Measuring Regulatory Complexity

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Roadmap

Motivation

- Perceived increase in the complexity of financial regulation. For instance:
  - Basel I, 1988: 30 pages.
  - Basel II, 2004: 347 pages.
  - Basel III, 2011-2014: 616 pages.
  - 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. $\simeq$ SSM headcount at ECB.
- Which French law code has 3,477 pages? (with comments)
- Code rural et de la peche maritime & Code forestier.
  Code monetaire et financier: 3,363 pages.
- What international set of standards has 338 titles?
- Codex Alimentarius. Basel III 600 *pages*.

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 fur future research.
  - No full-scale application to actual regulations yet.
- Looking for feedback from academics, supervisors, practitioners...

Roadmap

Regulation

Definition

A *regulation* f is a function from a set of regulated entities $\mathcal{E}$ to a set of actions $\mathcal{A}$: $f : \mathcal{A} \to \mathcal{A}$.

- An element of $\mathcal{E}$ is a list of relevant characteristics, e.g. balance sheet items.
- $\mathcal{A}$ includes "doing nothing", "closing the bank", "imposing a fine", etc.

Representation and supervision

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.

Complexity measure

Definition

A measure μ of complexity of a regulation f is defined as a mapping $\mu : f \to \mathbb{R}$.
A measure of complexity of a representation $\tilde{f}$ of a regulation f is a mapping $\tilde{\mu} : \tilde{f} \to \mathbb{R}$.

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

Roadmap

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

- Pioneering work of Halstead (1977).
- 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, η_1 the number of unique operators, η_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 = lines of code with the "best" character set:

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

- Potential volume V^* = 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

- Level of a program is:

$$L = \frac{V^*}{V} \simeq \frac{\eta_1^*}{\eta_1} \times \frac{\eta_2}{N_2}$$

- 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.

Example - Capital regulation

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%.

Example - Capital regulation, $a = 1$

for $x = 1$ to n
if $type = x$ and $attribute_{x1} = 1$ then $RW = w_{x1}$
if $type = x$ and $attribute_{x1} = 0$ then $RW = w_{x0}$

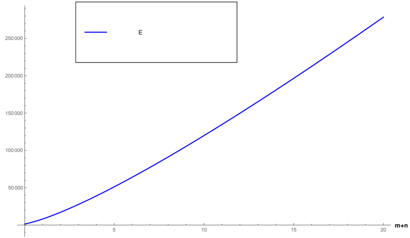
for $y = 1$ to m
if $type = y$ and $attribute_{y1} = 1$ then $RC = w_{c1}$
if $type = y$ and $attribute_{y1} = 0$ then $RC = w_{c0}$

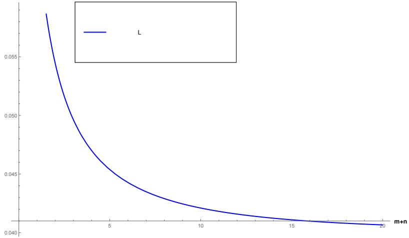
$RWA = \sum_{x=1}^{n} RW(x) \times volume_x$
$RC = \sum_{y=1}^{m} RC(y) \times volume_y$

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

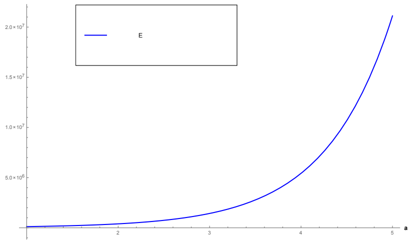
We can compute the different measures as a function of n, m, a.

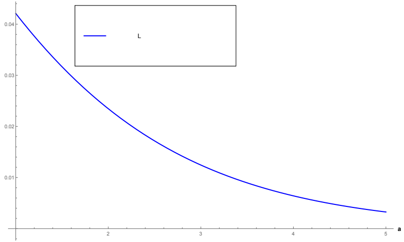
Number of balance sheet item types





Number of attributes





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.

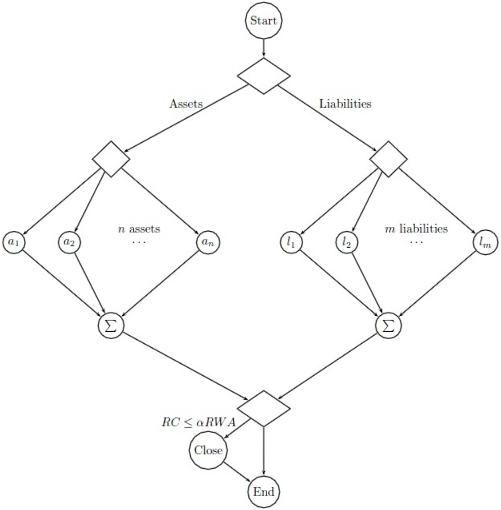
Roadmap

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.

Roadmap

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.

Conjectures

- 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!