

Table 1: Results of PRUC with different base models on XMRec with cluster number $K = 1$. The best results are marked with **bold face**.

Data	Method	Recall@20	F1@20	MAP@20	NDCG@20	Precision@20
France, Italy, India →Japan, Mexico	CDL (Base Model)	0.0143	0.0016	0.0028	0.0009	0.0009
	PRUC w/o Causality	0.1149	0.0138	0.0335	0.0093	0.0073
	PRUC (Full)	0.1193	0.0143	0.0369	0.0101	0.0076
	DLRM (Base Model)	0.0044	0.0004	0.0004	0.0002	0.0002
	PRUC w/o Causality	0.0165	0.0020	0.0019	0.0009	0.0010
	PRUC (Full)	0.0178	0.0021	0.0020	0.0010	0.0011
	PerK (Base Model)	0.1098	0.0128	0.0512	0.0112	0.0068
	PRUC w/o Causality	0.1345	0.0160	0.0562	0.0131	0.0085
	PRUC (Full)	0.1600	0.0189	0.0621	0.0148	0.0100
	NCF (Base Model)	0.0131	0.0015	0.0026	0.0008	0.0008
	PRUC w/o Causality	0.1099	0.0132	0.0233	0.0077	0.0070
	PRUC (Full)	0.1204	0.0146	0.0285	0.0090	0.0077
	LightGCN (Base Model)	0.0182	0.0021	0.0050	0.0014	0.0011
	PRUC w/o Causality	0.0836	0.0101	0.0255	0.0069	0.0054
	PRUC (Full)	0.0875	0.0106	0.0285	0.0074	0.0056

Table 2: Results of PRUC with different base models on XMRec with cluster number $K = 2$. The best results are marked with **bold face**.

Data	Method	Recall@20	F1@20	MAP@20	NDCG@20	Precision@20
France, Italy, India →Japan, Mexico	CDL (Base Model)	0.0143	0.0016	0.0028	0.0009	0.0009
	PRUC w/o Causality	0.0918	0.0110	0.0332	0.0083	0.0059
	PRUC (Full)	0.1032	0.0120	0.0476	0.0104	0.0063
	DLRM (Base Model)	0.0044	0.0004	0.0004	0.0002	0.0002
	PRUC w/o Causality	0.0194	0.0023	0.0031	0.0012	0.0012
	PRUC (Full)	0.0273	0.0031	0.0063	0.0018	0.0016
	PerK (Base Model)	0.1098	0.0128	0.0512	0.0112	0.0068
	PRUC w/o Causality	0.1198	0.0139	0.0539	0.0120	0.0074
	PRUC (Full)	0.1345	0.0153	0.0456	0.0113	0.0081
	NCF (Base Model)	0.0131	0.0015	0.0026	0.0008	0.0008
	PRUC w/o Causality	0.0960	0.0115	0.0234	0.0071	0.0061
	PRUC (Full)	0.1269	0.0151	0.0324	0.0096	0.0080
	LightGCN (Base Model)	0.0182	0.0021	0.0050	0.0014	0.0011
	PRUC w/o Causality	0.0723	0.0086	0.0205	0.0056	0.0046
	PRUC (Full)	0.0947	0.0111	0.0348	0.0085	0.0059

Table 3: Results of PRUC with different base models on XMRec with cluster number $K = 4$. The best results are marked with **bold face**.

Data	Method	Recall@20	F1@20	MAP@20	NDCG@20	Precision@20
France, Italy, India →Japan, Mexico	CDL (Base Model)	0.0143	0.0016	0.0028	0.0009	0.0009
	PRUC w/o Causality	0.1046	0.0123	0.0339	0.0087	0.0065
	PRUC (Full)	0.1350	0.0160	0.0571	0.0133	0.0085
	DLRM (Base Model)	0.0044	nan	0.0004	0.0002	0.0002
	PRUC w/o Causality	0.0270	0.0030	0.0057	0.0018	0.0016
	PRUC (Full)	0.0299	0.0035	0.0047	0.0018	0.0019
	PerK (Base Model)	0.1098	0.0128	0.0512	0.0112	0.0068
	PRUC w/o Causality	0.1390	0.0162	0.0558	0.0130	0.0086
	PRUC (Full)	0.1757	0.0203	0.0666	0.0158	0.0108
	NCF (Base Model)	0.0131	0.0015	0.0026	0.0008	0.0008
	PRUC w/o Causality	0.1090	0.0130	0.0241	0.0077	0.0069
	PRUC (Full)	0.1254	0.0149	0.0342	0.0099	0.0079
	LightGCN (Base Model)	0.0182	0.0021	0.0050	0.0014	0.0011
	PRUC w/o Causality	0.0975	0.0115	0.0298	0.0078	0.0061
	PRUC (Full)	0.1065	0.0127	0.0429	0.0102	0.0068