Measuring Regulatory Complexity

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Roadmap

Introduction

Regulation and algorithms

Psychological complexity

Logical complexity

Computational complexity
Motivation

- Perceived increase in the complexity of financial regulation. For instance:
  - Dodd-Frank Act, 2010: 848 pages.

- Calls for simpler regulations, for instance a leverage ratio (Haldane, 2012).

- Persuasive rhetoric against complexity (e.g., comparison with the 10 commandments), but:
  - How can we measure regulatory complexity?
  - Complexity will be neglected in the trade-off if it cannot be measured.
Usual measures of complexity

Quick quiz:

▶ What sector in the U.S. is supervised by 47,000 Federal employees?

▶ Which U.K. regulatory agency has over 11,200 employees?

▶ What French industry needs 1,000 on-site inspectors?

▶ Which French law code has 3,477 pages? (with comments)

▶ What international set of standards has 338 titles?
Usual measures of complexity

Quick quiz:

- What sector in the U.S. is supervised by 47,000 Federal employees?
  - Civil Aviation, FAA. Fed system 17,000, + 13,000 FDIC, OTS, OCC.

- Which U.K. regulatory agency has over 11,200 employees?
  - Environment agency. FSA had 3,800.

- What French industry needs 1,000 on-site inspectors?
  - Slaughterhouses. ≃ SSM headcount at ECB.

- Which French law code has 3,477 pages? (with comments)

- What international set of standards has 338 titles?

We need more than the “it’s a lot” rhetoric.
Our idea

▶ Similarities between regulation and algorithms:
  ▶ Take a bank as input.
  ▶ Apply a set of instructions and operations.
  ▶ Output is a regulatory action.

▶ Adapt the well-developed literature on algorithmic complexity. Two families:
  ▶ Psychological complexity: how difficult is it to understand the regulation / to write the regulatory text without “bugs”.
  ▶ Computational complexity: how long does it take to “test” a given bank (supervision). How much data needs to be stored?
Why is it important?

- Complexity can be strategically exploited by sophisticated agents (e.g., Carlin 2009).

- Complexity creates asymmetric information, Arora, Barak, Brunnermeier, and Ge (2009).

- Risk of capture by sophistication (Hellwig / Hakenes and Schnabel, 2013).

- Opacity to outsiders gives discretion to supervisors (Rochet, 2010).

- Further theoretical work on this issue hindered by lack of measures.
Today

- **Work in progress:**
  - General framework.
  - Some possible measures.
  - Simple examples.
  - Questions for future research.
  - No full-scale application to actual regulations yet.

- **Looking for feedback** from academics, supervisors, practitioners...
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Definition

A regulation $f$ is a function from a set of regulated entities $E$ to a set of actions $A$: $f : A \rightarrow A$.

- An element of $E$ is a list of relevant characteristics, e.g., balance sheet items.
- $A$ includes “doing nothing”, “closing the bank”, “imposing a fine”, etc.
Definition

A representation \( \tilde{f} \) of regulation \( f \) is a list of instructions that implement \( f \) for any \( e \in \mathcal{E} \).

Definition

Supervision of a given entity \( e \) is the fact of following the instructions \( \tilde{f} \) in order to implement \( f \) at a given \( e \in \mathcal{E} \).

- There are several ways to represent the same regulation, some more complex than others.
- Supervision may be long/complex even if the associated regulation is short/simple.
Definiton
A measure \( \mu \) of complexity of a regulation \( f \) is defined as a mapping \( \mu : f \rightarrow \mathbb{R} \).
A measure of complexity of a representation \( \tilde{f} \) of a regulation \( f \) is a mapping \( \tilde{\mu} : \tilde{f} \rightarrow \mathbb{R} \).

- \( \mu \) and \( \tilde{\mu} \) correspond to different questions.
- We can require traditional properties of a measure, e.g., monotonicity (additivity more problematic).
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Objective

- Measure the difficulty of understanding a regulation.
- Proxy for opacity to outsiders (hence capture), potential for misunderstandings, loopholes in the regulation.
- In computer science: link with the time it takes to code a program and the expected number of bugs.
Halstead measures


- Define an algorithm as a list of operands and operators:
  - Operands: variables, constants...
  - Operators: $+$, $-$, $=$, $if$, $end$, etc.

- Applied to regulation, two possibilities:
  - Adapt: assigning a risk-weight can be seen as an operator.
  - Apply: represent regulation as an algorithm.

- Denote $N_1$ the number of operators, $N_2$ the number of operands, $\eta_1$ the number of unique operators, $\eta_2$ the number of unique operands.
Volume

- Typical measure: lines of code. 600,000 for the Apollo program; 200 mln for Windows 7.

- Problem: depends on the language and the character set used.

- **Volume** $V = \text{lines of code with the “best” character set:}$

  $$V = (N_1^* + N_2^*) \log_2(\eta_1^* + \eta_2^*)$$

- **Potential volume** $V^* = \text{volume in the best programming language:}$

  $$V^* = (2 + \eta_2^*) \log_2(2 + \eta_2^*)$$

- $V^*$ depends only on the number of inputs and outputs, independent of the representation $f$. 
Level of a program is:

\[ L = \frac{V^*}{V} \approx \frac{\eta_1^*}{\eta_1} \times \frac{\eta_2}{N_2} \]

- Inversely proportional to the number of repetitions of operands \( \frac{\eta_2}{N_2} \).
- Inversely proportional to unnecessary operators \( \frac{\eta_1^*}{\eta_1} \).

In the context of regulation:
- High \( L \) corresponds to *efficient but specialized language*: complex operators and operands not defined based on more elementary ones.
- Measure can be part of a trade-off between transparency and length.
Difficulty and effort

- **Difficulty** of a program:

  \[ D = \frac{\eta_1}{\eta_2} \times N_2. \]

- **Effort** of a program:

  \[ E = V \times D. \]

- Intuitively, \( E \) is a measure of how long it takes to write a program, using a basic search model of program writing.

- Offers a measure of regulatory complexity that takes into account repetitions and richness of the vocabulary.
Bank reduced to a **detailed balance sheet**:

- $n$ asset types and $m$ types of capital, possibly with a “attributes” worth 0 or 1.

- E.g., sovereign debt, OECD or non-OECD country, maturity $< 1$ year or not ($a = 2$).

- Risk-weight $RW$ associated to a type of asset, regulatory capital $RC$ for a liability.

- Regulation: scan the balance sheet, compute total RWAs and total RC, compute the ratio and compare to 8%.
for $x = 1$ to $n$
if $type = x$ and $attribute_{x1} = 1$ then $RW = w_{x1}$
if $type = x$ and $attribute_{x1} = 0$ then $RW = w_{x0}$

for $y = 1$ to $m$
if $type = y$ and $attribute_{y1} = 1$ then $RC = w_{c1}$
if $type = y$ and $attribute_{y1} = 0$ then $RC = w_{c0}$

$RWA = \sum_{x=1}^{n} RW(x) \times volume_{x}$
$RC = \sum_{y=1}^{m} RC(y) \times volume_{y}$

if $RWA/RC \geq \alpha$ then $pass = 1$
else $pass = 0$

We can compute the different measures as a function of $n, m, a$. 

Example - Capital regulation, $a = 1$
Number of balance sheet item types
Number of attributes

- E
- L
Conjectures

- IRB vs. SA: reduction in volume, but increase in level, hence decrease in transparency.

- Liquidity regulation in Basel III: “more of the same”, increase in effort only proportional to number of new measures introduced.
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Goal and measurement

- Number of conditional statements and loops.

- Very long regulation might still be “linear” and not very complex in terms of structure.

- McCabe (1976): model an algorithm as a control-flow chart, complexity given by the number $V$ of possible paths.

$$V = \#edges - \#nodes + 2\#components$$
Example

\[ V = (8 + 2m + 2n) - (9 + m + n) + 2 = 1 + m + n \]
Remarks

- Risk-bucket approach very additive in nature.

- **Macroprudential regulation** can in principle be significantly more complex:
  - Conditions on one bank can depend on the entire system.
  - Different banks can be seen as different components, now linked with each other.
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Goal

- How costly is it to **supervise a particular bank**?
- Depends not only on the regulation $f(.)$, but also on the entity $e$ to which it is applied.
- Can potentially be measured in monetary terms.
Time complexity

- **Number of elementary operations** necessary to perform a supervision task.

- “Millions” of computations for a large bank (Haldane, 2011).

- But computing power is higher than in 1988.

- Probably more relevant: number of work hours necessary for different tasks.

- Exercise that requires data from supervisors.
Space complexity

- Number of elements that need to be kept in memory while performing the computation.
- Used to be very important for computer programs (RAM).
- May still reflect an important dimension of complexity for banks: managers need to keep track of more variables in their decision-making process.
Huge increase in time complexity with internal models (but maybe decrease in psychological complexity).

Macroprudential regulation can also have a large impact, e.g., network-based capital requirements (Alter, Craig and Raupach, 2014).

Liquidity regulation represents a large increase in space complexity.
Conclusion

- Work in progress. Only a framework for future research.

- New avenues for measuring several dimensions of regulatory complexity.

- Next step is to test the measures on actual regulatory texts (done for Basel I).

- Two possible uses in the future:
  - Test existing theories, and stimulate new ones by generating new stylized facts.
  - Offer a tool for drafting new regulations, measure the increase and complexity and trade it off against other objectives.
Thank you!