

# FairGE: Fairness-Aware Graph Encoding in Incomplete Social Networks

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## Abstract

Graph Transformers (GTs) are increasingly applied to social network analysis, yet their deployment is often constrained by fairness concerns. This issue is particularly critical in social networks, where sensitive attributes are frequently absent due to privacy and ethical restrictions. Existing solutions commonly generate incomplete attributes, which may introduce additional biases and compromise user privacy. To address this challenge, FairGE (Fair Graph Encoding) is introduced as a fairness-aware framework for GTs in incomplete social networks. Instead of generating sensitive attributes, FairGE encodes fairness directly through spectral graph theory. By leveraging the principal eigenvector to represent structural information and padding incomplete sensitive attributes with zeros to maintain independence, FairGE ensures fairness without data reconstruction. Theoretical analysis demonstrates that the method suppresses the influence of non-principal spectral components, thereby enhancing fairness. Extensive experiments on seven real-world social network datasets confirm that FairGE achieves at least a 16% improvement in both statistical parity and equality of opportunity compared with state-of-the-art baselines. The source code is shown in <https://anonymous.4open.science/r/FairGE-609E>.

## CCS Concepts

- Information systems → Social networks; Data mining.

## Keywords

Social Networks, Graph Learning, Graph Transformers, Fairness, Incomplete Data

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## Comparison Result

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**Table 1: Comparison on utility (ACC) and fairness ( $\Delta_{SP}$  and  $\Delta_{EO}$ ) in percentage (%) with Facebook and Income.  $\uparrow$  denotes the larger, the better;  $\downarrow$  denotes the opposite. The best results are red and bold-faced. The runner-ups are blue and underlined. OOM denotes out-of-memory.**

Missing Rate	Facebook(0.1)			Facebook(0.2)			Facebook(0.3)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	80.15 $\pm$ 1.02	5.52 $\pm$ 1.23	8.28 $\pm$ 0.54	77.10 $\pm$ 1.67	8.77 $\pm$ 0.85	5.34 $\pm$ 0.97	77.48 $\pm$ 2.07	8.21 $\pm$ 1.22	4.65 $\pm$ 0.89
SGFormer	<b>90.46<math>\pm</math>1.97</b>	4.51 $\pm$ 0.40	2.93 $\pm$ 0.40	<u>87.02<math>\pm</math>1.83</u>	17.73 $\pm$ 1.04	9.67 $\pm$ 1.41	84.35 $\pm$ 0.92	12.57 $\pm$ 0.79	3.89 $\pm$ 0.17
CoBFormer	80.53 $\pm$ 0.96	3.48 $\pm$ 0.35	4.24 $\pm$ 0.73	84.35 $\pm$ 1.88	3.26 $\pm$ 1.02	1.99 $\pm$ 0.32	<b>86.26<math>\pm</math>1.75</b>	10.70 $\pm$ 1.06	10.79 $\pm$ 0.73
Polynormer	86.26 $\pm$ 1.47	6.21 $\pm$ 0.48	3.63 $\pm$ 0.26	86.64 $\pm$ 1.79	11.38 $\pm$ 1.05	5.01 $\pm$ 0.62	84.35 $\pm$ 1.63	7.32 $\pm$ 0.61	3.63 $\pm$ 0.28
FMP	83.21 $\pm$ 1.45	3.50 $\pm$ 0.36	3.70 $\pm$ 0.23	82.82 $\pm$ 1.78	<u>1.92<math>\pm</math>0.25</u>	1.21 $\pm$ 0.22	82.06 $\pm$ 1.64	6.88 $\pm$ 0.78	3.03 $\pm$ 0.19
FairSIN	81.30 $\pm$ 0.50	2.40 $\pm$ 0.40	<u>1.38<math>\pm</math>0.43</u>	82.44 $\pm$ 1.03	2.71 $\pm$ 1.12	1.12 $\pm$ 1.82	81.68 $\pm$ 0.84	5.58 $\pm$ 0.23	4.83 $\pm$ 0.23
FairGT	88.17 $\pm$ 1.67	<b>2.02<math>\pm</math>0.24</b>	1.90 $\pm$ 0.14	<b>88.93<math>\pm</math>1.36</b>	2.56 $\pm$ 0.16	<u>0.69<math>\pm</math>0.03</u>	85.88 $\pm$ 1.92	<u>1.55<math>\pm</math>0.21</u>	<b>0.69<math>\pm</math>0.08</b>
FairGNN	80.53 $\pm$ 0.75	2.40 $\pm$ 1.45	2.07 $\pm$ 0.32	79.77 $\pm$ 1.08	2.35 $\pm$ 0.41	1.64 $\pm$ 0.45	71.37 $\pm$ 1.56	3.04 $\pm$ 0.16	4.42 $\pm$ 0.24
FairAC	78.37 $\pm$ 1.21	2.87 $\pm$ 1.65	2.13 $\pm$ 0.89	78.88 $\pm$ 1.73	2.90 $\pm$ 0.58	1.32 $\pm$ 0.89	79.01 $\pm$ 1.34	2.07 $\pm$ 0.59	1.39 $\pm$ 0.73
<b>FairGE</b>	<u>88.17<math>\pm</math>1.63</u>	<b>0.89<math>\pm</math>0.04</b>	<b>1.12<math>\pm</math>0.15</b>	86.64 $\pm$ 1.69	<b>0.89<math>\pm</math>0.17</b>	<b>0.17<math>\pm</math>0.08</b>	<u>85.50<math>\pm</math>0.99</u>	<b>1.35<math>\pm</math>0.18</b>	<b>0.95<math>\pm</math>0.29</b>
Missing Rate	Facebook(0.4)			Facebook(0.5)			Facebook(0.6)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	78.24 $\pm$ 1.57	7.12 $\pm$ 0.95	5.86 $\pm$ 0.39	78.63 $\pm$ 1.89	9.37 $\pm$ 0.63	7.93 $\pm$ 0.84	78.24 $\pm$ 1.67	8.26 $\pm$ 0.82	6.55 $\pm$ 0.68
SGFormer	84.35 $\pm$ 1.63	4.45 $\pm$ 0.67	4.05 $\pm$ 0.62	<b>86.26<math>\pm</math>1.73</b>	5.40 $\pm$ 0.73	3.28 $\pm$ 0.74	82.06 $\pm$ 1.93	3.59 $\pm$ 0.53	3.62 $\pm$ 0.68
CoBFormer	84.35 $\pm$ 1.38	3.11 $\pm$ 0.48	5.87 $\pm$ 0.28	84.35 $\pm$ 1.72	5.48 $\pm$ 1.03	1.55 $\pm$ 0.72	<b>83.97<math>\pm</math>1.55</b>	7.19 $\pm$ 0.62	3.86 $\pm$ 0.47
Polynormer	80.53 $\pm$ 1.49	6.18 $\pm$ 0.36	6.48 $\pm$ 0.72	83.59 $\pm$ 1.68	4.35 $\pm$ 1.63	4.06 $\pm$ 0.32	83.59 $\pm$ 0.88	7.65 $\pm$ 0.59	3.28 $\pm$ 0.17
FMP	82.44 $\pm$ 1.81	3.45 $\pm$ 0.61	2.32 $\pm$ 0.28	<u>85.11<math>\pm</math>1.85</u>	2.02 $\pm$ 0.34	3.19 $\pm$ 0.76	78.63 $\pm$ 1.54	4.59 $\pm$ 1.03	6.57 $\pm$ 0.68
FairSIN	82.06 $\pm$ 1.48	3.33 $\pm$ 0.27	<u>2.07<math>\pm</math>0.27</u>	80.53 $\pm$ 1.85	3.80 $\pm$ 0.63	<u>1.38<math>\pm</math>0.26</u>	80.15 $\pm$ 1.92	3.36 $\pm$ 0.57	2.76 $\pm$ 0.41
FairGT	<b>84.73<math>\pm</math>1.47</b>	7.19 $\pm$ 1.05	2.16 $\pm$ 0.62	84.35 $\pm$ 1.72	<u>1.55<math>\pm</math>0.93</u>	2.07 $\pm$ 0.62	<b>84.35<math>\pm</math>1.63</b>	3.65 $\pm$ 0.83	2.07 $\pm$ 1.17
FairGNN	72.90 $\pm$ 1.93	<b>2.75<math>\pm</math>0.45</b>	2.83 $\pm$ 0.17	73.28 $\pm$ 1.94	3.01 $\pm$ 1.01	2.52 $\pm$ 0.21	78.24 $\pm$ 1.73	<u>2.23<math>\pm</math>0.27</u>	<b>1.37<math>\pm</math>0.52</b>
FairAC	80.41 $\pm$ 1.56	3.72 $\pm$ 0.95	2.24 $\pm$ 0.86	79.26 $\pm$ 1.09	2.38 $\pm$ 0.22	1.91 $\pm$ 0.53	79.13 $\pm$ 1.16	2.25 $\pm$ 0.19	2.27 $\pm$ 0.84
<b>FairGE</b>	<b>84.73<math>\pm</math>1.97</b>	<b>0.75<math>\pm</math>0.19</b>	<b>1.38<math>\pm</math>0.89</b>	83.59 $\pm$ 1.73	<b>0.73<math>\pm</math>0.49</b>	<b>0.95<math>\pm</math>0.38</b>	83.59 $\pm$ 1.83	<b>1.27<math>\pm</math>0.68</b>	<b>0.17<math>\pm</math>0.04</b>
Missing Rate	Income(0.1)			Income(0.2)			Income(0.3)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	72.94 $\pm$ 0.78	8.72 $\pm$ 0.45	4.99 $\pm$ 0.67	72.75 $\pm$ 1.23	6.77 $\pm$ 0.23	6.13 $\pm$ 0.56	71.65 $\pm$ 1.05	10.51 $\pm$ 0.34	7.91 $\pm$ 0.76
SGFormer	76.69 $\pm$ 0.99	8.14 $\pm$ 0.12	6.57 $\pm$ 0.34	77.60 $\pm$ 0.87	7.87 $\pm$ 0.67	6.57 $\pm$ 0.23	78.29 $\pm$ 1.34	7.87 $\pm$ 0.12	6.57 $\pm$ 0.56
CoBFormer	<b>79.13<math>\pm</math>0.67</b>	4.72 $\pm$ 0.78	3.62 $\pm$ 1.00	78.35 $\pm$ 1.45	4.17 $\pm$ 0.56	3.83 $\pm$ 0.78	78.18 $\pm$ 1.12	4.64 $\pm$ 0.45	4.93 $\pm$ 0.89
Polynormer	77.84 $\pm$ 1.23	1.02 $\pm$ 0.34	1.21 $\pm$ 0.67	77.71 $\pm$ 1.02	0.95 $\pm$ 0.87	1.45 $\pm$ 0.67	77.91 $\pm$ 1.23	0.71 $\pm$ 0.78	1.23 $\pm$ 0.90
FMP	78.34 $\pm$ 0.87	2.37 $\pm$ 0.45	2.39 $\pm$ 0.91	78.34 $\pm$ 1.34	1.76 $\pm$ 0.78	2.09 $\pm$ 0.56	77.62 $\pm$ 1.12	2.33 $\pm$ 0.67	1.79 $\pm$ 0.78
FairSIN	78.16 $\pm$ 1.12	<u>0.46<math>\pm</math>0.26</u>	1.68 $\pm$ 0.78	78.32 $\pm$ 1.45	<u>0.65<math>\pm</math>0.34</u>	1.53 $\pm$ 0.67	78.17 $\pm$ 1.01	<u>0.65<math>\pm</math>0.87</u>	1.16 $\pm$ 0.91
FairGT	<b>78.87<math>\pm</math>1.01</b>	1.59 $\pm$ 0.67	1.69 $\pm$ 0.87	<b>78.83<math>\pm</math>1.34</b>	1.62 $\pm$ 0.45	1.93 $\pm$ 0.78	<u>78.32<math>\pm</math>1.23</u>	<b>1.66<math>\pm</math>0.9</b>	2.32 $\pm$ 0.78
FairGNN	78.69 $\pm$ 1.34	2.78 $\pm$ 0.45	<u>0.98<math>\pm</math>0.67</u>	<u>78.65<math>\pm</math>1.02</u>	2.87 $\pm$ 0.87	0.79 $\pm$ 0.56	78.29 $\pm$ 1.45	2.61 $\pm$ 0.78	<b>0.80<math>\pm</math>0.72</b>
FairAC	77.01 $\pm$ 0.91	1.44 $\pm$ 0.56	1.70 $\pm$ 0.78	78.28 $\pm$ 1.23	0.77 $\pm$ 0.45	<u>0.75<math>\pm</math>0.67</u>	75.20 $\pm$ 1.34	1.95 $\pm$ 0.87	4.41 $\pm$ 0.89
<b>FairGE</b>	78.36 $\pm$ 1.23	<b>0.09<math>\pm</math>0.06</b>	<b>0.75<math>\pm</math>0.67</b>	78.33 $\pm$ 1.12	<b>0.58<math>\pm</math>0.38</b>	<b>0.65<math>\pm</math>0.56</b>	<b>78.36<math>\pm</math>1.01</b>	<b>0.29<math>\pm</math>0.21</b>	<b>1.06<math>\pm</math>0.78</b>
Missing Rate	Income(0.4)			Income(0.5)			Income(0.6)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	71.22 $\pm$ 0.87	7.49 $\pm$ 0.23	7.78 $\pm$ 0.45	70.10 $\pm$ 1.12	6.41 $\pm$ 0.67	8.69 $\pm$ 0.34	69.11 $\pm$ 0.98	8.18 $\pm$ 0.12	9.65 $\pm$ 0.56
SGFormer	<b>78.75<math>\pm</math>1.23</b>	4.59 $\pm$ 0.45	4.21 $\pm$ 0.78	77.81 $\pm$ 0.92	3.02 $\pm$ 0.56	3.90 $\pm$ 0.23	78.07 $\pm$ 1.34	4.68 $\pm$ 0.45	3.90 $\pm$ 0.67
CoBFormer	78.47 $\pm$ 0.67	4.34 $\pm$ 0.78	4.23 $\pm$ 0.62	78.17 $\pm$ 1.45	3.89 $\pm$ 0.34	2.60 $\pm$ 0.67	77.96 $\pm$ 1.12	3.05 $\pm$ 0.56	2.24 $\pm$ 0.89
Polynormer	78.00 $\pm$ 1.12	<b>0.54<math>\pm</math>0.34</b>	1.05 $\pm$ 0.67	78.07 $\pm$ 1.23	0.91 $\pm$ 0.78	<b>0.72<math>\pm</math>0.56</b>	78.10 $\pm$ 1.02	0.93 $\pm$ 0.67	<b>0.69<math>\pm</math>0.25</b>
FMP	77.30 $\pm$ 0.98	1.24 $\pm$ 0.45	2.16 $\pm$ 0.78	77.76 $\pm$ 1.34	1.94 $\pm$ 0.56	2.54 $\pm$ 0.23	77.09 $\pm$ 1.23	1.94 $\pm$ 0.45	2.54 $\pm$ 0.78
FairSIN	78.16 $\pm$ 1.08	0.64 $\pm$ 0.56	0.85 $\pm$ 0.57	78.02 $\pm$ 1.45	<u>0.69<math>\pm</math>0.34</u>	1.81 $\pm$ 0.67	77.42 $\pm$ 1.12	0.65 $\pm$ 0.78	2.17 $\pm$ 0.16
FairGT	78.37 $\pm$ 1.23	1.54 $\pm$ 0.34	2.34 $\pm$ 0.67	<b>78.42<math>\pm</math>1.06</b>	1.59 $\pm$ 0.45	3.29 $\pm$ 0.78	<b>78.61<math>\pm</math>1.34</b>	1.31 $\pm$ 0.87	2.70 $\pm$ 0.95
FairGNN	<b>78.82<math>\pm</math>1.34</b>	2.64 $\pm$ 0.45	<u>0.79<math>\pm</math>0.78</u>	<b>78.59<math>\pm</math>1.23</b>	1.61 $\pm$ 0.56	1.94 $\pm$ 0.23	<b>78.72<math>\pm</math>1.45</b>	0.63 $\pm$ 0.67	1.94 $\pm$ 0.65
FairAC	78.18 $\pm$ 0.91	0.75 $\pm$ 0.56	1.06 $\pm$ 0.78	78.36 $\pm$ 1.12	<u>0.69<math>\pm</math>0.45</u>	1.00 $\pm$ 0.67	76.58 $\pm$ 1.34	<u>0.57<math>\pm</math>0.17</u>	0.75 $\pm$ 0.12
<b>FairGE</b>	78.12 $\pm$ 1.12	<b>0.47<math>\pm</math>0.34</b>	<b>0.30<math>\pm</math>0.27</b>	78.31 $\pm$ 1.01	<b>0.54<math>\pm</math>0.38</b>	<b>0.50<math>\pm</math>0.46</b>	78.44 $\pm$ 1.23	<b>0.53<math>\pm</math>0.37</b>	<b>0.30<math>\pm</math>0.18</b>

**Table 2: Comparison results in Bail and Credit.**

Missing Rate	Bail(0.1)			Bail(0.2)			Bail(0.3)		
Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$
GCN	90.23 $\pm$ 1.02	6.33 $\pm$ 0.45	4.05 $\pm$ 0.78	90.42 $\pm$ 0.67	6.53 $\pm$ 0.34	4.47 $\pm$ 0.21	90.60 $\pm$ 0.99	6.63 $\pm$ 0.53	4.41 $\pm$ 0.12
SGFormer	92.76 $\pm$ 0.89	8.24 $\pm$ 0.12	5.97 $\pm$ 1.45	92.47 $\pm$ 0.32	7.97 $\pm$ 0.67	5.68 $\pm$ 0.45	92.48 $\pm$ 0.23	7.73 $\pm$ 0.76	5.35 $\pm$ 0.21
CoBFormer	<b>96.22<math>\pm</math>0.56</b>	6.87 $\pm$ 0.78	2.96 $\pm$ 1.23	<b>95.50<math>\pm</math>0.56</b>	6.75 $\pm$ 0.45	2.66 $\pm$ 0.67	<b>94.97<math>\pm</math>0.34</b>	6.78 $\pm$ 0.87	2.47 $\pm$ 0.45
Polynormer	93.97 $\pm$ 1.23	<b>3.94<math>\pm</math>0.34</b>	2.13 $\pm$ 0.98	94.10 $\pm$ 0.67	4.86 $\pm$ 0.56	2.14 $\pm$ 0.23	<b>94.23<math>\pm</math>0.12</b>	5.12 $\pm$ 0.45	<b>1.99<math>\pm</math>0.67</b>
FMP	90.75 $\pm$ 0.99	7.85 $\pm$ 0.23	7.64 $\pm$ 1.45	90.66 $\pm$ 0.87	7.73 $\pm$ 0.34	7.38 $\pm$ 0.67	90.65 $\pm$ 0.56	7.62 $\pm$ 0.78	7.10 $\pm$ 0.21
FairSIN	85.90 $\pm$ 1.02	5.21 $\pm$ 0.45	3.47 $\pm$ 0.78	86.31 $\pm$ 0.67	5.41 $\pm$ 0.34	3.57 $\pm$ 0.21	86.11 $\pm$ 0.99	<b>5.98<math>\pm</math>0.53</b>	4.68 $\pm$ 0.12
FairGT	92.63 $\pm$ 0.89	4.05 $\pm$ 0.12	<b>1.88<math>\pm</math>1.45</b>	92.58 $\pm$ 0.32	<b>2.95<math>\pm</math>0.67</b>	<b>1.90<math>\pm</math>0.45</b>	91.52 $\pm$ 0.23	<b>3.09<math>\pm</math>0.76</b>	2.24 $\pm$ 0.21
FairGNN	92.31 $\pm$ 0.56	6.98 $\pm$ 0.78	3.62 $\pm$ 1.23	92.25 $\pm$ 0.56	6.87 $\pm$ 0.45	3.47 $\pm$ 0.67	82.23 $\pm$ 0.34	6.87 $\pm$ 0.87	3.53 $\pm$ 0.45
FairAC	88.77 $\pm$ 1.23	7.62 $\pm$ 0.34	4.54 $\pm$ 0.98	89.38 $\pm$ 0.67	8.40 $\pm$ 0.56	4.55 $\pm$ 0.23	89.83 $\pm$ 0.12	7.37 $\pm$ 0.45	4.30 $\pm$ 0.67
<b>FairGE</b>	<b>94.90<math>\pm</math>0.99</b>	<b>2.22<math>\pm</math>0.23</b>	<b>1.97<math>\pm</math>1.45</b>	<b>94.12<math>\pm</math>0.87</b>	<b>2.61<math>\pm</math>0.34</b>	<b>1.69<math>\pm</math>0.67</b>	94.11 $\pm$ 0.56	<b>2.99<math>\pm</math>0.78</b>	<b>1.77<math>\pm</math>0.21</b>
Missing Rate	Bail(0.4)			Bail(0.5)			Bail(0.6)		
GCN	90.74 $\pm$ 0.67	7.12 $\pm$ 0.14	4.73 $\pm$ 0.82	90.75 $\pm$ 0.95	7.17 $\pm$ 0.43	4.77 $\pm$ 0.31	90.76 $\pm$ 1.12	7.21 $\pm$ 0.69	4.90 $\pm$ 0.24
SGFormer	92.88 $\pm$ 1.45	7.35 $\pm$ 0.29	4.86 $\pm$ 0.56	92.95 $\pm$ 0.78	7.28 $\pm$ 0.51	5.09 $\pm$ 0.19	<b>92.74<math>\pm</math>0.87</b>	7.31 $\pm$ 0.32	5.01 $\pm$ 0.15
CoBFormer	<b>93.95<math>\pm</math>0.89</b>	5.95 $\pm$ 0.37	2.13 $\pm$ 1.02	<b>93.66<math>\pm</math>0.61</b>	5.94 $\pm$ 0.47	1.82 $\pm$ 0.25	92.59 $\pm$ 0.94	5.32 $\pm$ 0.58	<b>1.38<math>\pm</math>0.22</b>
Polynormer	<b>94.63<math>\pm</math>1.28</b>	5.50 $\pm$ 0.12	<b>1.57<math>\pm</math>0.93</b>	<b>94.11<math>\pm</math>0.54</b>	5.49 $\pm$ 0.39	<b>1.76<math>\pm</math>0.27</b>	<b>93.70<math>\pm</math>1.01</b>	5.08 $\pm$ 0.42	1.50 $\pm$ 0.18
FMP	90.54 $\pm$ 0.92	7.54 $\pm$ 0.41	6.78 $\pm$ 1.37	90.43 $\pm$ 0.83	7.59 $\pm$ 0.52	6.67 $\pm$ 0.33	90.33 $\pm$ 0.76	7.55 $\pm$ 0.64	6.42 $\pm$ 0.29
FairSIN	86.36 $\pm$ 1.11	6.29 $\pm$ 0.23	4.89 $\pm$ 0.74	85.53 $\pm$ 0.69	6.42 $\pm$ 0.45	4.78 $\pm$ 0.21	82.86 $\pm$ 1.23	6.70 $\pm$ 0.57	4.96 $\pm$ 0.31
FairGT	90.89 $\pm$ 1.34	<b>2.46<math>\pm</math>0.32</b>	2.17 $\pm$ 0.68	90.89 $\pm$ 0.72	<b>3.45<math>\pm</math>0.48</b>	2.30 $\pm$ 0.24	91.25 $\pm$ 1.19	<b>3.82<math>\pm</math>0.46</b>	2.03 $\pm$ 0.27
FairGNN	91.38 $\pm$ 0.76	6.89 $\pm$ 0.18	3.83 $\pm$ 1.15	91.12 $\pm$ 0.64	7.02 $\pm$ 0.59	3.95 $\pm$ 0.36	91.20 $\pm$ 0.92	6.95 $\pm$ 0.71	3.85 $\pm$ 0.33
FairAC	89.79 $\pm$ 1.03	7.08 $\pm$ 0.26	4.63 $\pm$ 0.87	89.26 $\pm$ 0.76	7.03 $\pm$ 0.44	4.15 $\pm$ 0.22	90.17 $\pm$ 1.08	6.70 $\pm$ 0.54	4.45 $\pm$ 0.28
<b>FairGE</b>	93.41 $\pm$ 0.97	<b>1.69<math>\pm</math>0.42</b>	<b>1.01<math>\pm</math>0.51</b>	93.45 $\pm$ 0.67	<b>1.88<math>\pm</math>0.53</b>	<b>1.67<math>\pm</math>0.34</b>	92.15 $\pm$ 1.35	<b>2.66<math>\pm</math>0.62</b>	<b>1.18<math>\pm</math>0.39</b>
Missing Rate	Credit(0.1)			Credit(0.2)			Credit(0.3)		
Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$
GCN	75.70 $\pm$ 0.82	<b>4.54<math>\pm</math>0.31</b>	4.44 $\pm$ 1.25	75.37 $\pm$ 0.96	<b>5.06<math>\pm</math>0.48</b>	<b>5.06<math>\pm</math>0.22</b>	75.37 $\pm$ 1.34	<b>5.06<math>\pm</math>0.73</b>	5.06 $\pm$ 0.29
SGFormer	72.23 $\pm$ 1.33	8.35 $\pm$ 0.27	7.39 $\pm$ 0.69	72.70 $\pm$ 0.84	4.85 $\pm$ 0.54	3.43 $\pm$ 0.19	73.23 $\pm$ 0.91	3.26 $\pm$ 0.46	3.55 $\pm$ 0.16
CoBFormer	75.67 $\pm$ 0.95	2.44 $\pm$ 0.39	2.22 $\pm$ 1.18	75.39 $\pm$ 0.73	2.11 $\pm$ 0.49	2.11 $\pm$ 0.25	76.01 $\pm$ 1.02	1.59 $\pm$ 0.59	1.78 $\pm$ 0.24
Polynormer	77.24 $\pm$ 1.08	<b>0.20<math>\pm</math>0.13</b>	<b>0.19<math>\pm</math>0.12</b>	76.99 $\pm$ 0.58	0.46 $\pm$ 0.37	0.28 $\pm$ 0.26	76.21 $\pm$ 1.17	<b>0.45<math>\pm</math>0.43</b>	<b>0.26<math>\pm</math>0.19</b>
FMP	75.96 $\pm$ 1.21	1.57 $\pm$ 0.42	1.87 $\pm$ 1.36	76.00 $\pm$ 0.65	1.28 $\pm$ 0.50	1.78 $\pm$ 0.33	76.11 $\pm$ 1.29	1.47 $\pm$ 0.61	1.85 $\pm$ 0.28
FairSIN	<b>77.64<math>\pm</math>1.14</b>	0.53 $\pm$ 0.23	0.57 $\pm$ 0.77	77.72 $\pm$ 0.68	0.56 $\pm$ 0.46	0.49 $\pm$ 0.21	77.50 $\pm$ 1.32	0.52 $\pm$ 0.50	0.54 $\pm$ 0.32
FairGT	77.27 $\pm$ 1.47	1.96 $\pm$ 0.32	1.30 $\pm$ 1.03	77.26 $\pm$ 0.79	2.08 $\pm$ 0.45	1.91 $\pm$ 0.24	77.29 $\pm$ 1.15	1.52 $\pm$ 0.48	1.46 $\pm$ 0.26
FairGNN	75.06 $\pm$ 0.78	1.12 $\pm$ 0.18	1.18 $\pm$ 1.15	74.29 $\pm$ 0.64	1.07 $\pm$ 0.59	0.98 $\pm$ 0.36	75.10 $\pm$ 0.92	1.94 $\pm$ 0.71	1.53 $\pm$ 0.33
FairAC	77.18 $\pm$ 1.03	2.21 $\pm$ 0.26	2.15 $\pm$ 0.87	<b>77.87<math>\pm</math>0.76</b>	<b>0.09<math>\pm</math>0.05</b>	<b>0.15<math>\pm</math>0.12</b>	<b>77.67<math>\pm</math>1.08</b>	2.84 $\pm$ 0.54	2.93 $\pm$ 0.28
<b>FairGE</b>	<b>77.72<math>\pm</math>0.97</b>	<b>0.03<math>\pm</math>0.02</b>	<b>0.12<math>\pm</math>0.10</b>	<b>78.08<math>\pm</math>0.67</b>	<b>0.24<math>\pm</math>0.13</b>	<b>0.07<math>\pm</math>0.04</b>	<b>77.67<math>\pm</math>1.35</b>	<b>0.16<math>\pm</math>0.12</b>	<b>0.30<math>\pm</math>0.09</b>
Missing Rate	Credit(0.4)			Credit(0.5)			Credit(0.6)		
GCN	75.85 $\pm$ 1.45	6.03 $\pm$ 0.29	4.04 $\pm$ 1.23	74.85 $\pm$ 0.98	5.03 $\pm$ 0.47	6.04 $\pm$ 0.31	74.85 $\pm$ 1.12	6.06 $\pm$ 0.69	6.04 $\pm$ 0.24
SGFormer	73.40 $\pm$ 0.89	3.89 $\pm$ 0.12	3.85 $\pm$ 0.56	73.34 $\pm$ 0.78	3.98 $\pm$ 0.51	3.58 $\pm$ 0.19	72.37 $\pm$ 0.87	4.89 $\pm$ 0.32	4.85 $\pm$ 0.15
CoBFormer	76.08 $\pm$ 1.02	1.47 $\pm$ 0.34	1.18 $\pm$ 0.78	75.92 $\pm$ 0.67	1.58 $\pm$ 0.45	1.97 $\pm$ 0.21	76.30 $\pm$ 0.99	1.91 $\pm$ 0.53	2.08 $\pm$ 0.12
Polynormer	76.18 $\pm$ 1.23	0.48 $\pm$ 0.34	<b>0.27<math>\pm</math>0.18</b>	76.61 $\pm$ 0.67	0.61 $\pm$ 0.56	<b>0.65<math>\pm</math>0.23</b>	<b>77.62<math>\pm</math>1.01</b>	<b>0.60<math>\pm</math>0.42</b>	<b>0.64<math>\pm</math>0.18</b>
FMP	75.59 $\pm$ 0.99	1.51 $\pm$ 0.23	1.92 $\pm$ 1.45	75.55 $\pm$ 0.87	1.91 $\pm$ 0.34	1.86 $\pm$ 0.67	75.48 $\pm$ 0.56	1.57 $\pm$ 0.78	1.23 $\pm$ 0.21
FairSIN	77.32 $\pm$ 1.11	<b>0.40<math>\pm</math>0.23</b>	0.51 $\pm$ 0.24	<b>77.21<math>\pm</math>0.69</b>	0.69 $\pm$ 0.45	0.70 $\pm$ 0.21	77.33 $\pm$ 1.23	0.92 $\pm$ 0.57	0.88 $\pm$ 0.31
FairGT	77.12 $\pm$ 1.34	2.15 $\pm$ 0.32	1.78 $\pm$ 0.68	77.09 $\pm$ 0.72	1.43 $\pm$ 0.48	1.48 $\pm$ 0.24	76.76 $\pm$ 1.19	2.00 $\pm$ 0.46	1.78 $\pm$ 0.27
FairGNN	75.03 $\pm$ 0.76	1.92 $\pm$ 0.18	1.52 $\pm$ 1.15	76.39 $\pm$ 0.64	1.75 $\pm$ 0.59	1.16 $\pm$ 0.36	75.66 $\pm$ 0.92	1.86 $\pm$ 0.71	1.47 $\pm$ 0.33
FairAC	<b>77.75<math>\pm</math>1.03</b>	0.62 $\pm$ 0.26	0.62 $\pm$ 0.87	<b>77.77<math>\pm</math>0.76</b>	<b>0.59<math>\pm</math>0.44</b>	<b>0.65<math>\pm</math>0.22</b>	77.56 $\pm$ 1.08	0.72 $\pm$ 0.54	0.96 $\pm$ 0.28
<b>FairGE</b>	77.60 $\pm$ 0.97	<b>0.04<math>\pm</math>0.03</b>	<b>0.15<math>\pm</math>0.09</b>	77.13 $\pm$ 0.67	<b>0.48<math>\pm</math>0.53</b>	<b>0.64<math>\pm</math>0.34</b>	<b>78.20<math>\pm</math>1.35</b>	<b>0.37<math>\pm</math>0.22</b>	<b>0.41<math>\pm</math>0.39</b>

Table 3: Comparison results in Pokec-z-R and Pokec-z-G.

Missing Rate	Pokec-z-R(0.1)			Pokec-z-R(0.2)			Pokec-z-R(0.3)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	62.59 $\pm$ 1.74	6.80 $\pm$ 0.82	6.66 $\pm$ 0.48	62.16 $\pm$ 1.93	5.54 $\pm$ 0.59	5.06 $\pm$ 1.02	61.96 $\pm$ 1.47	4.18 $\pm$ 0.59	3.70 $\pm$ 0.85
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	64.11 $\pm$ 1.76	2.29 $\pm$ 0.69	3.80 $\pm$ 0.88	66.95 $\pm$ 1.69	2.74 $\pm$ 0.94	1.49 $\pm$ 0.73	65.51 $\pm$ 1.83	1.20 $\pm$ 1.58	5.18 $\pm$ 0.84
Polynormer	66.64 $\pm$ 1.85	2.67 $\pm$ 0.33	1.68 $\pm$ 0.68	64.85 $\pm$ 1.93	1.79 $\pm$ 1.37	2.17 $\pm$ 0.96	63.87 $\pm$ 1.83	2.06 $\pm$ 0.49	2.57 $\pm$ 0.74
FMP	63.37 $\pm$ 1.72	1.92 $\pm$ 0.75	2.06 $\pm$ 0.58	62.31 $\pm$ 1.38	2.14 $\pm$ 1.38	2.86 $\pm$ 0.84	62.20 $\pm$ 1.58	1.59 $\pm$ 0.83	2.84 $\pm$ 0.74
FairSIN	62.80 $\pm$ 0.50	1.33 $\pm$ 0.63	0.81 $\pm$ 0.13	62.08 $\pm$ 1.83	1.65 $\pm$ 0.83	0.95 $\pm$ 0.68	61.39 $\pm$ 1.93	1.02 $\pm$ 0.46	1.19 $\pm$ 0.96
FairGT	63.90 $\pm$ 0.15	1.02 $\pm$ 0.37	1.76 $\pm$ 0.43	62.63 $\pm$ 1.38	1.67 $\pm$ 0.45	2.63 $\pm$ 0.60	62.11 $\pm$ 1.39	0.82 $\pm$ 0.11	1.86 $\pm$ 0.65
FairGNN	67.73 $\pm$ 1.07	1.73 $\pm$ 0.72	0.97 $\pm$ 0.39	67.38 $\pm$ 1.38	1.08 $\pm$ 0.27	1.95 $\pm$ 0.38	66.48 $\pm$ 1.55	1.92 $\pm$ 0.35	2.32 $\pm$ 0.49
FairAC	63.12 $\pm$ 1.44	2.52 $\pm$ 1.29	2.69 $\pm$ 0.48	62.35 $\pm$ 1.42	1.42 $\pm$ 0.43	1.72 $\pm$ 1.02	63.34 $\pm$ 0.89	2.76 $\pm$ 0.49	2.70 $\pm$ 0.06
FairGE	65.71 $\pm$ 1.04	0.79 $\pm$ 0.17	0.77 $\pm$ 0.24	64.73 $\pm$ 1.82	1.07 $\pm$ 0.46	0.62 $\pm$ 0.42	65.74 $\pm$ 1.28	0.67 $\pm$ 0.25	0.02 $\pm$ 0.02
Missing Rate	Pokec-z-R(0.4)			Pokec-z-R(0.5)			Pokec-z-R(0.6)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	60.87 $\pm$ 1.73	4.35 $\pm$ 0.38	5.42 $\pm$ 0.63	60.80 $\pm$ 1.86	3.45 $\pm$ 0.58	5.06 $\pm$ 1.21	59.59 $\pm$ 1.69	1.75 $\pm$ 0.73	3.89 $\pm$ 0.63
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	63.76 $\pm$ 1.59	1.28 $\pm$ 0.42	2.21 $\pm$ 0.31	64.50 $\pm$ 1.48	1.29 $\pm$ 0.63	1.52 $\pm$ 0.73	65.86 $\pm$ 1.48	3.33 $\pm$ 1.86	1.51 $\pm$ 0.58
Polynormer	64.46 $\pm$ 1.88	2.62 $\pm$ 1.52	3.47 $\pm$ 1.06	61.26 $\pm$ 1.37	3.97 $\pm$ 0.95	2.61 $\pm$ 0.84	60.48 $\pm$ 1.49	4.26 $\pm$ 0.58	3.15 $\pm$ 0.63
FMP	61.15 $\pm$ 1.78	1.25 $\pm$ 1.24	2.45 $\pm$ 0.47	61.34 $\pm$ 1.36	1.96 $\pm$ 0.73	2.48 $\pm$ 0.58	61.57 $\pm$ 1.97	1.94 $\pm$ 0.64	3.18 $\pm$ 0.57
FairSIN	60.83 $\pm$ 1.72	1.27 $\pm$ 0.26	1.33 $\pm$ 0.73	60.17 $\pm$ 1.47	0.33 $\pm$ 0.07	2.50 $\pm$ 0.52	59.46 $\pm$ 1.34	1.05 $\pm$ 0.12	1.14 $\pm$ 0.74
FairGT	61.72 $\pm$ 1.51	1.44 $\pm$ 0.22	1.36 $\pm$ 0.25	60.83 $\pm$ 1.83	0.72 $\pm$ 0.22	2.17 $\pm$ 0.39	60.99 $\pm$ 2.39	1.43 $\pm$ 0.51	1.33 $\pm$ 0.38
FairGNN	66.13 $\pm$ 1.64	1.99 $\pm$ 0.25	2.32 $\pm$ 0.78	66.91 $\pm$ 1.44	1.03 $\pm$ 0.78	1.68 $\pm$ 1.25	66.76 $\pm$ 1.84	1.42 $\pm$ 0.34	0.74 $\pm$ 0.26
FairAC	63.72 $\pm$ 1.56	2.39 $\pm$ 0.46	2.40 $\pm$ 1.02	63.94 $\pm$ 1.58	1.26 $\pm$ 0.47	1.53 $\pm$ 0.72	63.52 $\pm$ 1.39	1.80 $\pm$ 0.67	1.94 $\pm$ 0.88
FairGE	64.26 $\pm$ 1.75	1.03 $\pm$ 0.35	1.28 $\pm$ 0.68	64.11 $\pm$ 1.28	0.31 $\pm$ 0.15	1.08 $\pm$ 0.82	64.19 $\pm$ 1.63	0.11 $\pm$ 0.04	0.98 $\pm$ 0.67
Missing Rate	Pokec-z-G(0.1)			Pokec-z-G(0.2)			Pokec-z-G(0.3)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	61.70 $\pm$ 1.62	5.62 $\pm$ 0.49	6.58 $\pm$ 1.34	61.3 $\pm$ 0.87	5.63 $\pm$ 0.54	6.77 $\pm$ 0.22	61.15 $\pm$ 1.41	6.68 $\pm$ 0.76	6.81 $\pm$ 0.25
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.51 $\pm$ 1.24	1.99 $\pm$ 0.36	1.58 $\pm$ 0.95	65.46 $\pm$ 0.75	1.24 $\pm$ 0.49	2.24 $\pm$ 0.24	65.27 $\pm$ 1.18	1.02 $\pm$ 0.58	1.95 $\pm$ 0.23
Polynormer	65.32 $\pm$ 1.15	1.45 $\pm$ 0.17	3.83 $\pm$ 0.83	64.99 $\pm$ 0.69	1.63 $\pm$ 0.38	3.23 $\pm$ 0.26	64.92 $\pm$ 1.23	1.76 $\pm$ 0.47	2.77 $\pm$ 0.16
FMP	61.80 $\pm$ 1.37	2.92 $\pm$ 0.45	3.29 $\pm$ 1.42	62.05 $\pm$ 0.84	2.92 $\pm$ 0.52	3.29 $\pm$ 0.33	62.25 $\pm$ 1.31	2.54 $\pm$ 0.64	2.76 $\pm$ 0.29
FairSIN	60.57 $\pm$ 1.10	1.92 $\pm$ 0.22	3.41 $\pm$ 0.79	59.76 $\pm$ 0.68	1.09 $\pm$ 0.46	3.00 $\pm$ 0.21	60.47 $\pm$ 1.27	1.69 $\pm$ 0.59	2.94 $\pm$ 0.32
FairGT	63.43 $\pm$ 1.48	1.87 $\pm$ 0.34	2.19 $\pm$ 1.10	62.08 $\pm$ 0.79	1.93 $\pm$ 0.48	2.17 $\pm$ 0.25	61.53 $\pm$ 1.25	1.63 $\pm$ 0.63	1.25 $\pm$ 0.31
FairGNN	65.46 $\pm$ 0.82	1.65 $\pm$ 0.19	1.70 $\pm$ 1.17	65.75 $\pm$ 0.64	1.22 $\pm$ 0.59	2.63 $\pm$ 0.36	66.29 $\pm$ 0.92	1.43 $\pm$ 0.72	2.66 $\pm$ 0.34
FairAC	62.31 $\pm$ 1.05	2.52 $\pm$ 0.27	3.67 $\pm$ 0.88	61.53 $\pm$ 0.76	3.39 $\pm$ 0.44	3.93 $\pm$ 0.22	62.67 $\pm$ 1.09	2.85 $\pm$ 0.55	2.91 $\pm$ 0.29
FairGE	65.47 $\pm$ 1.01	0.73 $\pm$ 0.44	0.91 $\pm$ 0.23	66.84 $\pm$ 0.67	0.61 $\pm$ 0.53	0.85 $\pm$ 0.34	64.77 $\pm$ 1.36	0.28 $\pm$ 0.18	0.85 $\pm$ 0.37
Missing Rate	Pokec-z-G(0.4)			Pokec-z-G(0.5)			Pokec-z-G(0.6)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	61.15 $\pm$ 0.58	5.29 $\pm$ 0.12	5.23 $\pm$ 1.43	61.02 $\pm$ 0.76	5.87 $\pm$ 0.49	6.75 $\pm$ 0.21	60.38 $\pm$ 1.32	6.50 $\pm$ 0.65	7.74 $\pm$ 0.27
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.11 $\pm$ 1.35	1.12 $\pm$ 0.29	1.50 $\pm$ 0.97	65.23 $\pm$ 0.82	2.01 $\pm$ 0.47	1.05 $\pm$ 0.25	65.12 $\pm$ 1.19	2.40 $\pm$ 0.54	0.88 $\pm$ 0.22
Polynormer	64.71 $\pm$ 1.10	1.80 $\pm$ 0.15	3.09 $\pm$ 0.85	64.40 $\pm$ 0.66	1.09 $\pm$ 0.38	2.77 $\pm$ 0.27	64.36 $\pm$ 1.25	1.11 $\pm$ 0.46	3.24 $\pm$ 0.19
FMP	62.06 $\pm$ 1.43	2.84 $\pm$ 0.41	2.82 $\pm$ 1.38	61.96 $\pm$ 0.84	2.84 $\pm$ 0.52	2.82 $\pm$ 0.33	61.87 $\pm$ 1.31	1.99 $\pm$ 0.62	3.01 $\pm$ 0.28
FairSIN	58.57 $\pm$ 1.07	0.84 $\pm$ 0.23	3.47 $\pm$ 0.78	58.30 $\pm$ 0.69	0.53 $\pm$ 0.45	1.17 $\pm$ 0.21	58.34 $\pm$ 1.23	1.16 $\pm$ 0.58	3.56 $\pm$ 0.32
FairGT	62.49 $\pm$ 1.49	1.73 $\pm$ 0.35	1.50 $\pm$ 1.04	62.49 $\pm$ 0.79	1.73 $\pm$ 0.48	1.50 $\pm$ 0.24	62.63 $\pm$ 1.16	2.79 $\pm$ 0.49	2.13 $\pm$ 0.26
FairGNN	68.05 $\pm$ 0.73	1.01 $\pm$ 0.18	2.33 $\pm$ 1.16	67.13 $\pm$ 0.64	1.40 $\pm$ 0.59	1.69 $\pm$ 0.36	66.87 $\pm$ 0.93	1.88 $\pm$ 0.72	1.21 $\pm$ 0.34
FairAC	63.02 $\pm$ 1.04	1.93 $\pm$ 0.26	2.57 $\pm$ 0.89	62.76 $\pm$ 0.76	2.75 $\pm$ 0.44	2.92 $\pm$ 0.22	62.82 $\pm$ 1.09	1.64 $\pm$ 0.55	3.05 $\pm$ 0.29
FairGE	65.28 $\pm$ 0.98	0.54 $\pm$ 0.42	0.99 $\pm$ 0.22	64.50 $\pm$ 0.67	0.30 $\pm$ 0.43	0.88 $\pm$ 0.34	64.58 $\pm$ 1.35	0.72 $\pm$ 0.63	0.34 $\pm$ 0.28

Table 4: Comparison results in Pokec-n-R and Pokec-n-G.

Missing Rate	Pokec-n-R(0.1)			Pokec-n-R(0.2)			Pokec-n-R(0.3)		
	Metrics	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$	$\Delta_{EO}(\%) \downarrow$	ACC(%) $\uparrow$	$\Delta_{SP}(\%) \downarrow$
GCN	64.09 $\pm$ 1.32	6.18 $\pm$ 0.46	5.42 $\pm$ 1.19	62.59 $\pm$ 0.85	8.02 $\pm$ 0.52	6.44 $\pm$ 0.27	63.27 $\pm$ 1.24	6.31 $\pm$ 0.70	6.04 $\pm$ 0.19
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.73 $\pm$ 1.17	2.08 $\pm$ 0.33	2.39 $\pm$ 0.89	63.68 $\pm$ 0.74	3.05 $\pm$ 0.46	3.29 $\pm$ 0.25	64.36 $\pm$ 1.05	3.21 $\pm$ 0.58	4.55 $\pm$ 0.22
Polynormer	66.32 $\pm$ 1.05	2.64 $\pm$ 0.14	3.06 $\pm$ 0.93	64.09 $\pm$ 0.66	3.40 $\pm$ 0.38	4.70 $\pm$ 0.22	65.73 $\pm$ 1.17	2.28 $\pm$ 0.43	2.52 $\pm$ 0.17
FMP	64.23 $\pm$ 1.28	5.12 $\pm$ 0.41	5.46 $\pm$ 1.36	62.73 $\pm$ 0.83	2.87 $\pm$ 0.50	1.96 $\pm$ 0.33	62.27 $\pm$ 1.29	2.74 $\pm$ 0.61	1.63 $\pm$ 0.28
FairSIN	63.27 $\pm$ 1.12	3.32 $\pm$ 0.23	4.21 $\pm$ 0.77	62.08 $\pm$ 0.68	1.43 $\pm$ 0.45	1.79 $\pm$ 0.21	61.32 $\pm$ 1.32	2.10 $\pm$ 0.57	2.16 $\pm$ 0.31
FairGT	63.27 $\pm$ 1.47	2.42 $\pm$ 0.32	2.70 $\pm$ 1.03	61.75 $\pm$ 0.79	2.05 $\pm$ 0.45	3.08 $\pm$ 0.24	61.00 $\pm$ 1.15	2.40 $\pm$ 0.48	3.17 $\pm$ 0.26
FairGNN	66.00 $\pm$ 0.78	3.08 $\pm$ 0.18	1.23 $\pm$ 1.15	65.95 $\pm$ 0.64	2.13 $\pm$ 0.59	2.35 $\pm$ 0.36	65.68 $\pm$ 0.92	2.87 $\pm$ 0.71	2.22 $\pm$ 0.33
FairAC	63.76 $\pm$ 1.03	2.63 $\pm$ 0.26	5.47 $\pm$ 0.87	63.49 $\pm$ 0.76	2.59 $\pm$ 0.44	2.48 $\pm$ 0.22	63.90 $\pm$ 1.08	2.49 $\pm$ 0.54	3.45 $\pm$ 0.28
<b>FairGE</b>	<b>66.18<math>\pm</math>0.97</b>	<b>0.09<math>\pm</math>0.02</b>	<b>1.37<math>\pm</math>1.21</b>	<b>65.82<math>\pm</math>0.67</b>	<b>0.33<math>\pm</math>0.13</b>	<b>0.47<math>\pm</math>0.34</b>	<b>64.95<math>\pm</math>1.35</b>	<b>0.75<math>\pm</math>0.62</b>	<b>0.50<math>\pm</math>0.39</b>
Missing Rate	Pokec-n-R(0.4)			Pokec-n-R(0.5)			Pokec-n-R(0.6)		
GCN	62.82 $\pm$ 1.54	6.84 $\pm$ 0.37	5.87 $\pm$ 1.26	63.05 $\pm$ 0.91	8.52 $\pm$ 0.48	6.98 $\pm$ 0.23	62.23 $\pm$ 1.38	10.82 $\pm$ 0.72	9.70 $\pm$ 0.20
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.36 $\pm$ 1.19	2.72 $\pm$ 0.32	2.85 $\pm$ 0.92	64.05 $\pm$ 0.73	5.77 $\pm$ 0.46	5.12 $\pm$ 0.25	63.09 $\pm$ 1.05	2.38 $\pm$ 0.59	2.62 $\pm$ 0.22
Polynormer	63.36 $\pm$ 1.07	3.91 $\pm$ 0.16	3.83 $\pm$ 0.84	61.68 $\pm$ 0.67	3.86 $\pm$ 0.39	6.21 $\pm$ 0.26	58.41 $\pm$ 1.17	5.67 $\pm$ 0.44	2.48 $\pm$ 0.17
FMP	61.55 $\pm$ 1.26	2.57 $\pm$ 0.43	2.76 $\pm$ 1.36	60.95 $\pm$ 0.82	2.45 $\pm$ 0.51	1.80 $\pm$ 0.33	60.05 $\pm$ 1.29	2.14 $\pm$ 0.60	3.08 $\pm$ 0.28
FairSIN	61.44 $\pm$ 1.14	2.45 $\pm$ 0.23	2.64 $\pm$ 0.77	60.71 $\pm$ 0.68	1.73 $\pm$ 0.45	2.46 $\pm$ 0.21	57.05 $\pm$ 1.23	1.00 $\pm$ 0.57	1.22 $\pm$ 0.32
FairGT	58.81 $\pm$ 1.39	2.04 $\pm$ 0.35	2.68 $\pm$ 1.03	58.45 $\pm$ 0.79	2.12 $\pm$ 0.45	1.70 $\pm$ 0.24	57.45 $\pm$ 1.15	1.74 $\pm$ 0.48	1.74 $\pm$ 0.26
FairGNN	65.50 $\pm$ 0.76	3.06 $\pm$ 0.18	1.24 $\pm$ 1.15	65.00 $\pm$ 0.64	2.60 $\pm$ 0.59	2.12 $\pm$ 0.36	64.55 $\pm$ 0.92	4.01 $\pm$ 0.71	2.66 $\pm$ 0.33
FairAC	64.32 $\pm$ 1.03	2.46 $\pm$ 0.26	3.57 $\pm$ 0.87	63.77 $\pm$ 0.76	2.68 $\pm$ 0.44	1.99 $\pm$ 0.22	63.21 $\pm$ 1.08	2.78 $\pm$ 0.54	3.52 $\pm$ 0.28
<b>FairGE</b>	<b>62.59<math>\pm</math>0.97</b>	<b>0.20<math>\pm</math>0.12</b>	<b>0.04<math>\pm</math>0.01</b>	<b>63.23<math>\pm</math>0.67</b>	<b>1.10<math>\pm</math>0.53</b>	<b>0.24<math>\pm</math>0.14</b>	<b>61.95<math>\pm</math>1.35</b>	<b>0.13<math>\pm</math>0.02</b>	<b>0.99<math>\pm</math>0.39</b>
Missing Rate	Pokec-n-G(0.1)			Pokec-n-G(0.2)			Pokec-n-G(0.3)		
GCN	61.88 $\pm$ 1.2	5.36 $\pm$ 0.38	5.58 $\pm$ 1.45	61.56 $\pm$ 0.92	5.05 $\pm$ 0.51	5.45 $\pm$ 0.26	61.42 $\pm$ 1.37	5.19 $\pm$ 0.74	5.54 $\pm$ 0.29
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	65.98 $\pm$ 1.38	1.84 $\pm$ 0.27	5.43 $\pm$ 0.91	65.83 $\pm$ 0.75	1.89 $\pm$ 0.48	5.52 $\pm$ 0.24	64.86 $\pm$ 1.18	1.72 $\pm$ 0.58	6.61 $\pm$ 0.23
Polynormer	63.85 $\pm$ 1.12	3.60 $\pm$ 0.19	7.50 $\pm$ 0.84	64.07 $\pm$ 0.67	2.84 $\pm$ 0.39	6.06 $\pm$ 0.26	63.77 $\pm$ 1.24	1.87 $\pm$ 0.47	5.05 $\pm$ 0.17
FMP	63.71 $\pm$ 1.45	1.46 $\pm$ 0.42	1.95 $\pm$ 1.37	63.72 $\pm$ 0.84	1.53 $\pm$ 0.53	1.95 $\pm$ 0.33	63.71 $\pm$ 1.31	1.99 $\pm$ 0.64	1.20 $\pm$ 0.28
FairSIN	62.20 $\pm$ 1.09	2.28 $\pm$ 0.23	2.67 $\pm$ 0.79	63.03 $\pm$ 0.69	1.57 $\pm$ 0.46	3.97 $\pm$ 0.21	62.3 $\pm$ 1.28	0.69 $\pm$ 0.59	5.45 $\pm$ 0.32
FairGT	62.58 $\pm$ 1.47	2.28 $\pm$ 0.35	4.03 $\pm$ 1.05	62.24 $\pm$ 0.79	2.94 $\pm$ 0.48	2.83 $\pm$ 0.25	61.45 $\pm$ 1.25	2.03 $\pm$ 0.63	4.18 $\pm$ 0.31
FairGNN	65.66 $\pm$ 0.81	3.15 $\pm$ 0.19	1.50 $\pm$ 1.18	65.48 $\pm$ 0.64	3.30 $\pm$ 0.59	1.50 $\pm$ 0.36	65.37 $\pm$ 0.93	3.39 $\pm$ 0.72	1.50 $\pm$ 0.34
FairAC	62.87 $\pm$ 1.05	3.92 $\pm$ 0.27	2.04 $\pm$ 0.90	63.32 $\pm$ 0.76	3.75 $\pm$ 0.44	2.35 $\pm$ 0.22	63.55 $\pm$ 1.10	3.38 $\pm$ 0.55	3.01 $\pm$ 0.29
<b>FairGE</b>	<b>64.68<math>\pm</math>0.99</b>	<b>1.03<math>\pm</math>0.44</b>	<b>1.25<math>\pm</math>1.22</b>	<b>64.05<math>\pm</math>0.67</b>	<b>1.57<math>\pm</math>0.53</b>	<b>1.34<math>\pm</math>0.34</b>	<b>64.45<math>\pm</math>1.36</b>	<b>0.36<math>\pm</math>0.28</b>	<b>1.12<math>\pm</math>0.37</b>
Missing Rate	Pokec-n-G(0.4)			Pokec-n-G(0.5)			Pokec-n-G(0.6)		
GCN	61.42 $\pm$ 1.28	5.31 $\pm$ 0.45	5.93 $\pm$ 1.39	61.76 $\pm$ 0.93	5.89 $\pm$ 0.56	5.99 $\pm$ 0.22	62.38 $\pm$ 1.42	5.83 $\pm$ 0.78	6.48 $\pm$ 0.26
SGFormer	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM	OOM
CoBFormer	64.44 $\pm$ 1.33	1.99 $\pm$ 0.31	7.04 $\pm$ 0.94	64.58 $\pm$ 0.72	2.36 $\pm$ 0.47	6.97 $\pm$ 0.25	65.62 $\pm$ 1.19	2.32 $\pm$ 0.59	6.95 $\pm$ 0.21
Polynormer	63.69 $\pm$ 1.08	1.38 $\pm$ 0.14	4.50 $\pm$ 0.85	63.20 $\pm$ 0.68	2.48 $\pm$ 0.39	5.51 $\pm$ 0.26	63.25 $\pm$ 1.26	2.64 $\pm$ 0.47	5.34 $\pm$ 0.18
FMP	63.71 $\pm$ 1.42	2.22 $\pm$ 0.41	1.52 $\pm$ 1.37	63.93 $\pm$ 0.84	1.87 $\pm$ 0.53	1.38 $\pm$ 0.33	64.73 $\pm$ 1.32	1.67 $\pm$ 0.64	1.38 $\pm$ 0.27
FairSIN	61.23 $\pm$ 1.10	2.14 $\pm$ 0.23	5.28 $\pm$ 0.78	60.91 $\pm$ 0.69	1.87 $\pm$ 0.45	3.62 $\pm$ 0.21	60.73 $\pm$ 1.24	3.67 $\pm$ 0.58	4.32 $\pm$ 0.32
FairGT	63.27 $\pm$ 1.49	3.35 $\pm$ 0.35	0.55 $\pm$ 0.44	62.80 $\pm$ 0.79	2.34 $\pm$ 0.48	4.00 $\pm$ 0.24	61.11 $\pm$ 1.17	3.56 $\pm$ 0.49	3.51 $\pm$ 0.26
FairGNN	65.37 $\pm$ 0.75	3.54 $\pm$ 0.19	3.69 $\pm$ 1.16	65.56 $\pm$ 0.64	3.33 $\pm$ 0.59	3.69 $\pm$ 0.36	65.82 $\pm$ 0.94	2.55 $\pm$ 0.73	3.69 $\pm$ 0.35
FairAC	63.80 $\pm$ 1.04	2.74 $\pm$ 0.27	3.50 $\pm$ 0.89	63.71 $\pm$ 0.76	4.07 $\pm$ 0.44	3.86 $\pm$ 0.22	63.23 $\pm$ 1.10	4.21 $\pm$ 0.56	3.53 $\pm$ 0.29
<b>FairGE</b>	<b>64.27<math>\pm</math>0.98</b>	<b>0.68<math>\pm</math>0.43</b>	<b>0.35<math>\pm</math>0.23</b>	<b>64.09<math>\pm</math>0.67</b>	<b>0.65<math>\pm</math>0.54</b>	<b>1.59<math>\pm</math>0.35</b>	<b>64.14<math>\pm</math>1.36</b>	<b>1.57<math>\pm</math>0.65</b>	<b>0.73<math>\pm</math>0.38</b>

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Table 5: Comparison results in AMiner-S.

Missing Rate Metrics	AMiner-S(0.1)			AMiner-S(0.2)			AMiner-S(0.3)		
	ACC(%) $\uparrow$	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) $\uparrow$	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) $\uparrow$	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	88.85 $\pm$ 1.09	5.19 $\pm$ 2.63	4.98 $\pm$ 1.34	83.72 $\pm$ 1.06	8.61 $\pm$ 2.09	8.58 $\pm$ 2.12	83.13 $\pm$ 1.32	7.12 $\pm$ 1.16	6.43 $\pm$ 0.09
SGFormer	<b>89.54<math>\pm</math>0.07</b>	4.63 $\pm$ 0.69	4.75 $\pm$ 0.25	88.30 $\pm$ 0.08	4.64 $\pm$ 0.05	5.18 $\pm$ 1.61	<b>87.88<math>\pm</math>0.18</b>	4.33 $\pm$ 0.06	3.31 $\pm$ 0.53
CoBFormer	88.13 $\pm$ 1.26	4.65 $\pm$ 0.94	5.36 $\pm$ 2.65	87.86 $\pm$ 0.28	4.46 $\pm$ 0.78	4.99 $\pm$ 3.60	86.26 $\pm$ 0.40	5.19 $\pm$ 1.09	<b>3.05<math>\pm</math>1.57</b>
Polynormer	<b>89.42<math>\pm</math>0.19</b>	5.16 $\pm$ 0.91	3.98 $\pm$ 1.51	<b>88.68<math>\pm</math>0.34</b>	4.11 $\pm$ 0.21	5.86 $\pm$ 2.70	<b>87.99<math>\pm</math>1.34</b>	4.31 $\pm$ 0.79	4.18 $\pm$ 1.79
FMP	88.33 $\pm$ 0.96	7.10 $\pm$ 2.02	4.33 $\pm$ 1.92	86.46 $\pm$ 1.52	5.81 $\pm$ 1.57	6.03 $\pm$ 1.63	85.84 $\pm$ 1.26	4.44 $\pm$ 1.65	4.24 $\pm$ 0.78
FairSIN	85.74 $\pm$ 1.60	4.85 $\pm$ 3.78	4.88 $\pm$ 1.72	84.25 $\pm$ 0.01	4.52 $\pm$ 1.89	<b>4.68<math>\pm</math>1.24</b>	84.04 $\pm$ 0.16	4.29 $\pm$ 0.24	3.28 $\pm$ 0.22
FairGT	89.05 $\pm$ 1.00	4.51 $\pm$ 0.60	4.05 $\pm$ 0.89	87.25 $\pm$ 1.11	<b>3.54<math>\pm</math>0.23</b>	5.88 $\pm$ 1.90	86.59 $\pm$ 0.42	3.60 $\pm$ 0.63	3.57 $\pm$ 1.95
FairGNN	86.00 $\pm$ 1.05	4.03 $\pm$ 1.63	<b>3.75<math>\pm</math>2.86</b>	87.59 $\pm$ 1.81	4.81 $\pm$ 2.39	5.44 $\pm$ 2.37	86.62 $\pm$ 1.11	4.48 $\pm$ 0.65	4.23 $\pm$ 1.26
FairAC	78.94 $\pm$ 2.04	<b>3.63<math>\pm</math>2.10</b>	6.37 $\pm$ 2.03	79.61 $\pm$ 0.02	3.93 $\pm$ 0.04	6.43 $\pm$ 1.31	80.86 $\pm$ 0.06	<b>3.47<math>\pm</math>1.13</b>	5.88 $\pm$ 1.51
<b>FairGE</b>	89.12 $\pm$ 1.34	<b>3.59<math>\pm</math>0.28</b>	<b>2.97<math>\pm</math>0.37</b>	<b>88.33<math>\pm</math>2.03</b>	<b>3.52<math>\pm</math>1.05</b>	<b>3.52<math>\pm</math>1.06</b>	87.01 $\pm$ 1.01	<b>2.94<math>\pm</math>0.49</b>	<b>1.69<math>\pm</math>0.54</b>
Missing Rate Metrics	AMiner-S(0.4)			AMiner-S(0.5)			AMiner-S(0.6)		
	ACC(%) $\uparrow$	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) $\uparrow$	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$	ACC(%) $\uparrow$	$\Delta_{SP}(\%)_{\downarrow}$	$\Delta_{EO}(\%)_{\downarrow}$
GCN	83.08 $\pm$ 1.87	5.81 $\pm$ 1.27	4.96 $\pm$ 1.77	81.48 $\pm$ 1.36	4.49 $\pm$ 0.90	5.67 $\pm$ 1.08	81.89 $\pm$ 1.71	4.41 $\pm$ 1.01	6.13 $\pm$ 1.46
SGFormer	<b>85.54<math>\pm</math>1.35</b>	4.87 $\pm$ 0.86	4.11 $\pm$ 2.07	<b>84.57<math>\pm</math>0.51</b>	4.24 $\pm$ 0.37	4.00 $\pm$ 1.74	83.47 $\pm$ 1.00	4.90 $\pm$ 0.42	4.06 $\pm$ 0.84
CoBFormer	84.84 $\pm$ 1.29	<b>2.54<math>\pm</math>0.33</b>	4.40 $\pm$ 0.64	83.32 $\pm$ 2.58	<b>2.19<math>\pm</math>0.19</b>	5.46 $\pm$ 2.29	<b>84.18<math>\pm</math>0.30</b>	3.49 $\pm$ 0.14	4.07 $\pm$ 3.97
Polynormer	85.04 $\pm$ 2.48	3.79 $\pm$ 2.01	3.40 $\pm$ 1.49	<b>85.14<math>\pm</math>1.94</b>	3.57 $\pm$ 1.69	4.11 $\pm$ 1.91	83.17 $\pm$ 0.09	3.41 $\pm$ 0.14	4.87 $\pm$ 0.75
FMP	85.42 $\pm$ 1.25	4.76 $\pm$ 0.17	3.90 $\pm$ 1.65	84.23 $\pm$ 1.65	4.47 $\pm$ 1.16	4.76 $\pm$ 0.78	<b>85.50<math>\pm</math>1.32</b>	3.80 $\pm$ 0.62	5.68 $\pm$ 0.69
FairSIN	82.15 $\pm$ 0.07	3.16 $\pm$ 0.04	<b>3.15<math>\pm</math>0.04</b>	80.06 $\pm$ 0.29	2.21 $\pm$ 0.31	<b>2.07<math>\pm</math>0.05</b>	79.91 $\pm$ 0.80	3.63 $\pm$ 2.32	<b>3.69<math>\pm</math>3.46</b>
FairGT	84.26 $\pm$ 1.88	2.66 $\pm$ 1.39	4.65 $\pm$ 2.04	82.12 $\pm$ 0.38	2.60 $\pm$ 0.61	4.23 $\pm$ 1.87	80.24 $\pm$ 0.00	2.94 $\pm$ 0.60	3.92 $\pm$ 0.42
FairGNN	83.58 $\pm$ 0.35	4.84 $\pm$ 1.98	4.63 $\pm$ 2.49	83.36 $\pm$ 1.77	4.75 $\pm$ 1.22	4.64 $\pm$ 2.54	82.58 $\pm$ 1.93	<b>2.59<math>\pm</math>1.28</b>	6.33 $\pm$ 1.18
FairAC	81.44 $\pm$ 0.25	2.81 $\pm$ 0.35	5.92 $\pm$ 1.40	81.44 $\pm$ 1.61	4.18 $\pm$ 1.91	11.09 $\pm$ 2.01	81.93 $\pm$ 0.74	<b>5.23<math>\pm</math>2.95</b>	10.14 $\pm$ 2.74
<b>FairGE</b>	<b>85.56<math>\pm</math>0.53</b>	<b>2.26<math>\pm</math>1.89</b>	<b>2.42<math>\pm</math>0.24</b>	83.77 $\pm$ 0.69	<b>2.10<math>\pm</math>0.19</b>	<b>1.74<math>\pm</math>0.01</b>	83.52 $\pm$ 0.35	<b>1.92<math>\pm</math>0.29</b>	<b>2.21<math>\pm</math>0.43</b>

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