsibilities are divided between WFP Ethiopia and Rome in that while WFP Rome Logistics performs the tendering process for vessel contract fixing functions and other macro-duties, the WFP Ethiopia Logistics office works with Rome to determine more detail-specific considerations such as shipping terms. WFP-wide functions such as shipping documents (the Bill of Lading, Sailing Advice, and Inspection Certificate) are performed by Rome, while decisions that affect on-the-ground considerations such as cargo allocation to EDPs are managed by WFP Ethiopia.

1.3 Ethiopia Country History & Background

With the exception of a brief Italian occupation from 1936-1941, the ancient Ethiopian monarchy maintained its independence from colonial rule. Emperor Haile Selassie ruled from 1930 until 1974, when a group of military officers, the Derg, ruled the country after seizing power. The Derg established a socialist state, while Ethiopia suffered from pervasive drought, refugee issues, violence, and riots. In 1991, the regime was overthrown by a coalition of rebel forces, the Ethiopian People's Revolutionary Democratic Front (EPRDF). Ethiopia's border war with its geographic neighbor, Eritrea in the 1990s concluded in a peace treaty established late 2000. In November 2007, the Eritrea-Ethiopia Border Commission remotely demarcated the border by geographical coordinates, but actual country borders remain in dispute. (CIA, 2010)

Geographically, Ethiopia is located in East Africa, west of Somalia and east of Sudan. With an area comparable to slightly less than twice the size of Texas, Ethiopia is landlocked between Djibouti, Kenya, Somalia, Sudan and Eritrea. Its terrain is varied with high plateaus with a central mountain range divided by the Great Rift Valley. Ethiopia's climate ranges from tropical monsoons to frequent droughts. In May 1993, Ethiopia lost access to its entire Red Sea coastline when Eritrea became an independent state.

Within the country, railways are extremely limited (681 kilometers of track) and assumed inoperable. (CIA, 2010). Because of its landlocked geographical location, limited railway capacity and costly air transport, Ethiopia is largely dependent upon its 36,469 kilometers of roadways, of which 6,980 kilometers are paved and 29,489

kilometers remain unpaved. As seen in Figure 1.1 below, the WFP uses these roadways to transport food aid from the ports located in Djibouti, Berbera and Sudan to the Extended Delivery Point (EDP) and the Final Delivery Point (FDP) destinations.

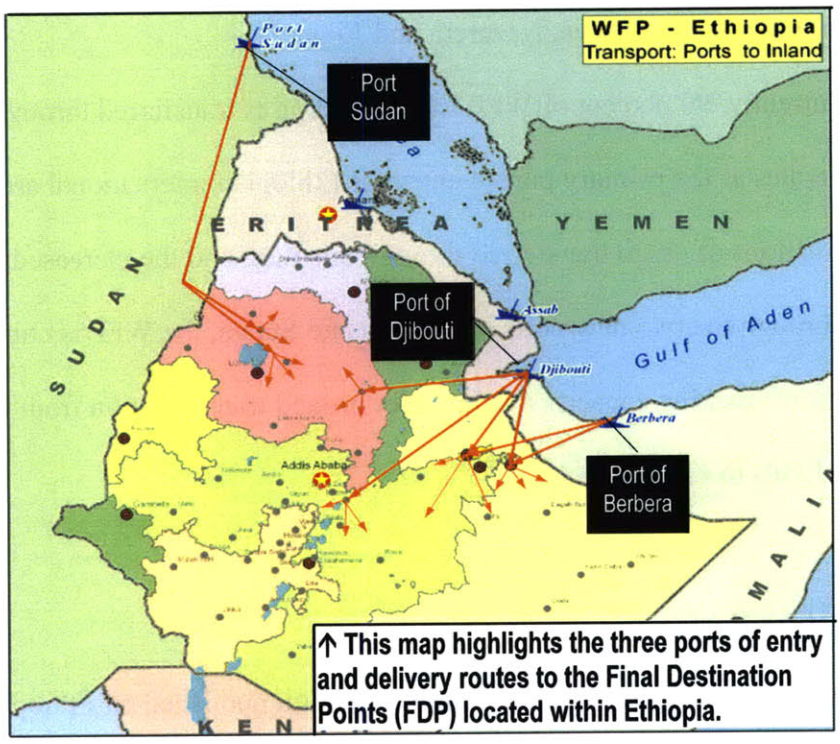

FIGURE 1.1: Three Utilized Corridors and EDPs

Grain, fertilizer, cement, and general cargo are transported through these three ports for both the government and commercial sectors within Ethiopia. Increases in cargo-flow necessitate services such as discharging facilities, transport capacity and storage facilities. Djibouti is the main corridor for humanitarian cargo to Ethiopia. In order to further reduce the long waiting time at the port, in July 2009, the WFP negotiated for extra berthing space and berthing priority for food aid vessels over EGTE grain vessels. The WFP and the Ethiopian Road Transport Authority collaborate to ensure enough trucks are available for uplifting food aid cargo in Port Djibouti. Food aid

arriving in the Sudan Port is transported by Sudanese trucking companies to the main hub in North-west Ethiopia (Woreta). Meanwhile, there is a 50/50 split between Ethiopian and Somaliland transport companies for transporting food aid arriving in Berbera to the Ethiopian EDPs in Dire Dawa, Nazareth and Jijiga.

Currently, 90 percent of WFP Ethiopia cargo is transferred through Djibouti, which operates as the primary port of entry for Ethiopian international arrivals. Given the high fluctuations of cargo transferred through this port, and the increased overall volume handled through the two new ports in Berbera and Sudan, the WFP is concerned with the sufficiency of trucking capacity available for in-land transportation from Port to EDPs and from EDPs to FDPs.

1.4 Literature Review

There is unfortunately very little written information published on Ethiopia, or the World Food Programme's food aid involvement in the region. As Benita Beamon notes

> "The majority of existing supply chain research focuses on managing and/or optimizing the commercial supply of goods and services. The humanitarian relief supply process is an important domain for supply chain management that has received little attention." (Beamon, 2004)

However, the WFP has been looking to change this by commissioning projects like this on-going thesis work at MIT, and other universities. As such, our approach has been to research general information on Ethiopia and the WFP separately. After developing an understanding of the core issues facing the WFP's work in Ethiopia, we gathered information regarding Ethiopia's infrastructure and both the current and planned humanitarian projects in the region. We also reviewed articles pertaining to transportation transactions and the infrastructures problems of developing countries. We used this

information to gain an understanding of the current environment that WFP operates in, draw comparables from other capacity constrained situations and analyze the divergent factors between past practices and future needs. Finally, we researched online periodicals (from sources ranging from the United States Central Intelligence Agency website to *The New York Times*) in order to obtain the facts upon which our Recommendations for the WFP in Ethiopia are based.

In these efforts, our thesis research fits within the context of humanitarian logistics work currently underway. Our work on the transportation process flow, supply chain communication in less-developed markets, point-to-point route logistics and total cost analysis relates to quantitative logistics work on World Bank data that examined logistics performance metrics in terms of time, cost and variability in time. (Hausman, Lee & Subramanian, 2005). Additionally, we focus on the challenges faced by the WFP due to its unique humanitarian characteristics and highly variable demand pattern (Beamon, 2004). Countries like Ethiopia can utilize our research in conjunction with quantitative logistics metrics to implement logistics improvements and measure their progress.

2 WFP's Current Ethiopia Food Transport Process

Given the geographic and political situation in Ethiopia, the WFP's involvement in food aid, and the WFP's organizational structure, an understanding how the WFP currently supplies food to Ethiopia provides the starting point of our analysis.

At a high level, humanitarian food aid for Ethiopia is either purchased by or donated to the WFP. The central WFP logistics headquarters in Rome manages the Estimated and Actual Times of Arrival for food shipments at each of the three ports in Ethiopia – Djibouti, Sudan or Berbera. Then, the WFP determines whether or not trucks are present at the dock before the food is loaded off the trucks either manually or through automatic bagging machines. Thus, WFP Rome manages all food transport up until the port delivery, and the WFP Ethiopia handles all in-land food transport.

This section describes the WFP's Ethiopia food transport process in relation to the corridors currently utilized for food transport, the road conditions for inland transport of food, and the nature of food aid delivered. Next, we describe the inland shipping methods, and take a closer look at trucking including the considerations involved in truck contracting. Finally, a breakdown of the current situation at each of the ports – Djibouti, Berbera, Sudan and Mombasa – includes details on the port operations and throughput capacity relevant to our analysis.

2.1 Corridors

The WFP has the ability to transport food aid for delivery to Ethiopia through four ports: Port of Sudan located in Sudan, Djibouti located in the Republic of Djibouti, Berbera located in Somalia, and Mombasa located in Kenya. Since its border war with Eritrea in

the 1990s, Ethiopia has remained landlocked and dependent upon these foreign ports located in other countries surrounding its borders. After receipt at foreign ports, the food aid then is transported inland via a set of corridors highlighted in Figures 2.1 below.

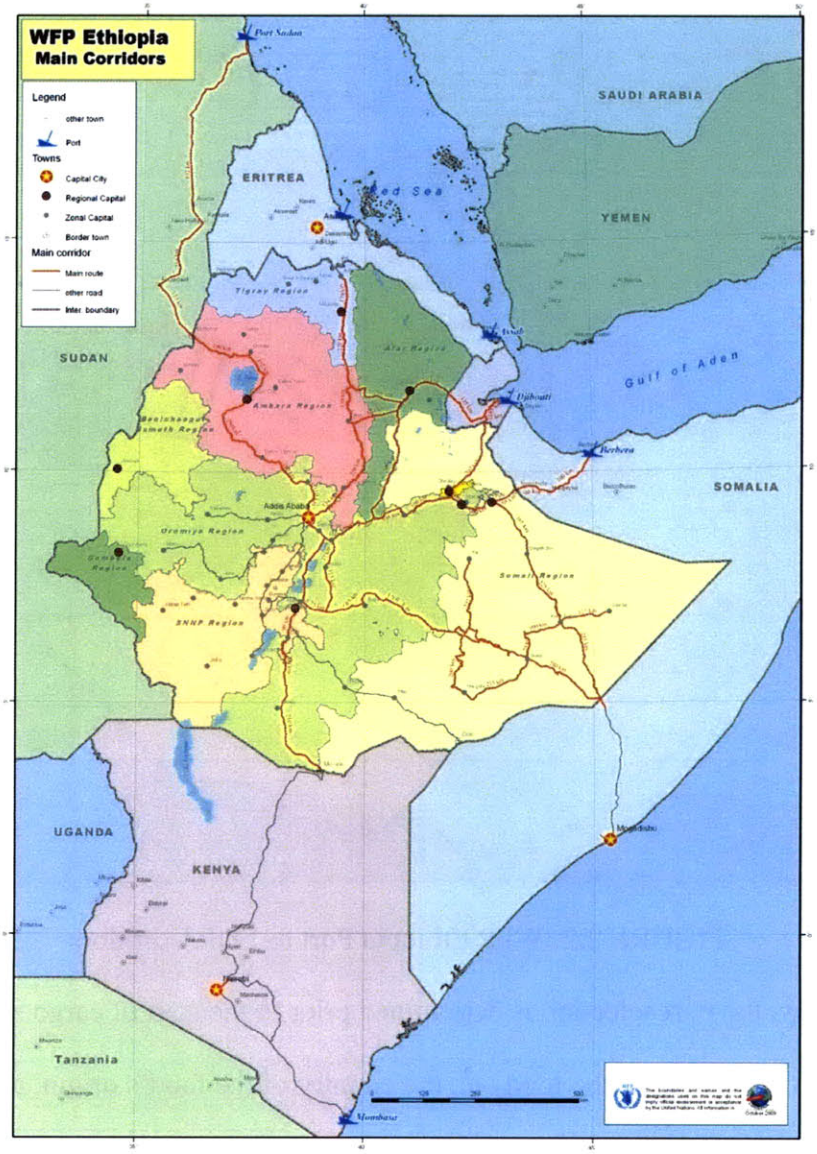

FIGURE 2.1: WFP Ethiopia Main Corridors

While the WFP can ship food aid through these four ports, Mombasa is not being utilized. The following Figure 3.2 highlights the most common corridors from the Port of Sudan, Djibouti and Berbera.

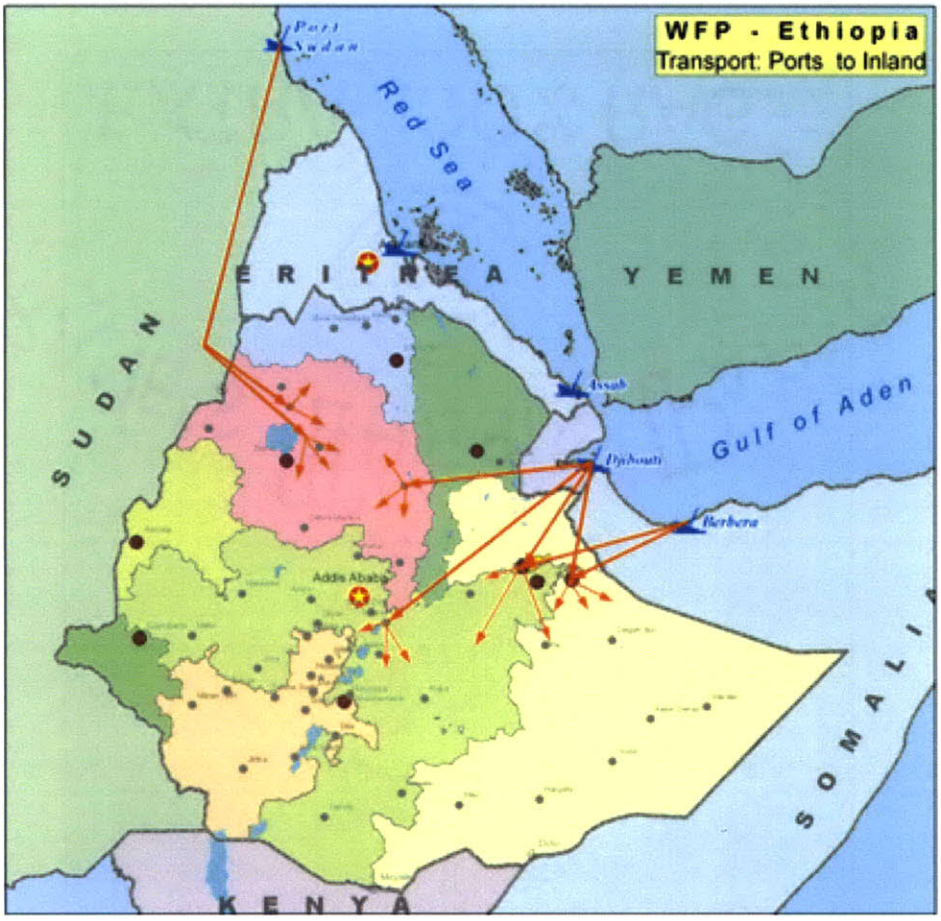

FIGURE 2.2: WFP Ethiopia Port to EDP Corridors

Usually, the port selection is determined prior to the start of cargo shipment. Depending on the source of the food aid, the country of the food's origin, and the shipping method, the WFP may be able to select and modify the port that the cargo will arrive at.

From the port, cargo is transported inland on trucks to EDPs. EDPs act as transshipment points and are located in strategic regions where warehouses are available to store food and in populous geographic locations that are close to government or

humanitarian residences. Food can then be moved to EDPs, which allow easy access to the FDPs.

At the FDPs, food is distributed to the vulnerable local populations and informally stored. FDPs receive various amounts of food aid based upon the need of local programs. In the Somali region of Ethiopia for example, roughly 20mt of food aid is distributed each month at each FDP. In most cases, the government handles the transportation and distribution of the food aid from the EDP to the FDP. For the purposes of our study, we have focused mainly on the supply chain up until the EDP.

2.2 Road Conditions

Road conditions play an important role in selecting corridor routes. Road conditions, in addition to the distances between ports and EDPs are a significant in determining the transportation costs and lead times. For instance, unpaved roads increase the cost of delivery. This increased cost is due the direct cost of the trucks necessitating longer lead times to deliver cargo as well as the indirect costs due to great wear and damage to vehicles (Chander & Shear, 2009).

The corridor from the Djibouti port to Ethiopia is paved. Additionally, the main roads in Ethiopia that connect major cities and towns are paved. However, an alternative route to Dire Dawa, a major hub in Ethiopia, is gravel (WFP Ethiopia, 2010).

The road conditions for the Berbera corridor are a mix of gravel and tarmac. The Ethiopian government has pledged to improve roughly 150 km of roads in the Somalia region of Ethiopia. Additionally, 565km of the corridor to Jijiga are currently under construction for improvement. The Ethiopian Government is planning to turn Jijiga into

an international hub. The WFP has been offered a plot near Jijiga to setup a freight terminal and warehouse. The improved road conditions are expected to reduce the transportation rates (WFP Ethiopia, 2010).

The conditions from Port of Sudan to the border area of Ethiopia are asphalt. However, the road to the major cities and EDPs in Ethiopia are gravel and span a difficult terrain.

The conditions from Mombasa into Ethiopia EDPs are the worst of any of the corridors; one of the primary reasons this route is rarely used (WFP Ethiopia, 2010).

Depending on the route, some trucks drive in convoys and are accompanied by a locally-based security detail. From our understanding, security details, when used, are typically for the EDP to the FDP portion of the supply chain. To speed up the time it takes to pass through customs, trucks coming from Berbera travel in a convoy.

2.3 Food Aid: Types, Conditions and Seasonality

Donations come in two forms, cash donations and in-kind donations. In the case of cash donations, the WFP chooses where to source the commodities (internationally, locally, regionally), and arranges for the transportation of the goods. In-kind donations are when donors provide food aid. From 2001 to 2005, the U.S. accounted for the vast majority of in-kind donations (in 2009, the U.S. accounted for 43% of all donations). In-kind donations are usually farming surpluses, which are donated to the WFP at the end of growing seasons (Lopez, 2003).

If the cargo is not shipped on a chartered vessel and is sent via multiple break bulk consignments or containerized on a liner, the WFP has less control over determining

the port destination or altering the port selection while the vessel is in transit. Bulk shipments are preferred, followed next by break bulk shipments as they are less costly.

The shipment of food aid is seasonal due to a number of factors. The two most significant factors causing this are the seasonal conditions in Ethiopia and the timing of in-kind donations from the US, which coincide with harvests. The Tables 2.1-2.2 below highlights the seasonality of food aid in metric tons that have been shipped to Ethiopia since 2000. The data comes from the WFP shipping file the team provided us. Historically, most food aid is imported between October and January. However, it should be noted that there is often significant variability in shipping volume each year due to factors such as emergency need. In addition to monthly shipping magnitude reflected in these percentages, monthly volume quantities as reflected in the "Amount" column indicate seasonality trends relevant for the WFP.

TABLE 2.1: Seasonality of Shipping Volume – All Food aid

2000-2008			2006			2007			2008		
Months	Amount	%	Months	Amount	%	Months	Amount	%	Months	Amount	%
Jan	614,045	8%	Jan	116,014	30%	Jan	107,346	21%	Jan	41,059	3%
Feb	285,092	4%	Feb	21,234	5%	Feb	12,928	3%	Feb	10,366	1%
Mar	420,397	6%	Mar	1,050	0%	Mar	57,740	11%	Mar	47,003	3%
Apr	586,450	8%	Apr	35,591	9%	Apr	55,288	11%	Apr	42,652	3%
May	574,121	8%	May	3,386	1%	May	20,776	4%	May	52,731	4%
Jun	772,990	10%	Jun	13,587	4%	Jun	100,968	20%	Jun	65,475	4%
Jul	602,974	8%	Jul	15,833	4%	Jul	14,296	3%	Jul	59,348	4%
Aug	694,562	9%	Aug	13,045	3%	Aug	5,010	1%	Aug	169,743	11%
Sep	662,285	9%	Sep	25,935	7%	Sep	6,519	1%	Sep	233,450	16%
Oct	1,009,581	14%	Oct	108,478	28%	Oct	38,550	8%	Oct	301,452	20%
Nov	729,130	10%	Nov	28,095	7%	Nov	76,487	15%	Nov	217,514	14%
Dec	496,856	7%	Dec	4,939	1%	Dec	8,309	2%	Dec	260,347	17%
Total	7,448,483	100%	Total	387,187	100%	Total	504,217	100%	Total	1,501,140	100%

TABLE 2.2: Seasonality of Shipping Volume – WFP Food aid

2000-2008		
Months	Amount	%
Jan	207,318	10%
Feb	63,563	3%
Mar	42,959	2%
Apr	133,498	7%
May	128,029	6%
Jun	201,998	10%
Jul	171,511	9%
Aug	179,298	9%
Sep	179,214	9%
Oct	381,801	19%
Nov	150,603	8%
Dec	154,967	8%
Total	1,994,759	100%

2006			2007			2008		
Months	Amount	%	Months	Amount	%	Months	Amount	%
Jan	96,010	33%	Jan	71,646	27%	Jan	21,979	3%
Feb	21,104	7%	Feb	12,928	5%	Feb	4,106	1%
Mar	1,050	0%	Mar	4,580	2%	Mar	11,853	2%
Apr	33,901	12%	Apr	50,288	19%	Apr	37,382	6%
May	3,386	1%	May	18,856	7%	May	9,371	1%
Jun	5,418	2%	Jun	21,448	8%	Jun	59,715	9%
Jul	9,213	3%	Jul	2,326	1%	Jul	50,348	8%
Aug	3,156	1%	Aug	3,890	1%	Aug	63,233	10%
Sep	22,885	8%	Sep	5,899	2%	Sep	110,955	17%
Oct	79,678	28%	Oct	34,740	13%	Oct	142,832	22%
Nov	6,100	2%	Nov	30,617	12%	Nov	72,679	11%
Dec	4,939	2%	Dec	6,659	3%	Dec	71,941	11%
Total	286,840	100%	Total	263,877	100%	Total	656,394	100%

Additionally, it should also be noted that the arrival of food aid often coincides with the arrival of fertilizer in Ethiopia. These correlated arrivals further constrain the port's ability to unload seasonal food aid due to differences in handling requirements, port congestion and limiting factors such as port berths available and trucking capacity.

2.4 Inland Shipping Options

Similar to other emerging nations, the infrastructure in Ethiopia is underdeveloped. As such, multi-modal transportation is not available for food aid transport into Ethiopia. A rail system, which would be the best alternative to trucking, is not currently a viable option. While some rail tracks exist from Djibouti port to Nazareth, Dire Dawa and Addis Ababa, the system is not functional. A rehabilitation project is in planned and investments have been made to renew the system but a good deal of uncertainty remains with regard to when improvements will be implemented. Additionally, the WFP has encountered issues of theft when utilizing trains in the past. Specifically, due to their slow speed they are easy targets for looting and stationary rail carts have been pilfered.

Another possible transportation alternative in Ethiopia is air transportation. However, Ethiopia has utilized air transportation in the past only in situations of extreme emergencies due to its high cost. Therefore, air transport is used on a case-by-case basis as a last resort under time constraints. For example, if conditions make it impossible to transport food via truck the WFP will airlift food to a site (WFP, 2000).

2.5 Trucking: Industry Background & Contracting Practices

The Ethiopian Government reports that there are 7000 trucks available for transporting food aid. Due to the need to shunt (temporally warehouse) food aid, and increasing wait times witnessed at the ports, the WFP has decided to investigate the transportation capacity. As such, the WFP is working with the Ministry of Transport, the DRMFSS (Disaster Risk Management and Food Security Sector), the World Bank and GTZ (Gesellschaft für Technische Zusammenarbeit) to perform a Freight Transportation Study.

On average, the WFP requires 120 40mt trucks worth of capacity each day to support the discharge of roughly 4000mt of food aid unloaded at the Djibouti port. The 40mt trucks are the standard truck size in Ethiopia and Somalia. Sudan, however, has a limitation of 8-10 tons per axel and utilizes 60mt trucks. This requires cargo imported from the Port of Sudan to be transshipped at the border to meet Ethiopia's payload weight limit of 40 metric tons.

Truck carriers operate in a quasi-private capacity. While the government has privatized its formerly public fleet, the Ethiopian government and Ministry of

Transportation still possess significant influence over the truck industry. If unrestricted, the carriers will compete and bid on business as in a free market.

The WFP contracts with transport truck carriers to move its cargo from ports to EDPs. The contracted transportation carriers are sometimes called "dedicated." It is important to note that this differs from the typical U.S. version of the definition of a dedicated fleet. While these carriers are contracted to transport WFP cargo, they are also allowed to move other buyer's goods when not employed by the WFP to pick-up and transport food aid.

As carriers are not dedicated fulltime, trucks may not always be immediately available to transport the WFP's food aid when requested. When the WFP offered a 25% premium on market rates for a truly dedicated fleet, the WFP received preferential treatment from carriers, allowing for more immediate transport of its cargo. Recently, however, the Ethiopian Government enforced more parity in transporting goods from the Djibouti port, precluding the WFP from paying this premium.

The RFP bid process and terms vary between ports. For the Port of Sudan, the WFP allows carriers that meet its standards to bid on the contract, contrary to the Ethiopia transporters a single Sudanese transporter has the capacity to uplift the cargo. The contract is therefore often awarded to a single Sudanese transport company. While cost is a significant factor in the selection process, the company offering the "best contract terms" is more likely to win the WFP transportation work.

The Request for Proposal (RFP) process for Ethiopian transporters is different from the RFP process for Sudanese contractors, since no single transporter in Ethiopia possesses the capacity sufficient to meet the WFP's needs. For the Djibouti port, the

WFP sends a tender, obtains quotes from transporters and then determines a fair rate. The WFP then selects transporters for employment if they agree to accept the set rates.

The WFP is currently investigating new contracting terms and methods in order to optimize capacity. The WFP would be willing to pay 50%-60% of transportation costs upfront against some kind of performance bond if a transportation carrier were willing to sign a contract agreeing to transport WFP cargo at an agreed upon capacity and service level. If the contractor failed to provide the service or if capacity was unavailable, they would have to pay the WFP a penalty fee. Not surprisingly, transportation carriers have been unhappy with penalties in contracts. The Ethiopian government, although not opposed to the penalty proposal, has also yet to adopt a penalty payment system. In the past, the WFP has agreed to pay a penalty to carriers if they are delayed at the port loading zone for more than 72 hours. For instance, in 2004, the WFP had agreed to pay USD $100 per truck per day after this 72 hour window (WFP, 2004).

2.6 Shipping: Port Conditions

The port throughput capacity specific to WFP shipments are dictated by the number of berths, berth offloading capacity, bagging capacity, and ability to shunt when necessary. The Djibouti port is the main point of entry for Ethiopian food aid, with roughly 90% of all WFP cargo being shipped through it. Until recently, it was the only port utilized for delivering food aid to Ethiopia. In the past year, Berbera port and Port of Sudan have been utilized for importing food aid. Below is a table of the 2009 Ethiopia bulk cereal imports by port (WFP Ethiopia, 2010).

TABLE 2.3: 2009 Bulk Cereal Imports into Ethiopia by Port

Cereal Consignee by Port - 2009 (metric tons)		
Djibouti	457,547	74%
Berbera	98,109	16%
Port of Sudan	64,730	10%
Total	620,386	100%

The 98,109mt of cereal shipped through Berbera represents approximately 70% of all the WFP food aid that arrived at Berbera port. The remaining 30% or 50,000mt of cargo that was imported through the port was used in Somalia (WFP Ethiopia, 2010).

2.6.1 Djibouti

In 2009, nearly 1.9 million metric tons of bulk food aid and fertilizer were transported through Djibouti's port. The 457,547mt of cereal the WFP delivered was transported on 14 bulk vessels. Table 2.4 below indicates the bulk food aid consigners for 2009 (WFP Ethiopia, 2010).

TABLE 2.4: Djibouti Port Cereal Food Aid Consigners in 2009

Djibouti Port Cereal Arrivals by Consignee - 2009 (metric tons)		
Government	486,299	41%
NGO / USAID	201,710	17%
Unreported	42,000	4%
WFP	457,547	39%
Total	1,187,556	100%

Note: The government imported 708,078mt of fertilizer in 2009

The WFP is a significant contributor to Djibouti port traffic, importing nearly 40% of all bulk food aid imported through the Djibouti port. The port handles bulk and break bulk

cargo. Containerized cargo is unloaded at Doraleh Container Terminal, located a few miles away from Djibouti.

The percentage of bulk, break bulk and containerized food aid imported through the Djibouti port are as follows:

TABLE 2.5: Bulk, Break Bulk and Containerized Food aid Volumes through Djibouti – WFP Only

WFP 2003-2008 (metric tons)			WFP 2008 (metric tons)		
Bulk	1,445,923	80.3%	Bulk	559,651	85.3%
Break Bulk	336,680	18.7%	Break Bulk	90,750	13.8%
Containerized	17,280	1.0%	Containerized	5,720	0.9%
Total	1,799,883	100%	Total	656,121	100%

TABLE 2.6: Bulk, Break Bulk and Containerized Food aid Volumes through Djibouti – Total

Total Food-aid 2003-2008 (metric tons)			Total Food-aid 2008 (metric tons)		
Bulk	4,619,892	83.8%	Bulk	1,359,487	90.6%
Break Bulk	772,918	14.0%	Break Bulk	135,660	9.0%
Containerized	121,504	2.2%	Containerized	5,720	0.4%
Total	5,514,314	100%	Total	1,500,867	100%

In the Djibouti port, there are two berths that are dedicated to bulk food aid and fertilizer handling. These berths are managed by SDTV (Societe Djiboutienne De Gestion Du Terminal Varaquer).

> "SDTV, owned by Sheik Mohammed Al-Amoudi, is a stevedoring company dealing with port handling, vessel discharge and bagging of bulk grain activities at Djibouti port.... Accordingly, the contract, which will become effective in January 2009, will give SDTV the responsibility of handling all bulk food commodities from ship to trucks hired by WFP and which will transport to locations in Ethiopia" (Daily Monitor, 2008).

Three berths are used for grain bulk vessels and can unload 7000mt/day with several vessels (WFP Ethiopia, 2010). The food is then either immediately bagged using automated bagging machines or placed on a conveyor belt to an onsite silo to be bagged later. The decision to silo the food aid or leave it on the vessel depends on the availability of trucks being present to transport the food aid to the EDPs. If the food aid is stored on the vessel while it is at the berth, the WFP can be charged between $20,000-$50,000 each day for blocking other vessels at the port. Given this cost, food aid is rarely stored on ships.

Before transporting the food aid to the EDPs, the bulk or break bulk cargo must first be bagged before it can be loaded onto trucks. There are two sets of bagging machines at the Djibouti port. Each set can unload up to 3000mt/day. However, one set of the bagging machines is predominately used for bagging fertilizer. During times this berth is not unloading fertilizer, the bagging machine can be switched over to bag food aid after a lengthy cleaning process (WFP Ethiopia, 2010). In addition, the bagging machines frequently break down, increasing unavailability and further constraining the process flow.

In the event that transportation is not available, or if offloaded food needs to be temporarily stored until bagging capacity is available, the Djibouti port offers three options for shunting food aid. Food aid can be siloed at the port via conveyer, which can hold 30,000mt. There is an additional 15,000mt of warehouse space available in the harbor storage. Additionally, the WFP can utilize the Djibouti Dry Port or Free Zone. Bagged food can be loaded on trucks and brought to these locations, which are both located outside of the port (WFP Ethiopia, 2010). The WFP had considered building a

warehouse at the port and had submitted a proposal to the government. Unfortunately for the WFP, there is not enough available space at the port at this time; forcing the WFP to investigate building a warehouse outside of the port. Transport carriers are not in favor of this as they prefer direct delivery from the vessel.

2.6.2 Berbera

The Berbera port in Somalia is designed to handle all types of cargo (bulk, break bulk and containerized) cargo. The bagging machines at the port have a machine capacity of 2,800mt per 24hrs (three 8hr shifts). However, due to frequent breakdowns of the old bagging equipment, the unloading capacity is less than 2,000mt per 24hrs. The port provides roughly 10,000-15,000mt of temporary storage to the WFP for 45 days without cost (WFP Ethiopia, 2010). The WFP has also been increasing its warehousing capacity by utilizing mobile storage units; providing for an additional 8,000mt of storage (Thomson Reuters Foundation, 2009).

Somalia's Berbera port faces a number of unique concerns relative to other ports. First, the WFP has entered into a verbal agreement with Somaliland and Ethiopian Authorities to utilize 50% Somali and 50% Ethiopian transportation carriers. Second, as noted before, roughly 70% of the WFP food aid that arrived in Berbera was intended for delivery to Ethiopia (WFP Ethiopia, 2010). This has raised concerns between WFP Ethiopia and WFP Somalia with regard to coordination of tasks and utilization of resources. Finally, Somalia is challenged with internal political issues such as lawlessness, pirating and terrorism. (Gettleman, 2010) Per conversations with Bernard

Chomilier (Head of WFP Logistics Development Unit), the WFP was also recently warned to stop operating in the country.

2.6.3 Port of Sudan

The Port of Sudan has the ability to handle both bulk and break bulk cargo.

> Port Sudan has 17 berths and discharge rate range from 2,000mt per day with discharge via bagging machines to 6,000mt per day for discharge to silos. 300 containers can be discharged per crane per day for break bulk cargo, 300mt can be attained per hatch per day.
>
> There is plenty of storage space available at the Port of Sudan, (between 150,000 - 200,000mt) depending on the type of cargo and WFP requirements. There are 2 options for WFP in Port Sudan; cargo can be moved to the silos and direct delivery using 60mt trucks. There is 15 days free storage after cargo is bagged (WFP Ethiopia, 2010).

2.6.4 Mombasa

The Mombasa port has been one of the busiest ports the WFP operates. In 2008, the port operations handled more than one million metric tons of food and nonfood cargo. Storage capacity at the port has generally not been considered an issue. The port handles bulk, break bulk, and containerized cargo (WFP, 2010b). Mombasa, however, has challenging road conditions and is located at a farther distance from the EDPs in Ethiopia that the WFP currently serves. (Please refer to the map in Figure 2.1 – WFP Ethiopia Main Corridors)

2.6.5 Port Cost Comparison

The total port costs per metric ton, not including shunting, for bulk and break bulk cargo is as follows:

TABLE 2.7: Total Port Costs per Metric ton by Cargo Type

Type of Cargo	Djibouti Port	Berbera Port	Port Sudan	Mombasa
Bulk	$19.70	$19.92	$19.00	$16.79
Break Bulk	$12.10	N/A	$19.00	$7.30

As noted before, these are the two predominate forms of cargo and less than 1% of 2008 cargo was delivered via containers. Containerized cargo, where available, is significantly more expensive per metric ton than bulk or break bulk costs.

The port shunting costs per metric ton by location are as follows:

TABLE 2.8: Shunting Costs per Metric Ton by Port and Shunting Location

Shunting location	Djibouti Port	Berbera Port	Port Sudan	Mombasa
PortWarehouse	$9.00	$5.66	$4.20	$4.10
Dry Port	$10.00	N/A	N/A	N/A
Free Zone	$13.00	N/A	N/A	N/A
Town Warehouse	$14.00	N/A	N/A	$2.40
WFP Warehouse	N/A	$5.66	$8.05	N/A

3 Analysis & Recommendations

With an understanding of the WFP's involvement in Ethiopia as established in the Introduction, and the current factors (road conditions, ports, trucking and food aid types) involved in the WFP's transport of food aid to Ethiopia, our approach in this next step of our analysis was three-fold. In our analysis, we focused on three primary objectives: 1) to holistically document the current food transport workflow for the WFP, 2) to drill down to the root causes of existing processes and 3) to identify areas of improvement and suggest practical ways to implement these solutions. Along the way, in each of these areas we aimed to challenge the assumptions driving the WFP's current transportation practices and develop clear decision-making solutions for implementation.

Throughout the course of the research process, we experienced challenges that altered the original planned course and scope of our project. The data that we had hoped to receive to identify if there was a trucking transportation capacity constraint never materialized. We had initially planned to obtain truck transportation metrics data from external international research organizations such as GTZ, a German government organization focused on promoting international cooperation for sustainable development. Specifically, we sought to gather data on the number and physical condition of available trucks in Ethiopia, the carriers that supply WFP, the frequency specific trucks entered and left the port and truck delays. We also requested transactional data from the WFP regarding Djibouti port shunting and truck delay information. The WFP indicated that this data would not be available because transaction-type shunting was not used for all the cargo shunted to the port warehouses.

Adapting to this lack of data, we shifted the focus of our research. In lieu of documenting the truck capacity available for the WFP to unload its ships in a timely manner, we instead focused our attention on comparing the balance of trucking transportation available between the three utilized ports. Since the WFP frequently has to shunt food aid, we were able to find evidence that there is often a supply and demand imbalance for trucking transportation at the ports. Additionally, WFP team members were able to visually identify food aid inventory building up at the port and that there was a lack of trucking transportation available. Even though truck transport data was unavailable, we attempted to obtain secondary data, such as port information, that could support the assertion that there are constraints in the supply chain caused in part by a trucking transportation constraint.

This section first outlines the research approach used in our analysis. Then, we analyze the details of the supply chain process flow, and identify the root impact points at which the WFP can more efficiently execute its procedures. Building upon the shipping and ground transport process flow, we then analyze the corridor selection, the supply chain capacity and the port conditions affecting bottlenecks in the process. Integrated within our analysis, we provide recommendations for improving the WFP's current procedures.

3.1 Research Methods

The approach taken during our analysis was deliberate and systematic. We began by actively listening to the WFP's needs, collaborating with the WFP team to develop our project's scope, and reviewing prior research results developed at MIT for the WFP.

Concurrently, we reviewed literature to gather background research focused on humanitarian logistics, Ethiopia, the WFP and its working relation in Ethiopia.

After having established the scope of our project, and gained a general understanding of the situation in Ethiopia, we then preceded to interview WFP Ethiopia Logistic team members to drill down to the details of our project. Through weekly calls with the WFP Ethiopia Logistics team, we clarified our understanding of the WFP's systems, and collected key metrics for data analysis. In doing this, we developed a supply chain decision making flow chart used to identify the tradeoffs made at these important decision making points. We then collected, cleaned, screened and analyzed data to better understand the supply chains.

While our approach maintained consistency, we frequently lacked the data necessary to quantify everything with the specificity we would have preferred. Setting metrics, collecting and transmitting data are issues all organizations must face, and the WFP is aware of the lack of existing data. Compounding the complications around data collection, the WFP operates with many external stakeholders in a developing country without access to the cutting-edge technology resources available to large, private corporations.

In our calls with the WFP Ethiopia team, we attempted to challenge the assumptions and dig deeper into the root causes for the existing processes. It was important to holistically indentify not only the bottlenecks in the supply chain, but also to identify the fixed constraints that the WFP must operate within.

This approach, with the assistance of the WFP Ethiopia team, allowed us to identify a number of limitations and inefficiencies. We were then able to propose

recommendations that can help mitigate these issues and optimize the supply chain by proposing changes that reduce cost, yet increase visibility, throughput and flexibility.

3.2 Supply Chain Process Flow

The WFP Ethiopia supply chain process flow can be divided into two segments: shipping and ground transport. The shipping portion of the process flow includes the categorization of food aid types, allocation to vessels for overseas shipment and port selection process. The ground transport portion of the process flow is composed of the procedures and decisions from the point at which the food aid arrives at the port, to the truck capacity and carrier selections, the options for food loading and storage, and finally, to the points of delivery inland to Extended Delivery Points and Final Destination Points. Figure 3.1 below displays WFP's logistics process.

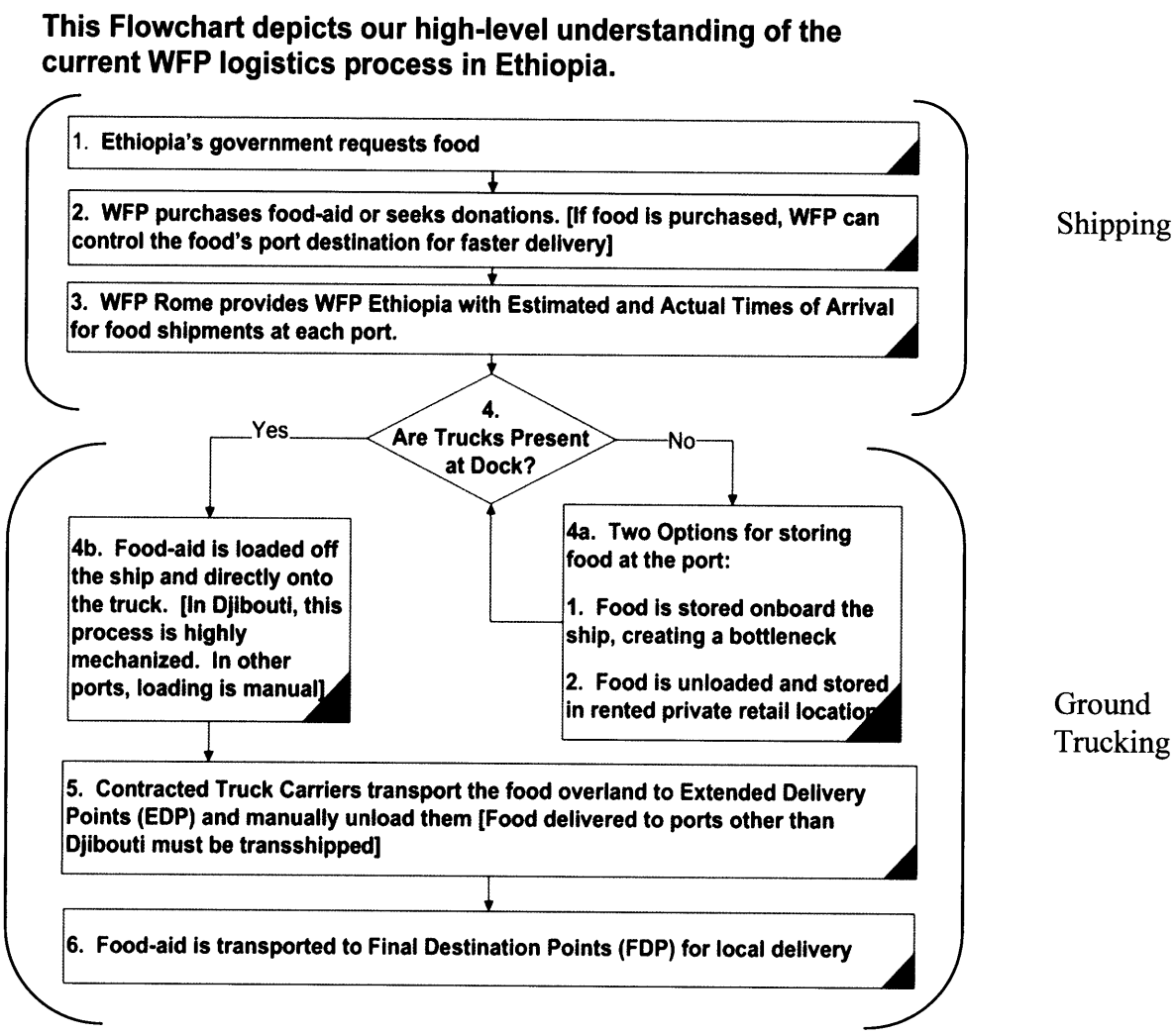

FIGURE 3.1: High-level WFP Ethiopia Logistics Process Flowchart

Through a collaborative effort with the WFP Logistics team in Ethiopia, we researched the details of this shipping and ground transport process flow from the point at which the WFP receives the cash or food donation, to the EDP within Ethiopia.

First, we identified the key process owners, responsible for carrying out the procedures in the WFP Ethiopia food distribution supply chain:

- WFP – World Food Programme
- CO – Country Office
- Port Clearing and Forwarding Agent appointed by WFP (stationed at each port)
- DRMFSS – Disaster Risk Management & Food Security Sector
- EFSRA – Emergency Food Security Reserve Adminstration

The following detailed flow figure and textual explanation of the WFP Ethiopia food transport supply chain was developed through a combination of weekly phone meetings with the WFP Ethiopia team, our own external research on the topic, and aggregated analysis from internal sources such as the WFP Corridor Report and other WFP publications.

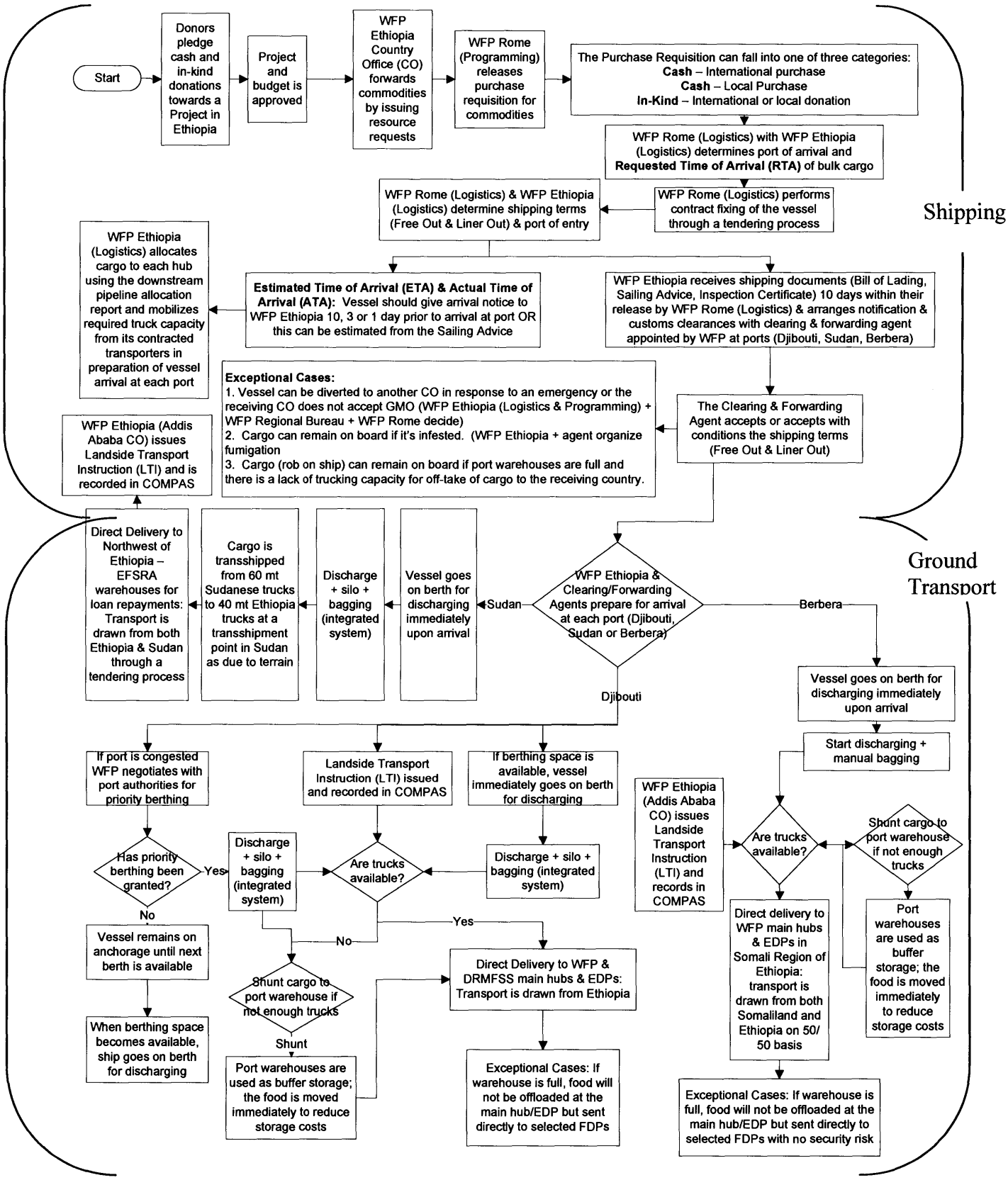

FIGURE 3.2: Detailed WFP Ethiopia Logistics Process Flowchart (Bulk Cargo)

3.2.1 The Overseas Shipping Process

The shipping process begins when donors commit to providing cash and in kind donations for Ethiopia. WFP Rome reviews the project and if approved, draws up a budget for the engagement. The Programming department of the WFP Ethiopia Country Office (CO) schedules and issues resource requests, and releases the purchase requisition for commodities. The donations are categorized into one of three buckets: cash for international purchases, cash for local purchases and in-kind for international or local donations. It is important to note that the WFP Rome handles donated food (in-kind donations) separately from purchased food (local & international) at the beginning of the process, but that these donations, once turned into bulk cargo are managed by the WFP Ethiopia CO in a similar, if not identical manner. There is currently no standard process in place for using cash donations to procure food aid. Procurement typically is sourced from the United States food surplus, the Black Sea countries or Asia. For in-kind shipments, there is even less control for deciding the date but the WFP can estimate the port of arrival that is most appropriate.

Next, the Logistics departments for both the WFP Rome and Ethiopia agencies determine port of arrival and Requested Time of Arrival (RTA) for the bulk cargo of purchased and donated food. In regards to the Estimated Time of Arrival (ETA) or the Actual Time of Arrival (ATA), the vessel should give arrival notice to WFP Ethiopia ten, three or one day prior to arrival at the port. The Country Office should receive the shipping documents within 10 days of their release. If the voyage is less than 10 days, then the documents will be sent via Fax (in 3 days). If the shipping documents have not arrived within 10 working days before the ETA, the country office in the discharge

country should immediately contact the office within one day. Alternatively, the arrival time can be estimated from the Sailing Advice document – a shipping document that provides the cargo specifications. At this point, the WFP Ethiopia Logistics department knows how much bulk cargo in each vessel is expected to arrive at each port because it allocates cargo to each hub using the Downstream Pipeline Allocation Report – a detailed report derived from the Bill of Lading containing information on the expected cargo and shipping allocations by project. Based on this information, WFP Ethiopia Logistics directs the sufficient capacity of contracted ground transport truck contractors at each port to prepare for the arrival and ground mobilization of the arriving cargo at each port. It is important to note however that WFP only has a Planned ETA but does not know the Actual ETA until the ship sets sail. The Actual Time of Arrival (ATA) is obtained about a week or two before the ship enters the port.

Meanwhile, WFP Rome Logistics uses a tendering process to fix the contract of the shipping vessel for oversea transport. Then, the Logistics departments of WFP Rome and Ethiopia CO coordinate to determine the port of entry for the shipment and terms of shipment (Free Out and Liner Out). Free Out shipping is where the cost of unloading the ship cargo is borne by the charterer (in this case, WFP). In the liner-out terms of freight rate, the freight is inclusive of carriage and cost of cargo handling at the loading and discharging ports. After ten days, the WFP Rome Logistics department sends to WFP Ethiopia the shipping documents for the vessel cargo shipment. These documents include the shipment's Bill of Lading, Sailing Advice and Inspection Certificate. Given these documents, WFP Ethiopia communicates with the Clearing / Forwarding Agent appointed by WFP at each port (Djibouti, Sudan and Berbera) to send notification of the

impending shipment and clear customs regulations for the shipment's passage through the port of entry. The Clearing/Forwarding Agent at the Port either "accepts" or "accepts with conditions" the shipping terms (Free Out and Liner Out). Most bulk cargo is shipped to one of three ports (Berbera, Sudan or Djibouti) but there are few exceptional cases that call for modified action:

1. In cases of emergency or if the receiving CO does not accept the shipment, then the vessel can be diverted to another CO destination. This decision is made at the discretion of the WFP Ethiopia Logistics and Programming departments, the WFP Regional Bureau and the WFP head office in Rome.
2. If infested, the cargo will remain on board the vessel until the WFP Ethiopia and Clearing/Forwarding Agent arrange for fumigation.
3. If port warehouses are full and trucking capacity is not sufficient for unloading the cargo at the port, the cargo can remain on board. It costs the WFP between $20,000 to $50,000 per day to delay a vessel at a port, depending on the vessel carrier and port fees. Each additional vessel expected to dock at the port, waiting on the delayed vessel to move from its parking space compounds the overall cost by adding an additional $20,000 to $50,000 per day. Further, the government and DP World Port Authority would prefer not to delay vessels at the port.

In spite of these exceptions, most shipments follow the standard process for receiving shipments at each of the three ports, Berbera, Sudan and Djibouti. The ship discharging, bagging and ground overland (from port to Extended Delivery Points; transport of goods from other countries to Ethiopia) and ground inland (from Extended Delivery Point to

Final Destination Points; transport of goods within Ethiopia) of the bulk cargo differs, however, depending on the port of entry.

3.2.2 Djibouti: Port & Ground Transport

Because the Djibouti Port has been the primary port of entry for Ethiopian international oversea arrivals, and the volume and unpredictability of cargo passing through the port is very high, berthing space may or may not be available for WFP shipments. Thus, there are two scenarios for bulk cargo handling of shipments into Djibouti, depending on whether or not berthing space is available at the port.

If berthing space is available, then the vessel arrives at the port and immediate goes alongside the berth. Similar to Port Sudan, Djibouti also utilizes an integrated system for the discharging, silo and bagging of bulk food aid. If trucks are available, WFP Ethiopia uses the Landside Transport Instruction (LTI) tool to formalize a request for transport services. The LTI serves as a means to allocate cargo to transporters; and as a release instruction to the store keepers. It also serves as a monitoring, performance evaluation and invoicing tool. The LTI is issued and recorded in COMPAS (the Commodity Management Processing and Analysis System), which is used to track food commodities from the point of origin through the supply chain to the final distribution points. COMPAS, a globally implemented system at the WFP, provides WFP Logistics with a point-in-time, updated snapshot of food inventory movement throughout the supply chain. Ethiopian truck contractors are employed to conduct this delivery. In the exceptional case where the EDP warehouse is full, WFP may send the food directly to selected Final Destination Points without offloading it at the EDP.

If, due to port congestion, berthing space is not available, then the WFP negotiates with port authorities for priority berthing options. If the Djibouti port authorities immediately grant permission, the berthing and discharge process starts immediately. Otherwise, as per Djibouti Port principle of "first come first serve," the vessel must wait at the Djibouti Port on anchorage in queue until the next berth is available. Once berthing space is available, the WFP employs its integrated discharging, silo and bagging system and follows the process for if trucks are available. If trucks are not available, cargo is shunted to the port warehouses, which are used as a buffer storage.

3.2.3 Berbera Port: Port & Ground Transport

At Berbera, the shipping vessel goes on berth for discharging immediately upon arrival. Bulk cargo is manually bagged at the port during the unloading process. If trucks are available, the shipment is directly delivered to the WFP EDPs located within the Somali Region of Ethiopia. The trucking transport of food aid in Berbera is allocated on a roughly 50/50 split between Somaliland and Ethiopian contractors. In exceptional cases at the country office and field level, such as if the warehouse is full, the cargo is not unloaded at the EDP but instead directly transported to FDPs pre-selected for their lower security risk. In the case that trucks are not available at Berbera, the WFP Ethiopia Logistics team directs the cargo to be shunted to the port warehouse. Port warehouses, utilized as a buffer storage, are costly due to inventory holding costs and the WFP will mobilize the cargo as soon as trucks become available. The vessel shipment and trucking transport delivery data is captured in COMPAS, the WFP Commodity Management Processing and Analysis System. For Berbera, the WFP Ethiopia (Addis Ababa Country

Office) uses the Landside Transport Instruction (LTI) report as an instruction document to communicate with the ports how much food aid to loaded and transported.

3.2.4 Sudan Port: Port & Ground Transport

In Sudan, the process is similar to Berbera in that the vessel cargo goes on berth for discharge immediately upon arrival, but the difference is that Sudan has an integrated bagging system in place for the discharging, silo and bagging of food. Cargo is then transshipped to a transshipment point in Gendarif, Sudan. Transshipment is defined as changing the mode of transportation between routes. In this case, because Sudanese trucks have a capacity of 60 metric tones, but the Gedarif to Ethiopia terrain requires trucks with only a 40 metric ton capacity, the cargo is offloaded from 60 metric ton to 40 metric ton trucks at the transshipment point. (WFP Ethiopia, 2010). The Northwest region of Ethiopia (cities like Wereta and Gonder) are usually the Final Desination Points of shipments through Port Sudan. The Sudan-Ethiopia route is drawn from both countries through a tendering process in order to leverage competitive rates. Similar to its process for Berbera, WFP Ethiopia (Addis Ababa country office) captures vessel shipment and trucking transport delivery data in COMPAS, and issues the Landside Landside Transport Instruction (LTI) report to communicate with the ports how much food aid to loaded and transported.. The Emergency Food Security Reserve Administration (EFSRA) warehouses the final shipments in exchange for loan repayments.

3.2.5 Process Flow: Root Cause Analysis

There are five primary areas within the shipping process flow where WFP can make a defined impact on reducing the cost and timing of bulk cargo transportation: The determination of port for arrival and Requested Time of Arrival (RTA) for bulk cargo, Communication of Estimated Time of Arrival (ETA) and Actual Time of Arrival (ATA), and the Reporting, Discharging and Overland/Inland transport from each of the three Ports. The following points describe ideas that we think could be useful for the WFP:

1. Determination of port arrival and Requested Time of Arrival (RTA) of bulk cargo. The roots of impact here affecting the timing and cost are the amount of bulk volume available, the port congestion and relative needs of communities at Extended Delivery Points. If the WFP intends to utilize 20 percent of the berth capacity, then the WFP can coordinate with other organizations and shift the utilization of each berth. In addition, depending on the shelf life of warehoused grains, the WFP should plan ahead and bring more food in to a different port, hold stock there and decrease it's utilization of the Djibouti port. Finally, in regards to seasonal volume fluctuations at the port, the WFP does not have the ability to easily pick one corridor (route from origin at port through to EDP) over another, but the WFP can instead influence the overall quantity of food that is sent to a different port. Further, the WFP can take seasonality into account by sending food to Ethiopia a month earlier or support FDP's in need, through utilizing alternative ports that are seasonally less congested.
2. Communicate Estimated Time of Arrival (ETA) and Actual Time of Arrival (ATA). There are two roots of impact that drive the ETA and ATA: contractual

shipping terms and shipping documents used to communicate these terms. It takes ten days for the WFP Ethiopia to obtain the Bill of Lading, Sailing Advice, and Inspection Certificates necessary to move forward with scheduling ship vessels and mobilizing truck capacity needed. More real-time communication between WFP Rome and WFP Ethiopia Country Offices could reduce the lead time at this critical early stage of the process. Further, the shipping terms of vessel contract fixing and Free Out vs. Liner Out are complex and determined on a case-by-case basis. The process could be more efficient if WFP could institutionalize the shipping term negotiation process by categorizing a set of standard contracts for use based upon defined scenarios (i.e. for shipments of x metric tones with y carrier to z destination, use shipping term contract A). The WFP would also benefit from increased communication with the Ethiopian Government, other NGOs, Port/berth managers, Fertilizer ships, and transportation carriers.

3. The LTI and waybill information data are recorded in COMPAS to track the flow of food supply and analyze transport performance. The WFP could use COMPAS to better predict trucking capacity based on historical truck availability at peak times throughout the year.
4. Manual bagging versus Integrated Discharging + Silo + Bagging System. Only the Berbera Port continues to utilize a manual bagging system upon the ship's arrival. If the WFP were to implement into the Berbera Port the integrated discharging + silo + bagging system used at Sudan and Djibouti, then more capacity could be shifted to Berbera. The potential for greater utilization of the

Berbera Port, along with the decreased risk of congestion at Djibouti would offset the costs of implementing this new automated bagging system.

5. Transshipment of Cargo and Port Warehouses. Only Sudan utilizes the transshipment of cargo at transshipment points. This practice was necessitated by the difference between Sudanese trucks and Ethiopia trucks in truck capacity. Sudanese trucks hold 60 mt. while Ethiopia trucks must be 40mt to navigate the mountainous terrain of the northwest region of Ethiopia that this port serves. This transshipment practice could be expanded, however, into other areas not necessitated by different size trucks. Transshipment, in lieu of utilizing EDP points, saves time and labor resources – and ultimately saves the WFP money. The WFP could test transshipment practices in a few of the most highly utilized EDP's in Djibouti first, and if these test cases are successful, implement transshipping in other EDP's in Berbera as well.

3.2.6 Communication, Transparency & Visibility of Supply Chain

Given the social, physical and cultural challenges facing the transportation of food aid in Ethiopia, one key way in which the WFP can reduce supply chain inefficiencies and bottlenecks in the process is to coordinate information flows with multiple partners. Implementing greater communication channels within the supply chain will allow the WFP to mitigate unexpected disruptions, diversify risks and increase the chain's flexibility to unavoidable environmental changes. As an added benefit, utilizing the community and other partners involved at the ground level at FDPs, EDPs and the Port locations can also contribute to building the infrastructure of Ethiopia's developing

economy. Within the WFP Supply Chain, we have identified the following four metrics which can greatly benefit from greater information dissemination:

1. Port delay to the berth
2. Truck timing and capacity
3. Number of trucks available to the WFP
4. Shunting costs and frequency

The faster flow of land transport information for each of these metrics would have a defined impact on the WFP's supply chain. Additionally, creating and tracking key supply chain metrics would help track the progress of these information flow increase efforts.

3.3 Corridor Landed Cost Analysis

Prior to 2009, the WFP utilized only the Djibouti corridor to transport food aid into Ethiopia. However, now that Port of Sudan, Berbera and Mombasa ports are available, the WFP must identify the most appropriate corridor and the best timing for utilizing that corridor to deliver food aid to the Ethiopian population in need. The criteria that WFP should use to determine the optimal corridor is based on a number of factors including time, cost, distance, reliability and relationship. As these factors are not mutually exclusive, it is important to understand how they influence each other. Figure 3.3 below is visual representation of the relationship between each of the factors affecting corridor selection.

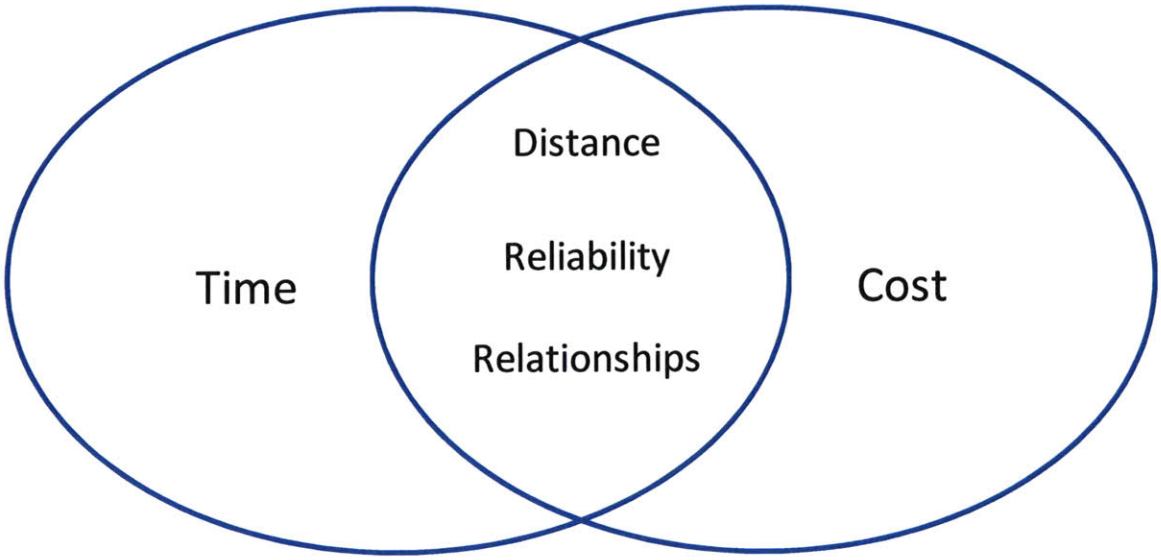

FIGURE 3.3: Corridor Selection Decision Factors

1. Distance – This factor considers the how far EDPs and FDPs are located away from a port. However, this distance alone does not provide a full understanding of the cost and time associated with serving an EDP. For example, an EDP can be located 1,000km away from the port, but may also happen to be a major city of commerce supplied by paved roads. Because of these additional road condition and commerce factors, it may be faster and cheaper than delivering to another closer EDP.
2. Time – This factor considers the critical importance of delivering food aid promptly to address the health and welfare of the in-need Ethiopia population. The time factor is influenced by loading and unloading speeds and capacity, road conditions and customs clearance. Additionally, distance, relationships and to an extent, cost impact delivery time. With stronger relationships, the WFP can gain greater reliability and preference in shipping its cargo. Additionally, if the WFP were capable of offering incentives to carriers, it could have their food delivered faster and with fewer delays.

3. Relationships – This factor considers how the WFP interacts with governments, carriers and local populations. For instance, in providing services to the Somalia region of Ethiopia, the WFP may have better success utilizing local populations for transportation and oversight. Additionally, strengthening the relationships between the major stakeholders provides WFP more opportunities and flexibility to operate, which in turn can help reduce cost and transit time as well as increase service levels.
4. Reliability & Quality – This factor considers the value proposition and variability of the transportation stakeholders. To provide food aid successfully, the WFP depends on the ports and transportation carriers to provide consistent service levels. Specifically, port facilities need to be capable of providing the required capacity to unload food aid and transportation needs to be available at the port to pick up the cargo.
5. Costs – This factor considers all the expenses that the WFP incurs in its supply chain. These cost factors include shrinkage, administration and corridor costs. The primary components of the corridor cost are associated with port, shunting and transportation costs. Port costs include bagging, clearance, handling and port charges. Shunting costs can vary by location and are charged on a per metric ton basis. Transportation costs are provided as a birr (Ethiopian currency) rate per metric ton. These transportation costs inherently take into account such factors as economic forces, distance, time, and road conditions facing truck carriers contracted by the WFP.

As the situation WFP faces is amorphous, it is difficult, if not impossible to quantify the impact of each factor in the corridor selection process. However, with the data provided, we are capable of analyzing the corridors (port to EDP) based on cost and location. While time and distance are not absolute indicators of cost, they are significant factors of transportation cost (Chander & Shear, 2009). This provides us a directional understanding that lower costs should correlate with lower transportation times.

3.3.1 Transportation Costs

In analyzing the corridor costs, we focused our attention on the major, direct cost categories that were unique to each corridor: transportation costs, port costs and shunting costs. Tables 3.1-3.3 below compare the shared EDPs of the Djibouti corridor with the newer Port of Sudan and Berbera port corridors. While there are additional EDPs in Ethiopia, we focused our analysis on these specific ports, given their close proximity to more than one corridor and data availability. The transportation costs for the newer ports to travel to all the EDPs would be exorbitant and cost prohibitive. Mombasa was not included in the analysis as the transportation costs were not available and the port has not been utilized. The rate data were provided by WFP.

For Tables 3.1-3.3, please note the following:

[1] 1 USD = 12.55 Birr
[2] Distance from Berbera Port to WARDER estimated; cost is actual
[3] GONDER via KOMBOLCHA for Djibouti Port
[4] WERETA via CHIFRA for Djibouti Port
[5] Djibouti shunting costs range from $9-$14, estimated at $10 for this analysis

TABLE 3.1: Transportation Costs from each Port to select EDPs

	Destination	Degehabor	Dire Dawa	Gode	Jijga	Kebridehar	Nazareth	Warder[2]	Gonder[3]	Wereta[4]
Djibouti Port	Distance	638	315	1,033	472	863	723	992	1,230	822
	$USD/ km/ mt[1]	$0.16	$0.13	$0.31	$0.14	$0.28	$0.07	$0.15	$0.09	$0.10
	Transportation	$104.30	$42.39	$318.65	$63.82	$238.25	$52.59	$150.60	$116.61	$84.54
Berbera Port	Distance	512	505	908	347	737	686	1,137	N/A	N/A
	$USD/ km/ mt[1]	$0.21	$0.16	$0.26	$0.16	$0.25	$0.16	$0.14	N/A	N/A
	Transportation	$105.98	$82.23	$239.04	$55.38	$182.47	$110.76	$159.36	N/A	N/A
Port Sudan	Distance	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,053	1,164
	$USD/ km/ mt[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0.11	$0.10
	Transportation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$115.83	$116.40
Difference vs. Djibouti		$1.68	$39.84	**-$79.61**	**-$8.44**	**-$55.78**	$58.17	$8.76	**-$0.78**	$31.86
Percent Difference vs. Djibouti		1.6%	94.0%	**-25.0%**	**-13.2%**	-23.4%	110.6%	5.8%	**-0.7%**	37.7%

During our analysis, it became immediately apparent that some EDPs could be served at a lower transportation cost through the Berbera port or Port Sudan. However, to obtain a more complete picture of the total costs of delivering one metric ton of food aid, it is important to consider port and shunting costs in addition to transportation costs alone.

3.3.2 Total Costs

To capture the total costs we analyzed the cost impact of cargo type (bulk or break bulk) as well as the impact of shunting. While containerized cargo is available at some ports, we did not include it in our analysis since it costs significantly more than bulk and break cargo and it is less than 1% of food aid volume. For the sake of simplicity, since the break bulk follows a similar relationship between the ports as bulk cargo, we are only going to focus our discussion on bulk cargo. The total cost data below is a composite of WFP corridor data and rate files. The total costs between Djibouti port corridor and the new port corridors are seen in tables 3.2-3.3 below.

TABLE 3.2: Total Bulk Costs For Select EDPs - Less Shunting

	Destination	Degehabor	Dire Dawa	Gode	Jijga	Kebridehar	Nazareth	Warder[2]	Gonder[3]	Wereta[4]
Djibouti Port	Transportation	$104.30	$42.39	$318.65	$63.82	$238.25	$52.59	$150.60	$116.61	$84.54
	Port	$19.70	$19.70	$19.70	$19.70	$19.70	$19.70	$19.70	$12.10	$12.10
	Total Costs	$124.00	$62.09	$338.35	$83.52	$257.95	$72.29	$170.30	$128.71	$96.64
Berbera Port	Transportation	$105.98	$82.23	$239.04	$55.38	$182.47	$110.76	$159.36	N/A	N/A
	Port	$19.92	$19.92	$19.92	$19.92	$19.92	$19.92	$19.92	N/A	N/A
	Total Costs	$125.90	$102.15	$258.96	$75.30	$202.39	$130.68	$179.28	N/A	N/A
Port Sudan	Transportation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$115.83	$116.40
	Port	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$19.00	$19.00
	Total Costs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$134.83	$135.40
Net Difference vs. Djibouti		$1.90	$40.06	**-$79.39**	**-$8.22**	**-$55.56**	$58.39	$8.98	$6.12	$38.76
Percent Difference vs. Djibouti		1.5%	64.5%	**-23.5%**	**-9.8%**	**-21.5%**	80.8%	5.3%	4.8%	40.1%

TABLE 3.3: Total Bulk Costs For Select EDPs - Including Shunting

	Destination	Degehabor	Dire Dawa	Gode	Jijga	Kebridehar	Nazareth	Warder[2]	Gonder[3]	Wereta[4]
Djibouti Port	Shunting[5]	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
	Total Costs	$134.00	$72.09	$348.35	$93.52	$267.95	$82.29	$180.30	$138.71	$106.64
Berbera Port	Shunting[5]	$5.66	$5.66	$5.66	$5.66	$5.66	$5.66	$5.66	N/A	N/A
	Total Costs	$131.56	$107.81	$264.62	$80.96	$208.05	$136.34	$184.94	N/A	N/A
Port Sudan	Shunting[5]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$6.00	$6.00
	Total Costs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$140.83	$141.40
Net Difference vs. Djibouti		**-$2.44**	$35.72	**-$83.73**	**-$12.56**	**-$59.90**	$54.05	$4.64	$2.12	$34.76
Percent Difference vs. Djibouti		**-1.8%**	49.5%	**-24.0%**	**-13.4%**	**-22.4%**	65.7%	2.6%	1.5%	32.6%

From Tables 3.2-3.3 above, we can see that some EDPs offer better or nearly similar costs than the Djibouti corridor. Without considering shunting, Gode, Jijga and Kebridehar, would be more cost effectively served utilizing one of the new corridors. Additionally, Degahabor and Gonder are within 5% of the Djibouti cost. If we consider shunting costs, Degahabor, Gode, Jijga, and Kebridehar would be more cost effectively served utilizing one of the new corridors.

In addition to lowering corridor costs, utilization of these corridors to reach the above noted EDPs can help provide more flexibility and agility to WFP's supply chain, reduce the time needed to deliver food aid, and reduce the strain on the Djibouti corridor. Transportation rates for these new corridors are expected to decrease as roads are improved. Additionally, if more cargo is shipped, the WFP may be able to gain economies of scale with the increase in volume, and pressure transportation carriers to decrease rates.

An exact analysis should be done at the FDP level. This would require a complete mapping of transportation network costs as well as FDP level demand. While the select EDPs noted before can be more cost effective to serve via one of the new port corridors, this doesn't take all of the supply chain factors into account. For example, it may not be effective to send a fully loaded, chartered vessel to the Port of Sudan just to serve the Gonder EDP. Shipping costs, potential food aid spoilage, extended warehousing costs and location demand would need to be considered before shifting significant food aid to a new corridor.

3.4 Supply Chain Capacity Analysis

At the WFP's request, we initially attempted to examine if there was a food aid transportation capacity constraint that limited the WFP's ability to meet Ethiopia's humanitarian food needs. Given the lack of specific quantitative transportation data currently available, we broadened our analysis to study all aspects of the supply chain from the Djibouti port to the EDP. We identified current and potential capacity constraints within a number of WFP processes. Within this and the remaining sections of

our thesis, we propose options to alleviate or eliminate the residing issues. The choke points in the supply chain may consist of berth access, berth unloading capacity, bagging capacity, shunting capacity and trucking capacity.

At a high level, the WFP port supply chain consists of five possible steps:

- Berth access
- Beth unloading capacity
- Shunting capacity
- Bagging capacity
- Trucking capacity

The annual Djibouti port throughput capacity for bulk and break bulk food aid is:

- 2 berths * *7000mt/day* * 365 days = 5,110,000mt

A single berth therefore has 2,550,000mt of unloading capacity.

The two sets of bagging machines have the following annual throughput capacity:

- 2 sets of bagging machines * *3000mt/day* * 365 days = 2,190,000mt

A single berth therefore has 1,095,000mt of unloading capacity.

Given these throughput capacities, we can determine the number of trucks necessary to meet daily throughput. Assuming each truck is loaded with 37mt of food aid on average, the port would require the following number of trucks each day:

If the port is fully utilized (bagging not considered):

- 2 x 7,000mt / 37mt = 378 trucks per day

If only one berth is fully utilized (bagging not considered):

- 7,000mt / 37mt = 189 trucks per day

If both sets of bagging machines are fully utilized:

- 2 x 3,000mt / 37mt = 162 trucks per day

If only one set of bagging machines are fully utilized:

- 3,000mt / 37mt = 81trucks per day

Depending on the number of bagging machine sets that are operating, the Djibouti port requires either 81 or 162 trucks to be loaded with 37 metric tons of food aid each day to meet the bagging throughput. In the current system, if even one berth is being fully utilized, the bagging machines sets become a bottleneck in the WFP supply chain as they provide less throughput than the berth. Increasing the number of bagging machines or sets could help expedite the WFP process, increasing throughput. Additional capacity or improved machines should only be considered if enough trucks are available to load the bagged food.

If bagging machines are unavailable, WFP must shunt the food aid via conveyer to the silos. We are unable to confirm if shunting capacity adversely impacts the supply chain. The four shunting options at the Djibouti port offer the following capacities:

- Silo – 30,000mt
- Dry Port – 15,000mt
- Djibouti Free Zone – unknown
- Town Warehouse – 8,000mt

Assuming that WFP is the only organization utilizing the warehouses, then it may have the capacity needed to match supply. For instance, in October 2008, 142,832mt of food aid was delivered to the Djibouti port, the largest single month of food aid recorded. If the minimum amount of trucks frequented the port necessary to meet the throughput of one bagging machine set (81 trucks), then the port would have the ability to shunt nearly

all the food aid at the onsite port warehouses. However, if any other organizations need to utilize the warehouses, bagging machine sets are unavailable or trucks are unavailable, then WFP will likely not have enough warehousing capacity. This would require WFP to delay the unloading process and incur greater costs.

The other bottleneck, as witnessed by the WFP is trucking capacity. The supply chain becomes constrained by the high variability in food aid supply and the high variability in transportation carrier supply. A lack of truck transport capacity forces WFP to shunt food aid; increasing delivery time and shortening the useful life of food aid. WFP must shunt the unbagged food aid in the silo or the bagged food aid in the Dry Port, Free Zone or Town Warehouse. During our thesis project, WFP visually identified a need for shunting and lack of transportation capacity. After relaying this information to the Ethiopian government, the government made assurances to increase the trucking capacity.

3.5 Shipping, Port and Carrier Specific Analysis

To better understand the capacity constraints that affect the WFP's supply chain, we focused our analysis on the Djibouti port, since the WFP currently ships 90 percent of their volume through this highly utilized port. The shipping data that we received consisted of all the food aid shipments that have gone through the Djibouti port since 2000. This is an important distinction to note as we are examining the totality of shipments at the port, including those apart from the WFP's consignee food aid. We decided to analyze data in aggregate for two reasons. The first is that it is more statistically relevant to have additional data points. Secondly, the practice of analyzing

the total data for all shipments provides a better representation of what is occurring at the two bulk and break bulk berths at the Djibouti port. Although currently unavailable, if we had access to the fertilizer vessels' data, we would have an even more complete picture of what occurs at the two accessible berths.

The Djibouti shipping file provided information on when vessels arrived and departed from the port. While we were able to quickly determine the number of days a vessel spent in the port, we didn't know if the vessel had been delayed or if it had stayed for an appropriate number of days. For instance, vessels carrying more food aid are expected to spend more time in port unloading its cargo. However, knowing the port's berth capacity, we are able to calculate the theoretical time a vessel should be in port. For example, a vessel carrying 70,000mt of food should be able to unload its cargo and leave the port in 10 days if the berth is operating at its 7,000mt level. We are then able to compare the actual time a vessel spent in the port to the calculated time that we derived from the berth unloading capacity. This provides us a days-of-delay metric that we can use to analyze the days of delay for each vessel arrival on a monthly basis.

For each month, we added together all the vessels that arrived in the port that month, the vessels' quantity of food aid delivered, and the number of days in spent in the port. We then compared the number of days the accumulated vessels spent in port to the number of days we calculated that the vessels should have spent in port based on various berth capacities. We choose the following unloading rates to compare against the actual days in port: 3,000mt (a single bagging machine set), 6,000mt (two bagging machine sets), 7,000mt (a single berth capacity), and 14,000mt of capacity (the capacity from both berths). Given the relationship of this metric, the larger the port capacity, the greater the

calculated delay; as we would expect the vessel to be able to unload and leave the port quicker. We believe that analyzing the shipping data based on 7,000mt daily throughput is the most realistic representation of the food aid capacity of the port. This takes into account that the berths are also used for other cargo like fertilizer, and that the berths are likely unable to constantly operate at 100% utilization.

The relationship between the actual quantity of food aid delivered and the calculated delay assuming a 7,000mt throughput can be seen in the below figure 3.4. Additionally, figure 3.5 shows a histogram of the calculated delays.

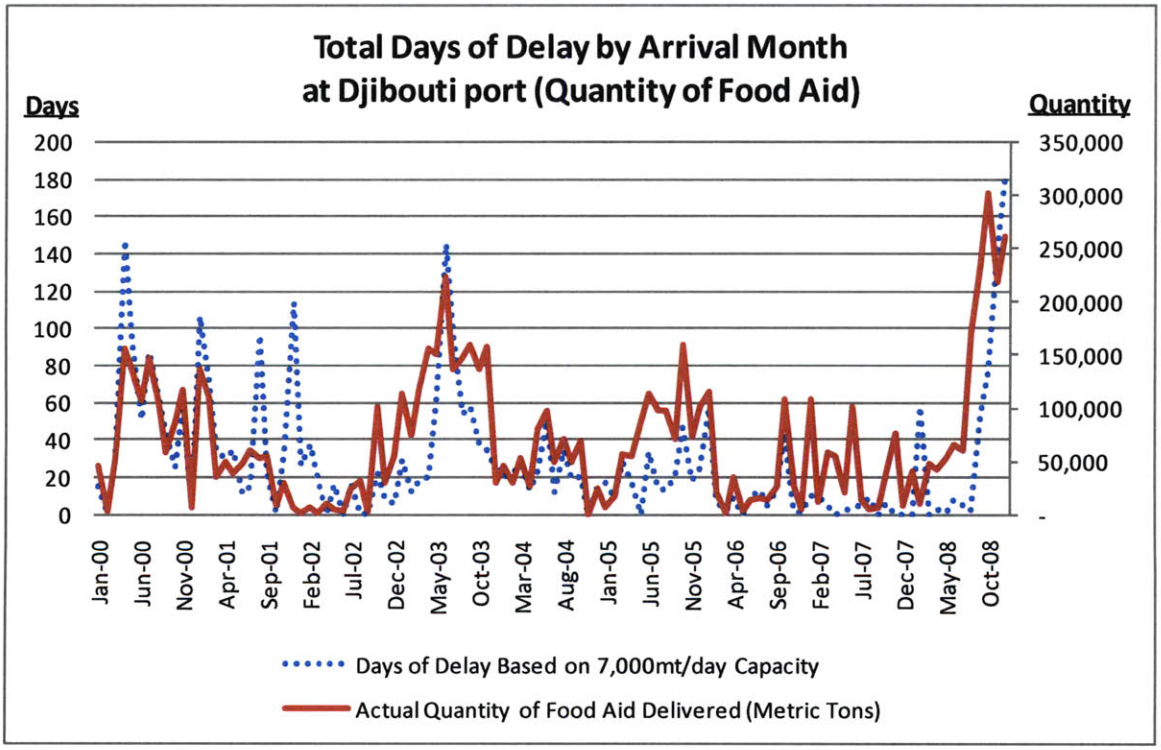

FIGURE 3.4: Djibouti Port Total Calculated Delays by Arrival Month

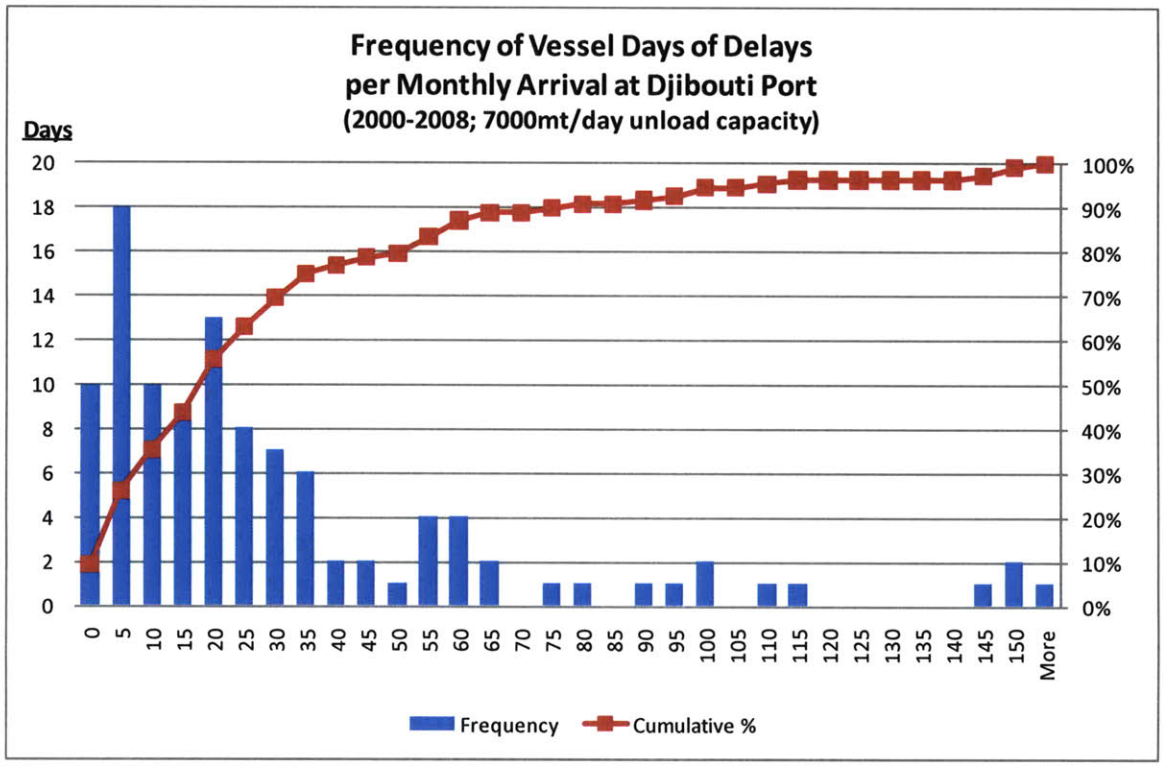

FIGURE 3.5: Djibouti Port Total Calculated Delays Frequency

Typically, as the quantity of food aid delivered increased, the calculated delay also had a lagging increase. Assuming a 7,000mt capacity has been consistently representative since 2000, it would appear that the port increases its efficiency at managing vessels from 2000-2003. This is likely due in part to the investments made at the port. Starting in 2008, we are beginning to see a troubling trend. With food aid having doubled from 2007 to 2008 and continuing to increase in 2009 and expecting to increase in 2010, WFP may encounter greater port delays.

As expected, the quantity of food aid delivered and quantity of vessels delivering food aid are highly correlated at 71 percent. When running a multiple regression with these two factors, the quantity of food aid appears statistically significant in determining the calculated delay while the number of vessels does not. When running each factor

independently, the quantity of food aid is more explanatory. As such, we have chosen to focus on the quantity of food aid for our analysis. For more information, please see the regression output in the Appendix.

With 44% explanatory power or fit (R^2), WFP could project the expected days of delay per vessel. The formula to do this is: $2.83 + .00038^* x$ if x is defined as the expected number of metric tons delivered in a month. A 44% R^2 is acceptable given the seasonality of food aid and significant number of statistical unknowns at the port, such as fertilizer data. Data entry mistakes and formatting could be a significant issue in the fit not being greater. For instance, dates in the shipping file were input both as Day/Month/Year and Month/Day/Year for the arrival and departure of the same vessel. Data issues could contribute to some the skew in the above histograms.

There are many potential causes for port delays at the Djibouti port. Of these, the most common cause is a lack of berths due to port congestion. The berth could be blocked due to poor port management, queuing of vessels due to seasonality or offloading issues. The offloading issues could be related to any number of problems such as cargo being tainted, equipment failure or issues with customs clearance. Additionally, as cargo is being unloaded it could be blocked by other port processes such as bagging and loading on to trucks. Finally, the type of cargo appears can impact the port unloading time.

For each issue there is typically a plausible solution although many require significant investments or greater coordination with internal and external stakeholders. The obvious port related options are to increase the number of ports and the capacity of each berth. This however is a costly, long-term solution. The introduction of additional

bagging machines may however be a cheaper alternative that could increase throughput and decrease delays. Another, option that could be more immediate and less costly would be to increase coordination with other consignees. Where possible, the consignees could share shipping forecasts which they could use to better plan shipments around each other and the port's capacity. Finally, WFP can explore the effect of shipping smaller more frequent batches of food aid. While large bulk shipments are most likely the cheapest option for vessel shipping costs, these shipment could be straining port and transportation capacity and actually increase the total supply chain costs. If financially and operationally viable, WFP may be able to achieve a more optimized supply chain by decreasing bulk batch shipments.

An ancillary benefit for reducing port delays could be to foster better relations with transportation carriers. By reducing delays, carriers will be happier to work with WFP. Specifically, trucking carriers wouldn't have to wait at the port as long allowing them to be attain higher capital utilization and profitable. This in turn could allow WFP to receive preferential treatment in the form or reduced rates and a better service level. (Teravanintrhorn & Raballand, 2009, pp. 76-77).

In analyzing the shipping data we observed that a number of vessels that had made multiple deliveries had significant calculated delays. Reviewing these instances could provide WFP some interesting discoveries. Table 3.4 below provides a list of these vessels.

TABLE 3.4: Djibouti Port Vessel Average Delays

Vessel	Average days of delay
Advantage	10-20
Canmar Spirt	0-10
Chesapeak Bay	0-10
Green Harbour	20+
Green Island	0-10
Green Wave	10-20
Judy Litrico	0-10
Kota Waruna	10-20
Liberty Spirit	20+
Maersk Arizona	10-20
Maersk Verginian	0-10
MSC Adele	0-10
Overseas Marilyn	0-10
S. W. Jackson	20+

The possible reasons that these vessels have such significant calculated delays are likely similar to the macro port delay factors discussed above. Some additional causes could be data entry issues, statistical outliers, seasonality, vessel design, relationships with the port and type of cargo transported. For instance, these carriers could be designed in a way that inhibits their ability to berth at Djibouti's port and unload cargo effectively. Additionally, some of these vessels are delivering containerized cargo, which likely unloads at a slower rate than the 7000mt rate the delays were calculated with. Finally, these vessels may have poor relationships with the port or file paper work differently which leads to them actually or reportedly remaining in the port longer. WFP should review the root cause that some vessels have processes that are faster than others at unloading goods. These best practices should then be shared with other carriers.

4 Conclusion

The WFP is actively working towards increasing its supply chain capacity and efficiency of operations, as evidenced in the Berbera and Sudan Port openings within the past year. The first step towards improving its supply chain is in tracking metrics and gathering the necessary data (i.e. truck capacity, delays at the port and corridor selections) in order for the WFP to make informed, optimal decisions. The WFP is in the process of gathering this data and hopes to move forward to implement google-maps lead-time displays, defining metrics for transparency including Key Performance Indicators (KPI's), and actively map programming, shipping, and procurement processes.

In addition to these efforts and the corridor optimization, supply chain process flow root cause analysis, and port bottleneck analysis recommendations explored in our thesis, the WFP has additional opportunities to improve its supply chain and make it more lean, flexible and resilient. Transportation networks, truck contracting, postponement and risk pooling are future areas of exploration in which the WFP's supply chain can greatly benefit.

4.1 Transportation networks

WFP should lobby the government to continue to make infrastructure improvements to Ethiopia and its surrounding countries. In addition to paving roads, WFP should push for rehabilitation of the train system to locations like Dire Dawa. As noted by Supee Teravanintrhorn and Gael Raballand in Transport Prices and Costs in Africa:

> On the main international corridors, an absence of rail services creates opportunities for the trucking industry to inflate its prices. That is why intermodal competition on these corridors is critical. Increase competition from rail services benefits transport users primarily through comparable or lower transport costs (Teravanintrhorn & Raballand, 2009, p. 38).

In addition to helping lower total costs, this initiative could also provide additional needed transport capacity.

4.2 Truck Contracting

Currently, there are 7000 trucks available for transporting food aid, according to Ethiopia government reports. Given that the WFP requires 120 trucks of 40mt. each per day to handle the flow of 4000 mt of food aid per day at the Djibouti port, the WFP may want to consider exploring opportunities for improving truck contracting practices. In Ethiopia, the government maintains control over the purchasing and allocation of trucks for use. Because this privatization of truck capacity is controlled by the government, trucks are typically allocated for use based on initiatives such as housing projects. In 2008, the Ethiopia Ministry of works and Urban Development facilitated truck procurement for "better performing contractors and transporters who are involved in the government's housing projects. The facility concerns 2000 trucks to be imported from China." (Tekle, 2008). Contractors of the 2000 trucks from China would be required to pay 30 percent of the truck purchasing price up-front, but have the option to pay the remaining 70 percent of the truck price via secure loans from the Commercial Bank of Ethiopia. The WFP could contract with the government to procure trucks from regions such as China under a similar 30% down-payment + 70% on-loan payment agreement.

Alternatively, the WFP could opt to purchase trucks from the ministry and build its own truly dedicated fleet. In this vertically integrated scenario, the WFP would be able to secure better control over the truck capacity issue, maximize efficiencies by mitigating the risk of bottlenecks at the port, eliminate concerns over penalizing unreliable truck contractors, and increase information flow and visibility along the supply chain. On the other hand, maintaining their own fleet would require the WFP to assume risks traditionally absorbed by the truck contractors such as driver employment, truck maintenance and management. Further, the WFP would have to make significant investments to modify the existing systems and infrastructure in order to viably utilize a dedicated fleet.

A compromising solution is to roll-out a dedicated fleet on a smaller scale – a hybrid model of truck contracting and the dedicated fleet options. Adding even a small dedicated fleet could help alleviate volume volatility spikes that affect port bottlenecks. For example, the WFP could manage or contract 20 trucks to be a truly dedicated fleet and significantly stabilize the demand for mobilizing food aid.

4.3 Postponement & Risk Pooling

A more radical option that the WFP can employ is risk pooling with postponement. This would be difficult to coordinate and potentially add a level of complexity to WFP's processes and organization. Compounding WFP's difficulty is that grain can only last between six to twelve months under ideal conditions (Government of Alberta, 2002). However, these challenges come with substantial benefits if developed and implemented correctly. One such benefit is that it could allow a greater geographic region, beyond that

of Ethiopia, to pool demand risk and minimize variability. Pre-positioning and pooling goods would allow the WFP to decouple its demand and supply of goods. Pooling even 5-10% of African food aid could help increase WFP's agility and ability to meet changing needs (Oloruntoba & Gray, 2006). The system could function more similarly to a multi-echelon DC feeding more local regions.

4.4 Final Note

These future areas of exploration – transportation networks, truck contracting, postponement and risk pooling – are based upon our analysis of corridor optimization, supply chain process flow root cause analysis, and port bottleneck analysis recommendations (mentioned in our Analysis and Recommendations section). Our methodology, analysis, process flow breakdown, and recommendations can also be used by humanitarian organizations other than the WFP to improve their supply chain performance.

References

Beamon, B.M. (2004), Humanitarian Relief Chains: Issues and Challenges," *Proceedings of the 34th International Conference on Computers & Industrial* Engineering San Francisco, CA

Central Intelligence Agency. (2010). The World Fact book: Africa: Ethiopia. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/geos/et.html

Chander, V. & Shear, L. (May 2009). An Analysis of World Food Programme Operations in the Somali Region of Ethiopia. (Maters thesis) Massachusetts Institute of Technology, Boston, MA.

Daily Monitor. (November 16, 2008). Ethiopia: WFP, Company Sign Accord on Handling Commodities through Djibouti Port. Retrieved from http://allafrica.com/stories/200811180773.html

Government of Alberta. (May 2002). Management of Cereal Grain in Storage. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex4509

Lopez, M. (May 2003). A Study on The Lead-Times in The United Nations World Food Programme Supply Chain. A Focus on the Country Offices. (Maters thesis) Massachusetts Institute of Technology, Boston, MA.

Oloruntoba, R. & Gray, R. (2006). Humanitarian Aid: An Agile Supply Chain?. *Supply Chain Management: An International Journal.* pp. 115-120 Retrieved from http://www.emeraldinsight.com/Insight/ViewContentServlet?Filename=Published/EmeraldFullTextArticle/Articles/1770110204.html

Gettleman, J. (March 9, 2010). *New York Times*. Somalia Food Aid Bypasses Needy, U.N. Study Says. Retrieved from http://www.nytimes.com/2010/03/10/world/africa/10somalia.html

Hausman, W., Lee, H. & Subramanian U. (October 10, 2005). *Global Logistics Indicators, Supply Chain Metrics, and Bilateral Trade Patterns*

Tekle, T. (January 11, 2008). Ethiopia Helps Import 2000 Trucks From China. *Africa News.com.* Retrived from http://www.africanews.com/site/Ethiopia_helps_import_2000_trucks_from_China/list_messages/14580

Teravaninthorn, S. & Raballand, G. (2009). Transport Prices and Costs in Africa: A Review of the International Corridors. Washington, DC: The World Bank pp. 38, 76-77.

Thomson Reuters Foundation. (April 29, 2009). Somalia: WFP Bid to Boost Capacity. Retrieved from http://www.alertnet.org/thenews/newsdesk/IRIN/eb090cbc5b043d93ce839c4d9f67e85b.htm

World Food Programme. (May 2000). WFP Launches Urgent Food Airlift For Thousands of People Displaced by Ethiopia and Eritrea War. Retrieved from http://one.wfp.org/english/?ModuleID=137&Key=96

World Food Programme. (September 2004) Agreement for Leased Transport Fleet. Khartoum, Sudan

World Food Programme. (2010a) WFP Logistics. Country Operations. Ethiopia. Retrieved from http://www.wfplogistics.org/country-operations/africa/east/ethiopia

World Food Programme. (2010b) WFP Logistics. Country Operations. Kenya. Retrieved from http://www.wfplogistics.org/country-operations/africa/east/kenya

World Food Programme Ethiopia. (2010). Corridor Report 2009-2010. Addis Ababa, Ethiopia.

Appendix

Regression Analysis

From Figure A1, we can see that when utilizing multiple regression, the number of Vessels (count of vessels) is not 95% significant. Additionally, its coefficient raises an immediate red flag as it is counter intuitive. As noted before, the factors are highly correlated (71%). As such, we have decided to focus on the more explanatory factor, food aid as seen from the below Figures A1:A3.

Sum of Vessel Delays per Month (7000mt) - Quantity of Food aid & Vessel Count					
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.68				
R Square	0.46				
Adjusted R Square	0.45				
Standard Error	26.54				
Observations	108				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	62230.97	31115.49	44.18	1.20E-14
Residual	105	73955.92	704.34		
Total	107	136186.89			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	9.158	5.126	1.787	0.077	
Quantity of Food aid	0.00046	5.93E-05	7.790	5.04E-12	
Count of Vessels	-1.399	0.751	-1.862	0.065	

FIGURE A1: Calculated Vessel Delays Multiple Regression Output

Figure A2 show the regression results based on the quantity of food aid per month. This regression output is used in creating the delay projection calculation.

Sum of Vessel Delays per Month (7000mt) - Quantity of Food aid					
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.66				
R Square	0.44				
Adjusted R Square	0.43				
Standard Error	26.85				
Observations	108				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	59788.76	59788.76	82.96	5.70E-15
Residual	106	76398.13	720.74		
Total	107	136186.89			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	2.836	3.885	0.730	0.467	
Quantity of Food aid	0.00038	4.21E-05	9.108	5.70E-15	

FIGURE A2: Vessel Delays Quantity of Food aid Regression Output

Figure A3 below show the regression results based on the number of vessels per month.

Sum of Vessel Delays per Month (7000mt) - Number of Vessels per Month					
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.38				
R Square	0.14				
Adjusted R Square	0.14				
Standard Error	33.18				
Observations	108				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	19490.87	19490.87	17.70	5.42E-05
Residual	106	116696.03	1100.91		
Total	107	136186.89			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	5.980	6.388	0.936	0.351	
CountOfVESSEL	2.77237	6.59E-01	4.208	5.42E-05	

FIGURE A3: Vessel Delays Vessel Quantity Regression Output