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# BENCHTEMP: A General Benchmark for Evaluating Temporal Graph Neural Networks

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## Authors' Response to Reviewer hWRt - Second Round

### Opportunities For Improvement:

One concern is that the eBay datasets (which is also the only datasets with node labels of the new ones added) is not shared publicly yet. The authors mentioned that it can only be shared with collaborators. I wonder if there is any plans to make the dataset public in the future. I understand that there might be delays or difficulties in sharing datasets, however as this is a part of the contribution, it would be important for the general public to have access to and benchmark on the eBay datasets.

For W1, novel datasets and the average rank are indeed interesting. However, it remains concerning that methods such as NAT and NeurTW already achieved 90%+ or even 95%+ AUC and AP performance on many of these datasets for both transductive and inductive settings thus leaving little room for improvement for future methods. Are the authors suggesting average rank should be the metric to rank these methods in terms of performance? There should also be more discussion regarding average rank in the main paper in this case. Regardless, I believe better evaluation setup and or metric is still needed. But might be left to future future. The authors have adequately addressed my other concerns.

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### 2 General Response:

3 Dear Reviewer hWRt:

4 We sincerely appreciate your feedback and valuable comments!

5 We have carefully thought through your concerns about the open source of the eBay datasets  
6 and the over-optimistic evaluation on many of datasets.

7 After a discussion with our industrial partner eBay, we are working on sharing the **eBay-Small**  
8 and **eBay-Large** datasets in a way that ensures availability and justifies the research purpose:

- 9 1. We will build a website that describes the eBay datasets and provides an application form.
- 10 2. The applicants input their email and affiliation in the form, and agree to the access terms (similar  
11 to ImageNet).
- 12 3. The backend will check the applicant's information and send a download link to the corresponding  
13 email.

14 In the meantime, eBay provide a Google form for the applicants to obtain the eBay datasets:  
15 <https://forms.gle/bP1RmyVJ1C6pgyS66> (**the applicants can remain anonymous**).

16 *Average Rank* metric has been widely used in the SOTA benchmarks and should be the metric  
17 to rank these methods in terms of performance. we will add *Average Rank* into the main paper.

18 As for NAT and NeurTW can achieved 90%+ or even 95%+ AUC and AP performance on many  
19 of these datasets, we have found that BenchTeMP with a *Historical Negative Sampling* or *Inductive*  
20 *Negative Sampling* strategy can addressed this issue. We have conducted experiments of NAT on  
Submitted to the 37th Conference on Neural Information Processing Systems (NeurIPS 2023) Track on Datasets  
and Benchmarks. Do not distribute.

21 those over-performance datasets with *Historical Negative Sampling* and *Inductive Negative Sampling*.  
22 The experimental results demonstrated the effectiveness of textitHistorical Negative Sampling and  
23 *Inductive Negative Sampling*.

24 Thank you and best regards!

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26 Yours sincerely,

27 Qiang Huang, Jiawei Jiang, Xi Susie Rao, Ce Zhang, Zhichao Han, Zitao Zhang, Xin Wang,  
28 Quanqing Xu, Yang Zhao, Chuang Hu, Shuo Shang, Yongjun He, Bo Du

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32 **We provide our response to each individual comment below:**

#### Comment 1

**W1.** One concern is that the eBay datasets (which is also the only datasets with node labels of the new ones added) is not shared publicly yet. The authors mentioned that it can only be shared with collaborators. I wonder if there is any plans to make the dataset public in the future. I understand that there might be delays or difficulties in sharing datasets, however as this is a part of the contribution, it would be important for the general public to have access to and benchmark on the eBay datasets.

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#### 34 **Response:**

35 We thank the reviewer for the suggestions! After a discussion with our industrial partner eBay, we  
36 are working on sharing the **eBay-Small** and **eBay-Large** datasets in a way that ensures availability  
37 and justifies the research purpose:

- 38 1. We will build a website that describes the eBay datasets and provides an application form.
- 39 2. The applicants input their email and affiliation in the form, and agree to the access terms (similar  
40 to ImageNet).
- 41 3. The backend will check the applicant's information and send a download link to the corresponding  
42 email.

43 Note that, many large-scale datasets also adopt this routine, e.g., YFCC100M from Yahoo (<http://www.multimediacommons.org/>) and ImageNet (<https://www.image-net.org/download.php>). We hope this solution can address the reviewer's concern. We will optimize this procedure  
44 according to the reviewer's further suggestions.

45 In the meantime, eBay provide a Google form for the applicants to obtain the eBay datasets:  
46 <https://forms.gle/bP1RmyVJ1C6pgyS66> (**the applicants can remain anonymous**).

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## Comment 2

**W2.** For W1, novel datasets and the average rank are indeed interesting. However, it remains concerning that methods such as NAT and NeurTW already achieved 90%+ or even 95%+ AUC and AP performance on many of these datasets for both transductive and inductive settings thus leaving little room for improvement for future methods. Are the authors suggesting average rank should be the metric to rank these methods in terms of performance? There should also be more discussion regarding average rank in the main paper in this case.

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## 52 **Response:**

### 53 **1. Average Rank**

54 We appreciate your valuable suggestion! *Average Rank* metric has been widely used in the SOTA  
55 models and benchmarks and should be the metric to rank these methods in terms of performance.

56 We have computed the *Average Rank* metric of the Table 3 and Table 5 in the main paper (<https://openreview.net/pdf?id=rnZm2vQq31>), as shown in the tables below.  
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Table 1: ROC AUC results on the link prediction task. "\*" denotes that the model encounters runtime error; "—" denotes timeout after 48 hours. The best and second-best results are highlighted as **bold red** and underlined blue. Some standard deviations are zero because we terminate those models that can only run one epoch within 2 days. We do not highlight the second-best if the gap is  $> 0.05$  compared with the best result.

| Dataset             | Model | Transductive        |                                       |                                       |                     |                                       |                                       |                                       |
|---------------------|-------|---------------------|---------------------------------------|---------------------------------------|---------------------|---------------------------------------|---------------------------------------|---------------------------------------|
|                     |       | JODIE               | DyRep                                 | TGN                                   | TGAT                | CAWN                                  | NeurTW                                | NAT                                   |
| Reddit              |       | 0.9760 $\pm$ 0.0006 | 0.9803 $\pm$ 0.0005                   | <u>0.9871 <math>\pm</math> 0.0001</u> | 0.981 $\pm$ 0.0002  | <b>0.9889 <math>\pm</math> 0.0002</b> | 0.9841 $\pm$ 0.0016                   | 0.9854 $\pm$ 0.002                    |
| Wikipedia           |       | 0.9505 $\pm$ 0.0032 | 0.9426 $\pm$ 0.0007                   | 0.9846 $\pm$ 0.0003                   | 0.9509 $\pm$ 0.0017 | <u>0.9889 <math>\pm</math> 0.0</u>    | <b>0.9912 <math>\pm</math> 0.0001</b> | 0.9786 $\pm$ 0.0035                   |
| MOOC                |       | 0.7899 $\pm$ 0.0208 | 0.8243 $\pm$ 0.0323                   | <u>0.8999 <math>\pm</math> 0.0213</u> | 0.7391 $\pm$ 0.0056 | <b>0.9459 <math>\pm</math> 0.0008</b> | 0.8071 $\pm$ 0.0193                   | 0.7568 $\pm$ 0.0305                   |
| LastFM              |       | 0.6766 $\pm$ 0.0590 | 0.6793 $\pm$ 0.0553                   | 0.7743 $\pm$ 0.0256                   | 0.5094 $\pm$ 0.0071 | <b>0.8746 <math>\pm</math> 0.0013</b> | 0.839 $\pm$ 0.0                       | <u>0.8536 <math>\pm</math> 0.0027</u> |
| Enron               |       | 0.8293 $\pm$ 0.0148 | 0.7986 $\pm$ 0.0358                   | 0.8621 $\pm$ 0.0173                   | 0.6161 $\pm$ 0.0214 | <u>0.9159 <math>\pm</math> 0.0032</u> | 0.8956 $\pm$ 0.0045                   | <b>0.9212 <math>\pm</math> 0.0029</b> |
| SocialEvo           |       | 0.8666 $\pm$ 0.0233 | 0.9020 $\pm$ 0.0026                   | <b>0.952 <math>\pm</math> 0.0003</b>  | 0.7851 $\pm$ 0.0047 | <u>0.9337 <math>\pm</math> 0.0003</u> | —                                     | 0.9202 $\pm$ 0.0065                   |
| UCI                 |       | 0.8786 $\pm$ 0.0017 | 0.5086 $\pm$ 0.0651                   | 0.8875 $\pm$ 0.0161                   | 0.7998 $\pm$ 0.0052 | <u>0.9189 <math>\pm</math> 0.0017</u> | <b>0.9670 <math>\pm</math> 0.0031</b> | 0.9076 $\pm$ 0.0116                   |
| CollegeMsg          |       | 0.5730 $\pm$ 0.0690 | 0.5382 $\pm$ 0.0058                   | 0.8419 $\pm$ 0.0084                   | 0.8084 $\pm$ 0.0032 | 0.9156 $\pm$ 0.004                    | <b>0.9698 <math>\pm</math> 0.0</b>    | 0.9059 $\pm$ 0.0122                   |
| CanParl             |       | 0.7939 $\pm$ 0.0063 | 0.7737 $\pm$ 0.0255                   | 0.7575 $\pm$ 0.0694                   | 0.7077 $\pm$ 0.0218 | 0.7197 $\pm$ 0.0905                   | <b>0.8920 <math>\pm</math> 0.0173</b> | 0.6917 $\pm$ 0.0722                   |
| Contact             |       | 0.9379 $\pm$ 0.0073 | 0.9276 $\pm$ 0.0206                   | <u>0.9769 <math>\pm</math> 0.0032</u> | 0.5582 $\pm$ 0.009  | 0.9685 $\pm$ 0.0028                   | <b>0.984 <math>\pm</math> 0.0</b>     | 0.9463 $\pm$ 0.021                    |
| Flights             |       | 0.9449 $\pm$ 0.0073 | 0.8981 $\pm$ 0.0056                   | <u>0.9787 <math>\pm</math> 0.0025</u> | 0.9016 $\pm$ 0.0027 | <b>0.9861 <math>\pm</math> 0.0002</b> | 0.9302 $\pm$ 0.0                      | 0.9747 $\pm$ 0.0061                   |
| UNTrade             |       | 0.6786 $\pm$ 0.0103 | 0.6377 $\pm$ 0.0032                   | 0.6543 $\pm$ 0.01                     | *                   | <u>0.7511 <math>\pm</math> 0.0012</u> | 0.5924 $\pm$ 0.0368                   | <b>0.783 <math>\pm</math> 0.0472</b>  |
| USLegis             |       | 0.8278 $\pm$ 0.0024 | 0.7425 $\pm$ 0.0374                   | 0.8137 $\pm$ 0.002                    | 0.7738 $\pm$ 0.0062 | <u>0.9643 <math>\pm</math> 0.0043</u> | <b>0.9715 <math>\pm</math> 0.0009</b> | 0.782 $\pm$ 0.0261                    |
| UNVote              |       | 0.6523 $\pm$ 0.0082 | 0.6236 $\pm$ 0.0305                   | <b>0.7176 <math>\pm</math> 0.0109</b> | 0.5134 $\pm$ 0.0026 | 0.6037 $\pm$ 0.0019                   | 0.5871 $\pm$ 0.0                      | <u>0.6776 <math>\pm</math> 0.0411</u> |
| Taobao              |       | 0.8405 $\pm$ 0.0006 | 0.8409 $\pm$ 0.0012                   | 0.8654 $\pm$ 0.0005                   | 0.5396 $\pm$ 0.009  | 0.7708 $\pm$ 0.0026                   | <u>0.8759 <math>\pm</math> 0.0009</u> | <b>0.8937 <math>\pm</math> 0.0015</b> |
| <b>Average Rank</b> |       | 4.47                | 5.07                                  | <u>2.8</u>                            | 6                   | <b>2.47</b>                           | 2.87                                  | 3                                     |
| Dataset             | Model | Inductive           |                                       |                                       |                     |                                       |                                       |                                       |
|                     |       | JODIE               | DyRep                                 | TGN                                   | TGAT                | CAWN                                  | NeurTW                                | NAT                                   |
| Reddit              |       | 0.9514 $\pm$ 0.0045 | 0.9583 $\pm$ 0.0004                   | 0.976 $\pm$ 0.0002                    | 0.9651 $\pm$ 0.0002 | <u>0.9868 <math>\pm</math> 0.0002</u> | 0.9802 $\pm$ 0.0011                   | <b>0.9906 <math>\pm</math> 0.0034</b> |
| Wikipedia           |       | 0.9305 $\pm$ 0.0020 | 0.9099 $\pm$ 0.0031                   | 0.9781 $\pm$ 0.0005                   | 0.9343 $\pm$ 0.0031 | 0.989 $\pm$ 0.0003                    | <u>0.9904 <math>\pm</math> 0.0002</u> | <b>0.9962 <math>\pm</math> 0.0026</b> |
| MOOC                |       | 0.7779 $\pm$ 0.0575 | 0.8269 $\pm$ 0.0182                   | 0.8869 $\pm$ 0.0249                   | 0.737 $\pm$ 0.006   | <b>0.9481 <math>\pm</math> 0.0006</b> | 0.8045 $\pm$ 0.0224                   | 0.7325 $\pm$ 0.0433                   |
| LastFM              |       | 0.8011 $\pm$ 0.0344 | 0.7990 $\pm$ 0.0444                   | 0.8284 $\pm$ 0.0142                   | 0.5196 $\pm$ 0.0144 | <u>0.9082 <math>\pm</math> 0.0015</u> | 0.884 $\pm$ 0.0                       | <b>0.9139 <math>\pm</math> 0.0038</b> |
| Enron               |       | 0.8038 $\pm$ 0.0223 | 0.7120 $\pm$ 0.0600                   | 0.8159 $\pm$ 0.0231                   | 0.5529 $\pm$ 0.015  | <u>0.9162 <math>\pm</math> 0.0016</u> | 0.9051 $\pm$ 0.0027                   | <b>0.952 <math>\pm</math> 0.0057</b>  |
| SocialEvo           |       | 0.8963 $\pm$ 0.0228 | 0.9158 $\pm$ 0.0039                   | <u>0.9244 <math>\pm</math> 0.0084</u> | 0.6748 $\pm$ 0.0021 | <b>0.9298 <math>\pm</math> 0.0002</b> | —                                     | 0.896 $\pm$ 0.0164                    |
| UCI                 |       | 0.7517 $\pm$ 0.0059 | 0.4297 $\pm$ 0.0428                   | 0.8083 $\pm$ 0.0237                   | 0.7024 $\pm$ 0.0048 | 0.9177 $\pm$ 0.0015                   | <b>0.9686 <math>\pm</math> 0.0031</b> | <u>0.9622 <math>\pm</math> 0.0167</u> |
| CollegeMsg          |       | 0.5097 $\pm$ 0.0306 | 0.4838 $\pm$ 0.0116                   | 0.777 $\pm$ 0.0522                    | 0.715 $\pm$ 0.0007  | 0.9163 $\pm$ 0.0038                   | <b>0.9726 <math>\pm</math> 0.0002</b> | <u>0.9603 <math>\pm</math> 0.0173</u> |
| CanParl             |       | 0.5012 $\pm$ 0.0155 | 0.5532 $\pm$ 0.0088                   | 0.5727 $\pm$ 0.0268                   | 0.5802 $\pm$ 0.0069 | 0.7154 $\pm$ 0.0967                   | <b>0.8871 <math>\pm</math> 0.0139</b> | 0.6214 $\pm$ 0.0734                   |
| Contact             |       | 0.9358 $\pm$ 0.0025 | 0.8650 $\pm$ 0.0431                   | 0.952 $\pm$ 0.0056                    | 0.5571 $\pm$ 0.0047 | <u>0.9691 <math>\pm</math> 0.0031</u> | <b>0.9842 <math>\pm</math> 0.0</b>    | 0.9466 $\pm$ 0.0127                   |
| Flights             |       | 0.9218 $\pm$ 0.0094 | 0.8689 $\pm$ 0.0128                   | 0.9519 $\pm$ 0.0043                   | 0.8321 $\pm$ 0.0041 | <b>0.9834 <math>\pm</math> 0.0001</b> | 0.9158 $\pm$ 0.0                      | <u>0.9827 <math>\pm</math> 0.003</u>  |
| UNTrade             |       | 0.6727 $\pm$ 0.0132 | 0.6467 $\pm$ 0.0112                   | 0.5977 $\pm$ 0.014                    | *                   | <b>0.7398 <math>\pm</math> 0.0007</b> | 0.5915 $\pm$ 0.0328                   | 0.6475 $\pm$ 0.0664                   |
| USLegis             |       | 0.5840 $\pm$ 0.0129 | 0.5980 $\pm$ 0.0097                   | 0.6128 $\pm$ 0.0046                   | 0.5568 $\pm$ 0.0078 | <u>0.9665 <math>\pm</math> 0.0032</u> | <b>0.9708 <math>\pm</math> 0.0009</b> | 0.7453 $\pm$ 0.0286                   |
| UNVote              |       | 0.5121 $\pm$ 0.0005 | 0.4993 $\pm$ 0.0103                   | 0.5881 $\pm$ 0.0118                   | 0.477 $\pm$ 0.0047  | 0.5911 $\pm$ 0.0006                   | 0.586 $\pm$ 0.0                       | <b>0.779 <math>\pm</math> 0.0082</b>  |
| Taobao              |       | 0.701 $\pm$ 0.0013  | 0.7026 $\pm$ 0.0006                   | 0.7017 $\pm$ 0.0026                   | 0.5261 $\pm$ 0.0119 | 0.7737 $\pm$ 0.0027                   | 0.8843 $\pm$ 0.0016                   | <b>0.9992 <math>\pm</math> 0.0002</b> |
| <b>Average Rank</b> |       | 4.93                | 5.4                                   | 3.6                                   | 6.2                 | <b>2</b>                              | 2.67                                  | <u>2.2</u>                            |
| Dataset             | Model | Inductive New-Old   |                                       |                                       |                     |                                       |                                       |                                       |
|                     |       | JODIE               | DyRep                                 | TGN                                   | TGAT                | CAWN                                  | NeurTW                                | NAT                                   |
| Reddit              |       | 0.9488 $\pm$ 0.0043 | 0.9549 $\pm$ 0.0029                   | 0.9742 $\pm$ 0.0004                   | 0.9639 $\pm$ 0.0004 | <u>0.9848 <math>\pm</math> 0.0002</u> | 0.9789 $\pm$ 0.0017                   | <b>0.9949 <math>\pm</math> 0.0017</b> |
| Wikipedia           |       | 0.9084 $\pm$ 0.0043 | 0.8821 $\pm$ 0.0031                   | 0.9703 $\pm$ 0.0008                   | 0.9178 $\pm$ 0.0023 | <u>0.9886 <math>\pm</math> 0.0002</u> | 0.9878 $\pm$ 0.0002                   | <b>0.9963 <math>\pm</math> 0.0021</b> |
| MOOC                |       | 0.7910 $\pm$ 0.0475 | 0.8274 $\pm$ 0.0132                   | 0.8808 $\pm$ 0.0326                   | 0.7438 $\pm$ 0.0063 | <b>0.949 <math>\pm</math> 0.0016</b>  | 0.8052 $\pm$ 0.0244                   | 0.7487 $\pm$ 0.0459                   |
| LastFM              |       | 0.7305 $\pm$ 0.0051 | 0.6980 $\pm$ 0.0364                   | 0.763 $\pm$ 0.0231                    | 0.5189 $\pm$ 0.003  | <u>0.8678 <math>\pm</math> 0.0030</u> | 0.8311 $\pm$ 0.0                      | <b>0.9144 <math>\pm</math> 0.0013</b> |
| Enron               |       | 0.7859 $\pm$ 0.0134 | 0.6915 $\pm$ 0.0650                   | 0.8100 $\pm$ 0.0204                   | 0.5589 $\pm$ 0.0235 | <u>0.9185 <math>\pm</math> 0.003</u>  | 0.9007 $\pm$ 0.0039                   | <b>0.9491 <math>\pm</math> 0.0079</b> |
| SocialEvo           |       | 0.8953 $\pm$ 0.0303 | <u>0.9182 <math>\pm</math> 0.0050</u> | <b>0.9257 <math>\pm</math> 0.0086</b> | 0.684 $\pm$ 0.0034  | 0.9155 $\pm$ 0.0002                   | —                                     | 0.8793 $\pm$ 0.0318                   |
| UCI                 |       | 0.7139 $\pm$ 0.0112 | 0.4259 $\pm$ 0.0397                   | 0.8015 $\pm$ 0.0269                   | 0.6842 $\pm$ 0.0078 | 0.9176 $\pm$ 0.0028                   | <u>0.9696 <math>\pm</math> 0.0039</u> | <b>0.9748 <math>\pm</math> 0.0163</b> |
| CollegeMsg          |       | 0.5168 $\pm$ 0.0360 | 0.4808 $\pm$ 0.0279                   | 0.7725 $\pm$ 0.0365                   | 0.7012 $\pm$ 0.005  | 0.9166 $\pm$ 0.0032                   | <u>0.968 <math>\pm</math> 0.0018</u>  | <b>0.9725 <math>\pm</math> 0.0189</b> |
| CanParl             |       | 0.5078 $\pm$ 0.0005 | 0.5393 $\pm$ 0.0204                   | 0.5691 $\pm$ 0.0223                   | 0.5724 $\pm$ 0.0063 | 0.7231 $\pm$ 0.085                    | <b>0.8847 <math>\pm</math> 0.0102</b> | 0.6277 $\pm$ 0.0811                   |
| Contact             |       | 0.9345 $\pm$ 0.0027 | 0.8574 $\pm$ 0.0454                   | 0.9527 $\pm$ 0.0052                   | 0.556 $\pm$ 0.0039  | <u>0.9691 <math>\pm</math> 0.0028</u> | <b>0.9841 <math>\pm</math> 0.0</b>    | 0.9351 $\pm$ 0.0202                   |
| Flights             |       | 0.9172 $\pm$ 0.0114 | 0.8650 $\pm$ 0.0126                   | 0.9503 $\pm$ 0.0043                   | 0.8285 $\pm$ 0.0038 | <u>0.9828 <math>\pm</math> 0.0002</u> | 0.9127 $\pm$ 0.0                      | <b>0.986 <math>\pm</math> 0.0034</b>  |
| UNTrade             |       | 0.6650 $\pm$ 0.0106 | 0.6306 $\pm$ 0.0139                   | 0.5959 $\pm$ 0.0171                   | *                   | <b>0.7413 <math>\pm</math> 0.001</b>  | 0.5965 $\pm$ 0.0371                   | 0.5812 $\pm$ 0.0957                   |
| USLegis             |       | 0.5801 $\pm$ 0.0213 | 0.5673 $\pm$ 0.0098                   | 0.5741 $\pm$ 0.0148                   | 0.5596 $\pm$ 0.0092 | <u>0.9672 <math>\pm</math> 0.0029</u> | <b>0.9682 <math>\pm</math> 0.0018</b> | 0.531 $\pm$ 0.1                       |
| UNVote              |       | 0.5208 $\pm$ 0.0075 | 0.5023 $\pm$ 0.0204                   | 0.5889 $\pm$ 0.0106                   | 0.4787 $\pm$ 0.0033 | 0.5933 $\pm$ 0.0007                   | 0.5878 $\pm$ 0.0                      | <b>0.7789 <math>\pm</math> 0.0192</b> |
| Taobao              |       | 0.6988 $\pm$ 0.0024 | 0.6992 $\pm$ 0.0001                   | 0.7025 $\pm$ 0.0038                   | 0.5266 $\pm$ 0.0239 | 0.7574 $\pm$ 0.0032                   | 0.8617 $\pm$ 0.0032                   | <b>0.9997 <math>\pm</math> 0.0001</b> |
| <b>Average Rank</b> |       | 4.87                | 5.4                                   | 3.47                                  | 6.13                | <b>1.93</b>                           | 2.8                                   | <u>2.67</u>                           |
| Dataset             | Model | Inductive New-New   |                                       |                                       |                     |                                       |                                       |                                       |
|                     |       | JODIE               | DyRep                                 | TGN                                   | TGAT                | CAWN                                  | NeurTW                                | NAT                                   |
| Reddit              |       | 0.9381 $\pm$ 0.0090 | 0.9525 $\pm$ 0.0050                   | 0.9811 $\pm$ 0.0004                   | 0.9597 $\pm$ 0.0043 | <u>0.9952 <math>\pm</math> 0.0016</u> | 0.9875 $\pm$ 0.0004                   | <b>0.9954 <math>\pm</math> 0.0011</b> |
| Wikipedia           |       | 0.9349 $\pm$ 0.0051 | 0.9261 $\pm$ 0.0030                   | 0.9858 $\pm$ 0.0007                   | 0.958 $\pm$ 0.0039  | 0.9934 $\pm$ 0.0005                   | <u>0.996 <math>\pm</math> 0.0001</u>  | <b>0.9984 <math>\pm</math> 0.0008</b> |
| MOOC                |       | 0.7065 $\pm$ 0.0165 | 0.7217 $\pm$ 0.0178                   | 0.8762 $\pm$ 0.0038                   | 0.7403 $\pm$ 0.0057 | <b>0.9422 <math>\pm</math> 0.0003</b> | 0.8048 $\pm$ 0.0087                   | 0.6562 $\pm$ 0.0287                   |
| LastFM              |       | 0.8852 $\pm$ 0.0090 | 0.8683 $\pm$ 0.0160                   | 0.8754 $\pm$ 0.0011                   | 0.5092 $\pm$ 0.0333 | <u>0.9697 <math>\pm</math> 0.0002</u> | 0.9628 $\pm$ 0.0                      | <b>0.9743 <math>\pm</math> 0.0015</b> |
| Enron               |       | 0.6800 $\pm$ 0.0017 | 0.6571 $\pm$ 0.0521                   | 0.7644 $\pm$ 0.0179                   | 0.531 $\pm$ 0.0179  | <u>0.9609 <math>\pm</math> 0.0051</u> | 0.9387 $\pm$ 0.0001                   | <b>0.9687 <math>\pm</math> 0.0051</b> |
| SocialEvo           |       | 0.6484 $\pm$ 0.0491 | 0.7740 $\pm$ 0.0215                   | 0.8791 $\pm$ 0.0045                   | 0.4659 $\pm$ 0.0068 | <b>0.9318 <math>\pm</math> 0.0003</b> | —                                     | <u>0.9275 <math>\pm</math> 0.0471</u> |
| UCI                 |       | 0.6393 $\pm$ 0.0158 | 0.4771 $\pm$ 0.0100                   | 0.8051 $\pm$ 0.021                    | 0.768 $\pm$ 0.0041  | 0.9245 $\pm$ 0.0027                   | <b>0.9716 <math>\pm</math> 0.0016</b> | <u>0.9472 <math>\pm</math> 0.0262</u> |
| CollegeMsg          |       | 0.5320 $\pm$ 0.0269 | 0.5269 $\pm$ 0.0049                   | 0.7969 $\pm$ 0.0111                   | 0.7832 $\pm$ 0.0026 | 0.9304 $\pm$ 0.0024                   | <b>0.9762 <math>\pm</math> 0.0008</b> | <u>0.9404 <math>\pm</math> 0.0371</u> |
| CanParl             |       | 0.4347 $\pm$ 0.0090 | 0.4430 $\pm$ 0.0068                   | 0.5625 $\pm$ 0.0396                   | 0.5955 $\pm$ 0.0074 | 0.7005 $\pm$ 0.1241                   | <b>0.8882 <math>\pm</math> 0.0045</b> | 0.5685 $\pm$ 0.0326                   |
| Contact             |       | 0.7531 $\pm$ 0.0059 | 0.6602 $\pm$ 0.0395                   | 0.9118 $\pm$ 0.0053                   | 0.5449 $\pm$ 0.0056 | <u>0.9652 <math>\pm</math> 0.0012</u> | <b>0.982 <math>\pm</math> 0.0</b>     | 0.9495 $\pm$ 0.0034                   |
| Flights             |       | 0.9303 $\pm$ 0.0083 | 0.8900 $\pm$ 0.0266                   | 0.9652 $\pm$ 0.0022                   | 0.857 $\pm$ 0.0056  | <u>0.9873 <math>\pm</math> 0.0009</u> | 0.9411 $\pm$ 0.0                      | <b>0.9905 <math>\pm</math> 0.0014</b> |
| UNTrade             |       | 0.5922 $\pm$ 0.0085 | 0.5362 $\pm$ 0.0147                   | 0.5068 $\pm$ 0.0061                   | *                   | <b>0.7458 <math>\pm</math> 0.0081</b> | 0.5938 $\pm$ 0.0600                   | 0.6876 $\pm$ 0.0177                   |
| USLegis             |       | 0.5390 $\pm$ 0.0075 | 0.5640 $\pm$ 0.0192                   | 0.5626 $\pm$ 0.0195                   | 0.5324 $\pm$ 0.0294 | <u>0.9738 <math>\pm</math> 0.0058</u> | <b>0.9787 <math>\pm</math> 0.0004</b> | 0.88                                  |

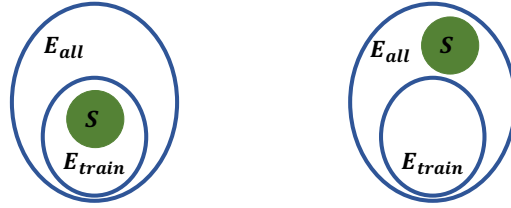
Table 2: ROC AUC results for the node classification task. The top-2 results are highlighted as **bold red** and underlined blue.

| Model \ Dataset | JODIE               | DyRep               | TGN                                   | TGAT                                  | CAWN                                  | NeurTW                                | NAT                 |
|-----------------|---------------------|---------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------|
| Reddit          | 0.6033 $\pm$ 0.0173 | 0.4988 $\pm$ 0.0066 | 0.6216 $\pm$ 0.007                    | <u>0.6252 <math>\pm</math> 0.0057</u> | <b>0.6502 <math>\pm</math> 0.0252</b> | 0.6054 $\pm$ 0.0352                   | 0.4746 $\pm$ 0.0207 |
| Wikipedia       | 0.8527 $\pm$ 0.002  | 0.8276 $\pm$ 0.008  | <b>0.8831 <math>\pm</math> 0.0009</b> | <u>0.8603 <math>\pm</math> 0.0051</u> | 0.8586 $\pm$ 0.0030                   | 0.8470 $\pm$ 0.0233                   | 0.5417 $\pm$ 0.0474 |
| MOOC            | 0.6774 $\pm$ 0.0066 | 0.6604 $\pm$ 0.0037 | 0.626 $\pm$ 0.0062                    | 0.6705 $\pm$ 0.005                    | <u>0.7271 <math>\pm</math> 0.0016</u> | <b>0.7719 <math>\pm</math> 0.0073</b> | 0.5175 $\pm$ 0.0143 |
| Average Rank    | 3.33                | 5.67                | 3                                     | <u>2.33</u>                           | <b>2</b>                              | 3.33                                  | 7                   |

We will update these *Average Rank* results into the main paper.

## 2. Negative Sampling

As for NAT and NeurTW can achieved 90%+ or even 95%+ AUC and AP performance on many of these datasets, we have found that BenchTeMP with *Historical Negative Sampling* and *Inductive Negative Sampling* can addressed this issue. [1].



(a) Historical Negative Sampling (b) Inductive Negative Sampling

Figure 1: *Historical Negative Sampling* and *Inductive Negative Sampling*.

Let  $E_{all}$ ,  $E_{train}$ ,  $S$  be the set of edges in dataset, the set of edges in train dataset, and the set of negative sampling edges, respectively. *Historical Negative Sampling* and *Inductive Negative Sampling* are illustrated in Figure 1.

- **Historical Negative Sampling.** Sampling negative edges from the set of edges that have been observed during previous timestamps but are absent in the current step.
- **Inductive Negative Sampling.** Sampling negative edges not observed during training.

We have conducted experiments of NAT on those over-performance datasets (Reddit, Wikipedia, Flights) with *Historical Negative Sampling* and *Inductive Negative Sampling*. Experimental results are shown in Table 3 and Table 4.

Table 3: ROC AUC results of NAT with *Historical Negative Sampling* and *Inductive Negative Sampling* for the dynamic link prediction task.

| Sampling     | Datasets  | Transductive        | Inductive           | Inductive New-Old   | Inductive New-New   |
|--------------|-----------|---------------------|---------------------|---------------------|---------------------|
| <b>Hist</b>  | Reddit    | 0.7759 $\pm$ 0.0065 | 0.8272 $\pm$ 0.0036 | 0.8532 $\pm$ 0.0019 | 0.9097 $\pm$ 0.0014 |
|              | Wikipedia | 0.6992 $\pm$ 0.0027 | 0.7924 $\pm$ 0.0022 | 0.8118 $\pm$ 0.0034 | 0.8448 $\pm$ 0.0015 |
|              | Flights   | 0.6145 $\pm$ 0.0034 | 0.6443 $\pm$ 0.0276 | 0.6418 $\pm$ 0.0566 | 0.8019 $\pm$ 0.0079 |
| <b>Induc</b> | Reddit    | 0.8058 $\pm$ 0.0049 | 0.858 $\pm$ 0.0045  | 0.8746 $\pm$ 0.0035 | 0.9515 $\pm$ 0.001  |
|              | Wikipedia | 0.731 $\pm$ 0.0022  | 0.7609 $\pm$ 0.0009 | 0.7593 $\pm$ 0.001  | 0.8323 $\pm$ 0.0045 |
|              | Flights   | 0.6145 $\pm$ 0.0034 | 0.6443 $\pm$ 0.0276 | 0.6418 $\pm$ 0.0566 | 0.8019 $\pm$ 0.0079 |

Table 4: AP results of NAT with *Historical Negative Sampling* and *Inductive Negative Sampling* for the dynamic link prediction task.

| Sampling     | Datasets  | Transductive        | Inductive           | Inductive New-Old   | Inductive New-New   |
|--------------|-----------|---------------------|---------------------|---------------------|---------------------|
| <b>Hist</b>  | Reddit    | 0.7958 $\pm$ 0.0097 | 0.8406 $\pm$ 0.0008 | 0.8558 $\pm$ 0.001  | 0.9063 $\pm$ 0.0033 |
|              | Wikipedia | 0.7128 $\pm$ 0.0019 | 0.7859 $\pm$ 0.0022 | 0.8017 $\pm$ 0.0031 | 0.8267 $\pm$ 0.0025 |
|              | Flights   | 0.6287 $\pm$ 0.0094 | 0.6596 $\pm$ 0.0248 | 0.6507 $\pm$ 0.0562 | 0.8428 $\pm$ 0.0042 |
| <b>Induc</b> | Reddit    | 0.8523 $\pm$ 0.0013 | 0.8902 $\pm$ 0.8979 | 0.8979 $\pm$ 0.0035 | 0.9648 $\pm$ 0.0009 |
|              | Wikipedia | 0.733 $\pm$ 0.0025  | 0.7525 $\pm$ 0.0043 | 0.747 $\pm$ 0.0     | 0.8238 $\pm$ 0.0088 |
|              | Flights   | 0.6287 $\pm$ 0.0094 | 0.6596 $\pm$ 0.0248 | 0.6507 $\pm$ 0.0562 | 0.8428 $\pm$ 0.0042 |

74 The experimental results demonstrated the effectiveness of *Historical Negative Sampling* and *Induc-*  
75 *tive Negative Sampling*.  
76 We leave the exploration of BenchTeMP with *Historical Negative Sampling* and *Inductive Negative*  
77 *Sampling* in detail for future works.  
78 Thank you and best regards!

## 79 **References**

- 80 [1] Farimah Poursafaei, Andy Huang, Kellin Pelrine, and Reihaneh Rabbany. Towards better evaluation for  
81 dynamic link prediction. In *Advances in Neural Information Processing Systems Datasets and Benchmarks*  
82 *Track*, 2022.