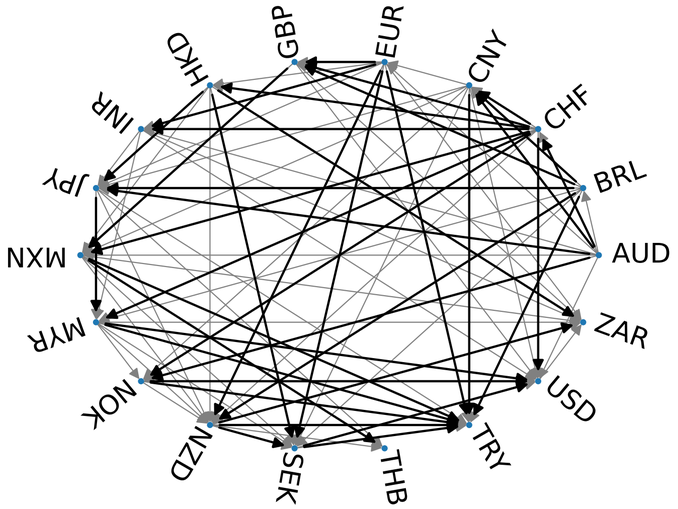
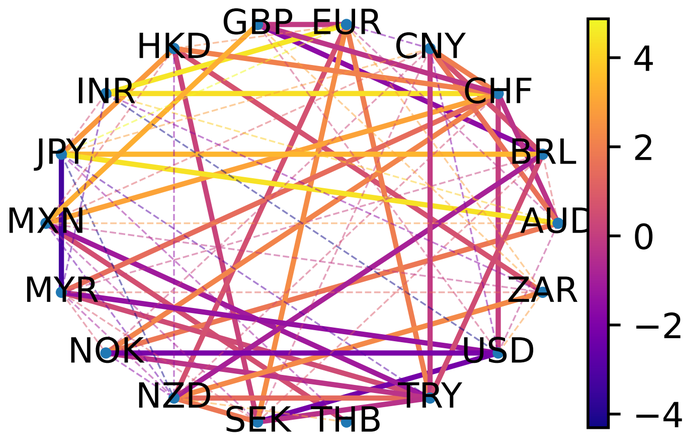
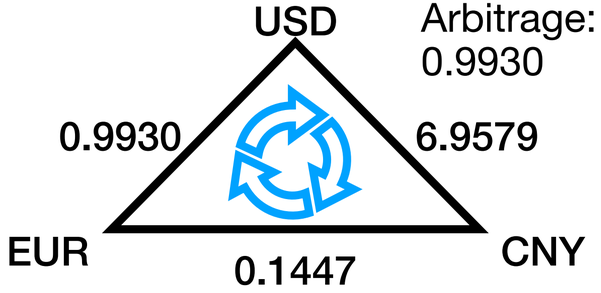
Learning for Forex







$$r^{a/b} r^{b/c} = r^{a/c}$$ Arbitrage-free

$$f_{[a,b]} + f_{[b,c]} - f_{[a,c]} = 0$$ Curl-free

Table 1: Forex results (nmse|total arbitrage, ↓).

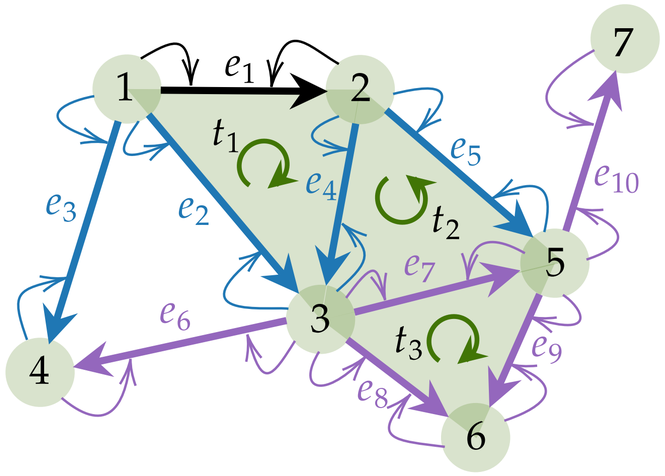
Methods	Random Noise	Curl Noise	Interpolation
Input	$0.119_{\pm 0.004}$|$29.19_{\pm 0.874}$	$0.552_{\pm 0.027}$|$122.4_{\pm 5.90}$	$0.717_{\pm .030}$|$106.4_{\pm 0.902}$
Baseline (ℓ_2 regularization)	$0.036_{\pm 0.005}$|$2.29_{\pm 0.079}$	$0.050_{\pm 0.002}$|$11.12_{\pm 0.537}$	$0.534_{\pm 0.043}$|$9.67_{\pm 0.082}$
SNN (Ebli et al., 2020)	$0.110_{\pm 0.005}$|$23.24_{\pm 1.03}$	$0.446_{\pm 0.017}$|$86.95_{\pm 2.20}$	$0.702_{\pm 0.033}$|$104.74_{\pm 1.04}$
PSNN (Roddenberry et al., 2021)	$0.008_{\pm 0.001}$|$0.984_{\pm 0.170}$	$0.000_{\pm 0.000}$|$0.000_{\pm 0.000}$	$0.009_{\pm 0.001}$|$1.13_{\pm 0.329}$
MPSN (Bodnar et al., 2021b)	$0.039_{\pm 0.004}$|$7.74_{\pm 0.88}$	$0.076_{\pm 0.012}$|$14.92_{\pm 2.49}$	$0.117_{\pm 0.063}$|$23.15_{\pm 11.7}$
SCCNN, id	$0.027_{\pm 0.005}$|$0.000_{\pm 0.000}$	$0.000_{\pm 0.000}$|$0.000_{\pm 0.000}$	$0.265_{\pm 0.036}$|$0.000_{\pm 0.000}$
SCCNN, tanh	$\mathbf{0.002_{\pm 0.000}}$|$\mathbf{0.325_{\pm 0.082}}$	$0.000_{\pm 0.000}$|$0.003_{\pm 0.003}$	$\mathbf{0.003_{\pm 0.002}}$|$\mathbf{0.279_{\pm 0.151}}$

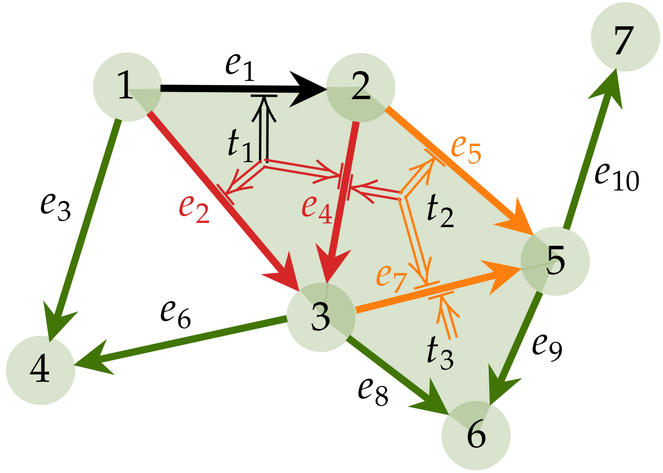
Convolutional Learning on SCs

Node-edge-triangle interactions

- $\text{SCCNN}_k^l : \{x_{k-1}^{l-1}, x_k^{l-1}, x_{k+1}^{l-1}\} \to x_k^l$, with simplicial order k and layer l

$$\mathbf{x}_k^l = \sigma(\mathbf{H}_{k,\mathrm{d}}^l \mathbf{x}_{k,\mathrm{d}}^{l-1} + \mathbf{H}_k^l \mathbf{x}_k^{l-1} + \mathbf{H}_{k,\mathrm{u}}^l \mathbf{x}_{k,\mathrm{u}}^{l-1})$$





$$\mathbf{x}_0^l = \sigma(\mathbf{H}_0^l \mathbf{x}_0^{l-1} + \mathbf{H}_{0,\mathrm{u}}^l \mathbf{B}_1 \mathbf{x}_1^{l-1})$$
$$\mathbf{x}_1^l = \sigma(\mathbf{H}_{1,\mathrm{d}}^l \mathbf{B}_1^\top \mathbf{x}_0^{l-1} + \mathbf{H}_1^l \mathbf{x}_1^{l-1} + \mathbf{H}_{1,\mathrm{u}}^l \mathbf{B}_2 \mathbf{x}_2^{l-1})$$
$$\mathbf{x}_2^l = \sigma(\mathbf{H}_{2,\mathrm{d}}^l \mathbf{B}_2^\top \mathbf{x}_1^{l-1} + \mathbf{H}_2^l \mathbf{x}_2^{l-1})$$

Convolution based (Ebli et al. 2020; Roddenberry et al. 2021; Yang et al. 2022, 2023)
Message passing (Bodnar et al. 2021)

Properties: locality, symmetry
Dirichlet energy perspective
Hodge-invariant
Stability to weights perturbations