Dilation Time Distribution Variability

The decision of when labor should end due to labor arrest and when it is optimal to take an observation to learn more depends on the DM's value of ξ_i and where that values lies in the intervals for $b_x(i)$. To better understand how the underlying assumptions of the probability distribution affects the intervals for $b_x(i)$, we allowed particular parameters to increase and decrease by 10% to see how much of an effect those small changes can have on the decision.

Model 1

In Model 1, the exponential distribution is used to model the time in labor, which we calculate based on the median of labor duration for every dilation state. We increased and decreased the estimate for the median by 10% for both vaginal delivery patients and C-section patients (Table 1). By increasing this measure, we see very little change in the values for b_1 (upper bound for deciding CS) and b_0 (upper bound for taking an observation). The values corresponding to an increase of 10% yield a less than 3% decrease in both b_1 and b_0. By decreasing the median values by 10%, we notice an increase in b_1 and b_0. This increase is also less than 3% for each dilation state.

For further analysis, if we increase vaginal delivery median times by 10% and the value for C-section remains the same, we see an increase in b_1 that is at most 4% and a decrease in b_0 that is at most 2% as shown in Table 2. Alternatively, increasing C-section median values and allowing vaginal delivery to remain the same, shows a decrease in b_1 of at most 5.5% and an increase in b_0 of less than 1%. Overall, increasing or decreasing the median values by 10% has a small effect on the thresholds for taking an observation as the endpoints will increase or decrease by less than 5%.

Model 2

In Model 2, the 5th percentile, 50th percentile, and 95th percentile values used to derive the log-

Table 1: Changes in b_0 and b_1 when the median value for VD and CS is increased by 10% and decreased 10% for Model 1.

	Original		Median up 10% for VD and CS				Median down 10% for VD and CS			
Dilation State	b1	b0	b1	Change in b1	b0	Change in b0	b1	Change in b1	b0	Change in b0
3 cm	0.50	0.71	0.50	-0.4%	0.71	-0.6%	0.50	0.6%	0.72	0.7%
4 cm	0.44	0.74	0.43	-0.9%	0.74	-0.8%	0.44	0.9%	0.75	1.1%
5 cm	0.38	0.80	0.38	-1.6%	0.79	-1.3%	0.39	1.8%	0.81	1.5%
6 cm	0.38	0.83	0.38	-2.1%	0.82	-1.4%	0.39	2.3%	0.85	1.7%
7 cm	0.37	0.86	0.36	-2.4%	0.85	-1.5%	0.38	3.0%	0.88	1.6%
8 cm	0.36	0.86	0.35	-2.5%	0.85	-1.0%	0.37	3.1%	0.88	2.1%
9 cm	0.42	0.85	0.41	-2.1%	0.84	-1.5%	0.43	2.4%	0.87	1.6%
10 cm	0.42	0.76	0.41	-1.0%	0.75	-1.1%	0.42	1.4%	0.77	1.2%

Table 2: Changes in b_0 and b_1 when the median value for VD increased by 10% and CS is unchanged and changes in b_0 and b_1 when the median value for CS increased by 10% and VD is unchanged for Model 1.

	Original		Median up 10% for VD; CS unchanged				Median up 10% for CS; VD Unchanged			
Dilation State	b1	b0	b1	Change in b1	b0	Change in b0	b1	Change in b1	b0	Change in b0
3 cm	0.50	0.71	0.52	4.0%	0.71	-1.0%	0.48	-4.4%	0.72	0.4%
4 cm	0.44	0.74	0.45	4.1%	0.73	-1.2%	0.41	-4.8%	0.74	0.4%
5 cm	0.38	0.80	0.40	3.7%	0.78	-1.6%	0.36	-5.5%	0.80	0.4%
6 cm	0.38	0.83	0.40	3.1%	0.82	-1.8%	0.36	-5.2%	0.84	0.4%
7 cm	0.37	0.86	0.38	3.0%	0.85	-1.9%	0.35	-5.1%	0.87	0.3%
8 cm	0.36	0.86	0.37	2.8%	0.85	-1.4%	0.34	-5.4%	0.87	0.7%
9 cm	0.42	0.85	0.43	2.6%	0.84	-2.0%	0.40	-4.8%	0.86	0.4%
10 cm	0.42	0.76	0.43	4.1%	0.75	-1.5%	0.40	-5.0%	0.76	0.4%

normal distribution were increased (Table 3) and decreased (Table 4) by 10% to see the effects on b_0 and b_1. Increasing the 5th percentile values by 10% resulted in a decrease in the value of b_1 and increase in the value of b_0 by less than 1% for all dilation states. When the 50th percentile was increased by 10%, the value of b_1 was increase by at most 5.6% and the values for b_0 were decreased by at most 2% for the dilation states. Increasing the 95th percentile by 10% resulted in a less that 1% increase in b_1 for dilation states 5-9 cm and a less than 0.5% decrease in b_1 for dilation states 4 and 10 cm. The 10% increase for the 95th percentile resulted in an increase of 0.3% for dilation state 4 cm and a less than 1% decrease in dilation sates 5-9 cm.

Decreasing the 5th percentile values by 10% resulted in no change for dilation states 5-7 cm and 10 cm, a less than 1% increase for dilation states 3, 4, and 8 cm, and a decrease of 0.2% in dilation state 9 cm in the cutoff value b_1. There was a less than 0.5% decrease in dilation states 3 cm, 4 cm, 5 cm, 8 cm, and 9 cm for b_0 and the remaining dilation states were unchanged. We noticed a decrease in the value of b_1 of at most 5% when the 50th percentile is decreased by 10% and an increase in b_0 as high as 2.2% percent. The values for b_1 and b_0 are unchanged for dilation state 3 cm when the 95th percentile is decreased by 10%. The values of b_1 are decreased by at most 1.2% and values of b_0 increased by at most 0.8% for dilation states 5-9 cm. For dilation states 4 cm and 9 cm, the values of b_1 were increased by less than 1% and the values for b_0 were decreased by 0.1%.

Small increases in the measurement for the 50th percentile has the most effect on the observation threshold values, b_1 and b_0. An increase in the 50th percentile results in increasing the interval for which CS is the best option and narrows the intervals of ξ_i in which you would take an observation. This in turns leads to a slightly larger interval for which ToL is optimal. Alternatively, small decreases in the value of the 50th percentile result in a smaller region for deciding CS, increases

Table 3: Changes in b_0 and b_1 when the 5th, 50th, and 95th percentile values are increased by 10% and for Model 2.

	Original		5th percentile up 10%				50th percentile up 10%				95th percentile up 10%			
Dilation State	b1	b0	b1	Change in b1	b0	Change in b0	b1	Change in b1	b0	Change in b0	b1	Change in b1	b0	Change in b0
3 cm	0.362	0.793	0.36	-0.3%	0.79	0.1%	0.38	3.9%	0.78	-1.5%	0.36	0.0%	0.79	0.0%
4 cm	0.375	0.781	0.37	-0.8%	0.78	0.4%	0.40	5.3%	0.77	-1.9%	0.37	-0.3%	0.78	0.3%
5 cm	0.340	0.845	0.34	-0.6%	0.85	0.1%	0.35	2.1%	0.84	-1.2%	0.34	0.3%	0.84	-0.2%
6 cm	0.352	0.879	0.35	0.0%	0.88	0.0%	0.36	1.1%	0.87	-0.8%	0.36	0.9%	0.87	-0.6%
7 cm	0.334	0.925	0.33	0.0%	0.93	0.1%	0.34	0.6%	0.92	-0.4%	0.34	0.9%	0.92	-0.6%
8 cm	0.314	0.941	0.31	0.0%	0.94	0.0%	0.32	0.3%	0.94	-0.3%	0.32	1.0%	0.94	-0.6%
9 cm	0.389	0.909	0.39	-0.2%	0.91	0.0%	0.39	0.3%	0.90	-0.6%	0.39	0.6%	0.90	-0.8%
10 cm	0.411	0.762	0.41	0.0%	0.76	0.0%	0.43	5.6%	0.75	-2.0%	0.41	-0.2%	0.76	0.0%

Table 4: Changes in b_0 and b_1 when the 5th, 50th, and 95th percentile values are decreased by 10% and for Model 2.

	Original		5th percentile down 10%				50th percentile down 10%				95th percentile down 10%			
Dilation State	b1	b0	b1	Change in b1	b0	Change in b0	b1	Change in b1	b0	Change in b0	b1	Change in b1	b0	Change in b0
3 cm	0.362	0.793	0.363	0.3%	0.792	-0.1%	0.347	-4.1%	0.807	1.8%	0.362	0.0%	0.793	0.0%
4 cm	0.375	0.781	0.378	0.8%	0.779	-0.3%	0.357	-4.8%	0.798	2.2%	0.378	0.8%	0.780	-0.1%
5 cm	0.340	0.845	0.340	0.0%	0.844	-0.1%	0.331	-2.6%	0.857	1.4%	0.337	-0.9%	0.848	0.4%
6 cm	0.352	0.879	0.352	0.0%	0.879	0.0%	0.348	-1.1%	0.886	0.8%	0.348	-1.1%	0.885	0.7%
7 cm	0.334	0.925	0.334	0.0%	0.925	0.0%	0.332	-0.6%	0.929	0.4%	0.331	-0.9%	0.932	0.8%
8 cm	0.314	0.941	0.315	0.3%	0.940	-0.1%	0.313	-0.3%	0.944	0.3%	0.312	-0.6%	0.947	0.6%
9 cm	0.389	0.909	0.388	-0.2%	0.908	-0.1%	0.385	-1.0%	0.913	0.4%	0.384	-1.2%	0.916	0.8%
10 cm	0.411	0.762	0.411	0.0%	0.762	0.0%	0.390	-5.1%	0.777	2.0%	0.412	0.2%	0.761	-0.1%

the region for taking an observation and reduces the region for ToL.

Model 3

Like for Model 2, the 5th, 50th, and 95th percentile measurements were decreased and increased by 10%, to see what effects this small change will have in the cutoff values of $b_x(i)$ (see Tables 5 and 6) and the probability transition matrix for ToL in Model 3 (Tables 7 and 8). Increasing the 5th percentile values by 10% reflected decreases for many transitions into the 7 cm and 10 cm dilation states. There was also a decrease in the probability of transitioning into the VD state for dilation states 4-6 cm and an increase in this probability for states 7-10 cm. There was an increase for transitioning into in the 9 cm dilation state for dilation states 4-8 cm and a decrease in the transition probability for 3 cm to 9 cm.

For the 10% increase change in the 50th percentile, the probability of transitioning to higher dilation states decreased for 3 cm and 4 cm. For dilation states 5-9 cm, the transition probability was increased for smaller transitions and decreased for larger transitions. That is, for 5 cm, the

transition to dilation states 5-7 cm increased but decreased for transitions into states 8 to VD. The probability for transitions into VD from all dilation states was decreased. The probability transition reflecting the 10% increase in the 95th percentile was decreased for transitioning into the 9 cm from 3, 5-7 cm and into the 10 cm dilation states from dilation states 6-9 cm. There was an increase from all dilation states into 8 cm and very little change in other transitions. The decrease in the 50th percentile showed an increase for all dilation states into VD, a decrease for smaller transitions and an increase in the transition probabilities for larger transitions; the effect of increasing the 50th percentile by 10%. The transition probabilities for transitioning into 6 cm and VD was decreased for all possible transitions and there was an increase for transitioning into 10 cm from all permissible dilation states.

With these changes, the conditions for choosing CS remains the same. The 10% increase and 10% decrease in the 5th percentile had no effect on the observation threshold interval. The 10% increase in the 50th percentile only slightly reduced the width of the observation interval for all dilation states with the largest decrease being 0.8%. This effect results in a slightly larger region for deciding ToL. Similarly, an increase in the 95th percentile reflected a small increase in the taking observation region for dilation states 5-9 cm where the largest increase was 0.2%. The 10% decrease in the 50th percentile values resulted in a slight increase in the region for taking an observation of at most 0.9% for dilation states 3 cm, 4 cm, and 9 cm. For dilation states 5-9 cm, the region for which an observation should be taken decreased by at most 7.6% resulting in a larger region for deciding ToL. A 10% decrease in the 95th percentile resulted in an at most 0.3% increase for the observation region for dilation states 3 cm and 5-9 cm. The region for taking an observation is unchanged for the 4 cm and 10 cm dilation states. When the interval for taking an observation is decreased, the region for ToL is expanded and when the interval for taking an

observation is increased, the ToL interval is decreased.

Overall, the small changes in the percentile measures had little effect on the observation region.

Table 5: Effects in threshold bounds when 50th percentile is decreased by 10%.

		b0	*b1*	*b2*	*b3*	*b4*	*b5*	*b6*	*b7*	*bvd*
3 cm	Original	0.715	0.502	0.099	0	0	0	0	0	0
	Down 10% 50th percentile	0.720	0.496	0.093	0	0	0	0	0	0
	Change	0.7%	-1.3%	-5.7%	-	-	-	-	-	-
		b0	*b1*	*b2*	*b3*	*b4*	*b5*	*b6*	*bvd*	
4 cm	Original	0.712	0.538	0.085	0	0	0	0	0	
	Down 10% 50th percentile	0.717	0.541	0.082	0	0	0	0	0	
	Change	0.6%	0.5%	-4.1%	-	-	-	-	-	
		b0	*b1*	*b2*	*b3*	*b4*	*b5*	*bvd*		
5 cm	Original	0.733	0.576	0.198	0	0	0	0		
	Down 10% 50th percentile	0.737	0.583	0.211	0	0	0	0		
	Change	0.4%	1.4%	6.6%	-	-	-	-		
		b0	*b1*	*b2*	*b3*	*b4*	*bvd*			
6 cm	Original	0.742	0.670	0.235	0.035	0	0			
	Down 10% 50th percentile	0.744	0.682	0.252	0.035	0	0			
	Change	0.3%	1.8%	7.2%	-0.2%	-	-			
		b0	*b1*	*b2*	*b3*	*bvd*				
7 cm	Original	0.758	0.694	0.132	0.019	0				
	Down 10% 50th percentile	0.759	0.709	0.142	0.018	0				
	Change	0.2%	2.2%	7.2%	-3.9%	-				
		b0	*b1*	*b2*	*bvd*					
8 cm	Original	0.759	0.667	0.111	0					
	Down 10% 50th percentile	0.759	0.688	0.113	0					
	Change	0.1%	3.1%	2.3%	-					
		b0	*b1*	*bvd*						
9 cm	Original	0.746	0.518	0						
	Down 10% 50th percentile	0.748	0.533	0						
	Change	0.2%	2.8%	-						
		b0	*bvd*							
10 cm	Original	0.725	0							
	Down 10% 50th percentile	0.731	0							
	Change	0.8%	-							

Table 6: Effects in threshold bounds when 50th percentile is increased by 10%.

		b0	*b1*	*b2*	*b3*	*b4*	*b5*	*b6*	*b7*	*bvd*
3 cm	Original	0.715	0.503	0.099	0	0	0	0	0	0
	Up 10% 50th percentile	0.711	0.504	0.106	0	0	0	0	0	0
	Change	-0.6%	0.3%	7.7%	-	-	-	-	-	-
		b0	*b1*	*b2*	*b3*	*b4*	*b5*	*b6*	*bvd*	
4 cm	Original	0.712	0.538	0.085	0	0	0	0	0	
	Up 10% 50th percentile	0.707	0.539	0.092	0	0	0	0	0	
	Change	-0.7%	0.1%	7.7%	-	-	-	-	-	
		b0	*b1*	*b2*	*b3*	*b4*	*b5*	*bvd*		
5 cm	Original	0.733	0.576	0.198	0	0	0	0		
	Up 10% 50th percentile	0.731	0.555	0.203	0	0	0	0		
	Change	-0.4%	-3.7%	2.4%	-	-	-	-		
		b0	*b1*	*b2*	*b3*	*b4*	*bvd*			
6 cm	Original	0.742	0.670	0.235	0.035	0	0			
	Up 10% 50th percentile	0.739	0.661	0.226	0.034	0	0			
	Change	-0.3%	-1.4%	-4.1%	-1.0%	-	-			
		b0	*b1*	*b2*	*b3*	*bvd*				
7 cm	Original	0.758	0.694	0.132	0.019	0				
	Up 10% 50th percentile	0.757	0.678	0.123	0.020	0				
	Change	-0.1%	-2.4%	-6.9%	6.5%	-				
		b0	*b1*	*b2*	*bvd*					
8 cm	Original	0.759	0.667	0.111	0					
	Up 10% 50th percentile	0.758	0.649	0.108	0					
	Change	-0.1%	-2.7%	-2.5%	-					
		b0	*b1*	*bvd*						
9 cm	Original	0.746	0.518	0						
	Up 10% 50th percentile	0.745	0.502	0						
	Change	-0.2%	3.2%	-						
		b0	*bvd*							
10 cm	Original	0.725	0							
	Up 10% 50th percentile	0.719	0							
	Change	-0.81%	-							

Table 7: Changes in the probability transition matrix for vaginal delivery when the 50th percentile is decreased by 10%.

	3 cm	*4 cm*	*5 cm*	*6 cm*	*7 cm*	*8 cm*	*9 cm*	*10 cm*	*VD*
3 cm	0.7236	0.1770	0.0609	0.0234	0.0104	0.0033	0.0013	0.0001	0
4 cm	0	0.7397	0.1401	0.0661	0.0323	0.0131	0.0063	0.0023	0.0001
5 cm	0	0	0.6515	0.1378	0.0906	0.0552	0.0413	0.0218	0.0018
6 cm	0	0	0	0.6108	0.1074	0.0958	0.0931	0.0845	0.0084
7 cm	0	0	0	0	0.5655	0.0914	0.1336	0.1791	0.0304
8 cm	0	0	0	0	0	0.5497	0.1165	0.2624	0.0714
9 cm	0	0	0	0	0	0	0.5741	0.2906	0.1353
10 cm	0	0	0	0	0	0	0	0.7591	0.2409
VD	0	0	0	0	0	0	0	0	1

(a) Original probability transition matrix for vaginal delivery.

	3 cm	*4 cm*	*5 cm*	*6 cm*	*7 cm*	*8 cm*	*9 cm*	*10 cm*	*VD*
3 cm	0.7057	0.1800	0.0663	0.0274	0.0134	0.0048	0.0017	0.0007	0
4 cm	0	0.7239	0.1383	0.0697	0.0353	0.0183	0.0106	0.0038	0.0001
5 cm	0	0	0.6414	0.1311	0.0873	0.0604	0.0459	0.0314	0.0025
6 cm	0	0	0	0.6034	0.0993	0.0901	0.0951	0.0979	0.0142
7 cm	0	0	0	0	0.5616	0.0856	0.1226	0.1871	0.0431
8 cm	0	0	0	0	0	0.5476	0.1091	0.2505	0.0928
9 cm	0	0	0	0	0	0	0.5703	0.2736	0.1561
10 cm	0	0	0	0	0	0	0	0.7372	0.2628
VD	0	0	0	0	0	0	0	0	1

(b) Probability transition matrix generated when the 50th percentile is decreased by 10%.

	3 cm	*4 cm*	*5 cm*	*6 cm*	*7 cm*	*8 cm*	*9 cm*	*10 cm*	*VD*
3 cm	-2.5%	1.7%	8.9%	17.1%	28.8%	45.5%	30.8%	600.0%	-
4 cm	-	-2.1%	-1.3%	5.4%	9.3%	39.7%	68.3%	65.2%	0.0%
5 cm	-	-	-1.6%	-4.9%	-3.6%	9.4%	11.1%	44.0%	38.9%
6 cm	-	-	-	-1.2%	-7.5%	-5.9%	2.1%	15.9%	69.0%
7 cm	-	-	-	-	-0.7%	-6.3%	-8.2%	4.5%	41.8%
8 cm	-	-	-	-	-	-0.4%	-6.4%	-4.5%	30.0%
9 cm	-	-	-	-	-	-	-0.7%	-5.8%	15.4%
10 cm	-	-	-	-	-	-	-	-2.9%	9.1%
VD	-	-	-	-	-	-	-	-	0.0%

(c) Percent change from original probability transition matrix to the probability transition matrix when the 50th percentile value is decreased by 10%.

Table 8: Changes in the probability transition matrix for vaginal delivery when the 50th percentile is increased by 10%.

	3 cm	*4 cm*	*5 cm*	*6 cm*	*7 cm*	*8 cm*	*9 cm*	*10 cm*	*VD*
3 cm	0.7236	0.1770	0.0609	0.0234	0.0104	0.0033	0.0013	0.0001	0
4 cm	0	0.7397	0.1401	0.0661	0.0323	0.0131	0.0063	0.0023	0.0001
5 cm	0	0	0.6515	0.1378	0.0906	0.0552	0.0413	0.0218	0.0018
6 cm	0	0	0	0.6108	0.1074	0.0958	0.0931	0.0845	0.0084
7 cm	0	0	0	0	0.5655	0.0914	0.1336	0.1791	0.0304
8 cm	0	0	0	0	0	0.5497	0.1165	0.2624	0.0714
9 cm	0	0	0	0	0	0	0.5741	0.2906	0.1353
10 cm	0	0	0	0	0	0	0	0.7591	0.2409
VD	0	0	0	0	0	0	0	0	1

(a) Original probability transition matrix for vaginal delivery.

	3 cm	*4 cm*	*5 cm*	*6 cm*	*7 cm*	*8 cm*	*9 cm*	*10 cm*	*VD*
3 cm	0.7382	0.1744	0.0572	0.0201	0.0076	0.0018	0.0006	0.0001	0
4 cm	0	0.7570	0.1396	0.0614	0.0271	0.0091	0.0042	0.0016	0.0000
5 cm	0	0	0.6610	0.1475	0.0918	0.0518	0.0313	0.0162	0.0004
6 cm	0	0	0	0.6176	0.1093	0.1043	0.0959	0.0683	0.0046
7 cm	0	0	0	0	0.5685	0.0993	0.1443	0.1685	0.0194
8 cm	0	0	0	0	0	0.5512	0.1302	0.2644	0.0542
9 cm	0	0	0	0	0	0	0.5779	0.3097	0.1124
10 cm	0	0	0	0	0	0	0	0.7815	0.2185
VD	0	0	0	0	0	0	0	0	1

(b) Probability transition matrix generated when the 50th percentile is increased by 10%.

	3 cm	*4 cm*	*5 cm*	*6 cm*	*7 cm*	*8 cm*	*9 cm*	*10 cm*	*VD*
3 cm	2.0%	-1.5%	-6.1%	-14.1%	-26.9%	-45.5%	-81.8%	0.0%	-
4 cm	-	2.3%	-0.4%	-7.1%	-16.1%	-30.5%	-33.3%	-30.4%	-100.0%
5 cm	-	-	1.5%	7.0%	1.3%	-6.2%	-24.2%	-25.7%	-77.8%
6 cm	-	-	-	1.1%	1.8%	8.9%	3.0%	-19.2%	-45.2%
7 cm	-	-	-	-	0.5%	8.6%	8.0%	-5.9%	-36.2%
8 cm	-	-	-	-	-	0.3%	11.8%	0.8%	-24.1%
9 cm	-	-	-	-	-	-	0.7%	6.6%	-16.9%
10 cm	-	-	-	-	-	-	-	3.0%	-9.3%
VD	-	-	-	-	-	-	-	-	0.0%

(c) Percent change from original probability transition matrix to the probability transition matrix when the 50th percentile value is increased by 10%.