Supplementary Material for "Setting reserve prices in second-price auctions with unobserved bids"

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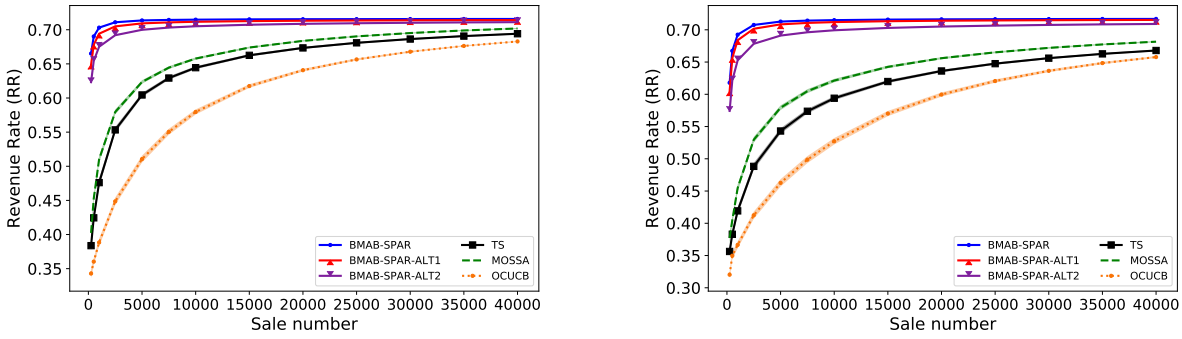
Supplementary Material

This document contains supplementary material for the main text. Sections EC.1, EC.2 and EC.3 present additional results related to Section 6 in the main text. Section EC.4 contains the results of a sensitivity analysis with respect to the parameters of BMAB-SPAR-NS. In Section EC.5 we present tables that show the performance of the algorithms discussed in Section 6 of the main text. In Section EC.6 we present tables that show the performance of the algorithms discussed in Section 7 of the main text.

EC.1. Impact of alternative arm selection methods

In this Section we perform additional experiments related to Section 6 of the main text. In this Section we investigate the impact of alternative arm selection methods for BMAB-SPAR on the performance of BMAB-SPAR.

In round $t+1$, BMAB-SPAR selects arm j^* such that $j^* = \arg\max_{j \in \mathcal{K}} I(j,t) \cdot m(j,t)$, where $I(j,t)$ is defined as $I(j,t) = \bar{x}_{j,t} + v_{j,t}$. Here $\bar{x}_{j,t}$ denotes the mean of the posterior distribution for arm j after t rounds, and $v_{j,t}$ denotes the posterior variance of arm j after t rounds. Recall that in BMAB-SPAR, the posterior distribution of arm j after t rounds follows a Beta distribution with parameters $\mathcal{B}(a_{j,t}, b_{j,t})$. Furthermore, recall that $I(j,t)$ is an approximation of the success probability for arm j and that $m(j,t)$ is an approximation of the mean revenue conditional on a sale when using arm j.



(a) $K = 30$ (b) $K = 60$

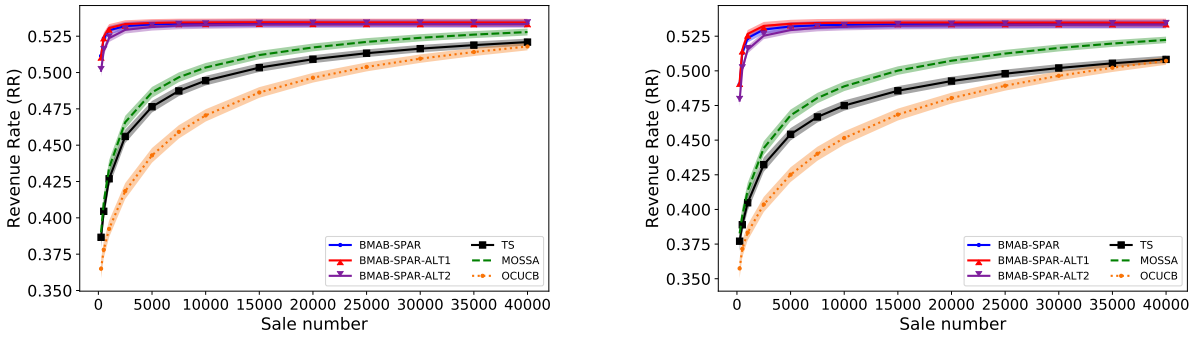
Figure EC.1 **Performance of the algorithms for dataset eBay-1, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**

In this Section, we propose two alternative arm selection methods.

- Alternative 1, denoted by BMAB-SPAR-ALT1. In round $t+1$, BMAB-SPAR-ALT1 selects arm j^* such that $j^* = \arg\max_{j \in \mathcal{K}} \hat{I}(j,t) \cdot m(j,t)$, where $\hat{I}(j,t)$ is a sample from a Beta distribution with parameters $\mathcal{B}(a_{j,t}, b_{j,t})$.
- Alternative 2, denoted by BMAB-SPAR-ALT2. In round $t+1$, BMAB-SPAR-ALT2 selects arm j^* such that $j^* = \arg\max_{j \in \mathcal{K}} \hat{I}(j,t) \cdot \hat{m}(j,t)$, where $\hat{I}(j,t)$ is a sample from a Beta distribution with parameters $\mathcal{B}(a_{j,t}, b_{j,t})$ and where $\hat{m}(j,t)$ is a sample from a Normal distribution with mean $m(j,t)$ and variance $\frac{1}{\bar{n}_{j,t}}$. Here $\bar{n}_{j,t}$ denotes the number of times that arm j has been selected up to and including round t.

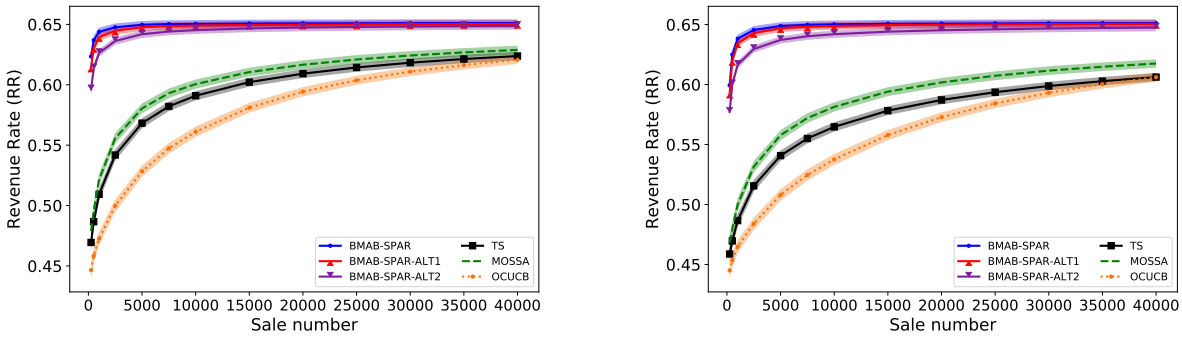
In BMAB-SPAR-ALT1 and BMAB-SPAR-ALT2, the exploration-exploitation trade-off is managed by sampling from a distribution, which mimics the idea used in Thompson Sampling.

Figures EC.1 to EC.4 shows the performance of BMAB-SPAR-ALT1 and BMAB-SPAR-ALT2 together with BMAB-SPAR and the best performing benchmark algorithms. The results indicate that the performance of BMAB-SPAR-ALT1 and BMAB-SPAR-ALT2 is qualitatively very similar to that of BMAB-SPAR. The results show that BMAB-SPAR-ALT1 and BMAB-SPAR-ALT2 outperform the best benchmark bandit algorithms.



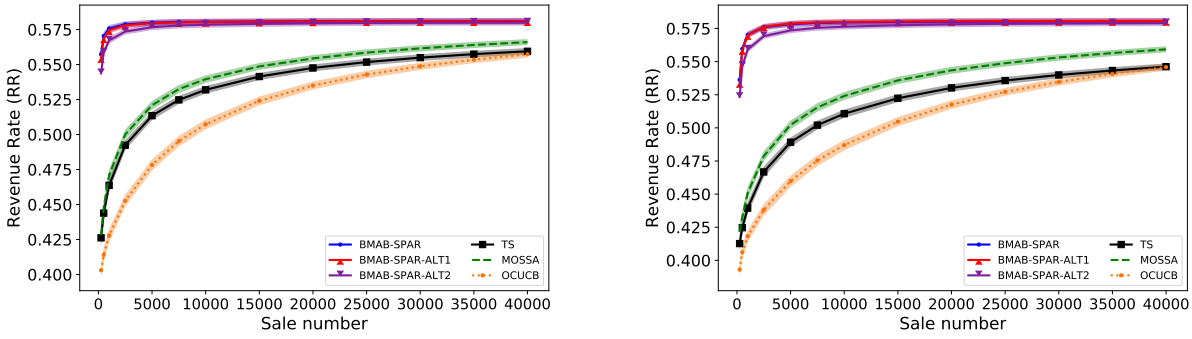
(a) $K = 30$ (b) $K = 60$

Figure EC.2 **Performance of the algorithms for dataset eBay-2, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) $K = 30$ (b) $K = 60$

Figure EC.3 **Performance of the algorithms for dataset eBay-3, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) $K = 30$ (b) $K = 60$

Figure EC.4 **Performance of the algorithms for dataset eBay-4, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**

EC.2. Impact of historical information

In this section we perform additional experiments related to Section 6 of the main text. In this section we investigate the impact of having some historical information in the form of samples from the bid distribution.

More specifically, we study how the performance of the algorithms differ when they have access to H samples from the joint distribution of the bids. In order to investigate the impact of the H samples on a problem instance with horizon T, we perform the following: we run the algorithms of Section 6 for $H+T$ rounds, and then only use performance in the last T rounds in order to calculate the performance metrics. In this approach, the first H samples from the bid distribution act as a "simulator" and the results in the first H rounds do not count in the calculation of the performance metrics. That is, the first H rounds are "offline", and the last T rounds are "online" and count in the calculation of the performance metrics. Intuitively, we use the first H samples in order to "warm-start" the algorithms so that they do not start from scratch.

In Figures EC.5 to EC.8, the performance of the algorithms in Section 6 of the main text are displayed when they have access to $H = 250$ samples from the joint distribution of the bids. In Figures EC.9 to EC.12 results are displayed for $H = 500$. In Figures EC.13 to EC.16 results are displayed for $H = 1000$.

Based on the results, we can make the following observations. First, the overall ranking of the algorithms remains the same as in the main text (i.e., without any historical information). Second, all of the algorithms benefit from the access to the extra H samples from the distribution of the bids, as the revenue rate in the figures starts at higher values compared to the figures in the main text. Third, having access to more than $H = 250$ samples tends to have negligible additional effects on the performance of BMAB-SPAR (compared to just having access to $H = 250$ samples) whereas it still has a significant impact on the performance of the other benchmark algorithms.

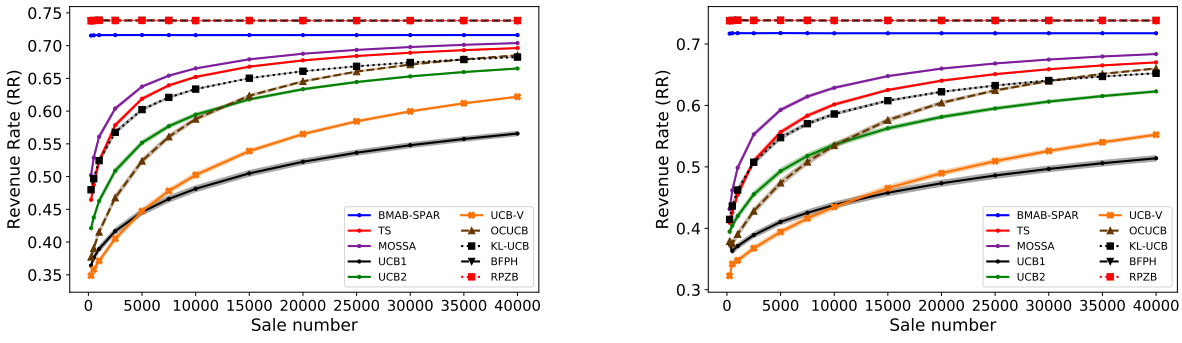
In Table EC.1 the aforementioned observations are illustrated for dataset eBay-1. Table EC.1 shows the revenue rate at different rounds and for different values of H, where $H = 0$ indicates that there are no samples available (i.e., the scenario in the main text). The table shows that, for all algorithms, the revenue rate after 250 rounds when $H = 0$ is lower than the revenue rate after 250 rounds when $H \in \{250, 500, 1000\}$. This shows that all algorithms benefit from access to historical information. For BMAB-SPAR, we observe that the

values in the columns where $H \in \{250, 500, 1000\}$ are essentially the same, which indicates that having access to more than $H = 250$ samples tends to have negligible additional effects on the performance of BMAB-SPAR. However, the results in Table EC.1 also show that a similar pattern does not hold for the other algorithms.

Overall, the results indicate that the extra samples have the most value for BMAB-SPAR, since the additional information allows the revenue rate of BMAB-SPAR to stabilize around its long term value much faster when compared to the other benchmark algorithms. In other words, giving BMAB-SPAR just $H = 250$ samples is enough for BMAB-SPAR to "close the learning gap", while this is not the case for the other benchmark algorithms.

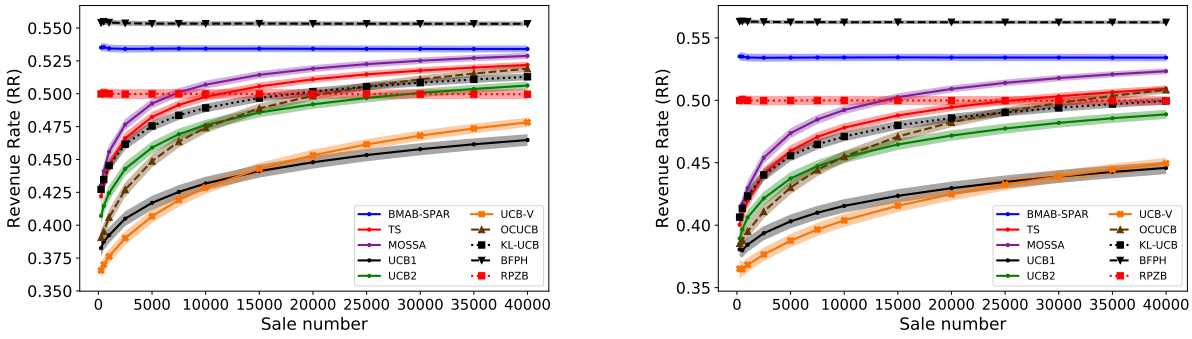
Table EC.1 Revenue rate of algorithms on eBay-1 dataset for $K = 30$.

	$H=0$			$H=250$			$H=500$			$H=1000$		
Round	250	500	40000	250	500	40000	250	500	40000	250	500	40000
BMAB-SPAR	0.665	0.690	0.716	0.715	0.716	0.716	0.716	0.716	0.716	0.717	0.716	0.716
TS	0.384	0.424	0.694	0.465	0.487	0.696	0.510	0.528	0.698	0.573	0.581	0.700
MOSSA	0.402	0.453	0.702	0.502	0.529	0.704	0.555	0.568	0.705	0.604	0.609	0.707
UCB1	0.345	0.355	0.564	0.364	0.376	0.566	0.388	0.392	0.567	0.409	0.413	0.570
UCB2	0.367	0.394	0.663	0.421	0.437	0.665	0.453	0.466	0.667	0.497	0.505	0.670
UCB-V	0.315	0.332	0.620	0.349	0.358	0.622	0.367	0.372	0.624	0.393	0.397	0.628
OCUCB	0.343	0.360	0.683	0.377	0.391	0.685	0.403	0.416	0.687	0.451	0.459	0.691
KL-UCB	0.398	0.439	0.681	0.480	0.497	0.683	0.513	0.527	0.684	0.561	0.569	0.686



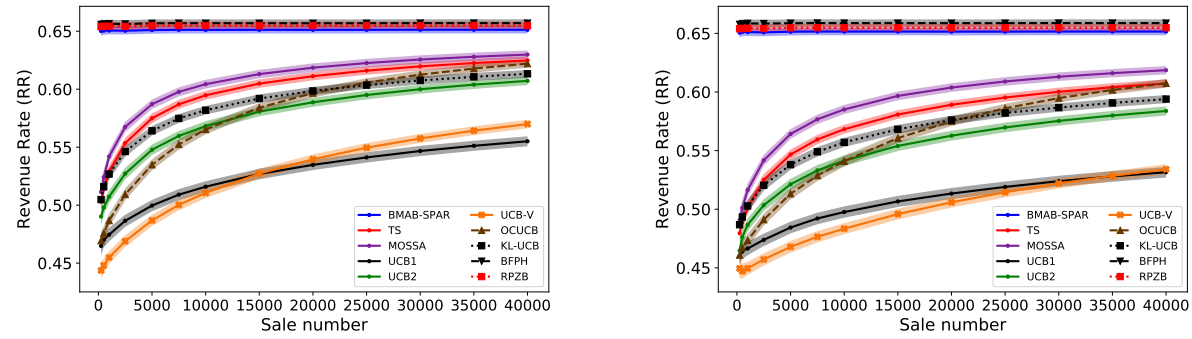
(a) $K = 30$ (b) $K = 60$

Figure EC.5 Performance of the algorithms for dataset eBay-1 with $H = 250$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.



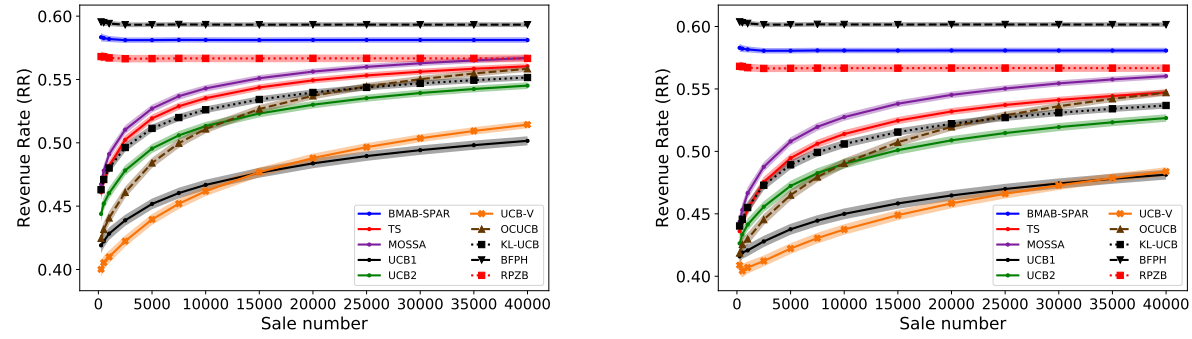
(a) $K = 30$ (b) $K = 60$

Figure EC.6 **Performance of the algorithms for dataset eBay-2 with $H = 250$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



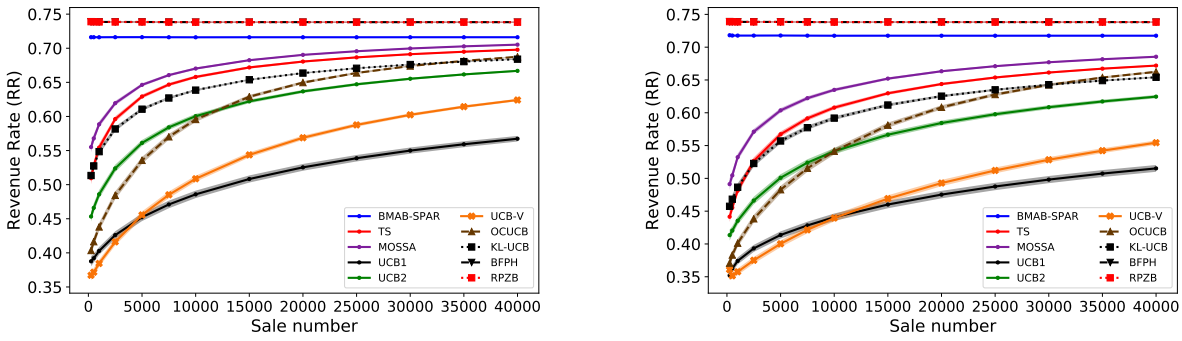
(a) $K = 30$ (b) $K = 60$

Figure EC.7 **Performance of the algorithms for dataset eBay-3 with $H = 250$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



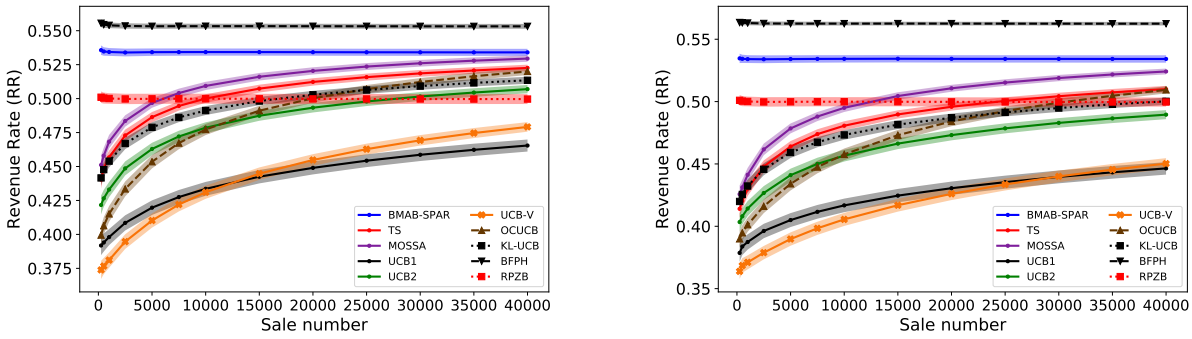
(a) $K = 30$ (b) $K = 60$

Figure EC.8 **Performance of the algorithms for dataset eBay-4 with $H = 250$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



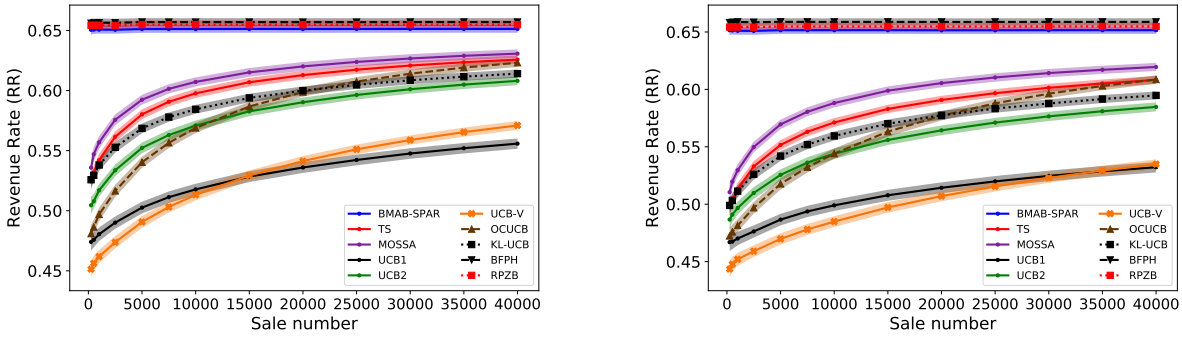
(a) $K = 30$ (b) $K = 60$

Figure EC.9 **Performance of the algorithms for dataset eBay-1 with $H = 500$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



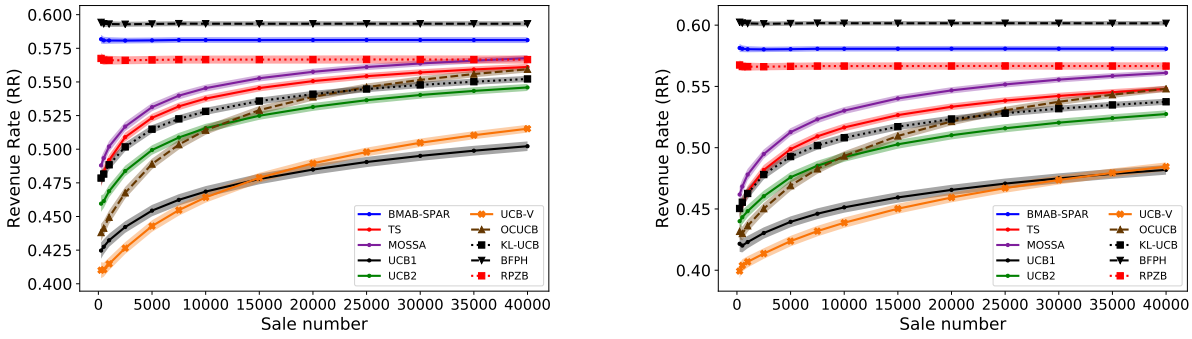
(a) $K = 30$ (b) $K = 60$

Figure EC.10 **Performance of the algorithms for dataset eBay-2 with $H = 500$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



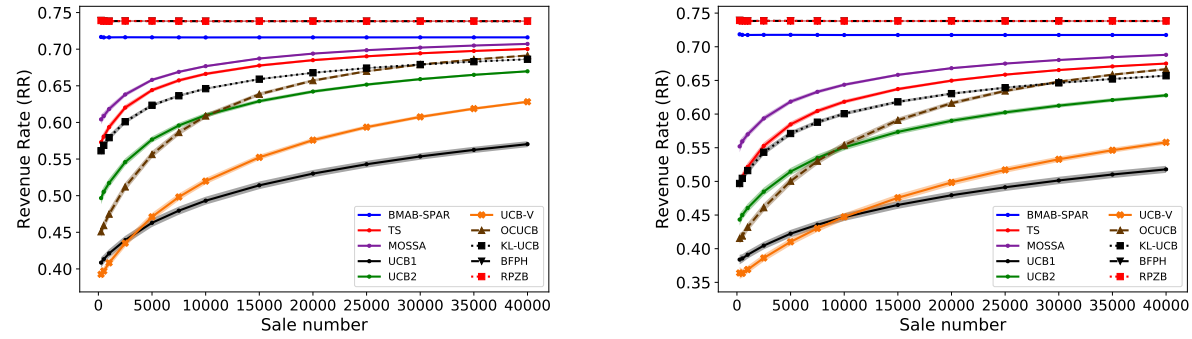
(a) $K = 30$ (b) $K = 60$

Figure EC.11 **Performance of the algorithms for dataset eBay-3 with $H = 500$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



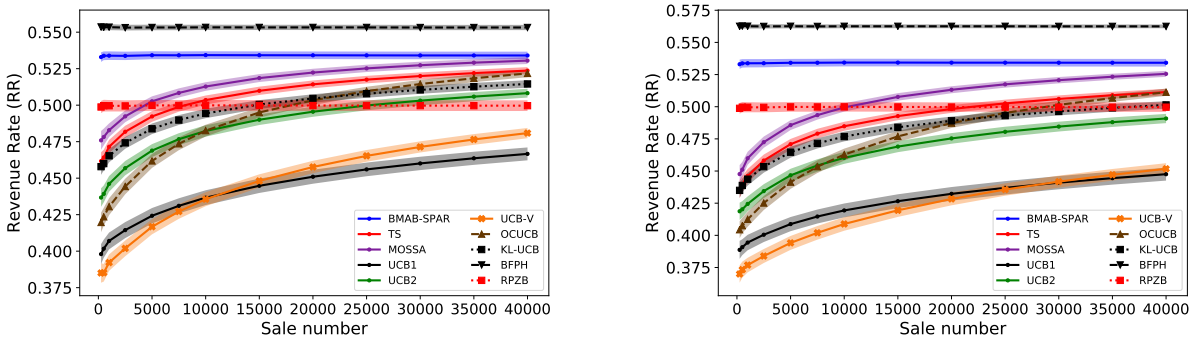
(a) $K = 30$ (b) $K = 60$

Figure EC.12 **Performance of the algorithms for dataset eBay-4 with $H = 500$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



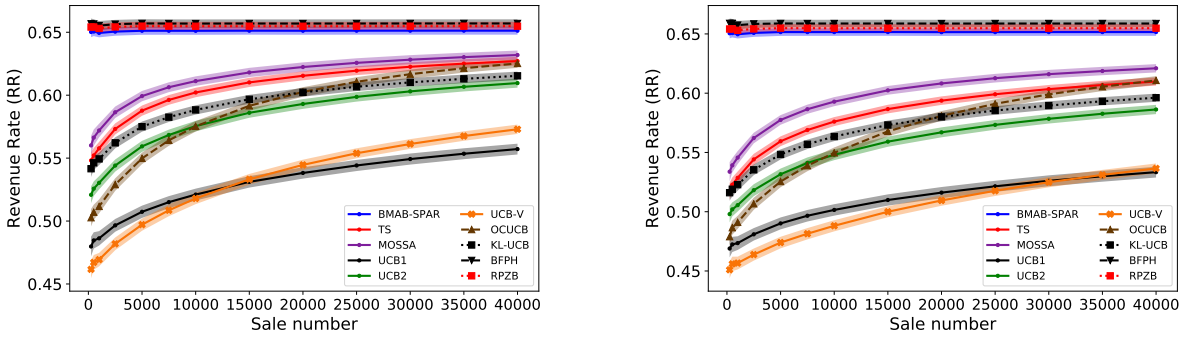
(a) $K = 30$ (b) $K = 60$

Figure EC.13 **Performance of the algorithms for dataset eBay-1 with $H = 1000$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



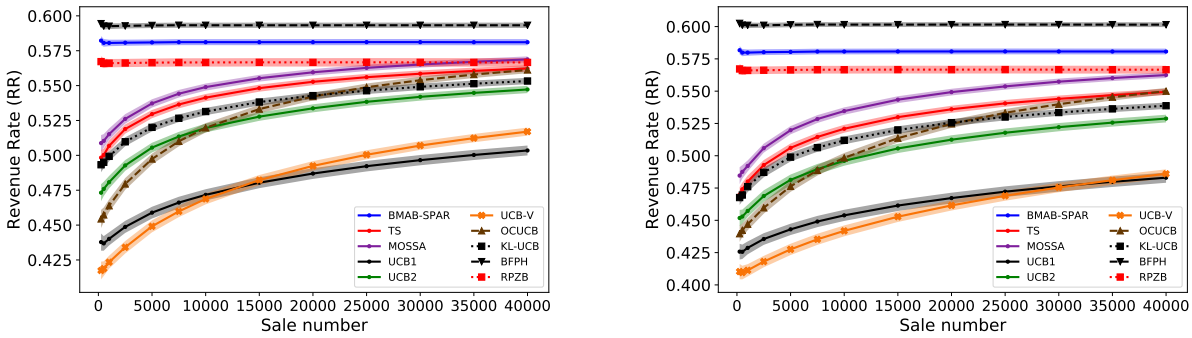
(a) $K = 30$ (b) $K = 60$

Figure EC.14 **Performance of the algorithms for dataset eBay-2 with $H = 1000$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) $K = 30$ (b) $K = 60$

Figure EC.15 **Performance of the algorithms for dataset eBay-3 with $H = 1000$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) $K = 30$ (b) $K = 60$

Figure EC.16 **Performance of the algorithms for dataset eBay-4 with $H = 1000$, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**

EC.3. Impact of alternative clustering

In this section we perform additional experiments related to Section 6 of the main text. In this section we study how the performance of the algorithms change if the clustering of the bids is performed in a different way. Similarly as in the main text, we define probability distributions over the clusters. However, in contrast with the main text, we do not use the relative gap between the second highest bid and the highest bid as a feature in the clustering.

The clustering is carried out as follows. First, we determine the 95-th percentile of $B_1 = \cup_{j=1}^{70213}\{b_1^j\}$. Denote the 95-th percentile by TP. Second, we remove outliers by removing pairs (b_1^j, b_2^j) for which the value of the top bid b_1^j exceeds the 95-th percentile TP, that is, we remove pairs j for which $b_1^j > TP$. We subsequently cluster the remaining bids (b_1^j, b_2^j) using the k-means clustering algorithm with $M = 6$ clusters. Next, we scale the remaining values

of (b_1^j, b_2^j) by the maximum value of b_1^j the dataset so that all the bids are in the range $[0,1]$. Figure EC.17 displays the resulting clustering of bids.

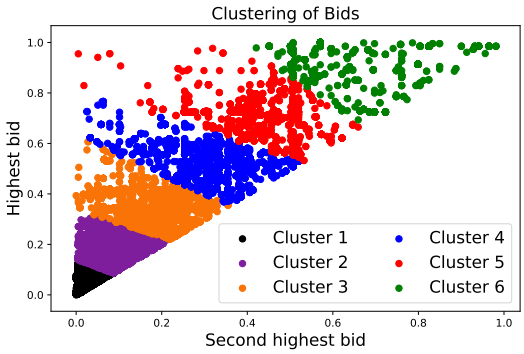


Figure EC.17 Clustering of bids in eBay dataset.

The description of these probability distributions can be found in Table EC.2. In Table EC.2, η_i is defined as $\eta_i = \frac{\hat{\eta}_i}{\sum_{i=1}^{6} \hat{\eta}_i}$, where $\hat{\eta}_i$ is an i.i.d. draw from an uniform distribution on $[0.25, 0.75]$ for $i = 1, \ldots, 6$. In other words, in order to construct the distribution P_j, we sample the values of $\hat{\eta}_i$ for $i = 1, \ldots, 6$ and then we normalized these values so that they sum up 1. We perform 200 independent runs of the above procedure and in each run we sample new values for $\hat{\eta}_i$.

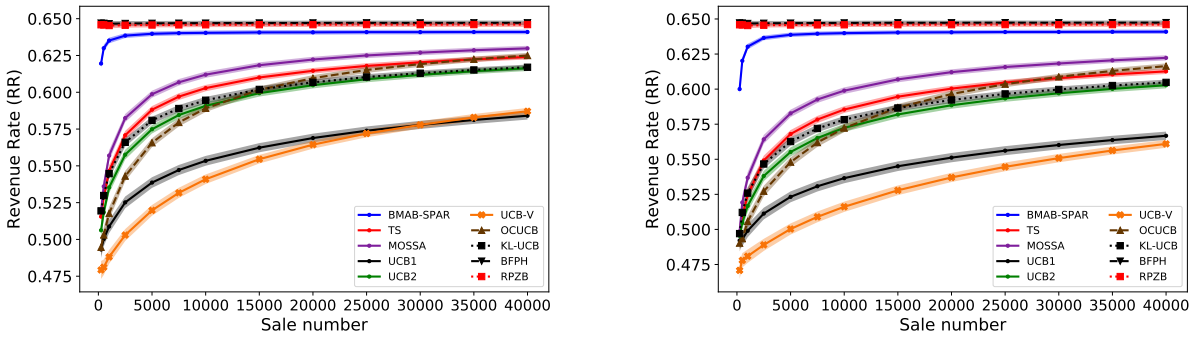
Table EC.2 Description of eBay datasets

dataset	distribution
eBay-5	$P_5 = (\eta_1, \eta_2, \eta_3, \eta_4, \eta_5, \eta_6)$
eBay-6	$P_6 = (\eta_1, \eta_2, 0.00, 0.00, 0.00, 0.00)$
eBay-7	$P_7 = (0.00, 0.00, 0.00, 0.00, \eta_1, \eta_2)$
eBay-8	$P_8 = (0.00, 0.00, \eta_1, \eta_2, 0.00, 0.00)$

Dataset eBay-5 models a case where the joint distribution is (in expectation) more evenly spread across $[0,1]$, dataset eBay-6 models a case where the joint distribution is concentrated in the lower part of $[0,1]$, dataset eBay-7 models a case where the joint distribution is concentrated in the upper part of $[0,1]$, and dataset eBay-8 models a case where the joint distribution is concentrated in the middle of $[0,1]$.

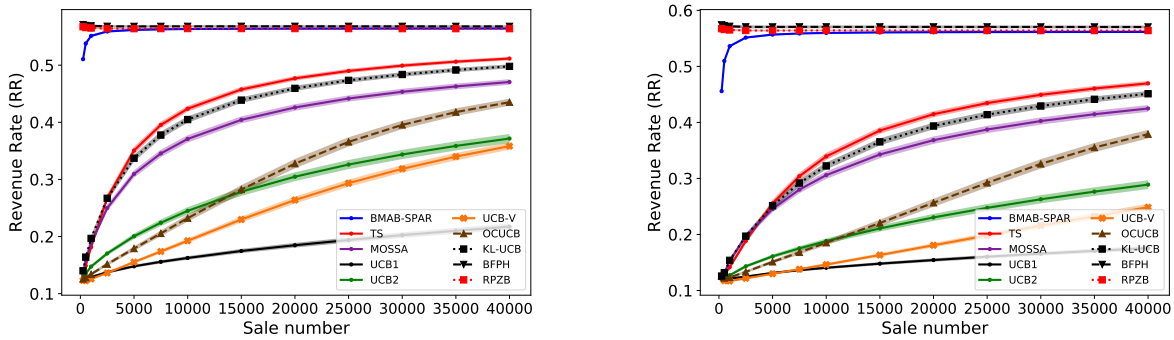
We consider a horizon of $T = 40000$. We consider the same set of algorithms as in the main text and all of the algorithms are run with $K \in \{30, 60\}$ arms which are equally spaced in the interval $[0,1]$. All results are averaged over 200 independent runs.

The results of the experiments can be found in Figures EC.18-EC.21. The results are qualitatively similar to those reported in the main text. We again see that BMAB-SPAR tends to outperform the benchmark bandit algorithms. Furthermore, we again see that the revenue rate of BMAB-SPAR approaches that of BFPH rather quickly. Also, we see that the performance of BMAB-SPAR is not very sensitive with respect to the number of arms K.



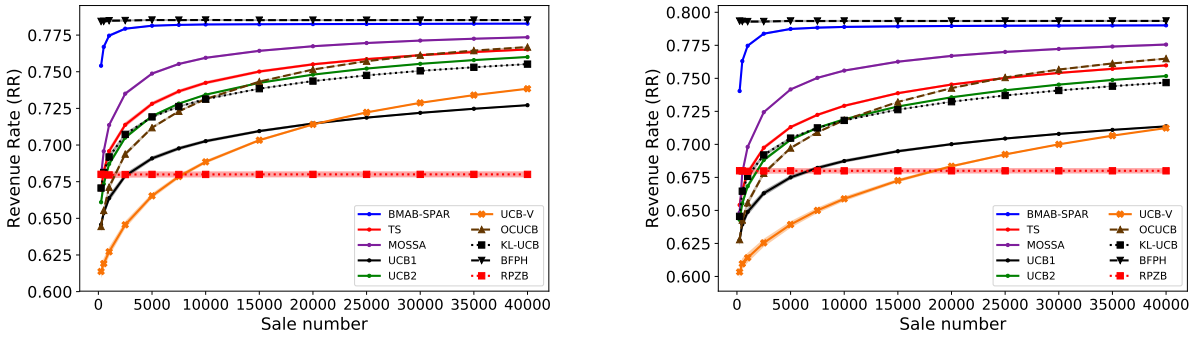
(a) $K = 30$ (b) $K = 60$

Figure EC.18 **Performance of the algorithms for dataset eBay-5, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



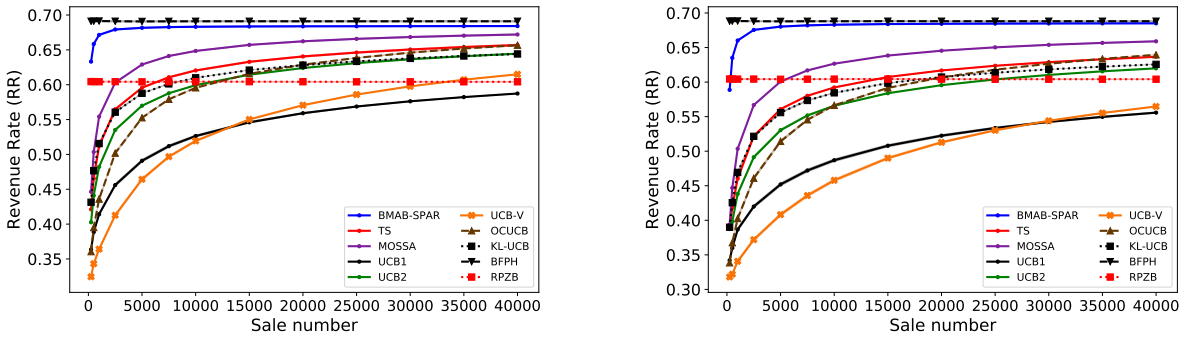
(a) $K = 30$ (b) $K = 60$

Figure EC.19 **Performance of the algorithms for dataset eBay-6, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) $K = 30$ (b) $K = 60$

Figure EC.20 **Performance of the algorithms for dataset eBay-7, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) $K = 30$ (b) $K = 60$

Figure EC.21 **Performance of the algorithms for dataset eBay-8, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**

EC.4. Sensitivity analysis for BMAB-SPAR-NS

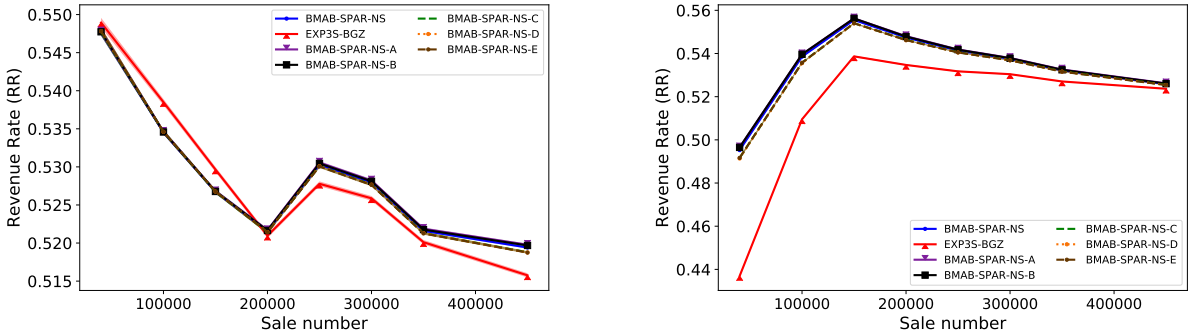
In this section we perform additional experiments related to Section 7 of the main text. In this section we present the results of a sensitivity analysis with respect to the parameters of BMAB-SPAR-NS. The experimental setting is identical to the setting in Section 7 of the main text, but we adjust several of the parameters of the BMAB-SPAR-NS algorithm in order to investigate the impact of these parameters on the performance. Table EC.3 below shows the parameter settings that are used in the sensitivity analysis and relates these to an abbreviation. In all of of the experiments we set $\kappa = 0.99$.

The results are presented in Figures EC.22 to EC.27. Figure EC.22 to EC.24 shows the performance for website A and Figure EC.25 to EC.27 shows the performance for website B. Overall, the results are qualitatively similar to those reported in the main text. The results

indicate that, in general, the settings for BMAB-SPAR-NS lead to the best performance. Furthermore, we observe that BMAB-SPAR-NS outperforms the best performing benchmark algorithms for all of the parameter values considered.

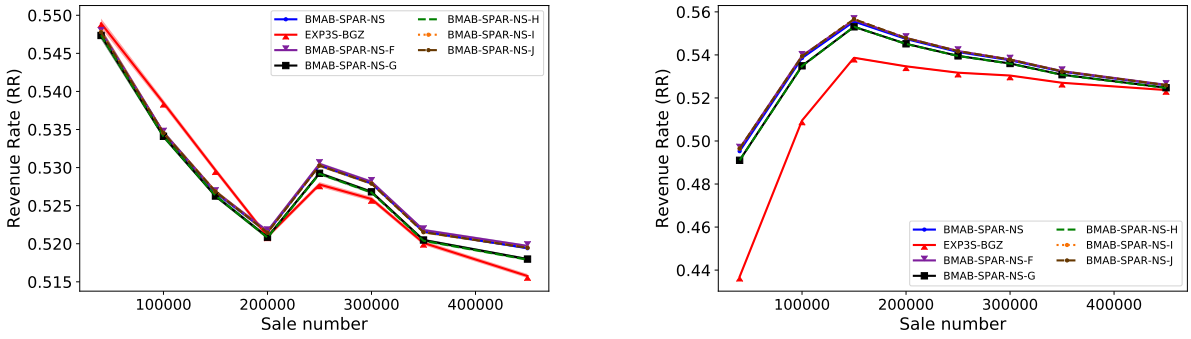
Table EC.3 Parameter values for sensitivity analysis.

parameter values	Abbreviation
$p^{ex}=0.015,\ \tau=0.003,\ q=500,\ w=1000$	BMAB-SPAR-NS
$p^{ex}=0.005,\ \tau=0.005,\ q=500,\ w=1000$	BMAB-SPAR-NS-A
$p^{ex}=0.005,\ \tau=0.005,\ q=1000,\ w=2000$	BMAB-SPAR-NS-B
$p^{ex}=0.05,\ \tau=0.001,\ q=500,\ w=1000$	BMAB-SPAR-NS-C
$p^{ex}=0.05,\ \tau=0.001,\ q=1000,\ w=2000$	BMAB-SPAR-NS-D
$p^{ex}=0.05,\ \tau=0.001,\ q=500,\ w=2000$	BMAB-SPAR-NS-E
$p^{ex}=0.005,\ \tau=0.001,\ q=500,\ w=2000$	BMAB-SPAR-NS-F
$p^{ex}=0.05,\ \tau=0.005,\ q=500,\ w=2000$	BMAB-SPAR-NS-G
$p^{ex}=0.05,\ \tau=0.005,\ q=1000,\ w=3000$	BMAB-SPAR-NS-H
$p^{ex}=0.005,\ \tau=0.001,\ q=750,\ w=4000$	BMAB-SPAR-NS-I
$p^{ex}=0.005,\ \tau=0.001,\ q=1000,\ w=4000$	BMAB-SPAR-NS-J
$p^{ex}=0.005,\ \tau=0.001,\ q=500,\ w=4000$	BMAB-SPAR-NS-K
$p^{ex}=0.005,\ \tau=0.001,\ q=1500,\ w=4000$	BMAB-SPAR-NS-L
$p^{ex}=0.05,\ \tau=0.005,\ q=1500,\ w=4000$	BMAB-SPAR-NS-M
$p^{ex}=0.05,\ \tau=0.005,\ q=1000,\ w=4000$	BMAB-SPAR-NS-N



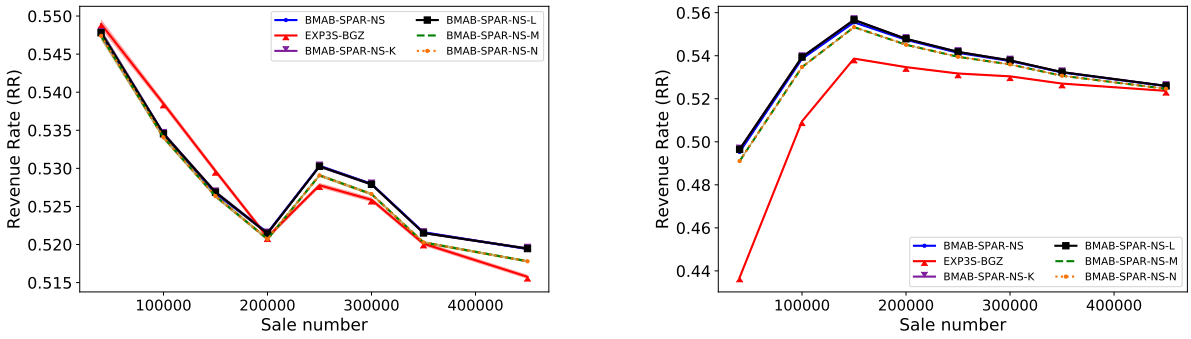
(a) Set A1 (b) Set A2

Figure EC.22 Performance of the algorithms for website A, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.



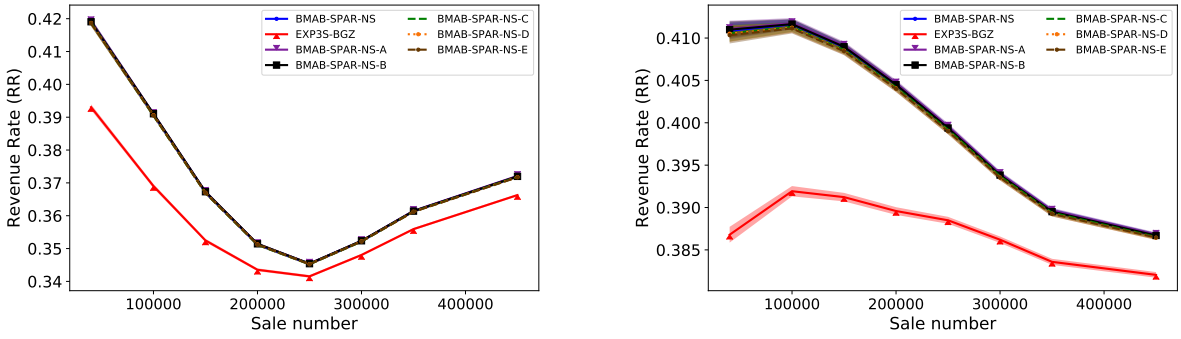
(a) Set A1 (b) Set A2

Figure EC.23 **Performance of the algorithms for website A, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



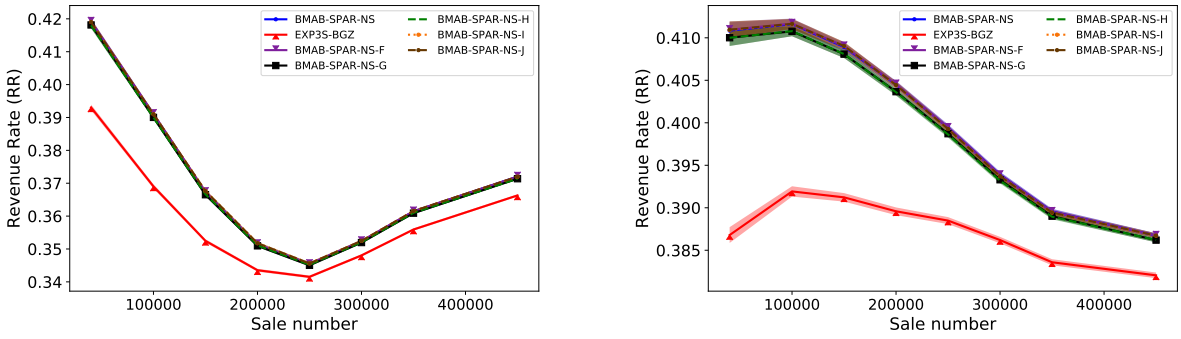
(a) Set A1 (b) Set A2

Figure EC.24 **Performance of the algorithms for website A, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



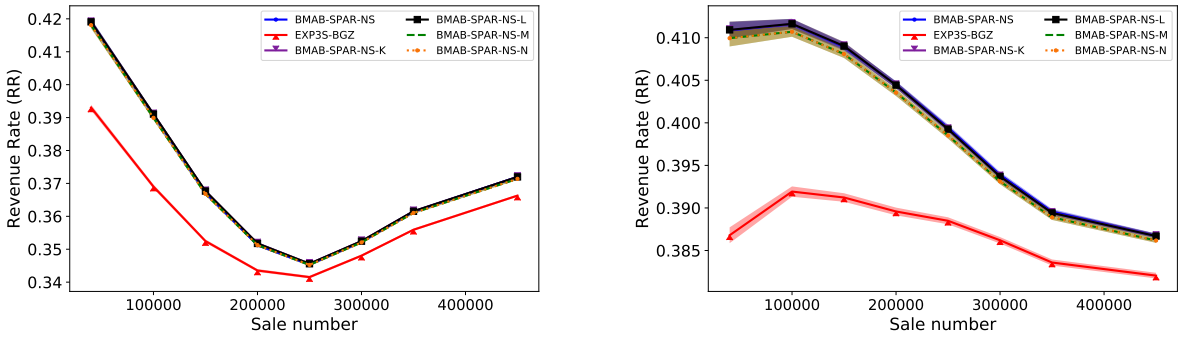
(a) Set B1 (b) Set B2

Figure EC.25 **Performance of the algorithms for website B, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) Set B1 (b) Set B2

Figure EC.26 **Performance of the algorithms for website B, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**



(a) Set B1 (b) Set B2

Figure EC.27 **Performance of the algorithms for website B, averaged over 200 runs. Lines indicate the mean and shaded region indicates 95% confidence interval.**

EC.5. Additional results for Section 6

In this section we present tables that show the performance of the algorithms discussed in Section 6 of the main text.

Table EC.4 Performance of algorithms on eBay-1 dataset with $K = 30$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.185	0.185	0.185	0.185	0.185	0.185	0.738	0.738	0.738	0.738	0.738	0.738
std	0.021	0.020	0.020	0.020	0.020	0.020	0.007	0.006	0.005	0.005	0.005	0.005
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.185	0.185	0.185	0.185	0.185	0.185	0.738	0.738	0.738	0.738	0.738	0.738
std	0.021	0.020	0.020	0.020	0.020	0.020	0.007	0.006	0.005	0.005	0.005	0.005
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.176	0.179	0.179	0.179	0.180	0.180	0.703	0.714	0.714	0.715	0.715	0.716
std	0.020	0.020	0.020	0.020	0.020	0.020	0.006	0.004	0.004	0.004	0.004	0.004
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.120	0.152	0.158	0.162	0.169	0.174	0.476	0.604	0.629	0.644	0.673	0.694
std	0.022	0.021	0.021	0.021	0.020	0.020	0.035	0.017	0.014	0.012	0.009	0.007
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.129	0.157	0.162	0.165	0.172	0.176	0.510	0.624	0.644	0.658	0.684	0.702
std	0.022	0.021	0.021	0.021	0.020	0.020	0.029	0.014	0.011	0.009	0.006	0.004
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.094	0.111	0.116	0.121	0.131	0.142	0.373	0.438	0.460	0.477	0.520	0.564
std	0.018	0.020	0.021	0.021	0.022	0.022	0.030	0.031	0.031	0.031	0.028	0.023
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.109	0.136	0.143	0.148	0.158	0.167	0.430	0.539	0.568	0.587	0.629	0.663
std	0.021	0.022	0.022	0.022	0.021	0.021	0.034	0.025	0.022	0.020	0.013	0.008
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.089	0.111	0.119	0.125	0.141	0.156	0.352	0.437	0.470	0.496	0.561	0.620
std	0.016	0.019	0.020	0.020	0.021	0.020	0.027	0.028	0.027	0.025	0.018	0.010
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.098	0.129	0.139	0.146	0.161	0.172	0.388	0.511	0.550	0.580	0.641	0.683
std	0.019	0.022	0.022	0.022	0.021	0.021	0.030	0.029	0.025	0.021	0.011	0.004
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.122	0.149	0.154	0.158	0.165	0.171	0.483	0.590	0.612	0.627	0.657	0.681
std	0.021	0.021	0.021	0.020	0.020	0.020	0.028	0.015	0.012	0.010	0.006	0.004

Table EC.5 Performance of algorithms on eBay-2 dataset with $K = 30$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.196	0.195	0.195	0.195	0.195	0.195	0.554	0.553	0.553	0.553	0.553	0.553
std	0.024	0.024	0.024	0.024	0.024	0.024	0.012	0.011	0.011	0.010	0.010	0.010
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.177	0.177	0.177	0.177	0.177	0.177	0.500	0.500	0.500	0.500	0.500	0.500
std	0.025	0.025	0.025	0.025	0.025	0.025	0.022	0.021	0.021	0.021	0.021	0.021
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.187	0.188	0.189	0.189	0.188	0.189	0.529	0.533	0.534	0.534	0.534	0.534
std	0.025	0.025	0.025	0.025	0.025	0.025	0.016	0.016	0.015	0.015	0.015	0.015
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.151	0.169	0.172	0.175	0.180	0.184	0.427	0.476	0.487	0.494	0.509	0.521
std	0.026	0.025	0.024	0.024	0.024	0.023	0.031	0.023	0.020	0.019	0.016	0.014
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.154	0.172	0.176	0.178	0.183	0.186	0.434	0.486	0.497	0.503	0.517	0.528
std	0.026	0.025	0.025	0.024	0.024	0.024	0.030	0.021	0.019	0.018	0.015	0.013
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.136	0.147	0.150	0.152	0.158	0.164	0.384	0.413	0.423	0.429	0.447	0.464
std	0.025	0.025	0.025	0.025	0.026	0.026	0.034	0.031	0.030	0.029	0.027	0.025
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.146	0.161	0.165	0.168	0.173	0.179	0.410	0.454	0.465	0.473	0.490	0.505
std	0.026	0.026	0.025	0.025	0.025	0.024	0.033	0.027	0.025	0.023	0.020	0.017
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.131	0.143	0.148	0.151	0.160	0.169	0.369	0.403	0.416	0.426	0.452	0.477
std	0.023	0.025	0.025	0.025	0.025	0.024	0.031	0.030	0.029	0.028	0.025	0.020
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.139	0.157	0.163	0.167	0.175	0.183	0.392	0.443	0.459	0.471	0.496	0.518
std	0.025	0.026	0.026	0.025	0.025	0.024	0.032	0.028	0.026	0.024	0.019	0.015
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.152	0.166	0.170	0.172	0.177	0.181	0.429	0.470	0.480	0.486	0.500	0.512
std	0.025	0.025	0.024	0.024	0.024	0.024	0.029	0.022	0.020	0.019	0.017	0.015

Table EC.6 Performance of algorithms on eBay-3 dataset with $K = 30$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.207	0.207	0.207	0.207	0.207	0.207	0.656	0.657	0.657	0.657	0.657	0.657
std	0.021	0.020	0.020	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.019	0.019
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.207	0.207	0.207	0.206	0.207	0.207	0.654	0.655	0.655	0.655	0.655	0.655
std	0.021	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.019	0.019	0.020	0.020
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.203	0.205	0.205	0.205	0.205	0.205	0.644	0.650	0.650	0.650	0.651	0.651
std	0.021	0.020	0.020	0.020	0.020	0.020	0.019	0.018	0.018	0.018	0.018	0.018
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.161	0.179	0.184	0.187	0.192	0.197	0.509	0.568	0.582	0.591	0.609	0.624
std	0.021	0.020	0.020	0.020	0.020	0.020	0.030	0.024	0.022	0.022	0.021	0.019
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.165	0.183	0.187	0.190	0.195	0.198	0.522	0.580	0.593	0.601	0.617	0.629
std	0.021	0.020	0.020	0.020	0.020	0.020	0.029	0.023	0.022	0.022	0.021	0.020
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.148	0.157	0.160	0.162	0.169	0.175	0.467	0.496	0.506	0.514	0.533	0.554
std	0.021	0.020	0.020	0.020	0.021	0.021	0.033	0.028	0.027	0.027	0.026	0.024
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.156	0.171	0.176	0.178	0.185	0.191	0.493	0.542	0.556	0.565	0.587	0.606
std	0.022	0.021	0.021	0.021	0.020	0.020	0.032	0.026	0.025	0.024	0.022	0.021
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.142	0.153	0.157	0.160	0.170	0.180	0.450	0.483	0.497	0.508	0.538	0.569
std	0.020	0.020	0.020	0.020	0.020	0.020	0.031	0.028	0.027	0.026	0.024	0.021
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.150	0.167	0.173	0.177	0.188	0.196	0.473	0.528	0.547	0.561	0.594	0.621
std	0.021	0.021	0.021	0.021	0.020	0.020	0.032	0.027	0.025	0.024	0.022	0.020
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.161	0.176	0.180	0.183	0.188	0.193	0.510	0.558	0.571	0.579	0.597	0.612
std	0.021	0.020	0.020	0.020	0.020	0.020	0.028	0.023	0.022	0.021	0.020	0.019

Table EC.7 Performance of algorithms on eBay-4 dataset with $K = 30$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.200	0.199	0.199	0.199	0.199	0.199	0.594	0.593	0.593	0.593	0.593	0.593
std	0.019	0.019	0.019	0.019	0.019	0.019	0.012	0.010	0.010	0.011	0.011	0.011
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.191	0.190	0.190	0.190	0.190	0.190	0.567	0.566	0.567	0.567	0.567	0.567
std	0.020	0.020	0.020	0.020	0.020	0.020	0.018	0.017	0.017	0.017	0.017	0.017
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.194	0.195	0.195	0.195	0.195	0.195	0.576	0.580	0.580	0.581	0.581	0.581
std	0.020	0.019	0.019	0.019	0.019	0.019	0.014	0.012	0.012	0.012	0.012	0.012
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.157	0.172	0.176	0.179	0.184	0.188	0.464	0.513	0.525	0.532	0.548	0.559
std	0.020	0.019	0.019	0.019	0.019	0.019	0.025	0.017	0.016	0.015	0.014	0.013
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.159	0.175	0.179	0.181	0.186	0.190	0.471	0.521	0.532	0.540	0.554	0.566
std	0.020	0.020	0.020	0.020	0.019	0.019	0.024	0.018	0.016	0.015	0.013	0.012
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.142	0.151	0.154	0.156	0.162	0.168	0.419	0.448	0.458	0.465	0.482	0.501
std	0.020	0.020	0.020	0.020	0.020	0.020	0.027	0.024	0.024	0.023	0.022	0.020
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.151	0.165	0.169	0.172	0.178	0.183	0.447	0.490	0.502	0.510	0.528	0.544
std	0.020	0.020	0.020	0.020	0.020	0.020	0.026	0.020	0.020	0.019	0.017	0.015
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.137	0.147	0.151	0.155	0.164	0.172	0.405	0.436	0.449	0.459	0.486	0.513
std	0.019	0.020	0.020	0.020	0.020	0.019	0.027	0.024	0.024	0.023	0.020	0.016
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.145	0.161	0.167	0.171	0.180	0.187	0.428	0.478	0.495	0.507	0.535	0.557
std	0.020	0.020	0.021	0.020	0.020	0.019	0.028	0.023	0.021	0.020	0.016	0.014
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.157	0.170	0.174	0.176	0.181	0.185	0.464	0.506	0.516	0.523	0.538	0.551
std	0.020	0.019	0.019	0.019	0.019	0.019	0.024	0.017	0.016	0.015	0.014	0.013

Table EC.8 Performance of algorithms on eBay-1 dataset with $K = 60$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.185	0.185	0.185	0.185	0.185	0.185	0.738	0.738	0.738	0.738	0.738	0.738
std	0.021	0.020	0.020	0.020	0.020	0.020	0.007	0.006	0.005	0.005	0.005	0.005
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.185	0.185	0.185	0.185	0.185	0.185	0.738	0.738	0.738	0.738	0.738	0.738
std	0.021	0.020	0.020	0.020	0.020	0.020	0.007	0.006	0.005	0.005	0.005	0.005
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.174	0.179	0.179	0.180	0.180	0.180	0.692	0.713	0.714	0.715	0.716	0.717
std	0.020	0.020	0.020	0.020	0.020	0.020	0.006	0.004	0.003	0.003	0.003	0.004
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.106	0.137	0.145	0.150	0.160	0.168	0.419	0.543	0.574	0.594	0.636	0.668
std	0.020	0.021	0.021	0.021	0.020	0.020	0.033	0.024	0.021	0.018	0.011	0.007
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.115	0.146	0.152	0.156	0.165	0.171	0.455	0.579	0.605	0.621	0.656	0.682
std	0.021	0.022	0.021	0.021	0.021	0.021	0.031	0.021	0.017	0.015	0.009	0.006
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.090	0.102	0.106	0.110	0.119	0.129	0.355	0.404	0.420	0.434	0.471	0.512
std	0.017	0.019	0.020	0.020	0.021	0.022	0.029	0.031	0.031	0.032	0.032	0.030
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.099	0.122	0.129	0.134	0.146	0.156	0.393	0.482	0.510	0.530	0.577	0.621
std	0.019	0.022	0.022	0.022	0.022	0.021	0.034	0.031	0.029	0.027	0.021	0.015
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.085	0.098	0.104	0.109	0.123	0.139	0.336	0.388	0.411	0.430	0.486	0.550
std	0.015	0.018	0.019	0.019	0.021	0.021	0.022	0.028	0.029	0.029	0.027	0.020
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.093	0.117	0.126	0.133	0.151	0.165	0.367	0.463	0.499	0.527	0.600	0.658
std	0.018	0.021	0.022	0.022	0.022	0.021	0.030	0.032	0.031	0.028	0.018	0.009
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.109	0.135	0.142	0.146	0.156	0.163	0.432	0.536	0.562	0.580	0.619	0.650
std	0.020	0.021	0.021	0.021	0.020	0.020	0.032	0.022	0.019	0.016	0.011	0.007

Table EC.9 Performance of algorithms on eBay-2 dataset with $K = 60$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.199	0.198	0.199	0.198	0.198	0.198	0.563	0.563	0.563	0.563	0.563	0.562
std	0.024	0.023	0.023	0.023	0.023	0.023	0.010	0.009	0.009	0.009	0.008	0.008
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.177	0.177	0.177	0.177	0.177	0.177	0.500	0.500	0.500	0.500	0.500	0.500
std	0.025	0.025	0.025	0.025	0.025	0.025	0.022	0.021	0.021	0.021	0.021	0.021
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.185	0.188	0.188	0.188	0.188	0.189	0.524	0.532	0.533	0.533	0.534	0.534
std	0.025	0.025	0.025	0.025	0.025	0.025	0.018	0.017	0.017	0.017	0.017	0.017
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.144	0.161	0.165	0.168	0.174	0.179	0.405	0.454	0.467	0.475	0.493	0.508
std	0.026	0.025	0.025	0.024	0.024	0.024	0.033	0.025	0.023	0.021	0.018	0.015
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.147	0.166	0.170	0.173	0.179	0.184	0.414	0.468	0.480	0.489	0.507	0.522
std	0.026	0.025	0.025	0.025	0.024	0.024	0.032	0.024	0.021	0.019	0.016	0.013
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.134	0.142	0.145	0.147	0.152	0.158	0.377	0.400	0.408	0.413	0.428	0.445
std	0.025	0.025	0.025	0.025	0.026	0.026	0.033	0.031	0.031	0.031	0.030	0.028
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.140	0.154	0.157	0.160	0.166	0.173	0.395	0.433	0.444	0.452	0.470	0.488
std	0.026	0.026	0.026	0.026	0.025	0.025	0.034	0.030	0.028	0.027	0.024	0.021
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.129	0.137	0.140	0.143	0.150	0.159	0.363	0.385	0.394	0.402	0.423	0.449
std	0.024	0.024	0.024	0.024	0.025	0.025	0.032	0.030	0.030	0.030	0.028	0.025
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.136	0.151	0.156	0.160	0.170	0.179	0.383	0.425	0.440	0.452	0.480	0.507
std	0.025	0.026	0.026	0.026	0.025	0.024	0.032	0.030	0.029	0.027	0.022	0.016
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.146	0.160	0.163	0.166	0.171	0.176	0.410	0.451	0.461	0.468	0.484	0.499
std	0.025	0.025	0.025	0.025	0.024	0.024	0.031	0.025	0.024	0.022	0.019	0.017

Table EC.10 Performance of algorithms on eBay-3 dataset with $K = 60$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.208	0.208	0.208	0.208	0.208	0.208	0.658	0.659	0.659	0.659	0.659	0.659
std	0.021	0.020	0.020	0.020	0.020	0.020	0.019	0.018	0.018	0.018	0.018	0.018
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.207	0.207	0.207	0.206	0.207	0.207	0.654	0.655	0.655	0.655	0.655	0.655
std	0.021	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.019	0.019	0.020	0.020
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.202	0.205	0.205	0.205	0.205	0.205	0.638	0.649	0.650	0.650	0.651	0.651
std	0.021	0.020	0.020	0.020	0.020	0.020	0.019	0.018	0.018	0.018	0.018	0.018
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.154	0.171	0.175	0.178	0.185	0.191	0.487	0.541	0.555	0.565	0.587	0.606
std	0.021	0.020	0.020	0.020	0.020	0.020	0.031	0.024	0.023	0.022	0.021	0.020
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.158	0.176	0.181	0.184	0.190	0.195	0.500	0.558	0.572	0.581	0.602	0.618
std	0.021	0.020	0.020	0.020	0.020	0.020	0.031	0.024	0.023	0.022	0.021	0.020
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.146	0.152	0.155	0.157	0.162	0.168	0.461	0.482	0.490	0.496	0.512	0.531
std	0.021	0.020	0.020	0.020	0.020	0.020	0.033	0.029	0.028	0.027	0.027	0.026
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.151	0.163	0.167	0.170	0.177	0.184	0.478	0.517	0.530	0.539	0.561	0.583
std	0.021	0.021	0.021	0.021	0.021	0.020	0.032	0.027	0.027	0.026	0.024	0.022
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.141	0.147	0.150	0.152	0.160	0.169	0.446	0.465	0.474	0.482	0.505	0.533
std	0.020	0.019	0.019	0.019	0.020	0.020	0.032	0.028	0.027	0.027	0.026	0.024
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.147	0.161	0.166	0.170	0.181	0.191	0.465	0.508	0.525	0.538	0.573	0.606
std	0.020	0.020	0.021	0.021	0.020	0.020	0.030	0.028	0.027	0.026	0.023	0.020
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.155	0.168	0.172	0.175	0.181	0.187	0.490	0.533	0.545	0.554	0.574	0.593
std	0.021	0.020	0.020	0.020	0.020	0.020	0.030	0.024	0.023	0.022	0.021	0.020

Table EC.11 Performance of algorithms on eBay-4 dataset with $K = 60$.

BFPH												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.203	0.202	0.202	0.202	0.202	0.202	0.602	0.601	0.602	0.602	0.602	0.602
std	0.019	0.018	0.019	0.019	0.018	0.019	0.012	0.011	0.011	0.011	0.011	0.011
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.191	0.190	0.190	0.190	0.190	0.190	0.567	0.566	0.567	0.567	0.567	0.567
std	0.020	0.020	0.020	0.020	0.020	0.020	0.018	0.017	0.017	0.017	0.017	0.017
BMAB-SPAR												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.192	0.194	0.194	0.195	0.195	0.195	0.570	0.578	0.579	0.580	0.580	0.580
std	0.019	0.019	0.019	0.019	0.019	0.019	0.014	0.012	0.012	0.013	0.013	0.013
TS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.148	0.164	0.169	0.172	0.178	0.183	0.439	0.489	0.502	0.511	0.530	0.546
std	0.020	0.020	0.020	0.020	0.019	0.019	0.026	0.020	0.019	0.018	0.016	0.014
MOSSA												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.152	0.169	0.173	0.176	0.182	0.188	0.451	0.502	0.515	0.524	0.543	0.559
std	0.020	0.020	0.020	0.020	0.019	0.019	0.027	0.019	0.018	0.017	0.015	0.013
UCB1												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.139	0.146	0.149	0.151	0.156	0.162	0.413	0.435	0.442	0.448	0.464	0.481
std	0.019	0.020	0.020	0.020	0.020	0.020	0.026	0.025	0.025	0.025	0.024	0.022
UCB2												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.146	0.157	0.161	0.164	0.171	0.177	0.432	0.468	0.479	0.487	0.507	0.526
std	0.020	0.020	0.021	0.021	0.020	0.020	0.027	0.023	0.023	0.022	0.019	0.017
UCB-V												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.136	0.141	0.144	0.147	0.154	0.162	0.402	0.420	0.428	0.436	0.457	0.483
std	0.019	0.019	0.019	0.019	0.020	0.020	0.026	0.024	0.024	0.024	0.022	0.020
OCUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.141	0.155	0.160	0.164	0.174	0.183	0.418	0.460	0.475	0.487	0.518	0.546
std	0.019	0.020	0.021	0.021	0.020	0.019	0.026	0.024	0.023	0.022	0.018	0.014
KL-UCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	1000	5000	7500	10000	20000	40000	1000	5000	7500	10000	20000	40000
mean	0.149	0.163	0.167	0.169	0.175	0.180	0.443	0.484	0.496	0.503	0.521	0.536
std	0.020	0.020	0.020	0.020	0.019	0.019	0.027	0.020	0.019	0.018	0.016	0.014

EC.6. Additional results for Section 7

In this section we present tables that show the performance of the algorithms discussed in Section 7 of the main text.

Table EC.12 Performance of algorithms for set A1.

BMAB-SPAR-NS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.081	0.080	0.071	0.064	0.058	0.055	0.548	0.535	0.521	0.528	0.520	0.519
std	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.001	0.001	0.001
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.078	0.078	0.069	0.062	0.056	0.054	0.528	0.518	0.505	0.513	0.506	0.506
std	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.001	0.001	0.001
EXP3-BGZ												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.081	0.081	0.071	0.063	0.058	0.055	0.549	0.538	0.521	0.526	0.518	0.516
std	0.001	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.002	0.002	0.002	0.002
EXP3-S												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.080	0.080	0.070	0.062	0.057	0.054	0.542	0.530	0.513	0.516	0.508	0.505
std	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.001	0.001	0.001
EXP3-P												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.080	0.079	0.069	0.060	0.055	0.052	0.538	0.524	0.505	0.502	0.492	0.487
std	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.001	0.001	0.001
SHIFTBAND												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.080	0.079	0.069	0.060	0.055	0.051	0.538	0.524	0.504	0.499	0.489	0.484
std	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.001	0.001	0.001
MUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.080	0.079	0.069	0.061	0.055	0.052	0.541	0.527	0.508	0.505	0.496	0.491
std	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.001	0.001	0.001	0.001	0.001

Table EC.13 Performance of algorithms for set A2.

BMAB-SPAR-NS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.033	0.041	0.054	0.061	0.062	0.064	0.495	0.538	0.547	0.538	0.528	0.526
std	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.001	0.001	0.001	0.001
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.032	0.039	0.053	0.059	0.060	0.062	0.481	0.524	0.535	0.525	0.515	0.512
std	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.002	0.001	0.001	0.001
EXP3-BGZ												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.029	0.038	0.053	0.060	0.062	0.064	0.437	0.509	0.535	0.530	0.524	0.524
std	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.003	0.002	0.002	0.001	0.001
EXP3-S												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.027	0.036	0.051	0.059	0.061	0.063	0.406	0.479	0.519	0.520	0.515	0.515
std	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.002	0.001	0.001	0.001
EXP3-P												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.026	0.034	0.049	0.057	0.058	0.061	0.391	0.451	0.493	0.500	0.497	0.499
std	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.001	0.001	0.001
SHIFTBAND												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.026	0.034	0.048	0.056	0.058	0.060	0.390	0.446	0.488	0.496	0.494	0.496
std	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.001	0.001	0.001
MUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.026	0.035	0.049	0.057	0.059	0.061	0.401	0.461	0.499	0.505	0.502	0.504
std	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.002	0.001	0.001	0.001

Table EC.14 Performance of algorithms for set B1.

BMAB-SPAR-NS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.012	0.011	0.012	0.013	0.014	0.419	0.391	0.351	0.352	0.369	0.372
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.002	0.002	0.001	0.001
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.012	0.011	0.012	0.013	0.013	0.411	0.380	0.338	0.340	0.358	0.361
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.002	0.002	0.001	0.001
EXP3-BGZ												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.014	0.012	0.011	0.012	0.013	0.014	0.393	0.369	0.343	0.348	0.363	0.366
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.002	0.002	0.002	0.002
EXP3-S												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.014	0.012	0.011	0.012	0.013	0.013	0.391	0.364	0.338	0.343	0.355	0.358
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.001	0.001
EXP3-P												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.014	0.011	0.011	0.012	0.013	0.013	0.390	0.362	0.336	0.341	0.352	0.355
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.001	0.001
SHIFTBAND												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.014	0.011	0.011	0.012	0.013	0.013	0.390	0.362	0.336	0.341	0.352	0.355
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.001	0.001
MUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.014	0.011	0.011	0.012	0.013	0.013	0.391	0.363	0.337	0.342	0.353	0.356
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.001	0.001

Table EC.15 Performance of algorithms for set B2.

BMAB-SPAR-NS												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.016	0.016	0.016	0.015	0.015	0.015	0.411	0.412	0.404	0.394	0.387	0.386
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.002	0.002
RPZB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.015	0.015	0.015	0.014	0.014	0.404	0.404	0.396	0.383	0.375	0.374
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.002	0.001
EXP3-BGZ												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.015	0.015	0.015	0.015	0.014	0.387	0.392	0.390	0.386	0.383	0.382
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.003	0.002	0.002	0.002
EXP3-S												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.015	0.015	0.015	0.014	0.014	0.385	0.389	0.384	0.380	0.376	0.375
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.002	0.001
EXP3-P												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.015	0.015	0.015	0.014	0.014	0.385	0.387	0.382	0.378	0.374	0.373
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.002	0.001
SHIFTBAND												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.015	0.015	0.015	0.014	0.014	0.385	0.387	0.381	0.378	0.374	0.372
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.002	0.001
MUCB												
	Average Cumulative Return (ACR)						Revenue Rate (RR)					
horizon	40000	100000	200000	300000	400000	450000	40000	100000	200000	300000	400000	450000
mean	0.015	0.015	0.015	0.015	0.014	0.014	0.385	0.388	0.382	0.379	0.375	0.373
std	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.002	0.002	0.002	0.001