Real-World Multi-Echelon Supply Chains Used for Inventory Optimization: Online Appendix

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This data set describes 38 multi-echelon supply chains that have been implemented in practice. These chains exhibit special structure that can be used to inform and test analytical models. Although the data were not collected with the intention of econometric analysis, it is possible that they could be useful in an empirical study. The data described in this paper are publicly available at the journal's web site http://www.msom.org.

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1. Introduction

This on-line appendix supplements Willems (2007) with a more complete description of the data set available on-line. The data set, found at http://www.msom.org/, sheds light on how practitioners equipped with an inventory optimization tool are modeling supply chains in reality. The paper's primary objective is to inform researchers developing analytical supply-chain models by presenting supply chains business users and consultants have created. In particular, each chain contains the exact supply chain network created by the contributor plus the exact characterization of leadtimes at every stage in the supply chain plus realistic yet disguised values for all the supply chain's data. A secondary use of this data might be to support empirical research into the nature of the supply chains created. The data, available in Microsoft Access, Microsoft Excel and XML formats, are open to all researchers as long as the researcher is willing to cite Willems (2007) as the source. Section 2 presents background information for the chains and Section 3 presents some observations to place the data in context.

2. High-Level Presentation of the Chains

The chains described in this paper comprise actual supply chain models created by either company analysts or consultants and models using the data have been implemented in practice. These chains demonstrate how real users have modeled their real-world supply chain situations.

2.1 Chain selection criteria

PowerChain Inventory (PCI) is a software application that optimizes inventory levels and locations across the supply chain. PCI is based on the guaranteed service model of inventory placement as described in Graves and Willems (2003). PCI's minimum data requirements include the bill of materials, the cost and time at every stage, and the demand characterization at demand stages (consisting of average demand per period, standard deviation per period, service level, and maximum time the customer is willing to wait). Given this data, PCI optimizes inventory cost across the network subject to the service requirements at demand stages.

Beginning in 2004, I asked companies using PCI to send me what they considered to be the most representative acyclic supply chain model they had created. Since several of the companies have tens of users that have created thousands of chains, the requirements were kept simple in order to achieve my goal of generating a test bed of general acyclic supply chain networks that can support the development of analytical models. The two major requirements for each contributor were that they only submit a single chain and that the single chain represents the complexity that they have to model in their business. Table 1 summarizes high level details of the data set.

Chain Name	Company Identifier	SIC Code	SIC Description
1	1	2869	Industrial Organic Chemicals, Not Elsewhere Classified
2	2	3674	Semiconductors and Related Devices
3	3	3577	Computer Peripheral Equipment, Not Elsewhere Classified
4	4	3944	Games, Toys, and Children's Vehicles, Except Dolls and Bicycles
5	5	2099	Food Preparations, Not Elsewhere Classified
6	6	3421	Cutlery
7	7	3531	Construction Machinery and Equipment
8	8	3845	Electromedical and Electrotherapeutic Apparatus
9	9	2043	Cereal Breakfast Foods
10	10	5064	Electrical Appliances, Television and Radio Sets
11	7	3531	Construction Machinery and Equipment
12	9	2043	Cereal Breakfast Foods
13	3	3674	Semiconductors and Related Devices
14	11	4731	Arrangement of Transportation of Freight and Cargo
15	12	2841	Soap and Other Detergents, Except Specialty Cleaners
16	8	3845	Electromedical and Electrotherapeutic Apparatus
17	13	3577	Computer Peripheral Equipment, Not Elsewhere Classified
18	14	3577	Computer Peripheral Equipment, Not Elsewhere Classified
19	13	3577	Computer Peripheral Equipment, Not Elsewhere Classified
20	15	3577	Computer Peripheral Equipment, Not Elsewhere Classified
21	16	2844	Perfumes, Cosmetics, and Other Toilet Preparations
22	17	2834	Pharmaceutical Preparations
23	18	2851	Paints, Varnishes, Lacquers, Enamels, and Allied Products
24	19	3546	Power-Driven Handtools
25	20	3523	Farm Machinery and Equipment
26	21	3724	Aircraft Engines and Engine Parts
27	22	3845	Electromedical and Electrotherapeutic Apparatus
28	23	3572	Computer Storage Devices
29	24	3692	Primary Batteries, Dry and Wet
30	25	4731	Arrangement of Transportation of Freight and Cargo
31	20	3523	Farm Machinery and Equipment
32	16	2844	Perfumes, Cosmetics, and Other Toilet Preparations
33	12	2844	Perfumes, Cosmetics, and Other Toilet Preparations
34	26	3661	Telephone and Telegraph Apparatus
35	22	3845	Electromedical and Electrotherapeutic Apparatus
36	27	3523	Farm Machinery and Equipment
37	28	2869	Industrial Organic Chemicals, Not Elsewhere Classified
38	29	3724	Aircraft Engines and Engine Parts

Table 1: General Classification of the Data Set

In the nine cases where two supply chains come from the same company, the chains come from users in different business units. For example, Chains 7 and 11 come from the same company and both supply chains represent a construction machinery supply chain.

It is fair to note that other criteria could have been suggested when requesting the chains. For example, one could have asked for the chain associated with the most successful supply-chain improvement initiative at the company where success might be defined in terms of dollars saved, or dollar-volume of business affected, or number of employees influenced. Another valid selection criterion could have been the most illustrative chain in an effort to demonstrate the modeling aptitude present at the company. While these are valid and potentially interesting criteria, the goal in identifying a chain with representative complexity is to capture what business users consider to be chains worth modeling and optimizing.

2.2 Introducing the chains

From a graph-theoretic perspective, a supply chain map forms a network of stages and arcs. A stage represents the processing activity of a stock keeping unit (SKU) at a location. For example, if two SKUs flow through a distribution center, the network will contain one stage for each SKU at the distribution center. A stage is a candidate location to hold safety stock; stages with no outgoing arcs are demand stages. Arcs denote the precedence relationship between stages; an arc's multiplier represents the number of units at the source stage required to produce one unit of output at the destination stage. Graves and Willems (2000, 2003) and Humair and Willems (2006a) each contain an example of a supply chain created using this framework.

Producing a useful data set for analytical research requires synthesizing some facets of the 38 supply chains. PCI has modeling functionality ranging from simple features like excluding stages from the optimization, bounding the replenishment time at stages, and modeling yield loss to advanced features addressing batching, capacity and review periods. I feel there are three reasons to prune much of this functionality from the data set. First, it helps focus on what is common across the chains and contributors. Second, some of these more advanced features did not exist in PCI when the first contributed chains were created. Third, the criteria I established did not mention advanced functionality so many contributors did not consider advanced functionality when submitting chains.

Since the submitted chains contain stage names that use company-specific acronyms or information-system-assigned labels, the first data synthesis step entails assigning each stage one of five classification labels that reflect the function the stage performed; within each classification, stages are numbered sequentially starting at 0001. The stage classifications are:

Classification label	Activity
Dist_	a stage that distributes an item
Manuf_	a stage that manufactures or assembles an item
Part_	a stage that procures an item
Retail_	a stage that acts as a demand origination point
Trans_	a stage that tranports an item between stages

Table 2: Classifications used to label every stage in the chains

Some judgment was required to determine the best classification for certain stages in some supply chains. For example, some stages perform multiple functions like transportation and manufacturing or transportation and distribution; in Chain 35, stages Manuf_0001 through Manuf_0613 handle and stage parts for assembly. In cases where the contributor has clearly labeled the intent of the stage, I have mapped the contributor's intent to the classification scheme. In cases where the contributor's intent is less clear, I have chosen the classification that best describes the stage's activity. Table 3 summarizes the classification information by chain.

Chain Name	Dist_	Manuf_	Part_	Retail_	Trans_	Total # Stages	Total # Arcs
1	0	2	3	3	0	8	10
2	0	5	0	4	4	13	13
3	4	4	5	0	4	17	18
4	11	7	4	0	0	22	39
5	1	5	13	8	0	27	31
6	12	10	0	0	6	28	28
7	0	6	13	6	13	38	78
8	10	4	12	2	12	40	48
9	26	4	16	3	0	49	52
10	0	13	45	0	0	58	176
11	0	6	13	18	31	68	108
12	51	9	23	0	5	88	107
13	0	108	0	0	0	108	452
14	5	9	0	66	36	116	120
15	28	28	21	56	0	133	164
16	84	53	8	0	0	145	224
17	93	32	21	5	1	152	212
18	31	24	49	28	22	154	225
19	15	56	43	0	42	156	263
20	0	44	74	2	36	156	169
21	17	59	76	34	0	186	359
22	3	123	0	123	4	253	253
23	0	48	198	25	0	271	524
24	77	48	209	0	0	334	1245
25	31	142	94	142	0	409	853
26	0	65	401	2	0	468	605
27	12	38	420	12	0	482	941
28	0	93	398	82	4	577	2262
29	0	70	128	365	54	617	753
30	48	175	1	220	182	626	632
31	30	30	76	570	0	706	908
32	222	222	289	0	111	844	1685
33	522	81	81	0	292	976	1047
34	0	58	1148	0	0	1206	4063
35	36	687	619	0	44	1386	1857
36	19	672	173	587	0	1451	4812
37	36	87	274	523	559	1479	2069
38	0	87	820	559	559	2025	16225

Table 3: Number of classified stages per chain

Table 4 specifies the data provided at each stage in the supply chain:

Data field	Applicable stages	Description
stageCost	all stages	Direct cost added at the stage
stageTime	all stages	Average processing time at the stage
stDevStageTime	all stages	Standard deviation of processing time at the stage
avgDemand	only demand stages	Daily demand rate
stdDevDemand	only demand stages	Daily standard deviation of demand
serviceLevel	only demand stages	Percentage of orders stage plans to satisfy
maxServiceTime	only demand stages	Maximum time the customer is willing to wait
relDepth	all stages	Relative depth of node to network root
stageClassification	all stages	Classification stage belongs to
xPosition	all stages	Horizontal distance from (0,0) picture position
yPosition	all stages	Vertical distance from (0,0) picture position

Table 4: Stage data

relDepth, stageClassification, xPosition, and yPosition are attributes I have added to the data set to facilitate the use of the chains by researchers. relDepth is the net number of forward arcs minus backward arcs traversed between the current stage and a root node in the network that is assigned a relative depth of zero; Humair and Willems (2006a) demonstrate the value in using relative depth to traverse stages in the supply chain. stageClassification is the stage's classification from Table 2. In a visual layout of the chain where (0,0) is the top right of the picture, xPosition and yPosition denote the number of pixels to the right and down, respectively, where the stage is positioned in the supply chain's picture included in the online data set.

The other fields in Table 4 correspond to data created by the chain's contributor. stageCost is the direct cost added at the stage; all costs are measured in US dollars. stageTime represents the time to complete its processing activity assuming all raw materials are available; all times are measured in days. A modeler can specify stage time as deterministic, normally distributed, or a discrete random variable. If the stage time is characterized as a normally distributed random variable then stageTime is the average processing time and stdDevStageTime is the associated standard deviation of stage time. Stage time can also be characterized with a discrete distribution where up to six discrete points, and their associated probabilities, are specified as stageTime_i and stageTime_%_i for i = 1, 2, … 6.

Stages without outgoing arcs are demand stages. By construction all Retail_ stages are demand locations but any stage can represent a demand origin if it has no outgoing arcs. For example, Chain 10 is a two-echelon network where the Manuf_ stages specify the demand parameters. For stages that are demand stages, demand per period is specified as a normally distributed random variable with mean avgDemand and standard deviation stDevDemand. Demand stages also specify a Type I serviceLevel and a maxServiceTime that that the customer is willing to wait to receive product. These demands then propagate back to non-demand stages as i.i.d. random variables; Humair and Willems (2006b) describe one method of demand propagation in general acyclic networks.

Many contributors were unwilling to share actual service level targets, stage costs (in particular related to transportation) and arc multipliers. These inputs were viewed as being at the core of how companies compete and unique enough to allow the identification of companies that contributed the chains. Therefore, all the data that is contained in the data set has been disguised in order to protect privileged information while still accurately representing the operating characteristics of the actual contributed chain. In the case of arc multipliers, all arc multipliers were set to 1 and the average and standard deviation of demand were scaled accordingly to represent the original demand stream. Next, all cost, time, and demand fields were perturbed plus or minus 20% by randomly generating percentage changes for each stage's data.

While these changes are significant in changing the characteristics at any given stage, they were done in a manner that preserved the overall metrics for the total supply chain; for example, the cost of goods sold and the average supply chain length were not changed significantly by this change. Furthermore, any dominant characteristic across a set of stages has been preserved. For example, if in reality a set of Retail_ stages have the same service levels or a set of Trans_ stages have the same stage times, the disguised chains preserve these common characteristics. This two-step process of classifying the stages and perturbing the stage values assured the companies that no confidential information would be divulged while at the same time preserving an exact representation of the chain's structure and a fair and accurate representation of its real-world performance characteristics.

Time is measured in business days and there are 260 business days in a year. The base time unit of all chains is set to one day. Some contributed chains originally had their underlying time unit equal to one week; in these cases, daily demand is assumed to be comprised of five independent and identically distributed random variables. Second, some of the chains adopted a non-stationary demand specification similar in spirit to Graves and Willems (2006). That is, the time horizon was broken into phases of arbitrary length where demand within a phase was independent and identically distributed but demand across phases was arbitrary. In the case of non-stationary demand, I created a stationary-time model by taking a weighted average of the demands in each phase.

Table 5 breaks down the number and type of stochastic stage times in use for every chain, plus metrics relating to the total time across each supply chain.

Chain Name	Average Supply Chain Length	Maximum Supply Chain Length	# Normally Distributed Stage Times	# Discrete Stage Times
1	38	38	-	1
2	64	64	-	-
3	77.04	79.8	-	8
4	193.42	204	-	-
5	45.28	47.35	7	9
6	88.35	96	16	-
7	81.14	85	38	-
8	91.04	91.04	-	-
9	44.32	47.38	9	2
10	116.97	162	21	-
11	55.89	60	39	6
12	105.03	108.6	16	12
13	24.09	26	-	-
14	86.56	128.32	36	-
15	21.72	26	77	-
16	150.05	163	106	-
17	48.79	57	-	-
18	76.19	100	-	-
19	117.08	125	-	-
20	129.07	160.9	-	63
21	86.93	96	101	-
22	524.25	691	245	-
23	52.66	77	-	-
24	64.58	68.53	-	207
25	61.29	82	-	-
26	315.33	394.07	-	-
27	88.39	105	-	406
28	114.3	123	1	-
29	24.13	43	431	-
30	19.18	71.05	188	-
31	16.37	17.92	643	-
32	63.37	112.2	511	111
33	46.76	72.36	128	182
34	68.13	89	-	-
35	49.95	81	-	-
36	31.79	49.55	-	1451
37	20.65	27.85	559	-
38	21.47	26.03	1379	-

Table 5: Stage time metrics for each chain

The maximum supply chain length is the longest stage-time path through the chain. The average supply chain length is a dollar-volume weighted average of each demand stage's maximum length. 26 of the 38 chains use stochastic stage times but only 15 chains have more than half of the stages employing variable stage times.

The cost of goods sold (COGS) per unit and a summary of the cost outputs by stage classification are displayed in Table 6.

Chain Name	Dist_	Manuf_	Part_	Retail_	Trans_	Average Cost of Goods Sold Per Unit
1	-	59.5%	40.5%	-	-	$71.88
2	-	99.6%	-	-	0.4%	$136.07
3	6.7%	8.2%	85.1%	-	0.1%	$3,820.00
4	4.1%	4.2%	91.7%	-	-	$212.67
5	16.0%	2.8%	75.3%	6.0%	-	$31.46
6	6.2%	87.1%	-	-	6.7%	$3.42
7	-	12.8%	85.5%	0.6%	1.2%	$150,816.00
8	0.9%	8.9%	87.1%	-	3.1%	$120.72
9	3.2%	6.0%	90.8%	-	-	$22.84
10	-	28.4%	71.6%	-	-	$5,477.00
11	-	13.0%	85.5%	-	1.5%	$142,853.00
12	6.7%	6.2%	24.4%	-	62.8%	$29.61
13	-	100.0%	-	-	-	$134.50
14	47.0%	48.3%	-	0.1%	4.6%	$16.74
15	3.3%	51.1%	45.6%	-	-	$9.17
16	0.6%	44.6%	54.8%	-	-	$342.88
17	10.6%	13.3%	69.0%	3.3%	3.8%	$33.16
18	6.4%	6.2%	84.8%	0.5%	2.2%	$91.68
19	0.1%	40.8%	59.1%	-	-	$135.40
20	-	28.5%	55.6%	0.3%	15.7%	$448.02
21	1.3%	12.0%	86.8%	-	-	$17.81
22	1.9%	98.0%	-	-	0.1%	$3.23
23	-	31.2%	68.8%	-	-	$110.54
24	0.0%	0.9%	99.1%	-	-	$949.26
25	0.3%	6.0%	93.7%	0.0%	-	$2,319.00
26	-	14.1%	83.4%	2.6%	-	$11,681.44
27	1.0%	16.0%	83.0%	-	-	$72.80
28	-	36.0%	63.6%	0.1%	0.2%	$149.71
29	-	52.0%	41.3%	2.2%	4.5%	$8.17
30	64.2%	6.1%	23.3%	-	6.4%	$6.73
31	7.5%	0.1%	88.5%	3.8%	-	$9,609.00
32	9.8%	19.9%	70.4%	-	-	$3.12
33	1.8%	60.0%	31.9%	-	6.4%	$6.29
34	0.4%	5.1%	94.5%	-	-	$130.79
35	-	35.9%	63.5%	-	0.7%	$6.54
36	-	30.7%	68.5%	0.8%	-	$422.44
37	-	18.9%	78.3%	2.8%	-	$231.75
38	-	12.8%	84.9%	2.1%	0.2%	$292.52

Table 6: Cost metrics for each chain

The percentages for each classification correspond to their total percentage of the supply chain's COGS. The average COGS per unit is the volume-weighted average cumulative cost at each demand stage.

3. Observations about the Data

First, many chains exhibit special structure. As defined in Humair and Willems (2006a), chains with clusters of commonality (CoC) can be transformed into a modified network that is itself a spanning tree. CoC chains reflect a network where there is a lot of commonality between a limited number of echelons but the rest of the chain is relatively disjoint. Half the submitted chains are CoC chains. And in the chains that are not CoC chains, very few have parts that skip echelons. So even among all the complexity that are general acyclic networks, real-world supply chains exhibit special structure and look more like Chain 12 in Figure 1 than Chain 19 in Figure 2.

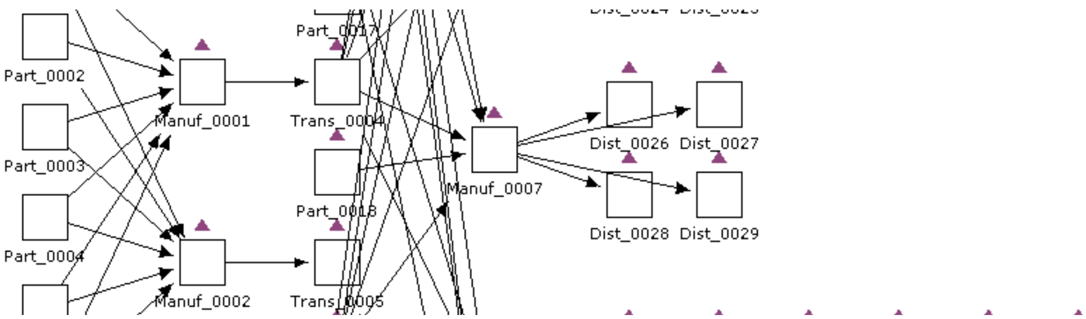

Figure 1: Chain 12 is a CoC network with significant commonality in two echelons

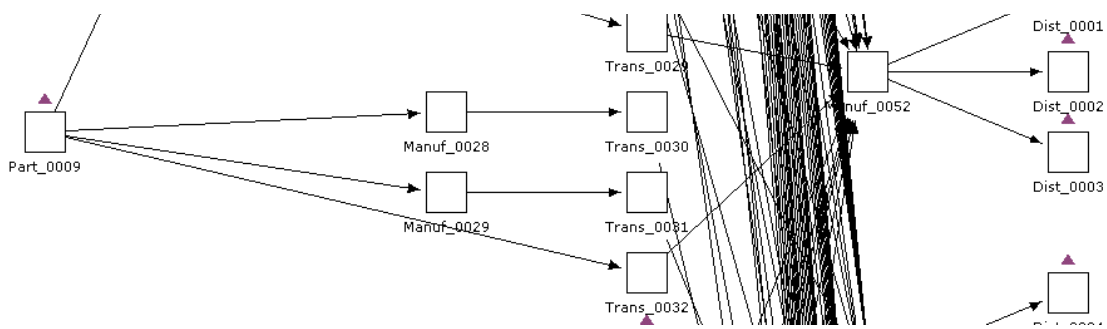

Figure 2: Chain 19 has stages that supply stages in multiple echelons

Second, most chains do not progress linearly through the classified processes of parts to manufacturing to transportation to distribution to retail. Figure 3 displays a sub-graph from Chain 33 that captures the implementation of delayed differentiation. Near the top of Figure 3, Manuf_0078 is a packaging operation that puts together two different intermediate products.

These intermediate products (of which Manuf_0072 is visible in the figure) are themselves distributed through a two-tier distribution network and sold separately.

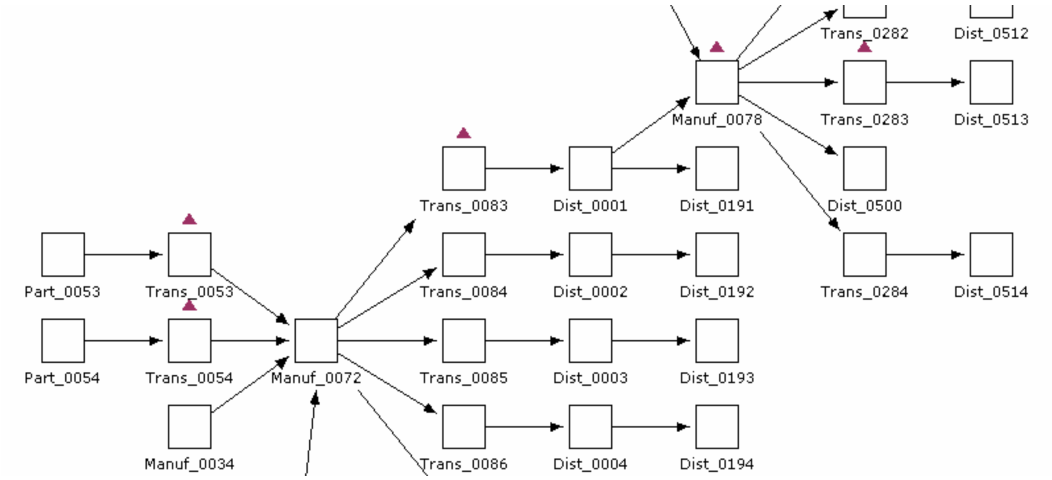

Figure 3: Subgraph from Chain 33 Showing a Postponement Operation

Third, chains between 150 and 350 stages demonstrate the greatest complexity. The intuition is that small chains are trivial and large chains replicate the bill of materials in an enterprise planning system. Users craft mid-size chains to solve thorny supply chain problems. Table 7 demonstrates this with the relative depths of the stages and Table 8 lists all the routings through each chain. The average number of routings for chains between 150 and 50 stages is 5.38 routings. Chains greater than 1000 stages have on average 2 routings and chains less than 100 stages have 1.83 routings on average. If one calculates the weighted average relative depth for a chain as the number of stages with each depth times that depth divided by the total number of stages, the average across the chains between 150 and 350 stages is 2.56, which is again the largest value among the chains.

Chain Name	0	1	2	3	4	5	6	7	8	9
1	3	2	3	-	-	-	-	-	-	-
2	4	4	4	1	-	-	-	-	-	-
3	3	3	4	3	4	-	-	-	-	-
4	4	7	7	4	-	-	-	-	-	-
5	8	4	8	1	6	-	-	-	-	-
6	12	4	6	6	-	-	-	-	-	-
7	6	6	13	13	-	-	-	-	-	-
8	2	2	2	2	2	12	10	8	-	-
9	26	3	11	3	6	-	-	-	-	-
10	13	45	-	-	-	-	-	-	-	-
11	18	18	6	13	13	-	-	-	-	-
12	51	7	19	5	6	-	-	-	-	-
13	10	98	-	-	-	-	-	-	-	-
14	36	45	30	5	-	-	-	-	-	-
15	28	56	28	21	-	-	-	-	-	-
16	24	48	12	12	16	28	5	-	-	-
17	93	33	12	4	10	-	-	-	-	-
18	3	3	28	28	24	59	8	1	-	-
19	15	5	53	41	20	15	5	1	1	-
20	2	6	2	58	49	19	13	3	2	2
21	34	17	17	48	52	12	6	-	-	-
22	24	24	86	99	14	3	1	1	1	-
23	25	64	182	-	-	-	-	-	-	-
24	42	35	17	157	60	23	-	-	-	-
25	173	142	94	-	-	-	-	-	-	-
26	2	86	264	82	24	10	-	-	-	-
27	12	12	67	382	9	-	-	-	-	-
28	67	45	53	397	2	6	5	2	-	-
29	365	54	103	16	79	-	-	-	-	-
30	175	175	227	48	1	-	-	-	-	-
31	570	30	30	76	-	-	-	-	-	-
32	222	111	371	111	29	-	-	-	-	-
33	20	25	312	190	190	38	120	81	-	-
34	53	972	181	-	-	-	-	-	-	-
35	36	36	44	44	613	613	-	-	-	-
36	19	672	587	173	-	-	-	-	-	-
37	559	559	87	274	-	-	-	-	-	-
38	559	559	87	820	-	-	-	-	-	-

Table 7: Number of stages with specific node depth per chain

1	Part -> Manuf -> Retail
2	Manuf -> Trans -> Manuf -> Retail
3	Part -> Manuf -> Trans -> Manuf -> Dist
	Part -> Trans -> Manuf -> Dist
	Part -> Manuf -> Trans -> Dist
4	Part -> Manuf -> Dist -> Dist
	Part -> Manuf -> Dist
5	Part -> Manuf -> Dist -> Manuf -> Retail
	Part -> Manuf -> Retail
6	Manuf -> Trans -> Manuf -> Dist
7	Part -> Trans -> Manuf -> Retail
8	Part -> Manuf -> Trans -> Manuf -> Dist -> Retail
	Part -> Trans -> Manuf -> Trans -> Manuf -> Dist -> Retail
	Part -> Trans -> Dist -> Manuf -> Trans -> Manuf -> Dist -> Retail
9	Part -> Manuf -> Trans -> Manuf -> Dist
	Part -> Trans -> Manuf -> Dist
	Part -> Manuf -> Dist
10	Part -> Manuf
11	Part -> Trans -> Manuf -> Trans -> Retail
12	Part -> Manuf -> Trans -> Manuf -> Dist
	Part -> Trans -> Manuf -> Dist
	Part -> Manuf -> Dist
13	Manuf -> Manuf
14	Dist -> Retail
	Dist -> Manuf -> Retail
	Dist -> Manuf -> Trans -> Retail
15	Part -> Manuf -> Dist -> Retail
	Part -> Manuf -> Retail
16	Part -> Manuf -> Manuf -> Manuf -> Dist -> Dist -> Dist
	Manuf -> Manuf -> Dist -> Dist -> Dist
	Part -> Manuf -> Dist -> Dist -> Dist
	Part -> Manuf -> Manuf -> Manuf -> Dist -> Dist
	Manuf -> Manuf -> Dist -> Dist
	Part -> Manuf -> Dist -> Dist
17	Part -> Retail
	Part -> Manuf -> Trans -> Retail
	Part -> Manuf -> Trans -> Manuf -> Dist
	Part -> Retail
	Part -> Manuf -> Dist
18	Part -> Trans -> Trans -> Manuf -> Dist -> Trans -> Dist -> Retail
	Part -> Trans -> Trans -> Manuf -> Dist -> Retail
	Part -> Trans -> Manuf -> Dist -> Trans -> Dist -> Retail
	Part -> Trans -> Manuf -> Dist -> Retail
	Part -> Manuf -> Dist -> Trans -> Dist -> Retail
	Part -> Manuf -> Dist -> Retail
19	Part -> Manuf -> Trans -> Manuf -> Manuf -> Manuf -> Trans -> Manuf -> Dist
	Part -> Manuf -> Trans -> Manuf -> Manuf -> Trans -> Manuf -> Dist
	Part -> Manuf -> Manuf -> Manuf -> Trans -> Manuf -> Dist
	Part -> Manuf -> Manuf -> Trans -> Manuf -> Dist
	Part -> Manuf -> Trans -> Manuf -> Manuf -> Dist
	Part -> Manuf -> Trans -> Manuf -> Dist
	Part -> Trans -> Manuf -> Dist
	Part -> Trans -> Manuf -> Trans -> Manuf -> Dist
	Part -> Manuf -> Manuf -> Dist
	Part -> Manuf -> Dist
20	Part > Manuf -> Manuf -> Manuf -> Manuf -> Trans -> Manuf -> Manuf -> Trans -> Retail
	Part -> Manuf -> Manuf -> Trans -> Manuf -> Manuf -> Trans -> Retail
	Part -> Manuf -> Manuf -> Trans -> Manuf -> Manuf -> Trans -> Retail
	Part -> Trans -> Manuf -> Manuf -> Manuf -> Trans -> Retail
	Part -> Manuf -> Trans -> Manuf -> Manuf -> Trans -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Trans -> Retail
	Part -> Trans -> Manuf -> Trans -> Retail
	Part -> Manuf -> Trans -> Retail

21	Part -> Manuf -> Manuf -> Dist -> Retail
	Part -> Manuf -> Dist -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Dist -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Manuf -> Dist -> Retail
22	Manuf -> Manuf -> Dist -> Dist -> Manuf -> Trans -> Trans -> Manuf -> Retail
	Manuf -> Manuf -> Dist -> Dist -> Manuf -> Retail
	Manuf -> Manuf -> Dist -> Retail
	Manuf -> Manuf -> Dist -> Dist -> Manuf -> Manuf -> Retail
	Manuf -> Manuf -> Dist -> Dist -> Manuf -> Retail
23	Part -> Manuf -> Retail
	Part -> Retail
24	Part -> Manuf -> Manuf -> Manuf -> Dist -> Dist
	Part -> Manuf -> Manuf -> Dist -> Dist
	Part -> Manuf -> Dist -> Dist
25	Part -> Manuf -> Retail
	-> Dist
26	Part -> Retail
	Part -> Manuf -> Retail
	Part -> Manuf -> Manuf -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Manuf -> Retail
27	Part -> Manuf -> Manuf -> Manuf -> Dist -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Dist -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Dist -> Retail
28	Part -> Manuf -> Manuf -> Retail
	Part -> Manuf -> Manuf
	Part -> Manuf -> Retail
	Part -> Manuf
	Manuf -> Manuf -> Manuf -> Retail
	Manuf -> Manuf -> Manuf
	Part -> Manuf -> Trans -> Manuf -> Manuf -> Manuf -> Manuf -> Retail
	Part -> Manuf -> Trans -> Manuf -> Manuf -> Manuf -> Manuf
	Part -> Manuf -> Manuf -> Manuf -> Manuf -> Manuf -> Retail
	Part -> Manuf -> Manuf -> Manuf -> Manuf -> Manuf
	Part -> Manuf -> Retail
29	Part -> Dist -> Trans -> Manuf -> Retail
	Part -> Dist -> Trans -> Manuf -> Retail
30	Part -> Manuf -> Retail
	Part -> Dist -> Retail
31	Part -> Manuf -> Dist -> Retail
32	Part -> Dist -> Dist
	Part -> Dist -> Retail
	Manuf -> Manuf -> Dist -> Dist
	Manuf -> Manuf -> Dist -> Retail
	Part -> Manuf -> Dist -> Dist
	Part -> Manuf -> Dist -> Retail
	Part -> Manuf -> Manuf -> Dist -> Dist
	Part -> Manuf -> Manuf -> Dist -> Retail
33	Part -> Trans -> Manuf -> Trans -> Dist -> Dist
	Manuf -> Manuf -> Trans -> Dist -> Dist
	Part -> Trans -> Manuf -> Trans -> Dist -> Manuf -> Trans -> Dist
	Manuf -> Manuf -> Trans -> Dist -> Manuf -> Trans -> Dist
	Part -> Trans -> Manuf -> Trans -> Dist -> Manuf -> Dist
	Manuf -> Manuf -> Trans -> Dist -> Manuf -> Dist
34	Part -> Manuf -> Manuf
	Part -> Manuf
35	Part -> Trans -> Manuf -> Dist
	Part -> Manuf -> Manuf -> Trans -> Manuf -> Dist
36	Part -> Manuf -> Retail
	Part -> Manuf -> Manuf
	Part -> Manuf -> Manuf -> Dist
37	Part -> Manuf -> Trans -> Retail
	Part -> Manuf -> Trans -> Dist
38	Part -> Manuf -> Trans -> Retail

Table 8: Routings through each supply chain

Fourth, within a chain, there are a lot of redundant patterns. Even complex chains like Chain 24 in Figure 4 have a jumble of complexity followed by repeated patterns. Larger networks like Chains 25, 30, 31 and 33 are even less complicated with a dominant pattern that replicates.

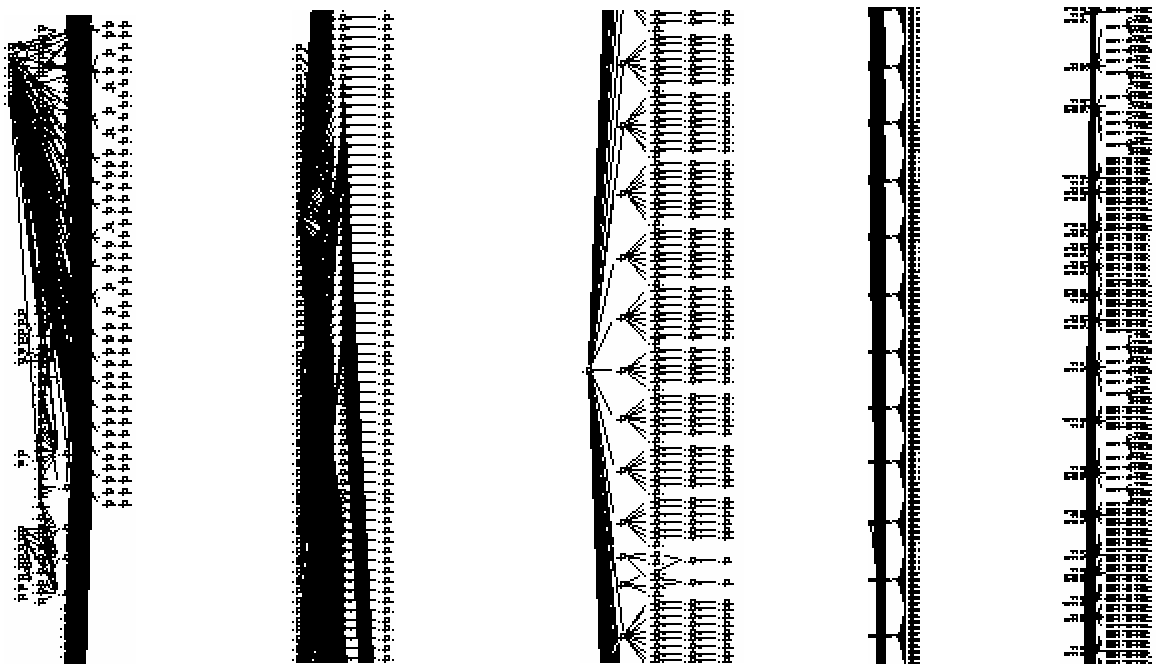

Figure 4: From left to right, Chains 24, 25, 30, 31, 33 are shown

Finally, chains span multiple divisions within the company. Since the contributors submitted acyclic networks, it is not surprising that the chains are multi-echelon but it is interesting to see that there are very few manufacturing-centric chains like Chain 10 or distribution-focused chains like Chain 30.

Conclusions

Real-world supply chains exhibit special structure. In order to inform research, this data set presents 38 supply actual supply chains that have been used in practice. Each chain contains the exact supply chain network created by the contributor plus the exact characterization of lead-times at every stage in the supply chain. While the data has been disguised it has been kept consistent with the overall metrics of the contributed chain. The objective of this data set is to enable researchers to utilize a test bed of supply chain models to test the efficiency and effectiveness of their algorithms.

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