

Do Customer Emotions Affect Agent Speed? An Empirical Study of Emotional Load in Online Customer Contact Centers — Online Appendix

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This document provides details of all the robustness tests reported in section 5.3 of the paper. The analysis reports different specifications of the following models:

$$\log(RT_{it}) = \delta_i + \beta EMO_{it-1} + \gamma W_{it} + \tau ConvStage_{it} + u_{it}, \quad (1)$$

$$\log(RT_{it}) = \delta_i + \beta_1 EMO_{it-1} + \beta_2 \log(NumWords_{it}) + \gamma W_{it} + \tau ConvStage_{it} + u_{it}; \quad (2)$$

$$\log(NumWords_{it}) = \delta_i + \beta_3 EMO_{it-1} + \gamma W_{it} + \tau ConvStage_{it} + v_{it}. \quad (3)$$

$$NTurns_i = \rho_{a(i)} + \beta_4 EMO_{i1} + \gamma W_i + \psi X_i + w_i. \quad (4)$$

$$\Phi^{-1}(\Pr(y_{it} = 1)) = \rho_{a(i)} + \beta_5 EMO_{it-1} + \alpha EMO_{i1} + \gamma W_{it} + \phi X_i, \quad (5)$$

$$EMO_{it} = \delta_i + \alpha \log(RT_{it-1}) + \tau ConvStage_{it} + e_{it}. \quad (6)$$

$$EMO_{it} = \delta_i + \alpha_1 \log(RT_{it-1}) + \alpha_2 \log(NumWords_{it-1}) + \alpha_3 Turn_{it} + \tau ConvStage_{it} + e_{it}. \quad (7)$$

1. Analyses using OLS, No Instrumental Variables

Table 1 Effect of Customer Emotion on Agent Behavior (Outliers Excluded, OLS with no IVs)

	Model(1) <i>log(RT)</i>	Model(2) <i>log(RT)</i>	Model (3) <i>log(NumWords)</i>	Model (4) <i>NTurns</i>
<i>EMO_{t-1}</i>	-0.096*** (0.002)	-0.097*** (0.001)	0.001 (0.001)	
<i>EMO₁</i>				-0.250*** (0.030)
<i>Concurrent_t</i>	0.056*** (0.003)	0.073*** (0.002)	-0.040*** (0.002)	-1.238*** (0.037)
<i>NumInQueue_t</i>	0.003*** (0.001)	0.003*** (0.001)	0.002* (0.001)	0.030*** (0.005)
<i>ConvStage_t</i>	0.168*** (0.004)	-0.040*** (0.004)	0.467*** (0.004)	
<i>log(NumWords_t)</i>		0.446*** (0.001)		
<i>log(CustWords₁)</i>				-0.328*** (0.021)
<i>IsWeekend</i>				-0.017 (0.041)
<i>SrvType</i>				5.975 (3.120)
<i>ShiftTime</i>				Included
<i>HourOfDay</i>				Included
Conversation Fixed Effect	Included	Included	Included	
Agent Fixed Effect				Included
Constant	3.634*** (0.007)	2.247*** (0.008)	3.112*** (0.006)	11.102*** (1.661)
Observations	650,856	650,856	650,856	141,654

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2. Analyses using Alternative Approach to Reduce Measurement Error using Factor Analysis

Table 2 Effect of Customer Emotion on Agent Behavior (Outliers Excluded, EMO_FA_{t-1} is based on Factor Analysis of *SentiStrength* and *CustSent*)

	Model (1) $\log(RT)$	Model (3) $\log(NumWords)$	Model (2) $\log(RT)$
EMO_FA_{t-1}	-0.124*** (0.0016)	0.003† (0.0064)	-0.125*** (0.0015)
$Concurrent_t$	0.056*** (0.0026)	-0.040*** (0.0024)	0.074*** (0.0024)
$NumInQueue_t$	0.003*** (0.0007)	0.002* (0.0006)	0.003*** (0.0006)
$ConvStage_t$	0.215*** (0.0040)	0.465*** (0.0037)	0.007*** (0.0040)
$\log(NumWords_t)$			0.446***
Conversation Fixed Effect	Included	Included	Included
Constant	3.570*** (0.007)	2.787*** (0.0064)	1.753*** (0.0100)
Indirect Effects			
EMO_FA_{t-1} via $\log(NumWords_t)$			0.0012† (0.0007)
Observations	650,856	650,856	650,856

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.1$

3. Analyses With and Without Log Transformation

Table 3 Effect of Customer Emotion on Agent Behavior (Outliers Excluded, Both EMO_1 and EMO_{t-1} are Instrumented Using *CustSent*. Models (1)–(3) are Without log transformations of the DVs, Model (4) is with log transformation of the DV)

	Model(1) <i>RT</i>	Model(2) <i>RT</i>	Model (3) <i>NumWords</i>	Model(4) <i>log(Nturns)</i>
EMO_1				-0.049*** (0.084)
EMO_{t-1}	-12.236*** (0.221)	-13.728*** (0.201)	1.454*** (0.091)	
$Concurrent_t$	3.125*** (0.208)	4.836*** (0.189)	-1.668*** (0.085)	
$Concurrent$ (chat level)				-0.102*** (0.003)
$NumInQueue_t$	0.160** (0.056)	0.122* (0.051)	0.036 (0.023)	
$NumInQueue$ (chat level)				0.003*** (0.000)
$ConvStage_t$	27.720*** (0.335)	11.087*** (0.308)	16.213*** (0.138)	
$log(NumWords_t)$		1.026*** (0.003)		
$log(CustWords_1)$				-0.024*** (0.002)
$IsWeekend$				-0.005 (0.003)
$SrvType$				0.531* (0.265)
$ShiftTime$				Included
$HourOfDay$				Included
Agent Fixed Effect				Included
Constant	44.666*** (0.552)	15.427*** (0.510)	28.502*** (0.227)	2.178*** (0.141)
Observations	650,856	650,856	650,856	141,654

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4. Analyses using Agent Emotion as an Additional Mediator

Table 4 Effect of Customer Emotion on Agent Behavior (Outliers Excluded, EMO_{t-1} is Instrumented using

	<i>CustSent_{t-1}</i>			
	Model (3) <i>log(NumWords)</i>	Model (3) ¹ <i>AgentEmo</i>	Model (2) <i>log(RT)</i>	Model (2) <i>log(RT)</i>
EMO_{t-1}	0.007** (0.002)	0.210*** (0.002)	-0.155** (0.002)	-0.197*** (0.002)
$log(NumWords_t)$			0.468*** (0.001)	0.446*** (0.001)
$AgentEmo_t$			-0.199*** (0.002)	
$Concurrent_t$	-0.040*** (0.002)	0.002 (0.002)	0.076*** (0.002)	0.074*** (0.002)
$NumInQueue_t$	0.002* (0.001)	0.001 (0.001)	0.003*** (0.001)	0.003*** (0.001)
$ConvStage_t$	0.464*** (0.004)	0.280*** (0.003)	0.055*** (0.004)	0.006† (0.004)
Conversation Fixed Effect	Included	Included	Included	Included
Constant	2.764*** (0.006)	0.209*** (0.005)	1.764*** (0.001)	1.809*** (0.001)
Indirect Effects				
EMO_{t-1} via $log(NumWords_t)$			0.003** (0.001)	0.003** (0.001)
EMO_{t-1} via $AgentEmo_t$			-0.042*** (0.001)	
Observations	650,856	650,856	650,856	650,856

*Note.*¹In the second column, we used Model 3 with a different DV ($AgentEmo_t$), and in the third column we used Model 2 including $AgentEmo_t$.

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.1$

5. Analyses using Alternative Measures of Concurrency

Table 5 Effect of Customer Emotion on Agent Behavior (Outliers Excluded, EMO_{t-1} is Instrumented using $CustSent_{t-1}$)

	Model(1) $\log(RT)$	Model (3) $\log(NumWords)$	Model (2) $\log(RT)$	Model(1) $\log(RT)$	Model (3) $\log(NumWords)$	Model (2) $\log(RT)$
EMO_{t-1}	-0.204*** (0.003)	0.007** (0.002)	-0.194*** (0.002)	-0.205*** (0.003)	0.007** (0.002)	-0.195*** (0.002)
$Concurrent_words_t$	0.009*** 0	0.002*** 0	0.008*** 0			
$Concurrent_msg_t$				0.419*** (0.001)	0.095*** (0.001)	0.382*** (0.001)
$NumInQueue_t$	0 (0.001)	0 (0.001)	0.001*** (0.001)	0 (0.001)	0 (0.001)	0 (0.001)
$ConvStage_t$	0.184*** (0.004)	0.460*** (0.004)	-0.033*** (0.003)	0.176*** (0.004)	0.458*** (0.004)	-0.035*** (0.003)
$\log(NumWords_t)$			0.402*** (0.001)			0.391*** (0.001)
Conversation Fixed Effect	Included	Included	Included	Included	Included	Included
Constant	3.616*** (0.003)	2.719*** (0.005)	2.184*** (0.009)	3.571*** (0.003)	2.718*** (0.005)	2.16*** (0.008)
Indirect Effects						
EMO_{t-1} via $\log(NumWords_t)$			0.003*** (0.001)		0.003*** (0.001)	
Observations	651,709	651,709	651,709	651,709	651,709	651,709

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6. Analyses using Clustered Standard Errors

Table 6 Effect of Customer Emotion on Agent Behavior (Outliers Excluded, EMO_{t-1} is Instrumented using $CustSent_{t-1}$. First column is with clustered standard errors. Second column is the original model)

	Model (1) $\log(RT)$	Model (1) $\log(RT)$
EMO_{t-1}	-0.206*** (0.003)	-0.206*** (0.003)
$Concurrent_t$	0.057*** (0.003)	0.057*** (0.003)
$NumInQueue_t$	0.003*** (0.001)	0.003*** (0.001)
$ConvStage_t$	0.246*** (0.005)	0.246*** (0.005)
Conversation Fixed Effect	Included	Included
Constant	3.617*** (0.007)	3.617*** (0.007)
Observations	650,856	650,856

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7. Survival Analysis with Categorical Emotion

Table 7 Effect of Customer Emotion on the Length of a Conversation (Outliers Excluded, In the first, fourth, and fifth columns *EMO* Variables are Instrumented using *CustSent*)

	Model (4) <i>Nturn</i>	Model (5) <i>Pr(LastTurn)</i>	Model (5) <i>Pr(LastTurn)</i>	Model (5) <i>Pr(LastTurn)</i>	Model (5) <i>Pr(LastTurn)</i>
<i>EMO</i> ₁ <i>_positive</i>	-0.726*** (0.1232)		-0.133*** (0.0049)		-0.265*** (0.0118)
<i>EMO</i> ₁ <i>_negative</i>	3.463*** (0.1766)		-0.069*** (0.0062)		-0.339*** (0.0154)
<i>EMO</i> <i>_positive</i> _{<i>t</i>-1}		0.443*** (0.0043)	0.478*** (0.0044)	0.872*** (0.0063)	0.920*** (0.0065)
<i>EMO</i> <i>_negative</i> _{<i>t</i>-1}		0.097*** (0.0067)	0.118*** (0.007)	0.061** (0.0196)	0.166*** (0.0204)
<i>Concurrent</i> _{<i>t</i>}		0.021*** (0.0031)	0.021*** (0.0031)	0.018*** (0.0031)	0.019*** (0.0031)
<i>NumInQueue</i> _{<i>t</i>}		0.001 (0.0005)	0.001* (0.0005)	0.001 (0.0005)	0.001* (0.0005)
<i>log(CustWords</i> _{<i>t</i>})		-0.060*** (0.0019)	-0.057*** (0.0019)	-0.062*** (0.0021)	-0.058*** (0.0021)
<i>log(CustWords</i> ₁)	-0.420*** (0.0239)				
<i>NumInQueue</i> (chat level)	0.030*** (0.0047)				
<i>Concurrent</i> (chat level)	-1.238*** (0.0369)				
<i>Turn</i> _{<i>t</i>}		-0.002*** (0.0005)	-0.002*** (0.0005)	-0.007*** (0.0005)	-0.006*** (0.0006)
<i>IsWeekend</i>	-0.023 (0.0416)	0.009* (0.0046)	0.009 (0.0046)	0.009* (0.0045)	0.010* (0.0045)
<i>SrvType</i>	6.473* (3.1506)	-0.306* (0.1308)	-0.329* (0.1306)	-0.286* (0.1295)	-0.353** (0.1298)
<i>ShiftTime</i>	Included	Included	Included	Included	Included
<i>HourOfDay</i>	Included	Included	Included	Included	Included
Agent Fixed Effect	Included	Included	Included	Included	Included
Constant	11.606*** (1.6853)	-0.857*** (0.1463)	-0.833*** (0.1464)	-1.225*** (0.1773)	-1.147*** (0.1773)
Observations	141,654	518,437	518,437	518,437	518,437

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

8. Analyses Including Outliers in the Sample

Table 8 Effect of Customer Emotion on Agent Behavior (Outliers Included, Both EMO_1 and EMO_{t-1} are Instrumented using $CustSent$)

	Model(1) $\log(RT)$	Model(2) $\log(RT)$	Model (3) $\log(NumWords)$	Model (4) $NTurns$
EMO_{t-1}	-0.343*** (0.0031)	-0.332*** (0.0030)	-0.024*** (0.0023)	
EMO_1				-1.677*** (0.0638)
$Concurrent_t$	0.098*** (0.0030)	0.112*** (0.0028)	-0.031*** (0.0022)	-1.153*** (0.0337)
$NumInQueue_t$	0.004*** (0.0008)	0.003*** (0.0008)	0.002*** (0.0006)	0.030*** (0.0043)
$ConvStage_t$	0.280*** (0.0048)	0.016*** (0.0046)	0.570*** (0.0035)	
$\log(NumWords_t)$		0.462*** (0.0016)		
$\log(CustWords_1)$				-0.299*** (0.0196)
$IsWeekend$				0.0171 (0.0385)
$SrvType$				5.612 (3.1187)
$ShiftTime$				Included
$HourOfDay$				Included
Conversation Fixed Effect	Included	Included	Included	
Agent Fixed Effect				Included
Constant	3.442*** (0.0079)	2.018*** (0.0089)	3.083*** (0.0058)	10.716*** (1.5582)
Observations	825577	825577	825583	162362

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9 Effect of Customer Emotion on Agent Behavior (Outliers Included, All *EMO* Variables are Instrumented using *CustSent*)

	Model(1) <i>log(RT)</i>	Model(2) <i>log(RT)</i>	Model (3) <i>log(NumWords)</i>	Model (4) <i>NTurns</i>
<i>EMO_positive</i> _{<i>t</i>-1}	-0.525*** (0.0046)	-0.512*** (0.0043)	-0.028*** (0.0034)	
<i>EMO_negative</i> _{<i>t</i>-1}	0.183*** (0.0143)	0.121*** (0.0134)	0.133*** (0.0105)	
<i>EMO_positive</i> ₁				-0.907*** (0.1140)
<i>EMO_negative</i> ₁				3.271*** (0.1638)
<i>Concurrent</i> _{<i>t</i>}	0.100*** (0.0030)	0.114*** (0.0028)	-0.031*** (0.0022)	-1.154*** (0.0337)
<i>NumInQueue</i> _{<i>t</i>}	0.004*** (0.0008)	0.003*** (0.0008)	0.002*** (0.0006)	0.029*** (0.0044)
<i>ConvStage</i> _{<i>t</i>}	0.315*** (0.0049)	0.050*** (0.0047)	0.574*** (0.0036)	
<i>log(NumWords)</i> _{<i>t</i>}		0.463*** (0.0016)		
<i>log(CustWords)</i> ₁				-0.371*** (0.0222)
<i>IsWeekend</i>				0.007 (0.0386)
<i>SrvType</i>				5.868 (3.1237)
<i>ShiftTime</i>				Included
<i>HourOfDay</i>				Included
Conversation Fixed Effect	Included	Included	Included	
Agent Fixed Effect				Included
Constant	3.481*** (0.0080)	2.058*** (0.0090)	3.075*** (0.0059)	9.734 (7.0542)
Observations	825,577	825,577	825,583	162,362

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10 Effect of Agent Behavior on Customer Emotion (Outliers Included. $\log(RT_{t-1})$ is Instrumented using

	<i>Concurrent_{t-1} and NumInQueue_{t-1}</i>	
	Model (6)	Model (7)
	<i>EMO</i>	<i>EMO</i>
$\log(RT_{t-1})$	-0.056*** (0.0100)	-0.328*** (0.0256)
$ConvStage_t$	0.875*** (0.0044)	1.114*** (0.0068)
$\log(NumWords_{t-1})$		0.163*** (0.0125)
$Turn_t$		-0.015*** (0.0003)
Conversation Fixed Effect	Included	Included
Constant	0.055 (0.0354)	0.528*** (0.0558)
Observations	725,805	725,805

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

9. Analyses using OLS, No Instrumental Variables

Table 11 Effect of Agent Behavior on Customer Emotion (Outliers Excluded)

	Model (6) <i>EMO</i>	Model (7) <i>EMO</i>
$\log(RT_{t-1})$	0.022*** (0.001)	0.022*** (0.001)
$ConvStage_t$	0.846*** (0.003)	1.133*** (0.006)
$\log(NumWords_{t-1})$		-0.009*** (0.001)
$Turn_t$		-0.015*** (0.000)
Conversation Fixed Effect	Included	Included
Constant	-0.2198*** (0.005)	-0.222*** (0.005)
Observations	776,551	776,551

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12 Effect of Agent Behavior on Customer Emotion (Outliers Excluded, using *CustSent* as the Main Measure of Customer Emotion)

	Model (6) <i>CustSent</i>	Model (7) <i>CustSent</i>
$\log(RT_{t-1})$	0.039*** (0.001)	0.035*** (0.001)
$ConvStage_t$	1.015*** (0.003)	1.366*** (0.006)
$\log(NumWords_{t-1})$		-0.004** (0.001)
$Turn_t$		-0.019*** (0.000)
Conversation Fixed Effect	Included	Included
Constant	-0.404*** (0.005)	0.414*** (0.005)
Observations	776,551	776,551

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

10. Analyses using *CustSent* as the Main Emotion Measure

Table 13 Effect of Customer Emotion on Agent Behavior (Outliers Excluded, using *CustSent* as the Main Measure of Customer Emotion)

	Model(1) <i>log(RT)</i>	Model(1) <i>log(RT)</i>	Model (3) <i>log(NumWords)</i>	Model (4) <i>Nturn</i>
<i>CustSent</i> ₁				-0.710*** (0.084)
<i>CustSent</i> _{t-1}	-0.184*** (0.003)	-0.185*** (0.003)	0.002 (0.003)	
<i>Concurrent</i> _t	0.058*** (0.003)	0.075*** (0.002)	-0.040*** (0.002)	
<i>Concurrent</i> (chat level)				-1.231*** (0.037)
<i>NumInQueue</i> _t	0.003*** (0.001)	0.002*** (0.001)	0.002* (0.001)	
<i>NumInQueue</i> (chat level)				0.029*** (0.005)
<i>ConvStage</i> _t	0.273*** (0.005)	0.064*** (0.004)	0.466*** (0.004)	
<i>log(NumWords)</i> _t		0.446*** (0.001)		
<i>log(CustWords)</i> ₁				-0.356*** (0.021)
<i>IsWeekend</i>				-0.017 (0.041)
<i>SrvType</i>				5.937 (3.114)
<i>ShiftTime</i>				Included
<i>HourOfDay</i>				Included
Agent Fixed Effect				Included
Constant	3.584*** (0.007)	2.194*** (0.008)	3.113*** (0.006)	11.138*** (1.658)
Observations	650,856	650,856	650,856	141,654

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$