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Regulatory Independence— It's not Just about Institutions

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Regulatory Independence – It's not Just about Institutions

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Abstract

Financial regulators perform *inter alia* a quality control function, as they search for recession-generating flaws in the financial system. Some groupings of regulations operate more or less independently to other groupings, as is the case when different agents – not necessarily different institutions – examining the same regulatory issues or monitor the same behaviours independently. We refer to these clusters as Independent Dimensions of Regulation (IDRs). They may appear inefficient if the same issue is explored repeatedly. However, statistical independence in this context can rapidly reduce the probability of crises. If quality control regulations are dependent, policymakers should make them more independent.

Keywords: Banking, Regulation, Monitoring, Financial Crises

JEL Codes: G01, G18, G28

Introduction

In the post-Great-Recession world, where the regulatory pendulum has swung back towards intervention, there is a robust discussion concerning the role and scope of financial regulation in many countries. The financial system has always been controlled, but contemporary regulation has a wide range of potential instruments with which to pursue ambitious macroeconomic and prudential objectives. This pastiche of instruments and goals mirrors the complexity of the financial system itself, where financial firms create consequences – sometimes unintended – in pursuit of their own goals with implications for maturity transformation, risk profiles of other financial firms, systemic risk, economic activity and much else besides.

Financial regulation could be approached by treating it as a special case of a more general theory of regulation, applied to the financial system in particular. However, it has long been recognized that

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unique features of the financial system limit the usefulness of such an approach. Regulation of banking differs in significant ways from general regulation in terms of its justification, its scope and its instruments (Freixas and Rochet, 2008).

This paper is about one unique feature of the system – the ever-present danger of systemic collapse. The inherent fragility of banks is as old as the fractional reserve system, and the debt of banks is held by uninformed and dispersed agents who have limited ability to monitor the bank's activities. All this occurs within the context of a rapidly evolving and highly complex system, which at times defies comprehensive understanding. The author recalls working in a central bank a number of years prior to the Great Recession, when understanding derivatives was thought to be a somewhat esoteric pastime not obviously related to macroeconomic stability.

Within such an environment regulators must scrutinize agents and institutions and search for defects which are likely to cause systemic collapse – what I call 'financial flaws' in this paper. In principle, the search for financial flaws should be subject to the dictates of cost benefit analysis. Any searching process involves costs. These should then be balanced against a reduced probability of a recession.

However, while it is one thing to outline the theoretical considerations for cost benefit analysis it is quite another measuring the actual costs and benefits. If the drivers of a recession operate at a level of detail below most macroeconomic model aggregation – as it did in the sub-prime housing market or the inter-bank lending market at the onset of the Great Recession – the task of doing proper cost benefit analysis is difficult. Even in the case of stress tests, which are relatively straightforward, if the number of banks is large enough, one would presumably have to worry about very complex feedback loops impairing the whole economy.

If, in a particular situation, measurement difficulties seem to preclude a useful cost benefit analysis, how are the authorities to proceed? One answer, which I shall elaborate below, is to think of the properties of the proposed regulations (or the regulations under consideration for removal) in terms of their independence from other regulatory measures. I call any regulation, or group of regulations, that can be argued to be relatively independent of other clusters an independent *dimension* of regulation, using the metaphor of spatial representation where each axis is orthogonal to each other.

An example might be a central bank and an institutionally independent prudential regulator both looking at the same set of systemic stability issues. The two regulators can represent two dimensions if the independence of the prudential regulator is statistical. Statistical independence occurs when the data collection, empirical analysis, and set of banking contacts² used to ascertain the health of the whole system have enough differences so that were one regulator to miss a financial flaw, it would not significantly reduce the chances that the other regulator would find it.³

Another example might be two parts *of the same organization* doing a stress test on a single bank, but using different assumptions and calling upon different staff in the targeted bank to provide guesstimates for the required quantities. As these examples make clear, institutional independence is neither sufficient nor necessary for statistical independence.

In both examples, it might be expected that the answers from searching for financial flaws will differ. This would be a cause for reassurance rather than concern. The concern would be if the outcomes of independent testing gave the same answer in every instance – then one might doubt their independence.

If independent dimensions of regulation (IDRs) exist, then the analytic metaphor used when searching for financial flaws is one of quality control, such as detecting faulty items on an assembly line. The relevant feature of quality control in assembly lines is that it uses the surprising power of statistical independence to generate very small proportion of failures by the multiplication of probabilities. If a quality check removes all but proportion p of defective items then two independent checks will change the proportion of defectives to p^2 . Halving the number of checks – from two to one – will not double the proportion of defectives, but rather increase it by a factor $1/p$. If p is smaller than one half, as is generally the case, the number of defectives will more-than-double.

² A different set of contacts is arguably important. If the same person is asked about systemic dangers they may ‘learn’ how to thwart a line of enquiry on the first attempt, creating a dependence between their responses.

³ In the real world, one might have to talk in terms of a high degree of independence rather than pure independence. As argued later, two parts of the same organization can be independent dimensions of regulation, such as two departments within the same central bank who examine issues using anecdotes and market commentary in one area, and using sophisticated econometric analysis in another.

The same probabilistic landscape can be detected whenever independence implies the multiplication of probabilities. Consider the addition of filters to a chimney stack. If a filter removes proportion $1-p$ of particulates from the emissions, leaving p , then two filters leave p^2 . Again, halving the number of filters does not double the proportion of particulates, as would be the case if the response was linear. It instead increases it by a factor $1/p$ which is usually much larger than two. Finally, consider Swiss cheese with random holes. We can imagine laying pieces of cheese from different blocks over each other and looking for the area which has a hole running all the way through. If the area of cut-out cheese is a proportion p of each slice, then two pieces will have a hole going through an area of p^2 of the whole, on average.

When probabilities of a banking crisis approach zero rapidly as they do for independent checks – or, to put the matter the other way, if the probability of a crisis rises rapidly as checks are removed – then important implications follow. It is demonstrated below that if the number of IDRs is optimal, it is very costly to remove even one, and, if you don't know if the number is optimal, it is very risky to remove even one.

It is the suggestion of this paper that if cost benefit analyses of quality control regulation is too difficult, the authorities should 'group' regulations that seem relatively independent of other regulations into clusters, and then use pure independence as the relevant conceptual benchmark. This seems more reasonable than the Scylla and Charybdis of assuming either that regulation that involves any duplication is 'red tape' that needs to be removed, or, that any regulation that can make a claim to effectiveness is to be kept or imposed no matter how tenuous that claim might seem.

Where regulations are highly dependent, the paper suggests that greater statistical independence should be a goal for policymakers. That is, layers of multidimensional regulation reduce the probability of a crisis more rapidly than dependent regulation, and so the authorities should pursue the ideal of multidimensional regulation as far as possible.

How many financial regulations involve searching for financial flaws? It is freely admitted that some regulations – for example, consumer protection or depositor insurance protocols – are not about this, and so this paper has nothing to add to ongoing debates in these areas. Other regulations achieve

multiple purposes, so the arguments in this paper are relevant to them only to the differential extent to which they relate to uncovering financial flaws.

As it happens, quite a few regulations do actually involve the probability of a financial sector crisis. If one may be forgiven a pastoral analogy (courtesy of Littrell, 2011) prudential regulators are like shepherds. They look for missing sheep (individual errant institutions) sometimes culling the weakest in the flock. They guide the herd when the whole group is heading the wrong way (for example, over-lending on sub-prime mortgages) and they make sure there are plans in place when hailstorms happen (preparing banks for exogenous unpredictable crises like a world recession). Each of these tasks involves a range of objectives, but all of them, with the possible exception of managing a very small institutional failure, are pursued with a nervous eye on the probability of a financial sector crisis.

In section 2, a stylized framework for assessing the optimal amount of regulatory effort is built, demonstrating non-trivial informational requirements for cost benefit analysis. In section 3 a benchmark with IDRs is analysed. Section 4 concludes.

2 The Model

2.1 Setup

We now set up a banking environment within a stylized economy. Consider an economy which produces output from a set of fixed factors, plus loans L . The production function $y(L)$ has $y' > 0$ and $y'' < 0$. The agents in the economy are 1. the public who are the residual claimants on output, 2. the government who undertake an amount n of regulatory effort, with a unit cost of T per unit of loan giving a total of LnT , 3. the bank managers who receive any profits the banks make and 4. the owners of bank capital who receive a return r_k on each dollar invested.

This is a three period model. In period 1, the government decides how much regulation to legislate and in period 2 all depositing, lending and production occurs together with any legislated regulation. In the final period any crisis in banking occurs with a probability $h(n)$ determined by period-2 regulation and all parties are paid what they are owed. If there is a great deal of regulatory effort expended in period 2, a crisis is unlikely, and if there is no regulatory effort expended, the crisis

occurs with background probability p_0 . The government knows everything about all the periods except whether a crisis will, in fact, occur in period 3. It does, however, know the probability of a crisis. The government assumes responsibility for the cost of a crisis, C . The government must balance its budget each period, and the public will permit the government to tax enough to fully finance any bailout.⁴

2.2 Crisis Cost

The probability of a crisis is assumed to be non-increasing in n such that $h' \leq 0$.⁵ The indicator random variable I takes a value of unity if there is a crisis and zero otherwise. The size of the crisis is also a random variable, where δ is the magnitude of the economic loss. The economic loss of the crisis is represented algebraically by $I\delta$.

$$C[\delta, I] = I\delta \quad I \sim \text{Bernoulli}(h(n)) \quad I = 1 \text{ in crisis} \quad \delta \sim (\mu, \sigma^2) \quad (1)$$

If I and δ are independent, the mean and variance of C come from a Bernoulli with $Pr(I=1)=h(n)$ and $E(I) = I h(n) + 0(1-h(n)) = h(n)$. Further, we assume $h(n)$ is small implying that $h(n)^2 \approx 0$.

$$E(C) = E(I\delta) = E(I)E(\delta) = h(n)\mu \quad (2)$$

$$\begin{aligned} V(C) &= E_{\delta}[V_{I\delta}(I\delta)] = E_{\delta}[\delta^2 h(n)(1-h(n))] \\ &\approx h(n) E_{\delta}[\delta^2] = h(n)\{\mu^2 + \sigma^2\} \end{aligned} \quad (3)$$

Thus reducing the chance of a crises $h(n)$ is desirable both because the expected (mean) loss is lowered but also because of the uncertainty of outcomes (variance) is reduced. A composite measure

⁴ There are a number of simplifications here. Since banks do not choose over different loan types, there is no moral hazard. However, in the absence of any regulation ($n=0$), we shall presently see that the financial system would be larger than it is socially optimal because banks would keep lending in the knowledge that the government is covering C . In the model the government forces banks to insure against this outcome, and the resultant drain on their profits means that only lending for the highest value projects goes ahead. In the model the owners of bank capital are like debt holders, since they don't take a loss in a crisis. It would be possible to change this – the required rate of return on bank capital r_k would then include a risk premium. As the parameter is exogenous in the model, not much insight is being lost by ignoring this possibility.

⁵ If the last bit of regulatory effort increases the chance of a crisis, and if regulatory effort is expensive, it goes without saying that the last bit of regulation should not occur. This is not a matter of cost benefit analysis, since there is no trade off to consider. It is doubtful that many regulations are obviously of this kind, so this issue will not be considered further.

is the mean loss with a weighted discount for variance. This could be given an expected utility justification or a less formal ‘dislike’ for variance.

$$\begin{aligned}
E(-C) - \Omega V(-C) &= -E(C) - \Omega V(C) \\
&= -h(n)\mu - \Omega h(n)\{\mu^2 + \sigma^2\} \\
&= -h(n)\left[\mu + \Omega\{\mu^2 + \sigma^2\}\right] = -h(n)\Phi
\end{aligned} \tag{4}$$

The payments to all agents net to output minus the crisis cost.

$$\underbrace{y - r_k K - \pi_{banks} - tax_{bailout}}_{public} + \underbrace{tax_{bailout} - C + \{TnL - TnL\}}_{government} + \underbrace{\pi_{banks}}_{managers} + \underbrace{r_k K}_{bank\ owners} = y - C \tag{5}$$

2.3 Maximizing Welfare

We define social welfare as the mean output net of crisis cost with a weighted discount for variance.

Only C is stochastic in (5) so (4) replaces C in (5) for the measure of welfare, W .

$$W = E(Welfare) - \Omega V(Welfare) = y - h(n)\Phi \tag{6}$$

The government chooses the amount of regulatory effort n to maximize welfare in (6).

$$\frac{dW}{dn} = \frac{\partial y}{\partial n} - h'\Phi = 0$$

$$\Leftrightarrow \underbrace{-h'\Phi}_{MB} = -\underbrace{\frac{\partial y}{\partial n}}_{MC} \tag{7}$$

Bearing in mind h' is non-positive, the LHS of (7) is non-negative. If extra regulatory effort decreases the probability of a crisis ($h' < 0$), it does so by attenuating the mean and variance of C in the LHS of (7). To understand the implicit transmission mechanism on the RHS we first need to derive the zero profit condition for the banking sector.

2.4 The Transmission Mechanism, the Balance Sheet and Optimal Regulation

Consider a banking sector which earns profits π_B which include a cost of nTL for regulation and a required rate of return paid to bank owners. The banks’ liabilities consist of deposits D paying r_d and capital K paying bank owners r_k ; its assets consists of loans L earning r_l and reserves R earning r_d . Reserves are subject to a binding minimum reserve ratio $R = r D$ and capital is subject to a binding capital adequacy requirement $K = k L$. The balance sheet identity $L+R=D+K$ implies $D=L(1-k)/(1-r)$.

Table 2: The Balance Sheet

Assets	Liabilities
L	D
R	K

We assume that banks enter or exit until π_B is driven to zero. This is a contestable banking industry, though not strictly a competitive one, since owners of bank capital are guaranteed an exogenously determined rate of return r_k which is generally assumed to be above the rate of return on loans or deposits. For this economy, a completely competitive banking industry would drive r_k down to $r_l=r_d$.⁶

The condition $\pi_B=0$ defines a loan supply function for exogenous interest rates, after R , D and K are substituted out using the balance sheet relationships.

$$\pi_B = r_l L + r_d R - r_d D - r_k K - nTL \quad (8)$$

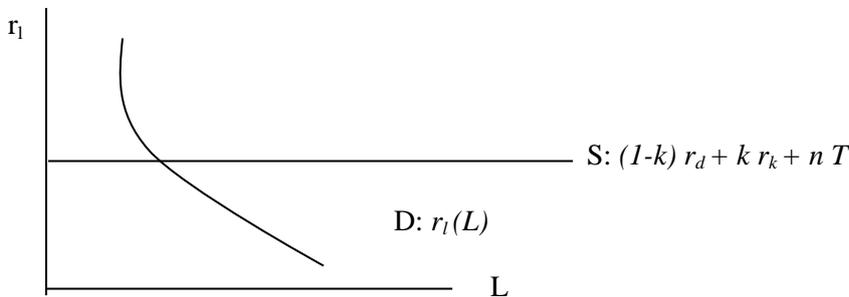
$$= r_l L + r_d \frac{r(1-k)}{1-r} L - r_d \frac{(1-k)}{1-r} L - r_k kL - nTL = 0 \Rightarrow$$

$$r_l = (1-k)r_d + k r_k + nT \quad (9)$$

Equation (9) is an infinitely elastic supply curve in $r_l \times L$ space which shifts up for increases in n , T , r_d , r_k and k (the latter because we assume the required return on bank capital exceeds the deposit rate). To solve the model we assume a downward sloping demand function for loans in $r_l \times L$ space which can be justified in a neoclassical manner, or in some other way (Kuttner and Shim 2013).

$$r_l = r_l(L) \quad r' < 0 \quad r'' > 0 \quad (10)$$

Figure 1: The Market for Loans



Solving (9) and (10) gives equilibrium L and r_l .

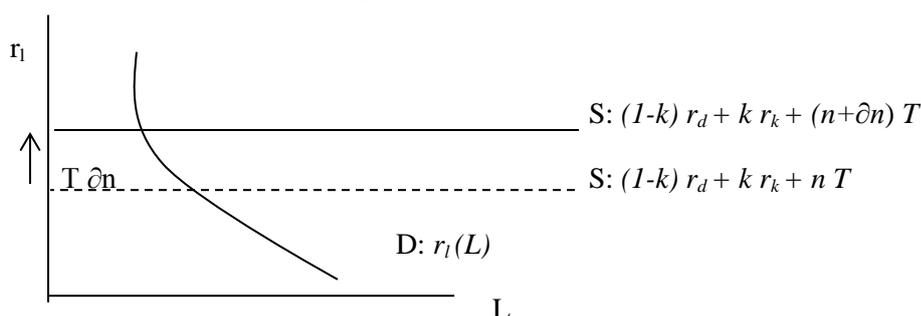
$$r_l(L) = (1-k)r_d + k r_k + nT \quad (11)$$

⁶ This makes sense in this setup because the government is insuring the banking sector. Were this not the case r_k would have a risk premium built into it.

We will come presently to consider the optimal amount of regulatory effort n , for which it is useful to know that how r_l changes as n is increased. We differentiate (11):

$$\frac{\partial r_l}{\partial n} = T. \quad (12)$$

Figure 2: An Increment in Regulatory Effort



The economic intuition of (12) is that an increase in n places a cost burden on marginal banks which makes them unprofitable at current lending levels. As banks leave the industry, the supply curve shifts up until the marginal loan can earn a premium over its original value that exactly offsets the incremental loss in profits $T \partial n$. At that point, profits become zero again and no further banks exit the industry.

We now return to the RHS of (7).

$$MC = -\frac{\partial y}{\partial n} = -\frac{\partial r_l}{\partial n} \frac{\partial L}{\partial r_l} \frac{\partial y}{\partial L} = -T \frac{\partial L}{\partial r_l} y' > 0 \quad (13)$$

Thus the marginal cost of additional regulatory effort depends first of all upon the cost of each round. To restore zero profits, loans must be cut back to the point where the marginal loan has a product T higher than before, and so the impact of this on the amount of equilibrium loans depends on the rudimentary transmission mechanism described by the last two terms in the triple-product of the RHS of (13). For a given increase in interest rates, the inverse of slope of the loan demand function $\partial L / \partial r_l$ determines how many loans the economy loses. The fall in equilibrium loans then impacts upon the economy via the marginal product y' of the forgone loans. The second order condition holds if the marginal benefit decreases rapidly enough.

$$\frac{d^2W}{dn^2} = \frac{d}{dn}(MB - MC) \quad (14)$$

$$\text{where } \left\{ \begin{array}{l} \frac{dMB}{dn} = -h''\Phi \\ \frac{dMC}{dn} = \frac{d\left[-T \frac{\partial L}{\partial r_l} y'\right]}{dn} = -T \left\{ y' \left(\frac{\partial r_l}{\partial n} \frac{\partial^2 L}{\partial r_l \partial r_l} \right) + \frac{\partial L}{\partial r_l} \left(\frac{\partial y'}{\partial n} \right) \right\} \\ \qquad \qquad \qquad = -T \left\{ \underbrace{y'}_{+} \left(\underbrace{T \frac{\partial^2 L}{\partial r_l^2}}_{+} \right) + \frac{\partial L}{\partial r_l} \left(\underbrace{\frac{\partial L}{\partial n}}_{-} \underbrace{y''}_{-} \right) \right\} \end{array} \right.$$

Two offsetting effects change MC as n increases. First, for a convex loan demand curve (such as Figure 2) increases in interest rates as tax-burdened unprofitable banks leave the market cause ever decreasing reductions in loans, which attenuates any effect on output. Second, for any given reduction in loans due to higher lending rates, a higher n and lower L increase the marginal product of the forgone loans on output, because of diminishing marginal product ($y'' < 0$), accentuating the effect on output. If h'' is sufficiently positive, it will dominate (14) leading to a maximum.⁷

It is now possible to go through (7) and describe qualitatively some factors which should be important in any cost benefit analysis that is used to determine optimal regulatory effort.

On the LHS the key factors are the mean and variance of δ which appear with positive coefficients in Φ . The larger the damage of the recession – either in mean or variance terms – the more attractive regulation is. Note that (7) is an understatement of the benefits of regulation. If regulation not only reduces the probability of a recession, but also the *size* of any recession, then the LHS of (7) is an understatement.⁸ On the RHS, unpacked in (13), extra regulation will force up interest rates to the extent of the unit cost of regulation T . This in turn will choke off lending in the economy to the extent

⁷ Since h is bounded below by zero (being a probability) it is convex to the origin, under the conditions that $h' < 0$, and that it never reaches zero. Proof: Suppose not, any negative gradient, if maintained as n increases, will eventually lead to $h=0$, which is impossible. Therefore the gradient must be becoming less negative i.e. $h'' > 0$. Q.E.D.

⁸ For example, caps on loan-to-valuation ratios may not only reduce the size of an asset price bubble, but also the magnitude of any required rescue package if the bubble ends badly.

that the demand for loans schedule (Figure 2) is relatively flat. Forgone lending impacts upon the economy via the link in the transmission mechanism chain that converts lending to output – the marginal product of loans. If the marginal product is high costly regulation will be very damaging.

2.5 Discrete and Dependent Regulations

Sometimes it makes sense to think in terms of particular regulations rather than a continuum of regulatory effort. With this in mind, we will alter our model somewhat and think of n as being the number of particular regulations, called *rounds*, proceeding as $1, 2, 3, \dots, n$. We can now talk in terms of $h(n)$ as the joint probability of missing a financial flaw in spite of n rounds of regulation. It is natural to ask what the marginal benefit of the last regulation is, given all the other rounds in place, and to further ask how this probability affects the marginal benefit on the LHS of (13). There is not at this stage the assumption that the rounds are independent so we must use the normal rules of conditional probability.

We will leave n as the generic name for the number-of-rounds variable, and define $h(j)$ as a product of conditional probabilities that together give the probability of missing the financial flaw and having recession after j rounds. Let M_i be the event that a financial flaw remains undetected by the i th regulation round.

$$\begin{aligned} h(j) &= p_0 \Pr(M_1 M_2 M_3 \dots M_{j-2} M_{j-1} M_j) \\ &= p_0 \Pr(M_1) \Pr(M_2 | M_1) \Pr(M_3 | M_2 M_1) \dots \Pr(M_j | M_{j-1} M_{j-2} M_{j-3} \dots M_2 M_1) \end{aligned}$$

As a matter of notation, let $\Pr(M_j | M_{<j})$ be the probability of missing the financial flaw on the j th regulatory round, after rounds $1, 2, 3, \dots, j-1$ also missed the flaw. We then have:

$$\begin{aligned} \frac{h(j)}{h(j-1)} &= \frac{p_0 \Pr(M_1) \Pr(M_2 | M_1) \Pr(M_3 | M_{<2}) \dots \Pr(M_{j-1} | M_{<j-1}) \Pr(M_j | M_{<j})}{p_0 \Pr(M_1) \Pr(M_2 | M_1) \Pr(M_3 | M_{<2}) \dots \Pr(M_{j-1} | M_{<j-1})} \\ &= \Pr(M_j | M_{<j}). \end{aligned} \tag{15}$$

Thus the required probability is just the ratio of $h(j)$ to $h(j-1)$. Now, if h is approximately linear over j to $j-1$ ⁹ we can use the fact that the derivative h' will be $[h(j)-h(j-1)]/[j-\{j-1\}]=h(j)-h(j-1)$. Thus,

$$\begin{aligned}
 \Pr(M_j | M_{<j}) &= \frac{h(j)}{h(j-1)} = \frac{h(j) - h(j-1) + h(j-1)}{h(j-1)} = \frac{\frac{h(j) - h(j-1)}{j - \{j-1\}} + h(j-1)}{h(j-1)} \approx \frac{h'}{h} + 1 && \Leftrightarrow \\
 h' &= (\Pr(M_j | M_{<j}) - 1)h && \Leftrightarrow \\
 MB &= -h'\Phi && \text{from (7)} \\
 &= h\Phi(1 - \Pr(M_j | M_{<j})). && (16)
 \end{aligned}$$

From (16) we can ascertain that the benefit of the last regulation depends multiplicatively on the mean-variance metric of the size of the crisis $h\Phi$ and a measure of the effectiveness of the last regulation, conditional on all the regulations that precede it failing to detect the flaw. If the chance of missing the financial flaw on round j is close to unity, given that rounds 1 to $j-1$ of regulation have missed the financial flaw, then there is little benefit to round j . This might be proverbial ‘red tape’ regulation that adds little to the overall effectiveness of regulation which, in this setup, is about detecting flaws likely to lead to a banking crisis.

On the other hand, suppose that regulations 1 to $j-1$ are part of a highly effective package of which regulation j is the ‘finishing touch’. Then even if 1 to $j-1$ have on their own been ineffective, regulation j might in conjunction with all of them have a low probability of missing the financial flaw. The bracketed term on the RHS of (16) will therefore be large, and with it the marginal benefit.

As useful as (16) is in theory, it is open to supporters and detractors of regulation to claim $\Pr(M_j/M_{<j})$ for their own cause. Supporters will claim that the j th round is indeed the ‘finishing touch’, while detractors will deride it as ‘red tape’. The latter is especially likely if it involves any duplication of other investigations into financial flaws. In the realpolitik of regulation, (16) would seem to trap us between the Scylla and Charybdis of assuming either that regulation that involves any duplication needs to be removed, or, that any regulation that can make a claim to effectiveness is to be kept or

⁹ In this discussion we assume the function h is continuous and defined over non-integer values of h , but that it is only economically meaningful at integer values when we speak in terms of discrete regulations rather than (continuous) regulatory effort. That is why we can differentiate the function.

imposed no matter how tenuous that claim might seem. The key problem is the difficulty in measuring $Pr(M_j|M_{<j})$.

3 Independent Dimensions of Regulation

3.1 The Difficulties of Cost-Benefit Analysis

It is open to a researcher to try and quantify all the elements in section 2, including $Pr(M_j|M_{<j})$, to ascertain whether a particular regulation is worth adopting, or removing. While this task is worth doing, it is very challenging not least because many regulations operate at a level of detail below the aggregation of macroeconomic models. Furthermore, (13) reminds us that the answers will depend on a full representation of a transmission mechanism, which is in itself a non-trivial task.

In this section, I explore another way of thinking about regulatory independence. The key question to answer is which regulations can be aggregated into clusters that are more or less independent across clusters –I call these independent clusters dimensions. The example used before is when a central bank looks at systemic stability with datasets, bank contacts and research methods which are all fairly independent from the methods of another regulator also looking at systemic stability.

For these kinds of regulations all of the analysis in section 2 can be repeated, but with one crucial difference. The clusters have special properties arising from their independence. The probability of missing a flaw with each new dimension added falls extremely rapidly.

More formally, an Independent Dimension of Regulation (IDR) is a process that is statistically independent of any other regulatory action, which detects a financial flaw with probability $1-p$, and misses it with probability p . It may or may not reduce the magnitude of any crisis, should it occur (but in the subsequent analysis it is assumed it doesn't, which understates the benefits of regulation), and its independence is statistical rather than institutional.

As outlined earlier, the intuition of the statistical properties of IDRs can be seen by considering independent sampling quality control on an assembly line which reduces defectives by a proportion p , or, from a filter on a chimney which captures proportion $1-p$ of a pollutant. In both examples, p is likely to be much smaller than one half, so doubling the cost (conducting the sample again, or adding another filter onto a chimney) does not halve the negative attribute (the probability of a defective

item, or the parts per million of the pollutant) but reduces it much more. For those who like food examples, the Swiss cheese with random holes had a similar probabilistic structure. We can imagine laying pieces of cheese from different blocks over each other and looking for the area which has a hole running all the way through. If the area of cut-out cheese is a proportion p of each slice, then two pieces will have a hole going through an area of p^2 of the whole, on average.

For all these illustrations – conveyor belts, chimneys and cheese – the logic works in reverse. Halving the cost increases the negative attribute by a factor of $1/p$ which implies much more than doubling the negative attribute. That is, *a linear cost reduction may be associated with a highly non-linear increase in the probability of a negative outcome.*

In keeping with the intuition, a financial entity subject to n IDRs experiences a crisis with probability $p_0 p^n$. where p_0 is the background probability of the crisis in the absence of any regulation.¹⁰ From before:

$$C[\delta, I] = I \delta \quad I \sim \text{Bernoulli}(p_0 p^n) \quad I = 1 \text{ in crisis} \quad \delta \sim (\mu, \sigma^2) \quad (17)$$

$$E(C) = E(I\delta) = p_0 p^n \mu \quad (18)$$

$$\begin{aligned} V(C) &= E_\delta[V_{I\delta}(I\delta)] = E_\delta[\delta^2 p_0 p^n (1 - p_0 p^n)] = p_0 p^n (1 - p_0 p^n) E_\delta[\delta^2] \\ &= p_0 p^n (1 - p_0 p^n) \{\mu^2 + \sigma^2\} \approx p_0 p^n \{\mu^2 + \sigma^2\} \end{aligned} \quad (19)$$

The probability of a crisis, being $p_0 p^n$ declines very rapidly as n increases. This gives us two interesting results, which do not occur for dependent regulation discussed in section 2.

3.2 If Regulation is Optimal it is Very Costly to Remove

Those who are concerned with wasteful regulation presumably believe that the marginal cost of it is high. So, we substitute $p_0 \ln(p) p^n$ for h' in (7), differentiate again, and use the fact $MC=MB$ at the optimum:

$$\frac{dMB}{dn} = \ln(p) MB = \ln(p) MC \quad (20)$$

¹⁰ Compared with section 2, there are two new assumptions. Independence removes the need to discuss conditional probabilities. And, for simplicity, all the probabilities of detecting the flaw are the same, namely p .

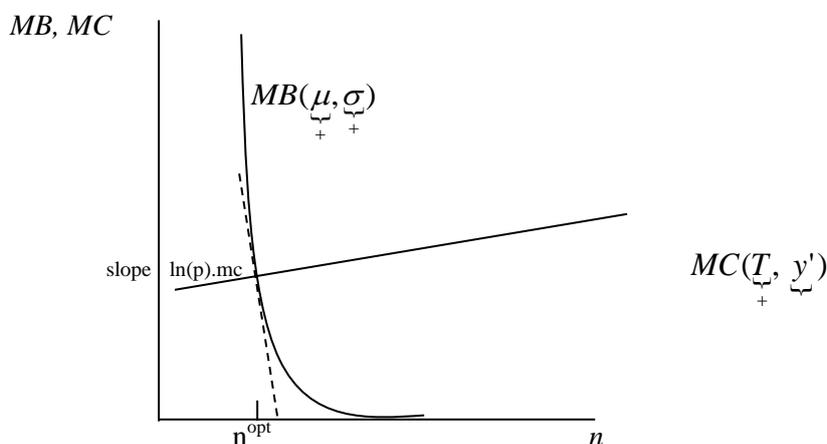
Thus if the marginal cost of regulation is high – for example because the unit cost of regulation T or the forgone output from reduced loans y' are high in (13) – then the marginal benefit will be very steeply and negatively sloped, from (20). This in turn implies that integer perturbations in setting n have huge consequences for the optimality of the system.¹¹

This is shown in Figure 3. The marginal cost curve is drawn as upward sloping, as would be the case if $r_l(L)$ were linear (and therefore $\partial^2 L / \partial r_l^2 = 0$), though of course it could be downward sloping from (14). If n is set away from the optimal level marginal benefits and costs diverge sharply. For this not to be the case, marginal costs would have to be very low (for example, with a very low T) in which case the whole policy discussion about regulation is a discussion about (next to) nothing.

Naturally the result begs the question: how likely is it that n is optimal?

One reason for believing that financial firms might sometimes choose n optimally is the widespread practice of senior figures or boards making attestations to fulfil various regulatory requirements. Consider the options facing a board that is required to make an affirmation (legally, an attestation) about some feature of their organization. If they know about the feature, they can simply make the attestation. If they do not, they will probably hire a consultant to analyse their firm so that they have more grounds for giving a truthful response to the regulator. To the extent that the regulator leaves the number of rounds – in the terminology of this paper – to the board, they might be expected to make an optimal choice.

Figure 3: Optimal Regulation is Fragile to Small Mistakes with IDRs



¹¹ The envelope theorem is not relevant because n can only move in increments of one.

3.3 The Risk of Removing Regulation when Optimality is Unknown is High

The second key insight concerns the cautionary principle. Recall from (7) that the marginal benefit curve in Figure 3 has ϕ as a shift parameter, where this parameter is defined in (4).

$$\Phi = \left[\mu + \Omega \left\{ \mu^2 + \sigma^2 \right\} \right] \quad (18)$$

It is clear from Figure 3 that caring about a sizable variance (high Ω and σ) will result in a higher number of rounds. This application of the cautionary principle is completely intuitive. Taking out insurance in the form of extra rounds in Figure 3 could be relatively cheap – to be precise, the rate of change of MC as the number of rounds increases is subject to both positive and negative influences as n increases. On the other hand, the risk of being to the left of an optimum is a serious one. Too few IDRs, just like too few filters or conveyor belt checks, has the potential to dramatically increase the probability of a costly recession.

5 Discussion and Conclusion

The central claim of this paper is that it is fruitful to consider regulation in terms of Independent Dimensions of Regulation (IDRs) thereby emphasising *statistical* independence. A discussion of the merits of independent *institutions*, while important, is completely alien to the spirit of this paper, since institutional independence is neither necessary nor sufficient for statistical independence.

An example where different institutions are not *necessary* for IDRs is furnished by central banks that monitor the effectiveness of various policy measures by two independent work groups.¹² One group might focus on anecdotes, short term media commentary, industry liaison and rudimentary econometrics. Another group might focus on exactly the same issues (or on a portfolio of issues with a large overlap) using more sophisticated theory and econometrics, and examining data over very long time horizons.

We might say that such an organization looks at a particular issue in a multi-dimensional way, and we note that this approach meets a possible objection raised against the notion of IDRs. While it is

¹² The policy measures relate to monetary policy, not financial regulation, but the overall point is still valid.

perfectly true that repeating exactly the same question with the same wording to the same person may create a dependence in their responses – especially if they feel they ‘got in trouble’ from the regulator the first time – it is equally true, as the example above shows, that there is often a wealth of available techniques and data sources that can get at essentially the same question in different ways, creating the kind of independence that makes IDRs feasible.

An example of independent institutions not being *sufficient* for statistically independent is furnished by any financial firm that has some control over who regulates it, or who rates it. Under these regrettable circumstances, the firm would be tempted to game the different options to find the ‘best deal’. Worst still, the regulators or providers of ratings might start ‘competing’ on how favourable their narratives about the financial firm are.¹³ Both of these would erode independence.

There are many fascinating institutional dilemmas that arise once the desirability of statistical independence is recognized. To use a monetary policy example again, does the publication of the Fed’s ‘beige book’¹⁴ force the Fed to manufacture an artificial consistency between the different sources of information? Other institutions that do not publish their compilation of information can let seemingly contradictory data sit alongside each other. This is often intellectually healthier, because ‘rough edges’ are often a sign of independently collected information.

For those parts of the financial systems where IDRs already exist, the analysis has established some general points about regulation that sidestep difficult cost benefit analysis. The general points are that if the probabilistic structure of the effect of regulation is akin to conveyor belts, chimneys or cheese – that is, if regulatory rounds are independent – then the cautionary principle of regulation is very strong indeed. We may summarise matters in this way: *if regulation is independent and optimal, it is very costly to remove*, and, *if regulation is independent but its optimality is unknown, it is very risky to remove*. Figure 3 illustrates both insights. It shows, first, that small mistakes in regulation are very costly. But it also shows that when we care about the uncertain effects of a crisis (Ω and σ are high)

¹³ Technically, this might morph into a problem of both a lack of independence – which in the extreme just means that 20 agencies might not tell you any more than one – and the development of a bias, where an agency (or 20 of them) overstate the positive attributes of the financial firm.

¹⁴ The formal name is the *Summary of Commentary on Current Economic Conditions*.

the optimal level of regulation will be correspondingly high, because the marginal benefit schedule in Figure 3 moves out, leading to a higher optimal n .

For those monitored activities where IDRs do not exist, there are good reasons for regulators to create them. Engineering rapidly declining probabilities of ‘defects’ should not be confined to conveyor belts or chimneys. Banking crises have different negative consequences compared with damaged goods or pollution, but that is not to say that they are less serious.

Regulators can encourage IDRs at the level of individual institutions, but their adoption can run counter to some deeply-held business intuitions about minimizing costs. For example; should our regulatory environment encourage ‘mixed teams’ to investigate issues or be responsible for outcomes? When faced with an issue it is common for a team of professionals to each comment on their own area of expertise, and to go no farther. In fact, they may risk severe penalties if they comment outside their ‘turf’. But if the goal is to interrogate the same issue from as many independent vantage points as possible, it is actually desirable to have a lot of overlap, which can appear to be a sign of ‘duplication’ or ‘inefficiency’.

The same principle applies at the level of whole organizations. Is it inefficient for a central bank and an (institutionally) independent prudential regulator to look at the same issue from different perspectives? If they do, is this evidence of inefficiency and the need to cut back the budget of both so that they will focus on core non-overlapping business? The answer given by this paper is ‘not necessarily’. Certainly wasteful replication is unlikely to discover any financial flaw, given other regulations in place, as equation (16) reminds us. But several IDRs with well-designed independent overlap are, like Swiss cheese, less likely to have holes running all the way through.

Alongside the appropriate concern for institutional independence, the framers of the financial system can and should be examining the statistical independence of regulatory measures, for which institutional independence is neither sufficient nor necessary. Regulations that search out financial flaws along a number of independent dimensions are more likely to serve the post-Great-Recession world better than the previous regimes, by leading to lower probabilities of costly banking crises.

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