

Anticipate Risk with the Value and Trade Flows Knowledge Graph

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27.05.2024.

Agenda

Introduction and Motivation

State of the Art

Research Questions

Value and Trade Flows Knowledge Graph

Federated Query Against the VTF and BACI Knowledge Graphs

Implementation REST API

Reference

Introduction and Motivation

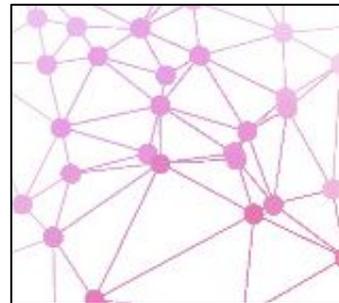


- This work is contribution to the Cognitive Economy Intelligence Platform for the Resilience of Economic Ecosystem (**CoyPu**) project.
 - **Motivation:** Supply chains in a global industry and economy are fragile objects
 - **Objective:** intelligent platform for **integrating, structuring, networking, analysing** and **evaluating heterogeneous data** from **economic value creation networks, the industry environment and the social context.**
- **Global production processes**
 - Highly dependent on the resilience of global supply chains [1]
 - The Economic Cooperation and Development (OECD) recognizes four keys to resilient supply chains [10]
 - Key 1: **To anticipate risks**
 - Key 2: Apply domestic tools to **minimize exposure** to risk
 - Key 3: Apply public-private tools to **build trust**
 - Key 4: Apply international tools to keep **market open**
- The need to implement solutions that strengthen the resilience of supply chains
 - A key action: **Standardized exchange** of data [9]
 - **Example:** Information exchange in semiconductor supply chains [12]

State of the Art

Global supply chain databases

- **World Input-Output Database (WIOD)** consists of a number of databases about supply chains that cover 28 EU countries and 15 other countries [4]
- **Eora Global Supply Chain Database** contains data about inter-sectoral transfers amongst 15,909 sectors across 190 countries [5]
- **Global Trade Analysis Project (GTAP)** is a global network of researchers which use analytical models to study global supply chains [6]



State of the Art

Global supply chain databases

- **Trade in Value Added (TiVA) indicators**
 - Monitor countries' integration into global supply chains [2]
 - Guide to OECD TiVA indicators (see Table 1) [15]
 - Mappings between TiVA industry sector classifications and Standard Industrial Classification of all Economic Activities (ISIC) Rev. 4
 - Tree structure of four dimensional TiVA indicators is available on GitLab [14]
- **Trade Flows at Product Level (BACI) [3]**
 - Publishes data on bilateral trade flows at product level
 - There are n-ary relations between entities
 - Contains information on
 - Product names
 - Harmonized System (HS) nomenclature for trade
 - Export and import country codes
 - Unit of measure
 - Trade value
- **Motivation to use TiVA and BACI databases**
 - License model
 - Both databases have key information in common
 - Both databases are extensive
 - Both databases share information about import and export trade locations

indicator code name	fdva_bsci	exgr_bsci	imgr_bsci	fd_exgr_va	exgr_dva
number of dimensions	4	4	4	4	3
value added origin	(C,I)	(C,I)	(C)	(C)	
exports		(C,I)	(C,I)	(C,I)	(C,I)
imports			(C)		(I)
final demand	(C,I)			(C)	
value	USD	USD	USD	USD	USD
year	2018	2018	2018	2018	2018

Table 1. Selected TiVA indicators with four and three dimensions

State of the Art

Application knowledge graphs in supply chain resilience

- A knowledge graph-based risk management framework (SCRM) [16]
 - Application KG in supply chain resilience
 - Monitoring risks and long-term disruptions (see Figure 1)
 - Constructed knowledge graph contains 2.5 million entities
- Knowledge graph completion methods are used to predict missing information and identify critical entities in the supply network [17]

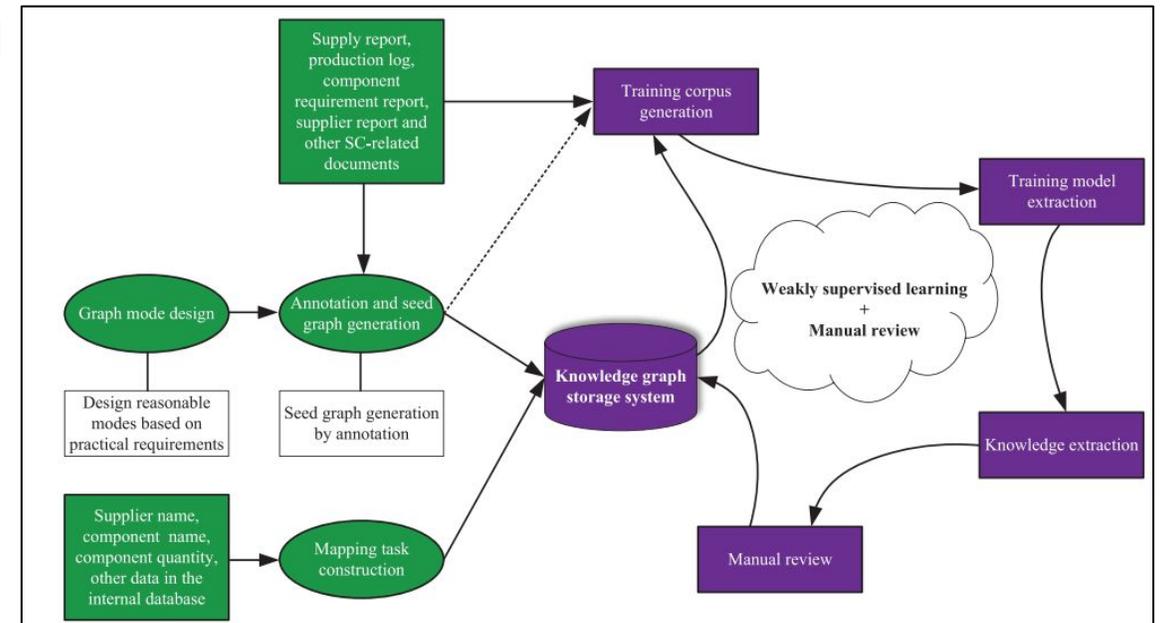


Figure 1. SC-KG framework [16]

State of the Art

N-ary relation design pattern

- OWL does not support n-ary relations [13]
- N-ary relation example (borrowed from [13]): **Christine has breast tumor with high probability.** (see Figure 2)

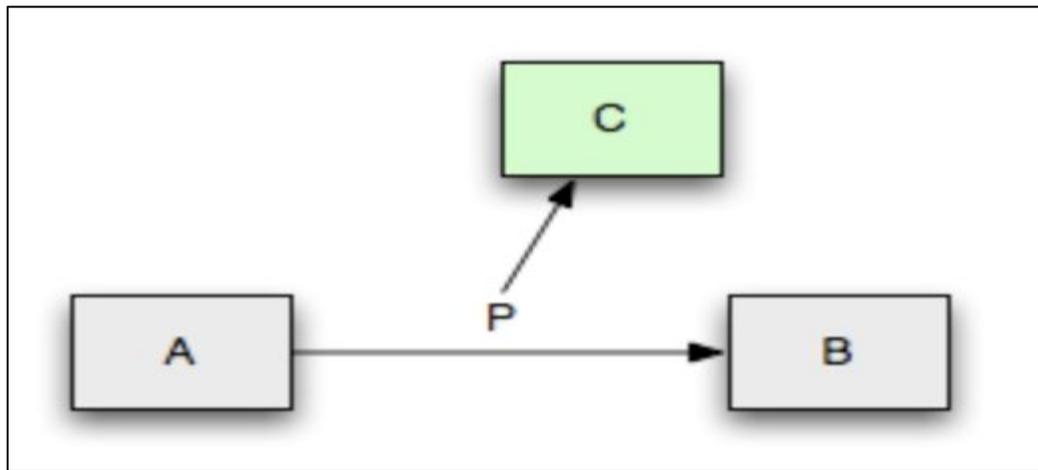


Figure 2. Additional attribute to describe binary relation [13]

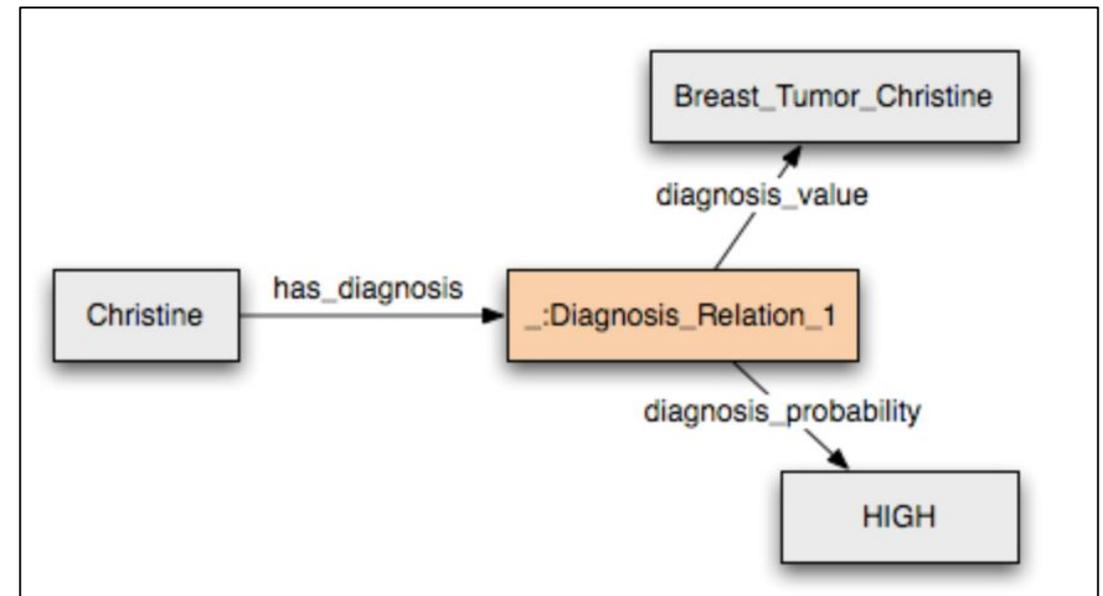


Figure 3. A n-ary relation model using binary relations [13]

State of the Art

COY ontology

- Describe companies and their supply network, employees, products, production materials, industries, events and relations.
- Online **available** at <https://schema.coypu.org/global/2.3>

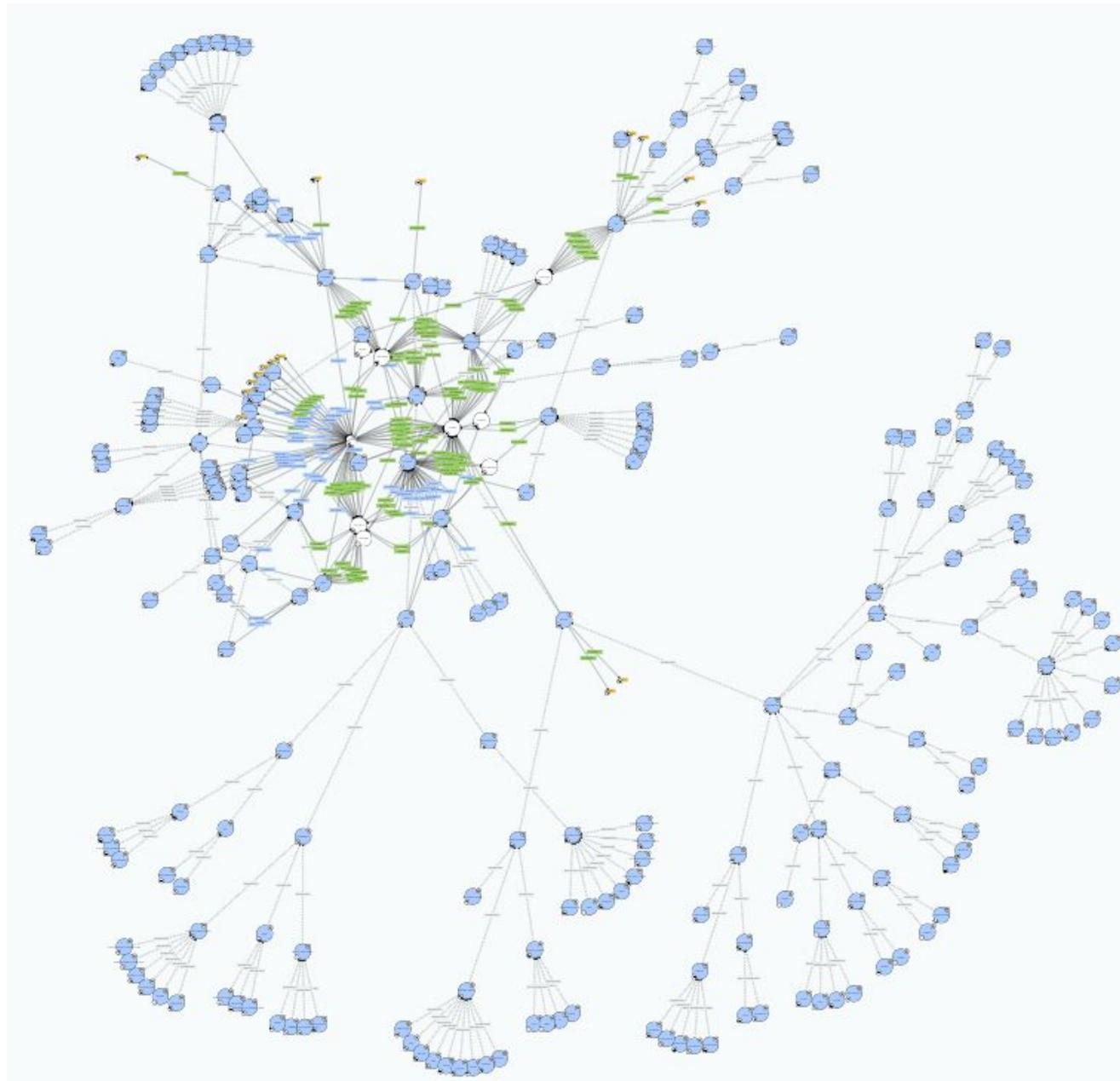


Figure 4. COY ontology - SC4EU view: <https://service.tib.eu/ocp/>

Research Questions



- Global supply chain databases such as TiVA and BACI are not interconnected, but share some metadata
- Global supply databases are in CSV files. They **can not be shared** between various computational tools
- Global supply chain databases **lack advanced analytical capabilities**
 - Using knowledge graphs for semantic data integration
 - Sharing data across the various computational tools employed in resilience analytics

Research Question 1: Can we apply n-ary relations to overcome the challenge of developing a model that integrates existing data sources related to supply chains?

Research Question 2: How can federated querying be leveraged to efficiently retrieve information from the integrated ontology model concerning global supply chains?

Research Question 3: How do we ensure interoperability between different industry classification standards used in these data sources?

Value and Trade Flows (VTF) KG

Contributions



- Address Research Questions 1 and 3
- The **VTF Knowledge Graph** contains
 - The **VTF ontology**
 - The **TiVA** and the **ISIC Rev. 4 industry code thesauruses**, and the **mappings** between them
 - **Individual assertions** of VTF ontology derived from TiVA CSV files available at [7]
 - The **TiVA KG SPARQL** endpoint is available at <https://tiva.coypu.org/tiva>
 - The VTF KG contains **1128749054 triples**

Value and Trade Flows (VTF) KG

VTF ontology

- Addresses Research Question 1
- Generic **trade and value flow model**, tailored and applied to TiVA and BACI databases
- Applies **n - ary relations** ontology design pattern to model domestic value added content of gross exports (exgr_dva code name)
- Serves as a schema for **TiVA and BACI knowledge graphs**
- **Online available**
 - Raw file: <https://schema.coypu.org/vtf/1.4.ttl>
 - Documentation: <https://schema.coypu.org/vtf/1.4>
 - It is part of coy ontology: <https://schema.coypu.org/global/2.3.ttl>

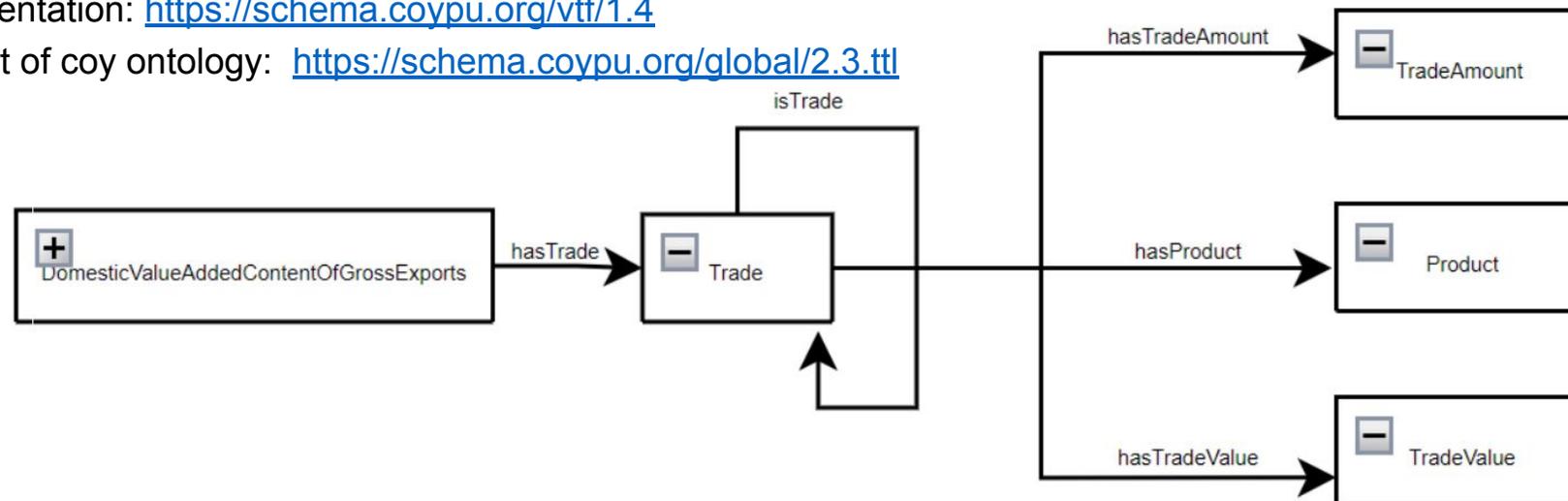


Figure 5. Modeling domestic value added content of gross exports (exgr_dva code name) using n-ary relation ontology design pattern

Value and Trade Flows (VTF) KG

VTF ontology visualisation

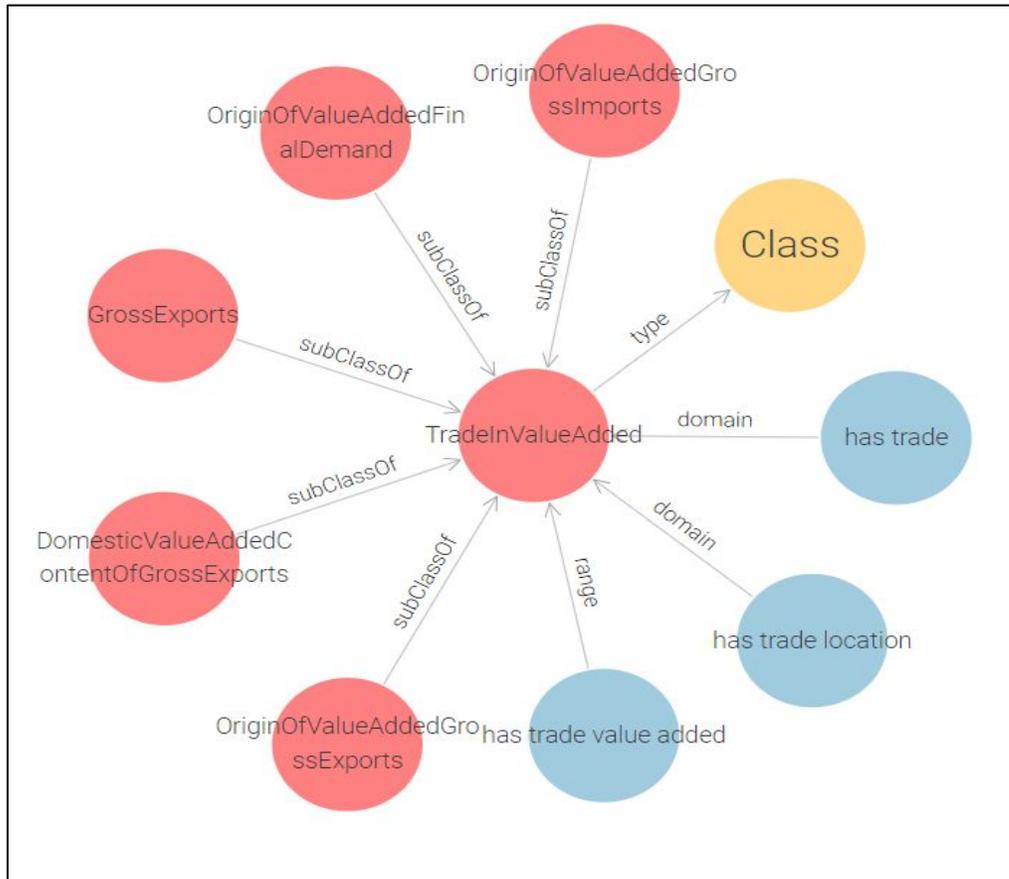


Figure 6. A snapshot of the VTF ontology

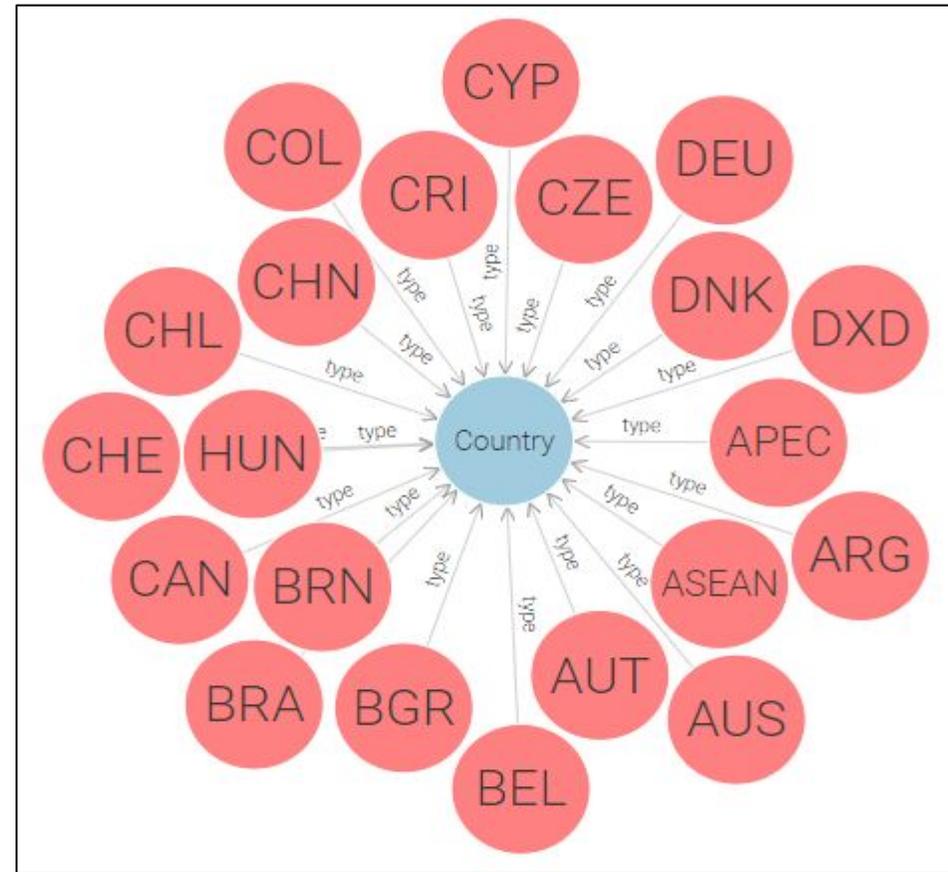


Figure 7. Country codes in VTF ontology (instantiation)

Value and Trade Flows (VTF) KG

TiVA and ISIC rev. 4 industry code mapping

- Address Research Question 3
- **Mapping input:**
 - The TiVA industry sector codes thesaurus
 - The ISIC Rev. 4 industry sector codes thesaurus
- **Automatically** produced mapping between these two thesauruses
 - It can be used to produce and validate mappings between any other industry codes that are not explicitly given
 - Industry sector codes may change over time and this generic solution can be used to produce and validate mappings
 - Implementation available in [11]

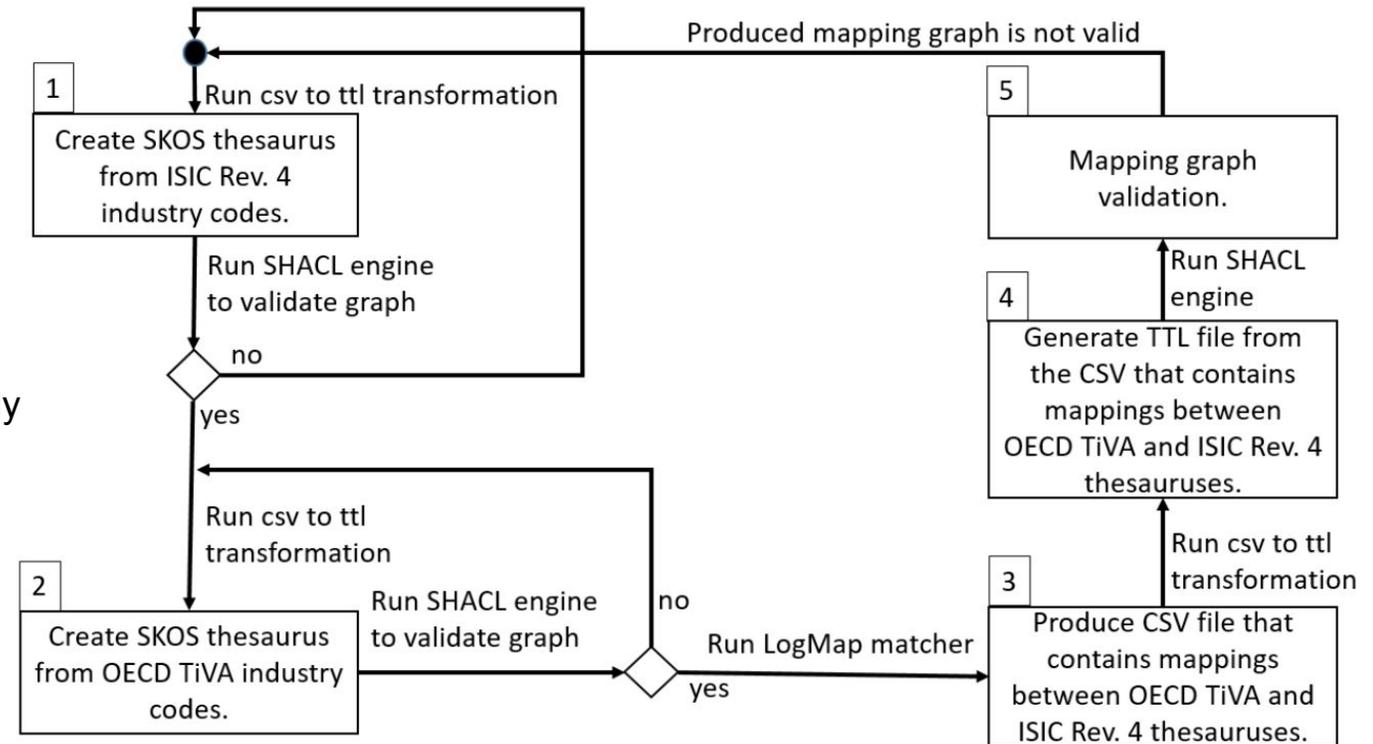


Figure 8. The ontology development workflow for the ISIC Rev. 4 and the TiVA industry sector codes

Value and Trade Flows (VTF) KG

Federated query against TiVA and BACI KG

- Address Research Question 2
- Executed programmatically against TiVA and BACI SPARQL endpoints
 - TiVA KG: Origin of value added in gross imports (imgr_bsci) four dimensional indicator
 - BACI KG (CoyPu partners): Domestic value added content of gross exports (exgr_dva) three dimensional indicator
- Export and import trade locations in TiVA KG must match import and export trade locations of exgr_dva indicator available in BACI KG

- Resulting JSON object contains

- Import value
- Import year
- Export trade location
- Import location
- Product name (label)
- Product code
- Quality value
- Year of trade
-

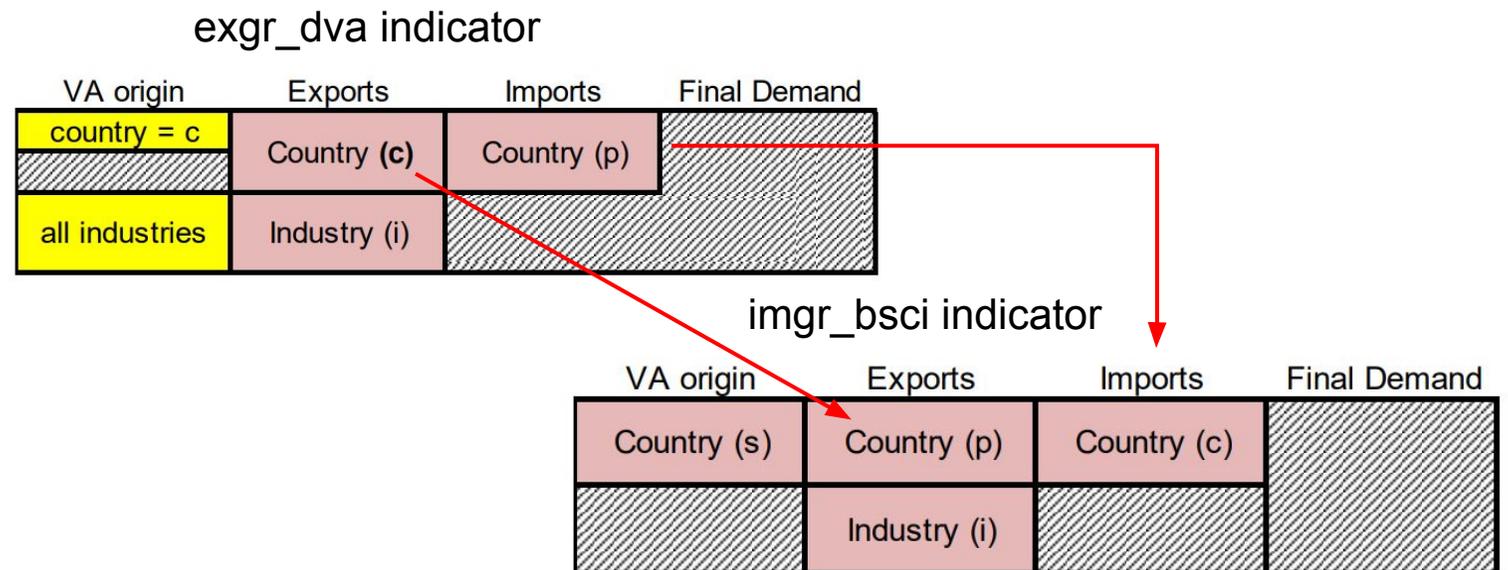


Figure 9. Links between 4-dimensional imgr_bsci and 3-dimensional exgr_dva indicators

Implementation REST API

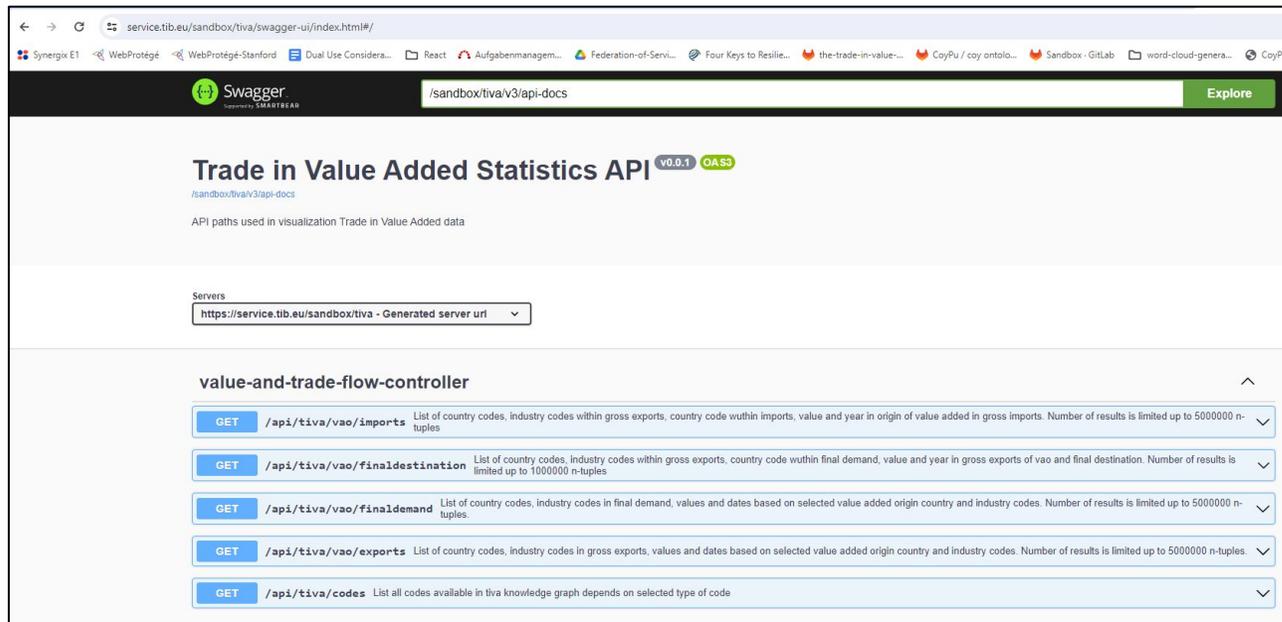


Figure 10. Swagger page to query VTF KG:
<https://service.tib.eu/sandbox/tiva/swagger-ui/index.html#/>

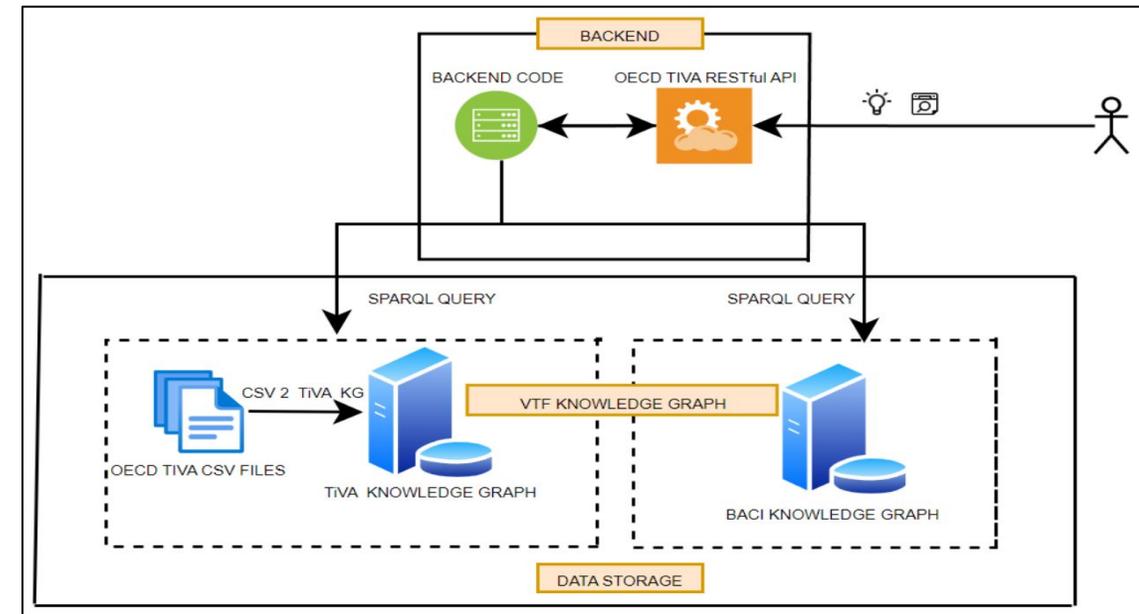


Figure 11. Pipeline to query VTF KG

THANKS

The research has received funding from the Federal Ministry for Economic Affairs and Energy of Germany in the project Cognitive Economy Intelligence Plattform für die Resilienz wirtschaftlicher Ökosysteme - CoyPu (project number 01MK21007[A-L]).



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