Adversarial Learning of “Deepfakes” in Accounting

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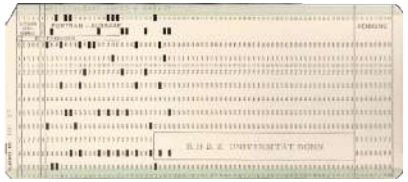
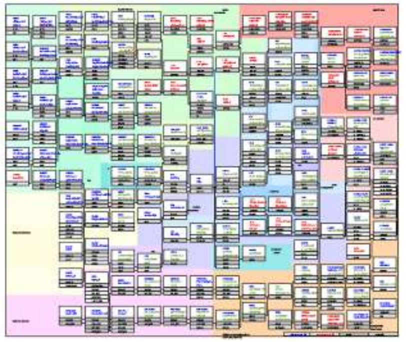
Evolution of Financial Accounting

1920‘s

1960‘s



1990‘s



Data Volume

- Continuous digitization of business activities and processes.
- Accumulation of exhaustive transactional and business process data.
- „Every“ activity within an organization leaves a **digital trace.**

Evolution of Financial Accounting

1920‘s **1960‘s** **1990‘s**

> ‘Approx. 77% of the worlds revenue touches one of our ERP systems.’ SAP AG’s Corporate Factsheet 2019

Data Volume

- Continuous digitization of business activities and processes.
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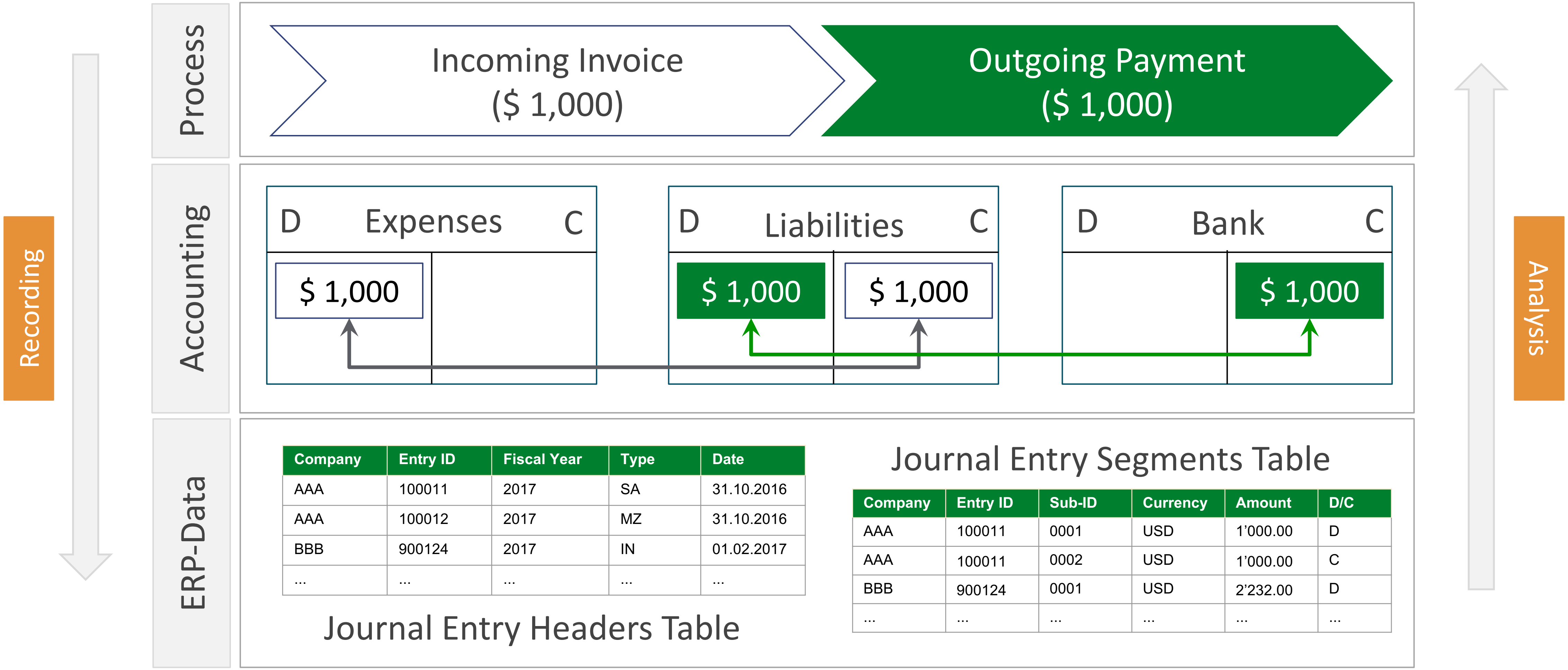
Enterprise Ressource Planning (ERP) Systems



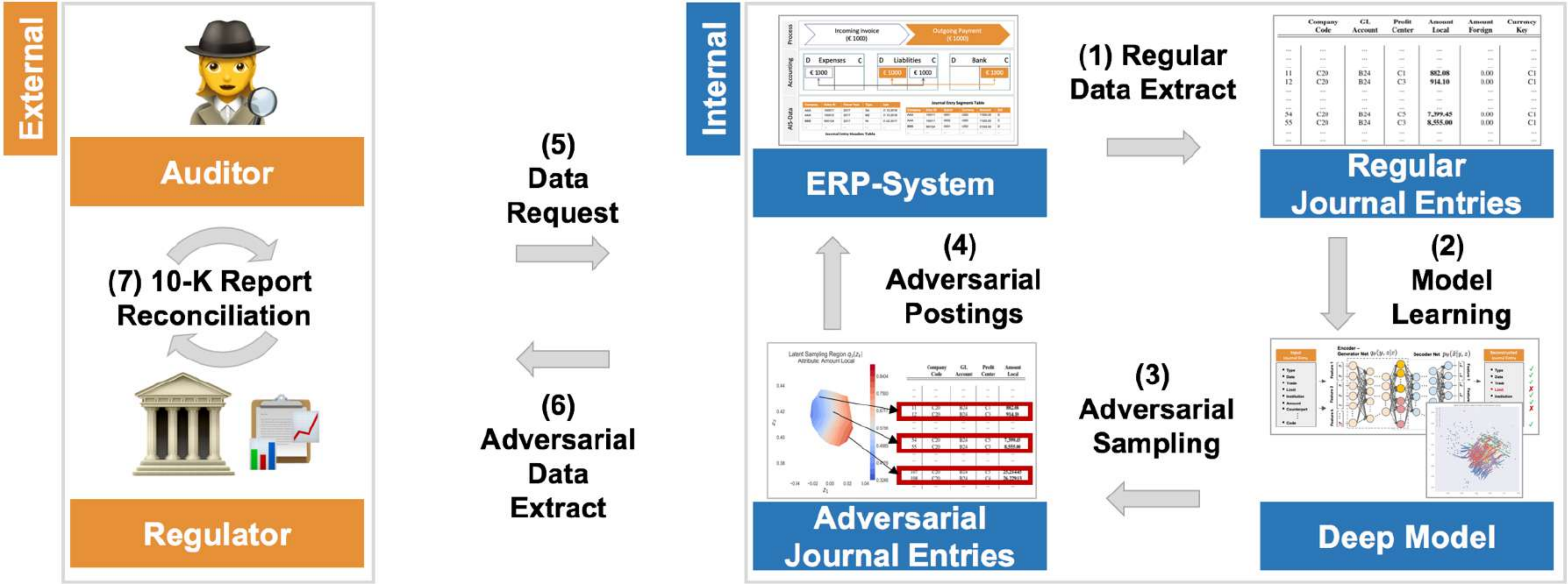
Company	Entry ID	Fiscal Year	Type	Date
AAA	100011	2017	SA	31.10.2016
AAA	100012	2017	MZ	31.10.2016
BBB	900124	2017	IN	01.02.2017
…	…	…	…	…

Journal Entry Headers Table

Journal Entry Segments Table

Company	Entry ID	Sub-ID	Currency	Amount	D/C
AAA	100011	0001	USD	1'000.00	D
AAA	100011	0002	USD	1'000.00	C
BBB	900124	0001	USD	2'232.00	D
…	…	…	…	…	…

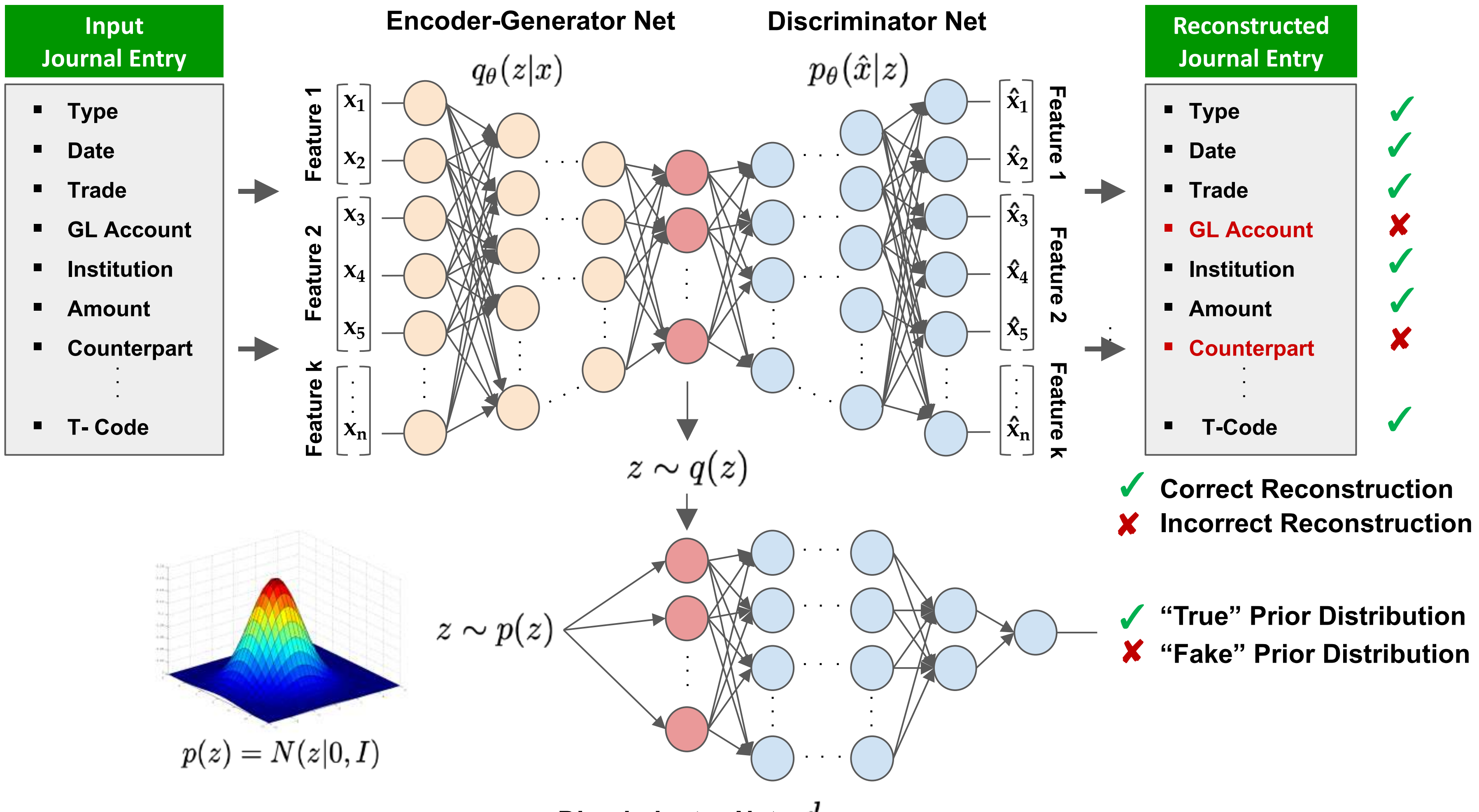
Audit Threat Model



Journal Entry Audit

Adversarial Model Learning & Journal Entry Sampling

Adversarial Autoencoder NNs[1,2]



Input Journal Entry

- Type
- Date
- Trade
- GL Account
- Institution
- Amount
- Counterpart
- T- Code

Encoder-Generator Net $q_\theta(z|x)$

Discriminator Net $p_\theta(\hat{x}|z)$

$z \sim q(z)$

$z \sim p(z)$

$p(z) = N(z|0, I)$

Discriminator Net $d_{\phi(z)}$

Reconstructed Journal Entry

- Type ✓
- Date ✓
- Trade ✓
- GL Account ✗
- Institution ✓
- Amount ✓
- Counterpart ✗
- T-Code ✓

✓ **Correct Reconstruction**

✗ **Incorrect Reconstruction**

✓ **“True” Prior Distribution**

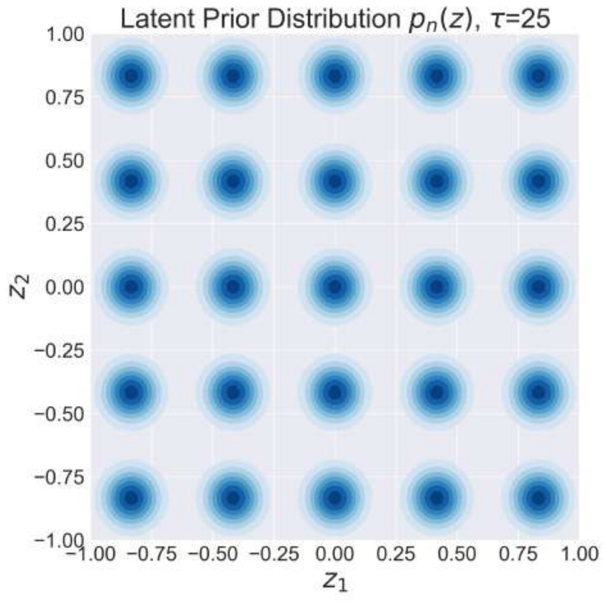
✗ **“Fake” Prior Distribution**

[1] Makhzani, Alireza, et al. "Adversarial autoencoders." *arXiv preprint arXiv:1511.05644,* 2015

[2] Goodfellow, Ian, et al. "Generative adversarial nets." *Advances in neural information processing systems,* 2014

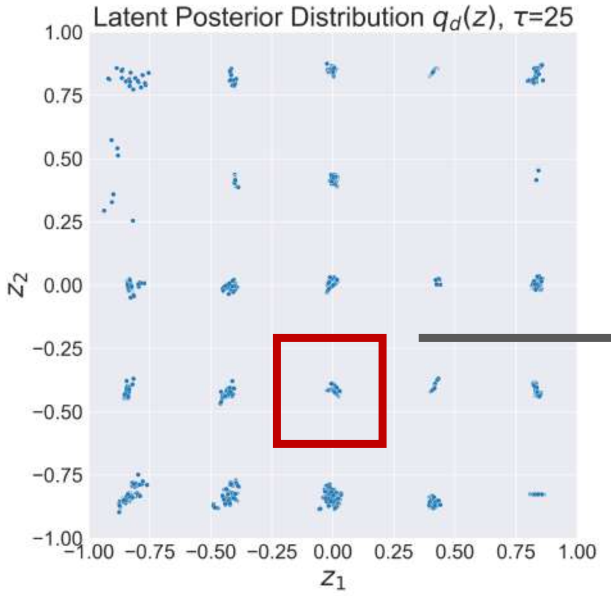
Learning Disentangled Representations

Imposed Latent Prior Distribution



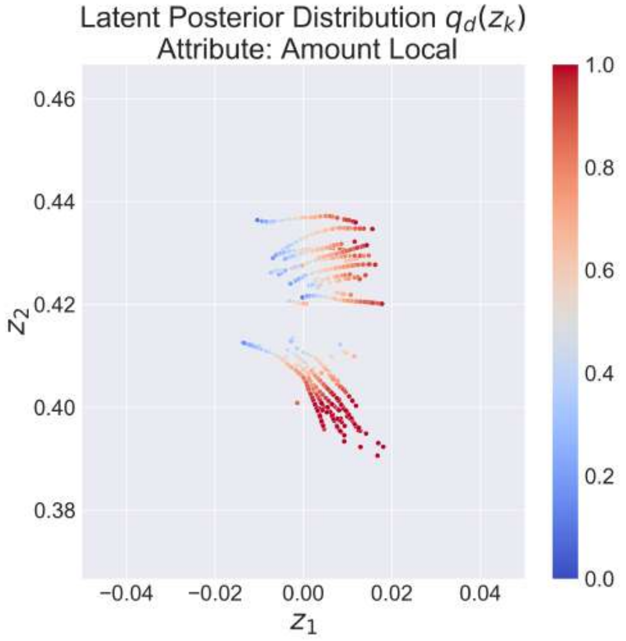
Target Distribution

High-Order Generative Factor Disentanglement



Disentanglement of Accounting Processes

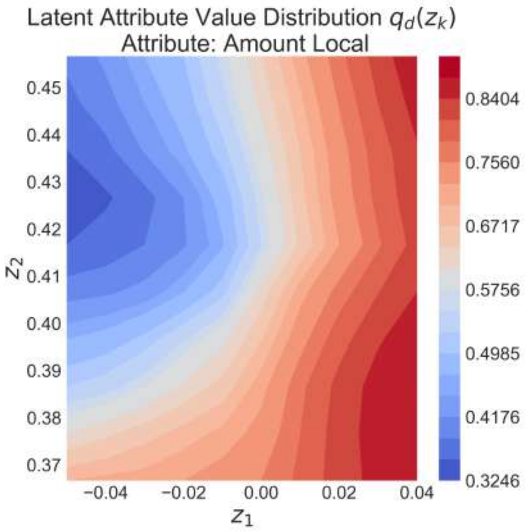
Low-Order Generative Factor Disentanglement



Disentanglement of Journal Entries

Learning Disentangled Representations

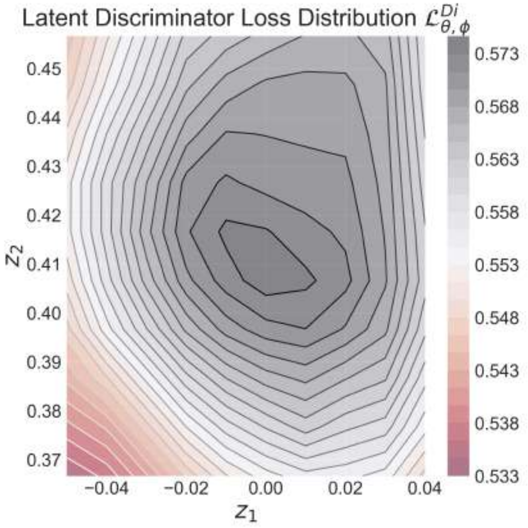
Journal Entry Amount Value Distribution



$$\max p_\theta(\hat{x}_j|z) \neq \max p_\theta(\hat{x}_j|z+\delta)$$

-

Discriminator Loss Distribution

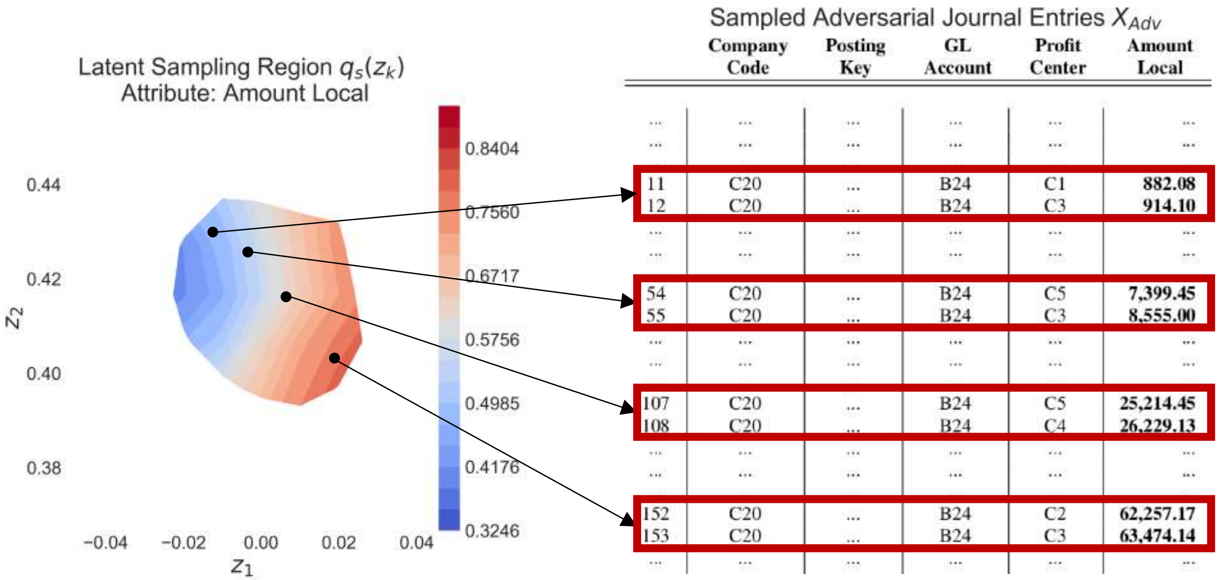


$$\|d_\phi(z+\delta)\| \geq d_\phi(z) + \rho$$

=

"Adversarial Sampling Map"

Adversarial Journal Entries



Sampled Adversarial Journal Entries X_{Adv}

	Company Code	Posting Key	GL Account	Profit Center	Amount Local
...	...	...	...	...	...
...	...	...	...	...	...
11	C20	...	B24	C1	**882.08**
12	C20	...	B24	C3	**914.10**
...	...	...	...	...	...
...	...	...	...	...	...
54	C20	...	B24	C5	**7,399.45**
55	C20	...	B24	C3	**8,555.00**
...	...	...	...	...	...
...	...	...	...	...	...
107	C20	...	B24	C5	**25,214.45**
108	C20	...	B24	C4	**26,229.13**
...	...	...	...	...	...
...	...	...	...	...	...
152	C20	...	B24	C2	**62,257.17**
153	C20	...	B24	C3	**63,474.14**
...	...	...	...	...	...

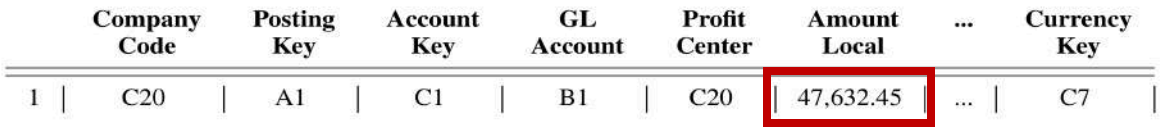
$$z_{adv} \sim q_s(z)$$

$$\hat{x}_{adv}$$

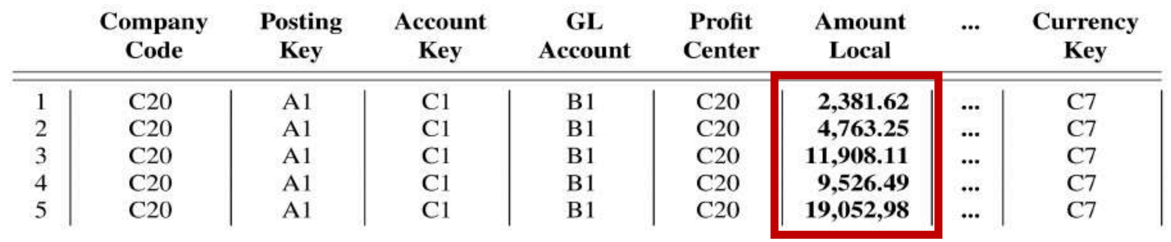
Sampled “Deepfake“ Accounting Records

“Anomaly Replacement” attack scenario:

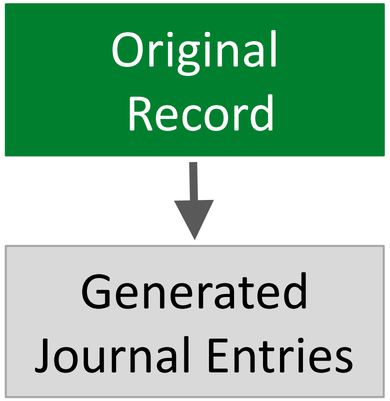
“camouflage the circumvention of an invoice approval limit”



	Company Code	Posting Key	Account Key	GL Account	Profit Center	Amount Local	...	Currency Key
1	C20	A1	C1	B1	C20	47,632.45	...	C7



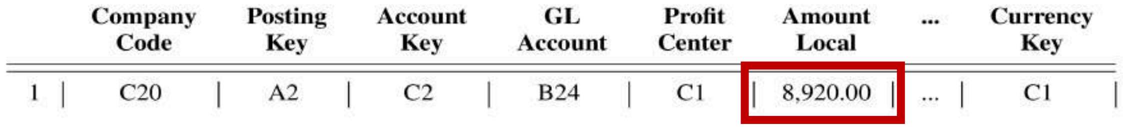
	Company Code	Posting Key	Account Key	GL Account	Profit Center	Amount Local	...	Currency Key
1	C20	A1	C1	B1	C20	**2,381.62**	...	C7
2	C20	A1	C1	B1	C20	**4,763.25**	...	C7
3	C20	A1	C1	B1	C20	**11,908.11**	...	C7
4	C20	A1	C1	B1	C20	**9,526.49**	...	C7
5	C20	A1	C1	B1	C20	**19,052,98**	...	C7


Original Record

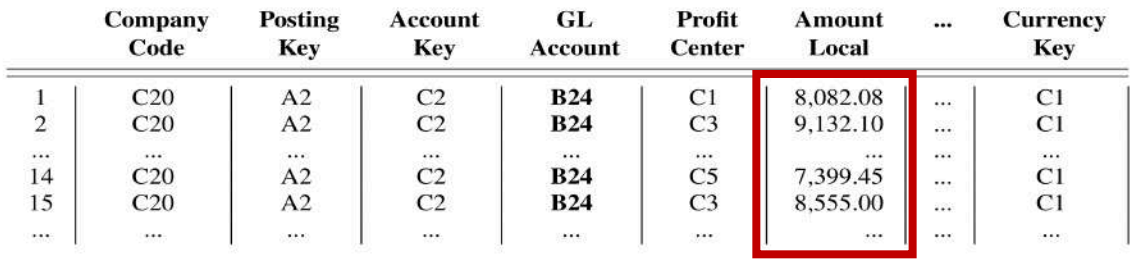
Generated Journal Entries

“Anomaly Augmentation” attack scenario:

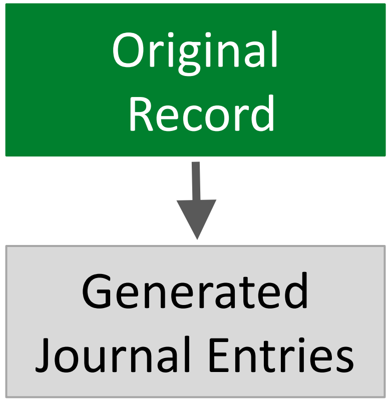
“camouflage the usage of seldom used general ledger accounts”



	Company Code	Posting Key	Account Key	GL Account	Profit Center	Amount Local	...	Currency Key
1	C20	A2	C2	B24	C1	8,920.00	...	C1



	Company Code	Posting Key	Account Key	GL Account	Profit Center	Amount Local	...	Currency Key
1	C20	A2	C2	**B24**	C1	8,082.08	...	C1
2	C20	A2	C2	**B24**	C3	9,132.10	...	C1
...	...	...	...	...	...	...	...	...
14	C20	A2	C2	**B24**	C5	7,399.45	...	C1
15	C20	A2	C2	**B24**	C3	8,555.00	...	C1
...	...	...	...	...	...	...	...	...


Original Record

Generated Journal Entries

Thank you

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Publication available on arXiv:
https://arxiv.org/abs/1910.03810

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