

Technical Report: Sampling Methodology

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1. Introduction

As part of the Rail Freight Service Review, QGI Consulting on behalf of Transport Canada will conduct a quantitative assessment of railway performance in Canada. The two key aspects of the quantitative assessment of rail freight service are the evaluation of; railway transit time performance and order fulfillment. The review of order fulfillment will be comprised of two distinct parts:

- the measurement of railway and customer forecast demand versus actual shipments and;
- the measurement of rail cars ordered by customers versus rail cars supplied by the railways.

Both the transit time analysis and the order fulfillment analysis are, by agreement between Transport Canada and the railways, to be conducted on a representative sample of railway traffic data.

QGI Consulting met with both Canadian National Railway (CN) and Canadian Pacific Railway (CP) to discuss Transport Canada's requirements for the quantitative analysis of the Canadian rail freight logistics system. These discussions resulted in agreement between QGI and both railways with respect to the level of detail in the transit time and order fulfillment data that will be required to provide a comprehensive review of railway and shipper/receiver performance in the movement of rail freight in Canada.

QGI, with the assistance of Dr. Jonathan Berkowitz,¹ developed a sampling methodology for the identification of the data to be used in each of these analyses. The data samples developed using this methodology was shown to be highly representative of summary data provided by CN and CP to QGI that formed the sampling frames for the transit time and order fulfillment studies.

1.1 Data Provided by Railways

CN and CP each provided QGI with two separate sets of summary rail traffic data that were used to develop the samples for the transit time and order fulfillment analyses. These data sets each provided a summary view of the railways' total freight business for the years 2006, 2007, and the first nine months of 2008².

The data sets contained the following information.

- Total number of rail cars or intermodal units shipped per year
- Total tons shipped per year
- CN – full year 2006, 2007, and to end Q3 2008
- CP – Q3 2006, full year 2007, and to end Q3 2008

¹ Dr. Berkowitz is an expert with over 20 years of experience in applied statistics. He is the President of Berkowitz and Associates Consulting Inc. and Adjunct Professor with the Sauder School of Business at the University of British Columbia.

² Due to constraints within CP's internal information systems data for the year 2006 was limited to the period from October 1 – December 31 as compared to CN that provided traffic data for the full year 2006.

Totals by:

- Shipper name and shipper number
- Origin name and station number
- Destination name and station number
- Origin and destination subdivision
- Railway business unit / commodity
- Competitive rail status at origin

While similar in many respects the data sets for transit time analysis and those for order fulfillment analysis differed in two principal ways, reflecting the specific data elements and level of aggregation appropriate for each analysis. The transit time data was summarized at the shipper / origin / destination / commodity level. This level of aggregation was consistent with the need to randomly select traffic flows for individual shippers. The order fulfillment data sets were provided at a higher level of aggregation reflecting individual shipper / origin / commodity combinations or flows and included information on the rail car type used for each flow.

The summary data set provided to QGI by CP excluded traffic data for 9 major shippers within the railway's coal, sulphur, potash and automotive businesses. Data for these shippers were withheld by CP on the basis that traffic for these customers was governed by confidential contracts that contained explicit service provisions. It was CP's initial position that such service provisions made it inappropriate to include traffic for these shippers in the broader service review. As such initial sampling was conducted without these data included.

The exclusion of these data was discussed at length between Transport Canada, QGI and Canadian Pacific Railway. CP subsequently agreed to provide the summary data for these movements following an agreement with Transport Canada regarding confidentiality and on the condition that each shipper consented to the release of the data by CP. Supplementary summary data for 8 of the previously withheld shippers³ was received by QGI on April 13, 2009 at which time QGI conducted supplementary sampling for the transit time and order fulfillment analyses and submitted a request to CP for the additional detailed data.

1.2 Validation of Railway Data

Prior to developing the samples the summary data for each railway were reviewed by QGI in comparison with published sources such as annual reports and Statistics Canada railway traffic data to validate the total car counts by line of business. In addition, Transport Canada's Surface Marine Statistics and

³ One of the shippers contacted by CP refused to provide its consent for the release of data.

Forecast Division reviewed the data to confirm that they were consistent with the confidential data that were provided to them by CN and CP.⁴

In reviewing the data, QGI determined that the data provided by the railways:

- Included Canadian originated traffic on a forwarded basis on both railways
- Included traffic originating and terminating on short line railways⁵ – but excluded some traffic originating on regional railways such as the SRY and ONR⁶
- Excluded traffic originating on CP for nine customers with whom CP has confidential contracts containing service provisions⁷

1.3 Data Enhancements

The Request for Proposals (RFP) issued by Transport Canada identified a number of shipper and shipment characteristics or dimensions for which transit time and order fulfillment performance were to be measured and assessed. Key characteristics to be examined included:

- shipper size
- order size
- industry subgroup
- service type (manifest versus unit train operations)
- competitive rail status at origin
- geographic origin and / or destination
- core versus noncore network location
- length of haul
- short line versus Class 1 origin or destination of traffic

Measuring and assessing railway performance across each of these dimensions required QGI to enhance the data at the individual record level to reflect each of these dimensions within an individual railway's data and to provide a common basis for comparison of performance across railways. In some instances QGI was required to define a characteristic – e.g. shipper size – while in others it required only the codification of a characteristic – e.g. short line origin – using the existing railway data provided supplemented by other publicly available data.

Key definitions or dimensions added to the summary data sets provided by the railways for both transit time and order fulfillment include the following:

⁴ Transport Canada did not reveal any detail regarding their findings as the information provided to them by Canada's railways is covered by separate confidentiality arrangements that do not include the review of their data for the purposes of the Rail Freight Service Review. They did, however, confirm QGI's findings that the data were accurate and complete subject to the exceptions noted by QGI and described herein.

⁵ The data did not, for either railway, explicitly identify all rail traffic originating or terminating on short line railways in a consistent manner. Using external sources and public CN and CP information QGI identified all railway stations in Canada served by short lines and applied identifiers or flags at the individual record level to identify all such traffic. QGI requested and received validation from the railways of its short line railway traffic definition.

⁶ CN subsequently enhanced the data provided to QGI to include traffic originating on the SRY and ONR.

⁷ Data for eight of the nine customers was subsequently supplied and supplementary sampling completed.

Shipper Size

The shipper size variable categorized shippers based on groupings of the total number of units shipped with each railway for all commodities in a given reference year (2007). The shipper size groupings selected were:

Figure 1 Shipper Size Definitions

Large:	Greater than 5000 shipments per year
Medium:	1001 – 5000 shipments per year
Small:	301 – 1000 shipments per year
Very Small:	up to 300 shipments per year

The shipper size designations for individual shippers were developed separately for each railway.

Major Group / QGI Industry Subgroup

Because the railways include different commodities in their respective business unit and industry sector groupings QGI created a line of business classification (major group) and an industry subsector definition (industry subgroup) common to both railways. Establishing these common classifications allows for comparisons of performance for specific industry groups across the two railways.

Within each of their respective summary data sets both CN and CP grouped their commodities into business units and within each of these industry subgroups. CN grouped 162 commodities into 7 business units and 14 industry subgroups. CP grouped 112 commodities into 11 business units and 55 industry subgroups. QGI created 6 major group and 23 industry subgroup definitions common to both railways.

These groupings provided higher levels of classification of data for use in both the sampling and ultimately in the analytical work to follow that is common to both railways. All information provided by the railways on line of business descriptions and commodities was retained within the data. The major and industry subgroup definitions created by QGI were:

Figure 2 QGI Major and Industry Subgroup Definitions

QGI Major Group	QGI Industry Subgroup
Automotive	<ul style="list-style-type: none"> • Finished Vehicles • Machinery & Equipment • Vehicle Parts
Bulk	<ul style="list-style-type: none"> • Coal • Coke • Potash • Sulphur
Fertilizers	<ul style="list-style-type: none"> • Fertilizer • Phosphate Rock
Grain	<ul style="list-style-type: none"> • Agricultural & Food Products • Grain • Pulses & Special Crops
Intermodal	<ul style="list-style-type: none"> • Intermodal (Domestic) • Intermodal (Impex)
Merchandise ⁸	<ul style="list-style-type: none"> • Agricultural & Food Products • Building Materials • Chemicals • Lumber & Panels • Machinery & Equipment • Metal Products • Miscellaneous • Ores & Concentrates • Other Forest Products • Paper Products • Petroleum Products • Plastics • Railway Equipment & Materials • Woodpulp

Appendix 1 provides the relationships between the railway supplied industry subgroups and the QGI defined major groups.

Equipment Type

As CN and CP provided slightly different rail car type definitions, QGI created new descriptive rail car type designations based on the CN and CP designations that could be used for both railways for the car order and supply analysis. The QGI equipment type designations are:

⁸ The broad Merchandise group includes commodities such as; Forest Products, Ores and Metals and Chemicals and Petroleum products. Intermodal includes all commodities shipped via the Intermodal services of both railways. A detailed definition of the subgroups included for each railway in Major Groups is included in Appendix 1.

Figure 3 QGI Equipment Type Definitions

QGI Equipment Type	QGI Equipment Type 2
Box Car	<ul style="list-style-type: none"> • Box 50-52 • Box Auto • Box Double Door • Box Insulated • Box Other • Box Newsprint • Box Reefer
Covered Hopper	<ul style="list-style-type: none"> • Hopper Covered Gravity • Hopper Covered Other • Hopper Covered Private
Flat Car	<ul style="list-style-type: none"> • Flat Bulkhead Greater Than 53 feet • Flat Bulkhead Less Than 53 feet • Flat Center Beam 73 feet • Flat Center Beam Other • Flat Heavy Specialized • Flat Miscellaneous • Flat Pipe • Flat Pulpwood • Flat Standard • Flat Standard Auto/Truck
Gondola	<ul style="list-style-type: none"> • Gondola Covered Coil • Gondola Covered Short • Gondola Open Coil • Gondola Open Long • Gondola Open Short • Gondola Other • Gondola Rotary • Gondola Woodchip
Hopper	<ul style="list-style-type: none"> • Hopper Open
Container	
Intermodal Car	
Locomotive	
Multi-level	
Other	
Stack Car	
Tank Car	
Trailer	

Appendix 2 provides the relationships between the car type designations provided by the railways and those developed by QGI.

Order Size

For the purposes of the car supply analysis, an additional characteristic was calculated and applied to the data in the order fulfillment summary data set. This was a measure of “order size”, which was defined as the sum of all car trips for each shipper / origin / QGI equipment type combination.

Each combination of shipper/origin/ QGI equipment type was fit to one of the following categories.

Figure 4 QGI Order size definitions

Order size	Number of cars per year⁹
1	Less than 50
2	51 - 100
3	101 - 1000
4	Greater than 1000

⁹ Calculated based on reference year 2007

2. Sample Development

As noted earlier, the quantitative analysis of railway performance is to be conducted on two key aspects of railway service; railway transit time performance and order fulfillment. Order fulfillment performance will be examined in two distinct parts; the measurement of railway and customer forecast demand versus actual shipments and; the measurement of rail cars ordered by customers versus rail cars supplied by the railways. QGI developed three distinct samples, as described below, one for each of the analyses.¹⁰

2.1 Transit Time

The transit time sample was the first to be developed reflecting the early agreement between QGI and the railways on the structure of the transit time data to be provided for analysis and the railways' ability to provide QGI with the summary data.

The enhanced summary data sets for CN and CP were combined into a single Microsoft Excel file. When combined, these data sets created a spreadsheet of 100,021 rows of data with each row comprising a unique railway-shipper-origin-destination-commodity combination. Each data row was assigned a unique row identifier or primary key by QGI. The total number of rail cars shipped by both railways in the sampling frame was 4.1 million using 2007 as a reference year.

Objectives of Sampling

The unit of analysis for this stage of the project will be an individual "car trip." The purpose of sampling is to identify a subset of rows of the database which are individual combinations of railway-shipper-origin-destination-commodity that is sufficiently large to allow us to analyze car trip performance across all of the variables identified in the RFP with an acceptable level of precision (i.e. margin of error) within each cross tabulation of characteristics of interest. As identified earlier, these characteristics of interest include:

- Geographic region
- Length of haul
- Commodity (at Industry sub-group level)
- Competitive rail access at origin
- Railroad
- Shipper size
- Short line versus Class 1 origin
- Core / Non Core network

¹⁰ A separate sampling exercise using the same methodology as described herein was undertaken after the initial sampling process to specifically select data records from the previously withheld CP data for inclusion in the final detailed data request submitted to CP. The supplementary data added 681 unique traffic flows to the original 100,021 and resulted in an additional 37 flows being selected for inclusion in the sample. These included 3 Merchandise, 5 Bulk and 29 Automotive flows which are represented in the cross tabulations shown in the sampling results section of this report.

The sample must also be representative of the entire population of car trips being assessed (the sampling frame).

For this project, we have used stratified random sampling. In this method, members of the population are separated into mutually exclusive groups called strata, and a simple random sample is taken from each stratum. The key variables used to create the strata were those expected to provide groupings that would be helpful in ensuring a representative sample across all of the key characteristics of the data in the sampling frame, as well as the additional characteristics created by QGI based on the data provided.

Sampling Process

In order to choose a random sample of rows from each of the strata that were to be constructed, a random number was assigned to each row using Microsoft Excel’s random number generator. As mentioned earlier, each row had also been assigned a unique identifier by QGI.

A large number of flows in the data were comprised of very small volumes of traffic both by flow and as a percentage of the overall traffic base in the sampling frame. Of these small flows, 68,543 flows of 3 cars per year or less accounted for only 42,084 shipments or only 1.02% of the total traffic base. In order to ensure that these very small flows were not over sampled resulting in an overweighting of this traffic; these very small flows were removed from the sampling frame. It is important to note, that the shippers represented by these very small flows were broadly proportional to the population of shippers by size and Major Group in the sampling frame generally.

The population of shippers is, for both railways, not evenly distributed by shipper size. The following cross-tabulations by shipper size for the number of shippers and the volume of cars by size group for both railways illustrates this point.

Figure 5 Shippers by size and by overall traffic volume

Shipper Size	Number Shippers		Percentage traffic on railway	
	CN	CP	CN	CP
Large	101	74	82%	76%
Medium	155	127	12%	14%
Small	195	204	4%	6%
Very Small	2107	2132	2%	4%

While it is important that all shipper groups be represented in the sample and ensuing analysis, given the very small proportion of the rail traffic generated by the large number of Very Small (VS) shippers, it was decided to treat the flows of the very small shippers separately from those of the other shippers in order to ensure that they were not over sampled. Therefore, the 5,153 flows greater than 3 cars per year moved by VS shippers were removed from the initial sampling frame (but retaining all their data including random

number designations) so that they could be sampled separately. From the remaining 26,325 flows for the Large, Medium and Small shippers, it was decided to take a 10% sample of the data. The level of precision provided by a sample of this size can be closely estimated using the formula of $1/\sqrt{n} = 1/\sqrt{2633} = 0.019$ or 1.9%.

Thus, for the sample as a whole, at the flow level (database rows) the margin of error will be approximately 1.9%, nineteen times out of twenty. When the same calculation is done using the number of cars in the sample, the margin of error will be much lower.¹¹ Perhaps more importantly, a sample of this size would be expected to provide sufficient data in each cell in relevant cross tabulations to allow assessments within an acceptable margin of error.

Experimental strata were constructed by sorting the data according to a number of characteristics. Samples were then taken by sorting the data within the strata according to random numbers and then selecting 10% of the records in each stratum. The sample data were then subdivided using cross tabulations based on system characteristics and the resulting proportions compared to those in the sampling frame. This was done to determine whether the sample was both representative, and large enough within the cross tabulations, to allow for sufficiently precise and accurate estimation of performance. This process of comparing the sample characteristics to the sampling frame characteristics was done at both the count of rows of data level, and at the sum of cars level.

Since the sampling was done by selecting rows of data, it was important to check the sample in order to ensure that the random sampling process provided the expected representative result at the cross tabulation level of analysis. However, as any individual row could account for anywhere from one car to many thousands of cars, it was also important to check for representativeness of the sample at the car count level.

The stratification that was selected and found to provide a satisfactory preliminary sample was to sort and split the data first by railway and then by major group.¹²

After sampling the traffic flows for Large, Medium and Small customers, the traffic flows for Very Small customers were sampled. In order to ensure that the flows selected from within the Very Small customer traffic base contributed sufficient cars to support the analysis, shippers shipping less than 12 cars per year were also removed from the sampling frame for VS customers. A random sample of 5% of the remaining

¹¹ As shown below, the actual sample chosen included 453,205 cars. The margin of error for a sample of this size will be approximately $1/\sqrt{453205} = 0.0015$ or 0.15%.

¹² The exact steps of the sampling were: sort the population, (not including flows of less than 4 cars per year or the flows for the Very Small (VS) customers) first by railway, and then within railway groupings by major group. These railway/major group sub-groups were then sorted numerically by their assigned random number and the first 10 % of rows in each sub-group were added to the sample.

rows was selected using the same stratification as was used for the larger customers (I.E. sorted by railway and Major Group).

The entire sample was then examined using the following cross tabulations to compare the sample to the sample frame system characteristics.

- Volume of cars by shipper size, by major group
- Volume by major group, by railway
- Volume by railway, by originating region
- Number and percentage of shippers by shipper size, by railway
- Number and percentage of flows by flow size by railway.

After reviewing the cross-tabulations we identified strata within the sample that were under-represented in the sample as compared to the sampling frame. Flows were selected randomly within the desired strata from the sampling frame until sufficient traffic volume was added to each sample strata as noted above to make up for the volume deficiencies in the sample as compared to the sampling frame.

These were:

- Merchandise traffic originating in Quebec 16,767 cars in 13 flows added
- Merchandise traffic originating in British Columbia 1,233 cars in 2 flows added
- Merchandise traffic originating in Ontario 4,687 cars in 3 flows added
- Merchandise traffic originating in Alberta 4,001 cars in 2 flows added
- Fertilizer traffic originating on the Prairies 2,944 cars in 8 flows added
- Grain traffic originating across all regions 5,385 cars in 29 flows added
- Intermodal traffic originating in Quebec 8,681 cars in 2 flows added

Sampling Results

The sample selected for study included a total of 2,866 flows and 541,025 car trips with the following distribution by railway and major business unit¹³.

Figure 6 Sampling Frame and Sample System Characteristics – Railway and Major Group

<u>Sampling Frame: Sum of Cars (2007) by Major Group</u>							
<i>Railway</i>	<i>Automotive</i>	<i>Bulk</i>	<i>Fertilizers</i>	<i>Grain</i>	<i>Intermodal</i>	<i>Merchandise</i>	<i>Grand Total</i>
CN							56.7%
CP							43.3%
<i>Grand Total</i>	4.8%	11.0%	1.3%	10.5%	47.5%	25.0%	100.0%

¹³ Distribution of traffic by major group for the individual railways is not provided as this is considered commercially sensitive information.

<u>Sample: Sum of Cars (2007) by Major Group</u>							
<u>Railway</u>	<u>Automotive</u>	<u>Bulk</u>	<u>Fertilizers</u>	<u>Grain</u>	<u>Intermodal</u>	<u>Merchandise</u>	<u>Grand Total</u>
CN					-----		57.3%
CP		-----					42.7%
Grand Total	3.2%	19.7%	1.1%	8.7%	45.2%	22.0%	100.0%

As mentioned above, the system characteristics of the data in the sampling frame were checked against the same system characteristics in the sample. Two of the key cross tabulations of data and their proportions in the sampling frame and in the selected random sample are shown below for illustration purposes.¹⁴

As seen in Figure 7, the cross tabulations of the sampling frame and the working sample by shipper size demonstrate that the sample is representative of the Large, Medium and Small shippers. While Very Small shippers are somewhat underrepresented, the sample drawn for these shippers is still large enough to allow this group to be adequately studied in the transit time analysis.

Figure 7 Data validation by railway and shipper size

<u>Sampling Frame:</u>	
<u>Percentage Break Down Sum of Cars 2007 by Shipper Size</u>	
	<u>Average CN-CP</u>
Large	80.9%
Medium	12.4%
Small	4.1%
Very Small	2.7%

<u>Sample:</u>	
<u>Percentage Break Down Sum of Cars 2007 by Shipper Size</u>	
	<u>Average CN-CP</u>
Large	84.7%
Medium	10.7%
Small	4.2%
Very Small	0.3%

Two cells in Figure 6 (highlighted in yellow) had noteworthy variances (i.e. discrepancies) at the car-trip level.

¹⁴ Cross tabulations and comparisons between the sampling frame and the sample were also conducted to ensure that the sample was representative by: competitive status at origin, core and non-core origins, and short line origins.

CN Intermodal

The proportion of car-trips in the sampling frame for CN Intermodal was -----% of the total whereas the sample for CN Intermodal accounted for -----% of the car trips. Examination of the sample revealed that this was due to the fact that a number of high volume flows for international container shipments (IMPEX traffic) were included in the sample. The overall sample for CN Intermodal is highly representative at the flow level and the overweighting of the car trips in the international container shipments can and will be dealt with by reducing the weighting of this segment in its impact on any system performance measures that are created. When considered as a population stratum on its own, the overweighting as compared to the sample frame will have no effect on analysis of the traffic.

CP Bulk

The proportion of car-trips in the sampling frame for CP Bulk was -----% of the total whereas the sample for CP Bulk accounted for -----% of the car trips. This is a result of the high concentration of CP Bulk traffic with a single customer and the inclusion of a number of specific flows for this particular customer in the sample. The overall sample for CP Bulk is highly representative at the flow level and the overweighting of the car trips can and will be dealt with by reducing the weighting of this segment in its impact on any system performance measures that are created. When considered as a population stratum on its own, the overweighting as compared to the sample frame will have no effect on analysis of the traffic.

2.2 Order Fulfillment

Given that a sample had already been selected for the transit time analysis, QGI reviewed this data to determine whether or not the customers and traffic represented in the transit time sample would also be suitable for use in the order fulfillment analysis.

Customer Forecast Demand vs. Actual Shipments

As was described earlier, CN and CP provided QGI with summary traffic flow data containing the following information.

- Total number of rail cars or intermodal units shipped per year
- Total tons shipped per year
- CN – full year 2006, 2007, and to end Q3 2008
- CP – Q3 2006, full year 2007, and to end Q3 2008

Totals by:

- Shipper name and shipper number
- Origin name and station number
- Destination name and station number
- Commodity/business unit
- Competitive rail status at origin
- Origin and destination subdivisions

In addition to the summary data sets noted above, the railways provided QGI with additional data sets which added information on the rail car types used for each flow. As with the transit time analysis, two additional key system characteristics - shipper size, and major group - were calculated and added to the data by QGI. The traffic flows were then summarized by shipper, origin, commodity and rail car type.¹⁵

It is important to note that while both sets of data included information on 4.1 million car trips the two files (data sets) were significantly different in size. The sampling frame for the order fulfillment analysis contained only 51,402 data rows as compared to 100,021 data rows in the sampling frame for the transit time analysis. This is because the sampling frame for transit time analysis summarized car trips by shipper-origin-destination-commodity whereas the sampling frame for the order fulfillment analysis summarized data at the origin rather than the origin-destination level.

As noted earlier, QGI determined that the data in the sample that was selected for transit time analysis were sufficiently representative of the sampling frame at the level of detail required to complete the transit time analysis. The dimensions of analysis for this first part of the order fulfillment analysis are the same as those for the transit time analysis. Therefore, QGI has concluded that the shippers and origins represented in the order fulfillment sample will provide a suitable basis for developing the sample for the analysis of railway forecast demand versus traffic moved by shippers.

If these same shipper-origin combinations are to be used for the order fulfillment analysis then the car trips originating from those origins will also include commodities and car trips to destinations that were not selected for the transit time analysis. When the flows matching the same shipper-origin flows were included in the proposed order fulfillment sample, the total volume of units (cars and intermodal containers) shipped was 2.9 million from a total sampling frame of 4.1 million. Summarized at the shipper-origin-commodity level the spreadsheet containing these flows included 4,499 data rows.

However, it would be neither practical nor necessary for the railways to provide QGI with forecast information on all 4,499 rows. Firstly, for many of the smallest customers, neither railway specifically forecasts volumes at the customer-origin-commodity level. Instead they forecast at the commodity flow level, based on information provided from a variety of customer, commodity market, and macroeconomic data. In addition, in the Intermodal market segment, information on the commodities in containers is not always readily available and it is expected that forecasts will generally be at the shipper-origin-flow level of analysis. Therefore, QGI's request for data for the first part of the order fulfillment analysis excluded a request for forecast information for the Very Small (VS) customer segment (less than 300 cars per year) and it focused on those customer flows which comprise over 90% of the railway volume and excluded small

¹⁵ CN provided a data set summarized as indicated in the text above. CP provided a file at the detailed flow level as in the original transit time data, with the AAR car type indicator field added to the data. CP subsequently provided translation keys that enabled QGI to define car types more precisely and at a level comparable to the equipment categories provided by CN. This data was then summarized by QGI to the same level as the CN data – I.E. at the Shipper/Origin/Commodity/Car type level.

flows for shippers of all sizes. In addition, this stage of analysis segregated the request for Intermodal forecast data – which was only requested at the shipper-origin level excluding commodity information.

After examination of the data, QGI determined that excluding all VS customers from the sample and setting a threshold level of a minimum of 300 cars per year per railway-shipper-origin-commodity flow allows for the analysis of forecasting and order fulfillment on over 60% of non-intermodal railway traffic. The following table illustrates the proportion of the data that would be included in the analysis if the above proposed selection criteria were used.

Figure 8 Key statistics on proposed order fulfillment sample for non-intermodal traffic

	Railway	
	<u>CN</u>	<u>CP</u>
Number of flows in sample	520	313
Number of cars in sample	870271	387500
Percentage of Non-Intermodal flows in sampling frame	17%	14%
Percentage of Non-Intermodal traffic in sampling frame	63%	68%

If we apply these same flow characteristics (over 300 cars per year) to the sampling frame approximately 87% of all non-intermodal traffic flows are captured. Therefore, a request was sent to the railways asking them to provide detailed datasets including the following data fields and record structures for carload and intermodal traffic.

<u>Carload Shipment</u>	<u>Intermodal Shipments</u>
<ul style="list-style-type: none"> • QGI Record Key Indicator • Shipper Name • Shipper Number • Railway Business Unit • Railway Industry Subgroup • Commodity Description • 3-Digit Commodity Code • Origin Station Name • Origin Station FSAC Number • Year • Month • Number of Cars Forecast • Number of Cars Released Loaded 	<ul style="list-style-type: none"> • QGI Record Key Indicator • Shipper Name • Shipper Number • Railway Business Unit • Railway Industry Subgroup • Origin Station Name • Origin Station FSAC Number • Year • Month • Number of Cars Forecast • Number of Cars Released Loaded

To ensure consistency across the railways and recognizing the limitations CP has in providing certain historical data, the study period for both elements of the data fulfillment analysis is defined as October 1, 2006 to September 30, 2008.

Car Supply Analysis

For the second part of the order fulfillment analysis which requires the comparison and analysis of rail cars ordered by shippers and supplied by railways, it was necessary to check whether or not the sample was representative at the rail car type level. As was noted earlier CN and CP provided slightly different rail car type definitions. QGI created new descriptive rail car type designations based on the CN and CP designations that could be used for both railways.

As a practical matter, as with the analysis of traffic forecast versus moved, it is impossible to restrict the car supply analysis on an origin-destination basis to match exactly the sample selected for the transit time analysis. This is because virtually all car orders (excluding some grain traffic) are made on a shipper-origin basis and are not specific to the destination of the traffic. For this stage of the analysis, the data were summarized at the shipper-origin-QGI equipment type level, creating a spreadsheet with 1767 rows.

For the purposes of the car supply analysis, an additional characteristic was calculated and applied to the data. This was a measure of “order size”, which was defined as the sum of all car trips for each shipper-origin-QGI equipment type combination. As noted earlier each combination of shipper-origin-QGI equipment type was fit to one of four categories.

In addition, the car supply analysis will only be conducted for situations where the railway controls car supply to the shipper and will exclude intermodal traffic. The following situations will therefore be excluded from the review of rail car supply:

- Intermodal traffic
- Tank Cars
- Automotive traffic
- Bulk commodities
- Cars in customer assigned pools
- Privately owned cars controlled by customers

Intermodal is excluded because, in the case of import/export traffic, container supply is provided by shipping lines rather than railways. In addition, for domestic intermodal the railways’ information systems do not include a sufficiently detailed and consolidated equipment order and supply database to allow for meaningful analysis.

Within the non-Intermodal business segments, tank cars for petroleum and chemical traffic are supplied exclusively by shippers. For shipments of finished vehicles, the supply of multi-level rail cars is controlled

on an industry-wide basis in North America by the Reload Group of the TTX Company¹⁶ and the railways neither take car orders directly from automotive customers nor do they control the supply of railcars.

For most bulk commodities, rail car supply is managed on a monthly forecast basis at the trainload level and the systems for capturing and tracking demand are unique to the business segments on each railway. Discussions will be held with the railways to confirm how best to evaluate demand fulfillment for these specialized categories of railway business.

Finally, for customers in a number of the automotive and merchandise business segments on both railways, where specialized equipment is required for individual customers, fleets are sized and placed in exclusive pools for the use of these individual customers and there is no on-going car order process that is subject to measurement. Therefore, customers supplied through customer assigned pools will be excluded from analysis. Taking into account the above exclusions, the car order and supply process will focus on the following business segments on both railways.

Figure 9 Major Groups and QGI car types covered by ordered/supplied analysis

Major Groups	QGI Car Types
Merchandise	Boxes
Grain	Flats
Fertilizer	Covered Hoppers
	Gondolas
	Open Hoppers

When the restrictions listed above were applied to the shipper/origin combinations included in the transit time sample data it created a database of 959 rows at the shipper/origin/QGI equipment type level.¹⁷ In order to obtain a statistically representative sample for the car supply analysis, it will not be necessary to examine car supply for all 959 of these potential rail car orders. A review of the data showed that for the Large, Medium and Small shippers, a very high proportion of the traffic was covered by order sizes of 3-4; or in excess of 100 cars per year. The following cross tabulation of the data in the sampling frame illustrates this fact.

¹⁶ The TTX Reload Group manages the flow of most of the North American autorack cars. Reload operations use optimization modeling to assist in distributing an industry-wide fleet of 59,000 multi-level autorack cars to 131 automotive loading points serving 17 auto manufacturers.

¹⁷ Using the more detailed QGI Equipment type 2, yielded a database of 1856 rows. For CP data, an indicator of which car order types were private cars was not provided. As a result, these numbers will include some private fleets on CP that will need to be excluded from the analysis when the detailed car order data is provided to QGI.

Figure 10 Number of cars shipped by shipper and order size in sampling frame

Sampling Frame**Sum of Cars - by Order Size by Shipper Size (Excludes Automotive / Intermodal / Bulk)****Absolute Count**

Order Size	Shipper Size				Total
	L	M	S	VS	
1	6,537	3,961	3,641	13,468	27,607
2	6,456	2,188	3,749	8,746	21,139
3	128,100	42,629	62,543	18,259	251,531
4	713,360	128,440		-	841,800
Grand Total	854,453	177,218	69,933	40,473	1,142,077

Percent Distribution (of Total)

Order Size	Shipper Size				Total
	L	M	S	VS	
1	0.6%	0.3%	0.3%	1.2%	2.4%
2	0.6%	0.2%	0.3%	0.8%	1.9%
3	11.2%	3.7%	5.5%	1.6%	22.0%
4	62.5%	11.2%			73.7%
Grand Total	74.8%	15.5%	6.1%	3.5%	100.0%

Further examination of the proposed sample showed that it contained a very small number of CP shippers in the VS category (7 Grain, 11 Merchandise). As this would provide too small a number of customers to allow for a robust analysis of car supply for these strata of customers and railway business, a supplementary sample of VS customers in the CP supplied data was identified to add to the sample.¹⁸

With the additional CP VS customers included in the sample and with the smaller orders for all but the VS customers removed from the data, the sample was found to be sufficiently representative of the sampling frame to support the desired analysis at an acceptable level of accuracy. The overall sample contained a total of 824,094 cars with the following distribution by order size and shipper size.

¹⁸ This was done by sorting by an assigned random number a list of all CP VS customers whose shipments met the criteria for selection in the car supply analysis as described earlier. The first 18 customers were then selected from the list. The flows associated with these customers were then added to the sample. This doubled the number of customers in the sample to 36 and increased the number of rows of data by 139.

Figure 11 Number of cars shipped by shipper and order size in sample

Sample

Sum of Cars - by Order Size by Shipper Size (Excludes Automotive / Intermodal / Bulk)

Absolute Count

Order Size	Shipper Size				Total
	L	M	S	VS	
1				1,036	1,036
2				1,342	1,342
3	85,964	25,959	35,510	4,761	152,194
4	579,574	89,948			669,522
Grand Total	665,538	115,907	35,510	7,139	824,094

Percent Distribution (of Total)

Order Size	Shipper Size				Total
	L	M	S	VS	
1				0.1%	0.1%
2				0.2%	0.2%
3	10.4%	3.2%	4.3%	0.6%	18.5%
4	70.3%	10.9%			81.2%
Grand Total	80.8%	14.1%	4.3%	0.9%	100.0%

Various cross tabulations comparing the sampling frame to the sample were conducted to ensure that the sample was representative and large enough at the desired levels of analysis.

Figure 12 Proportion of cars shipped by railway and major group

Sampling Frame**Percent Distribution (of Total)**

Railway	Fertilizers	Grain	Merchandise	Total
CN				60.1%
CP				39.9%
Grand Total	1.9%	38.2%	59.9%	100.0%

Sample**Percent Distribution (of Total)**

Railway	Fertilizers	Grain	Merchandise	Total
CN				60.8%
CP				39.2%
Grand Total	2.4%	37.2%	60.5%	100.0%

Figure 13 Proportion of shippers by shipper size and major group

Sampling Frame**Absolute Count**

Shipper Size	Fertilizers	Grain	Merchandise	Total
L	5	19	48	68
M	5	26	98	123
S	6	43	118	159
VS	15	301	812	1,119
Grand Total	31	389	1,076	1,469

Sample**Absolute Count**

Shipper Size	Fertilizers	Grain	Merchandise	Total
L	4	18	43	61
M	4	16	54	72
S	1	18	59	74
VS		33	39	71
Grand Total	9	85	195	278

The sample of data rows represented in the railway data was sent to the railways with a request for them to provide car order data for the selected customers. This data should include all cars ordered, supplied, and released by car type, by week for all weeks in the study period. The detailed datasets to be provided to QGI by the railways should include the following data fields and record structure.

- QGI Record Key
- Shipper Name and Number
- Railway Business Unit and Industry Subgroup
- Commodity Description
- 3-Digit Commodity Code
- Origin Station Name
- Origin Station FSAC Number
- Railway Car Group Number
- Railway Car Group Description
- Railway Car Ownership (Private or Railway)
- Year
- Month
- Week
- Number of Cars Ordered
- Number of Cars Supplied
- Number of Cars Released Loaded

Appendix 1 QGI Major Group Definition

Table 1 CN Industry sub-group consolidation into QGI Major Groups

<u>Major Group (QGI)</u>	<u>CN Business Unit</u>	<u>CN Industry Major Subgroup</u>
Automotive	Automotive	FINISHED VEHICLES
		VEHICLE PARTS
Bulk	Coal	COAL
	Grain & Fertilizer	FERTILIZERS
	Petroleum & Chemicals	PETROLEUM PRODS (Dry & Molten Sulphur only)
Fertilizers	Grain & Fertilizer	FERTILIZERS
Grain	Grain & Fertilizer	GRAIN
Intermodal	Intermodal	DOMESTIC
		OVERSEAS
Merchandise	Forest Products	LUMBER & PANELS
		PULP & PAPER
	Metals & Minerals	IRON ORE
		METALS
		MINERALS
	Petroleum & Chemicals	CHEMICALS
	PETROLEUM PRODS	

Table 2 CP Industry sub-group consolidation into QGI Major Groups

<u>Major Group (QGI)</u>	<u>CP Major Group</u>	<u>CP Industry Subgroup</u>
Automotive	Automotive	<i>no CP sample selected yet</i>
Bulk	Coal / Coke / Sulphur	Coal
		Coke
		Sulphur
	Fertilizers	Potash
Fertilizers	Fertilizers	Fertilizers (Dry and Wet)
Grain	Grain	Animal Feeds
		Grain Products
		Other Agricultural
		Other Grain
		Veg. Oil & Sweeteners
		Wheat
Intermodal	Import / Export Containers	Import / Export Containers
	Intermodal	Intermodal

Merchandise	Aggregates / Mines / Steel	Cement
		Clay
		Copper
		Copper Ores & Concentrates
		Copper-Nickel Ores and Concentrates
		Gypsum
		Iron & Steel
		Iron & Steel Scrap
		Lead & Zinc Ores
		Other Mine Products
		Other Non Ferrous Metals
		Other Ores & Concentrates
		Salt
		Salt Cake
		Sand & Stone
	Consumer Products	Building Materials
		Miscellaneous
		Packaging Products
		Pool Cars
		Waste Products
	Energy / Chemicals	Chemicals & Acids
		Fuel Oil
		Gasoline
		L.P.G.
		Other Gas
		Other Refined Petroleum
		Plastics
		Sulphuric Acid
	Food Products	Beverages
		Dairy & Food Products
		Fruits and Vegetables
		Meats and By Products
		Sugar
	Forest Products	Logs & Poles
		Lumber
		Newsprint
		Panel Products
		Paperboard
		Printing Papers
		Pulp Chips
		Woodpulp

Appendix 2 QGI Equipment Type Definition

Table 3 CP versus QGI car type descriptions

<u>CP Revenue Plan Car Code</u>	<u>CP Description</u>	<u>QGI Equipment Type</u>	<u>QGI Equipment Type 2</u>
B0	BOXCARS OTHER	Box Car	Box Other
B1	50 FT STANDARD BOXCAR	Box Car	Box 50-52
B2	50 FT NEWSPRINT BOXCAR	Box Car	Box Newsprint
B3	DOUBLE DOOR BOXCAR	Box Car	Box Double Door
B4	50 FT HEATER DFB BOXCAR	Box Car	Box Other
B5	RBL/REEFER BOXCAR	Box Car	Box Reefer
B6	50 FT INSULATED BOXCAR	Box Car	Box Insul
B8	60 FT AUTOPARTS BOXCAR	Box Car	Box Auto
B9	86 FT AUTOPARTS BOXCAR	Box Car	Box Auto
D1	DEPRESSED FLAT	Flat Car	Flat Heavy Specialized
F1	BULKHEAD FLAT GT 53' LT 60'	Flat Car	Flat BH GT 53
F2	BULKHEAD FLAT 60' OR GREATER	Flat Car	Flat BH GT 53
F3	BULKHEAD FLAT LT 53'	Flat Car	Flat BH LT 53
F5	CENTREBEAM FLATS 60' OR MORE	Flat Car	Flat CB Other
F6	CENTREBEAM FLATS LT 53'	Flat Car	Flat CB Other
F7	FLAT OTHER (PIPE LOADING)	Flat Car	Flat Pipe
F8	CENTREBEAM FLATS 73' DROP DECK	Flat Car	Flat CB 73
G1	OPEN COIL GONDOLA	Gondola	Gon Open Coil
G2	COVERED COIL GONDOLA	Gondola	Gon Cov Coil
G3	OPEN SHORT GONDOLA	Gondola	Gon Open Short
G4	COVERED GONDOLA	Gondola	Gon Cov Short
G5	OPEN LONG GONDOLA	Gondola	Gon Open Long
G7	ROTARY DUMP GONDOLA	Gondola	Gon Rotary
H1	GRAVITY COVERED HOPPER LOWCUBE	Covered Hopper	Hopper Cov Gravity
H2	GRAVITY COVERED HOPPER HI CUBE	Covered Hopper	Hopper Cov Gravity
H3	OTHER COVERED HOPPER LOW CUBE	Covered Hopper	Hopper Cov Other
H4	OTHER COVERED HOPPER HI CUBE	Covered Hopper	Hopper Cov Other
H5	OPEN TOP UNEQUIPPED HOPPER	Hopper	Hopper Open
H6	OPEN TOP EQUIPPED HOPPER	Hopper	Hopper Open
H7	ORE CAR	Gondola	Gon Open Short
I1	20' MARINE CONTAINER	Container	(blank)
I2	40' MARINE CONTAINERS	Container	(blank)
I3	DRY VAN TRLRS AND CONTAINERS	Container	(blank)

I5	REEFER TRAILERS AND CONTAINERS	Container	(blank)
I6	HEATER TRAILERS AND CONTAINERS	Container	(blank)
I8	53' CONTAINERS	Container	(blank)
L1	LOG FLATS GT 53' LT 60'	Flat Car	Flat Miscellaneous
L2	LOG FLATS 60' OR GREATER	Flat Car	Flat Miscellaneous
L4	PULPWOOD FLATS	Flat Car	Flat Pulpwood
M1	BI LEVEL	Multi-level	(blank)
M2	TRI LEVEL	Multi-level	(blank)
M3	AUTOMAX TRI LEVEL	Multi-level	(blank)
QB	2 SLOT PIGGYBACK, TOFC ONLY	Intermodal Car	(blank)
QC	41' CONVENTIONAL, COFC	Intermodal Car	(blank)
QF	81' CONVENTIONAL, COFC	Intermodal Car	(blank)
QG	89' CONVENTIONAL, COFC	Intermodal Car	(blank)
QI	89' CONVENTIONAL DUAL PURPOSE	Intermodal Car	(blank)
QJ	5 PLATFORM SPINE, DUAL PURPOSE	Intermodal Car	(blank)
QK	5 PLATFORM SPINE, COFC ONLY	Intermodal Car	(blank)
QR	5 PLATFORM DOUBLE STACK	Stack Car	(blank)
S1	STANDARD FLATS GT 53' LT 60'	Flat Car	Flat Standard
S2	STANDARD FLATS GT 60'	Flat Car	Flat Standard
S3	STANDARD FLATS LT 53'	Flat Car	Flat Standard
S4	STANDARD FLAT (AUTO/TRUCK)	Flat Car	Flat Standard Auto/Truck
T1	TANK CARS LT OR EQ 11000 GALS	Tank Car	(blank)
T2	TANK CARS 12000 TO 21000 GALS	Tank Car	(blank)
T4	TANK CARS 25000 GALS AND OVER	Tank Car	(blank)
WA	MAINTENANCE OF WAY	Other	(blank)
(blank)	Container	Container	(blank)
	Flat Car	Flat Car	Flat Miscellaneous
	Locomotive	Locomotive	(blank)
	Other	Other	(blank)
	Tank	Tank Car	(blank)
	Trailer	Trailer	(blank)

Table 4 CN versus QGI car type descriptions

<u>CN Car Group</u>	<u>CN Description</u>	<u>QGI Equipment Type</u>	<u>QGI Equipment Type 2</u>
10	BOX 50 FT OVER 70 TON COMPARTMENTIZER	Box Car	Box 50-52
11	BOX 50-FT OVER FOREIGN	Box Car	Box 50-52
12	BOX 50-FT 100 TON PLUG DOOR PLATE F	Box Car	Box 50-52
13	BOX 50-60FT 70-100 TON PLUG/DOUBLE DOOR CUF P&P SVC	Box Car	Box Newsprint
14	BOX 50-FT 75-100 TON SLIDING DOOR CUF	Box Car	Box Newsprint
15	BOX 52-FT 70-100 TON DOUBLE DOORPLATE C	Box Car	Box Double Door
16	BOX 50-FT 75-80 TON DOUBLE DOOR PLATE B & C	Box Car	Box Double Door
17	BOX 50-FT 75-80 TON 12 FT PLUG DOOR	Box Car	Box 50-52
18	BOX 50-52 FT 100 TON 10-12 FT PLUG/SLIDING DOOR PLATE C	Box Car	Box 50-52
19	BOX 50 FT 70-80 TON 10 FT SLIDING/COMBINATION DOOR	Box Car	Box 50-52
2	BOX 50 FT 70-80 TON GRAIN SVC	Box Car	Box 50-52
21	COVERED HOPPER GRAVITY 100 TON CAP 3800-4550 CUBIC FT. ROUND HATCH	Covered Hopper	Hopper Cov Gravity
22	COVERED HOPPER GRAVITY 100 TON CAP 4350 CUBIC FT. TROUGH HATCH	Covered Hopper	Hopper Cov Gravity
23	COVERED HOPPER GRAVITY 100 TON CAP 4500 CUBIC FT. AND LARGER	Covered Hopper	Hopper Cov Gravity
24	COVERED HOPPER PNEUMATIC UNLOADING 80-100 TON CAP 3300-4550 CUBIC FT.	Covered Hopper	Hopper Cov Other
25	COVERED HOPPER PRESSURIZED UNLDG. 100 TON CAP 3300 CUBIC FT.	Covered Hopper	Hopper Cov Other
28	FLAT TRAILER PIGGYBACK SVC	Intermodal Car	(blank)
29	FLAT CONTAINER SERVICE	Intermodal Car	(blank)
30	FLAT HEAVY DUTY SPECIALIZED LDG	Flat Car	Flat Heavy Specialized
31	FLAT MISC.	Flat Car	Flat Miscellaneous
32	FLAT EQUIPPED 52-89 FT	Flat Car	Flat Standard Auto/Truck
33	FLAT FRAME/PEDESTAL 56-89 FT	Flat Car	Flat Standard Auto/Truck
35	BOX - EQUIPPED - AUTO PARTS SVC	Box Car	Box Auto
36	FLAT BI-LEVEL 89 FT	Multi-level	(blank)
37	FLAT TRI-LEVEL 89 FT	Multi-level	(blank)
38	FLAT 89 FT PIPE SVC	Flat Car	Flat Pipe
39	FLAT 52-62 FT STANDARD	Flat Car	Flat Standard
40	FLAT BULKHEAD 66 FT 100 TON	Flat Car	Flat BH GT 53
42	FLAT BULKHEAD 51 FT. 6 IN. 75-80 TON	Flat Car	Flat BH LT 53
43	FLAT BULKHEAD 52 FT. 8 IN. 80 TON	Flat Car	Flat BH LT 53
44	FLAT STD OR BHF - PULPWOOD SVC	Flat Car	Flat Pulpwood
45	FLAT BULKHEAD METAL SVCE	Flat Car	Flat Miscellaneous

46	FLAT BULKHEAD CENTERBEAM	Flat Car	Flat CB 73
47	FLAT BULKHEAD CENTERSTAKE	Flat Car	Flat CB Other
49	GONDOLA WOODCHIP	Gondola	Gon Woodchip
50	GONDOLA 65 FT 70 TON	Gondola	Gon Open Long
51	GONDOLA 65 FT 100 TON	Gondola	Gon Open Long
52	GONDOLA 52 FT 70-85 TON	Gondola	Gon Open Short
53	GONDOLA 52 FT 100 TON	Gondola	Gon Open Short
54	GONDOLA 52 FT 100T CONCENTRATE	Gondola	Gon Open Short
57	GONDOLA 53 FT 100 TON FIBR/STEEL COVERS	Gondola	Gon Cov Short
59	OPEN COIL FLAT	Flat Car	Flat Miscellaneous
61	COVERED COIL FLAT/GON	Gondola	Gon Cov Coil
65	GONDOLA GYPSUM SVCE	Gondola	Gon Other
66	GONDOLA / GENERAL SERVICE / HART CARS	Gondola	Gon Other
67	GONDOLA ROTARY 51-52 FT 102 TON COAL / SULPHUR SVC	Gondola	Gon Rotary
7	BOX HI CUBE 40 FT OVER FOREIGN	Box Car	Box Other
70	HOPPER OPEN 3-4 POCKETS 40-50 FT 80-100 TON	Hopper	Hopper Open
76	BOX INSULATED / COMPART 50-52 FT 65-75 TON	Box Car	Box Insul
78	BOX INSULATED / STANDARD 50-60 FT 70-85 TON	Box Car	Box Insul
79	BOX MECHANICAL REEFER 50 FT ALL PURPOSE	Box Car	Box Reefer
8	BOX 52-60 FT 100 TON DOUBLE DOOR OSB SVC	Box Car	Box Double Door
81	REEFER...MISC... GENERAL USE	Box Car	Box Reefer
86	GOV. COVERED HOPPER 52 FT 88-100 TON 4100-4500 CUBIC FT GRAIN SVC	Covered Hopper	Hopper Cov Gravity
87	PRIVATE LINE CAR EQUIPMENT	Covered Hopper	Hopper Cov Private
88	PRIVATE LINE.. ROTARYGONDOLAS	Gondola	Gon Rotary
89	TANK VARIOUS	Tank Car	(blank)
9	BOX 60 FT SINGLE OR DOUBLE DOOR LOW CAP	Box Car	Box Other
99	PASSENGER / CABS / ENGINES / OTHERS	Other	(blank)
IM	CONTAINER	Container	(blank)
(blank)	CONTAINER OR TRAILER	Container	(blank)