A Dataset Characteristics

A.1 Dataset statistics

We report dataset statistics in Table 3. The density each network is denoted with δ_A. The label homophily of a node u, denoted $h_u = \frac{1}{d_u} \sum_{v \in \mathcal{N}(u)} \mathbb{1}(y_u = y_v)$, corresponds to the proportion of its neighbourhood sharing its label. We denote with $\mathcal{H}$ the average label homophily across all nodes.

We show in Figure 6 the node label homophily distributions for all the considered networks. `Cora`, `Pubmed`, `Citeseer`, `CS`, `Photo` and `Ogbn-arxiv` are highly homophilous networks. On the contrary, `Actor`, `Cornell` and `Wisconsin` are considered heterophilous.

Despite their differences, the aforementioned networks are highly specific. In this work, we also consider real-world networks with smoother label homophily distributions, namely `Wikivitals`, `Wikivitals-fr`, `Wikischools` and `Wikivitals+`.

A.2 Dataset details

`Cora`, `Pubmed` and `Citeseer` [42] are citation networks, where nodes represent articles and edges represent citation links. We notice differences in the feature matrix between pre-computed online versions of the `Pubmed` graph and the graph we have built from sources, denoted with `Pubmed`$\star$. It appears that these differences come from the ordering of the rows of the feature matrix. In this paper, we rely on the `Pubmed`$\star$ version of the graph, provided in the repository of this project[2].

`Actor` dataset is the actor-induced subgraph [30]. In this graph, each node corresponds to an actor and edges are connecting actors whose names co-occur on the same Wikipedia page. The node features are generated from the bag-of-words representation of keywords in these Web pages.

The `Photo` [26] dataset is an Amazon co-purchase network, where a node represents a good and an edge denotes a frequent co-purchase between these items on the platform. Features are constructed from the bag-of-words extracted from product reviews.

The `CS` [2] dataset is a co-authorship graph originating from the KDD Cup 2016 Challenge. Nodes represent authors, and edges denote co-authorship relations between these authors. The features are bag-of-words of the scientific paper keywords.

`Cornell` and `Wisconsin`[3] are universities web pages graphs, where each page is manually classified into a category (for example, student, faculty, etc). Features correspond to bag-of-words from page texts, after removing words with highest Mutual Information with the category variable.

We consider four Wikipedia-based real-world networks[4]. The `Wikivitals` and `Wikivitals+` datasets focus on Wikipedia's so-called "vital articles", a community-made selection of Wikipedia pages. They are extracted from respectively levels 4 and 5 from WikiData. `Wikivitals-fr` contains the vital articles written in French, and `Wikischools` contains articles related to material taught in schools. For all these datasets, an edge exist between two articles if they are referencing each other in Wikipedia, and node features correspond to the bag-of-words representations of the articles.

Finally, `Ogbn-arxiv` [11] is a citation network between Computer Science papers. Each paper comes with a 128-dimensional vector of features built according to the embedding of the words contained in its abstract and title.

B Literature review on GNN for link prediction

We evaluate the extent to which simple heuristics are overviewed in the GNN benchmarks for the link prediction task. Detailed information about all the reviewed literature articles and baseline counting will be uploaded as supplementary material on the conference paper submission website.

We consider the following four categories of baselines. For each reviewed article, we record the existence of these categories of baselines in the benchmark.

GNN: Includes all GNN-based model (GCN, GAE, SEAL, etc.).

Embedding: Includes all latent feature-based models that do not rely on a message passing framework, such as matrix factorization or random walk methods (DeepWalk, node2vec, TransE, etc.).

Topological heuristic: Includes all indexes relying solely on graph structure (CN, RA, AA, etc.).

Enhanced topological heuristics: Includes all topological heuristics baselines that may have been modified to become valid competitors to GNNs.

We extract GNN-based articles from the Scopus database using the following procedure:

1. We extract all articles mentioning Graph Neural Network and link prediction, but not corresponding to a survey. We restrict our search for articles with a publication year greater than 2016. This year corresponds to the publication of the GCN model [14], which is often considered as a stepping stone in the GNN field evolution. For this purpose, we use the following query `` `TITLE-ABS-KEY ( "graph neural network" AND "link prediction" AND NOT "survey" ) AND PUBYEAR > 2016` ``, which returns 880 documents.
2. From this corpus, we only consider the top-10% most cited articles that do not contradict our selection criteria; some articles may be discarded if the proposed approach is solely evaluated on a graph classification task or if it does not contain a novel GNN proposal (for instance when the article is actually a book chapter or a tutorial). We end up with 88 articles.
3. For each of the remaining 88 articles, we record which categories of baselines are used in the proposed benchmark.

C Models

To demonstrate the effectiveness of the proposed approach, we compare its performance to three topological heuristics and six GNN models.

Topological heuristics. For topological heuristics, we use Common Neighbours (CN) [28], Adamic-Adar index (AA) [1] and Resource Allocation index (RA) [47]. These approaches do not involve any learning process as they only rely on the topological information of the graph.

Graph Neural Networks. For GNNs, we use GCN [14], GraphSage [10], GAT [37], GAE and VGAE [13]. All these models learn node representations and combine pairwise embeddings through a similarity function to predict the existence of a link. Additionally, we include GNNs specifically boosted to increase structural expressiveness. Drawing inspiration from topological heuristics, SEAL [45]

[2] Remote repository: https://github.com/simondelarue/link-prediction-without-learning.

[3] Data related to the World Wide Knowledge Base Project: https://www.cs.cmu.edu/afs/cs.cmu.edu/project/theo-11/www/wwkb/

[4] Wikipedia-based networks: https://netset.telecom-paris.fr/.

Table 3. Dataset statistics

Dataset	#nodes	#edges	#features	#labels	δ_A	$\mathcal{H}$
Cora	2708	10556	1433	7	2.88×10^{-3}	0.825
Pubmed⋆	19717	88651	500	3	4.56×10^{-4}	0.792
Citeseer	3327	9104	3703	6	1.65×10^{-3}	0.717
Actor	7600	30019	932	5	1.04×10^{-3}	0.224
CS	18333	163788	6805	15	9.75×10^{-4}	0.832
Photo	7650	238162	745	8	8.14×10^{-3}	0.849
Cornell	183	298	1703	5	1.79×10^{-2}	0.203
Wisconsin	251	515	1703	5	1.64×10^{-2}	0.198
Wikivitals	10011	824999	37845	11	8.23×10^{-3}	0.472
Wikivitals-fr	9945	558427	28198	11	5.65×10^{-3}	0.447
Wikischools	4403	112834	20527	16	5.82×10^{-3}	0.411
Wikivitals+	45149	3946850	85512	11	1.93×10^{-3}	0.487
Ogbn-arxiv	169343	1166246	128	40	8.14×10^{-5}	0.632

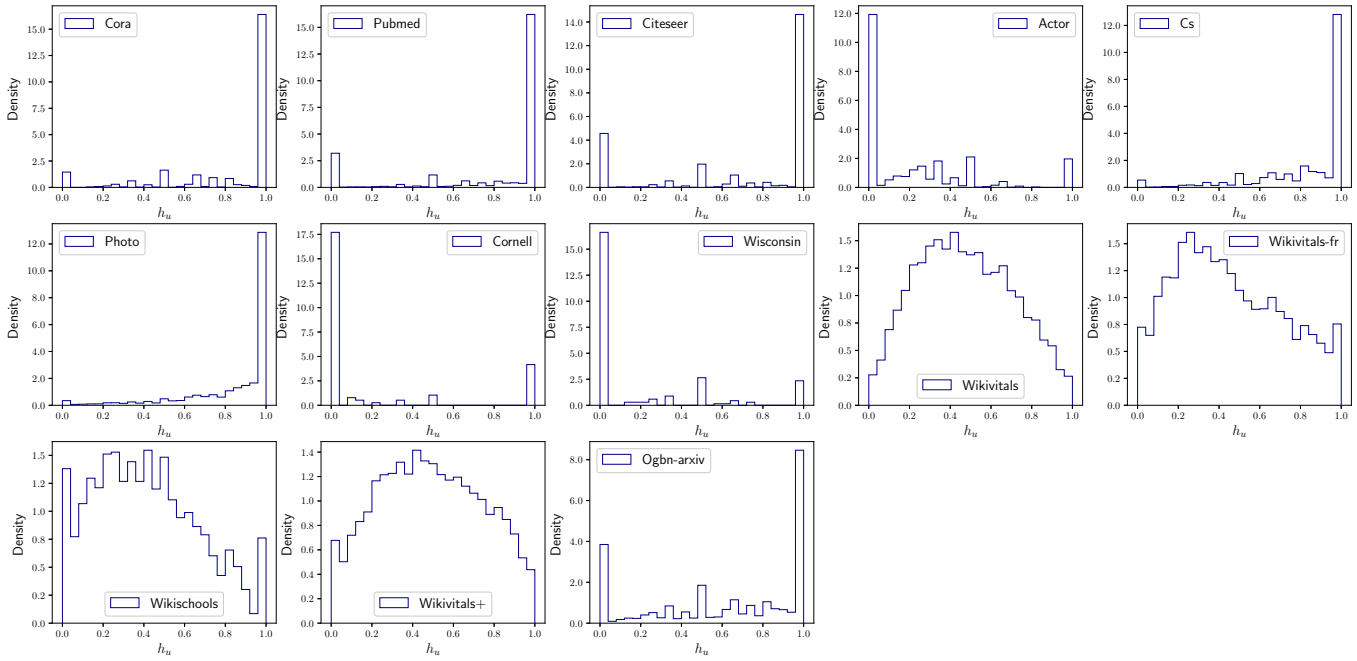

Figure 6. Node label homophily distributions.

and Neo-GNN [44] are designed to incorporate local topological information near the predicted edge. We provide implementation details of each model in Appendix D.

D Hyperparameters and settings

We detail GNN-based hyperparameters in Table 4. For all models we used the Binary Cross Entropy Loss and Adam optimizer. The following model's hyperparameters were tuned using grid search, GCN, GraphSAGE, GAT, GAE, VGAE and Neo-GNN. The search space was over hidden and output dimension $[16, 32, 64, 128]$ for all neural models. Additionally, the search space for the number of heads in GAT was over $[4, 8]$. The search space for the neural link predictor in Neo-GNN was over $[16, 32, 64, 128]$. All models were tuned on Cora, and the hyperparameters that achieved the best results on validation AUC were used for all other datasets. For SEAL, the best hyperparameters found for Cora induced an untractable learning process for larger datasets. Consequently, we used the hyperparameters found in the original paper. For all datasets, the number of edges included in training-validation-test sets are 85%-5%-10%. The number of epochs, learning rate and optimizer corresponds to the ones used in the original model implementations.

The original implementation of SEAL uses a $2-$hops subgraph extraction in the vicinity of the predicted edge. This setting led to an out-of-memory error for CS, Photo, Wikivitals, Wikvitals-fr, Wikischools, Wikivitals+ and Ogbn-arxiv. Therefore, for these datasets, we reduced the dimension of the extracted subgraph to the $1-$hop neighbourhood. Moreover, as proposed in its original implementation [45], we restrict the SEAL approach not to include any explicit feature and rely only on the graph structure features learned during the training.

It is useful to note that both GAE and VGAE models perform negative sampling **at each epoch** during the training procedure, which deviates from our choice for a systematic comparison on the same train-validation and test splits across models. In our experiments, we

Table 4. Final hyperparameters for GNNs in link prediction.

Model	Encoder	Decoder	#epochs	learning rate	Optimizer
GCN	2-layers GCN(64, 64)	Inner product	200	1×10^{-2}	Adam
GRAPHSAGE	2-layers GraphSage(128, 128)	Inner product	100	1×10^{-2}	Adam
GAT	2-layers GAT(16, 64) (heads=4)	Inner product	100	5×10^{-2}	Adam
GAE	2-layers GCN(128, 64)	Inner product	200	1×10^{-2}	Adam
VGAE	2-layers GCN(128, 128)	Inner product	200	1×10^{-2}	Adam
SEAL	2-layers DGCNN(128, 128) + MLP(32)	-	50	1×10^{-4}	Adam
NEO-GNN	3-layers GCN(128, 64) + 3-layers Linear(64, 32)	-	200	1×10^{-3}	Adam

maintained this setting to keep the implementation as close as possible to the original one. However, we noticed that relying on a fixed set of negative edges shared for all epochs drastically lower the overall performance.

Rankings. For all experiments, in cases where settings ran out of memory during training process, we assigned the corresponding models the same rank, which corresponds to the lowest possible rank. We make this decision to avoid introducing bias in favor of computationally expensive methods, aligning with our belief that scalability considerations should be weighted equally with performance in our evaluation.

Considering the small number of edges available in `Cornell` and `Wisconsin`, we did not include results from Hit@k with $k > 20$ in the rankings.

E Detailed results

We provide average results and standard deviations for each of the evaluated performance metric on the link prediction task: AUC (Table 5), Mean Reciprocal Rank (Table 6), Hit@20 (Table 7), Hit@50 (Table 8), Hit@100 (Table 9) and Hit@200 (Table 10). For each metric, best and second best scores are highlighted. – is used when a model returns an out-of-memory error or runs for longer than 24 hours. For each evaluation metric, the average rank across all datasets is reported in the last column.

We ran all models on Intel(R) Xeon(R) CPU E5-2660 v3 @ 2.60GHz with 362GB memory. For the training of GNN-based models, we chose not to use any GPU. This decision was motivated by our aim to maintain simplicity in the models, ensuring compatibility with various computing environments.

On `Wikivitals+` and `Ogbn-arxiv`, SEAL method required longer than 24 hours only for the extraction of the enclosing subgraphs.

E.1 Performance improvement vs. simple topological heuristics

We illustrate the benefits of incorporating node-level and graph-level feature information into topological heuristics in Figure 7.

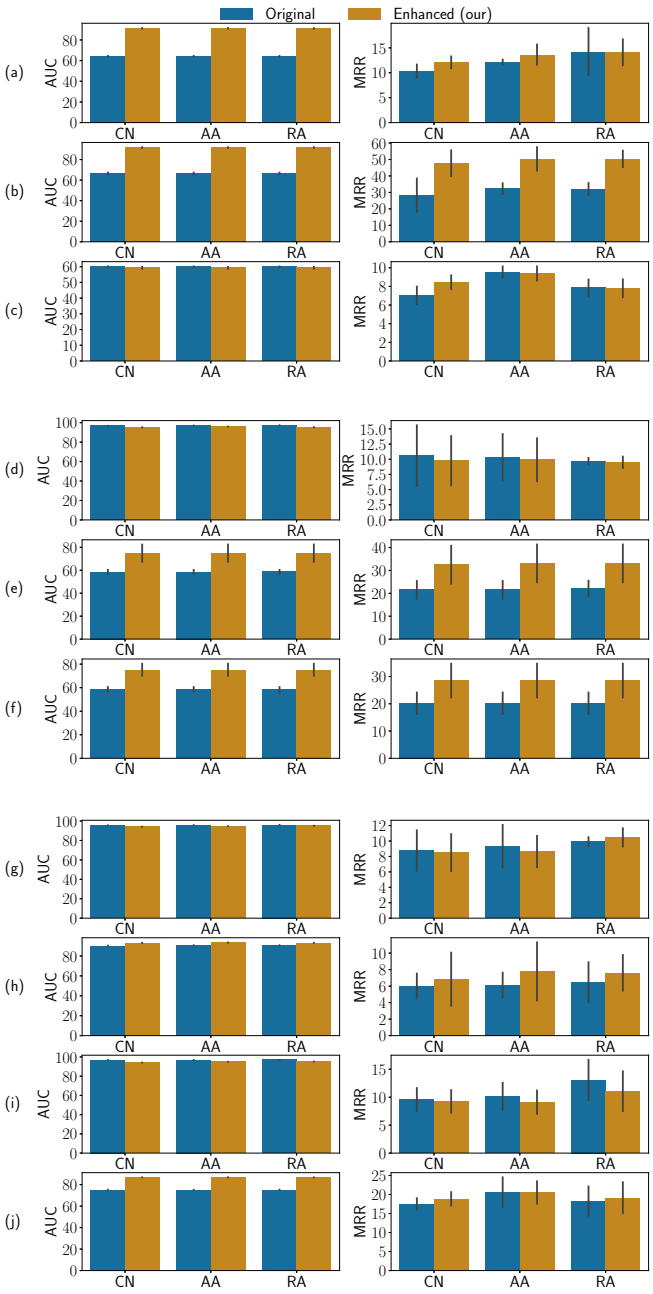

Figure 7. Benefits of weighting topological heuristics with feature information for `Pubmed*` (a), `Citeseer` (b), `Actor` (c), `Photo` (d), `Cornell` (e), `Wisconsin` (f), `Wikivitals` (g), `Wikischools` (h), `Wikivitals+` (i), and `Ogbn-arxiv` (j).

Table 5. AUC for link prediction.

Model	Cora	Pubmed*	Citeseer	Actor	CS	Photo	Cornell	Wisconsin
CN	72.06 ±0.71	64.29 ±0.24	66.49 ±0.89	60.00 ±0.18	89.77 ±0.16	96.75 ±0.00	58.54 ±1.73	58.50 ±2.04
AA	72.13 ±0.73	64.29 ±0.23	66.50 ±0.88	60.00 ±0.18	89.80 ±0.16	97.02 ±0.00	58.56 ±1.73	58.50 ±2.04
RA	72.13 ±0.72	64.29 ±0.23	66.50 ±0.88	60.00 ±0.19	89.79 ±0.16	97.24 ±0.01	58.60 ±1.72	58.50 ±2.04
GCN	93.71 ±0.78	92.75 ±0.95	93.46 ±0.63	76.97 ±0.20	94.15 ±0.25	61.98 ±20.75	64.37 ±11.08	63.24 ±3.46
GRAPHSAGE	54.75 ±8.31	90.95 ±0.17	74.25 ±2.59	78.53 ±1.65	63.33 ±4.52	50.00 ±0.00	56.30 ±10.25	48.90 ±5.13
GAT	94.56 ±0.53	81.56 ±3.78	93.35 ±0.43	70.77 ±1.14	87.95 ±3.46	50.11 ±0.07	64.35 ±5.49	57.14 ±2.70
GAE	98.42 ±0.33	97.90 ±0.12	97.96 ±0.26	80.70 ±0.81	97.18 ±0.04	50.00 ±0.00	64.05 ±1.63	58.50 ±9.07
VGAE	98.80 ±0.34	96.25 ±0.23	98.71 ±0.21	80.86 ±0.32	98.32 ±0.04	91.83 ±3.76	63.85 ±6.38	61.86 ±4.08
SEAL	96.75 ±0.39	97.61 ±0.28	93.66 ±1.32	81.09 ±0.33	93.54 ±0.03	97.57 ±0.02	58.68 ±1.71	68.47 ±0.98
NEO-GNN	80.60 ±4.92	66.75 ±31.75	51.28 ±24.87	60.38 ±24.60	34.65 ±36.76	42.30 ±4.27	70.81 ±9.69	48.79 ±20.08
ECN	87.50 ±0.28	91.24 ±0.29	91.67 ±0.37	59.27 ±0.58	99.03 ±0.00	95.19 ±0.10	74.87 ±7.45	75.28 ±5.06
EAA	87.54 ±0.29	91.26 ±0.29	91.69 ±0.35	59.29 ±0.58	99.24 ±0.02	95.93 ±0.08	74.91 ±7.50	75.28 ±5.06
ERA	87.20 ±0.22	91.16 ±0.29	91.67 ±0.32	59.28 ±0.58	99.22 ±0.02	95.37 ±0.06	74.91 ±7.50	75.28 ±5.06

Model	Wikivitals	Wikivitals-fr	Wikischools	Wikivitals+	Ogbn-arxiv	Rank
CN	95.47 ±0.05	94.59 ±0.08	90.28 ±0.12	96.77 ±0.02	75.26 ±0.02	8.27
AA	95.72 ±0.05	94.89 ±0.09	90.62 ±0.11	96.87 ±0.02	75.26 ±0.02	6.96
RA	95.92 ±0.05	95.04 ±0.10	90.63 ±0.11	96.92 ±0.02	75.26 ±0.02	6.81
GCN	79.83 ±4.26	80.19 ±3.59	86.36 ±2.53	76.46 ±22.95	93.64 ±0.61	6.08
GRAPHSAGE	50.00 ±0.00	50.00 ±0.00	51.76 ±1.50	–	88.47 ±0.78	10.46
GAT	53.67 ±6.25	56.56 ±8.54	58.35 ±7.95	62.23 ±9.49	86.03 ±0.76	8.62
GAE	50.00 ±0.00	68.07 ±17.74	87.44 ±0.65	64.04 ±24.32	93.17 ±1.01	6.19
VGAE	74.92 ±21.59	87.88 ±1.51	80.54 ±8.16	94.08 ±0.51	94.74 ±0.09	5.23
SEAL	91.63 ±3.91	93.21 ±0.09	90.04 ±0.03	–	–	6.00
NEO-GNN	49.49 ±5.92	52.51 ±1.40	36.33 ±17.87	–	53.19 ±10.13	11.15
ECN	94.16 ±0.04	93.40 ±0.07	93.03 ±0.19	94.10 ±0.01	86.74 ±0.03	5.85
EAA	94.69 ±0.04	94.11 ±0.08	93.47 ±0.15	94.90 ±0.01	86.74 ±0.03	4.50
ERA	95.12 ±0.04	94.41 ±0.08	93.11 ±0.10	95.18 ±0.01	86.72 ±0.04	5.12

Table 6. Mean Reciprocal Rank for link prediction.

Model	Cora	Pubmed*	Citeseer	Actor	CS	Photo	Cornell	Wisconsin
CN	21.33 ±2.64	10.32 ±1.33	28.35 ±10.07	7.04 ±0.94	32.47 ±11.91	10.58 ±5.02	21.53 ±3.86	20.19 ±3.92
AA	29.51 ±1.81	12.13 ±0.52	32.28 ±3.31	9.53 ±0.61	35.05 ±12.30	10.38 ±3.77	21.53 ±3.86	20.19 ±3.92
RA	29.29 ±2.04	14.25 ±4.74	32.15 ±3.53	7.84 ±0.90	26.68 ±7.06	9.69 ±0.54	22.11 ±3.41	20.19 ±3.92
GCN	13.36 ±4.45	6.47 ±0.07	8.37 ±2.54	4.35 ±0.69	3.76 ±0.85	1.26 ±2.17	23.59 ±3.37	13.64 ±0.56
GRAPHSAGE	0.62 ±0.75	5.53 ±1.21	3.88 ±1.19	4.97 ±0.85	0.61 ±0.61	0.01 ±0.00	19.51 ±7.23	5.72 ±2.00
GAT	15.95 ±3.62	1.32 ±0.40	21.57 ±3.22	1.49 ±1.04	0.28 ±0.14	0.01 ±0.00	22.84 ±11.64	9.86 ±3.55
GAE	38.59 ±7.39	9.22 ±0.98	42.51 ±13.42	6.17 ±0.28	5.97 ±1.23	0.01 ±0.00	31.04 ±15.36	16.65 ±5.86
VGAE	47.42 ±11.34	7.58 ±1.69	52.26 ±14.22	5.55 ±0.94	10.07 ±4.50	3.21 ±2.01	24.22 ±3.78	19.26 ±0.31
SEAL	74.76 ±11.23	66.33 ±8.91	66.89 ±16.23	6.14 ±0.06	25.80 ±3.32	13.10 ±3.15	19.14 ±2.78	15.08 ±1.42
NEO-GNN	17.48 ±5.22	2.80 ±2.46	2.83 ±3.14	0.53 ±0.39	2.66 ±4.51	0.05 ±0.05	44.79 ±9.08	18.32 ±12.59
ECN	33.09 ±0.76	12.10 ±1.18	47.72 ±7.81	8.45 ±0.74	35.70 ±5.03	9.77 ±4.06	32.51 ±8.28	28.49 ±6.18
EAA	37.14 ±0.39	13.64 ±2.03	50.33 ±7.14	9.39 ±0.76	35.06 ±8.64	9.92 ±3.55	33.09 ±8.24	28.49 ±6.18
ERA	38.11 ±3.28	14.12 ±2.60	50.38 ±4.97	7.80 ±0.97	35.05 ±6.77	9.49 ±0.95	33.09 ±8.24	28.49 ±6.18

Model	Wikivitals	Wikivitals-fr	Wikischools	Wikivitals+	Ogbn-arxiv	Rank
CN	8.77 ±2.61	7.84 ±2.99	6.01 ±1.51	9.60 ±2.03	17.54 ±1.47	6.04
AA	9.32 ±2.76	8.39 ±3.32	6.13 ±1.50	10.12 ±2.47	20.64 ±3.86	4.42
RA	9.92 ±0.58	9.16 ±2.56	6.46 ±2.43	13.09 ±3.59	18.28 ±3.83	4.69
GCN	0.46 ±0.12	0.96 ±0.18	2.96 ±0.09	0.17 ±0.15	1.83 ±0.70	9.46
GRAPHSAGE	0.00 ±0.00	0.00 ±0.00	0.12 ±0.09	–	1.14 ±0.27	11.81
GAT	0.00 ±0.00	0.01 ±0.01	0.04 ±0.03	0.00 ±0.00	0.05 ±0.02	11.46
GAE	0.00 ±0.00	0.33 ±0.57	2.82 ±0.56	0.19 ±0.34	1.83 ±0.66	8.19
VGAE	0.29 ±0.28	0.89 ±0.80	0.28 ±0.40	0.26 ±0.09	1.84 ±0.62	7.15
SEAL	2.99 ±1.21	6.30 ±1.76	3.46 ±0.29	–	–	6.85
NEO-GNN	0.01 ±0.00	0.03 ±0.01	0.10 ±0.07	–	0.04 ±0.04	10.46
ECN	8.49 ±2.40	7.78 ±2.95	6.84 ±3.21	9.24 ±2.02	18.88 ±1.74	4.31
EAA	8.63 ±2.02	8.18 ±3.09	7.78 ±3.52	9.11 ±2.09	20.53 ±2.93	3.35
ERA	10.47 ±1.18	9.15 ±3.09	7.61 ±2.16	11.08 ±3.55	19.13 ±4.08	3.04

Table 7. Hit@20 for link prediction.

Model	Cora	Pubmed⋆	Citeseer	Actor	CS	Photo	Cornell	Wisconsin
CN	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	53.81 ±0.39	26.18 ±0.21	100.00 ±0.00	16.99 ±4.08
AA	44.80 ±1.54	28.67 ±0.36	33.11 ±1.67	20.30 ±0.27	66.76 ±4.43	31.30 ±1.59	100.00 ±0.00	16.99 ±4.08
RA	44.80 ±1.54	28.67 ±0.36	33.11 ±1.67	20.30 ±0.27	65.45 ±5.33	32.38 ±1.56	100.00 ±0.00	16.99 ±4.08
GCN	42.37 ±4.41	16.93 ±1.25	44.40 ±5.61	14.10 ±1.72	12.42 ±1.61	3.36 ±5.83	79.31 ±9.12	60.78 ±7.84
GRAPHSAGE	1.99 ±3.45	22.85 ±2.02	9.89 ±1.92	16.65 ±2.30	1.31 ±1.38	0.00 ±0.00	71.26 ±12.11	3.27 ±4.08
GAT	50.90 ±1.42	6.08 ±1.42	47.22 ±3.61	4.60 ±2.49	0.83 ±0.74	0.00 ±0.00	80.46 ±13.94	43.79 ±7.42
GAE	84.04 ±2.50	29.72 ±0.74	90.04 ±2.04	18.77 ±2.69	18.49 ±1.86	0.00 ±0.00	77.01 ±7.18	42.48 ±9.27
VGAE	92.70 ±1.83	23.84 ±3.80	95.60 ±1.48	20.52 ±1.04	23.65 ±2.53	7.94 ±4.30	77.01 ±5.27	56.21 ±4.08
SEAL	86.73 ±4.00	82.27 ±0.95	80.11 ±2.60	18.84 ±2.07	65.30 ±0.64	29.51 ±0.37	70.11 ±8.68	66.01 ±3.00
NEO-GNN	45.24 ±7.64	8.23 ±7.28	19.49 ±30.76	0.50 ±0.44	4.13 ±6.75	0.00 ±0.00	78.16 ±18.99	39.87 ±20.03
ECN	55.80 ±1.10	28.27 ±1.62	66.74 ±1.65	20.73 ±0.43	61.92 ±1.96	28.30 ±0.82	86.21 ±6.90	77.78 ±7.92
EAA	56.40 ±0.90	31.20 ±1.15	66.74 ±1.65	20.73 ±0.43	71.55 ±2.35	27.53 ±1.14	86.21 ±6.90	77.78 ±7.92
ERA	55.04 ±1.54	29.59 ±1.27	66.41 ±1.71	20.72 ±0.43	71.40 ±2.38	29.04 ±0.73	86.21 ±6.90	77.78 ±7.92

Model	Wikivitals	Wikivitals-fr	Wikischools	Wikivitals+	Ogbn-arxiv	Rank
CN	18.95 ±0.57	14.87 ±0.40	21.40 ±1.74	22.95 ±0.68	43.50 ±12.20	6.54
AA	20.61 ±1.41	16.89 ±0.43	23.65 ±0.89	26.16 ±0.34	49.01 ±1.54	5.04
RA	26.60 ±1.08	26.13 ±3.52	24.89 ±3.13	34.96 ±3.72	48.61 ±2.09	4.50
GCN	1.20 ±0.14	2.93 ±0.16	9.79 ±2.48	0.54 ±0.47	9.55 ±0.84	8.85
GRAPHSAGE	0.01 ±0.02	0.00 ±0.00	0.06 ±0.05	–	3.49 ±0.78	11.65
GAT	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.07 ±0.06	10.46
GAE	0.00 ±0.00	1.18 ±2.04	11.11 ±0.18	0.49 ±0.84	9.77 ±0.42	7.88
VGAE	0.93 ±0.82	2.63 ±2.51	0.31 ±0.54	1.13 ±0.59	10.18 ±0.81	6.88
SEAL	7.84 ±1.47	18.78 ±2.00	12.71 ±2.80	–	–	6.46
NEO-GNN	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	–	0.02 ±0.03	11.12
ECN	18.19 ±0.27	14.12 ±0.34	22.26 ±0.23	22.61 ±1.22	47.56 ±2.33	5.00
EAA	18.12 ±0.44	15.28 ±0.23	23.89 ±0.44	23.23 ±1.29	48.54 ±1.56	3.69
ERA	26.42 ±1.33	23.65 ±3.09	26.49 ±0.36	32.30 ±2.82	48.67 ±1.53	3.15

Table 8. Hit@50 for link prediction.

Model	Cora	Pubmed⋆	Citeseer	Actor	CS	Photo	Cornell	Wisconsin
CN	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	62.41 ±15.16	35.86 ±1.85	100.00 ±0.00	100.00 ±0.00
AA	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	76.12 ±2.73	42.00 ±1.93	100.00 ±0.00	100.00 ±0.00
RA	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	76.39 ±2.43	49.45 ±1.12	100.00 ±0.00	100.00 ±0.00
GCN	64.61 ±3.69	28.50 ±1.69	63.70 ±5.78	21.53 ±1.91	19.05 ±0.58	4.54 ±7.87	100.00 ±0.00	99.35 ±1.13
GRAPHSAGE	3.16 ±5.47	34.71 ±1.38	17.07 ±1.43	26.91 ±2.18	2.49 ±2.38	0.00 ±0.00	100.00 ±0.00	94.77 ±5.99
GAT	71.56 ±1.28	10.04 ±1.95	68.28 ±3.37	9.69 ±3.11	2.06 ±1.78	0.00 ±0.00	100.00 ±0.00	98.69 ±1.13
GAE	94.15 ±0.90	48.37 ±1.29	94.76 ±0.73	31.79 ±3.56	29.80 ±1.48	0.00 ±0.00	100.00 ±0.00	97.39 ±4.53
VGAE	97.22 ±1.06	37.02 ±2.78	96.74 ±0.62	31.82 ±1.49	37.44 ±1.08	13.69 ±6.86	100.00 ±0.00	98.04 ±3.40
SEAL	90.52 ±1.52	83.72 ±0.81	83.81 ±1.93	30.31 ±0.57	72.21 ±2.68	42.48 ±0.60	100.00 ±0.00	100.00 ±0.00
NEO-GNN	62.09 ±8.47	13.10 ±11.35	26.70 ±38.75	1.02 ±0.19	6.01 ±9.38	0.00 ±0.00	100.00 ±0.00	84.31 ±22.10
ECN	64.61 ±1.95	38.75 ±0.53	73.88 ±1.82	21.36 ±0.61	70.17 ±1.56	38.73 ±1.32	100.00 ±0.00	100.00 ±0.00
EAA	64.58 ±1.83	40.34 ±0.48	73.88 ±1.82	21.36 ±0.61	79.09 ±1.35	40.99 ±1.41	100.00 ±0.00	100.00 ±0.00
ERA	63.19 ±1.74	38.80 ±0.34	73.81 ±1.76	21.35 ±0.62	78.64 ±1.10	45.08 ±1.77	100.00 ±0.00	100.00 ±0.00

Model	Wikivitals	Wikivitals-fr	Wikischools	Wikivitals+	Ogbn-arxiv	Rank
CN	25.70 ±2.57	23.27 ±0.63	33.66 ±4.02	30.55 ±0.07	50.54 ±0.05	7.27
AA	28.43 ±2.68	25.74 ±0.19	35.68 ±2.06	33.40 ±0.42	50.54 ±0.05	5.91
RA	36.83 ±1.30	34.23 ±2.10	37.22 ±1.05	42.01 ±2.50	50.54 ±0.05	4.91
GCN	2.85 ±0.78	5.26 ±0.34	16.64 ±4.08	1.15 ±1.07	16.14 ±0.52	8.05
GRAPHSAGE	0.01 ±0.02	0.00 ±0.00	0.06 ±0.05	–	6.30 ±0.68	10.68
GAT	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.19 ±0.14	10.91
GAE	0.00 ±0.00	2.61 ±4.52	18.84 ±1.59	1.03 ±1.78	15.74 ±0.50	6.91
VGAE	2.13 ±1.86	5.02 ±4.68	3.97 ±6.88	2.57 ±1.11	16.67 ±0.75	6.09
SEAL	15.18 ±1.86	26.35 ±1.70	25.35 ±1.35	–	–	5.91
NEO-GNN	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	–	0.26 ±0.22	11.50
ECN	24.84 ±2.33	22.80 ±0.79	32.00 ±0.60	29.96 ±0.56	52.56 ±0.17	5.45
EAA	25.76 ±2.42	24.78 ±0.60	35.42 ±1.01	31.19 ±0.33	52.56 ±0.17	4.05
ERA	34.10 ±1.48	32.61 ±0.80	37.34 ±0.28	40.08 ±1.17	52.48 ±0.16	3.64

Table 9. Hit@100 for link prediction.

Model	Cora	Pubmed⋆	Citeseer	Actor	CS	Photo	Cornell	Wisconsin
CN	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	79.77 ±0.27	47.24 ±3.92	100.00 ±0.00	100.00 ±0.00
AA	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	79.77 ±0.27	53.40 ±3.65	100.00 ±0.00	100.00 ±0.00
RA	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	79.77 ±0.27	62.61 ±2.54	100.00 ±0.00	100.00 ±0.00
GCN	81.20 ±2.84	38.77 ±0.62	82.05 ±3.64	29.82 ±2.62	27.72 ±0.96	6.34 ±10.98	100.00 ±0.00	100.00 ±0.00
GRAPHSAGE	3.16 ±5.47	45.92 ±1.24	19.71 ±2.89	36.45 ±0.75	3.11 ±3.13	0.00 ±0.00	100.00 ±0.00	100.00 ±0.00
GAT	84.04 ±2.37	15.62 ±2.07	82.82 ±2.22	15.36 ±2.57	4.03 ±3.50	0.00 ±0.00	100.00 ±0.00	100.00 ±0.00
GAE	97.38 ±0.79	65.08 ±2.77	95.82 ±0.76	42.01 ±3.05	40.07 ±0.52	0.00 ±0.00	100.00 ±0.00	100.00 ±0.00
VGAE	98.29 ±0.78	50.06 ±2.40	97.36 ±0.90	42.24 ±1.06	50.85 ±0.79	19.24 ±9.24	100.00 ±0.00	100.00 ±0.00
SEAL	92.51 ±0.83	84.85 ±0.69	87.00 ±2.26	42.06 ±1.32	82.68 ±0.03	54.45 ±0.35	100.00 ±0.00	100.00 ±0.00
NEO-GNN	71.85 ±14.86	17.64 ±15.31	31.87 ±37.89	2.47 ±1.39	7.87 ±12.16	2.54 ±4.38	100.00 ±0.00	100.00 ±0.00
ECN	71.34 ±1.54	47.29 ±1.47	79.96 ±0.71	22.53 ±0.58	77.72 ±0.46	48.71 ±2.88	100.00 ±0.00	100.00 ±0.00
EAA	71.28 ±1.56	48.24 ±1.14	79.96 ±0.71	22.53 ±0.58	83.98 ±0.26	51.63 ±1.96	100.00 ±0.00	100.00 ±0.00
ERA	70.14 ±1.31	46.93 ±1.06	80.04 ±0.61	22.74 ±0.51	83.75 ±0.42	57.01 ±0.94	100.00 ±0.00	100.00 ±0.00

Model	Wikivitals	Wikivitals-fr	Wikischools	Wikivitals+	Ogbn-arxiv	Rank
CN	32.64 ±1.64	31.64 ±1.03	46.54 ±0.35	37.47 ±0.51	50.54 ±0.05	6.82
AA	35.34 ±2.05	35.22 ±0.73	45.19 ±0.81	40.14 ±0.53	50.54 ±0.05	6.18
RA	43.33 ±0.99	42.07 ±0.92	47.38 ±1.33	48.21 ±0.96	50.54 ±0.05	5.09
GCN	4.77 ±1.13	8.07 ±0.87	23.80 ±5.49	1.93 ±1.82	20.98 ±0.54	7.45
GRAPHSAGE	0.01 ±0.02	0.00 ±0.00	3.88 ±3.37	–	11.13 ±1.22	10.82
GAT	0.00 ±0.00	0.05 ±0.08	0.59 ±1.02	0.00 ±0.00	0.38 ±0.23	10.36
GAE	0.00 ±0.00	3.76 ±6.51	26.54 ±2.38	1.82 ±3.15	20.82 ±0.92	7.00
VGAE	3.76 ±3.28	7.86 ±7.15	7.82 ±13.55	4.83 ±1.81	22.48 ±0.84	5.82
SEAL	22.42 ±3.28	33.92 ±1.15	37.18 ±0.54	–	–	5.82
NEO-GNN	0.00 ±0.00	0.00 ±0.00	1.85 ±2.54	–	0.32 ±0.28	11.36
ECN	31.60 ±2.02	31.60 ±0.44	41.93 ±1.43	36.36 ±0.45	53.49 ±0.29	5.95
EAA	32.83 ±1.95	33.51 ±0.32	45.01 ±1.28	37.44 ±0.36	53.49 ±0.29	4.77
ERA	41.45 ±1.73	40.75 ±0.50	47.27 ±0.60	46.44 ±0.91	53.41 ±0.28	3.82

Table 10. Hit@200 for link prediction.

Model	Cora	Pubmed⋆	Citeseer	Actor	CS	Photo	Cornell	Wisconsin
CN	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	79.77 ±0.27	62.56 ±3.31	100.00 ±0.00	100.00 ±0.00
AA	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	79.77 ±0.27	68.26 ±1.58	100.00 ±0.00	100.00 ±0.00
RA	44.80 ±1.54	28.75 ±0.49	33.11 ±1.67	20.30 ±0.27	79.77 ±0.27	75.39 ±1.15	100.00 ±0.00	100.00 ±0.00
GCN	92.58 ±1.35	52.16 ±1.21	95.57 ±0.28	41.25 ±2.11	39.25 ±0.89	8.19 ±14.19	100.00 ±0.00	100.00 ±0.00
GRAPHSAGE	3.16 ±5.47	57.41 ±1.66	32.16 ±23.89	47.20 ±1.87	3.92 ±4.44	0.00 ±0.00	100.00 ±0.00	100.00 ±0.00
GAT	93.14 ±1.11	22.20 ±3.00	93.11 ±1.54	25.24 ±2.78	10.84 ±3.71	0.00 ±0.00	100.00 ±0.00	100.00 ±0.00
GAE	98.86 ±0.76	79.21 ±2.66	97.29 ±0.67	53.63 ±3.83	54.09 ±0.57	0.00 ±0.00	100.00 ±0.00	100.00 ±0.00
VGAE	98.89 ±0.49	65.75 ±0.99	98.50 ±0.17	54.82 ±0.40	67.53 ±0.84	26.81 ±11.19	100.00 ±0.00	100.00 ±0.00
SEAL	94.60 ±0.25	86.76 ±0.63	89.56 ±2.87	53.04 ±0.83	83.54 ±0.03	66.92 ±0.29	100.00 ±0.00	100.00 ±0.00
NEO-GNN	75.55 ±13.08	28.44 ±26.39	39.60 ±33.85	9.29 ±11.09	9.40 ±13.67	3.03 ±5.23	100.00 ±0.00	100.00 ±0.00
ECN	79.27 ±1.56	56.77 ±0.31	86.52 ±0.56	24.98 ±0.49	83.46 ±0.55	61.62 ±1.37	100.00 ±0.00	100.00 ±0.00
EAA	79.27 ±1.56	57.10 ±0.25	86.52 ±0.56	24.98 ±0.49	88.21 ±0.47	64.30 ±1.63	100.00 ±0.00	100.00 ±0.00
ERA	78.58 ±1.43	55.80 ±0.36	86.52 ±0.56	24.97 ±0.49	87.85 ±0.52	67.17 ±0.56	100.00 ±0.00	100.00 ±0.00

Model	Wikivitals	Wikivitals-fr	Wikischools	Wikivitals+	Ogbn-arxiv	Rank
CN	39.81 ±1.77	41.05 ±0.13	57.41 ±0.00	43.89 ±0.68	50.54 ±0.05	7.27
AA	43.19 ±1.51	44.65 ±0.57	58.47 ±0.68	46.51 ±0.71	50.54 ±0.05	6.00
RA	50.91 ±1.20	50.90 ±0.70	58.26 ±0.41	55.02 ±0.46	50.54 ±0.05	5.45
GCN	7.61 ±1.10	11.88 ±1.27	33.21 ±7.07	3.13 ±2.87	27.60 ±0.83	7.36
GRAPHSAGE	0.01 ±0.02	0.00 ±0.00	4.13 ±3.58	–	17.29 ±1.20	10.64
GAT	0.00 ±0.00	0.10 ±0.17	0.80 ±1.39	0.00 ±0.00	0.85 ±0.42	9.73
GAE	0.00 ±0.00	5.14 ±8.90	37.36 ±1.14	3.03 ±5.24	27.29 ±1.90	6.91
VGAE	6.57 ±5.77	14.83 ±4.48	11.78 ±20.40	8.72 ±1.75	29.36 ±0.35	5.73
SEAL	30.57 ±5.30	42.28 ±0.71	48.16 ±0.32	–	–	6.18
NEO-GNN	0.00 ±0.00	0.00 ±0.00	10.21 ±11.50	–	0.39 ±0.34	11.36
ECN	39.32 ±1.59	41.58 ±0.19	54.75 ±0.61	43.08 ±0.60	54.67 ±0.13	5.68
EAA	40.95 ±1.63	43.20 ±0.38	57.17 ±0.69	44.38 ±0.31	54.67 ±0.13	4.59
ERA	48.75 ±1.34	49.82 ±0.84	57.94 ±0.83	52.88 ±0.25	54.61 ±0.12	4.36