

Turning Tax Law into Computer Code

Denis MERIGOUX

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Inria, Paris

Turning Law into Code

Presentation mostly derived from ideas in :

Huttner, L., Merigoux, D. *Catala : Moving towards the future of legal expert systems.*

Artif Intell Law (2022). <https://doi.org/10.1007/s10506-022-09328-5>

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US Tax Code, Section 121

(a) Exclusion

Gross income shall not include gain from the sale or exchange of property if, during the 5-year period ending on the date of the sale or exchange, such property has been owned and used by the taxpayer as the taxpayer's principal residence for periods aggregating 2 years or more.

(b) Limitations — (1) In general

The amount of gain excluded from gross income under subsection (a) with respect to any sale or exchange shall not exceed \$250,000.

Turning law into (pseudo-)code

```
INCOME_EXCLUSION          =  
    if  
  
    ...  
  
    then GAIN_FROM_SALE_OR_EXCHANGE  
    else $0
```

« *Gross income shall not include gain from the sale or exchange of property if, [...] »*

Turning law into (pseudo-)code

```
INCOME_EXCLUSION          =  
    if  
        ... truncate(PERIODS_OWNED, DATE_SALE - 5 years) ...  
    and  
        ... truncate(PERIODS_USED, DATE_SALE - 5 years) ...  
    then GAIN_FROM_SALE_OR_EXCHANGE  
    else $0
```

« [...] during the 5-year period ending on the date of the sale or exchange, such property has been owned and used by the taxpayer as the taxpayer's principal residence [...] »

Turning law into (pseudo-)code

```
INCOME_EXCLUSION          =  
    if  
        aggregate(truncate(PERIODS_OWNED, DATE_SALE - 5 years)) > 2 years  
    and  
        aggregate(truncate(PERIODS_USED, DATE_SALE - 5 years)) > 2 years  
    then GAIN_FROM_SALE_OR_EXCHANGE  
    else $0
```

« [...] for periods aggregating 2 years or more. »

Turning law into (pseudo-)code

```
INCOME_EXCLUSION_UNCAPPED =  
    if  
        aggregate(truncate(PERIODS_OWNED, DATE_SALE - 5 years)) > 2 years  
    and  
        aggregate(truncate(PERIODS_USED, DATE_SALE - 5 years)) > 2 years  
    then GAIN_FROM_SALE_OR_EXCHANGE  
    else $0
```

```
INCOME_EXCLUSION =  
    if INCOME_EXCLUSION_UNCAPPED > $250,000  
    then $250,000 else INCOME_EXCLUSION_UNCAPPED
```

« The amount of gain excluded from gross income under subsection (a) with respect to any sale or exchange shall not exceed \$250,000. »

Computing income tax in France

```
RDSTARDIF_DEF = max(0,FLAG_RETARD *  
(FLAG_TRTARDIF * RDBASE_MAJO  
+ FLAG_TRTARDIF_R * SUPRD[00]  
+ FLAG_TRTARDIF_F *  
(positif(TARDIFEVT2) * positif(RDSTARDIF_A +CODCOR-CODCOR_A - RDBASE_MAJO)  
* (positif(FLAG_RECTIF) * min(SUPRD[2],RDBASE_MAJO)  
+ (1 - positif(FLAG_RECTIF)) * min(max(0,RDBASE_MAJO-SUPRD[00]*(1 - positif(FLAG_RETARD0718))),RDSBASE_REF))  
+ (1 - positif(TARDIFEVT2) * positif(RDSTARDIF_A +CODCOR-CODCOR_A- RDBASE_MAJO))  
* (positif(FLAG_RECTIF) * min(SUPRD[00],RDBASE_MAJO)  
+ (1 - positif(FLAG_RECTIF)) * RDSBASE_REF)  
)  
+ (1 - positif(FLAG_TRTARDIF+FLAG_TRTARDIF_R+FLAG_TRTARDIF_F+FLAG_TRMAJOP))  
* (positif(FLAG_RECTIF) * SUPRD[00]  
+ (1 - positif(FLAG_RECTIF)) * (RDSTARDIF_A +CODCOR-CODCOR_A))  
));  
PSOLBASE_DEF = positif(FLAG_TRTARDIF) * positif(FLAG_RETARD) * PSOLBASE_MAJO  
+ (1 - positif(FLAG_TRTARDIF)) * PSOLBASE_REF;
```

Excerpt of the « M » code (2020), chap-cmajor.m, lines 347 to 363

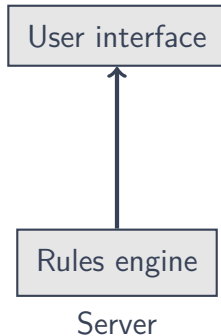
Typical tax computation software infrastructure

Website/Professional application

User interface

Typical tax computation software infrastructure

Website/Professional application



Correspondance law ↔ code

An article of law can correspond to multiple rules scattered in the codebase

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Redability for lawyers

Interactions with QA team limited to test cases, no discussion about the code.

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Abstraction and concision

Logic of the law : base case/exceptions, dependent on context. ⇒ concepts alien to most programming languages.

A transversal problem

Name	Entity	Langage	Taille (lignes)
Income tax	DGFiP/SI/BSI-4	M/C	100k
Income tax	DGFiP/GF/DESF	SAS	50k
Income tax	DGFiP/SI/BSI-2	APL	30k
Housing tax	DGFiP/SI/BSI-4	C	10k
Corporate tax	DGFiP/SI/BSI-3	Java	10k
Social contributions	URSAAF	SQL	20k
Various benefits	CNAF	COBOL	6,9M
Unemployment benefit	Pôle Emploi	Java	1,3M
Pensions	CNAV, ...	?	?
Inheritance tax	Notaries	?	?

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Law changes each year \Rightarrow constant evolution !

Points of improvement

Which specifications ?

What do we want from a computer program derived from legislative texts ?

Which specifications ?

What do we want from a computer program derived from legislative texts ?

1. Legal security
2. Efficient production and maintenance of the code
3. Transparency

Current situation

- Validation by test cases
- Good for « standards » cases
- Difficult to cover all exceptions
- Costly maintenance of test cases

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What we propose

Check the correspondence code↔law directly

Literate programming

Current situation

- Multiple levels of specification :
law + orders, etc. \Rightarrow sources of truth
- No direct correspondence specification \leftrightarrow code
 \Rightarrow where to update the code ?
- Organization does not foster interactions lawyers \leftrightarrow developers

Efficient production and maintenance of the code

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What we propose

Lawyers and developers work together
Pair programming

Current situation

Legal transparency obligation :

- art. 22 of RGPD (EU)
- art. 47-2 of *loi informatique et libertés de 1978* (France)
- art. L.311-3-1 of CRPA (France)

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What we propose

Open development of the specification/code
Open source

Our proposal : Catala

An interdisciplinary team (selected members)

Denis Merigoux (Inria Paris)	Post-doc	Formal methods
Jonathan Protzenko (Microsoft Research)	Principal Researcher	Formal methods
Sarah Lawsky (Northwestern Pritzker School of Law)	Professor	Tax law and logic
Liane Huttner (EUI)	PhD candidate	Digital law
Marie Alauzen (LISIS)	Post-doc	Sociology of the State's digital transformations

US Tax Code, section 121 (a)

Gross income shall not include gain from the sale or exchange of property if, during the 5-year period ending on the date of the sale or exchange, such property has been owned and used by the taxpayer as the taxpayer's principal residence for periods aggregating 2 years or more.

scope `Section121SinglePerson`:

rule `requirements_ownership_met` **under condition**

`aggregate_periods_from_last_five_years` **of**

`personal.property_ownership` `>= 730 day`

consequence fulfilled

rule `requirements_met` **under condition**

`requirements_ownership_met` **and** `requirements_usage_met`

consequence fulfilled

US Tax Code, section 121 (b)(1)

The amount of gain excluded from gross income under subsection (a) with respect to any sale or exchange shall not exceed \$250,000.

```
scope Section121SinglePerson:
```

```
  definition amount_excluded_from_gross_income state uncapped equals
    if requirements_met
    then gain_from_sale_or_exchange_of_property
    else $0
```

```
  definition amount_excluded_from_gross_income state capped
    if amount_excluded_from_gross_income >= $250,000 then
      $250,000
    else
      amount_excluded_from_gross_income
```

The non-monotonic legal reasoning

(A) \$500,000 Limitation for certain joint returns Paragraph (1) shall be applied by substituting “\$500,000” for “\$250,000” if— (i) either spouse meets the ownership requirements of subsection (a) with respect to such property; (ii) both spouses meet the use requirements of subsection (a) with respect to such property; and (iii) neither spouse is ineligible for the benefits of subsection (a) with respect to such property by reason of paragraph (3).

(B) Other joint returns If such spouses do not meet the requirements of subparagraph (A), the limitation under paragraph (1) shall be the sum of the limitations under paragraph (1) to which each spouse would be entitled if such spouses had not been married. For purposes of the preceding sentence, each spouse shall be treated as owning the property during the period that either spouse owned the property.

US Tax Code, Section 121, (b), (2)

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[Base case : condition]

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[Base case : condition] \Rightarrow [Base case : consequence]
[Exception : condition]

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Interpretation ✗

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Compilation ✓

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« *Single source of truth* »

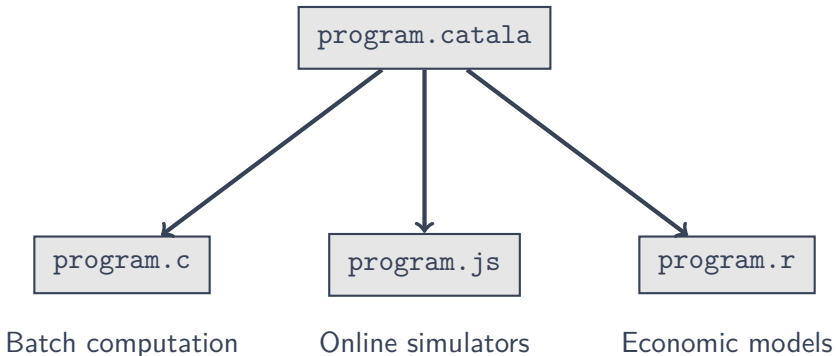
```
program.catala
```

Deploying Catala code in production

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Real-world evaluation : French housing benefits

106 pages documents with all the law (collected by us)

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1,5 to 2 man-month cumulated work on French housing benefits implementation

Fixing and improving the texts is part of normal regulatory work

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⇒ reported and fixed in executive order of July 29th, 2022

Transforming law into code under Tax Administration 3.0

- Back to basics : yes, shaky foundations for current IT systems

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- How to manage different tax-computing software ? How to check they are correct ?
- How to ensure full explainability of the different automatic decision-making ?
- Inequalities of process streamlining for different categories of taxpayers