A STUDY ON THE LEAD-TIMES IN THE UNITED NATIONS WORLD FOOD PROGRAMME SUPPLY CHAIN. A FOCUS ON THE COUNTRY OFFICES.

by

Marc Lopez

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ABSTRACT

The United Nations World Food Programme (WFP), the largest humanitarian agency in the world and the logistical arm of the United Nations, reached more than 113 million people in 80 countries in 2004 and delivered more than 50% of all the food aid in the world. In its endeavor of planning, designing, executing, monitoring and completing each and every one of the projects in which they are involved, all WFP business decisions and logistic steps are tracked down via an information technology tool called WINGS (WFP Information Network and Global System). This database is of extreme importance not only for the actions described above but also because it enables WFP Officers to learn from their past experience and improve their operations and efficiency in the future. This thesis aims to contribute to it.

The first half of this study is addressed to briefly describing which business steps are in the WFP commodity pipeline and how the information flows from one another. It then moves into a deep statistical analysis in which lead-times from the moment the donor confirms its contribution to the moment food reaches the port of discharge are calculated. Some very interesting conclusions are derived from the analysis, such as which donors are more efficient in their efforts or which kinds of projects require less time and why.

The second half of this thesis focuses on calculating some performance and inventory management measures that may help Country Officers. The aim here is to provide them with a wide study regarding performance of the final delivery to the implementing partners. Thus, lead-times from the moment the food has reached the port of discharge until it is delivered to the ending control point are calculated and are used to compute the measures mentioned above. This study had never been done before due to the existence of many uncertain and unique variables in the last part of the delivery system, e.g. transport infrastructure or security situation. Being aware of the limitations in the extrapolation of the results, however, the study performed here may well represent the starting point for a more customized one.

Thesis Supervisor: Henry S. Marcus
Title: Professor of Marine Systems

ACKNOWLEDGMENTS

This work would have been impossible without the help and support of many people. I am indebted to all of them.

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Second, I would like to express my gratitude to Professor Henry Marcus for his permanent support and wise advice on both my M.I.T. career and the development of this thesis. I also want to take this opportunity to thank him for his critical and ironical points of view on the business environment and for making the students aware of the "real world" outside M.I.T.

Third, I would like to thank Chris Nikoi, chief officer of the Freight Analysis and Support Service within the Transport and Procurement Division of the United Nations World Food Programme, for providing me the opportunity of interning in the UNWFP for three months. This internship helped me experience the behavioral and logistical difficulties encountered in an organization with such a commendable mission.

Finally, I want to thank my girlfriend Erika for always being on my side during my research development.

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1. General Overview

The United Nations World Food Programme (WFP), the largest humanitarian agency in the world and the logistical arm of the United Nations, reached more than 113 million people in 80 countries in 2004 and delivered more than 50% of all the food aid in the world. In its endeavor of planning, designing, executing, monitoring and completing each and every one of the projects in which they are involved, all WFP business decisions and logistic steps are tracked down via an information technology tool called WINGS (WFP Information Network and Global System). This database is of extreme importance not only for the actions described above but also because it enables WFP Officers to learn from their past experience and improve their operations and efficiency in the future. This thesis aims to contribute to it but claims not to be seen as a results-oriented study, rather as an academic exercise, a way of thinking about the possibilities, sometimes hidden, in most data warehouses. Thus, the analysis will focus on the procedures to get to the results so that further studies can be developed in the same direction.

The study hereby reflects the results from an extensive statistical study of the lead-times on the WFP supply chain. The data that has been used for this thesis was obtained from the WINGS database as at August 15th, 2005, so it fairly represents WFP performance from 2001 until that date. The database is a valuable source of information for the purpose of analyzing the various steps in the WFP commodity pipeline, from the moment the donor pledges either cash or in-kind donation until the food is delivered to its final destiny. However, there are some intrinsic limitations in the database which will be discussed in following sections.

The main purposes of this thesis are twofold:

1) to produce a description of the lead-times on the WFP commodity pipeline based on some statistical measures. The reason behind this point is to understand the general dynamics in the WFP supply chain and, in particular, to understand which influencing factors are more important in determining lead-times in the overall commodity pipeline.

2) to identify which countries are worse served and to provide their Country Offices not only with a wide statistical study about the lead-times from donor confirmation to final delivery to their countries but also with some control parameters and indicators for their inventory management.

2. Focus on First Half of WFP Commodity Pipeline

2.1 WFP Business Steps

Before proceeding with the statistical analysis, it is necessary to know what the business steps are in the organization, what differences and relationships exist among them and which internal departments and external agencies are involved in the supply chain. Although the purpose of this thesis is not to fully describe WFP's logistical and business structure, this point is crucial for the understanding of the way in which the statistical study has been divided. The different stages are:

1) Resource Request (RR)

2) Purchase Requisition (PR)

3) Purchase Order (PO)

4) Shipping Instruction (SI)

5) Bill of Lading (BL)

6) Actual Time of Arrival (ATA)

2.1.1 Resource Request

Ideally, the Resource Request is issued when the Country Office (CO) issues a particular need of food. However, there has to be a contribution confirmation from the donor side, a commitment to a certain project from which the CO calls forward the commodities needed. Therefore, there is a timely gap between the time when the country really needs the food and the time when they can call forward the food (negotiation process between the Fundraising & Communications Department (FRD) and the donor) that cannot be controlled in this thesis. In fact, this negotiation process for the donor to confirm the contribution may take between days and months depending on the contribution type and its conditions. There are two main kinds of contributions:

- Multilateral: WFP chooses project or operation, although there may be donor regulations as for countries, regions, commodity type or others.

- Directed multilateral: the donor directs contribution to a specific WFP activity.

Multilateral cash contributions and directed multilateral cash contributions that do not require any funding proposal from WFP are directly declared confirmed; thus, their negotiation time is the lowest of all. However, multilateral in-kind contributions, directed multilateral cash contributions that do require funding proposals from WFP and directed multilateral in-kind contributions need funding proposals for the donor to understand all associated costs and to verify that all of its conditions are in place.

In the case of an emergency project, however, the commodities are served through the Immediate Response Account-funding, which is later on replenished with the appropriate donor contribution.

2.1.2 Purchase Requisition

Once the contribution is declared confirmed, the Programming Service (ODP) Officers have to check whether there is a need of updating the initial funding proposal or not. In some cases, they will have to prepare the funding proposal for the first time.

Before releasing the Purchase Requisition to the appropriate people in the Food Procurement Service (ODF) or the Ocean Transport Service (OTS) (for cash contributions and in-kind contributions, respectively), in the CO and in the Regional Bureau, ODP needs to ensure that no budget revision is needed and that the initial Resource Request released is well planned.

2.1.3 Purchase Order

There is a different treatment for the purchase order depending on the type of contribution:

a) Cash donation

ODF reviews the Purchase Requisition (price per metric ton, donor constraints, delivery date) and decides whether to buy the commodity in the international, local or regional market. When ODF decides on buying the commodity in the international market, the tendering process includes the ocean transport and is handled in Headquarters (HQ), whereas for both the regional and local market, the tendering process is handled in the Regional Bureaus and COs and includes the overland transport.

In the tendering process, the PO stipulates not only the commodity type and its quantity, but also the shipment period (from – to) within which the commodity must be at port ready for loading. It is the commodity supplier's responsibility to comply with this requirement.

There is also a case within cash purchases when there is not such a tendering process, but a direct purchase. This situation usually arises in two cases: a) in urgent emergency operations when the minimum required number of suppliers (3) cannot be reached – due to some restrictions on the donor side or because the departments involved in WFP do not know enough suppliers, b) after a tendering process is closed, WFP receives a last minute urgent PR for the same commodities tendered. In this case, it is up to WFP Officers to decide whether to assign this extra quantity to the winning supplier or to conduct a direct purchase for this extra amount of food.

b) In-kind donation

The PO is automatically released after the PR. For directed multilateral US in-kind contributions, the overall RR-PR-PO-SI span is released after Donor Confirmation.

2.1.4 Shipping Instruction

The SI is automatically released after the PO and it contains all the information related to the shipment. After issuing the SI, the commodity supplier needs to get the food at port within the shipment period and, parallel to this process, WFP needs to start the arrangement of a vessel and/or overland transport (depending on the origin: international vs. local/regional purchases). However, this latter process usually takes less time and thus, it does not influence the performance of the overall supply chain.

Therefore, the commodity suppliers' lead-time is one of the most decisive and constraining business steps from all, since WFP has very little or no control at all over it. True to say is that whereas for cash contributions WFP can exercise some power over the suppliers, for in-kind contributions WFP has the least influence (especially for US in-kind contributions), as it will be shown later on.

Before explaining the processes for the commodity and shipping tenders, it is important to describe the main differences between the two ocean transport options, charter and liner vessels, and the reasons that drive WFP to choose between them.

- Charter vessels: in a general basis, a charterer, who owns the cargo, contacts a shipbroker to find a ship owner who can deliver the cargo from one point to another at a certain freight rate. It involves a negotiation process between the two parties and it is usually used when the loading period is difficult to predict and for certain types of cargo (e.g. bulk cargo). In WFP's case, WFP Officers contact the commodity supplier to know when the cargo will be at the load port and the CO Officers to know what are their preferred arrival dates, so that congestion in the discharge port is avoided. All this information is gathered in a document and sent out to WFP's shipbrokers, who will receive several offers from ship owners. These offers are forwarded to WFP Officers, who will have the last word on this negotiation process. The last point to stress regarding the chartering process is that WFP Officers need to give a pre-advice notice to commodity suppliers within a minimum time, in which it is specified the arrival time of the vessel at load port.

- Liner vessels: liner vessels serve a defined route per a published sailing, regular schedule. In this case, the SI is sent to the forwarding agent, who will collect different liner shipping offers from representatives at the load port, prepare a freight proposal and send it out to WFP Officers, who decide on which liner to award the contract. The last step is for the forwarding agent to inform the winning liner about the results.

It may happen in this case that not all shipments leave the load port in one vessel (either because the CO cannot manage all the cargo at once at the discharge port or because the liner vessel did not have enough free space). In this case, the SI is broken down into different delivery orders, so that tracking of the cargo starts getting more complex.

The last point to say regarding liner vessels is that most of the cargo is carried in containers.

For non-US contributions and US cash contributions, the SI already defines the kind of ocean transport to use. This decision is basically based upon the quantity and packing of the commodity and the load and discharge port characteristics. In order to understand the different responsibilities until the cargo is in the vessel, it is important to note that 92% of charter and liner shipments are Free on Board – WFP organizes the shipment, but it is the supplier who is responsible for loading.

For US in-kind contributions, the business process and delivery system is completely different. In this case, the complete span of RR-PR-PO-SI is issued after the donor confirms its contribution and the US Department of Agriculture (USDA) takes care of both the tendering process for the commodity purchases and the ocean transport. The following sections try to describe how the USDA organizes both of them.

First of all, there is a different procedure depending on the type and packing of the commodity:

Processed commodities/Packed cargo (bagged, cartons): Examples of this category include bagged wheat, wheat flour, bagged rice, bagged maize and others. These commodity categories are subject to the official USDA Procurement Schedule on which WFP has no influence, since both the commodity and shipping tender are organized by the USDA.

The official US Procurement Schedule starts with the fixed date on the 4^{th} of each month for the SI submission. The USDA then issues one commodity tender in the next month. Therefore, after a USDA estimation of 60 to 90 days to get the food to the US port from the moment the food was purchased, the overall lead-time in this case amounts for 3 to 4 months.

After closing the commodity tender, the USDA informs the WFP forwarding agent about the SIs included in it. Then, the forwarding agent issues the shipping tender (by the middle of the month after the month of the SI issuance) for both charter and liner carriers. The information collected is sent to the USDA, who divides them by:

- US flag liner
- US flag charter
- Foreign flag liner

- Foreign flag charter

Since "according to the requirements of the Merchant Marine Act of 1936, as amended, and the Food Security Act of 1985, as amended, at least 75 percent of the annual tonnage of all commodities under these (food aid) programs (need) be shipped on U.S.-flag vessels"[1], the USDA assigns the flag for each SI and, sometimes, it also designates if it has to be carried in a charter or a liner vessel.

As it can be easily inferred, the main drawback in this process is that if there is any delay in the SI submission to the USDA, it is going to cost a full month of lost time, since there is only one commodity tendering per month. However, there are other reasons that may cause a one-month delay such as a certain commodity being unavailable at the time of the tendering. In any case, WFP has no influence at all since these decisions are purely managed at the USDA.

Non-processed commodities/bulk cargo: bulk wheat, bulk maize, bulk soy beans and others. These are not subject to any rigid schedule. The USDA organizes commodity tenders as they receive the SIs and WFP issues the shipping tender in conjunction with US authorities. As it can be inferred, lead-times in this case are significantly shorter than for the previous commodity category. Needless to say that US-in-kind bulk cargo is always shipped on charter vessels (due to the high tonnage and the nature of the cargo).

[1] Information extracted from http://www.fsa.usda.gov/daco/crd/transport6.htm

The shipping tender is organized by WFP. When all the offers are received, WFP, via the forwarding agent, sends the information to USDA, who analyzes the flagging issue. Then, WFP negotiates with the chosen ship owner.

2.1.5 Bill of Lading

When the loading is completed (either on a charter or a liner vessel), the carrier releases the BL, which reaches WFP Officers via the forwarding agent. The BL date is usually the departure date.

2.1.6 Actual Time of Arrival

This is the date when the vessel actually reaches the discharge port. It is important to note here that some cargo may be discharged to one country (gateway-discharge country), whereas the recipient country is another one (the main reason being the inexistence of a port in the recipient country). This thesis has, as its second main point of study, the purpose of performing for the first time a wide analysis on the lead-times from the ATA until the final delivery in the recipient country. This study was rejected to be performed in 2003 at WFP HQ because of the uncertainty in the overland lead-times for the disparity of influencing factors, such as the corridor, the means of transport, the transport capacity and market, the transport infrastructure, the season, the security situation, whether there are police/military checks/control points or not, the administrative procedures or the capacity of CO warehouses.

Despite these difficulties and constraints, the analysis performed here may well represent the starting point for having a fully integrated view of the overall lead-times and work that WFP is performing around the world.

2.2 Statistical Analysis from Resource Request to Actual Time of Arrival

The starting point of this thesis is a previous study developed at WFP in July 2003 called "A Statistical Study of Lead-times in the WFP Commodity Pipeline". One of the main conclusions from their study is that lead-time distributions typically are asymmetric and bimodal, for which appropriate identification measures have to be used in statistical analysis. Therefore, in the course of this thesis, the statistical measures that were used to capture the complexity of the distributions are, as in the study of 2003:

a) General measures

In order to get a sense of the range in which lead-times occur, maximum and minimum lead times were taken into account. Since there are some negative lead-times as well (due to some factors that will be explained later on), the percentage of negative lead-times was also calculated, so that the reader is aware of the frequency in which they occur.

b) Tendency measures

These measures describe the general trend of the lead-times. They are the average, the mode and the upper trimmed average. The mode describes the most likely lead-time to happen and it is not influenced by some extreme data, as is the average. The modal class is a measure implicit in the mode concept, since it describes the range of lead-times most likely to occur. Finally, the upper trimmed average measures the arithmetical average without considering the highest ten (10) percent of the data. Therefore, it gives an idea of the expected lead-time without any exceptional event.

c) Uncertainty measures

The use of uncertainty measures helps the reader understand the variability of the distribution. These measures are the standard deviation, the coefficient of variation, the 9^{th} percentile and the frequency over a specific threshold.

Both the standard deviation (the square root of the average of the squares of deviations about the mean of a set of data) and the coefficient of variation (defined as the standard deviation divided by the average) give an idea about the reliability on the average as a general expression of the distribution. High values of these two measures indicate that the distribution is widely spread and therefore, the average does not fairly represent the overall distribution pattern. On the contrary, low values of these two measures indicate that the average is a fair measure of the distribution.

The 9^{th} percentile is the lead-time exceeded in 10% of the times. Therefore, it is the maximum value for the upper trimmed average described above.

The last measure within the uncertainty ones is the frequency over a specific threshold. This concept is extracted from the study developed at WFP in July 2003, in which several WFP managers defined a threshold that should, by no means, be exceeded. Despite being a subjective measure, it is of relevant importance for where this measure comes from.

Once all the statistical measures have been presented and all the business steps have been introduced, it is time to proceed with the first part of the thesis: the statistical study on the lead times of the first half of the WFP commodity pipeline. The purpose of this part of the study is to analyze how WFP activities are generally performed throughout the world and to compute the lead times distributions from the donor confirmation date to the actual time of arrival (at port facilities).

In order to understand how general lead-times are affected by some of the intrinsic characteristics of the projects, this study computes the lead-times for several different cases based on several different factors:

- Project type: this category includes Country Programme, Development Projects (to support economic & social development), Regional Emergency Operations (EMOP), Regional Protracted Relief & Recovery Operations (PRRO), Single-Country EMOP and Single-Country PRRO. EMOPs respond to natural and man-made disasters, whereas PRROs focus on getting from the crisis situation to a recovery one. These two kinds of projects exist at both the country and the regional level.
- Purchase Request type: Cash or In-kind
- Commodity category: canned, cereals, dairy products, fruit, mixed high energy biscuits, mixed blended food, mixed other, miscellaneous other, salt, sugar, oil, other or pulses
- Donor country

2.2.1 Negative Lead-Times

Finally, before showing the results of the statistical analysis, a comment on negative lead-times needs to be addressed. The main reason for negative lead-times to happen is when a document that should be issued before another document is, for some reason, issued later. Thus, it does not reflect the real flow of food but an administrative problem. Clearly, negative lead-times would distort the statistical results so they need to be cleared out from the database. However, it is interesting to track this phenomenon so that some corrective measures can be used in the future. The percentage of negative lead-times is, therefore, included in this study.

Some of the reasons behind the negative lead-times in WFP's business steps are:

- RR to PR: In some of the EMOPs, a PR needs to be released as soon as possible and, therefore, is linked to the IRA-funding. However, once a donor contribution is confirmed, the PR is de-linked from the IRA-funding and linked to the new and RR, with a later release date.
- PR to PO: new PRs can be added to an old PO line, but in that case, the PO date should be changed manually, and it is often not.
- PO to SI: in this case, negative lead-times may occur because a change in the PO required a re-release of the PO.
- SI to BL: some in-kind donors may request to WFP Officers not to issue an SI because their supplier is not ready yet to provide the commodity to the load port,

but they then forget to inform WFP about the SI issuance, so the BL is issued before the SI is.

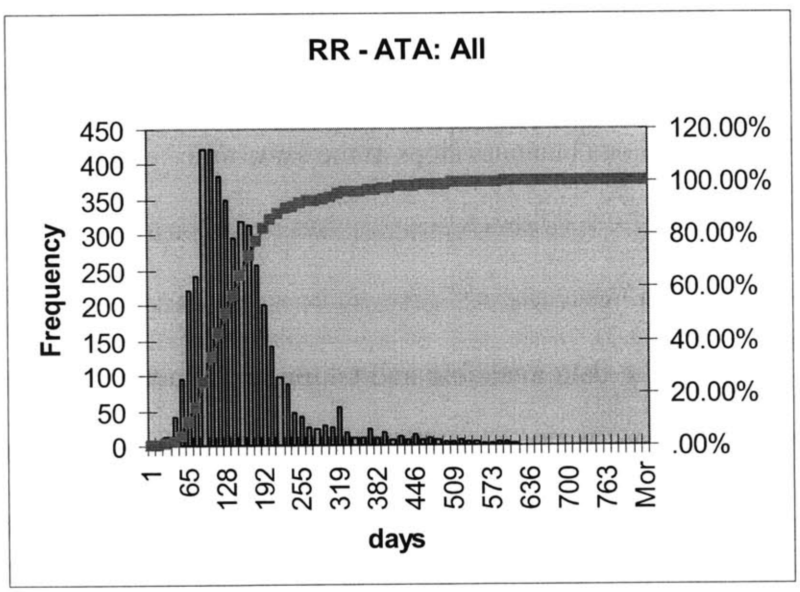
- BL to ATA: because of the manual entrance of both the BL and ATA dates into the database, mistakes may happen.

So, for the purpose of having a reliable analysis of the real flow of food, all negative lead-times between each and every business step have been cleared out, summing a total of 4,789 lines (corresponding to deliveries) out of 9,143. This figure represents 52% of all the data, and most of them are associated to the RR-PR step (947 lines) and the PR-SI step (3,303 lines) – note here that the rest (539 = 4,789-947-3,303) is not the total amount attributable to the other business steps, since some of the lines in the database have negative lead-times in various business steps at the same time.

2.2.2 Overall Lead-Time

Overall, considering all the data available and taking no influencing factor into account, the average lead-time in the WFP commodity pipeline is 146 days and the mode is 111 days. The coefficient of variation is 0.59, for which some more measures need to be considered to have a general view of the performance. Had the highest 10% of the cases not happened, the average would be 137 days, and 236 days is exceeded only 10% of the time. In 11.40% of the cases, the overall lead-time exceeds the maximum recommended by the WFP Officers (210 days).

	RR - ATA
Count	9,143
Count negative	4,789
% negative Lead-times	52%
Count positive	4,354
min	1
max	827
average	146
mode	111
mode class	84-109
st. deviation	87
coefficient of variation	0.59
9-th decile	236
Freq. higher than threshold	11.40%
Threshold	210
Uppertrimmed average	137



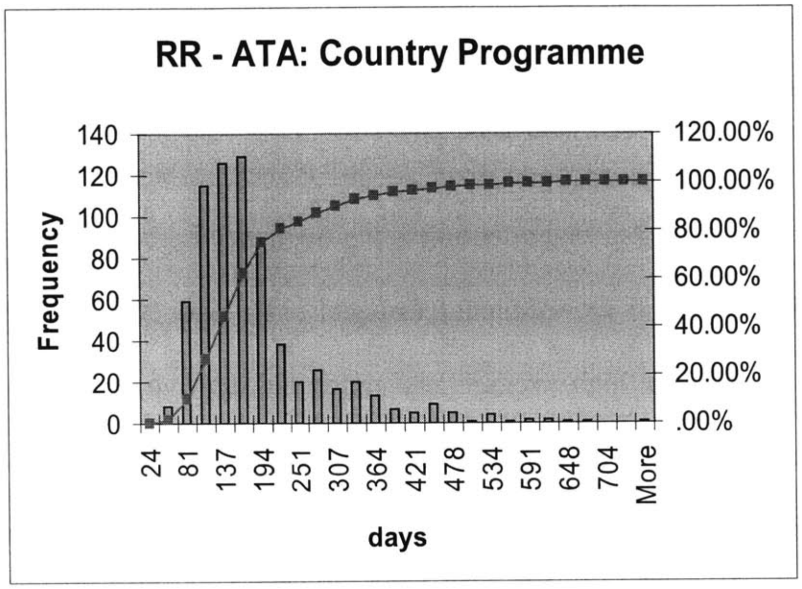
2.2.3 Project Category

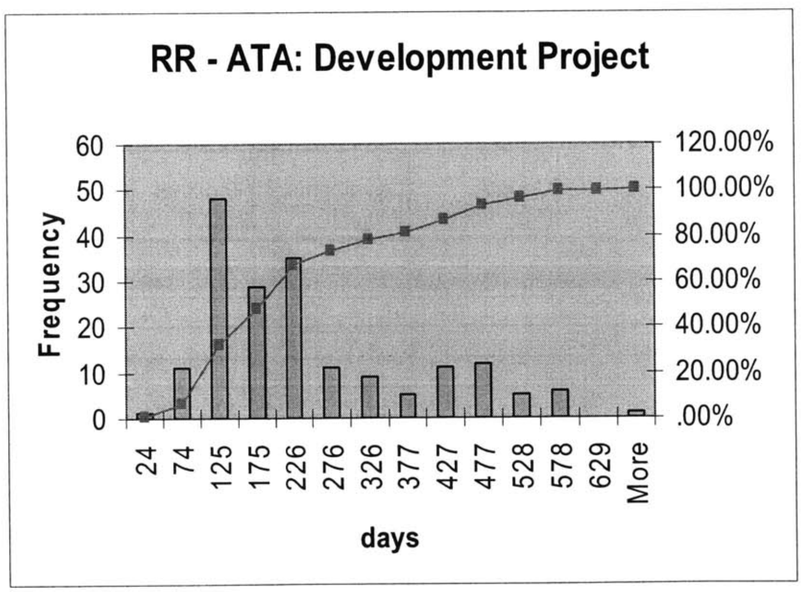
Average lead-times for Country Programmes and Development Projects exceed by far the overall average and PRRO lead-times are close to the average, whereas EMOP lead-times are the lowest of all. It is important to point here that the main reason for EMOP lead-times be the lowest is that most of the EMOP contributions require a funding proposal to be accepted by the donor before they confirm the contribution. Therefore, there is no time spent in preparing any funding proposal after RR.

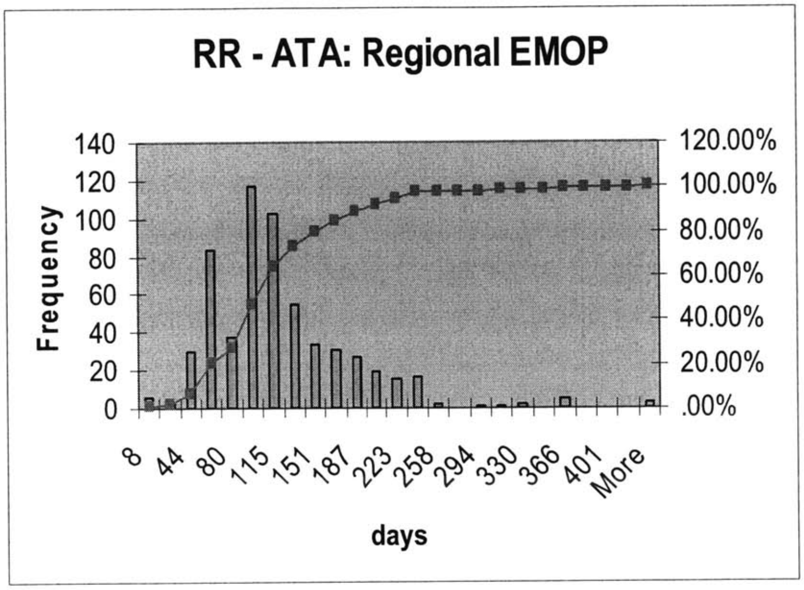
Another figure that needs special attention is the frequency higher than threshold for both Country Programmes and Development Projects (24% and 58%, respectively). These high numbers explain the high average lead-times and upper trimmed averages of these two categories, especially in the case of the Country Programmes, in which the mode is well below the average.

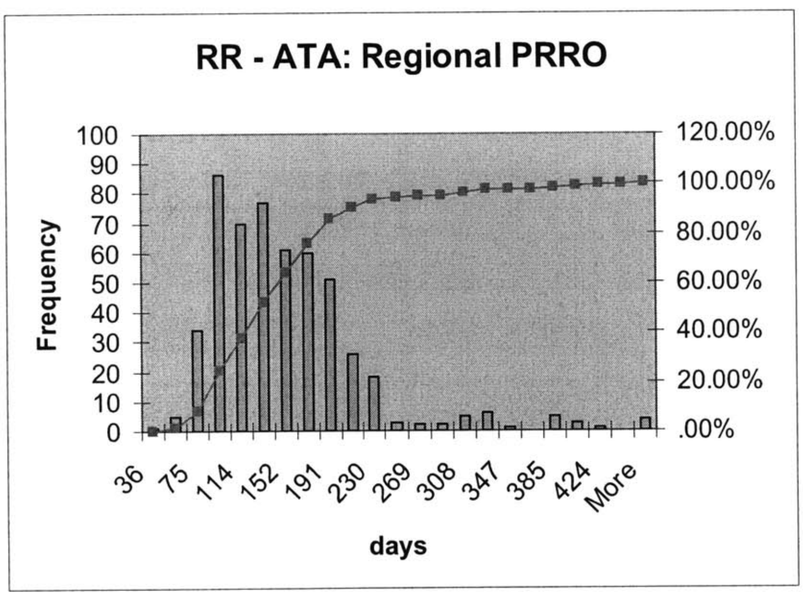
Finally, it can be inferred from the table that WFP operations are kind of evenly distributed across the different project categories, although the highest part of their efforts concentrates in Single EMOPs and PRROs.

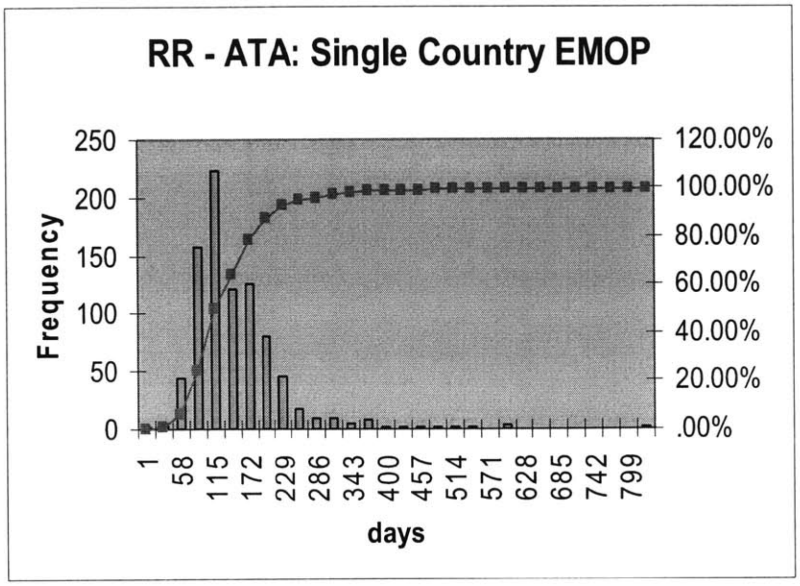
	Total	Country Programme	Development Project	Regional EMOP	Regional PRRO	Single EMOP	Single PRRO
Count	9,143	1,370	450	939	1,041	2,122	2,449
Count negative	4,789	669	266	349	520	1,261	1,213
% negative Lead-times	52%	49%	59%	37%	50%	59%	50%
Count positive	4,354	701	184	590	521	861	1,236
min	1	24	24	8	36	1	14
max	827	761	679	437	463	827	772
average	146	171	219	112	142	134	152
mode	111	114	152	86	84	88	122
mode class	84-109	151-181	100-150	88-106	123-143	100-130	90-110
st. deviation	87	101	141	61	67	75	87
coefficient of variation	0.59	0.59	0.64	0.55	0.47	0.56	0.57
9-th decile	236	312	452	190	211	215	245
Freq. higher than threshold	11%	24%	58%	7%	10%	11%	15%
Threshold	210	210	210	210	210	210	210
Uppertrimmed average	137	160	209	107	135	126	143

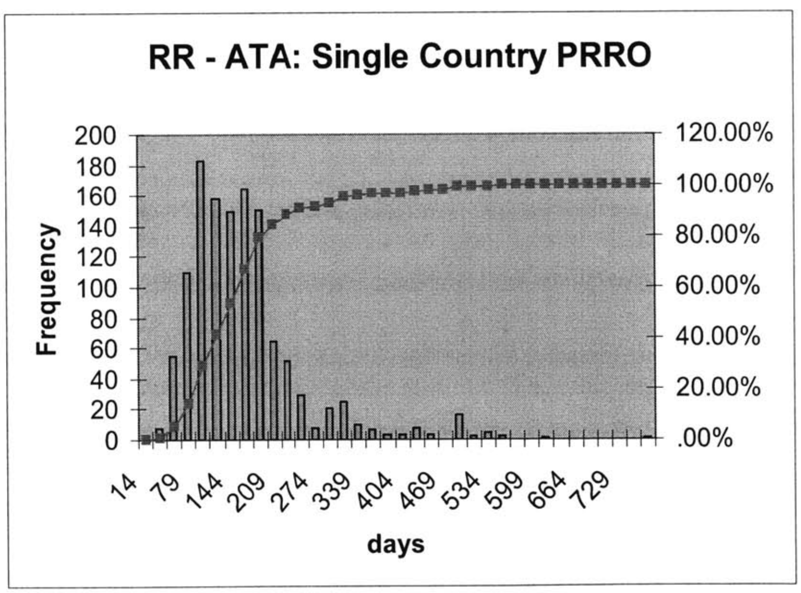

RR - ATA: Country Programme
Frequency
140
120
100
80
60
40
20
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
24
81
137
194
251
307
364
421
478
534
591
648
704
More
days


RR - ATA: Development Project
Frequency
60
50
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
24
74
125
175
226
276
326
377
427
477
528
578
629
More
days


RR - ATA: Regional EMOP
Frequency
140
120
100
80
60
40
20
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
8
44
80
115
151
187
223
258
294
330
366
401
More
days


RR - ATA: Regional PRRO
Frequency
100
90
80
70
60
50
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
36
75
114
152
191
230
269
308
347
385
424
More
days

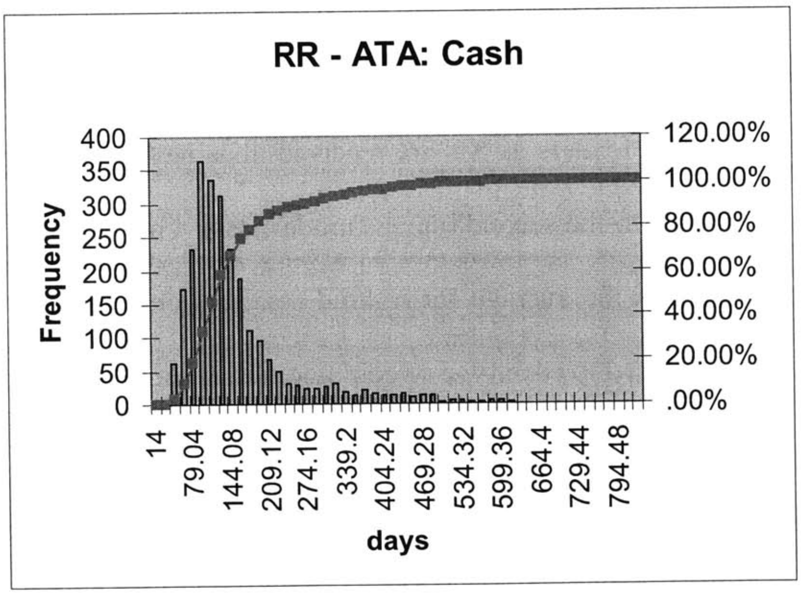

RR - ATA: Single Country EMOP
Frequency
250
200
150
100
50
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
1
58
115
172
229
286
343
400
457
514
571
628
685
742
799
days

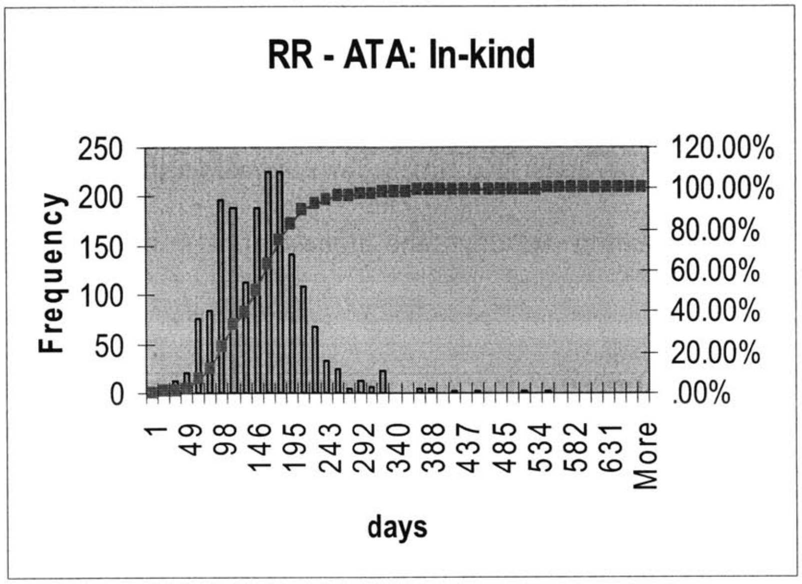

RR - ATA: Single Country PRRO
Frequency
200
180
160
140
120
100
80
60
40
20
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
14
79
144
209
274
339
404
469
534
599
664
729
days

2.2.4 Cash vs. In-kind Contributions

The difference between cash and in-kind contributions regarding the overall RR-ATA lead-time is not that clear. Whereas both average lead-times are very similar, the mode for in-kind contributions is much lower than for cash contributions. However, the mode class for in-kind contributions is much higher than for cash contributions. The reason behind this issue remains in the bimodality of the in-kind contributions. It can be observed from In-kind Figure that there are two main mode classes: the one around 86 days and the other one around 160 days. These two mode classes respond to the two commodity tendering processes that the US, the main in-kind donor as it will be shown later on, has. On one hand, for processed commodities/packed cargo, the US has its rigid procurement schedule, so the lead-time will never go below 150 days (corresponding to the main mode class). On the other hand, for non-processed commodities/bulk cargo, the US organizes commodity tenders as SIs are received, thus having a much lower overall lead-time (corresponding to the second biggest mode class). Therefore, it can be inferred from this explanation that the average for in-kind contributions will vary depending on the relative weights assigned to each type of commodities, thus, tendering processes.

	Total	Cash	In-kind
Count	9,143	5,542	3,601
Count negative	4,789	2,972	1,817
% negative Lead-times	52%	54%	50%
Count positive	4,354	2,570	1,784
min	1	14	1
max	827	827	679
average	146	146	147
mode	111	122	86
mode class	84-109	88-102	90-106
st. deviation	87	99	65
coefficient of variation	0.59	0.68	0.44
9-th decile	236	287	215
Freq. higher than threshold	11%	0.15	0.11
Threshold	210	210	210
Uppertrimmed average	137	134	143





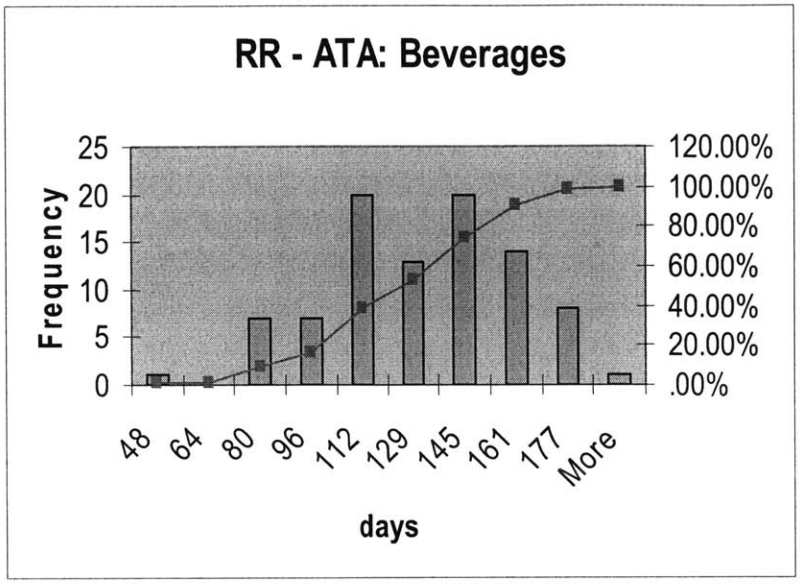
2.2.5 Commodity Category

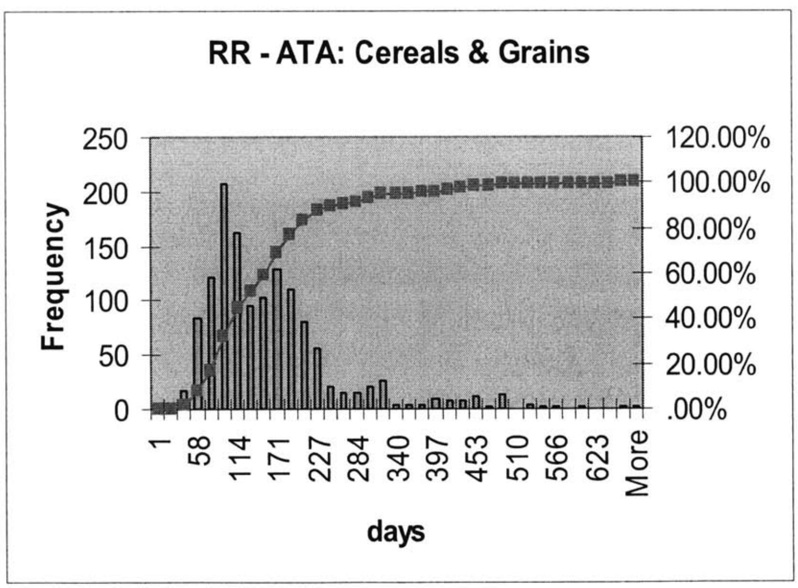
The first point to look at in these tables is the relative weight of each commodity category compared to the total amount. On one hand, cereals and grains, pulses, oil and fats and mixed and blended foods are, by far, the most delivered kind of foods, and all of them have average lead-times around 150 days. On the other hand, much less frequent commodity categories as beverages, dairy products, fruits, fish and canned meat have much lower average lead-times. In most of these last cases, the number of occasions may well be statistically insignificant, for which no general conclusions can be extracted. However, of particular interest is the 53 days on average under the fruits category. Looking inside the database, these 53 days correspond to a single-country EMOP with a shipment from Saudi Arabia to Pakistan.

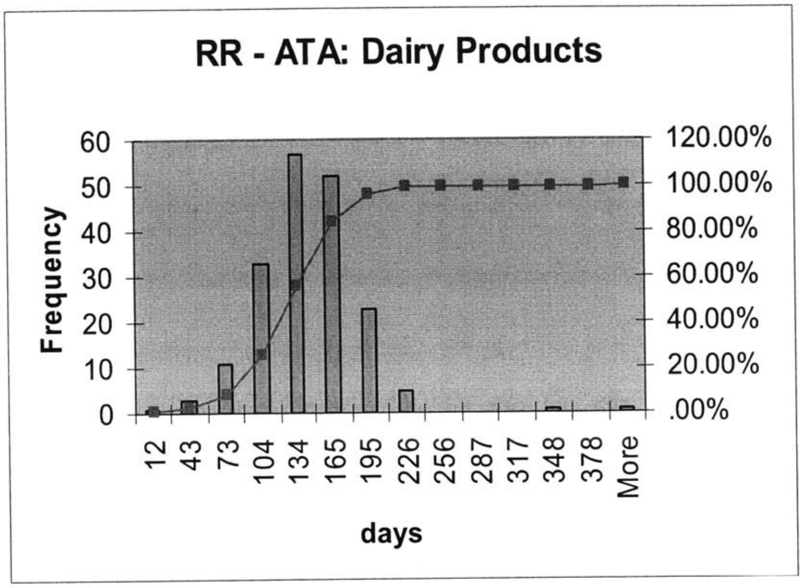
Finally, let's take a closer look to the main commodity category (cereals and grains). The mode in this case (86 days) is below the overall RR-ATA mode (111 days). But, although the most likely lead-time to happen is 86 days, the average goes up to 150 days due to the high amount of cases of very long lead-times. Two indicators that give an idea about this fact are its standard deviation (93 days, the highest of all) and the 9th percentile (265 days).

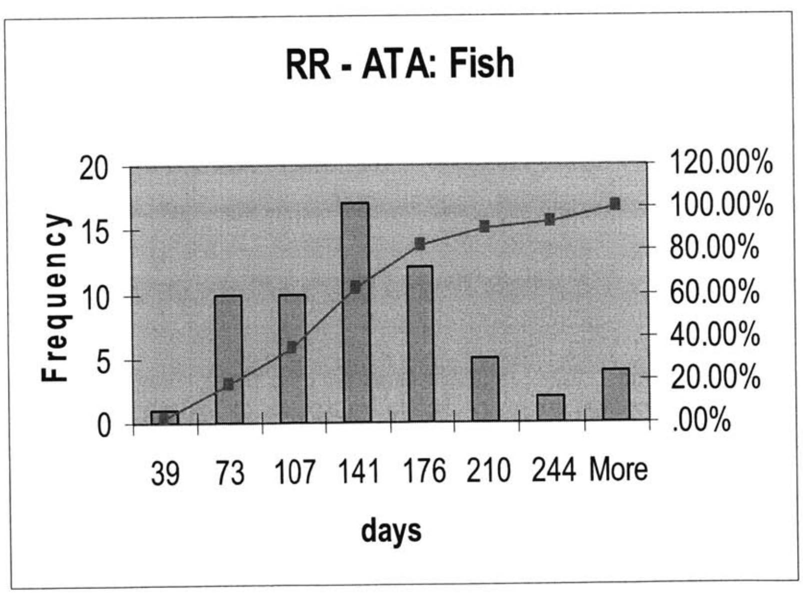
	Total	Beverages	Cereals & Grains	Dairy Products	Fruits	Fish
Count	9,143	116	2,856	372	11	133
Count negative	4,789	25	1,519	185	5	72
% negative Lead-times	52%	22%	53%	50%	45%	54%
Count positive	4,354	91	1,337	187	6	61
min	1	48	1	12	20	39
max	827	193	679	409	95	278
average	146	123	150	130	53	129
mode	111	119	86	148	#N/A	114
mode class	84-109	100-155	85-105	119-149	73-end	124-158
st. deviation	87	27	93	45	31	57
coefficient of variation	0.59	0.22	0.62	0.35	0.58	0.44
9-th decile	236	161	265	180	-	210
Freq. higher than threshold	11%	0%	16%	3%	0%	10%
Threshold	210	210	210	210	210	210
Uppertrimmed average	137	124	140	129	53	125

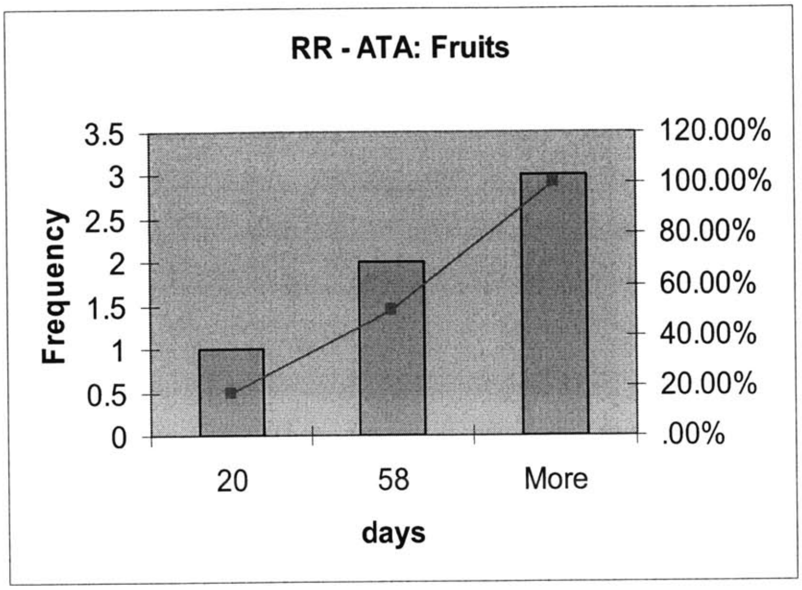
	Canned meat	Mixed and blended foods	Miscellaneous	Non-food commodities	Oil & Fats	Pulses
Count	10	1,136	593	48	1,908	1,960
Count negative	4	545	308	40	1,142	944
% negative Lead-times	40%	48%	52%	83%	60%	48%
Count positive	6	591	285	8	766	1,016
min	41	27	36	20	13	8
max	129	601	590	113	772	827
average	93	154	124	81	145	153
mode	84	124	92	101	89	98
mode class	100-end	159-183	88-122	87-more	115-135	154-180
st. deviation	31	84	75	31	86	91
coefficient of variation	0.33	0.54	0.60	0.39	0.59	0.60
9-th decile	-	245	193	-	238	246
Freq. higher than threshold	0%	18%	9%	-	14%	14%
Threshold	210	210	210	210	210	210
Uppertrimmed average	93	145	114	81	135	143

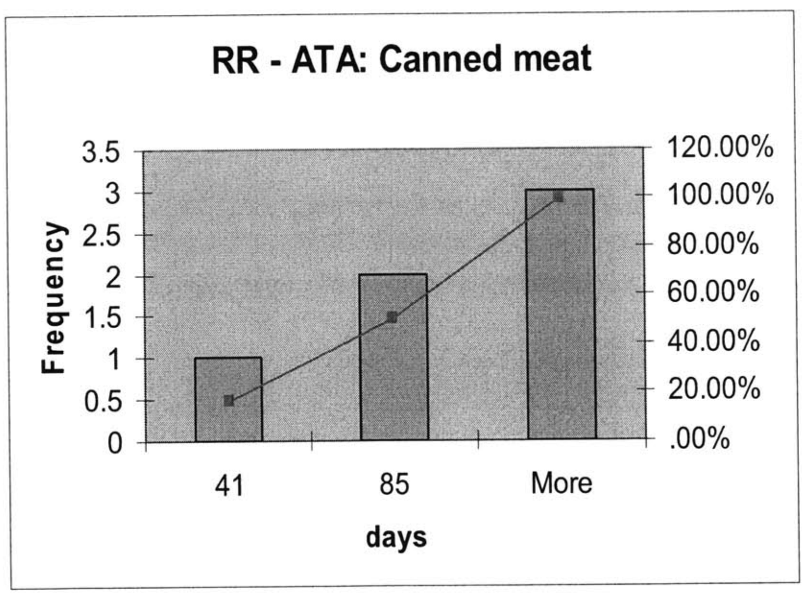

RR - ATA: Beverages
Frequency
25
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
48
64
80
96
112
129
145
161
177
More
days

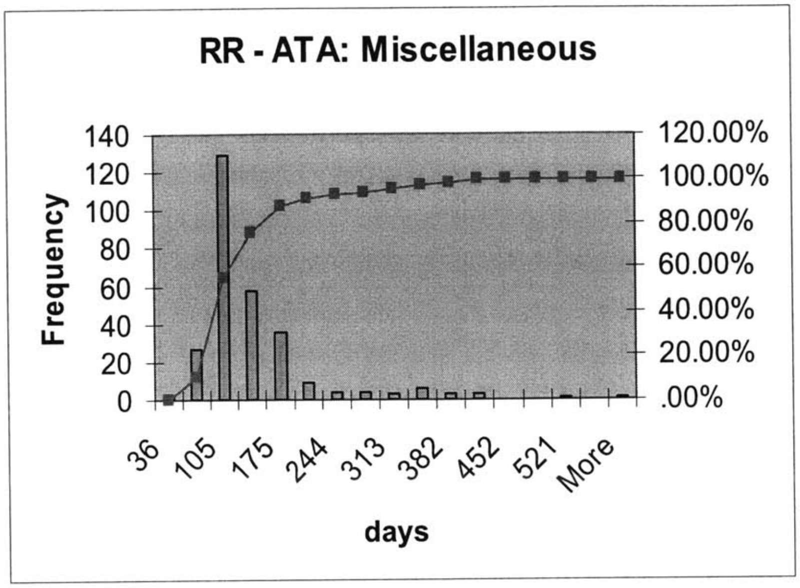

RR - ATA: Cereals & Grains
Frequency
250
200
150
100
50
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
1
58
114
171
227
284
340
397
453
510
566
623
More
days

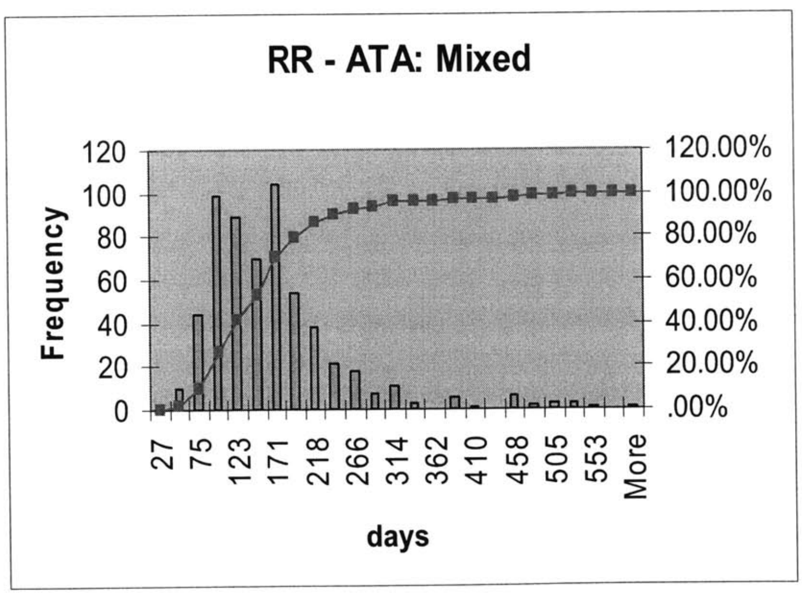

RR - ATA: Dairy Products
Frequency
60
50
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
12
43
73
104
134
165
195
226
256
287
317
348
378
More
days

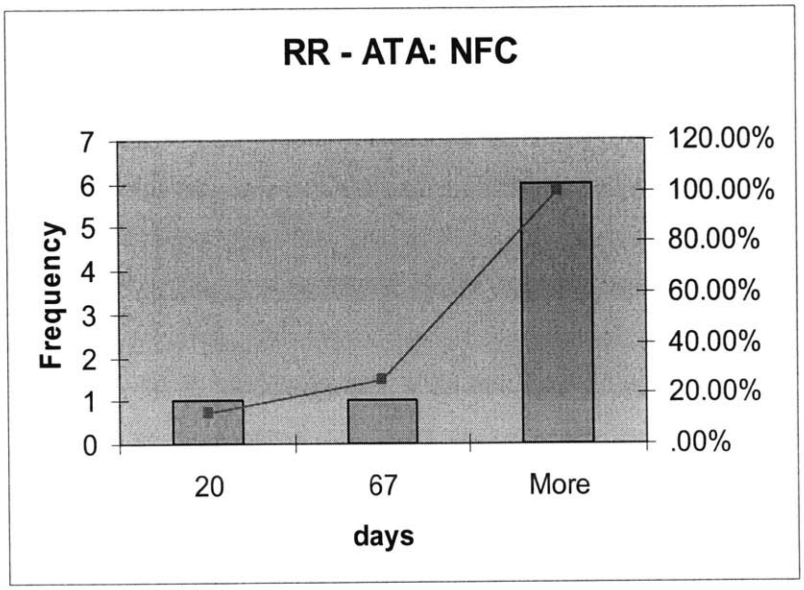

RR - ATA: Fish
Frequency
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
39
73
107
141
176
210
244
More
days


RR - ATA: Fruits
3.5
3
2.5
2
1.5
1
0.5
0
Frequency
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
20
58
More
days

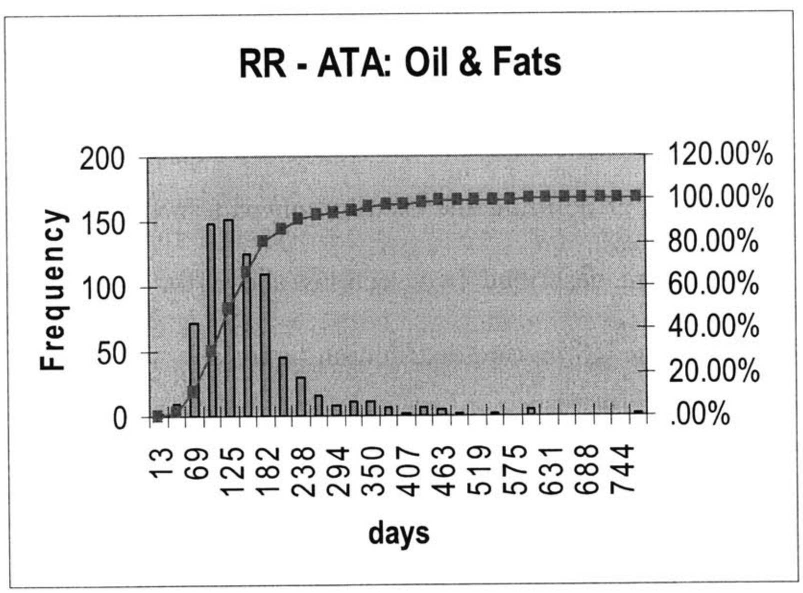

RR - ATA: Canned meat
3.5
3
2.5
2
1.5
1
0.5
0
Frequency
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
41
85
More
days


RR - ATA: Miscellaneous
Frequency
140
120
100
80
60
40
20
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
36
105
175
244
313
382
452
521
More
days

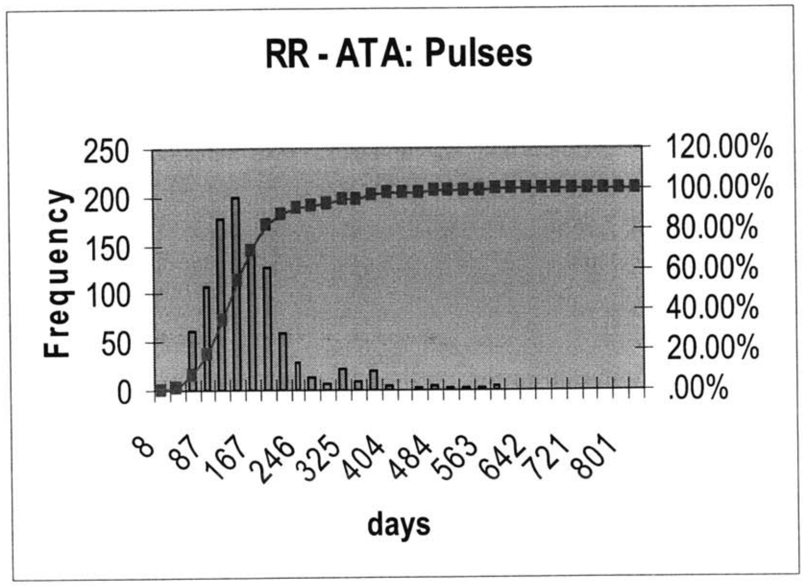

RR - ATA: Mixed
Frequency
120
100
80
60
40
20
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
27
75
123
171
218
266
314
362
410
458
505
553
More
days



RR - ATA: NFC
Frequency
days
20
67
More
0
1
2
3
4
5
6
7
.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%



RR - ATA: Oil & Fats
Frequency
days
0
50
100
150
200
.00%
20.00%
40.00%
60.00%
80.00%
100.00%
120.00%
13
69
125
182
238
294
350
407
463
519
575
631
688
744



2.2.6 In-kind Donors

When it comes down to analyze which in-kind donors are the higher contributors from all, it appears to be clear that the US is the biggest by far. Summarizing the last 4 years of the available data, US in-kind donations account for 83% of all the in-kind donations and for about one third of all the donations (cash and in-kind). Therefore, US performance in these types of donations is defining the distribution pattern of in-kind donations as a whole (see In-kind Figure described two sections above for a full description of the bimodality observed on the US in-kind distribution figure).

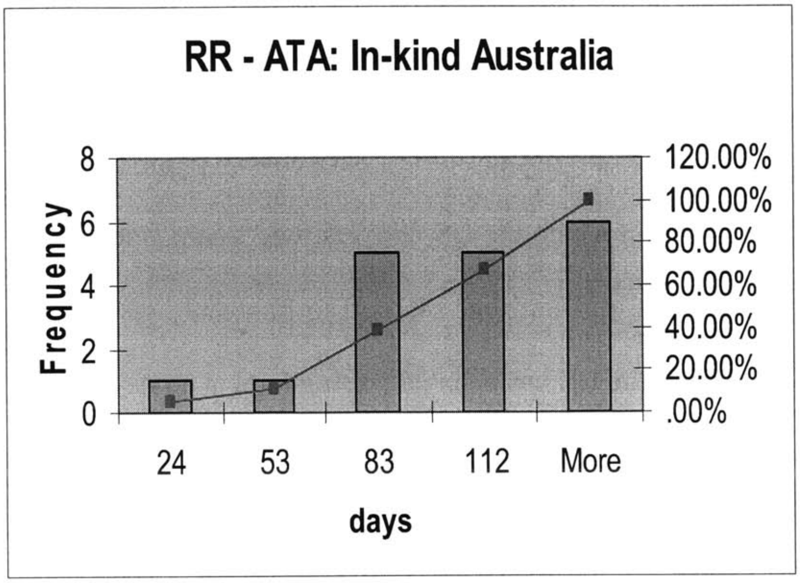
Being aware that another point of interest is the "real" contribution of the donors in terms of tons delivered, this study has also computed these amounts. They are shown in Table 1.

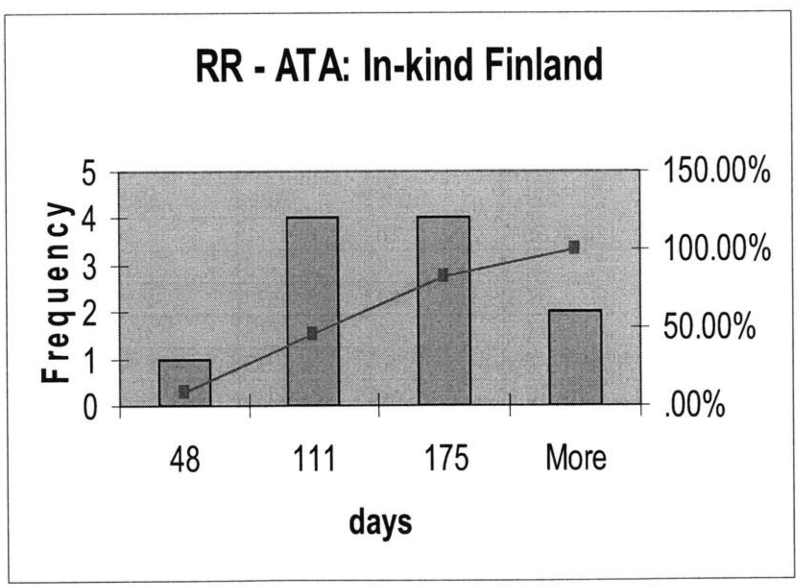
Australia and the US are the biggest contributors in terms of tons delivered (in fact, in terms of tons carried in the vessels, since this part of the study followed the commodities until the port of discharge and not until the final delivery point). In order to get a flavor about the frequency within which the US delivers food to any one country, let's consider the total amount of 5.545 million tons of food to be evenly distributed in the four (4) years of data. Therefore, the US has been delivering food at a rate of 3,800 tons per day.

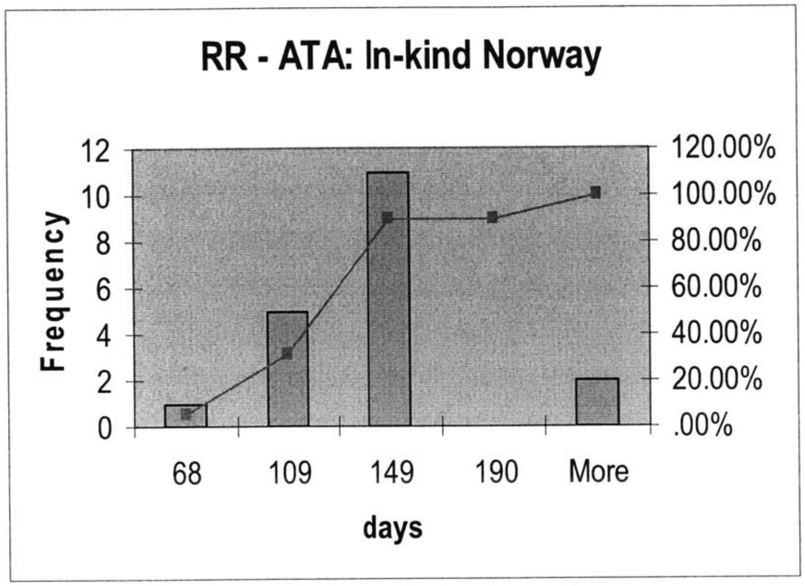
In-kind donors	NET (T)
Austria	1,279
Switzerland	3,077
Norway	4,929
Finland	7,756
India	7,970
Canada	11,705
Australia	117,747
United States	5,545,594

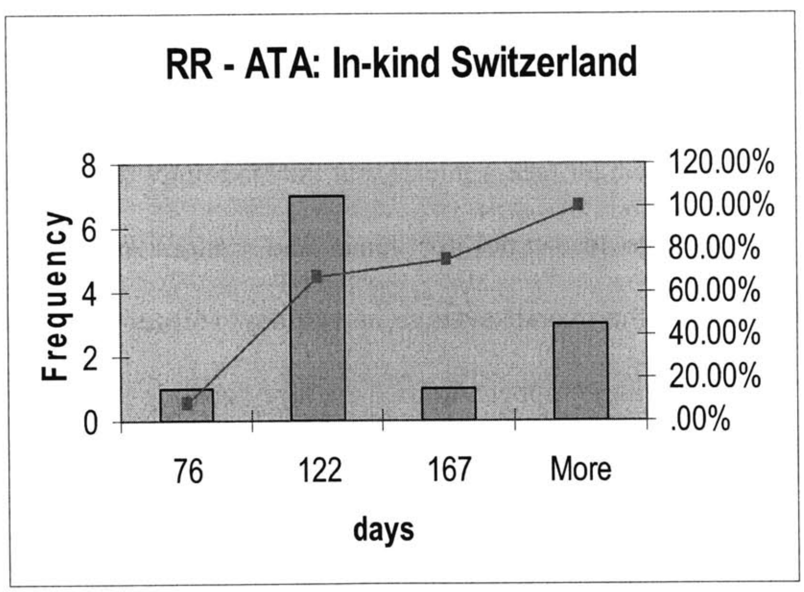
Table 1. In-kind contributions in tons

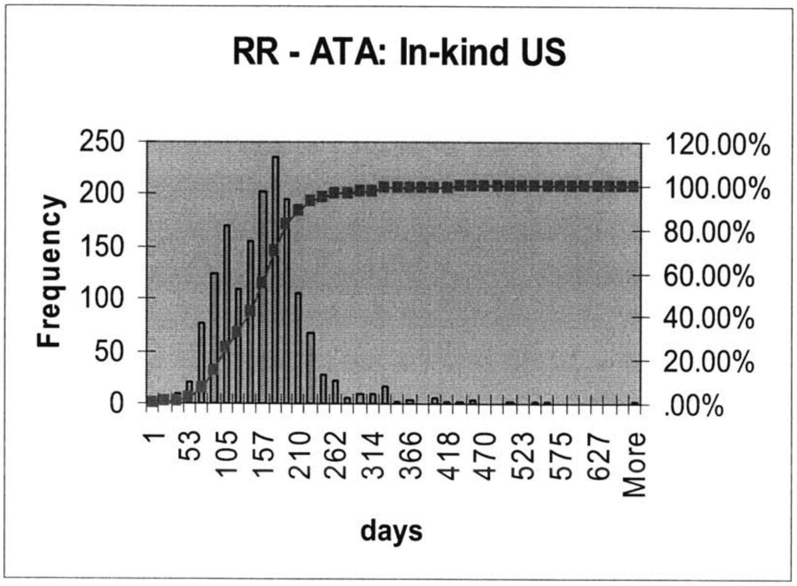
	Total	Australia	Finland	Norway	Switzerland	USA
Count	9,143	52	45	28	24	2,986
Count negative	4,789	34	34	9	12	1,397
% negative Lead-times	52%	65%	76%	32%	50%	47%
Count positive	4,354	18	11	19	12	1,589
min	1	24	48	68	76	1
max	679	141	238	230	213	679
average	147	94	123	121	125	151
mode	86	96	133	114	#N/A	86
mode class	90-106	127-more	80-205	129-169	100-140	167-183
st. deviation	65	30	58	42	46	64
coefficient of variation	0.44	0.32	0.47	0.35	0.37	0.43
9-th decile	215	-	-	149	-	218
Freq. higher than threshold	11%	0%	5%	10%	1%	11%
Threshold	210	210	210	210	210	210
Uppertrimmed average	143	94	123	121	125	147


RR - ATA: In-kind Australia
Frequency
8
6
4
2
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
24
53
83
112
More
days


RR - ATA: In-kind Finland
Frequency
5
4
3
2
1
0
150.00%
100.00%
50.00%
.00%
48
111
175
More
days


RR - ATA: In-kind Norway
12
10
8
6
4
2
0
Frequency
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
68
109
149
190
More
days


RR - ATA: In-kind Switzerland
8
6
4
2
0
Frequency
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
76
122
167
More
days



2.2.7 Cash Donors

In this case, all the cash contributions are spread over a larger amount of donors than in the in-kind contributions – the 16 donor countries/regions shown below account for almost 70% of all the cash contributions. Japan, Canada and the US are the three biggest cash contributors from them all (see Table 2), but the lead times differ substantially from one another. The average lead-times for Japan and Canada are 162 and 156 days, respectively, well above the overall average of 146 days; however, this same lead-time for the US is 105 days, with an upper trimmed average equaling 95 days, thus giving the idea that exceptional events do not tend to occur under US control.

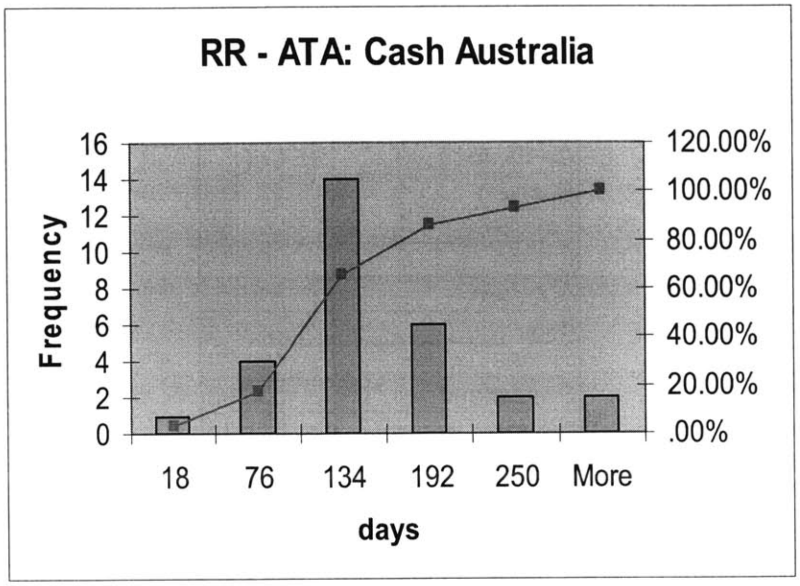
A particular mention needs to be done regarding the highest and the lowest average lead-times from all. On the high side, Belgium's 328 days (a 125% over the overall average) raises a red flag on the procedures and the restrictions that may be imposed by this country. On the low side, European Community Humanitarian Office's (ECHO) 99 days with a low 33 days for standard deviation indicate the efficiency under the ECHO.

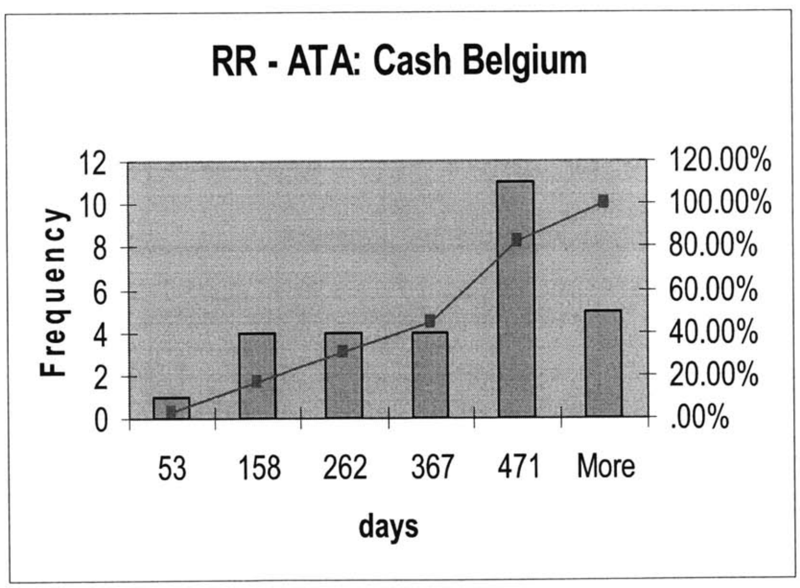
Cash donors	NET (T)
Belgium	18,018
Finland	22,250
Ireland	25,419
Australia	27,056
Italy	43,674
France	49,191
Switzerland	53,093
Norway	62,518
ECHO	80,239
Denmark	105,654
Sweden	115,882
Netherlands	131,859
Germany	138,284
United States	251,974
Canada	375,662
Japan	463,998

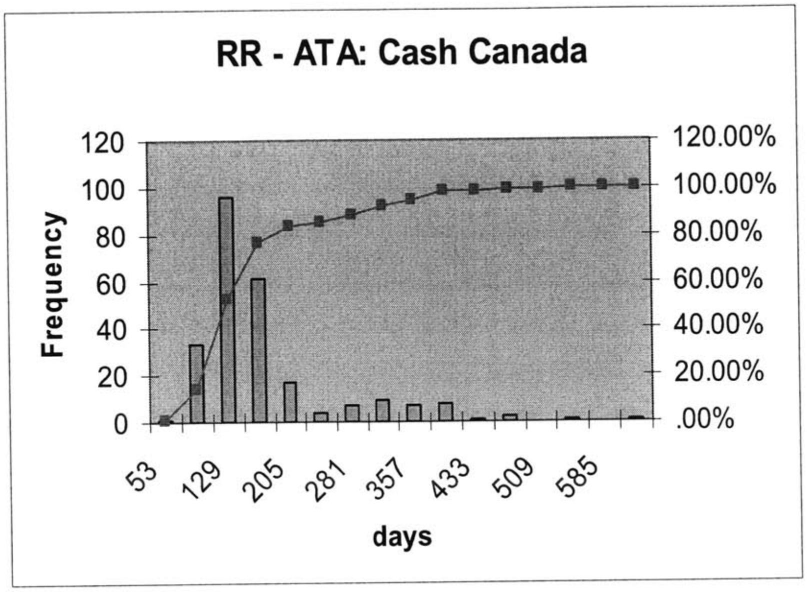
Table 2. Cash contributions in tons

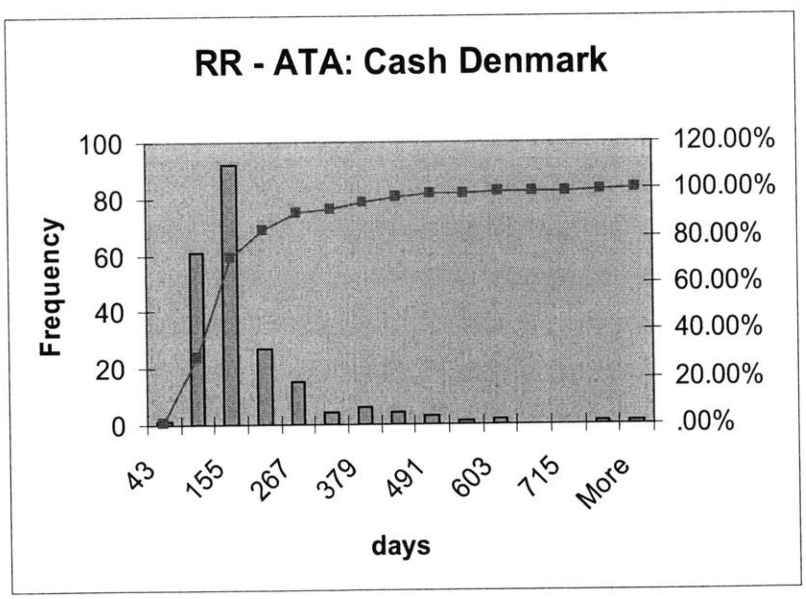
	Total	Australia	Belgium	Canada	Denmark	ECHO	Finland	France
Count	9,143	65	49	495	471	142	91	106
Count negative	4,789	36	19	247	253	82	42	53
% negative Lead-times	52%	52%	52%	52%	52%	52%	52%	52%
Count positive	4,354	29	30	248	218	60	49	53
min	14	18	53	53	43	49	27	30
max	827	308	576	623	827	179	588	485
average	146	123	328	156	158	99	130	151
mode	122	135	288	96	102	57	131	132
mode class	88-102	104-164	421-521	109-149		76-96	67-147	103-190
st. deviation	99	65	146	89	113	33	113	127
coefficient of variation	0.68	0.53	0.45	0.57	0.71	0.33	0.87	0.84
9-th decile	287	222	525	300	267	152	227	420
Freq. higher than threshold	15%	11%	76%	16%	0%	0%	11%	10%
Threshold	210	210	210	210	210	210	210	210
Uppertrimmed average	134	120	329	147	143	98	115	142

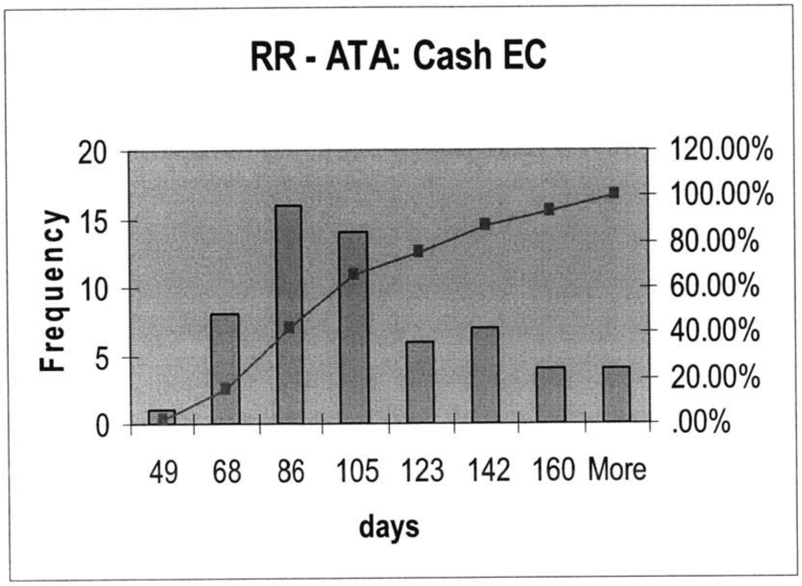
	Germany	Ireland	Italy	Japan	Netherlands	Norway	Sweden	Switzerland	US
Count	290	92	170	477	359	132	329	195	313
Count negative	140	49	59	300	185	67	153	87	207
% negative Lead-times	52%	52%	52%	52%	52%	52%	52%	52%	52%
Count positive	150	43	111	174	174	65	176	108	106
min	22	47	53	14	41	49	41	35	54
max	500	411	659	526	772	591	601	477	463
average	161	151	183	162	145	183	119	153	105
mode	106	188	87	187	106	93	89	95	72
mode class	82-122	138-198	84-144	191-231	72-122	82-152	107-147	103-143	75-115
st. deviation	103	84	140	91	109	127	90	98	66
coefficient of variation	0.64	0.56	0.76	0.56	0.75	0.69	0.76	0.64	0.62
9-th decile	321	210	417	290	296	359	213	322	130
Freq. higher than threshold	23%	10%	27%	20%	28%	28%	10%	25%	3%
Threshold	210	210	210	210	210	210	210	210	210
Uppertrimmed average	152	143	170	156	132	170	105	146	95

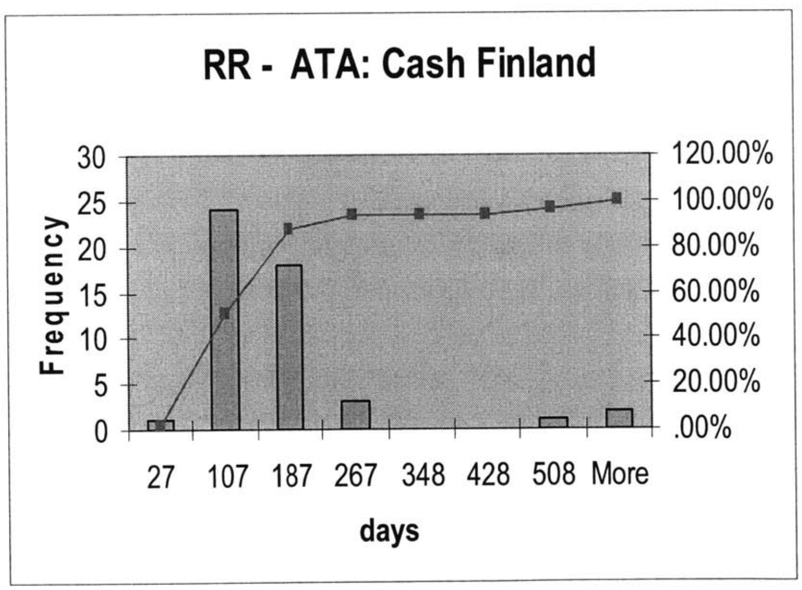

RR - ATA: Cash Australia
Frequency
16
14
12
10
8
6
4
2
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
18
76
134
192
250
More
days

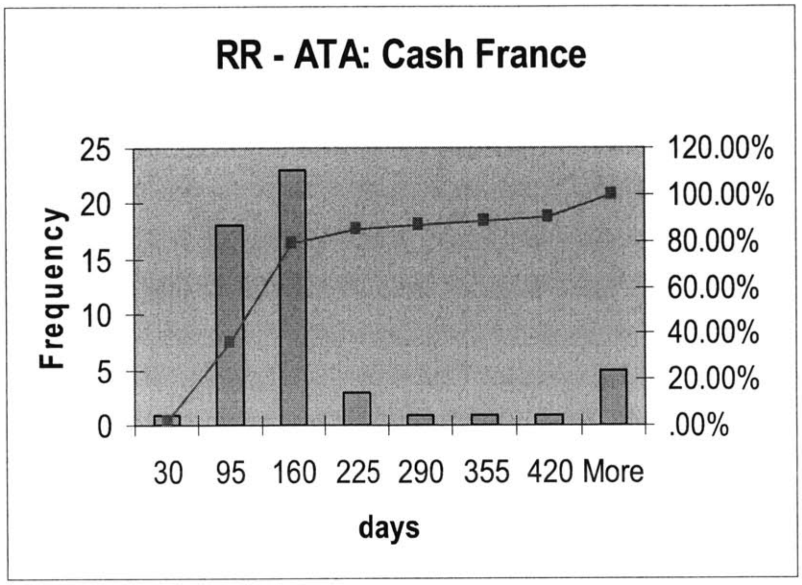

RR - ATA: Cash Belgium
Frequency
12
10
8
6
4
2
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
53
158
262
367
471
More
days

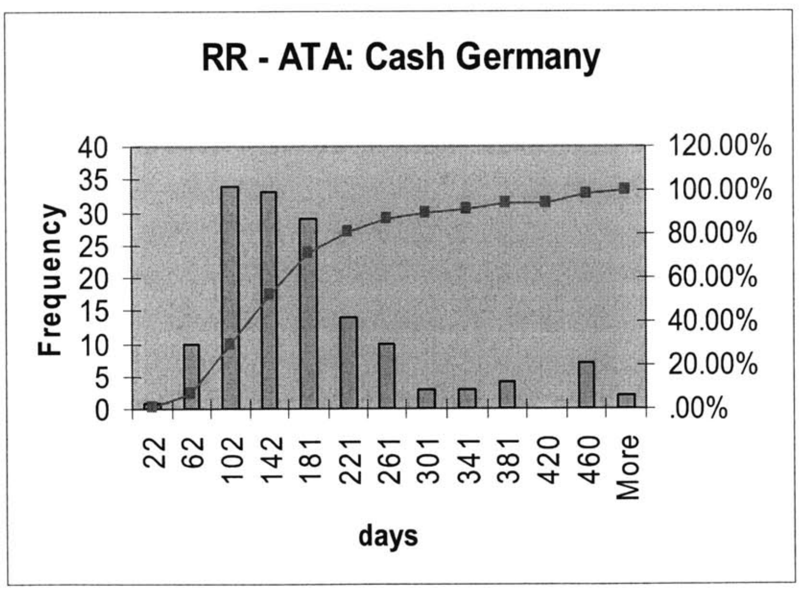

RR - ATA: Cash Canada
Frequency
120
100
80
60
40
20
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
53
129
205
281
357
433
509
585
days

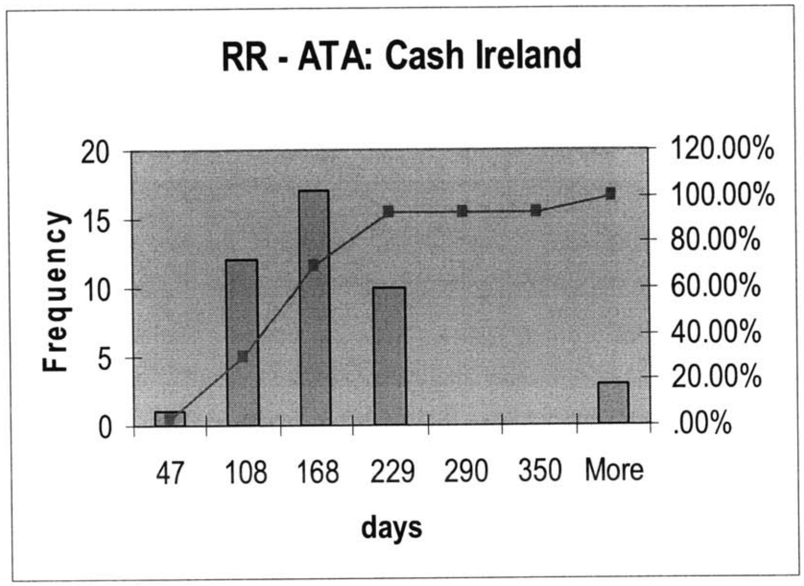

RR - ATA: Cash Denmark
Frequency
100
80
60
40
20
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
43
155
267
379
491
603
715
More
days

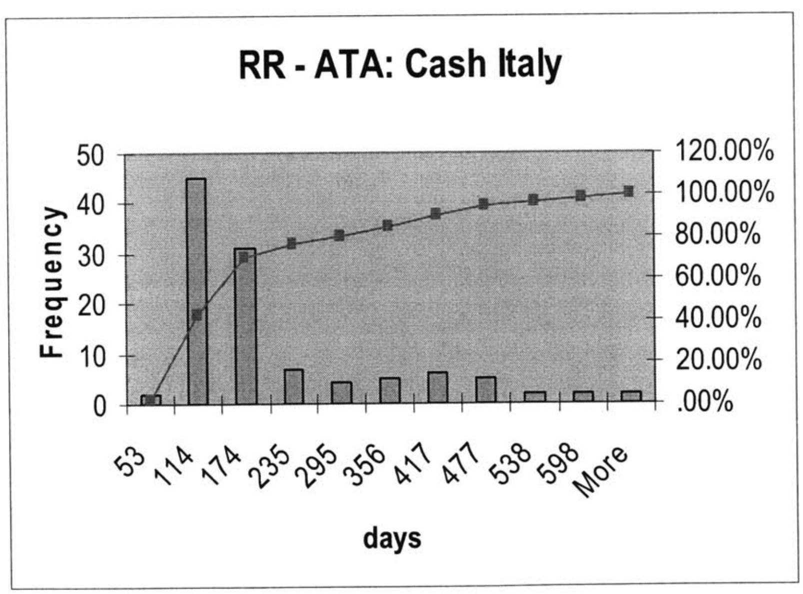

RR - ATA: Cash EC
Frequency
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
49
68
86
105
123
142
160
More
days

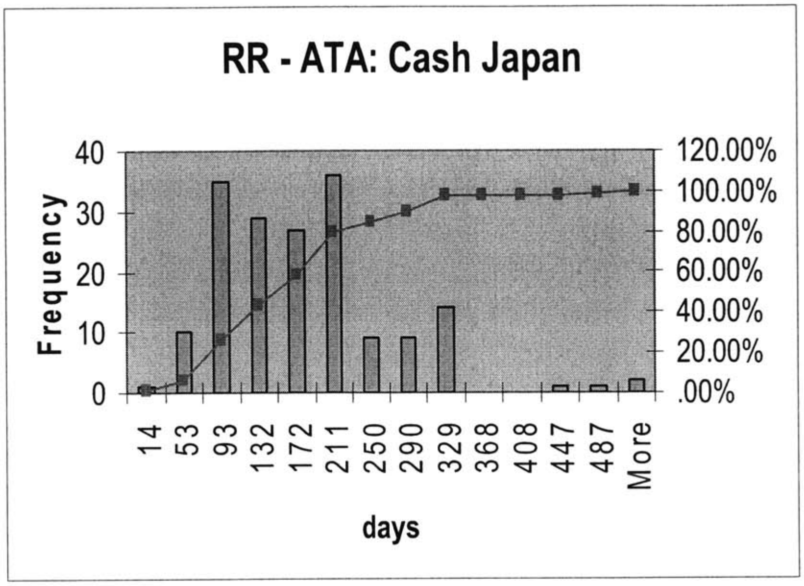

RR - ATA: Cash Finland
Frequency
30
25
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
27
107
187
267
348
428
508
More
days

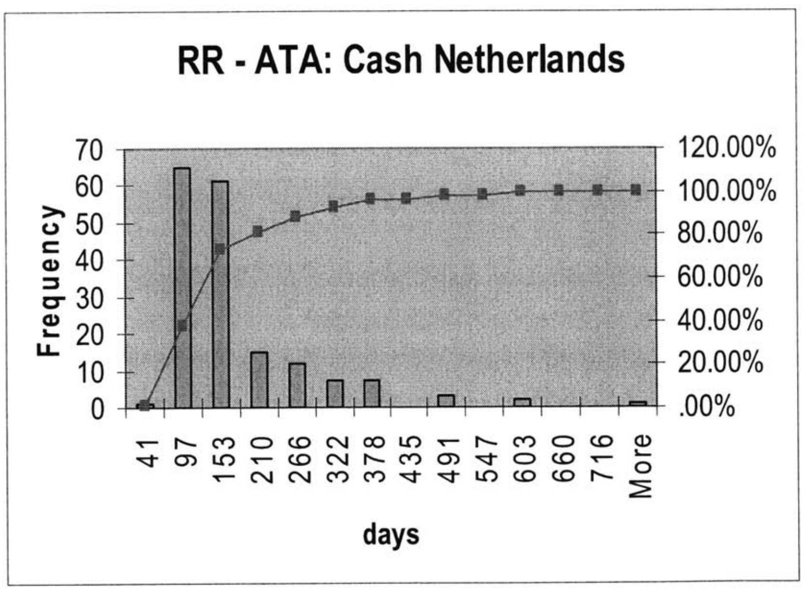

RR - ATA: Cash France
Frequency
25
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
30
95
160
225
290
355
420
More
days

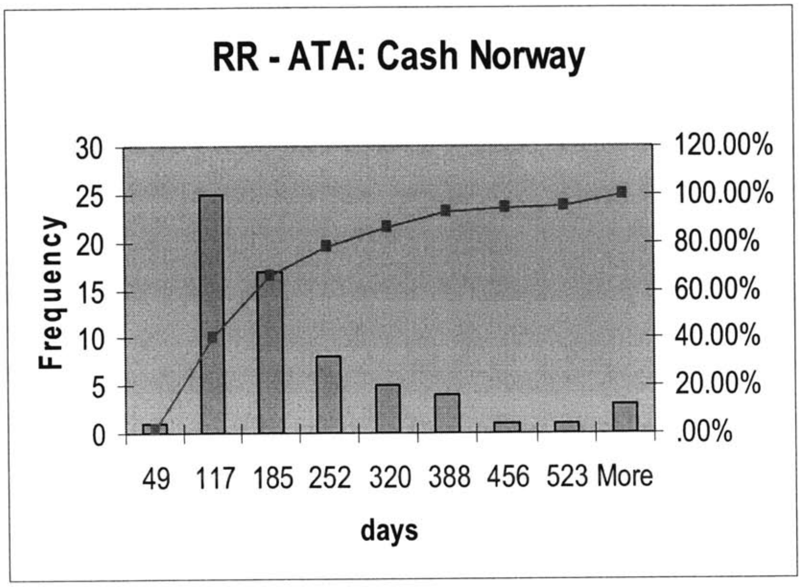

RR - ATA: Cash Germany
Frequency
40
35
30
25
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
22
62
102
142
181
221
261
301
341
381
420
460
More
days

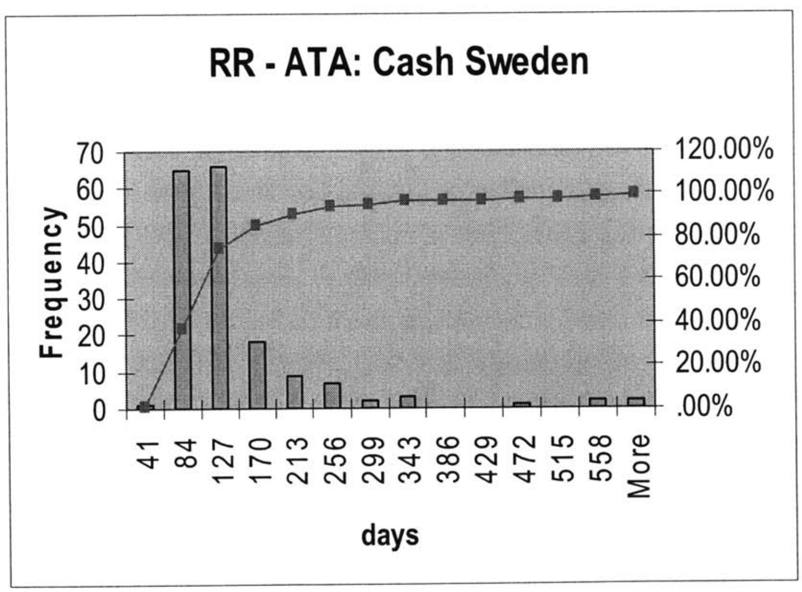

RR - ATA: Cash Ireland
Frequency
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
47
108
168
229
290
350
More
days

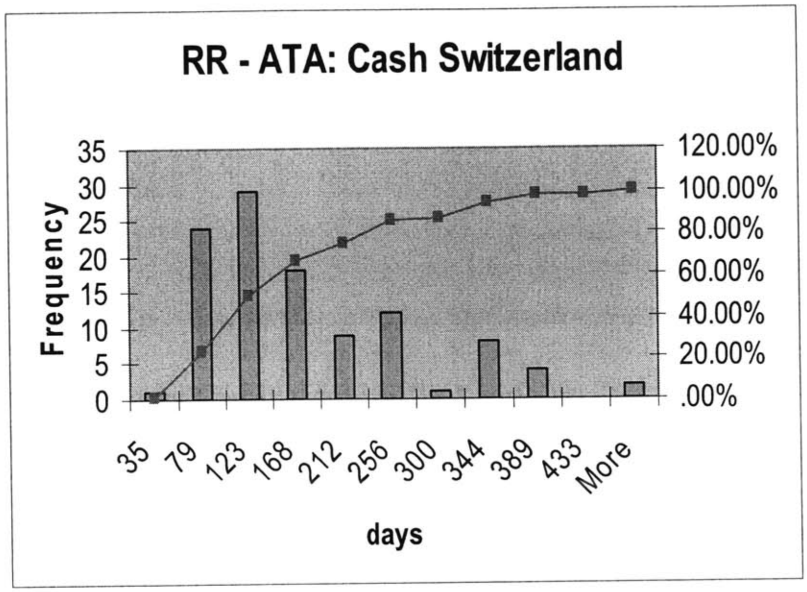

RR - ATA: Cash Italy
Frequency
50
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
53
114
174
235
295
356
417
477
538
598
More
days

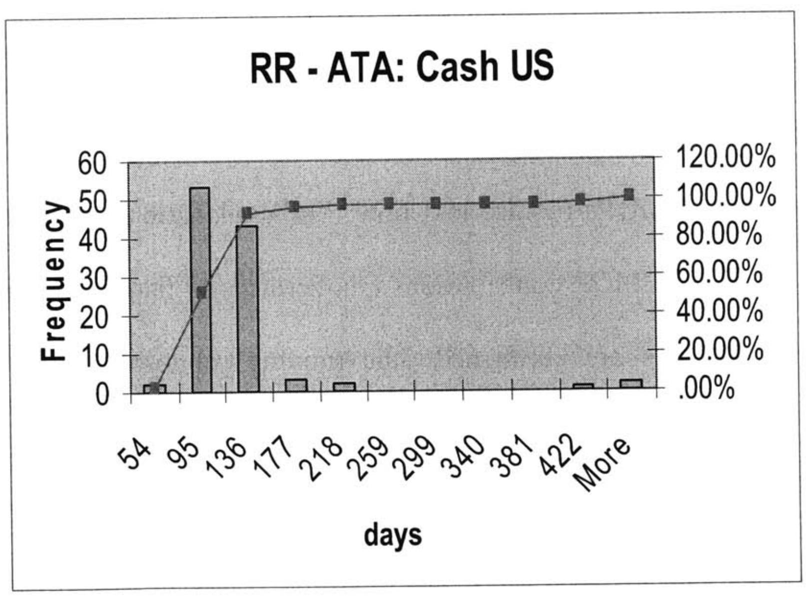

RR - ATA: Cash Japan
Frequency
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
14
53
93
132
172
211
250
290
329
368
408
447
487
More
days


RR - ATA: Cash Netherlands
Frequency
70
60
50
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
41
97
153
210
266
322
378
435
491
547
603
660
716
More
days


RR - ATA: Cash Norway
Frequency
30
25
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
49
117
185
252
320
388
456
523
More
days


RR - ATA: Cash Sweden
Frequency
70
60
50
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
41
84
127
170
213
256
299
343
386
429
472
515
558
More
days


RR - ATA: Cash Switzerland
Frequency
35
30
25
20
15
10
5
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
35
79
123
168
212
256
300
344
389
433
More
days


RR - ATA: Cash US
Frequency
60
50
40
30
20
10
0
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
.00%
54
95
136
177
218
259
299
340
381
422
More
days

2.3 Conclusions

It is time to recapitulate the main findings from the statistical analysis on the WFP commodity pipeline.

The overall average lead-time from RR to ATA is 146 days. Its standard deviation, 87 days, leads the coefficient of variation to 0.59, for which other statistical measures need to be looked at for a deeper understanding of the lead-time distribution pattern. Those are the 9th percentile, 236 days, and the upper trimmed average, 137 days. In fact, this last number coincides with the proposal from a consultancy project that was being carried out in July 2005 by the Boston Consulting Group. Their project was trying to re-organize the organization structure and business procedures so that the overall lead-time was 137 days, the same amount of time had not happened the highest 10% of the cases.

Development Projects, Country Programmes and PRROs require longer lead-times than the average, whereas EMOPs require less time. The explanation behind these results is that the majority of the EMOP contributions are directed, so that programming can start as soon as contributions are confirmed –the funding proposals have been prepared beforehand.

Cash and in-kind contributions have very similar average lead-times, but in-kind donations have a much slower mode –although there are two main mode classes, the higher one being by the 160 days.

With regard to commodity categories, beverages, dairy products, fruits, fish, canned meat and miscellaneous have significant lower lead-times than the average, although most of the cases are statistically insignificant. On the other hand, the main commodity categories involved in the WFP commodity pipeline, cereals and grains, mixed and blended products, oil products and pulses require longer lead-times than the average.

Finally and, regarding the donors, Australia, Finland, Norway, ECHO, Switzerland and the US (for cash contributions) have lower lead-times than the average, whereas Japan, Germany, Italy, Canada and the US (for in-kind contributions) have higher lead-times than the average.

3. Focus on Second Half of WFP Commodity Pipeline

The first part of this thesis has focused on the description of the business steps in the WFP supply chain and has performed a deep statistical analysis on the lead-times from the moment donor contribution is confirmed until the food reaches the port of discharge.

Clearly, the supply chain does not finish in this point; rather, food needs to be delivered from the port of discharge to the final Implementing Partner (IP) (e.g. NGOs, government agencies), who will take care of the food until the final end users (e.g. schools, towns). This thesis moves into this second part of the supply chain with the purpose of providing Country Officers with a statistical study on the lead-times from the port of discharge until the IPs on one hand, and with some controlling parameters as for their inventory management purposes, on the other.

This analysis of the lead-times in the overland transportation has never been performed before due to various different reasons: 1) the high number of uncertainties and peculiarities within the country where the overland transport is performed (e.g. transport infrastructure, security situation, transport capacity or administrative procedures), 2) the need of the direct implication of Country Officers in these studies, since their expertise and knowledge is crucial in the understanding of the whole situation, and 3) the lack of time in the CO to perform these kind of studies. However, the aim of this study is to serve as an academic exercise that represents the starting point in the analysis of the second half of the supply chain. It tries to initiate a way of thinking about the possibilities embodied in such big data warehouses as for the learning process.

3.1 Theoretical Approach to Inventory Policies

Before proceeding on the statistical analysis of the lead-times in the second half of the WFP commodity pipeline and the inventory policy proposed in this thesis (and for which countries the analysis has been performed), let's explain a little bit which kind of inventory policies are commonly described in the academic books, what the main characteristics are for each one of them and which one of those is currently being used in WFP.

One of the first questions to answer regarding inventory policy is how often inventory levels should be checked or how long the time between two moments where the inventory status is known should be. Two different solutions arise to answer this question.

One way to do it is with continuous review; that is, the inventory status is known at each moment and, thus, corrective measures and actions could be undertaken at any time. However, continuous review needs to be understood as a system in which every transaction (receipt, shipment, etc.) updates the status; thus, continuous review needs specialized software and tracking systems so that the update is fast and efficient. A classical example of this kind is any retail business in which bar codes are used to track which inventory has been received and which one has been sold.

The other way to do it is with periodic review; that is, the inventory status is known only when an exhaustive counting is undertaken. Therefore, the stock units at any time between the counting moments are uncertain. In this case, the use of computerized systems is not imperative. A classical example of this kind is the soda machine in-campus, which is replenished once per week, only when the soda man comes for replenishment.

There are some advantages and disadvantages for both systems. The main advantages for periodic review are threefold: first, it implies a rhythmic ordering process for which a prediction of the staff and resources may be easy (from the supplier point of view, this option is very appealing because they can plan ahead the resources that will be needed in the future); second, it does not need any complex electronic devices and computerized systems and therefore, it is cheaper; third, a physical review of the stock is mandatory, whereas in the continuous case, the review is optional. However, the main disadvantage for the periodic review is that safety stock levels (to be described later on this chapter) are higher than for continuous review and so are carrying costs, for a certain service level. For the case of large volume inventories, these costs may be very important.

There are two kinds of control systems within the continuous and periodic review options: a) the order-point, order-quantity system (s, Q), b) the order-point, order-up-to-level system (s, S), c) the periodic-review, order-up-to-level system (R, S) and d) the (R, s, S) system. Control systems *a* and *b* assume continuous review whereas *c* and *d* assume periodic review. Let's briefly describe each one of them.

a) The order-point, order-quantity system (s, Q): this is a continuous review system. It consists of ordering Q items every time the inventory is at a level s or below. The main advantages of this system are its simplicity and its quantity predictability from the supplier point of view (although they do not know when they will have to ship it). The main disadvantage is that the selection of Q is critical, since it should be chosen to minimize costs, and its best value is difficult to calculate.

b) The order-point, order-up-to-level system (s, S): again, this is a continuous review system. In this case, every time the inventory status is at level s or below, an order is issued to reach the level S in the inventory. Therefore, the order quantity is going to be a variable, depending on how distant from level s the inventory is at that particular moment. This issue may be a disadvantage from the supplier point of view, since they would prefer a fixed order. The (s, S) is frequently used in practice, although the parameters may be chosen in an arbitrary way. In most cases though, there is not an optimal value for those parameters (that minimize the overall costs) and reasonable values should be chosen.

c) The periodic-review, order-up-to-level system (R, S): this is a periodic review system, and consists of ordering up to the level *S* every *R* times. This system is commonly used when computerized control is not in place. It is also used when complex and multilateral coordination is required, since periodic review gives time to different suppliers to plan for the work and do it in a more efficient way. The main drawback of this system is its associated costs, which are the highest from all.

d) (R, s, S) system: this system can be seen as an (s, S) with a periodic perspective. That is, every *R* times, the inventory is checked. If it is at the *s* level or below, an order up to the *S* level is issued. Otherwise, no action is undertaken. Finding the optimal parameter values (that would give the minimum costs of all four systems) requires a high computational effort. Instead, reasonable values are usually provided.

3.2 Inventory Policy at WFP Country Offices

As it was explained in case *c*, periodic reviews allow a better coordination among different parties than continuous reviews do. Because the scope of work of WFP activities involves parties from all over the world with deliveries to more than 80 different countries spread everywhere, coordination is the first and main concept that must be achieved.

Thus, the inventory policy at WFP Country Offices is based on a periodic review system, but with a continuous review system infrastructure. The solution that WFP chooses in their COs is a very deterministic one; they order every R times a fixed quantity Q.[2] This periodic ordering process seems to be chosen to minimize all the uncertainty in the planning process, especially for suppliers, but the fact that the ordering quantity is also fixed implies that inventory levels are not checked at that moment. However, this information could be extracted from their information systems tools, since all receipts and deliveries are tracked down as in a continuous review system. Clearly, their solution implies high costs, but it is WFP's main concern to coordinate all the different parties and get the food delivered as soon as possible.

3.3 Inventory Policy Proposal

It is understood and agreed in this thesis that the periodic review systems are the most appropriate ones to be applied in the WFP commodity pipeline due to its intrinsic complexity. And the main reasons why WFP chooses one of the simplest replenishment systems have also been explained. However, the large amount of information that is kept in the WINGS database should be of enough relevance and value to estimate different useful parameters for a more efficient inventory management. The second half of this thesis aims to provide the COs with a way of thinking towards the calculation of reasonable values for the parameter s of the different inventory policies.

The purpose of this section is neither to propose any other inventory policy nor to qualify the existing one as incomplete or inefficient. Instead, its aim is to show a way to estimate

[2] Information extracted from a conversation with Boston Consulting Group consultants.

what it has been defined as the s parameter, so that COs have extra valuable information for their decision analysis in the reordering process. The next section tries to briefly explain what the s parameter consists of and how it could be calculated.

3.3.1 Theoretical and Practical Approach to the s Parameter

The reorder point or s parameter is usually defined as $s = x_L + SS$, where x_L is the expected demand over the lead-time and SS the Safety Stock, defined as the average net stock just before a replenishment hits the warehouse. The SS can be estimated in different ways (based on a simple-minded approach, on minimizing cost, on customer service or on an aggregate of considerations).[3] For the purpose of this thesis, the simple-minded approach (the most common one) is used in conjunction with a customer service oriented one. This combinational approach may be the most adequate one regarding that WFP's main concern is to get the food as soon as possible maximizing the customer service level. In this case, the SS is defined as $SS=k\sigma_L$ where σ_L is the expected standard deviation of the demand over the lead-time and k, the SS factor. This SS factor is directly related to the probability in the system of not having any stock outs in the replenishment cycle (or else said, the Cycle Service Level or CSL). In order to calculate all the variables involved in the s parameter, some considerations need to be taken into account.

To begin with, demand is assumed to be normally distributed. This is a fair assumption when there are large volumes of items to be consumed. With that in mind, the k factor is directly calculated from the CSL: k is the number of standard deviations above the

[3] See page 241 in "Inventory Management and Production Planning and Scheduling"

expected demand so that the area below the curve accounts for the probability of not stocking out.

Secondly, x_L and σ_L need to be calculated under stochastic conditions; that is, the lead time from the moment the resource request is issued until the food hits the gateway-control point is not constant. In that case, in order to calculate those two variables, independence between demand and lead time variables need to be assumed. The formulas for the parameters are as follows:

$$E(D_{Leadtime}) = E(L)E(D)$$

$$\sigma_{Leadtime} = \sqrt{E(L)\sigma_D^2 + (E(D))^2 \sigma_L^2}$$

where $E(L)$ is the expected lead time; $E(D)$, the expected demand; σ_L, the standard deviation of the lead time distribution and σ_D, the standard deviation of the demand distribution. Total lead time, as it will be explained in the next section, is defined as the sum of L_1 (RR-SI), L_2 (SI-ATA) and L_3 (ATA-gateway/control point). Thus, the calculation of $E(L)$ and σ_L is as follows:

$$E(L) = E(L_1)+E(L_2)+E(L_3)$$

$$\sigma^2_L = \sigma^2_{L1} + \sigma^2_{L2} + \sigma^2_{L3} + 2Cov(L_1,L_2) + 2Cov(L_1,L_3) + 2Cov(L_2,L_3)$$

In this study, covariances are assumed to be zero based on several correlation studies between L_1 and L_2 for all kind of commodities and type of projects and donor. The overall results show that no correlation between these two lead times exists, so they can be considered independent variables (see Table 3). This is consistent with the fact that these two lead times depend on different entities (HQ and the suppliers, respectively). So, for the same reason, since L_3 depends mostly on the COs, this study makes the assumption that L_3 is also independent from both L_1 and L_2, thus, leading to all covariances being zero.

	RR-SI
SI-ATA	-0.19

Table 3. Correlation factors between RR-SI and SI-ATA performed for all data.

A brief note also needs to be addressed regarding the expected demand and its standard deviation (*E(D)* and σ_D, respectively). Since not enough clear data can be extracted from the database with regard to the demand pattern, this distribution has been assumed to follow the supply's one. The assumption is based on the fact that WFP would try to emulate the demand pattern to maximize efficiency. Thus, the standard deviation of the demand distribution has been assumed to be the one for the supply. However, the expected demand has been assumed to total a 40% amount above the calculated supply, which reflects the fact that commodities shortages are present in the WFP deliveries. It will be shown in next sections where the 40% comes from and what procedures were used to calculate it. The study, however, could be refined if the demand distribution were known from field studies, and should not be inferred from the supply distribution.

Finally, the study performed here concentrates on the lead times for the different kinds of commodities. The assumption is that COs would control their inventory status and would perform their decision analysis based on the kinds of commodities.

3.4 Countries Selection

The study on the second half of the WFP supply chain will be performed on two different countries. This selection depends on the stage at which Country Officers establish their own gateway/control point for the food. There are two different cases to analyze:

a) The discharge country is the same as the recipient country
b) The discharge country is different from the recipient country

In the first case, the control point is the same port of discharge. COs may know at "every moment" how much food is on the way to their ending users, since they know their beginning inventory, the food arrivals and the ending inventory at "every point in time".

In the second case, food is discharged into one country and needs to be delivered to another one (the recipient country). In this case, the recipient CO establishes its own gateway/control point as the first warehouses in its own country. Therefore, there is one more lead-time involved in the process.

Thus, in principle, this study should divide the overall lead-time into two (2) or three (3) parts, depending on the situation:

1) RR-ATA
2) ATA-Gateway/control point in recipient country
3) Gateway/control point in recipient country-IP

As it was stated above, point two (2) is only relevant when the discharge country is different to the recipient country. Otherwise, the lead-time for step two (2) is zero (0) (port of discharge would be the same as the gateway, control point).

However, for the study of the second half of the WFP commodity pipeline and, in particular, for the purpose of calculating the s parameter, the RR-ATA period is also divided into two parts: RR-SI and SI-ATA. The reason behind this division is that these two steps are responsibility of different parties and thus, they should be treated separately. The RR-SI period is HQ's responsibility, since all the business operations and transactions are performed from HQ (Rome), whereas the SI-ATA period responsibility remains in the hands of the suppliers – and the USDA, for US in-kind contributions only. Therefore, the overall time span is finally divided into four (4) steps:

1) RR-SI (HQ responsibility)
2) SI-ATA (suppliers' responsibility)
3) ATA-1st warehouse in gateway-recipient country (control point)
4) 1st warehouse in recipient country-IP (final delivery)

Now, it is time to select for which countries the study is going to be performed. Three different criteria have been used:

1) Countries whose RR-ATA lead-times exceed 150 days. The purpose here was to choose some of the countries that already experience a delay in their deliveries compared to the average (average lead-time is 146 days).
2) Countries for which a significant statistical analysis can be performed. The criterion here is to have enough data to perform a significant analysis (threshold: minimum 98 deliveries).
3) Select the two kinds of countries explained above: a) the recipient country is the discharge country, and b) the recipient country is not the discharge country.

RECIPIENT	AVERAGE RR-ATA	COEF VARIATION	ST DEV	COUNT	STUDY?
AFGHANISTAN	169	0.48	81.28	116	YES
ALGERIA	97	0.44	42.20	72	NO
ANGOLA	200	0.63	126.31	176	YES
AZERBAIJAN	134	0.50	66.83	39	NO
BANGLADESH	159	0.71	113.38	50	NO
BURKINA FASO	225	0.67	151.59	32	NO
BURUNDI	174	0.41	70.68	50	NO
CAPE VERDE	328	0.42	136.67	41	NO
CHAD	171	0.68	116.90	74	NO
CONGO, DEMOCRAT	158	0.34	53.19	145	YES
CÔTE D'IVOIRE	171	0.59	100.76	42	NO
ERITREA	106	0.42	45.05	133	NO
ETHIOPIA	112	0.41	45.86	173	NO
GEORGIA	128	0.72	91.93	40	NO
GUATEMALA	158	0.61	96.70	47	NO
GUINEA	199	0.66	131.84	75	NO
HAITI	178	0.49	87.83	137	YES
HONDURAS	141	0.52	73.48	48	NO
INDONESIA	111	0.54	60.41	49	NO
IRAQ	107	0.36	38.74	637	NO
ISRAEL	162	0.47	75.16	63	NO
KENYA	149	0.37	54.33	101	NO
LESOTHO	166	0.47	78.73	30	NO
LIBERIA	127	0.39	49.29	107	NO
MADAGASCAR	231	0.67	153.69	56	NO
MALAWI	171	0.37	62.88	39	NO
MALI	137	0.62	84.59	37	NO
MAURITANIA	250	0.61	153.75	31	NO
MOZAMBIQUE	180	0.47	83.63	126	YES
NICARAGUA	144	0.38	54.66	89	NO
RWANDA	136	0.40	54.72	50	NO
SENEGAL	220	0.63	138.45	32	NO
SIERRA LEONE	173	0.68	117.70	103	YES
SOMALIA	122	0.42	51.17	58	NO
SRI LANKA	114	0.88	99.90	112	NO
SUDAN	117	0.38	44.73	307	NO
TAJIKISTAN	141	0.30	41.59	57	NO
TANZANIA	144	0.54	77.61	107	NO
UGANDA	168	0.34	56.95	99	YES
YEMEN	167	0.81	134.83	38	NO
ZAMBIA	159	0.37	58.17	32	NO
ZIMBABWE	171	0.29	50.37	87	NO
Limit	150	0.5		98	

Table 4. All recipient countries, their average RR-ATA lead-times and standard deviation

With the two first criteria in mind, Table 4 shows, on the last column, which countries would be selectable for the second part of the study.

Now, the countries selected above can be divided into the two (2) groups described in the point three (3):

a) The recipient country is the same as the discharge country: Angola, Haiti, Mozambique and Sierra Leone.
b) The recipient country is not the same as the discharge country: Afghanistan, Democratic Republic of Congo and Uganda.

The two countries selected are Haiti on one side and Uganda on the other.

3.5 Analysis on Haiti

The average RR – ATA lead time in the case of Haiti as the recipient country is 178 days and its standard deviation is 95 days. The total amount of shipments recorded to Haiti sum 137.

GENERAL	RR - SI	SI - ATA
Minimum	0	23
Maximum	430	253
Average	63	115
Mode	41	117
Standard deviation	83	46
Coef. Of Variation	1.31	0.40
Count	137	137

If the analysis is done for commodity types, the results are as follows:

	CER		FSH	
	RR - SI	SI - ATA	RR - SI	SI - ATA
Minimum	0	69	1	68
Maximum	430	175	74	123
Average	76	128	29	98
Standard deviation	87	26	27	24
Coef. Of Variation	1.15	0.21	0.94	0.25
Count	50	50	5	5

	MIX		MSC	
	RR - SI	SI - ATA	RR - SI	SI - ATA
Minimum	2	23	0	43
Maximum	371	253	86	164
Average	45	143	24	100
Standard deviation	74	66	24	44
Coef. Of Variation	1.64	0.46	0.99	0.44
Count	27	27	15	15

	OIL		PUL	
	RR - SI	SI - ATA	RR - SI	SI - ATA
Minimum	2	39	0	23
Maximum	352	147	300	219
Average	87	86	73	91
Standard deviation	103	28	92	43
Coef. Of Variation	1.19	0.33	1.25	0.48
Count	16	16	24	24

The first conclusion that can be extracted from these results is that the average and standard deviation of the RR – ATA time span for fish, miscellaneous food and oil are much lower than for cereals, mixed and blended food and pulses. However, the largest amount of shipments corresponds to the latter ones (50, 27 and 24, respectively). Therefore, only these last three commodity categories have been taken into account for the calculation of the SS and reorder point since they are the most significant for COs.

It is time now to analyze the overland transport in Haiti after food has reached the port. To start with, and regarding the lead times for inventory control, food is already at the gateway/control point, so no more lead times need to be considered. However, for the consideration of how long it takes for the food to be delivered to the IP, lead time corresponding to the overland transport needs to be considered. In this case, two times have been computed: the minimum time that it takes to reach the IP (ATA-min) and the maximum one (ATA-max). This division is of extreme importance due to the urgency associated with the process. It can be extracted from the following table that the minimum time spent between the port and the IP is 101 days on average, with an associated standard deviation of 98 days. That time would lead to a minimum of 238 days from the RR until IP, on average. The column for the maximum times, in conjunction with the last line of the table, indicates that 40% of the total amount of food is served during the first 82 days after the first delivery. Finally, and for the purpose of calculating the *s* parameter, the supply distribution pattern has also been analyzed. In the case of Haiti and, in a general basis, the average food received at the IP's facilities is 3.88 tons per day, with a high standard deviation of 7.19 tons per day. These numbers will be calculated again for each kind of commodity, since inventory policies have been assumed in this thesis to run independently for each one of them.

GENERAL	**ATA-min**	**ATA-max**
Minimum>0	5	18
Maximum	510	627
Average	101	183
Mode	28	53
Standard deviation	98	116
Coef. Of Variation	0.96	0.63
% negative Lead-times	4%	1%
Count	170	170
Average received food at IP's (T/day)	3.88	
Standard deviation of received food at IP's	7.19	
Average time between min and max	82	
% DELIVERED / VESSEL at time of study	40%	

The next three tables show the same variables described above for each one of the six commodity types.

	CER		FSH	
	ATA-min	**ATA-max**	**ATA-min**	**ATA-max**
Minimum>0	5	18	30	104
Maximum	302	327	510	627
Average	71	130	186	291
Standard deviation	79	89	154	160
Coef. Of Variation	1.11	0.69	0.83	0.55
% negative Lead-times	4%	1%	0%	0%
Count	74		12	
Average received food at IP's (T/day)	5.71		0.38	
Standard deviation of received food at IP's	8.72		0.32	
Average time between min and max	59		105	
% DELIVERED / VESSEL at time of study	40%		34%	

	MIX		MSC	
	ATA-min	**ATA-max**	**ATA-min**	**ATA-max**
Minimum>0	28	53	33	47
Maximum	219	369	326	423
Average	48	139	154	272
Standard deviation	100	83	98	123
Coef. Of Variation	2.08	0.59	0.64	0.45
% negative Lead-times	18%	0%	0%	0%
Count	17		15	
Average received food at IP's (T/day)	2.41		0.26	
Standard deviation of received food at IP's	3.73		0.39	
Average time between min and max	91		118	
% DELIVERED / VESSEL at time of study	44%		67%	

	OIL		PUL	
	ATA-min	**ATA-max**	**ATA-min**	**ATA-max**
Minimum>0	14	22	28	48
Maximum	362	463	272	416
Average	115	219	139	227
Standard deviation	79	116	81	85
Coef. Of Variation	0.69	0.53	0.58	0.38
% negative Lead-times	0%	0%	0%	0%
Count	24		28	
Average received food at IP's (T/day)	2.10		4.90	
Standard deviation of received food at IP's	3.72		8.41	
Average time between min and max	104		88	
% DELIVERED / VESSEL at time of study	44%		40%	

For the three most statistically significant commodity types (cereals, mixed and blended food and pulses), average minimum lead times range from the 48 to 139 days, with high standard deviations in all cases. The average supply for these commodities also ranges from the low 2.41 tons per day in the case of mixed and blended food to the high 5.71 tons per day in the case of cereals. This difference is due to the fact that 44% of the total mixed and blended cargo is delivered in 91 days, whereas those numbers are 40% and 59 days in the case of cereals. Finally and, before proceeding with the calculation of the *s* parameter and the SS, two more concepts need to be clarified.

First, the average demand has been assumed to be 40% higher than the average supply. The reasoning behind this number is that since, on average, 40% of the total amount of cargo is delivered in the first 82 days, 60% of the total cargo should be delivered in about 120 days. Thus, it is an assumption of this study that the total cargo should be delivered in a maximum of four (4) months; otherwise, it is not considered to be effectively delivered. Had it been possible to get the real demand distribution, no assumption would have been necessary to be made.

Second, the probability of not stocking out has been assumed to be 75%, leading to a *k* factor value of 0.67. High as it may seem, this value would reflect the importance for WFP of not stocking out, since human lives are the directly involved.

With all, Table 5 shows a good summary of the most relevant data and the results of the calculations of the *s* parameter and the SS.

	CER			MIX			PUL		
	RR-SI	*SI-ATA*	*ATA-min*	*RR-SI*	*SI-ATA*	*ATA-min*	*RR-SI*	*SI-ATA*	*ATA-min*
average (days)	76	128	71	45	143	48	73	91	139
st. dev. (days)	87	26	79	74	66	100	92	43	81
average delivery (T/day)	5.71			2.41			4.9		
st. dev. Delivery (T/day)	8.72			3.73			8.41		
Avg. Demand (140% delivery)	7.99			3.37			6.86		
TOTAL LT (days) for inventory policy	204			188			164		
st. dev. LT (days) for inventory policy	91			99			102		
E(Demand over LT) (T)	1,631			634			1,125		
St. dev. Over LT (T)	736			338			705		
Probability of no stock out	0.75			0.75			0.75		
k (SS factor)	0.67			0.67			0.67		
SS (safety stock) (T)	**493**			**227**			**472**		
s (reorder point) (T)	**2,124**			**861**			**1,597**		

Table 5. Summary of all the most relevant data in the case of Haiti.

There are two main results to be extracted from Table 5. First, in the case of Haiti and depending on the type of commodity, the second half of the WFP supply chain ranges from 71 days to 139 days, on average. Second, the analysis show that the reorder point, under all the assumptions made in this study, range somewhere between one thousand and two thousand tons of food, depending on the commodity type. These values could be of a big importance for the COs for their inventory management purposes because they could try to push WFP HQ to advance their deliveries. It would not mean going from a push system to a pull one (something completely unrealistic), but it would give a sense of responsiveness into the supply chain. Even in the case that no prompt shipments could be made, the theoretical reorder point could be compared to the inventory on hand for planning purposes.

It has been the purpose of the study to show the procedures to reach to the numbers stated above, so that future analyses can be performed.

3.6 Analysis on Uganda

The process to be followed in the case of Uganda is very similar to the one in Haiti, but the fact that Uganda is not the discharge country adds an additional lead time in the analysis: The lead time from the port of discharge to the gateway/control point in Uganda. There are two different countries through which the food gets into Uganda: Kenya and Tanzania. The lead time and occurrence results for them both are displayed in the following table:

	KENYA		TANZANIA	
	RR - SI	SI - ATA	RR - SI	SI - ATA
Minimum	0	41	1	125
Maximum	239	262	3	198
Average	18	149	2	168
Standard deviation	34	55	1	31
Coef. Of Variation	1.90	0.37	0.67	0.18
Count	95	95	4	4

As it can be observed, almost 95% of all shipments to Uganda are discharged at Kenya's port. Therefore, for the purpose of this analysis, Kenya is going to be considered the only gate through which all food is delivered to Uganda.

With that in mind, let's have a look at the overall RR-ATA time span for Uganda being the recipient country. The average time from the resource request to the actual time of arrival at Kenya's facilities is 167 days, with a standard deviation of 57 days. The total number of shipments to Uganda sum 99.

GENERAL	RR - SI	SI - ATA
Minimum	0	41
Maximum	239	262
Average	17	150
Mode	1	96
Standard deviation	34	54
Coef. Of Variation	1.94	0.36
Count	99	99

If the study is run for commodity types (as in the case of Haiti, this study aims to provide some conclusions depending on the commodity type and not only on a general basis), the results are as follows:

	CER		MIX	
	RR - SI	SI - ATA	RR - SI	SI - ATA
Minimum	0	45	0	96
Maximum	51	262	51	262
Average	8	164	7	172
Standard deviation	17	59	15	34
Coef. Of Variation	2.03	0.36	2.04	0.20
Count	24	24	22	22

	MSC		OIL		PUL	
	RR - SI	SI - ATA	RR - SI	SI - ATA	RR - SI	SI - ATA
Minimum	47	45	0	41	0	54
Maximum	239	77	92	206	169	223
Average	112	66	24	127	18	148
Standard deviation	110	18	25	49	34	56
Coef. Of Variation	0.98	0.28	1.07	0.39	1.85	0.38
Count	3	3	22	22	28	28

From the tables above, it can be inferred that the commodity types with a higher number of deliveries are cereals, mixed and blended food, oil products and pulses. Thus, only these commodity types will be considered for lead time and safety stock calculations.

Once the food is at the port of Kenya, it needs to be transported to the implementing partners (IP) in Uganda. This part of the supply chain is the so-called overland transportation. However, unlike in the case of Haiti, this part of the commodity pipeline is divided into two: the first leg of the overland transport between two different countries (Kenya and Uganda), and the second leg of the overland transport, all happening in Uganda's soil.

The table below refers to the first leg of the overland transport and shows that, on average, the minimum time that it takes for the food to get from the port of Kenya to the gateway/control point in Uganda is 45 days, with a standard deviation of 30 days. However, it is interesting to note that, on average, the maximum time from the port of discharge to the gateway in Uganda is 99 days (more than double the average minimum time). The numbers that will be used for lead time and safety stock purposes are the ones related to the minimum times, since it can be inferred that some food is available at the gateway warehouses for further deliveries to the IPs in Uganda; that is, the supply chain is not interrupted.

Discharge Country	**From**	**To**
KENYA	**KENYA**	**UGANDA**
	ATA-min	**ATA-max**
Minimum	1	20
Maximum	174	505
Average	45	99
Standard deviation	29.94	60.74
Coef. Of Variation	0.67	0.61
% negative Lead-times	0%	0%
Count	215	215
Average time between min and max	54	

Once the food is at the gateway warehouses in Uganda, the final overland transport to the IPs takes place. The computational results are showed in the following tables.

GENERAL	**ATA-min**	**ATA-max**
Minimum	1	10
Maximum	368	1150
Average	86	208
Standard deviation	75	150
Coef. Of Variation	0.87	0.72
% negative Lead-times	3%	1%
Count	393	
Average time between min and max	121	
Average received food at IP's (T/day)	8	
Standard deviation of received food at IP's	14	
% DELIVERED / VESSEL at time of study	60%	

On a general basis, without considering any commodity type in particular, the minimum lead time from ATA to the IP is 86 days, on average. Since the lead time from the discharge port to the first gateway in Uganda was already calculated (45 days), this study concludes that the lead time from the gateway to the IP is 41 days (86 – 45 days).

Also on a general basis, 60% of the food in the vessel is delivered in about 120 days, at a rate of 8 tons per day. This percentage leads to the same conclusion as in the case of Haiti: for safety stock calculations, this study assumes that the expected demand is 140% the supply (since the food is only considered to be effectively distributed in the first 3 months).

Performing the same analysis on a commodity category basis, the results are as follows.

	CER		MIX	
	ATA-min	ATA-max	ATA-min	ATA-max
Minimum	1	34	1	10
Maximum	316	1150	323	605
Average	68	176	106	216
Standard deviation	59	123	86	142
Coef. Of Variation	0.87	0.70	0.81	0.66
% negative Lead-times	2%	1%	3%	2%
Count	134		63	
Average time between min and max	108		110	
Average received food at IP's (T/day)	14		6	
Standard deviation of received food at IP's	20		10	
% DELIVERED / VESSEL at time of study	61%		51%	

	MSC		OIL	
	ATA-min	ATA-max	ATA-min	ATA-max
Minimum	54	105	22	52
Maximum	237	620	354	666
Average	119	436	131	282
Standard deviation	59	182	86	171
Coef. Of Variation	0.50	0.42	0.66	0.61
% negative Lead-times	0%	0%	1%	0%
Count	8		67	
Average time between min and max	317		152	
Average received food at IP's (T/day)	2		4	
Standard deviation of received food at IP's	4		8	
% DELIVERED / VESSEL at time of study	66%		52%	

	PUL	
	ATA-min	ATA-max
Minimum	3	17
Maximum	368	681
Average	69	181
Standard deviation	67	142
Coef. Of Variation	0.97	0.78
% negative Lead-times	3%	1%
Count	121	
Average time between min and max	112	
Average received food at IP's (T/day)	5	
Standard deviation of received food at IP's	8	
% DELIVERED / VESSEL at time of study	63%	

With all the previously stated calculations, Table 6 shows the results for both lead time and safety stock/reorder point purposes.

	CER				MIX			
	RR-SI	*SI-ATA*	*ATA-1st wh*	*1st wh-IP*	*RR-SI*	*SI-ATA*	*ATA-1st wh*	*1st wh-IP*
average (days)	8	164	45	23	7	172	45	61
st. dev. (days)	17	59	30	59	15	34	30	86
average delivery (T/day)	14				6			
st. dev. Delivery (T/day)	20				10			
Avg. Demand (140% delivery)	19.6				8.4			
TOTAL LT (days) for inventory policy	217				224			
st. dev. LT (days) for inventory policy	68				48			
E(Demand over LT) (T)	4,253				1,882			
St. dev. Over LT (T)	1,371				428			
Probability of no stockout	0.75				0.75			
k (SS factor)	0.67				0.67			
SS (safety stock) (T)	**919**				**287**			
s (reorder point) (T)	**5,172**				**2,168**			

	OIL				PUL			
	RR-SI	*SI-ATA*	*ATA-1st wh*	*1st wh-IP*	*RR-SI*	*SI-ATA*	*ATA-1st wh*	*1st wh-IP*
average (days)	24	127	45	86	18	148	45	24
st. dev. (days)	25	49	30	86	34	56	30	67
average delivery (T/day)	4				5			
st. dev. Delivery (T/day)	8				8			
Avg. Demand (140% delivery)	5.6				7			
TOTAL LT (days) for inventory policy	196				211			
st. dev. LT (days) for inventory policy	63				72			
E(Demand over LT) (T)	1,098				1,477			
St. dev. Over LT (T)	368				518			
Probability of no stockout	0.75				0.75			
k (SS factor)	0.67				0.67			
SS (safety stock) (T)	**247**				**347**			
s (reorder point) (T)	**1,344**				**1,824**			

Table 6. Summary of all the most relevant data in the case of Uganda

As in the case of Haiti, two main conclusions can be extracted from the results above. First, regarding the second half of the overall supply chain (the overland transportation), lead times between the port of discharge and the final delivery to the IPs account between 68 and 131 days, depending on the commodity category. Second, the reorder points vary from 1,300 tons for oil products to 5,100 tons for cereals, while the safety stock threshold moves around the 18% of the reorder point. These values should not be understood as absolute numbers but as relative ones. That is, they should be seen as a helping tool for the COs for their inventory management, but they should not be used for a change in the inventory policy, for instance. However, the values obtained in this thesis could well assist the Country Officers for their planning purposes as well as for their day-to-day activities.

It has been the purpose of the study to show the procedures to reach to the numbers stated above, so that future analyses can be performed.

4. General Conclusions

The World Food Programme, the UN food aid agency, plays a crucial role in meeting emergency food needs and in supporting the economic and social development in more than 80 underdeveloped countries around the globe. WFP provides the logistical support to get the food aid delivered to the people in need at the right place and at the right time, no matter if the reasons for hunger are natural disasters, wars, lack of agriculture infrastructure, an over-exploited environment or, just, poverty. In this commendable endeavor, WFP uses a complex information system, WINGS, to keep track of every single piece of data that may be relevant for an effective management of the resources and for a precise execution of the logistical operations. This thesis has tried to contribute on this latter part of the chain, showing that very interesting feedback may be inferred from the data kept in the system.

Regarding the first part of the commodity pipeline, from the moment the contribution is confirmed to the actual time of arrival of the food aid at the discharge port, this study analyzed the lead-times between different business steps within the organization so that some actions could be undertaken to decrease the volatility or the uncertainty among them (it is usually the uncertainty in the supply chain what worry the managers most). This study also analyzed some other features such as the delivery efficiency depending on the project category, the contribution type, the donor, and the commodity category. The results of this first part could help managers at WFP either to analyze the success on the short-time deliveries or to improve those contributions that behave below the average.

But it is regarding the study on the second half of the commodity pipeline that this thesis contributes in a more innovative way. While a similar study had been developed at WFP HQ in 2003 regarding the first part of the supply chain, never had there been one that considered the second part of it, that is, down to the delivery to the implementing partner (either it be a governmental agency or an NGO). The reason for this negative situation, as it was explained throughout the thesis, is the uncertainty involved in the overland transport due to security reasons, transport capacity and transport infrastructure. Being aware of these limitations, however, this thesis has tried to point out a way of thinking towards the learning process to which all projects should be subjected. With that concept in mind, the second part of this thesis has a twofold purpose: First, to analyze with statistical tools the lead-times in the overland transport; and second, to serve as a guideline to estimate some inventory management and control parameters, such as the reorder point and the safety stock threshold. These parameters could well be used by the Country Offices to anticipate future shortage problems or to faster react to them. It would be presumptuous to assume that with these parameters in place managers should think towards a radically different ordering and inventory policies (since the main difficulty in the supply chain is getting all the parties coordinated), but by using them, they could introduce some flexibility into the system, which could be translated into more efficient operations.

Finally, it is important to stress that, due to the fact that some unknown variables needed to be included in the analysis of this thesis, lots of assumptions were made. All the results and conclusions here are coherent with them, but needless to say that, the more accurate the assumptions are, the more precise the results will be. Therefore, it is the ultimate aim of this study to encourage students at universities and managers in the organization to pursue further analysis with the unique purpose of making the life of WFP Officers easier.

Glossary

ATA	Actual time of arrival
BL	Bill of lading
CER	Cereals
CO	Country Office
CSL	Cycle Service Level
ECHO	European Community Humanitarian Office
EMOP	Emergency operation
FRD	Fundraising & Communications Department, Donor Relations
FSH	Fish
HQ	Headquarters
IP	Implementing Partner
IRA	Immediate response account
LT	Lead Time
MIX	Mixed and blended food
MSC	Miscellaneous
NFC	Non-food commodities
NGO	Non Governmental Organization
ODF	Food Procurement Service
ODP	Programming Service
OTS	Ocean Transportation Service
PO	Purchase order
PR	Purchase requisition
PRRO	Protracted relief and recovery operation
PUL	Pulses
RR	Resource request
SI	Shipping instruction
SS	Safety Stock
US	United States
USDA	US Department of Agriculture
WFP	World Food Programme
WINGS	WFP Information Network and Global System

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