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Deliverable 1.8

Design of data structure definition for public spending data

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Abstract: In this deliverable we deal with RDF vocabularies to which we link the OpenBudgets.eu data model based on the RDF Data Cube Vocabulary. First, we provide an overview of the identified target vocabularies, then we describe the method we used for the manual linking process, and provide the links and transformation rules. Finally, we show how the produced links can be used to actually transform data from other vocabularies to the OpenBudgets.eu data model.

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Executive Summary

In this deliverable we enhance the OpenBudgets.eu data model described in deliverables D1.2, D1.3, and D1.4 with links to related third-party vocabularies, some identified in Deliverable D1.1 and some newly discovered in vocabulary catalogues such as Linked Open Vocabularies or Linked Statistical Data Dimensions. The deliverable contains links to 11 vocabularies in the form of RDF triples linking properties and classes from the OpenBudgets.eu data model to properties and classes from the other vocabularies. An overview of the third-party vocabularies is provided as well as the description of the method chosen to produce the links. The use of the links is demonstrated on a SPARQL Update operation transforming data from an external dataset to the data model of OpenBudgets.eu.

Abbreviations and Acronyms

DCV	Data Cube Vocabulary
DSD	Data Structure Definition
RDF	Resource Description Framework
SDMX	Statistical Data and Metadata eXchange

Table of Contents

1 Introduction

In this deliverable we link the component properties and classes of the OpenBudgets.eu data model to third-party RDF vocabularies. The links were created manually based on human assessment. The resulting links can then be used to migrate instance data to for the purpose of data integration.

The manual approach to ontology alignment was chosen due to a small number of entities to compare and the requirement for high precision. As Falconer and Noy write: *"In most cases where high precision is required, manual intervention will be necessary to verify or fine-tune the matchings produced by the automatic algorithms"* (2011, p. 29). Configuring automated ontology alignments tools to achieve a level of precision comparable to manual matching would incur too much overhead.

2 Survey of related vocabularies

Before we proceeded with linking we conducted a survey of related vocabularies to determine suitable linking targets. We surveyed the relevant vocabularies in the Deliverable D1.1 (Klímek et al., 2015). Additionally, we discovered other vocabularies relevant for the budget domain and included them in linking.

2.1 SDMX

The RDF version of the Statistical Data and Metadata Exchange – Content oriented guidelines (SDMX-COG) forms a linking backbone of the RDF Data Cube Vocabulary (DCV) component properties. SDMX-COG is used in the DCV specification, which lends it a privileged status of a central vocabulary for linked statistical data. It offers generic concepts and components that are widely reused by deriving more specific concepts and components.

Prefix	Namespace	Description
sdmx-concept	http://purl.org/linked-data/sdmx/2009/concept#	SKOS Concepts for each COG defined concept
sdmx-dimension	http://purl.org/linked-data/sdmx/2009/dimension#	component properties corresponding to each COG concept that can be used as a dimension
sdmx-attribute	http://purl.org/linked-data/sdmx/2009/attribute#	component properties corresponding to each COG concept that can be used as an attribute
sdmx-measure	http://purl.org/linked-data/sdmx/2009/measure#	component properties corresponding to each COG concept that can be used as a measure

Table 1 - SDMX-COG RDF vocabularies (Cyganiak & Reynolds, 2014)

2.2 Linked Open Vocabularies

Linked Open Vocabularies (LOV) is a collection of openly available RDF vocabularies used for describing linked data.[1] In addition to the vocabularies in Deliverable D1.1 we found relevant vocabulary terms to be linked to the OpenBudgets.eu data model in FRAPO[2].

2.3 Linked Statistical Data Dimensions

Linked Statistical Data Dimensions (LSD Dimensions)[3] aggregates dimension properties from data structure definitions of datasets represented using the Data Cube Vocabulary (Meroño-Peñuela, 2015). Dimension properties are retrieved from linked open data catalogued in DataHub.io[4]. LSD Dimensions indexes 2760 dimension properties from 578 SPARQL endpoints. We searched this repository for component properties related to the domain of fiscal data. We used free-text search via keywords and thus discovered several relevant properties that we linked further on.

2.4 Additional vocabularies

Besides the above vocabulary sources we included the following additional vocabularies:

- Publicspending.net[5]
- DCV component properties defined for data of the Czech Ministry of Finance (mfcr)[6]
- DCV component properties defined for the Combined Online Information System (COINS)[7]
- LinkedSpending ontology[8]
- DCLG Finance Ontology[9]

3 Linking

Our original intention was to reuse an established methodology for manual ontology alignment. Surprisingly, we have not discovered such a methodology. In fact, most of the surveyed literature on ontology alignment tends to discuss automated matching and shuns seemingly “unscientific” manual matching. Some work in the domain of automated ontology alignment discusses using auxiliary human input or intervention, but accounts of purely manual approaches of ontology alignment are rare to find. Euzenat and Shvaiko (2013) include human interaction into a machine-led matching, providing input parameters, combining strategies, or giving feedback to the machine. In general, manual alignment is still used for creating reference links, yet scant evidence is available about the methods employed for this task. We argue that this is a serious deficiency of this field of research as automation cannot be based on solid ground without establishing how manual alignment should be conducted. Similarly, Falconer

[1] http://lov.okfn.org

[2] http://purl.org/cerif/frapo/

[3] http://lsd-dimensions.org

[4] http://datahub.io

[5] We wanted to include the related Publicspending.gr vocabulary mentioned in D1.1, but it is no longer available, since, as of December 5, 2015, http://publicspending.gr leads to a password-protected server.

[6] http://opendata.vse.cz/mfcr/vocab.ttl

[7] http://finance.data.gov.uk/def/coins/coins-dsd.ttl

[8] https://github.com/AKSW/openspending2rdf/blob/master/schema/ontology.ttl

[9] http://opendatacommunities.org/def/ontology/dclg/finance

and Storey remark that so far *"research has largely ignored the issue of user intervention and instead has focused on algorithms to compute candidate mappings"* (2007).

Therefore, we had to define our approach to linking from piecemeal mentions on how reference alignments are made in related research. We adopted several principles proposed for automated ontology alignment, such as comparison of lexical similarity of labels, and "executed" them manually. We selected the OpenBudgets.eu data model as the central vocabulary for ontology alignments, so that we linked the third-party vocabularies only to the the data model and not among themselves.

3.1 Linking method

All authors of this deliverable were involved in creating links between the data model of OpenBudgets.eu and third-party vocabularies. We started with a single vocabulary (LinkedSpending ontology) each of the authors linked separately. Subsequently, we compared the links each author created and had a *"discussion about disagreements in order to achieve consensus"* (Meilicke et al., 2012). In this way, we resolved inconsistencies in linking approaches and highlighted concerns that were overlooked by some of us, such as inferences drawn from `rdfs:domain` and `rdfs:range` of the linked component properties. This initial experiment also served as a cross-validation of links. Having addressed the differences in our linking approaches further vocabularies were processed by the individual authors to save effort.

All parts of OBEU RDF data model were merged into one file in order to make comparison with other vocabularies easier. The resulting file was then loaded into Protégé[10] and visualized in its Entity Browser. Each surveyed vocabulary was displayed in the same way. The surveyed vocabulary was first searched for a property representing monetary amount, i.e., a property equivalent or similar to `obeu-measure:amount`. The amount served as an anchor for further links. The following was used to assess the similarity:

- `rdfs:label`
- `rdfs:comment`
- `rdf:type`
- `rdfs:domain` and `rdfs:range`
- documentation of the vocabulary
- examples of usage retrieved from SPARQL endpoint

We compared `rdfs:label` and `rdfs:comment` to establish their lexical similarity. The `rdf:type` of the linked component properties was used to distinguish object (`owl:ObjectProperty`) and data type (`owl:DatatypeProperty`) properties. While few properties directly instantiated these OWL classes, their instantiation could be inferred from membership in DCV classes (e.g., `qb:DimensionProperty` is an `owl:ObjectProperty`). The domain (`rdfs:domain`) and range (`rdfs:range`) of the considered properties were used to assess the semantic compatibility of the inferred class instantiations of subjects and objects of these properties. If available, we consulted the documentation of the linked vocabularies to clarify the meaning of the RDF description of the properties in question. In some cases, examples of use of the linked properties were retrieved from SPARQL endpoints or RDF data dumps to verify if the properties are used as it is suggested in their description.

The properties `owl:equivalentProperty` or `rdfs:subPropertyOf` were used to link the property to `obeu-measure:amount` if applicable. All properties with the same domain as the amount property were compared to the properties from the OBEU data model and linking continued in the same way. Other properties in the surveyed vocabulary were evaluated based on the above criteria. Additionally, classes from the target vocabulary were compared in a

[10] http://protege.stanford.edu

similar fashion and linked. For example, this was the case of subclasses of `skos:Concept` comprising code list values.

Instance data was used only to decide similarity when the meaning of the target property was unclear and instance data was available. We looked only at a few examples to clarify if the property's objects matched our understanding of the property's use. It was frequently the case that instance data was unavailable.

3.2 Linking properties

The properties representing the semantics of links were selected from RDF Schema,[11] OWL,[12] and DCV. We used the following predicates:

Linking property	Use
`owl:equivalentProperty`	Equivalent and mutually interchangeable properties
`rdfs:subPropertyOf`	Properties specifying or generalizing each other
`qb:concept`	Properties instantiating incompatible subclasses of `qb:ComponentProperty` that relate to the same underlying concept
`rdfs:subClassOf`	Classes specifying or generalizing each other

Table 2 - Use of linking properties

We used `qb:concept` for linking component properties of instantiating different subclasses of `qb:ComponentProperty`. For example, location may be modelled either as dimension (i.e. `qb:DimensionProperty`) or attribute (i.e. `qb:AttributeProperty`). In that case, it is not correct to link the component properties directly. Instead, we link both properties to the same `skos:Concept`, such as `sdmx-concept:refArea`, using the `qb:concept` property. The same approach was employed to link data type and object properties. For example, the date property is often defined as a data type property with the range of `xsd:date`, while in the OBEU data model it is an object property with the range of `time:Interval`. To resolve this mismatch we can link both properties to the same `qb:concept`, such as `sdmx-concept:refPeriod`.

We also encountered cases in which the expressive power of above-listed linking properties was insufficient. For example, the property `pay:grossAmount` from the Payments Ontology maps to the measure property `obeu-measure:amount` if the `obeu-attribute:taxesIncluded` is set to `true`. In such cases, we represented the relationship as a part of SPARQL Update operation for migrating instance data. For example, the `pay:grossAmount` property can be mapped using the following transformation:

```
PREFIX obeu-attribute: <http://data.openbudgets.eu/ontology/dsd/attribute/>
PREFIX obeu-measure:   <http://data.openbudgets.eu/ontology/dsd/measure/>
PREFIX pay:            <http://reference.data.gov.uk/def/payment#>
PREFIX qb:             <http://purl.org/linked-data/cube#>
```

[11] http://www.w3.org/TR/rdf-schema

[12] http://www.w3.org/TR/owl2-syntax

```
INSERT {
  ?expenditureLine a qb:Observation ;
    obeu-measure:amount ?amount ;
    obeu-attribute:taxesIncluded true .
}
WHERE {
  ?expenditureLine a pay:ExpenditureLine ;
    pay:grossAmount ?amount .
}
```

Example 1 - SPARQL Update operation mapping pay:grossAmount

4 Use of links

The produced links between vocabularies can be used in several ways. A traditional semantic web approach is to use the links in a reasoner to infer data via RDFS and OWL semantics. Alternatively, the links can help understand linked data for users already familiar with the data model of OpenBudgets.eu.

A more practical way of using the links is to implement data migration rules to integrate instance data. The rules can translate instance data described by a vocabulary to another linked vocabulary. An RDF-native data migration rules can be developed using SPARQL Update operations that match source vocabulary graph patterns and produce target vocabulary graph patterns. We decided to accompany the created links with SPARQL Update operations defining possible data transformations. The migration rules were created for COINS, LinkedSpending, Publicspending.net, and the Payments Ontology. These rules are provided in the SPARQL Transformation appendices. We ruled out other data models as too different to allow a direct data transformation via SPARQL. The transformation of the excluded datasets will be done as part of ETL processing.

Unfortunately, implementation of generic migration rules is elusive. It is often the case that instance data deviates from its vocabulary. For example, even though the Payments Ontology defines the `pay:expenditureCategory` property to distinguish among capital expenditure and revenue, some datasets use this property to distinguish functional classification. Therefore, custom amendments to the generic migration rules are required for most datasets.

As an example of data migration via the provided links we chose the spending for Q1 of 2015 of the Surrey city council,[13] which is represented using the Payments Ontology. This dataset contains the following payment:

```
@prefix odcp: <http://opendatacommunities.org/def/transparency/local/payments/> .
@prefix pay:  <http://reference.data.gov.uk/def/payment#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

<http://data.surreycc.gov.uk/id/expenditure-line/2015-03-01/not-assigned/34863>
    a <http://reference.data.gov.uk/def/payment#Payment> ;
    pay:currency <http://dbpedia.org/resource/Pound_sterling> ;
    pay:date <http://reference.data.gov.uk/id/day/2015-03-01> ;
    pay:expenditureCategory
<http://data.surreycc.gov.uk/def/payments/expenditure-category/rates> ;
    pay:netAmount 11548.0 ;
    pay:payee <http://data.surreycc.gov.uk/id/supplier/gerald-eve> ;
    pay:payer <http://opendatacommunities.org/id/county-council/surrey> ;
    pay:unit <http://data.surreycc.gov.uk/id/department/not-assigned> ;
    odcp:merchantCategory "Valuation" ;
```

[13] http://data.surreycc.gov.uk/data/transparency/spending/2015-Q1

```
    rdfs:label "Payment 34863, 2015-Q1, *01.03.2015-01.03.2015-Bus Rates Payable,
Rates March 2015" .
```

Example 2 - Payment from the Surrey city council

We can use a SPARQL Update operation to translate the payment from the Payments Ontology to the data model of OpenBudgets.eu:

```
PREFIX obeu-attribute: <http://data.openbudgets.eu/ontology/dsd/attribute/>
PREFIX obeu-dimension: <http://data.openbudgets.eu/ontology/dsd/dimension/>
PREFIX obeu-measure:   <http://data.openbudgets.eu/ontology/dsd/measure/>
PREFIX obeu:           <http://data.openbudgets.eu/ontology/>
PREFIX pay:            <http://reference.data.gov.uk/def/payment#>
PREFIX qb:             <http://purl.org/linked-data/cube#>

INSERT {
  ?observation a qb:Observation ;
    obeu-measure:amount ?amount ;
    obeu-attribute:taxesIncluded ?taxesIncluded ;
    ?obeuDimension ?dimensionValue ;
    ?obeuAttribute ?attributeValue ;
    ?obeuProperty ?propertyValue .
}
WHERE {
  # Measures
  VALUES (?amountProperty ?taxesIncluded) {
         (pay:grossAmount true)
         (pay:netAmount   false)
  }
  # Attributes
  VALUES (?payAttribute ?obeuAttribute) {
         (pay:currency  obeu-attribute:currency)
  }
  # Dimensions
  VALUES (?payDimension           ?obeuDimension) {
         (pay:date                obeu-dimension:date)
         (pay:expenditureCategory obeu-dimension:operationCharacter)
         (pay:payee               obeu-dimension:partner)
         (pay:payer               obeu-dimension:organization)
         (pay:procurementCategory obeu-dimension:functionalClassification)
  }
  # Other properties
  VALUES (?payProperty ?obeuProperty) {
         (pay:contract obeu:contract)
         (pay:invoice  obeu-dimension:accountingRecord)
         (pay:unit     obeu-dimension:administrativeClassification)
  }

  ?observation ?amountProperty ?amount ;
    ?payDimension ?dimensionValue .
  OPTIONAL { ?observation ?payAttribute ?attributeValue . }
  OPTIONAL { ?observation ?payProperty ?propertyValue . }
}
```

Example 3 - SPARQL Update operation mapping the Payments Ontology

If we transform the payment using the SPARQL Update operation, we get the following result:

```
@prefix obeu-attribute: <http://data.openbudgets.eu/ontology/dsd/attribute/> .
@prefix obeu-dimension: <http://data.openbudgets.eu/ontology/dsd/dimension/> .
@prefix obeu-measure:   <http://data.openbudgets.eu/ontology/dsd/measure/> .
@prefix pay:            <http://reference.data.gov.uk/def/payment#> .
@prefix qb:             <http://purl.org/linked-data/cube#> .

<http://data.surreycc.gov.uk/id/expenditure-line/2015-03-01/not-assigned/34863>
  a qb:Observation ;
  obeu-attribute:currency <http://dbpedia.org/resource/Pound_sterling> ;
  obeu-attribute:taxesIncluded false ;
```

```
  obeu-dimension:administrativeClassification
<http://data.surreycc.gov.uk/id/department/not-assigned> ;
  obeu-dimension:date <http://reference.data.gov.uk/id/day/2015-03-01> ;
  obeu-dimension:operationCharacter
<http://data.surreycc.gov.uk/def/payments/expenditure-category/rates> ;
  obeu-dimension:organization          <http://opendatacommunities.org/id/county-
council/surrey> ;
  obeu-dimension:partner <http://data.surreycc.gov.uk/id/supplier/gerald-eve> ;
  obeu-measure:amount 11548.0 .
```

Example 4 - Payment from the Surrey city council mapped to OBEU data model

Data migration can serve as means to integrate data. In this way, the transformed data can be used in combination with other datasets represented using the OpenBudgets.eu data model, such that queries spanning multiple datasets can be answered.

5 Conclusions

In this deliverable, we provided an overview of third-party vocabularies semantically related to the OpenBudgets.eu data model, partly based on Deliverable D1.1. We described a method used for linking the vocabularies to the model and we provided the resulting links and more complex transformation rules and demonstrated their usage on an example of a SPARQL Update operation that transforms data modelled using a third-party vocabulary to the OpenBudgets.eu data model.

6 References

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- Meroño-Peñuela, A. (2015): LSD dimensions: use and reuse of linked statistical data. In Lambrix, P. [et al.] (eds.). Knowledge Engineering and Knowledge Management: EKAW 2014 Satellite Events, VISUAL, EKM1, and ARCOE-Logic, Linköping, Sweden, November 24-28, 2014. Revised Selected Papers. Berlin; Heidelberg: Springer, 2015, pp. 159-163. Lecture Notes in Computer Science, vol. 8982. DOI 10.1007/978-3-319-17966-7_22.

7 Appendix: Links to third-party vocabularies

This appendix (`links.ttl`) contains links to other vocabularies.

```
@prefix dbo:            <http://dbpedia.org/ontology/> .
@prefix obeu:           <http://data.openbudgets.eu/ontology/> .
@prefix obeu-attribute:
<http://data.openbudgets.eu/ontology/dsd/attribute/> .
@prefix obeu-dimension:
<http://data.openbudgets.eu/ontology/dsd/dimension/> .
@prefix obeu-measure:   <http://data.openbudgets.eu/ontology/dsd/measure/>
.
@prefix obeu-operation:
<http://data.openbudgets.eu/resource/codelist/operation-character/> .
@prefix owl:            <http://www.w3.org/2002/07/owl#> .
@prefix pay:            <http://reference.data.gov.uk/def/payment#> .
@prefix qb:             <http://purl.org/linked-data/cube#> .
@prefix rdfs:           <http://www.w3.org/2000/01/rdf-schema#> .
@prefix sdmx-concept:   <http://purl.org/linked-data/sdmx/2009/concept#> .

#####################################
### Links to the Payments Ontology ###
#####################################

pay:contract owl:equivalentProperty obeu:contract .

pay:currency owl:equivalentProperty obeu-attribute:currency .

pay:date owl:equivalentProperty obeu-dimension:date .

pay:expenditureCategory rdfs:subPropertyOf obeu-
dimension:operationCharacter .

pay:invoice rdfs:subPropertyOf obeu-dimension:accountingRecord .

pay:payee rdfs:subPropertyOf obeu-dimension:partner .

pay:payer rdfs:subPropertyOf obeu-dimension:organization .

pay:procurementCategory rdfs:subPropertyOf obeu-
dimension:functionalClassification .

pay:unit rdfs:subPropertyOf obeu-dimension:administrativeClassification .

############################################
### Links to publicspending.net/ontology ###
############################################

@prefix psnet:                    <http://publicspending.net/ontology#> .

psnet:Payment rdfs:subClassOf qb:Observation .

obeu-dimension:organization rdfs:subPropertyOf psnet:payer .

obeu-dimension:partner rdfs:subPropertyOf psnet:payee .

# Defined as data property but used as object property, values are typed
also as <http://www.e-nvision.org/ontologies/CPVOntology.owl#CPVCategory>.
psnet:cpv rdfs:subPropertyOf obeu-dimension:functionalClassification .
```

```
psnet:paymentAmount rdfs:subPropertyOf obeu-measure:amount .

# psnet:paymentCategory is defined as data property, but its values are
blank nodes without
# any further description (psnet:paymentCategory corresponds to obeu-
dimension:classification/skos:notation).

#################################################################
### Links to MFČR (http://opendata.vse.cz/mfcr/vocab.ttl) ###
#################################################################

@prefix mfcr: <http://linked.opendata.cz/resource/domain/mfcr/monitor/dsd/>
.

mfcr:konecnyRozpocet rdfs:subPropertyOf obeu-measure:amount .
mfcr:schvalenyRozpocet rdfs:subPropertyOf obeu-measure:amount .
mfcr:bezneObdobi rdfs:subPropertyOf obeu-measure:amount .
mfcr:rozpocetPoZmenach rdfs:subPropertyOf obeu-measure:amount .
mfcr:vysledekZaRok rdfs:subPropertyOf obeu-measure:amount .
mfcr:mimorozpoctoveProstredky rdfs:subPropertyOf obeu-measure:amount .
mfcr:prevodDoRezervnihoFondu rdfs:subPropertyOf obeu-measure:amount .

mfcr:fiskalniObdobi owl:equivalentProperty obeu-dimension:fiscalPeriod .
mfcr:ic rdfs:subPropertyOf obeu-dimension:budgetaryUnit .
mfcr:kapitola rdfs:subPropertyOf obeu-
dimension:administrativeClassification .
mfcr:rozpoctovyProgram rdfs:subPropertyOf obeu-
dimension:programmeClassification .
mfcr:vykazTabulka rdfs:subPropertyOf obeu-
dimension:functionalClassification .
mfcr:polozkaVykazu rdfs:subPropertyOf obeu-dimension:economicClassification
.
mfcr:bankovniUcet rdfs:subPropertyOf obeu-
dimension:functionalClassification .
mfcr:ucelovyZnak rdfs:subPropertyOf obeu-dimension:economicClassification .
mfcr:paragraf rdfs:subPropertyOf obeu-dimension:functionalClassification .
mfcr:pomv rdfs:subPropertyOf obeu-dimension:classification .
mfcr:lau qb:concept sdmx-concept:refArea .

#################################################################################
### Links to COINS (http://finance.data.gov.uk/def/coins/coins-dsd.ttl) ###
#################################################################################

@prefix coins-measure:   <http://finance.data.gov.uk/dsd/coins/measure/> .
@prefix coins-dimension: <http://finance.data.gov.uk/dsd/coins/dimension/>
.
@prefix coins-attribute: <http://finance.data.gov.uk/dsd/coins/attribute/>
.

coins-measure:amount rdfs:subPropertyOf obeu-measure:amount .

coins-dimension:accountCode rdfs:subPropertyOf obeu-
dimension:economicClassification .

coins-dimension:counterpartyCode rdfs:subPropertyOf obeu-dimension:partner
.

coins-dimension:departmentCode rdfs:subPropertyOf obeu-
dimension:organization .

coins-dimension:programmeObjectCode rdfs:subPropertyOf obeu-
dimension:programmeClassification .
```

```
coins-attribute:cofog rdfs:subPropertyOf obeu-
dimension:functionalClassification .

#######################################################
### Links to Frapo <http://purl.org/cerif/frapo/> ###
#######################################################

@prefix frapo: <http://purl.org/cerif/frapo/> .

obeu-measure:amount rdfs:subPropertyOf frapo:hasMonetaryValue .

frapo:Payment rdfs:subClassOf qb:Observation .
frapo:BudgetedAmount rdfs:subClassOf qb:Observation .

#########################################################################
######################
### Links to DCLG Finance Ontology
(http://opendatacommunities.org/def/ontology/dclg/finance) ###
#########################################################################
######################

@prefix dclg-finance: <http://opendatacommunities.org/def/finance/> .

dclg-finance:RevenueAccountBudgetCategory rdfs:subClassOf
obeu:OperationCharacter .

dclg-finance:amount rdfs:subPropertyOf obeu-measure:amount .

dclg-finance:serviceExpenditureCategory rdfs:subPropertyOf obeu-
dimension:functionalClassification .

dclg-finance:authority rdfs:subPropertyOf obeu-dimension:organization .

dclg-finance:revenueAccountBudgetCategory rdfs:subPropertyOf obeu-
dimension:operationCharacter .

#########################################################
### Links to dimensions found on lsd-dimensions.org ###
#########################################################

obeu-dimension:fiscalYear owl:equivalentProperty
<http://worldbank.270a.info/property/fiscal-year> .

<http://logd.tw.rpi.edu/source/data-rpi-edu/dataset/research-
centers/vocab/enhancement/2/funding_type> rdfs:subPropertyOf obeu-
dimension:classification .

#################################################################
### Links to DBpedia Ontology <http://dbpedia.org/ontology/> ###
#################################################################

obeu-attribute:currency rdfs:subPropertyOf dbo:currency .

######################
### Links to SDMX ###
######################

obeu-attribute:location qb:concept sdmx-concept:refArea .
obeu-attribute:currency qb:concept sdmx-concept:currency .
obeu-dimension:fiscalPeriod qb:concept sdmx-concept:refPeriod .
obeu-dimension:fiscalYear qb:concept sdmx-concept:refPeriod .
obeu-dimension:date qb:concept sdmx-concept:refPeriod .
```

```
obeu-dimension:currency qb:concept sdmx-concept:currency .
obeu-dimension:budgetaryUnit qb:concept sdmx-concept:statUnit .
obeu-dimension:organization qb:concept sdmx-concept:statUnit .
obeu-dimension:partner qb:concept sdmx-concept:statUnit .
obeu-measure:amount qb:concept sdmx-concept:obsValue .

################################
### Links to LinkedSpending ###
################################

@prefix ls:             <http://linkedspending.aksw.org/ontology/> .

ls:refDate owl:equivalentProperty obeu-dimension:date .
ls:refYear qb:concept sdmx-concept:refPeriod .
```

8 Appendix: SPARQL transformation: COINS

This appendix (`coins_to_obeu.ru`) contains SPARQL transformation rules for transformation of data using the COINS vocabulary to the OpenBudgets.eu data model.

```
PREFIX obeu-attribute: <http://data.openbudgets.eu/ontology/dsd/attribute/>
PREFIX obeu-currency:
<http://data.openbudgets.eu/resource/codelist/currency/>
PREFIX obeu-dimension: <http://data.openbudgets.eu/ontology/dsd/dimension/>
PREFIX obeu-measure:   <http://data.openbudgets.eu/ontology/dsd/measure/>
PREFIX obeu-operation:
<http://data.openbudgets.eu/resource/codelist/operation-character/>
PREFIX obeu:           <http://data.openbudgets.eu/ontology/>
PREFIX org:            <http://www.w3.org/ns/org#>
PREFIX owl:            <http://www.w3.org/2002/07/owl#>
PREFIX pay:            <http://reference.data.gov.uk/def/payment#>
PREFIX qb:             <http://purl.org/linked-data/cube#>
PREFIX rdfs:           <http://www.w3.org/2000/01/rdf-schema#>
PREFIX time:           <http://www.w3.org/2006/time#>

PREFIX coins-measure:   <http://finance.data.gov.uk/dsd/coins/measure/>
PREFIX coins-dimension: <http://finance.data.gov.uk/dsd/coins/dimension/>
PREFIX coins-attribute: <http://finance.data.gov.uk/dsd/coins/attribute/>

INSERT {
  ?coinsRecord a qb:Observation ;
    obeu-measure:amount ?amount ;
    obeu-attribute:currency obeu-currency:GBP ;
    obeu-dimension:economicClassification ?accCode ;
    obeu-dimension:functionalClassification ?cofog ;
    obeu-dimension:organization ?depCode ;
    obeu-dimension:partner ?counterCode ;
    obeu-dimension:programmeClassification ?progCode ;
    obeu-dimension:operationCharacter ?operationCharacter .
}
WHERE {
  ?coinsRecord coins-measure:amount ?amountInThousands ;
    coins-dimension:departmentCode ?depCode ;
    coins-dimension:counterpartyCode ?counterCode ;
    coins-dimension:programmeObjectCode ?progCode ;
    coins-attribute:cofog ?cofog ;
    coins-dimension:accountCode ?accCode .

  BIND (abs(?amountInThousands) * 1000.0 AS ?amount) # negative numbers are
considered as revenues
  BIND (IF(?amountInThousands < 0, obeu-operation:revenue, obeu-
operation:expenditure) AS ?operationCharacter)
};

# Expects existing GBP currency
INSERT DATA {
  obeu-currency:GBP a skos:Concept ;
    skos:prefLabel "Pound sterling"@en ;
    skos:notation "GBP" ;
    dbp:isoCode "GBP" ;
    owl:sameAs <http://dbpedia.org/resource/GBP> ;
    skos:topConceptOf obeu-codelist:currency ;
    skos:inScheme obeu-codelist:currency .
};
```

```
# Conversion of time/date probably impossible with SPARQL
# Time specification looks like this
# <http://finance.data.gov.uk/def/coins/time/m2010m>
<http://www.w3.org/2004/02/skos/core#prefLabel> "March 2010 MTH"@en .
# <http://finance.data.gov.uk/def/coins/time/m2010m>
<http://www.w3.org/2004/02/skos/core#notation> "m2010m" .
# <http://finance.data.gov.uk/def/coins/time/m2010m>
<http://www.w3.org/2000/01/rdf-schema#label> "March 2010 MTH"@en .
# <http://finance.data.gov.uk/def/coins/time/m2010m>
<http://www.w3.org/2000/01/rdf-schema#comment> "" .
# <http://finance.data.gov.uk/def/coins/time/m2010m>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/2004/02/skos/core#Concept> .
# <http://finance.data.gov.uk/def/coins/time/m2010m>
<http://www.w3.org/2004/02/skos/core#topConceptOf>
<http://finance.data.gov.uk/def/coins/time> .
# <http://finance.data.gov.uk/def/coins/time/m2010m>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://finance.data.gov.uk/def/coins/Time> .
# i.e. only free text spec of the date value, needs parsing
# linked from observation with sdmx:refPeriod
```

9 Appendix: SPARQL transformation: LinkedSpending

This appendix (`linkedspending_to_obeu.ru`) contains SPARQL transformation rules for transformation of data using the LinkedSpending vocabulary to the OpenBudgets.eu data model.

```
PREFIX dbo:             <http://dbpedia.org/ontology/>
PREFIX ls:              <http://linkedspending.aksw.org/ontology/>
PREFIX obeu-attribute: <http://data.openbudgets.eu/ontology/dsd/attribute/>
PREFIX obeu-dimension: <http://data.openbudgets.eu/ontology/dsd/dimension/>
PREFIX owl:             <http://www.w3.org/2002/07/owl#>
PREFIX rdfs:            <http://www.w3.org/2000/01/rdf-schema#>
PREFIX sdmx-attribute: <http://purl.org/linked-data/sdmx/2009/attribute#>

INSERT {
  ?observation obeu-dimension:date ?dateUri ;
    obeu-dimension:fiscalYear ?yearUri ;
    obeu-attribute:currency ?currency ;
    obeu-attribute:location ?refArea .
}
WHERE {
  ?observation ls:refDate ?refDate ;
    ls:refYear ?refYear ;
    dbo:currency ?currency ;
    sdmx-attribute:refArea ?refArea .

  BIND("http://reference.data.gov.uk/id/" AS ?refDataGov)
  BIND(URI(CONCAT(?refDataGov, "gregorian-day/", ?refDate)) AS ?dateUri)
  BIND(URI(CONCAT(?refDataGov, "gregorian-year/", ?refYear)) AS ?yearUri)
}
```

10 Appendix: SPARQL transformation: Payments Ontology

This appendix (`payments_to_obeu.ru`) contains SPARQL transformation rules for transformation of data using the Payments Ontology to the OpenBudgets.eu data model.

```
PREFIX obeu-attribute: <http://data.openbudgets.eu/ontology/dsd/attribute/>
PREFIX obeu-dimension: <http://data.openbudgets.eu/ontology/dsd/dimension/>
PREFIX obeu-measure:   <http://data.openbudgets.eu/ontology/dsd/measure/>
PREFIX obeu:           <http://data.openbudgets.eu/ontology/>
PREFIX pay:            <http://reference.data.gov.uk/def/payment#>
PREFIX qb:             <http://purl.org/linked-data/cube#>

INSERT {
  ?observation a qb:Observation ;
    obeu-measure:amount ?amount ;
    obeu-attribute:taxesIncluded ?taxesIncluded ;
    ?obeuDimension ?dimensionValue ;
    ?obeuAttribute ?attributeValue ;
    ?obeuProperty ?propertyValue .
}
WHERE {
  # Measures
  VALUES (?amountProperty ?taxesIncluded) {
         (pay:grossAmount true)
         (pay:netAmount   false)
  }
  # Attributes
  VALUES (?payAttribute ?obeuAttribute) {
         (pay:currency  obeu-attribute:currency)
  }
  # Dimensions
  VALUES (?payDimension           ?obeuDimension) {
         (pay:date                obeu-dimension:date)
         (pay:expenditureCategory obeu-dimension:operationCharacter)
         (pay:payee               obeu-dimension:partner)
         (pay:payer               obeu-dimension:organization)
         (pay:procurementCategory obeu-dimension:functionalClassification)
  }
  # Other properties
  VALUES (?payProperty ?obeuProperty) {
         (pay:contract obeu:contract)
         (pay:invoice  obeu-dimension:accountingRecord)
         (pay:unit     obeu-dimension:administrativeClassification)
  }

  ?observation ?amountProperty ?amount ;
    ?payDimension ?dimensionValue .
  OPTIONAL { ?observation ?payAttribute ?attributeValue . }
  OPTIONAL { ?observation ?payProperty ?propertyValue . }
}
```

11 Appendix: SPARQL transformation: Publicspending.net

This appendix (psnet_to_obeu.ru) contains SPARQL transformation rules for transformation of data using the Publicspending.net vocabulary to the OpenBudgets.eu data model.

```
PREFIX obeu-attribute: <http://data.openbudgets.eu/ontology/dsd/attribute/>
PREFIX obeu-dimension: <http://data.openbudgets.eu/ontology/dsd/dimension/>
PREFIX obeu-measure:   <http://data.openbudgets.eu/ontology/dsd/measure/>
PREFIX obeu-operation:
<http://data.openbudgets.eu/resource/codelist/operation-character/>
PREFIX obeu:           <http://data.openbudgets.eu/ontology/>
PREFIX org:            <http://www.w3.org/ns/org#>
PREFIX owl:            <http://www.w3.org/2002/07/owl#>
PREFIX pay:            <http://reference.data.gov.uk/def/payment#>
PREFIX psnet:                    <http://publicspending.net/ontology#>
PREFIX qb:             <http://purl.org/linked-data/cube#>
PREFIX rdfs:           <http://www.w3.org/2000/01/rdf-schema#>
PREFIX skos:           <http://www.w3.org/2004/02/skos/core#>
PREFIX time:           <http://www.w3.org/2006/time#>

PREFIX example:        <http://example.openbudgets.eu/vocabulary/>

INSERT {
  ?payment a qb:Observation ;
    obeu-measure:amount ?amount ;
    obeu-dimension:functionalClassification ?cpv ;
    obeu-dimension:organization ?payer ;
    obeu-dimension:partner ?payee ;
    obeu-dimension:date ?dateUri ;
    example:paymentCategory ?paymentCategoryUri .

  ?cpv skos:notation ?cpvCode .
  ?paymentCategoryUri skos:notation ?paymentCategory .
}
WHERE {
  ?payment a psnet:Payment ;
     psnet:paymentAmount ?amount ;
     psnet:payer ?payer ;
     psnet:payee ?payee ;
     psnet:cpv ?cpv ;
     psnet:date ?date ;
     psnet:paymentCategory ?paymentCategory .

  ?cpv psnet:cpvCode ?cpvCode .

  BIND(URI(CONCAT("http://reference.data.gov.uk/id/gregorian-day/", ?date))
AS ?dateUri)
  BIND(URI(CONCAT("http://example.openbudgets.eu/paymentCategory/",
?paymentCategory)) AS ?paymentCategoryUri)

};

#Creation of additional properties
INSERT DATA {
  example:paymentCategory rdfs:subPropertyOf obeu-dimension:classification
.
}
```