

## S1. Colab notebook (baseline, illustrative)

- **Purpose:** sanity-check the idealised behaviour, validate the metric pipeline ( $\hat{p}$ , bias, RMSE, BER, margin), and provide a clean reference for expected transfer curves under nominal/ideal components.
- **What is included:** idealised Jones model runs (no/weak non-idealities), baseline transfer curves  $\hat{p}_{out}(\hat{p}_{in})$ , and basic one-at-a-time sweeps demonstrating the trend directions.
- **What is not claimed:** S1 is **not** used to draw engineering conclusions or tolerance limits; numerical values are illustrative and may appear near-ideal by design.
- **Link to main results:** paper figures, rankings, and tolerance conclusions are derived from S2/S3 (non-idealities + automated sweeps + joint Monte-Carlo).
- **Reusability:** S1 is structured so measured component specifications can be injected (same parameter names as S2/S3), enabling a quick “ideal-to-real” transition.

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Saved figures to: S1\_outputs

Saved sensitivity figures to: S1\_outputs

/usr/local/lib/python3.12/dist-packages/numpy/lib/\_function\_base\_impl.py:2922:

RuntimeWarning: invalid value encountered in divide

c /= stddev[:, None]

/usr/local/lib/python3.12/dist-packages/numpy/lib/\_function\_base\_impl.py:2923:

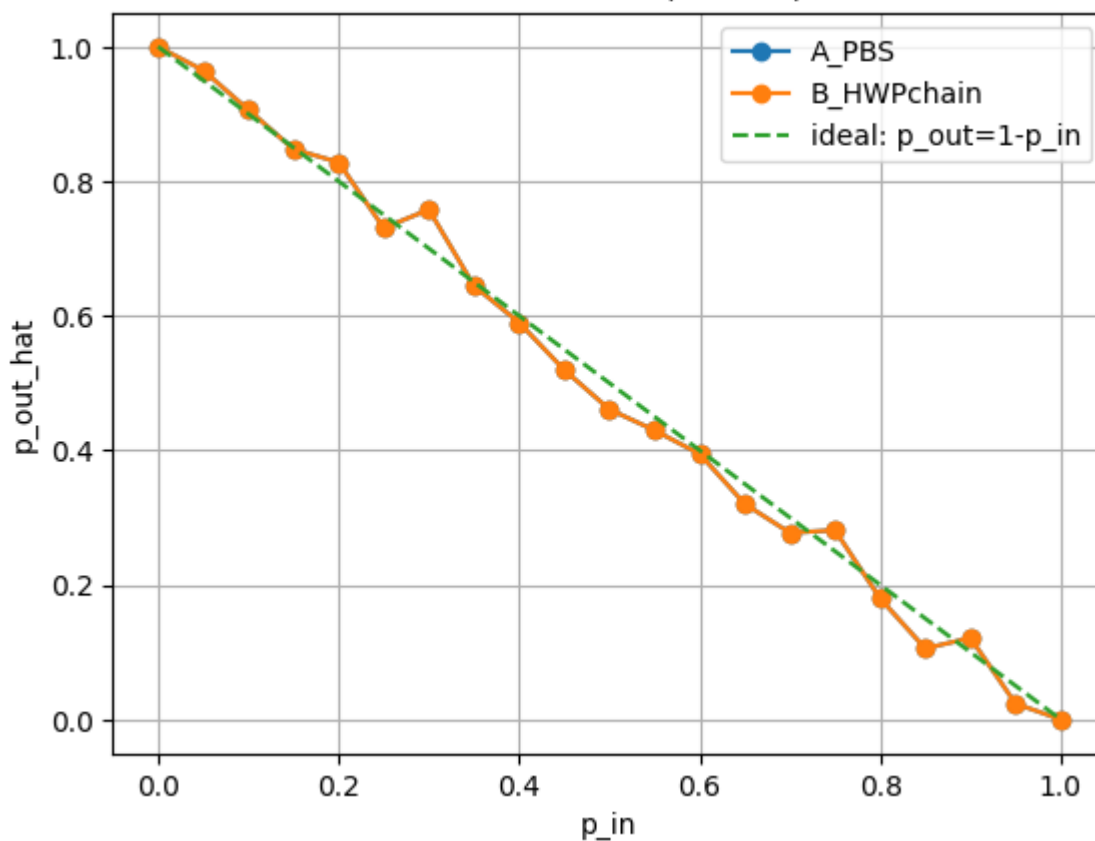
RuntimeWarning: invalid value encountered in divide

c /= stddev[None, :]

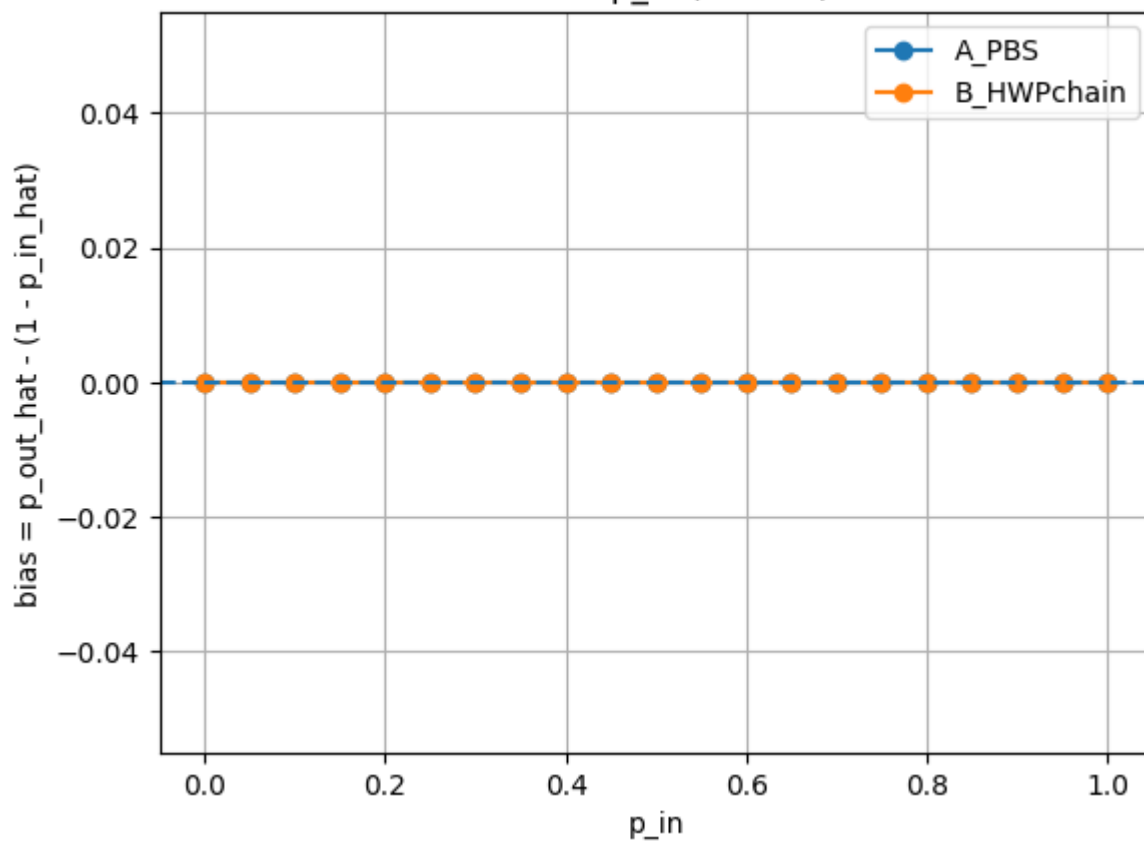
Export index written: S1\_outputs/S1\_export\_index.json

Figures: ['Fig\_BER\_vs\_ER.png', 'Fig\_BER\_vs\_theta.png', 'Fig\_bias\_N1024.png', 'Fig\_bias\_N256.png', 'Fig\_bias\_N4096.png', 'Fig\_transfer\_N1024.png', 'Fig\_transfer\_N256.png', 'Fig\_transfer\_N4096.png']

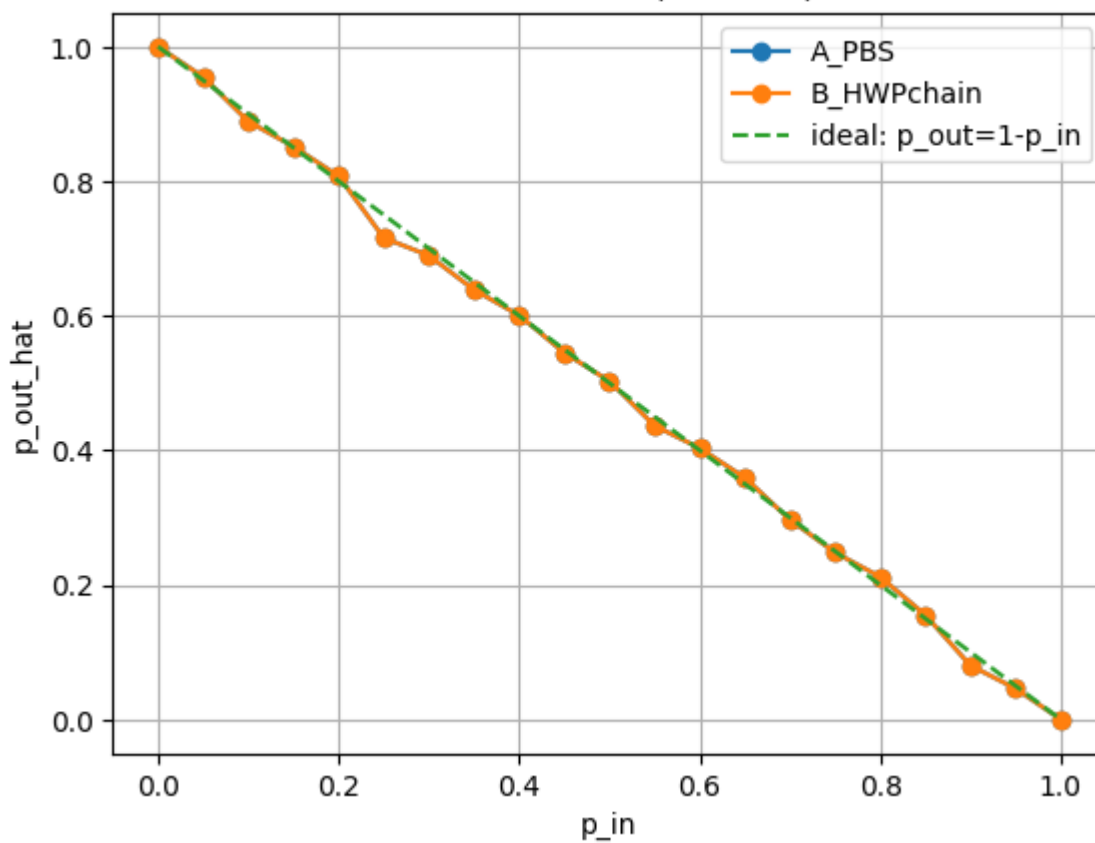
Transfer curve (N=256)



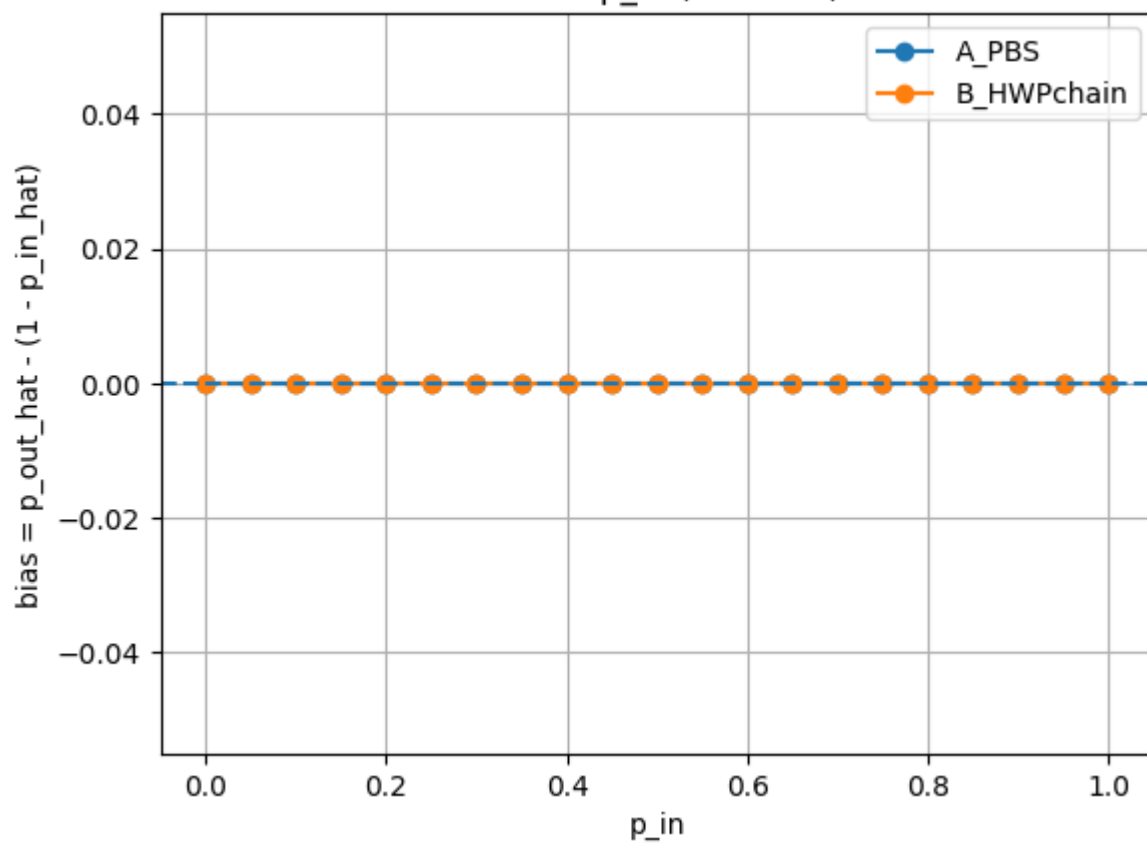
Bias vs  $p_{in}$  (N=256)



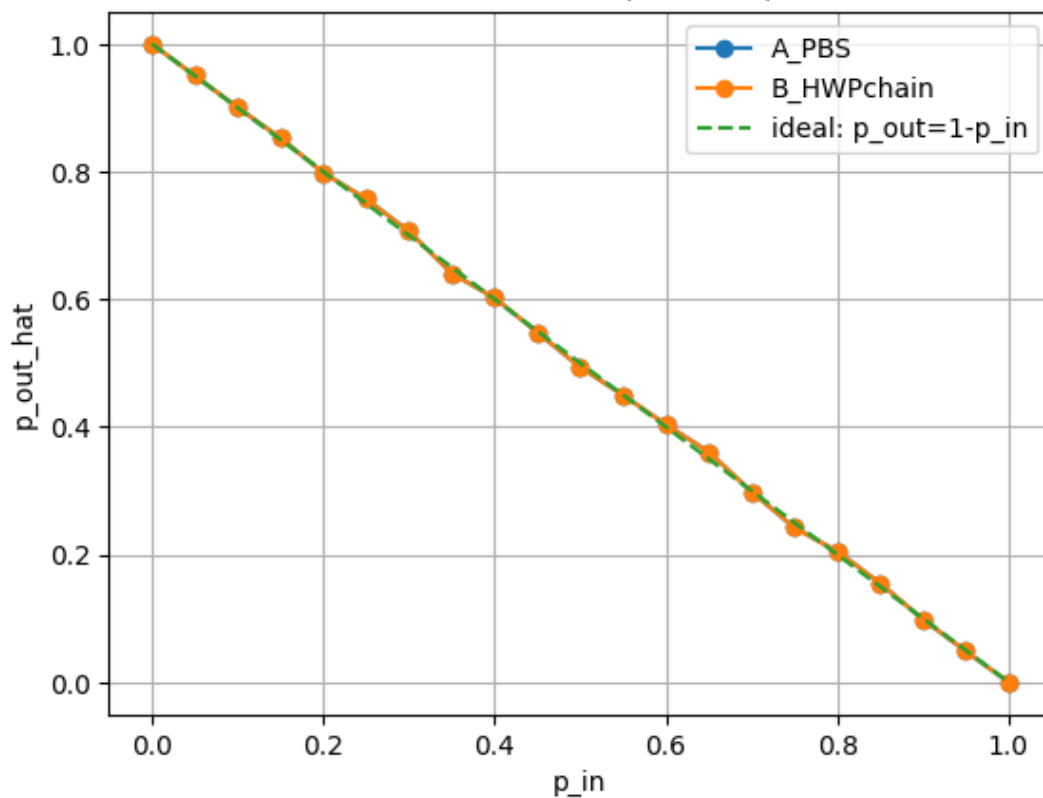
Transfer curve (N=1024)



Bias vs  $p_{in}$  (N=1024)



Transfer curve (N=4096)



Bias vs  $p_{in}$  (N=4096)

