“Buy Till You Die” to Improve Operational Efficiency: Realigning the Sales Force Using the BG/NBD

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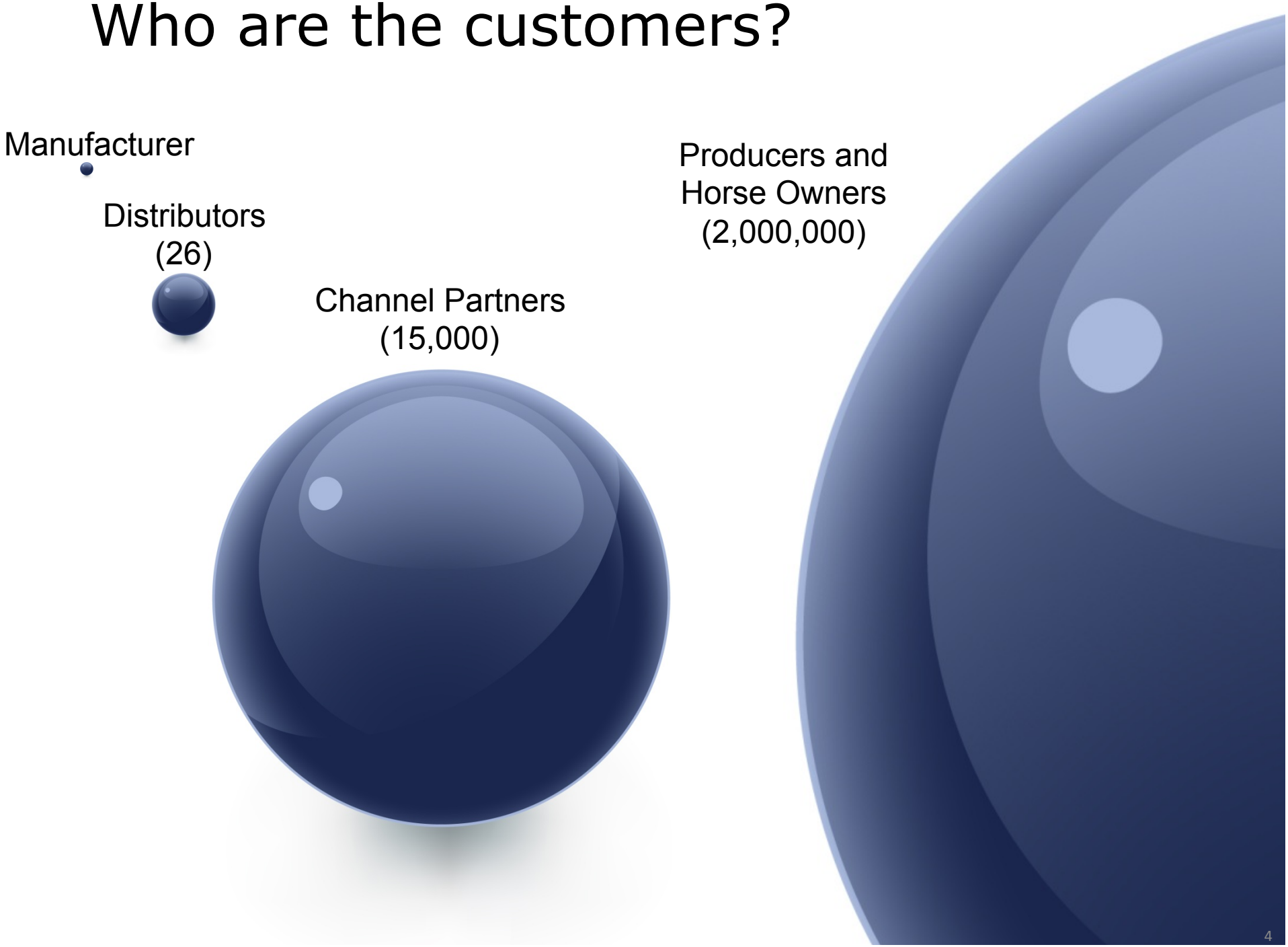
Introduction and Alignment

- The data that you'll see today come from a division of a company that you likely don't even know exists.
- It's highly likely that you've never heard of the products being purchased, even though they are brand leaders in their space.
- It would be nearly impossible for you to describe the market into which these products are sold.
- Happily, none of that matters!!!

Introduction and Alignment

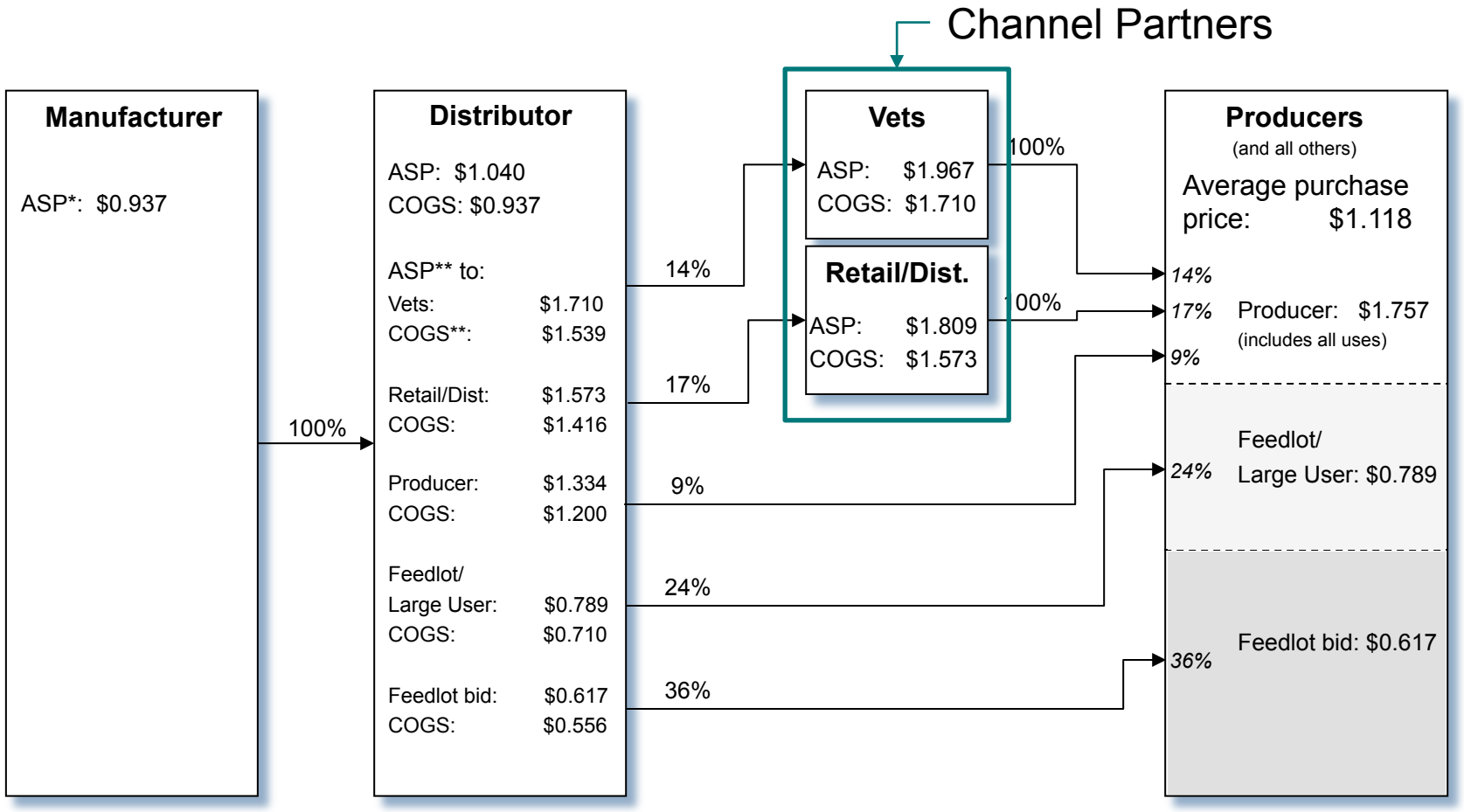
- The majority of these products are sold B2B or B2C.
- There is no contract in place with the customer.
- Every transaction with the customer is captured and is available for use.

Who are the customers?



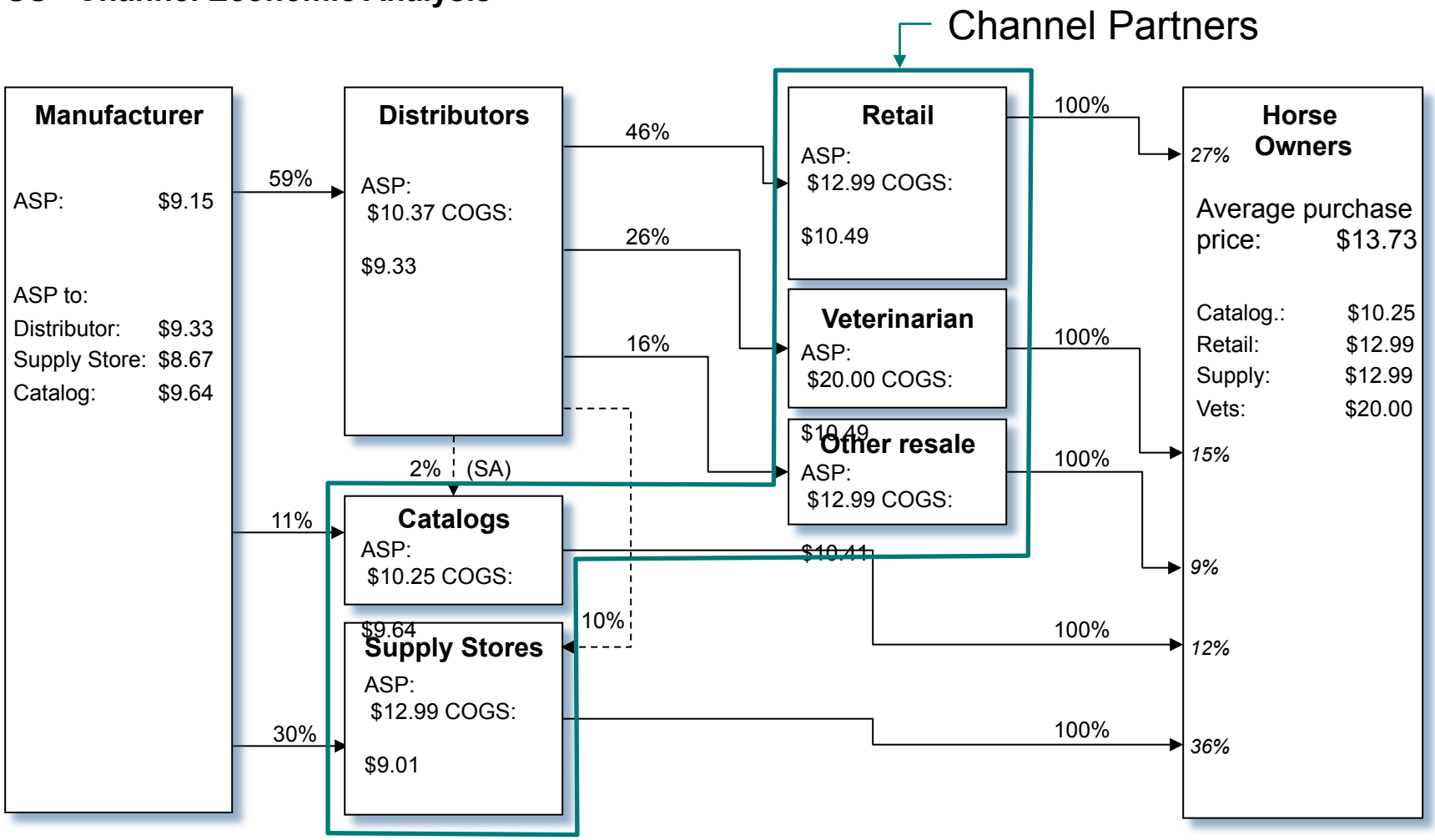
"Simple" Channel Economics

US - Channel Economic Analysis



“Less Simple” Channel Economics

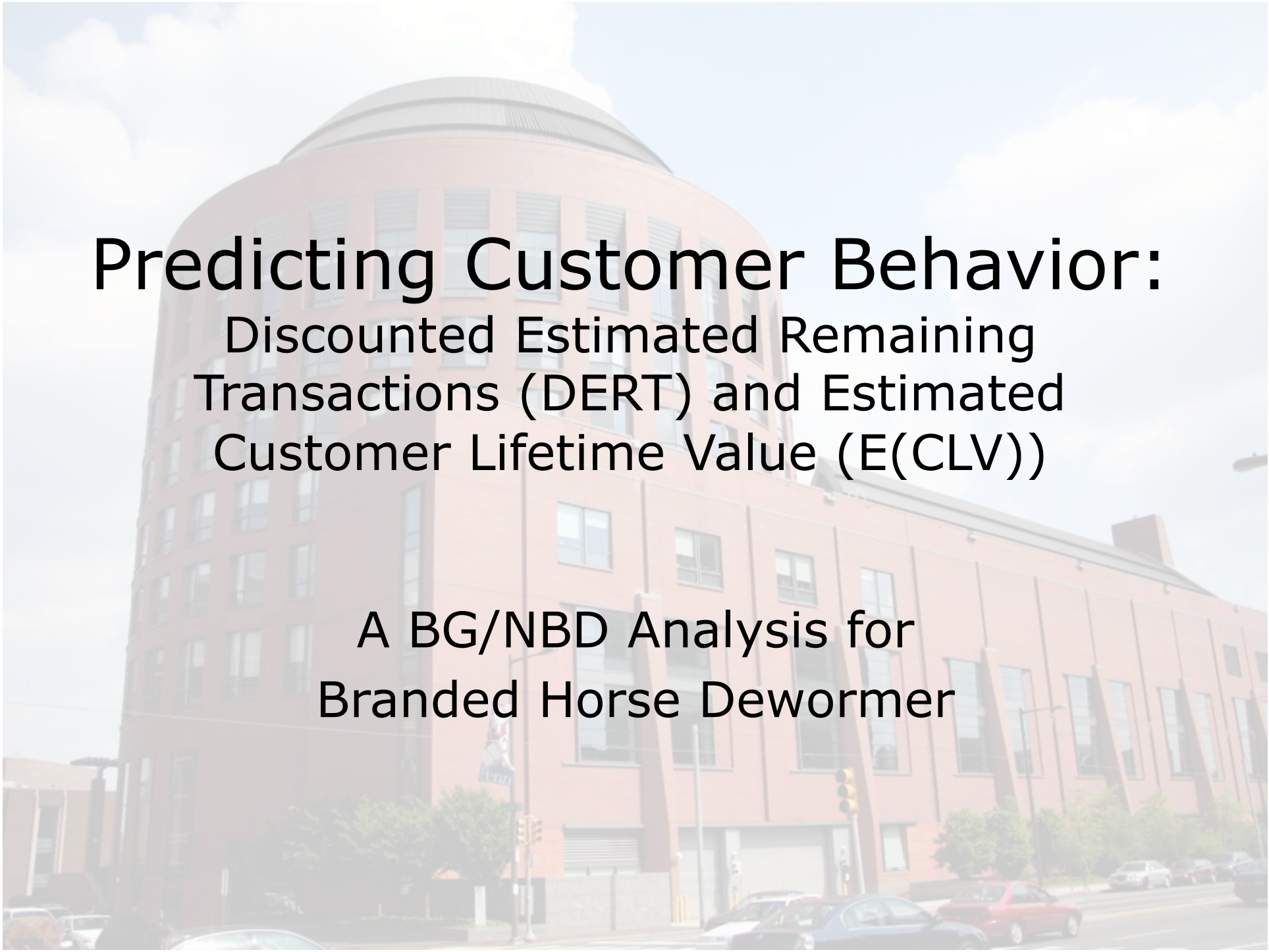
US - Channel Economic Analysis



Summary #1

- The majority of the marketing spend targets consumers to move them from awareness, through trial use and adoption, and finally, to advocacy (pull).

- The majority of the sales force activities target channel partners to improve/maintain presence of product and to foster recommendation (push).



Predicting Customer Behavior:

Discounted Estimated Remaining Transactions (DERT) and Estimated Customer Lifetime Value (E(CLV))

A BG/NBD Analysis for

Branded Horse Dewormer

The Answer YOU SEEK IS

IN THE POO.

IT'S ALSO IN THIS BOX.

Predicting repeat purchasing behavior for four cohorts of customers

- Cohorts selected based on first purchase being in different quarters of 2007.
- Purchases reported from January 1, 2007, through July 31, 2008.
- Returns and free samples were excluded from this analysis.
- Cohort 1 is enriched for repeat purchasers as we don't use their previous purchases for inclusion in the dataset.
- Cohort 2 customers didn't buy in the 1st quarter of 2007; Cohort 3 customers didn't buy in the 1st half of 2007; Cohort 4 customers didn't buy for the 1st nine months of 2007 – these cohorts are, therefore, sequentially enriched for new customers.

Assumptions of the BG/NBD Model

Purchase Process:

- While active, the number of transactions made by a customer follows a Poisson process with transaction rate λ.
- Heterogeneity in transaction rates across customers is estimated using a distributed gamma (r, α)

Dropout Process:

- After any transaction, a customer becomes inactive with a probability p.
- Heterogeneity in dropout probabilities across customers is estimated using a distributed beta (a, b)

The Poisson Distribution

In probability theory and statistics, the Poisson distribution is a discrete probability distribution that expresses the probability of a number of events occurring in a fixed period of time if these events occur with a known average rate and independently of the time since the last event. The Poisson distribution can also be used for the number of events in other specified intervals such as distance, area or volume.

The distribution was discovered by Siméon-Denis Poisson (1781–1840) and published, together with his probability theory, in 1838 in his work *Recherches sur la probabilité des jugements en matières criminelles et matière civile* ("Research on the Probability of Judgments in Criminal and Civil Matters"). The work focused on certain random variables N that count, among other things, a number of discrete occurrences (sometimes called "arrivals") that take place during a time-interval of given length. If the expected number of occurrences in this interval is λ, then the probability that there are exactly k occurrences (k being a non-negative integer, k = 0, 1, 2, ...) is equal to

$$f(k;\lambda) = \frac{\lambda^k e^{-\lambda}}{k!},$$

where
e is the base of the natural logarithm (e = 2.71828...)
k is the number of occurrences of an event - the probability of which is given by the function
k! is the factorial of k
λ is a positive real number, equal to the expected number of occurrences that occur during the given interval. For instance, if the events occur on average 4 times per minute, and you are interested in the number of events occurring in a 10 minute interval, you would use as model a Poisson distribution with λ = 10*4 = 40.
As a function of k, this is the probability mass function. The Poisson distribution can be derived as a limiting case of the binomial distribution.

Shifted Beta Geometric/Negative Binomial Distribution Model

Given frequency of repeated transactions (x), recency of repeated transactions (t_x), and duration in the database (T) and maximum likelihood estimation techniques, the four parameters of our sBG/NBD model (r, alpha, a, and b) were estimated and then used to project future purchasing behavior.

	A	B	C
1	**Cohort 1**		
2		n	3,836
3		r	1.3492
4		alpha	17.2795
5		a	0.0059
6		b	92.1178
7		LL	-77407.0
8			

=IF(C10>0,LN(C$5)-LN(C$6+C10-1)-(C$3+C10)*LN(C$4+D10),0)

=-(C$3+C10)*LN(C$4+E10)

=GAMMALN(C$3+C10)-GAMMALN(C$3)+C$3*LN(C$4)

=GAMMALN(C$5+C$6)+GAMMALN(C$6+C10)-GAMMALN(C$6)-GAMMALN(C$5+C$6+C10)

	ID	x	t_x	T	ln(.)	ln(A_1)	ln(A_2)	ln(A_3)	ln(A_4)
10	1	1	7.14	78.29	-6.57	4.14	0.00	-10.71	-17.16
11						13.20	0.00	-37.33	-46.99
12						15.32	0.00	-42.74	-52.44
13	4	7	79.29	72.29	-24.33	13.20	0.00	-37.53	-47.87
14									-38.57
15									-71.20
16	7	2	33.00	80.43	-10.35	5.00	0.00	-15.35	-22.78
3842	3833	3	65.29	70.43	-13.25	6.21	0.00	-19.46	-28.87
3843	3834	9	74.14	74.29	-29.19	17.55	0.00	-46.75	-56.46
3844	3835	2	53.14	75.14	-10.16	5.00	0.00	-15.16	-23.91
3845	3836	1	63.43	73.00	-6.43	4.14	0.00	-10.58	-19.96
3846									

Results of Maximum Likelihood Estimation

Cohort 1	
n	3,833
r	1.3482
alpha	17.2788
a	0.0042
b	92.1178
LL	-77309.6

Cohort 2	
n	1,615
r	1.1638
alpha	29.6458
a	0.0000
b	1.5630
LL	-16663.1

Cohort 3	
n	866
r	0.8585
alpha	28.8208
a	0.0000
b	0.9612
LL	-5610.5

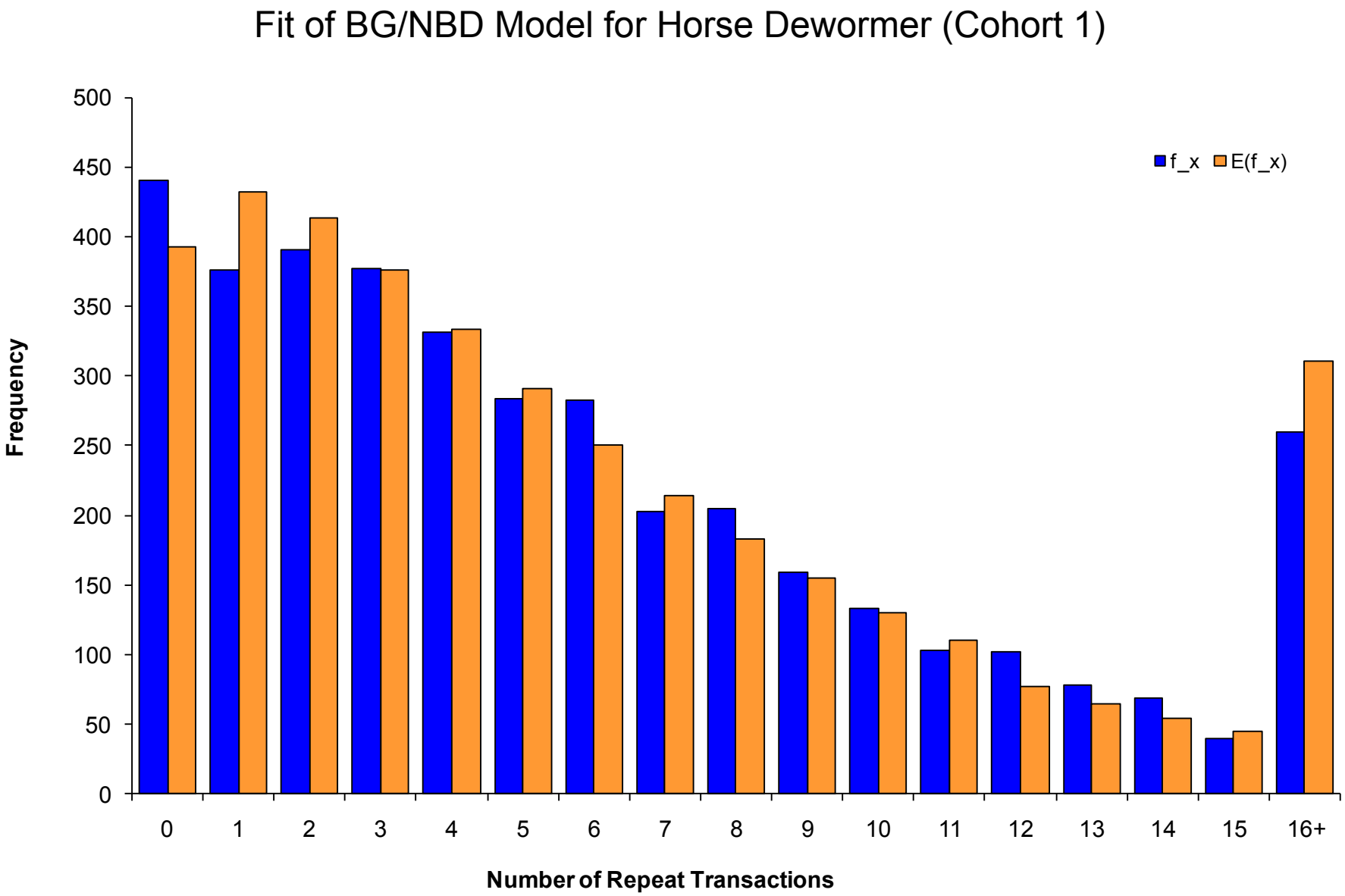
Cohort 4	
n	630
r	0.8122
alpha	30.7093
a	0.0000
b	10.4797
LL	-2839.1

Over 50,000 data points on 6,944 customers buying only one product during a 19-month period

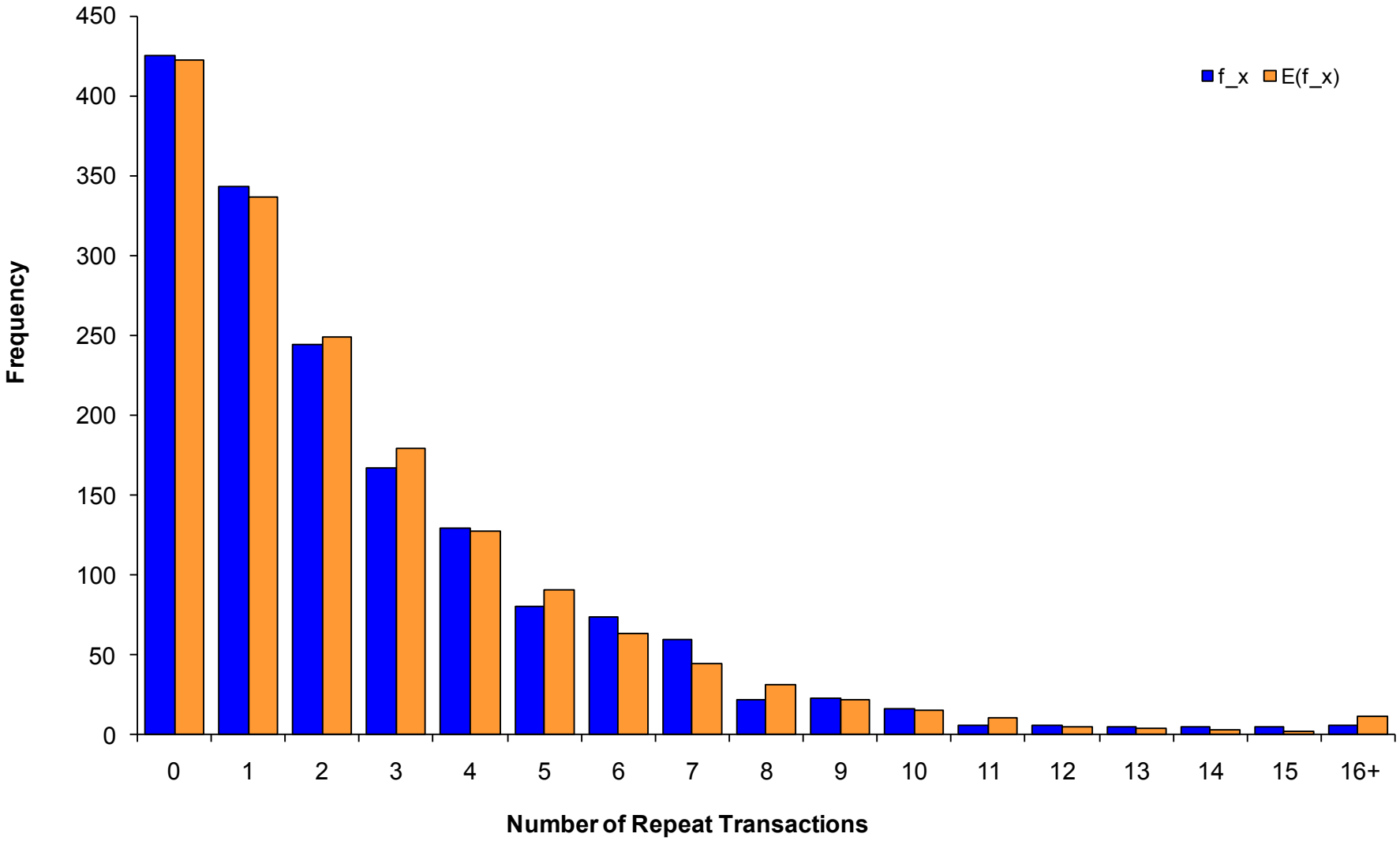
Distribution of Customers Based on Number of Repeated Transactions

	A	B	C	D	E	F		
1	r	1.3482		B(a,b)	233.4316			
2	alpha	17.2788						
3	a	0.0042						
4	b	92.1178						
5								
6				**Time of trial purchase:**		0.1429	0.2857	0.4286
7				**Number of customers:**		76	97	100
8					T	82.43	82.29	82.14
9	x	f_x	E(f_x)	(O-E)^2/E				
10	0	441	392.4	6.03	0	0.0941	0.0943	0.0945
11	1	376	431.4	7.11	1	0.1049	0.1051	0.1053
12	2	391	412.9	1.16	2	0.1019	0.1020	0.1021
13	3	377	375.7	0.00	3	0.0940	0.0941	0.0942
14	4	332	333.0	0.00	4	0.0844	0.0845	0.0846
15	5	284	290.5	0.14	5	0.0747	0.0747	0.0747
16	6	283	250.6	4.18	6	0.0653	0.0653	0.0653
17	7	203	214.7	0.64	7	0.0567	0.0567	0.0567
18	8	204	182.8	2.47	8	0.0489	0.0489	0.0489
19	9	159	154.9	0.11	9	0.0420	0.0420	0.0419
20	10	133	130.8	0.04	10	0.0359	0.0359	0.0359
21	11	102	110.1	0.60	11	0.0307	0.0306	0.0306
22	12	101	77.5	7.12	13	0.0221	0.0221	0.0221
23	13	78	64.8	2.67	14	0.0188	0.0187	0.0187
24	14	69	54.2	4.05	15	0.0159	0.0158	0.0158
25	15	40	45.2	0.60	16	0.0134	0.0134	0.0133
26	16+	260	311.7	8.58	16+	0.0962	0.0958	0.0954
27			chi-sq	45.50				
28					0	1.0000	1.0000	1.0000
29					1	2.1146	2.1142	2.1139
30					2	3.1964	3.1955	3.1945
31					3	4.1946	4.1928	4.1909
32					4	5.0917	5.0887	5.0858
33					5	5.8849	5.8808	5.8766

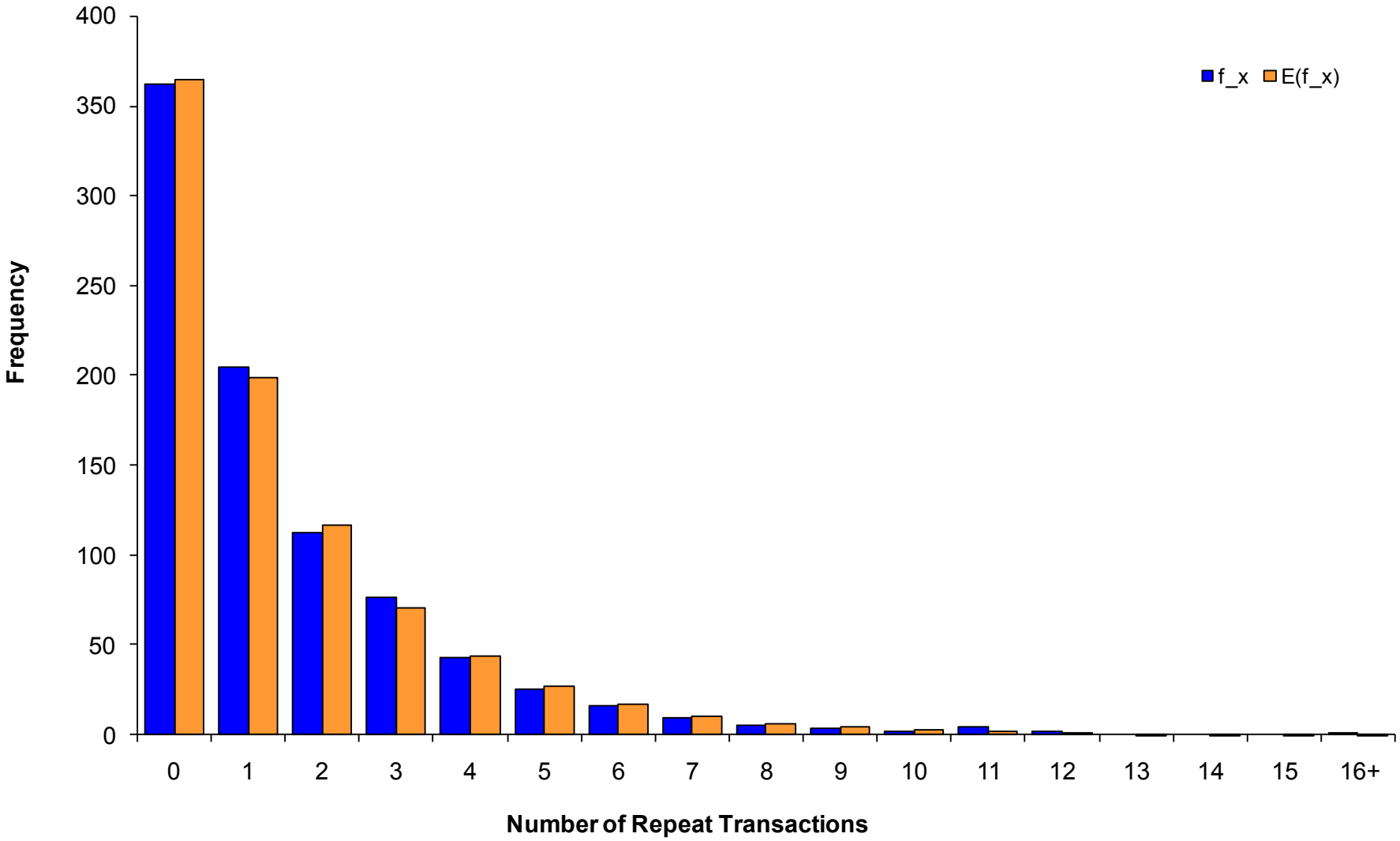
Using the actual data of day of first purchase and the BG/NBD parameters, the estimated number of repeated transactions is determined (E(f_x)) and is compared to the actual number of repeated transactions (f_x) using a χ^2 analysis.


Fit of BG/NBD Model for Horse Dewormer (Cohort 1)
f_x
E(f_x)
Frequency
500
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16+
Number of Repeat Transactions

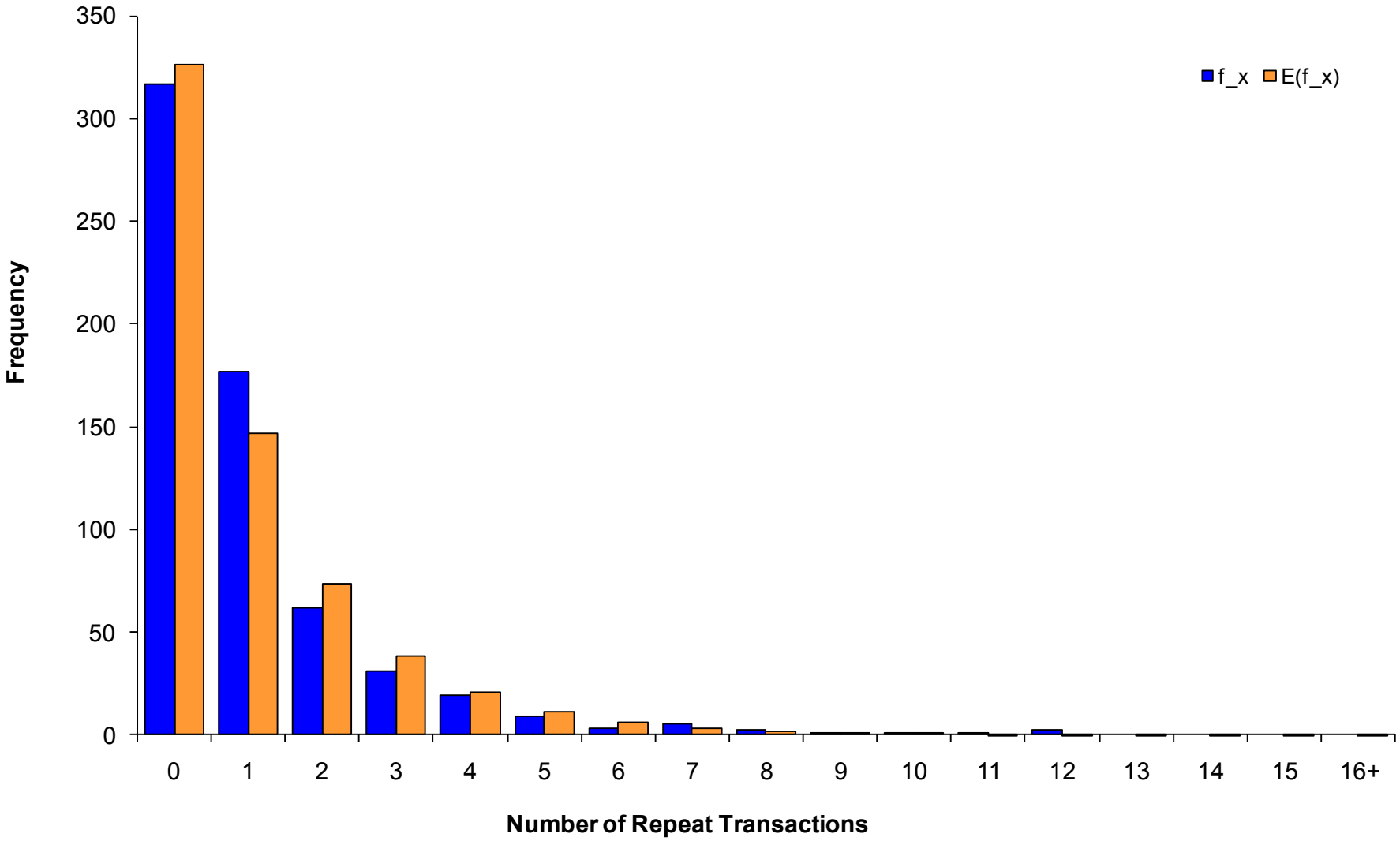
Fit of BG/NBD Model for Horse Dewormer (Cohort 2)



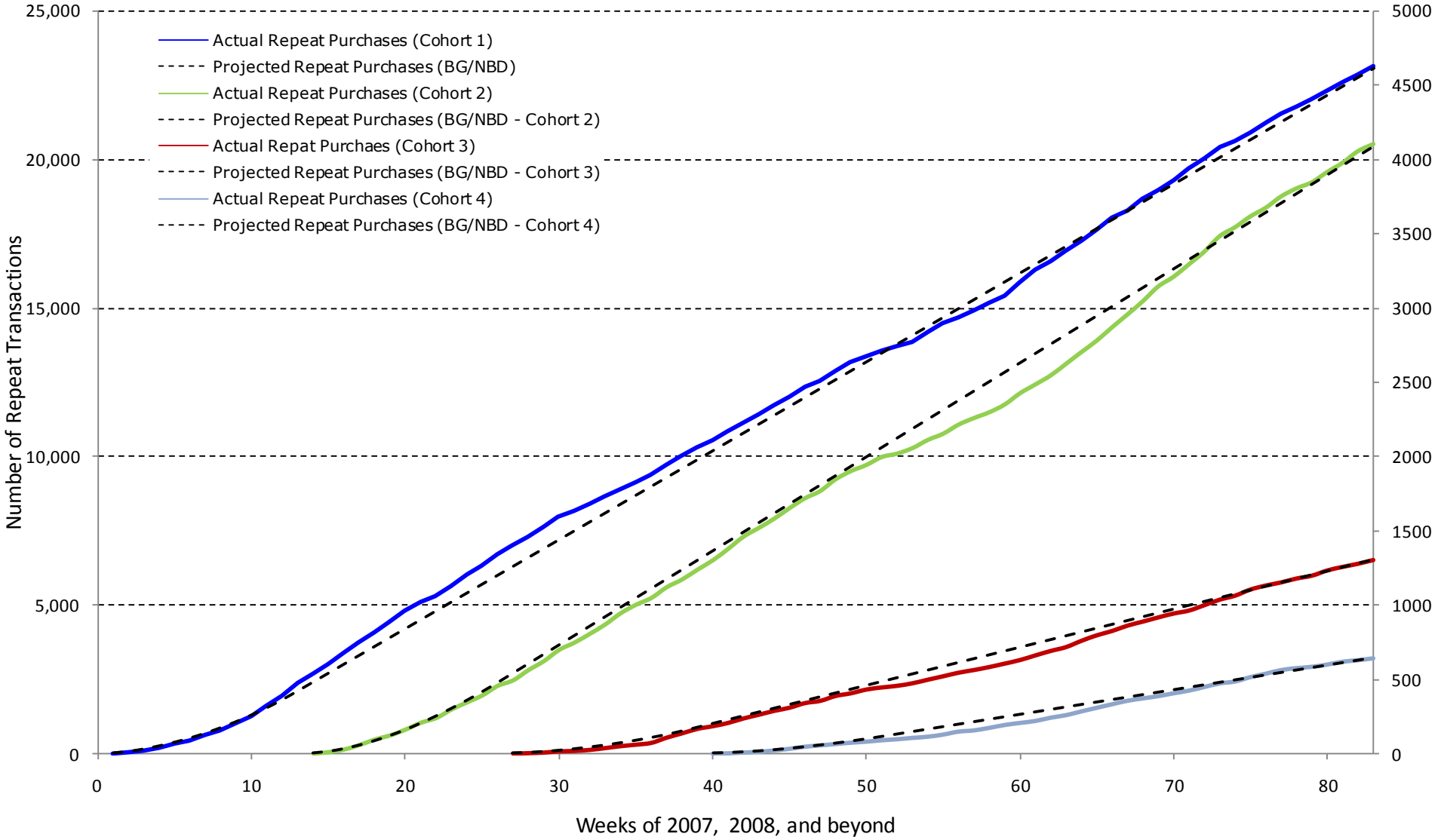
Fit of BG/NBD Model for Horse Dewormer (Cohort 3)



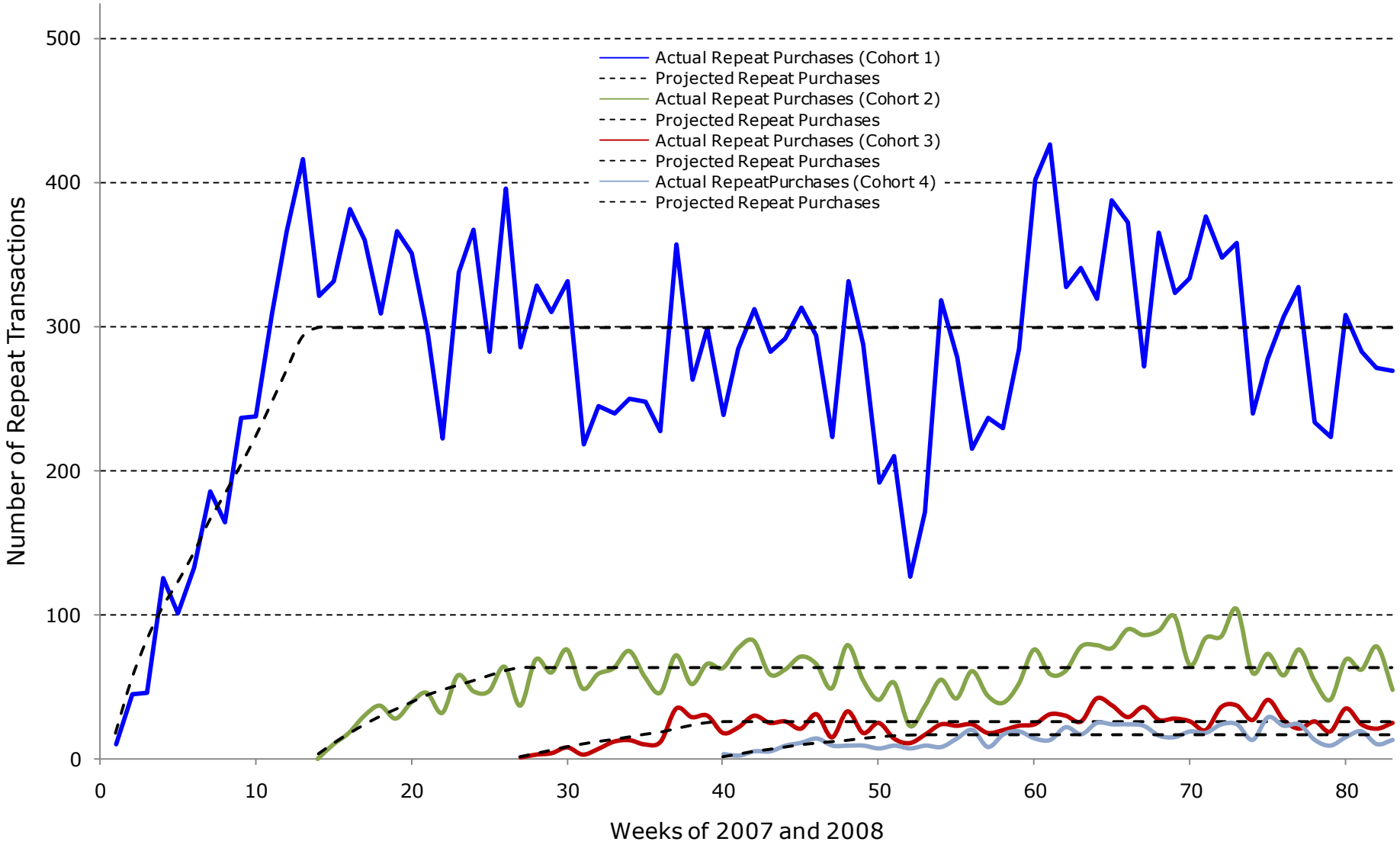
Fit of BG/NBD Model for Horse Dewormer (Cohort 4)

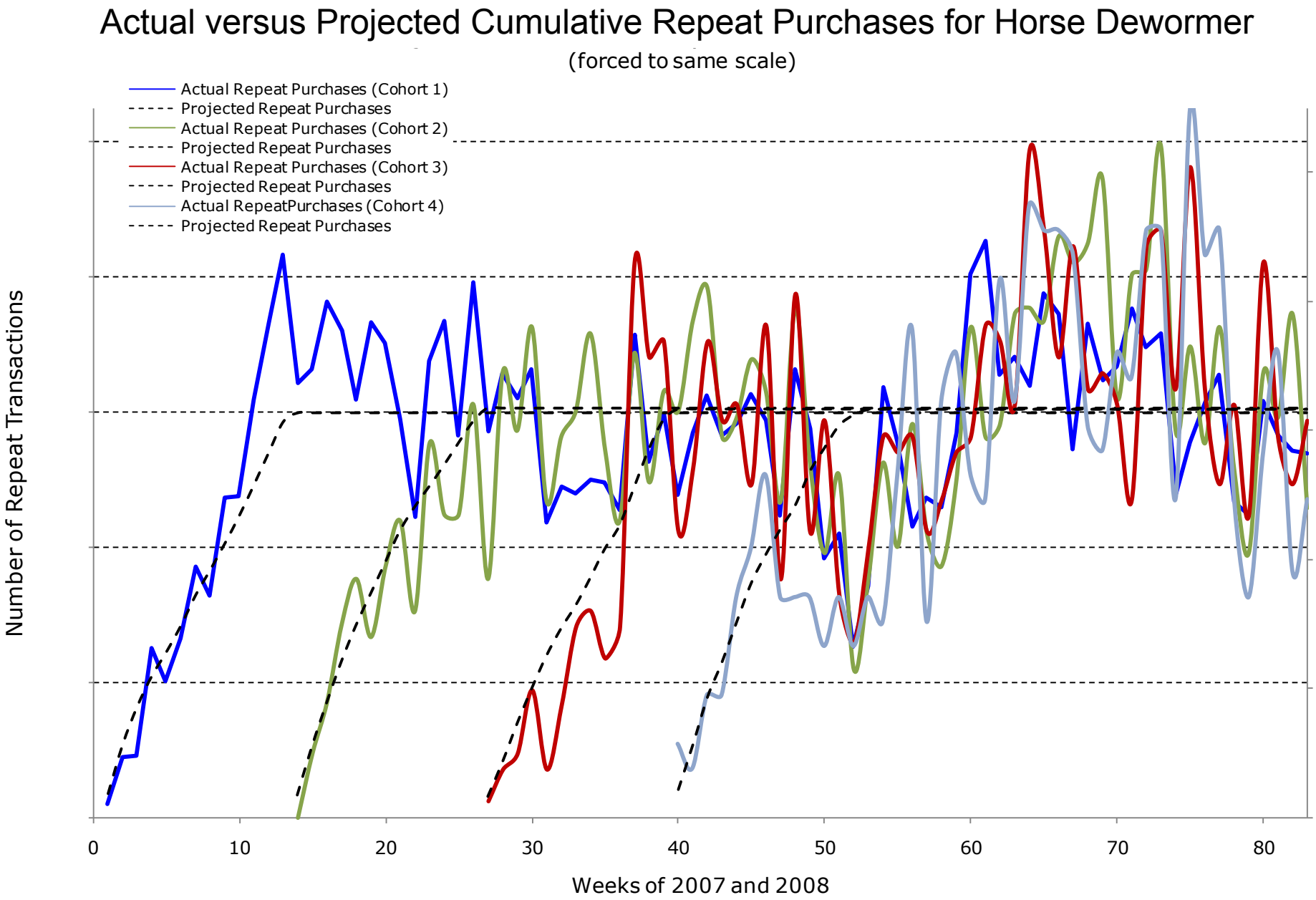


Actual versus Projected Cumulative Repeat Purchases for Horse Dewormer

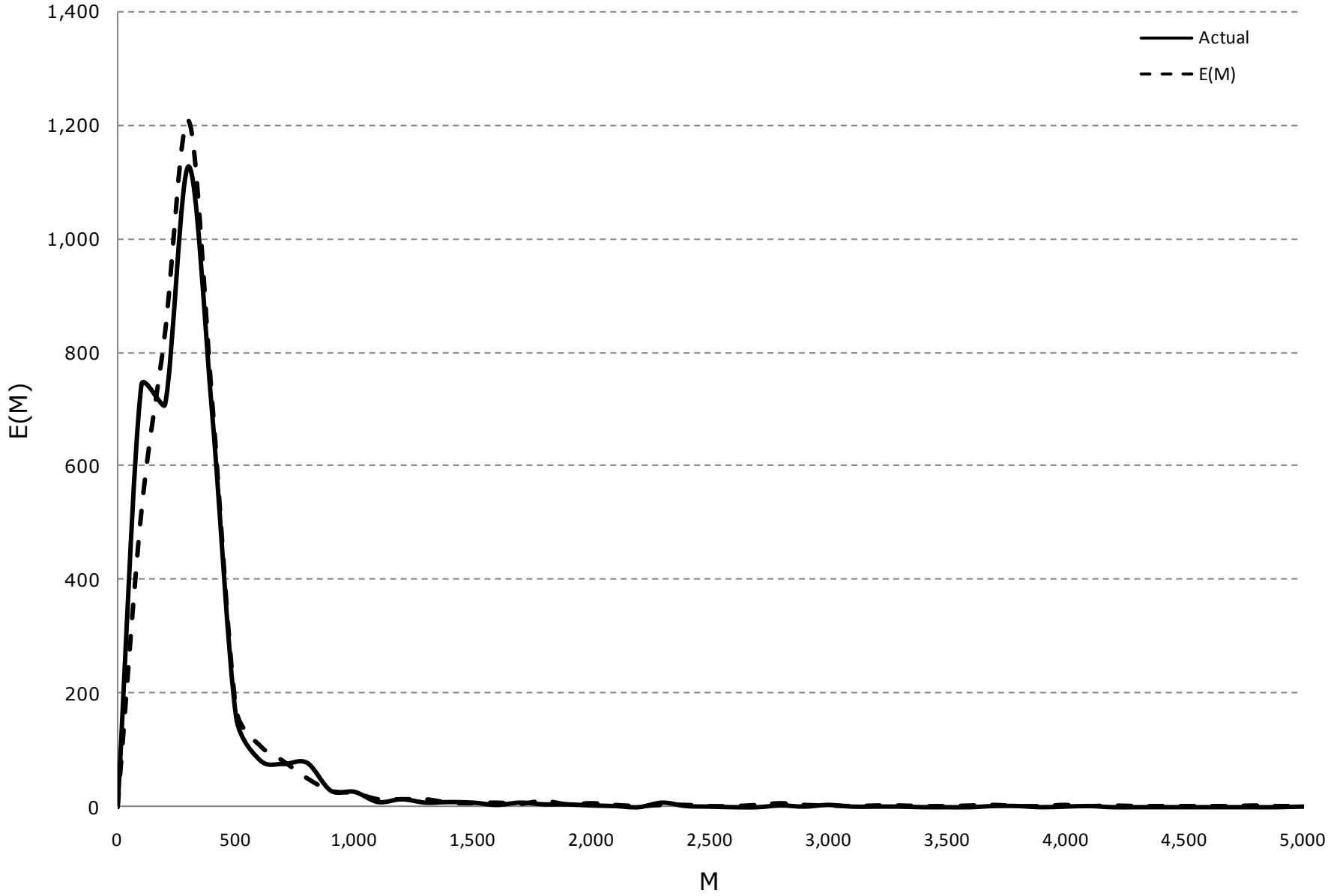


Actual versus Projected Cumulative Repeat Purchases for Horse Dewormer




Actual versus Projected Cumulative Repeat Purchases for Horse Dewormer
(forced to same scale)
Actual Repeat Purchases (Cohort 1)
Projected Repeat Purchases
Actual Repeat Purchases (Cohort 2)
Projected Repeat Purchases
Actual Repeat Purchases (Cohort 3)
Projected Repeat Purchases
Actual RepeatPurchases (Cohort 4)
Projected Repeat Purchases
Number of Repeat Transactions
0
10
20
30
40
50
60
70
80
Weeks of 2007 and 2008

Distribution of Monetary Values - Cohort 1



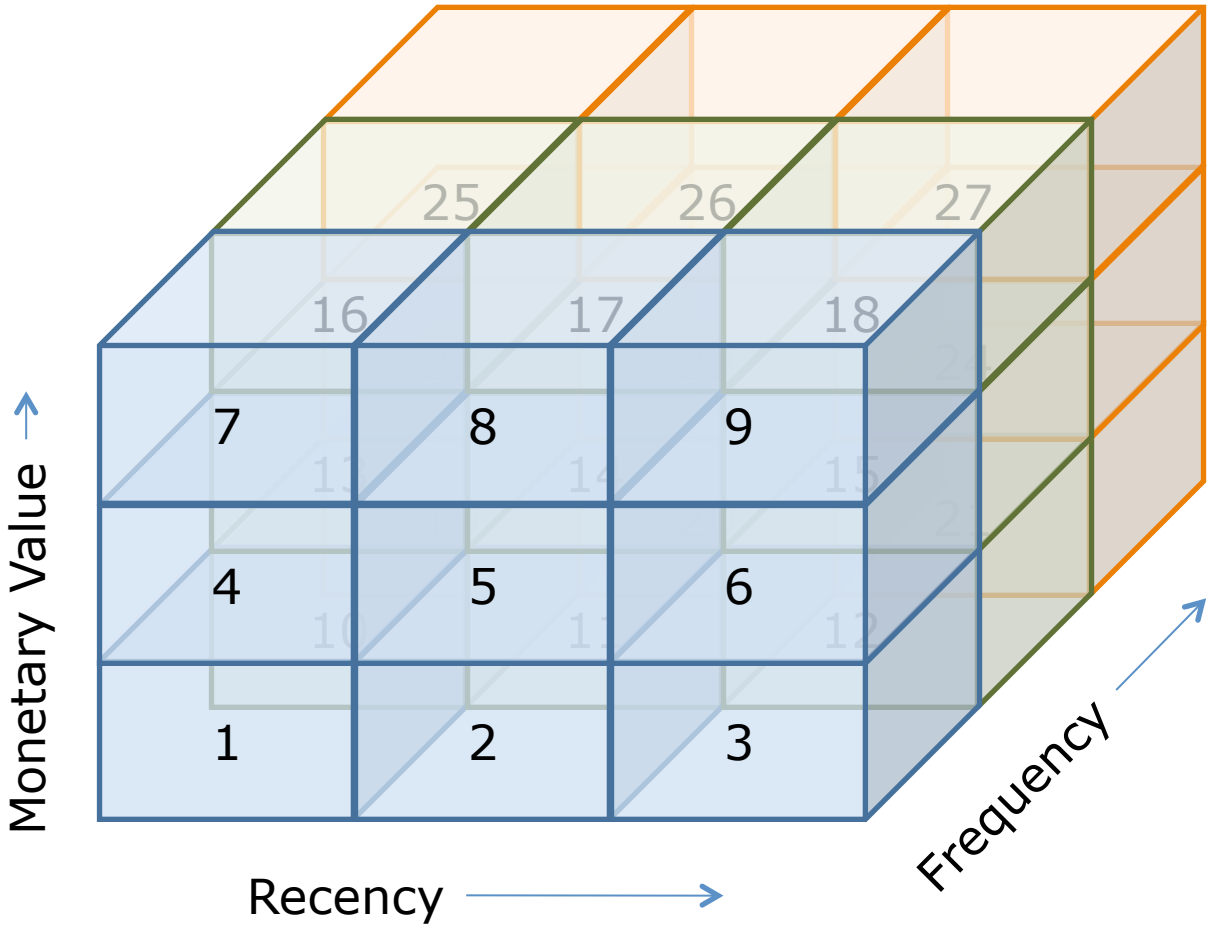
Calculation of DERT and $E(CL_{10}V)$

	A	B	C	D	E	F	G	H	I	J	K	L	S	T	U	V	W	X	Y	Z
1	r	1.348					d	11.0%	Discount	0.94916	0.85510	0.77036	0.37105							
2	alpha	17.279																		
3	a	0.004																		
4	b	92.118									$4,921,986									
5	t	104																		
6											0	1	2	3	10					
7	Obs	x	t_x	T	Group	E[M|data]	E(CLV)	E(Y(t)|X=x,t_x,T)			0	52	104	156	520	DERT				
8	1	12	81.43	77.43	27	$808	$36,682	14.653			0.000	7.328	14.652	21.974	73.159	45.41				
9	2	23	81.43	80.43	24	$245	$19,636	25.904			0.000	12.954	25.899	38.838	129.245	80.22				
10	3	8	81.43	79.14	24	$214	$6,674	10.080			0.000	5.041	10.080	15.118	50.347	31.25				
11	4	3	67.29	70.14	5	$211	$3,390	5.172			0.000	2.587	5.173	7.758	25.845	16.04				
12	5	9	79.14	77.29	27	$306	$10,774	11.378			0.000	5.690	11.377	17.063	56.819	35.26				
13	6	6	76.43	72.29	14	$199	$5,268	8.531			0.000	4.266	8.531	12.795	42.613	26.45				
14	7	11	77.29	72.86	21	$52	$2,287	14.243			0.000	7.123	14.242	21.359	71.113	44.14				
15	8	5	82.43	81.43	18	$610	$12,653	6.687			0.000	3.344	6.688	10.030	33.411	20.73				
16	9	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
17	10	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
18	11	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
19	12	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
20	13	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
21	14	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
22	15	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
23	16	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
24	17	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
25	18	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
26	19	1	81.43	81.14	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
27	20	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
28	21	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
29	22	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
30	23	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
31	24	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
32	25	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
33	26	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
34	27	2	81.43	81.00	3	$164	$1,797	3.543			0.000	1.772	3.543	5.315	17.708	10.99				
35	28	11	82.14	76.43	21	$112	$4,745	13.700			0.000	6.851	13.700	20.545	68.407	42.46				
36	29	3	71.00	78.43	2	$78	$1,145	4.724	0.000	2.363	4.725	7.086	23.609	14.65	2.57E+01	4.35	95.12	94.12	0.52	
37	30	18	62.14	82.14	25	$678	$42,308	20.172	0.000	10.075	20.145	30.209	100.554	62.41	1.23E+06	19.35	110.12	109.12	0.51	
38	31	1	65.57	73.29	5	$251	$2,100	2.696	0.000	1.349	2.697	4.045	13.480	8.36	6.20E+00	2.35	93.12	92.12	0.53	
39	32	22	72.00	81.43	23	$220	$16,750	24.580	0.000	12.290	24.572	36.848	122.630	76.12	2.41E+07	23.35	114.12	113.12	0.51	
40	33	8	81.43	72.86	21	$84	$2,812	10.783	0.000	5.392	10.783	16.172	53.854	33.42	1.44E+03	9.35	100.12	99.12	0.54	
41	34	9	77.00	81.43	27	$283	$9,567	10.900	0.000	5.451	10.899	16.346	54.435	33.78	1.90E+03	10.35	101.12	100.12	0.51	
42	35	0	0.00	71.29	0	$357	$1,753	1.583	0.000	0.792	1.584	2.376	7.918	4.91	2.90E+00	1.35	92.12	91.12	0.54	
43	36	0	0.00	81.14	0	$357	$1,577	1.425	0.000	0.713	1.426	2.138	7.126	4.42	2.68E+00	1.35	92.12	91.12	0.51	
44	37	7	74.00	73.86	17	$388	$11,462	9.524	0.000	4.763	9.524	14.284	47.571	29.52	6.32E+02	8.35	99.12	98.12	0.53	
45	38	2	47.43	81.14	4	$234	$2,566	3.537	0.000	1.769	3.538	5.306	17.679	10.97	1.16E+01	3.35	94.12	93.12	0.51	

$[E(Y_{(t)}|X=x,t\_x,T)]$. Projecting this estimate through 10 years and applying an 11% discount rate gives us an individual customer's Discounted Estimated Residual Transactions (DERT). DERT times the estimated average monetary value of a transaction gives us an individual customer's Estimated Customer (Residual) $\text{Lifetime}_{(\text{next 10 years})}$ Value $[E(CL_{10}V)]$.

Separating Customers based on RFM Group

Customers from each cohort were sorted into 27 groups based on the terciles for recency, frequency, and monetary value.



Estimated Customer Lifetime Value per Customer

Cohort 1			Frequency			
			0	1	2	3
Monetary	0	Recency 0	$1,679			
	1	1		$1,382	$2,521	$3,785
		2		$1,703	$2,632	$4,298
		3		$1,721	$2,967	$5,015
	2	1		$2,481	$4,666	$8,198
		2		$2,892	$5,009	$9,120
		3		$2,962	$5,483	$10,871
	3	1		$8,486	$24,646	$30,331
		2		$6,448	$12,003	$25,331
		3		$10,594	$14,592	$41,121

Estimated Customer Lifetime Value per Customer

Cohort 2			Frequency			
			0	1	2	3
Monetary	0	Recency 0	$927			
	1	1		$2,953	$3,884	$2,965
		2		$2,179	$3,396	$4,654
		3		$2,646	$4,699	$7,519
	2	1		$1,839	$3,712	$3,153
		2		$2,012	$3,541	$5,126
		3		$1,893	$2,946	$6,109
	3	1		$1,851	$15,921	$2,741
		2		$2,309	$9,157	$4,481
		3		$1,912	$3,460	$5,652

Number of Customer per RFM Group

Cohort 1			Frequency			
			0	1	2	3
Monetary	0	Recency 0	441			
	1	1		230	62	20
		2		113	198	146
		3		48	118	345
	2	1		230	32	10
		2		150	209	102
		3		60	126	206
	3	1		181	56	11
		2		80	172	93
		3		52	129	213

Number of Customer per RFM Group

Cohort 2			Frequency			
			0	1	2	3
Monetary	0	Recency 0	425			
	1	1		129	15	3
		2		69	47	18
		3		36	40	48
	2	1		110	18	4
		2		62	40	32
		3		24	39	75
	3	1		102	15	4
		2		45	51	40
		3		11	31	82

E(CLV) per RFM Group

Cohort 1			Frequency			
			0	1	2	3
Monetary	0	Recency 0	$740,224			
	1	1		$317,767	$156,298	$75,698
		2		$192,401	$521,053	$627,441
		3		$82,620	$350,084	$1,730,197
	2	1		$570,601	$149,305	$81,976
		2		$433,850	$1,046,811	$930,204
		3		$177,694	$690,898	$2,239,527
	3	1		$1,535,969	$1,380,182	$333,644
		2		$515,871	$2,064,457	$2,355,748
		3		$550,899	$1,882,420	$8,758,759

E(CLV) per RFM Group

Cohort 2			Frequency			
			0	1	2	3
Monetary	0	Recency 0	$394,121			
	1	1		$380,977	$58,256	$8,894
		2		$150,349	$159,630	$83,779
		3		$95,269	$187,950	$360,916
	2	1		$202,328	$66,819	$12,613
		2		$124,714	$141,638	$164,042
		3		$45,423	$114,909	$458,179
	3	1		$188,844	$238,820	$10,965
		2		$103,922	$466,986	$179,251
		3		$21,030	$107,265	$463,451

How much do we spend and on whom?

Number of Customer per RFM Group

Cohort 1				Frequency			
				0	1	2	3
Monetary	0	Recency	0	441			
	1		1		230	62	20
			2		113	198	146
			3		48	118	345
	2		1		230	32	10
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E(CLV) per RFM Group

Cohort 1				Frequency			
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Monetary	0	Recency	0	$740,224			
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			2		$515,871	$2,064,457	$2,355,748
			3		$550,899	$1,882,420	$8,758,759

Summary #2

- Not all channel partners are created equal.
- An RFM analysis enables **objective** segmentation based on more than just the sum of prior years purchases.
- Pareto's Rule is, in fact, a rule; 20% of our Channel Partners purchase 80% of our goods.

An Obvious Problem . . .

- In 2009, there were 34 Territory Managers
  - On average, each had >1,800 channel partners for which they "got credit" in our compensation system (a total of 61,384 locations)
  - TMs average less than five "sales call" a day
  - TMs average about 170 days "in the field"
  - The vast majority of channel partners never got a call

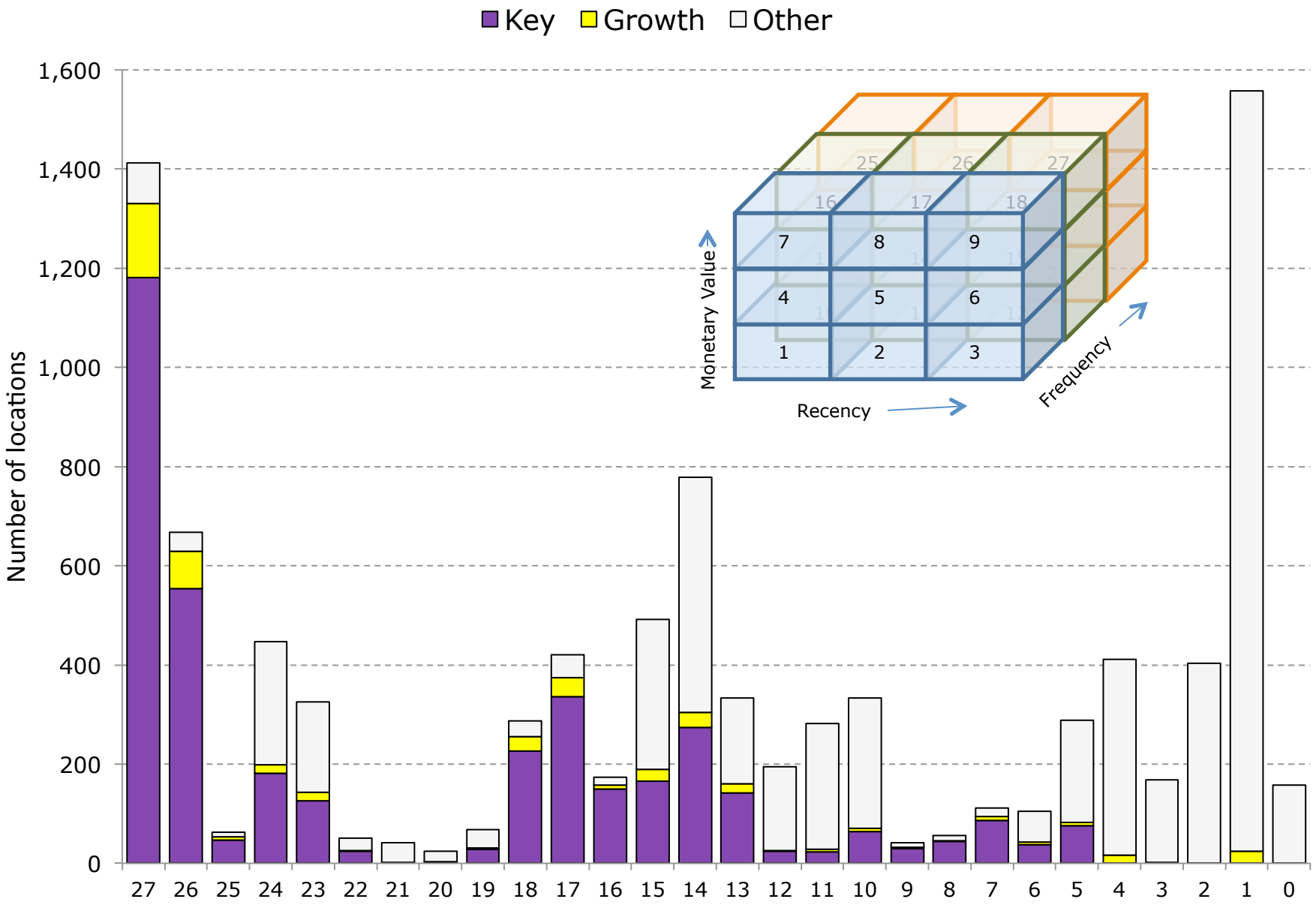
The First Attempt at a Solution . . .

- In 2010, there were 34 Territory Managers
  - We eliminated over 51,000 channel partners from our TM-facing sales reporting system
  - Each TM was assigned 120 “key” accounts and 15 “growth” accounts
  - An additional 150 “other” accounts remained in their systems, due to prior purchase histories
  - A Post-hoc RFM analysis was conducted in July

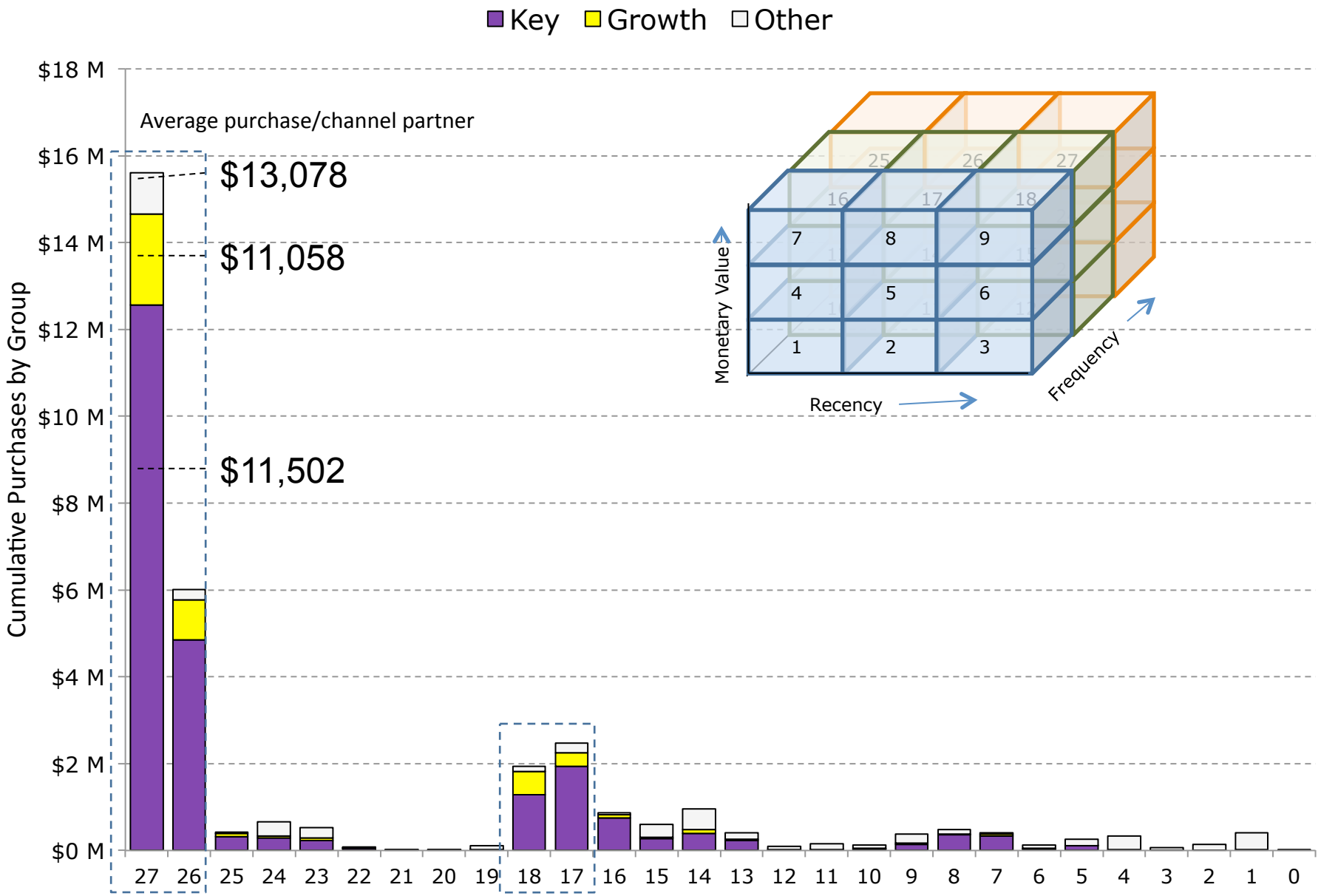
Getting closer

- 9,702 channel partners had made at least one purchase in the first quarter of 2009.
  - 3,828 were “Key” channel partners
  - 498 were “Growth” channel partners
  - 5,376 were “Other” channel partners
- Results of the RFM for 2009 were used to predict purchase behavior in the first six months of 2010
  - Predicted purchases totaled $34.7M; actual purchases totaled $33.7M (a 3% variance)
  - But, who bought what?

Distribution of Channel Partners by RFM Group and Type



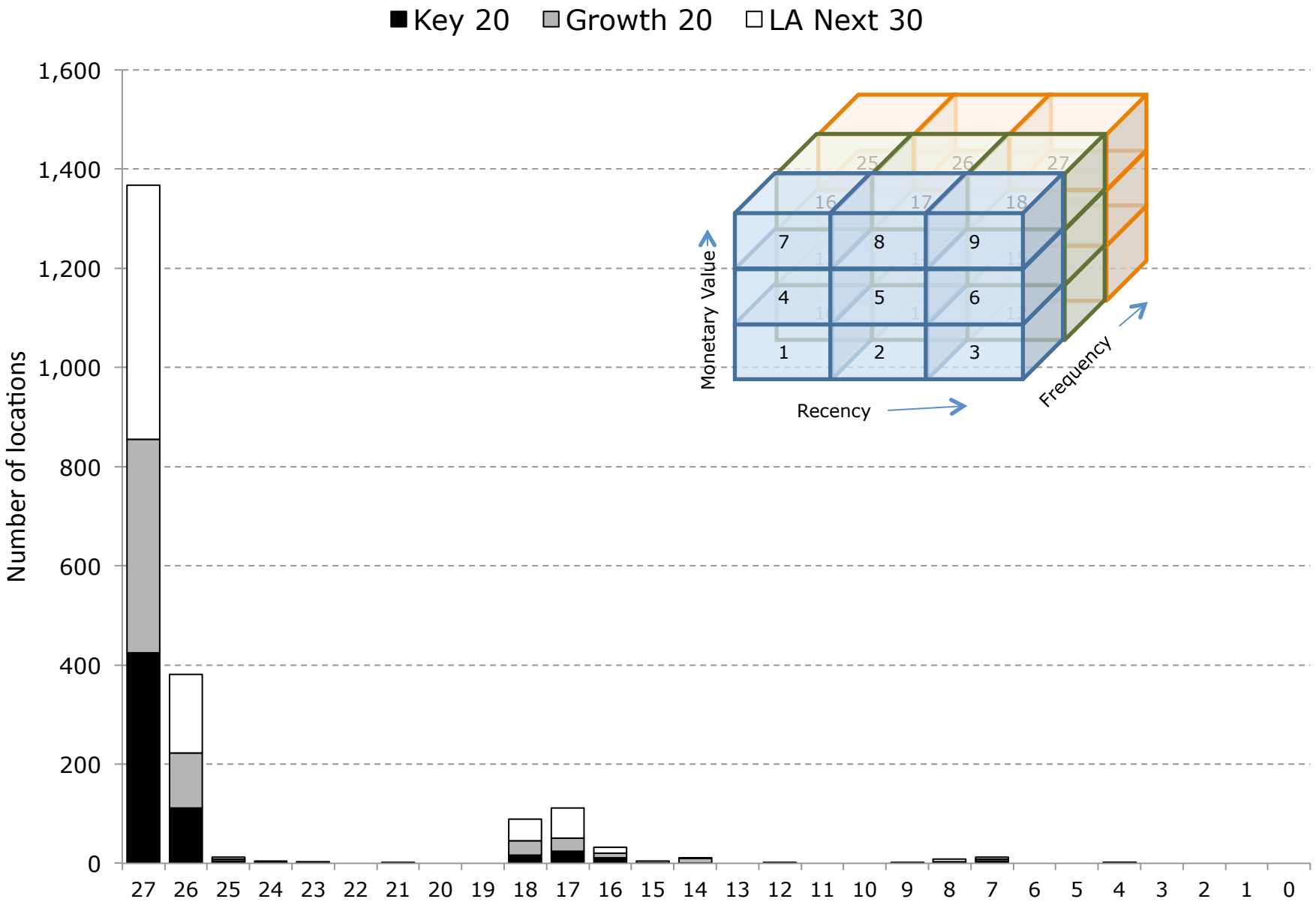
Distribution of Sales by RFM Group and Channel Partner Type



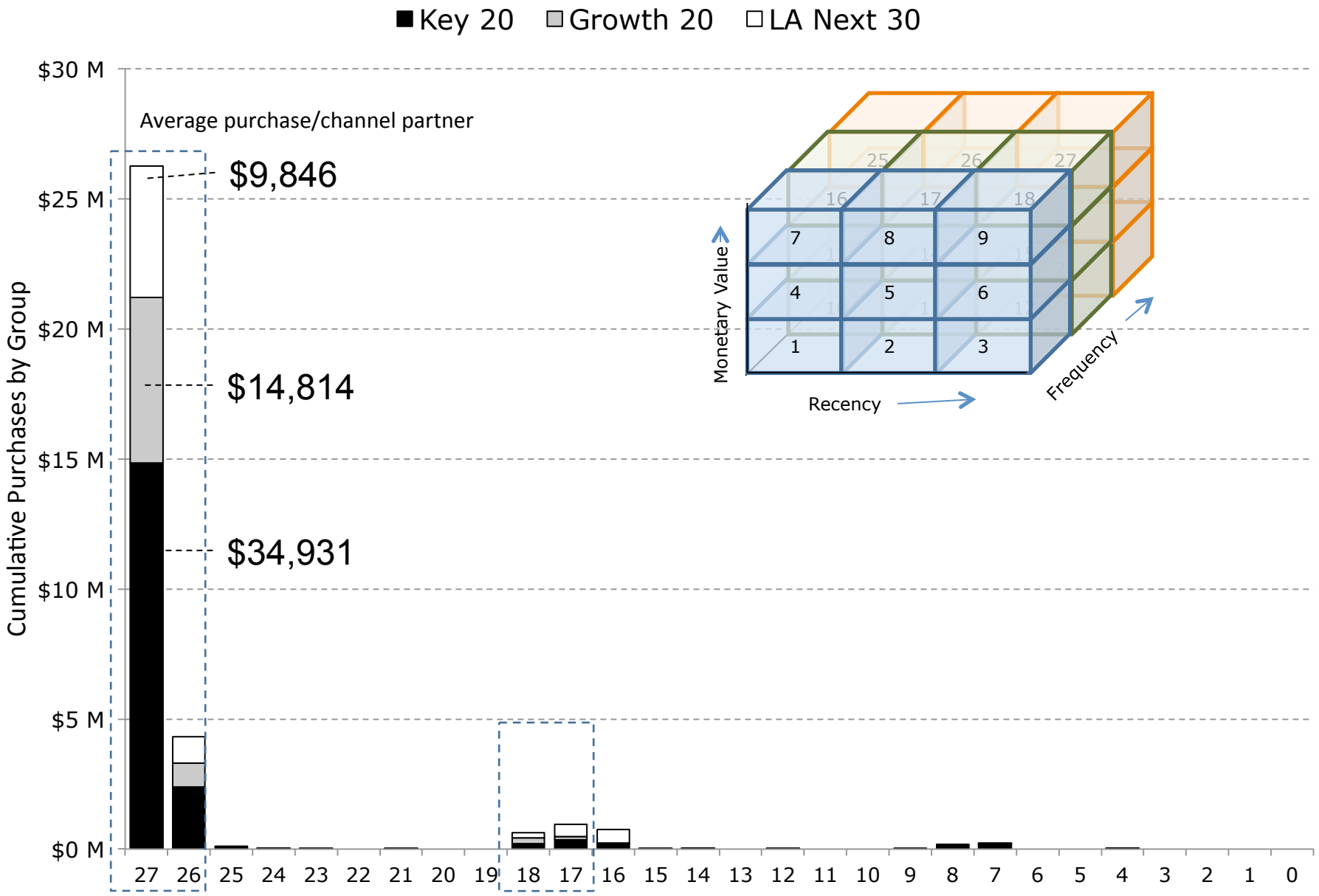
Does it work?

- In 2011, there were 34 Key Account Managers
  - We focused on approximately 2,400 accounts
  - Each KAM was assigned 70 accounts and had a specific call frequency for each (Key 20, Growth 20, and LA Next 30); they account for 70% of all sales.
  - No other accounts remained in their systems – period.
  - At year end, sales were up 17% over prior year!

2011: Distribution of Channel Partners by RFM Group and Type



2011: Distribution of Sales by RFM Group and Channel Partner Type



Summary #3

- Over three years with no significant monetary investment, we transitioned from
  - Territory Managers with 1,900 channel partners to
  - Key Account Managers with 70 designated accounts.

- A post-hoc RFM analysis supports our assignment of channel partners to account type.

- Churn, “by location” accounting, and “pooling for the deal” continue to keep variation versus prediction alive and well.

Conclusion

- Segmentation of channel partners, based on their past behavior, was a highly effective method to improve the efficiency of the field force and to increase sales.

“Buy Till You Die” to Improve Operational Efficiency: Realigning the Sales Force Using the BG/NBD

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