

Large Language Models and Advanced Agents for Economic Analysis,
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Exchange rate contagion: channels, quantification and impact during
financial crises, Virginie Gautier (TAC ECONOMICS)

Large Language Models and Advanced Agents for Economic Analysis

Forecasting Financial Markets
University of Oxford - Sept. 2024

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ECONOMICS



Economic Analyses, Forecasts and Country Risk on more than 150 countries with AI decision tools.

- Cyclical analysis
- Early warning signals on financial markets and currency forecasts
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- Country monitoring
- And more !

Data Analytics, AI, Machine Learning, and Generative AI in various sectors:

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- Energy Transition
- Marine World
- Finance
- Forecasting and Time Series Analyses

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Encoder : Embeddings model.

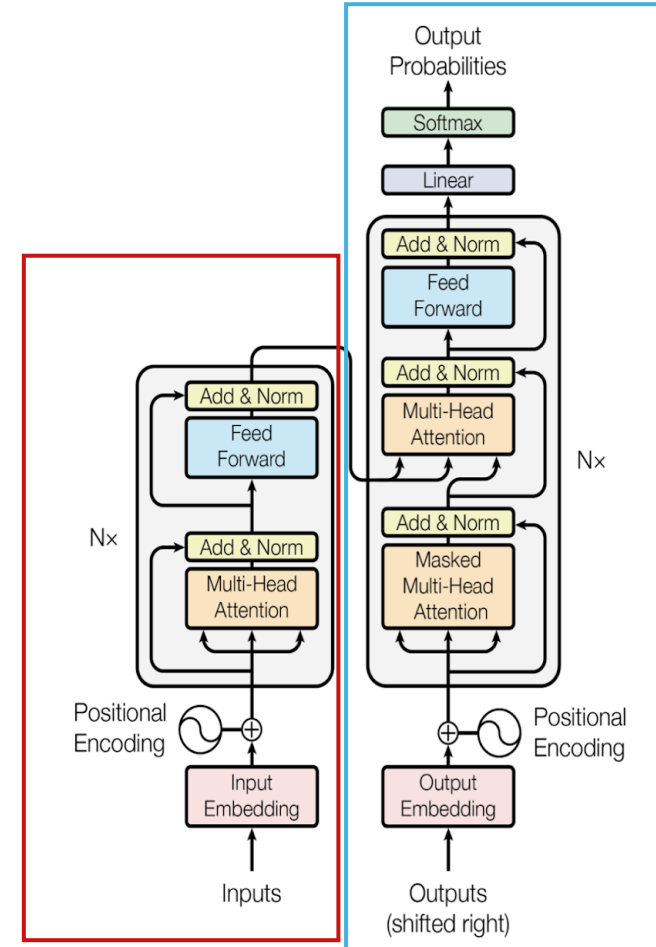
Decoder : Word/token prediction model.

Key points :

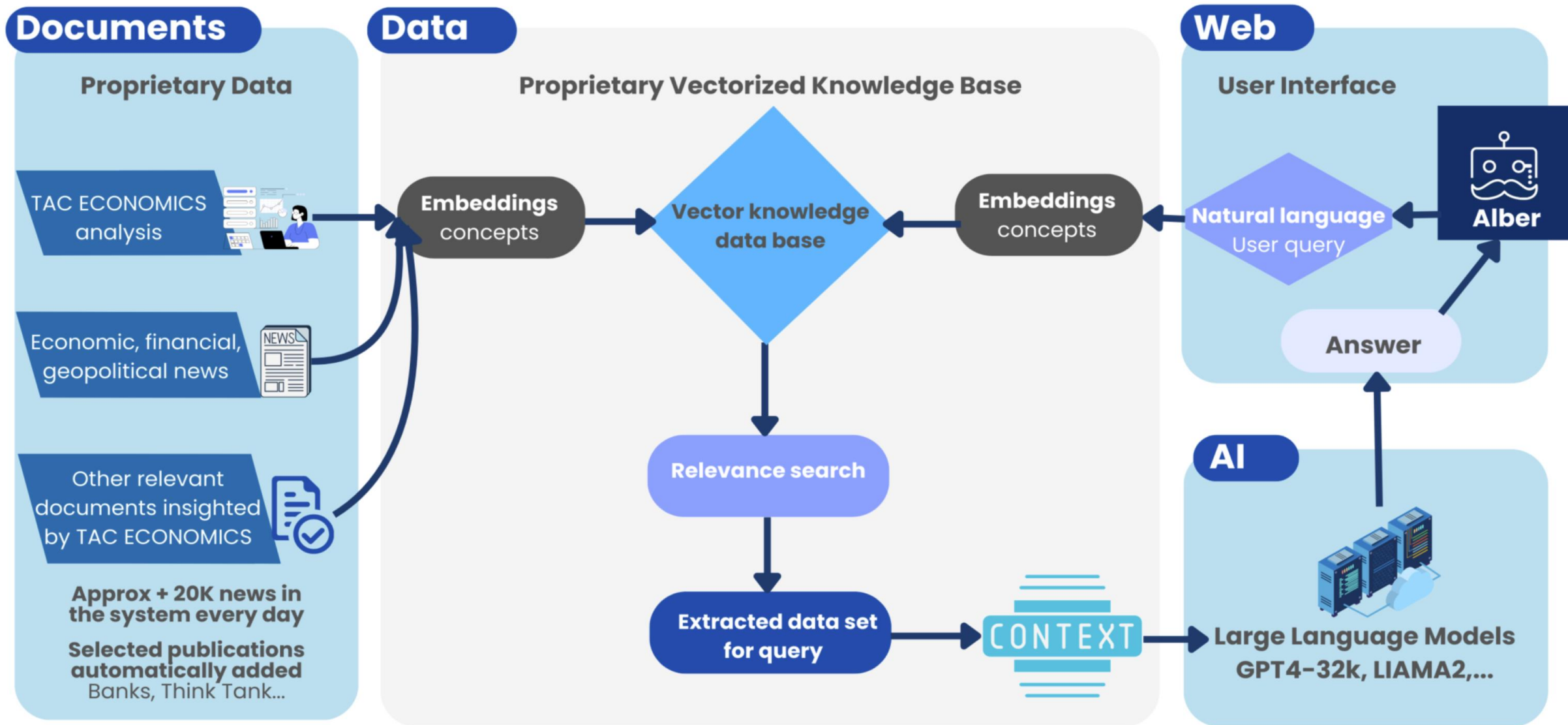
1. Better text-to-text tasks.
2. Resolve some RNN problems.
3. New architecture only based on attention.
4. New attention mechanism : Multi-head self attention.

Multi-head self attention :

1. Matrice of embeddings in input.
2. Separation in many heads.
3. 3 Q (Query), K(key), V(Value) weights matrices per head.



Attention is all you need, Ashish Vaswani, et al (2017)



Alber – your virtual economist assistant

Developed by [TAC ECONOMICS](#) and [Gwenlake](#)

Describe in details the monetary policy of the Eurozone in 2024?

In 2024, the monetary policy of the Eurozone is expected to remain accommodative, with the European Central Bank (ECB) maintaining low interest rates and continuing its asset purchase program. The ECB is likely to keep its key interest rates unchanged, with the main refinancing rate at 0% and the deposit rate at -0.5%.

The ECB's asset purchase program, known as the Pandemic Emergency Purchase Program (PEPP), is expected to continue throughout 2024. The PEPP was introduced in response to the COVID-19 pandemic to provide liquidity support to the economy and stabilize financial markets. The program involves the purchase of government bonds and other assets to inject liquidity into the financial system.

The ECB's monetary policy stance is driven by the goal of achieving price stability in the Eurozone, which is defined as an inflation rate of close to, but below, 2% over the medium term. Inflation in the Eurozone is expected to decline in 2024, but remain above the ECB's target.

The ECB will closely monitor economic developments and inflationary pressures to determine the appropriate course of monetary policy. If inflation remains below target or economic growth weakens, the ECB may consider further easing measures, such as lowering interest rates or expanding its asset purchase program.

Overall, the monetary policy of the Eurozone in 2024 is expected to support economic recovery and ensure price stability, while remaining flexible to respond to changing economic conditions.

Hello, how can I help you?

Openbank, banco digital de Santander, llegará a EU en 2024

diariodequeretaro.com.mx – Apr 09, 2024

Openbank ya da servicio a más de dos millones de clientes en España, Portugal, Alemania y Países Bajos...



Bloomberg Markets Today 04/09/2024

youtube.com – Apr 09, 2024

Bloomberg Markets Today 04/09/2024 Markets Today has everything you need to know as markets open across Europe. With analysis you won't find anywhere else, we break down the biggest stories of the day and speak to top guests who have skin in the game. Hosted by Anna Edwards and Guy Johnson. Today's guests: Daniel Vernazza, UniCredit Chief International Economist; Martin Eberhard, Tesla Former CEO & Co-Founder; Sebastian Raedler, BofA Global Research Head of European Equity Strategy...

This solutions already worked almost 2 years ago, but had basic answers. So we worked on many critical fields of LLM's to improve it !

Significant advancements in LLMs are released daily, covering a wide range of fields

Here is 4 important fields we worked on :

Data retriever

1. Use of metas
2. Improvement of embedding techniques and databases technologies

Advanced RAG techniques

1. Data Retrieval
2. Indexing
3. Query construction

Prompting

1. Context improvement
2. Better definition of the task
3. Work on the output's shape

Agentic

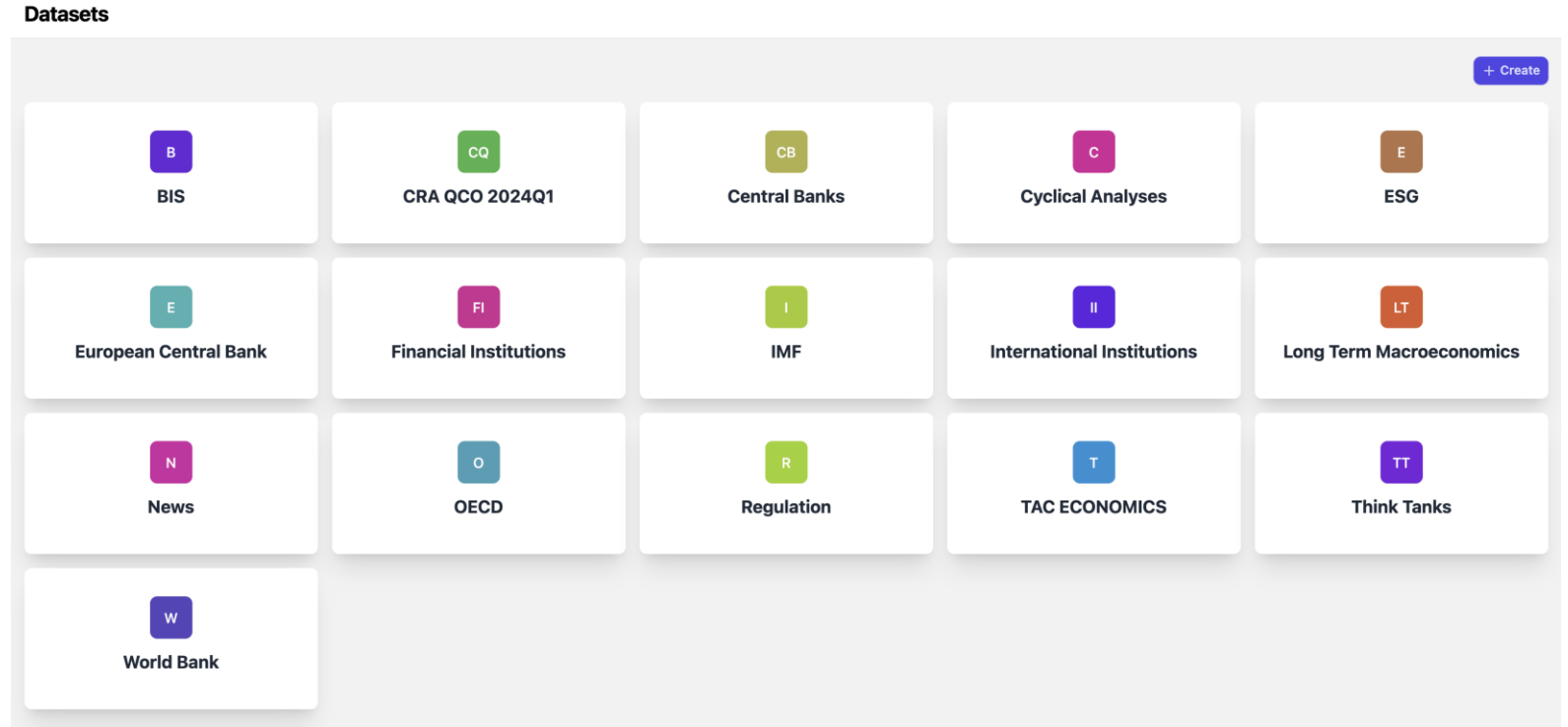
1. Tools integration
2. Graph extension

New feature : add metas to each embedd vectors.

- Select articles using a date attribute from the metas !
- Combining sources.

Improvement of embedding and storage techniques :

- Faster and better results.



Addition of hybrid search: a mix of vector search and external database (SQL)

Prompting

agent-usa taceconomics/agent-usa private	alber-rag taceconomics/alber-rag private	Augmented-text taceconomics/Augmented-text private
bale4 taceconomics/bale4 private	basel-4 taceconomics/basel-4 private	comparaison taceconomics/comparaison private
conjoncture taceconomics/conjoncture private	cyclical taceconomics/cyclical private	economic-and-political-risk taceconomics/economic-and-political-risk private
emotional-another-look gwenlake/emotional-another-look public	emotional-career gwenlake/emotional-career public	emotional-excellence gwenlake/emotional-excellence public

USER

Context information is below.

{context}

Given the context information and not prior knowledge, answer the query.
Are you sure that's your final answer? Believe in your abilities and strive for excellence. Your hard work will yield remarkable results.

Query: **{query}**

Answer:

SYSTEM

You are a senior financial analyst working for a leading consultancy specializing in regulatory compliance and risk management for financial institutions. Your firm has been commissioned to produce an expert-level report on Basel 4 and its potential implications for the banking sector, addressing concerns about the readiness of banks for its impending implementation and the regulator's stance on the timeline.

USER

Context
{context}

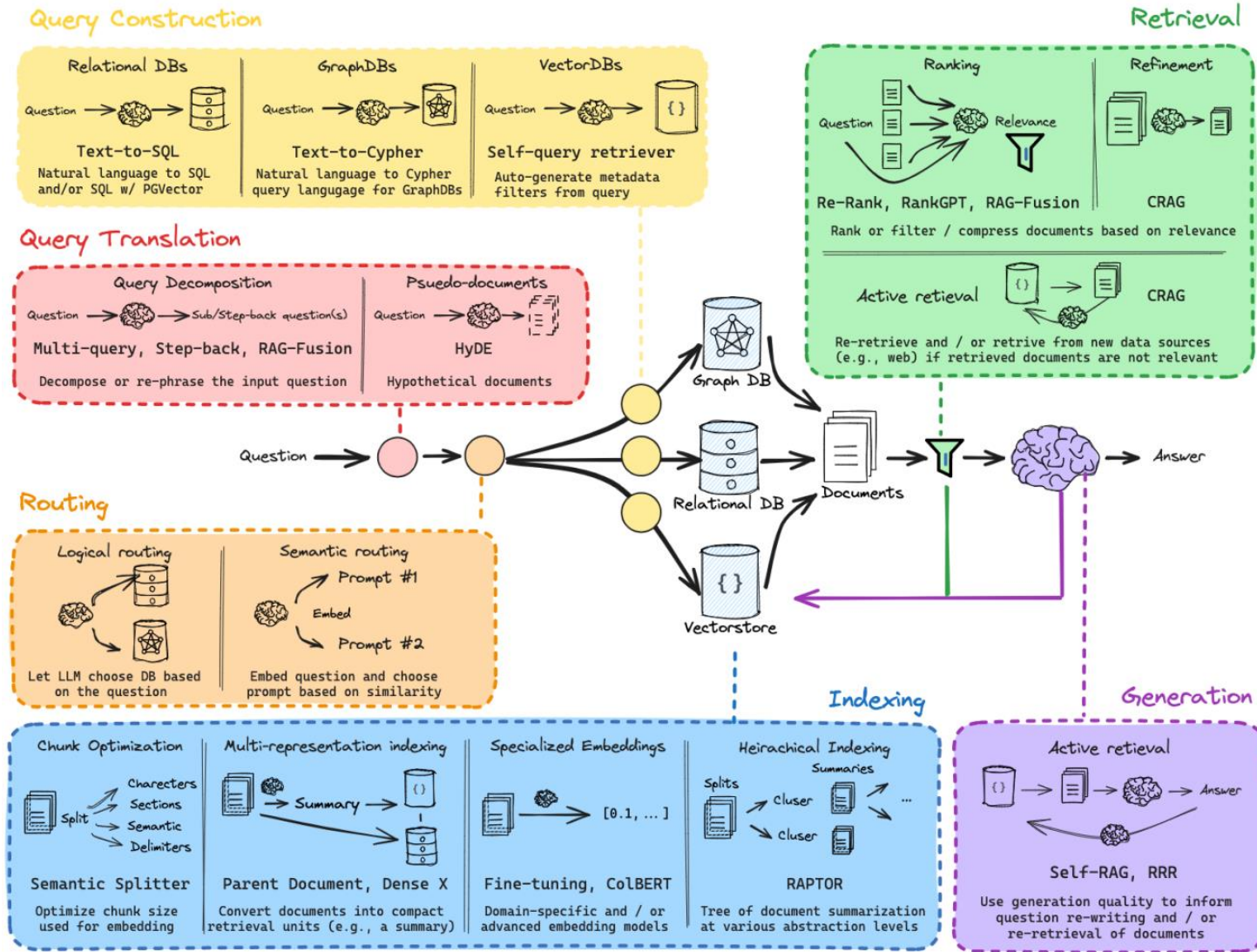
Task

- Answer the question based on the context. If the question can't be answered based on the context or previous messages, say "I don't know".
- Write the answer in the same language as the question.
- Write a report with a few paragraph of max 1000 words each.
- Conclude the report with strategic recommendations.
- The report should be structured professionally.

Question
{query}

Answer

Advanced RAG techniques

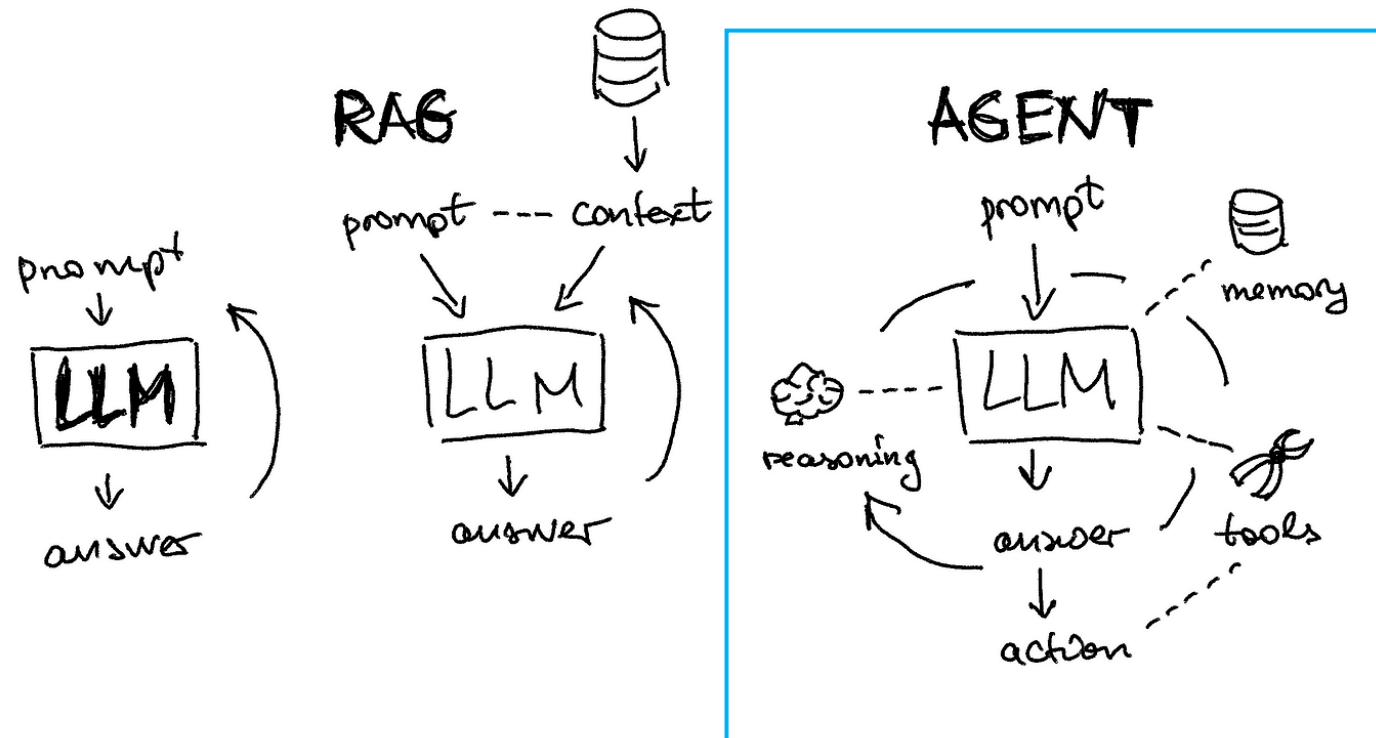


Basic

- Indexing
- Retrieval
- Generation

Advanced

- Query transformations
- Routing (Hybrid search, ...)
- Query construction (Hyde, ...)
- Re-ranking, RAG fusion
- Retrieval
- Generation (self-RAG, ...)



Alex Honchar, *Intro to LLM Agents with Langchain: When RAG is Not Enough*

Agent

- Reason and Act process
- Complete more advanced tasks
- Add reasoning on the query
- Set of tools available

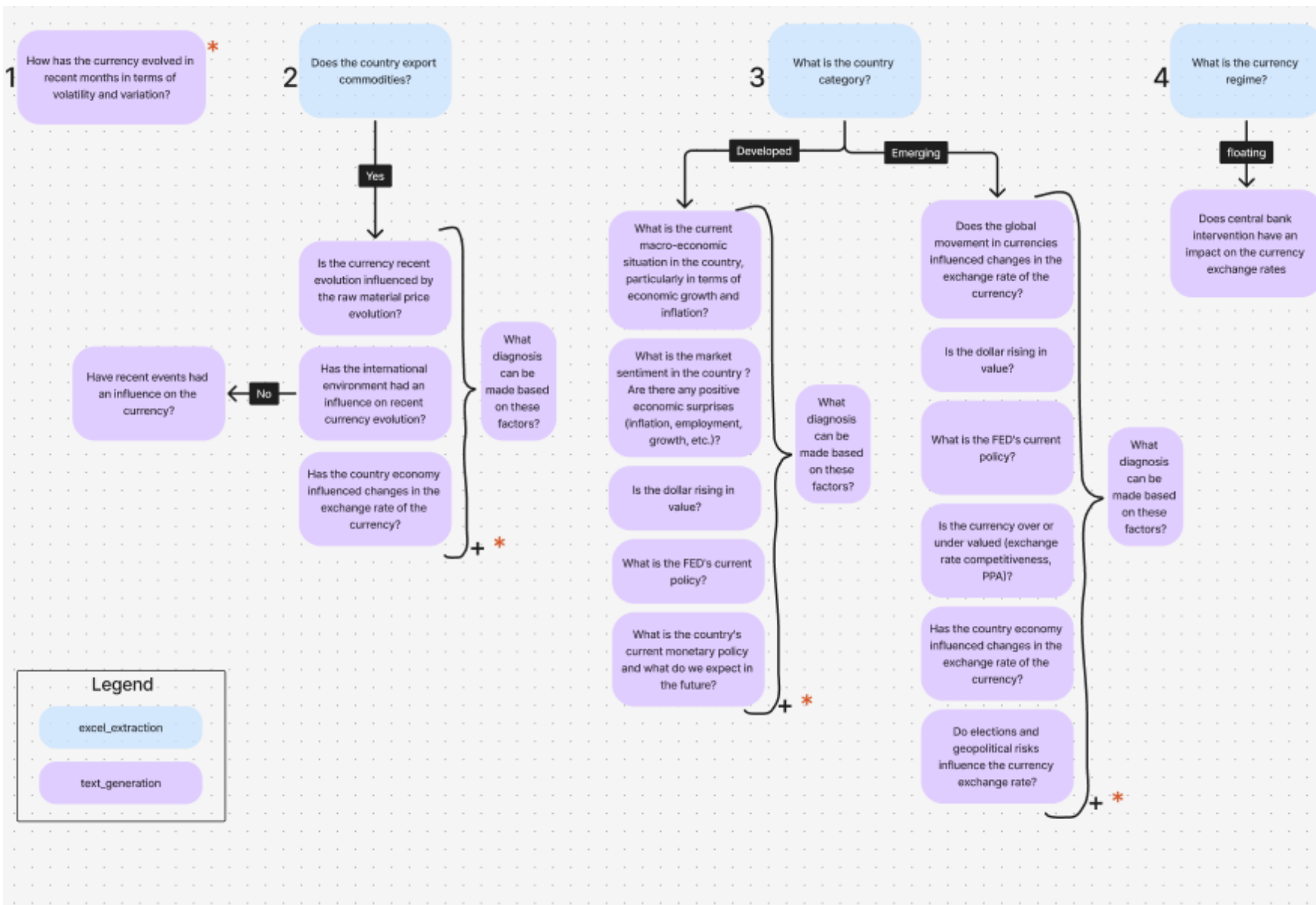
Examples

- Agent able to search on website
- Math teacher agent, with a calculator tool

Multi-agents graph

- Combine agents, conditions, llm calls, ...
- Build our own language
- Autonomous tasks completion

Final system architecture



FX agent graph

- Country in query
- Questions about the country :
Recent volatility's change of FX?
Commodity exporter?
Emerging/developed? Currency regime?
- External databases (SQL, ...)
- Economic Analyses Agents
- RAG systems on news, proprietary data, ...

1. Australia

1.1 Factors contributing to the recent decline in the Australian dollar

The primary factors that have led to the recent decline in the value of the Australian dollar are:

1. **Weaker Retail Sales:** Australian retail sales unexpectedly declined in March, which put pressure on the currency [Doc 2, Doc 4].
2. **Geopolitical tensions and policy divergences:** The Australian dollar typically acts as a sentiment gauge, following the S&P 500. Risks of a broader conflict in the Middle East and policy divergences have kept the Australian dollar on the back foot [Doc 3].
3. **Decrease in key export commodities:** Prices for Australia's key export commodities such as iron ore, LNG, and coal have decreased in recent months, putting pressure on the trade balance [Doc 1, Doc 5].
4. **High inflation and interest rates:** Australian consumer confidence has taken a hit due to high inflation and interest rates [Doc 9].
5. **Expectations of RBA rate cuts:** The expectations for a rate cut by the Reserve Bank of Australia (RBA) have been pushed to September, which has kept the Australian dollar under pressure [Doc 1].
6. **Wage growth and labor market:** The labor market in Australia has a low unemployment rate, which paves the way for high wage growth rates. However, improvements are not expected quickly, and the process of slowing average wage growth is too slow for the RBA to ignore this inflationary factor [Doc 1].

In summary, the recent decline in the value of the Australian dollar can be attributed to weaker retail sales, geopolitical tensions, decrease in key export commodities, high inflation and interest rates, expectations of RBA rate cuts, and wage growth dynamics in the labor market.

1.2 The Impact of Australian Inflation on the AUD/USD Exchange Rate

Based on the provided news articles, the relationship between Australian inflation data and the AUD/USD exchange rate can be summarized as follows:

- Australian inflation data has a significant impact on the AUD/USD exchange rate. [Doc 2, Doc 4, Doc 6, Doc 9]
- Rising inflation in Australia may prompt action from the Reserve Bank of Australia (RBA), which can influence the Australian Dollar. [Doc 9]

- The AUD/USD exchange rate is influenced by the interplay of China's inflation figures and Australian business confidence. [Doc 3]
- Australian inflation figures are closely watched by economists for insights into the RBA's interest rate outlook. [Doc 6]
- The AUD/USD exchange rate is affected by the relationship between Australian inflation and the RBA's rate path. [Doc 4]
- The AUD/USD forecast is linked to Australian Producer Prices and Personal Income and Expenditures Report, which are indicators of inflation. [Doc 6]
- Investors analyze Australian inflation data alongside key US economic indicators to forecast the AUD/USD exchange rate. [Doc 8]
- Rising wages in Australia, which are related to inflation, may prompt action from the RBA and influence the Australian Dollar. [Doc 9]

In summary, Australian inflation data plays a crucial role in shaping the AUD/USD exchange rate. Rising inflation can lead to actions from the RBA and impact the value of the Australian Dollar against the US Dollar.

1.3 The Impact of the US Jobs Report on the Australian Dollar

The US jobs report is expected to have an impact on the future performance of the Australian dollar. Here are the key points from the news articles:

- The Australian dollar is influenced by news from the United States and the dynamics of the US dollar [Doc 2].
- The AUD/USD exchange rate is affected by US labor market reports [Doc 6].
- The AUD/USD forecast depends on US labor data [Doc 9].
- The US jobs report is one of the crucial economic forecasts that can reveal potential shifts in AUD/USD [Doc 4].
- Investors analyze US labor data to forecast the AUD/USD exchange rate [Doc 9].

Based on these points, it can be concluded that the US jobs report will have an impact on the future performance of the Australian dollar. Positive or negative outcomes in the US jobs report can influence investor sentiment and expectations regarding the US economy, which in turn can affect the value of the US dollar. As the Australian dollar is influenced by the dynamics of the US dollar, any significant changes in the US jobs report can lead to fluctuations in the AUD/USD exchange rate. Therefore, it is important for investors to closely monitor the US jobs report as it can provide clues about future central bank actions and impact the performance of the Australian dollar. [Doc 2, Doc 4, Doc 6, Doc 9]

1.4 Factors Affecting AUD/USD Exchange Rate: Decline in Australian Retail Sales and US Economic Indicators

The unexpected decline in Australian retail sales had a negative impact on the AUD/USD exchange rate. Here are the factors that contributed to this impact:

Thank you for your attention!

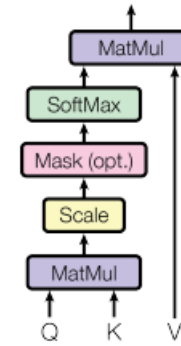
Guillaume Béguet

gwen**lake.**

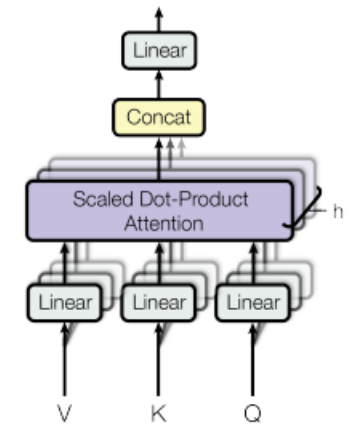
Didier Liron

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1. Initialization of Q (Query), K(key), V(Value) matrices fgh
2. Multi head separation
3. Calcul of attention score for each head



Scaled Dot-Product



Attention Multi-Head Attention

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

EXCHANGE RATE CONTAGION: CHANNELS, QUANTIFICATION AND IMPACT DURING FINANCIAL CRISES

Virginie Gautier

PhD student and data scientist
CREM & TAC Economics

Forecasting Financial Markets Conference, September 2024

1 Introduction

2 Methodology

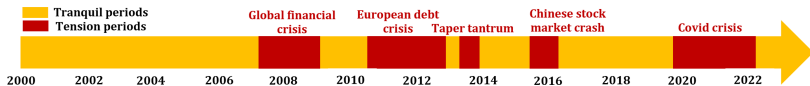
3 Results

4 Conclusion

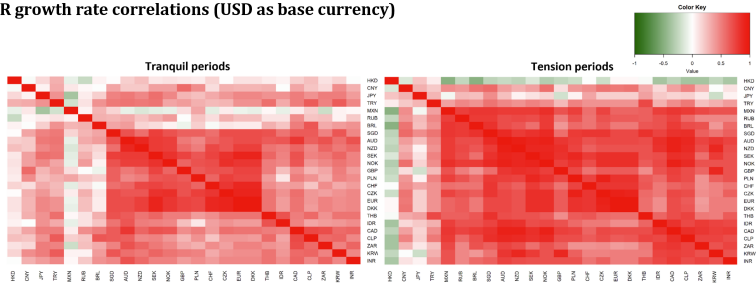
Introduction

Stylized facts

Dating periods of financial stress



EXR growth rate correlations (USD as base currency)



Objectives

- Detect and quantify the magnitude of contagion on the foreign exchange market and analyze its evolution over time.
- Propose two methods for identifying causal links between exchange rates (trade and financial integration vs. graph theory).
- Analyze the link between foreign exchange contagion and financial crises.
- Measure the extent to which contagion explains fluctuations on the foreign exchange market.

Literature and definition

- Forbes & Rigobon (2002) propose the adjusted correlation test to detect contagion between financial assets.
- Fratzscher (2002) analyzes the role of contagion in the emergence of currency crises (trade and financial channels).
- Wang et al. (2021) identify forex transmission channels using the copula approach.
- Rigana et al. (2023) use graph theory to identify contagion links between exchange rates.

Contagion

Additional variation experienced by an exchange rate, caused by one or more other exchange rates, once the reasonable effect of macroeconomic fundamentals and common shocks has been taken into account.

Methodology

Three-step procedure

- **Step 1:** Model 1 or fundamentals and global shocks model.

$$X_{i,t} = B_{0,i} + B_{1,i}dinfl_{i,t-2} + B_{2,i}drate_{i,t-1} + B_{3,i}tbrent_{t-1} + B_{4,i}VIX_{t-1} + B_{5,i}GRET_{t-1} + u_{i,t} \quad (1)$$

- **Step 2:** Identify parent/child exchange rates.
- **Step 3:** Model 2 or model on the residuals of Model 1.

$$\hat{u}_{i,t} = C_{0,i} + \sum_{j=1, j \neq i}^k C_{j,i} \hat{u}_{j,t} + e_{i,t} \quad (2)$$

$X_{i,t}$: y/y growth rate of the EXR involving the currency of economy i .

$GRET$: average y/y return of the S&P500, FTSE100, and Nikkei225.

k : set of all $j \neq i$.

j : exchange rate(s) identified as parent(s) of the i exchange rate.

Features

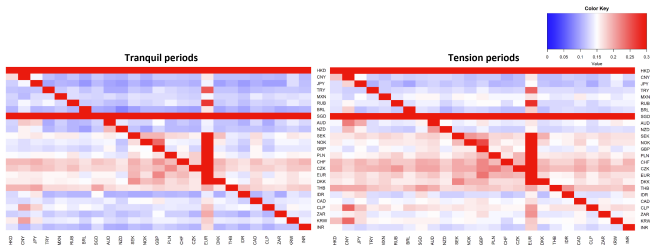
- **Target:** 25 exchange rates (USD as base currency, y/y growth rate)
- **Macroeconomic fundamentals:**
 - Inflation differential with the US
 - Central bank policy rate differential with the US
- **Global factors:**
 - Oil price fluctuations (Brent)
 - Financial market volatility (VIX)
 - Synthetic stock index return (S&P500, FTSE100, and Nikkei225)

Study conducted on monthly data between 2000 and 2023.

Traditional channels

$$I_{ij,t} = [0.75 \cdot Cl_{1,ij,t} + 0.25 \cdot Cl_{2,i,t}] + [0.25 \cdot Fl_{1,ij,t} + 0.75 \cdot Fl_{2,i,t}] \quad (3)$$

- $Cl_{1,ij,t}$: weight of exports from country i to j in exports from country i .
- $Cl_{2,i,t}$: weight of total exports of country i in its GDP.
- $Fl_{1,ij,t}$: 12m rolling correlation between the stock index returns of i and j .
- $Fl_{2,i,t}$: FDI net inflows of country i as a percentage of its GDP.

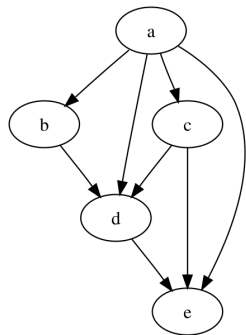


Directed Acyclic Graph (DAG)

Directed Acyclic Graph using the Peter-Clark algorithm:

- 1 Test of conditional independence relationships** \Rightarrow skeleton.
- 2 Collider rule** \Rightarrow orientation of the main edges.
- 3 Consistency rules** \Rightarrow orientation of remaining edges.

a is a parent of *b*, *c*, *d* and *e*.
d is a child of *a*, *b* and *c*.



Network Contagion Factor (NECOF)

Contagion component in the exchange rate equation:

$$NECO_{i,t} = \sum_{j=1, j \neq i}^k C_{j,i} \hat{u}_{j,t} \quad (4)$$

Components of the exchange rate equation:

$$X_{i,t} = \theta_{0,i} + \text{Fundamentals}_{i,t} + \text{Global factors}_t + NECO_{i,t} + \text{Residuals}_{i,t}$$

with $\theta_{0,i} = B_{0,i} + C_{0,i}$

(5)

Contagion indicator:

$$NECOF_{i,t} = \frac{\sigma_{NECO_{i,t}}^2}{\sigma_{\text{Fundamentals}_{i,t}}^2 + \sigma_{\text{GlobalFactors}_t}^2 + \sigma_{NECO_{i,t}}^2 + \sigma_{\text{Residuals}_{i,t}}^2} * 100 \quad (6)$$

Results

Estimations and OOS performances

Model 1 and Model 2 adjusted R2

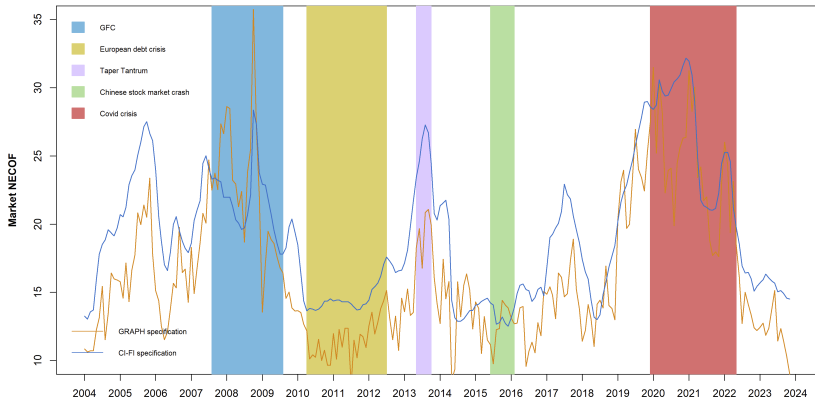
	Model 1	CI-FI (Model 2a)	GRAPH (Model 2b)
EUR	0.55	0.93	0.69
JPY	0.65	0.06	0.17
GBP	0.60	0.48	0.25
AUD	0.68	0.26	0.57
CHF	0.52	0.89	0.35
CAD	0.63	0.23	0.29
CNY	0.69	0.12	0.18
HKD	0.44	0.70	0.07
SEK	0.65	0.88	0.60
NZD	0.61	0.57	0.57
NOK	0.63	0.69	0.54
MXN	0.65	0.01	0.31
SGD	0.54	0.93	0.59
KRW	0.64	0.40	0.38
INR	0.56	0.15	0.36
ZAR	0.63	0.14	0.34
RUB	0.67	0.22	0.18
DKK	0.53	0.95	0.90
BRL	0.70	0.05	0.47
TRY	0.46	0.06	0.45
PLN	0.63	0.68	0.60
THB	0.52	0.83	0.46
CZK	0.61	0.89	0.53
CLP	0.65	0.48	0.44
IDR	0.66	0.22	0.34
MARKET	0.60	0.47	0.43

Out-of-sample performance

	RMSE			Sign agreement		
	Model 1	CI-FI (Model 1 and 2a)	GRAPH (Model 1 and 2b)	Model 1	CI-FI (Model 1 and 2a)	GRAPH (Model 1 and 2b)
EUR	6.9	4.3	5.1	0.7	0.8	0.8
JPY	5.0	5.0	4.6	0.8	0.8	0.8
GBP	5.7	4.9	5.2	0.7	0.8	0.8
AUD	6.4	5.9	5.3	0.8	0.8	0.9
CHF	5.0	3.5	4.5	0.7	0.8	0.7
CAD	4.0	4.1	4.0	0.8	0.8	0.8
CNY	2.2	2.0	1.9	0.8	0.9	0.8
HKD	0.3	0.3	0.3	0.7	0.8	0.7
SEK	7.0	5.1	5.6	0.7	0.8	0.8
NZD	7.0	6.1	6.3	0.8	0.8	0.8
NOK	6.1	4.9	5.4	0.7	0.9	0.8
MXN	6.1	6.1	5.6	0.7	0.7	0.7
SGD	2.5	1.9	2.2	0.8	0.9	0.9
KRW	5.2	4.5	4.9	0.8	0.8	0.8
INR	4.6	4.4	4.2	0.8	0.8	0.8
ZAR	9.4	8.9	8.1	0.8	0.8	0.8
RUB	9.8	8.9	9.4	0.8	0.8	0.8
DKK	6.6	4.0	4.3	0.7	0.9	0.9
BRL	9.8	9.9	8.8	0.8	0.8	0.8
TRY	13.4	13.5	11.7	0.8	0.8	0.8
PLN	7.0	5.4	5.9	0.7	0.8	0.8
THB	4.1	2.8	3.4	0.7	0.8	0.7
CZK	6.6	4.8	5.8	0.7	0.8	0.8
CLP	6.4	5.2	5.6	0.8	0.9	0.8
IDR	5.4	5.3	4.8	0.7	0.7	0.8
MARKET	6.1	5.3	5.3	0.7	0.8	0.8

CI-FI refers to the specification based on trade and financial integration. GRAPH refers to the specification using DAGs.

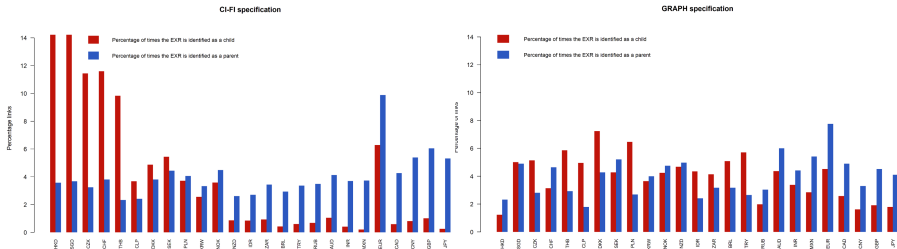
Contagion and financial crises



In blue, the market NEOF of the specification based on trade and financial integration.

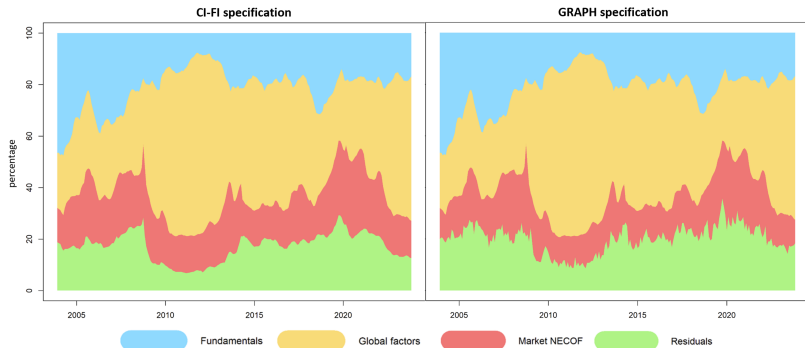
In orange, the market NEOF of the specification using DAGs.

Clusters, parents and children



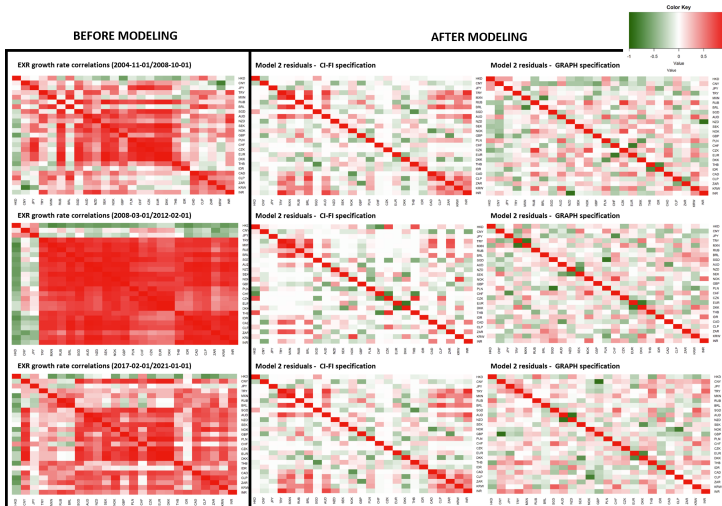
In red, the number of times (% of total number of links) a child role is assigned to the exchange rate. In blue, the number of times a parent role is assigned to the exchange rate.

Contributions



Conclusion

Stylized facts



Conclusion

- A simple methodology based on systems of linear equations and two mechanisms for identifying the relationships of influence between exchange rates.
- A mechanism for transmitting fluctuations between exchange rates is always at work, and this is reinforced in periods of financial stress.
- The resulting contagion indicator (market NECOF) is a good indicator of the severity and duration of financial crises.
- The inclusion of contagion considerations improves exchange rate forecasting in real conditions.
- The DAG-based approach is a good way of reconstructing the contagion generated by trade and financial integration at the market level. However, the two specifications lead to different contagion structures, with a more limited and less polarized number of links for the DAG-based specification (net contagion).