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Regulatory Experiments: Putting GM Crops and Financial Markets on Trial

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Introduction

Sometimes regulators become experimenters: they try ideas out before implementing them, put novel schemes to the test in order to predict their likely impact, or conduct pilot programmes before executing new policies. Regulators find experiments very expedient, as they allow them to forecast the probable consequences of their actions before making irreversible decisions. In some areas of policy-making experimentation is becoming a normal phase of regulatory practice[1]. Regulatory experiments are, however, a peculiar type of governmental action, with particular epistemological and political dimensions. Through them regulators try to produce new knowledge about the world, but also to test the resilience of new regulatory instruments, and to persuade broad audiences of the effectiveness of their plans. How can we begin to analyse this form of regulatory intervention?

To draw out the implications of regulatory experiments we will analyse two examples. First, we describe the recent UK Farm-Scale Evaluations (FSEs) of genetically modified crops. Second, we analyse the pilot programme that accompanied the introduction of stock options into the American financial markets of the 1970s. Both experiments were designed to assist controversial regulatory decisions, and involved objects – genetically modified organisms and financial options contracts – that, once released into their respective environments, would be difficult to control or retrieve. The experiments were thus the last chance regulators had to monitor the behaviour of these novel entities under controlled conditions, before taking an irreversible decision to authorise them. This fact attracted a great deal of attention and debate

[1] Experimentation has generally a positive connotation. The ability to experiment policies in small-scale contexts is often mentioned as one of the advantages of federalist systems of government, and of government decentralisation efforts more generally. In the US, individual states are often described as 'laboratories' for policies that are later implemented (or discarded) at the national level. In the late 1990s, the state of Wisconsin was often described as 'the great American welfare lab' (Time, 21 April 1007), thanks to its novel 'welfare-to-work' policies, later adopted by the Clinton Administration. The advantages of experimentation extend to highly contentious moral issues. Note for instance the following defense of the decision of the Supreme Court of Massachusetts to allow gay marriages: "The only way to find out what would happen if same-sex couples got marriage certificates is to let some of us do it. Turning marriage into a nationwide experiment might be rash, but trying it in a few states would provide test cases on a smaller scale. Would the divorce rate rise? Would the marriage rate fall? We should get some indications before long. Moreover, states are, as the saying goes, the laboratories of democracy. One state might opt for straightforward legalisation. Another might add some special provisions (for instance, regarding child custody or adoption). A third might combine same-sex marriage with counseling or other assistance… . Variety would help answer some important questions," Jonathan Rauch, 'A More Perfect Union,' *The Atlantic Monthly*, April 2004. For an older example of the advocacy of experimentation as an instrument of social amelioration, in the context of the 'Great Society' programmes of the 1960s, see Campbell, 1969.

from interested publics, and gave the experiments a central role in the regulators' strategies of justification.

By regulatory experiments we mean trials of new policies that are explicitly connected to a particular regulatory decision. That is, the experiments we have in mind are designed to assist a particular policy decision, or set of decisions, by producing new knowledge under controlled conditions. The concept of regulatory experiment is semantically close to that of 'regulatory science,' or policy-relevant science more generally (Jasanoff, 1985, 1990), and indeed most regulatory experiments involve a techno-scientific apparatus of assessment and measurement. Yet, not every instance of scientific research conducted or drawn upon for their regulatory implications qualifies as a regulatory experiment. For that to be the case, a policy needs to be put on trial, and an obvious regulatory purpose needs to be inscribed into the particular experimental design of that trial[2].

As a preliminary analytical framework, we propose to categorise regulatory experiments on the basis of the kind of evidence they are meant to produce. Regulatory experiments can be designed primarily to produce knowledge and evidence that, from the regulator's point of view, adds immediate practical value to their deliberations, and can be easily incorporated into the policy-making process. The study of the uses of experiments in the natural sciences tells us that the usefulness of an experiment usually derives from the differences between experimental context and the world at large. An experiment is useful because it is conducted under circumstances that differ from those of the outside world. Like laboratories, as described by Knorr-Cetina, regulatory experiments are: "Relational units that gain power by instituting differences with their environment," (Knorr-Cetina, 1999: 44). These differences can be a matter of time (eg a pilot program that is conducted *before* a full policy is implemented), or of scale (the context of experiment is usually smaller than that of real-world regulation), but they always involve conditions that give regulators a degree of control over relevant variables that do not exist (or would be extremely costly to obtain) in the world at large. We term the set of differences the 'experimental gap' – the conditions, dissimilar to those of the world at large, from which the practical usefulness of the experiment emerges.

On the other hand, experiments can also be designed to produce results that are *scientifically valid*; that is, empirical data capable of resisting the institutionalised tests of scientific soundness (ie publication in a peer-reviewed journal, acceptability by the relevant community of scientific practitioners, transferability across settings). The Farm Scale Evaluations of genetically modified crops were, as we will see below, an example of a regulatory experiment that tried to take the form of a scientific one. In general terms, the validity of a regulatory experiment refers to the applicability of the data outside the experimental space – what is described as 'ecological validity' in social psychology, or as 'the problem of parallelism' in experimental economics (Guala 2001)[3].

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[2] We are aware that qualifications such as 'obvious,' or 'explicit,' may be empirically problematic. However, we think we can justify, for analytical purposes, a preliminary demarcation of explicit regulatory experiments from the larger field of regulatory science, or of all policy-relevant science, and we want to argue that the explicitness of the regulatory purposes of a regulatory trial can be partly deduced from its experimental design. Moreover, most of the scholarly analysis on regulatory science has focused on the use by regulators of ready-made knowledge – usually in the form of opinions produced by scientific advisory committees, which generally draw on already existing evidence. In contrast, experiments imply an explicit search for new knowledge. They often generate unexpected findings and open up new lines of inquiry.

[3] An experiment can also be designed with the primary purpose of making it eminently *replicable*. That is to facilitate future efforts to reproduce it under slightly different conditions. Collins and others have showed that the ability to replicate an experiment is not reducible to formal protocols or criteria (Collins, 1985).

The validity of experimental evidence is always problematic, because, as we have argued, the experimental conditions are by definition dissimilar from those of the world at large. In principle, any experimental result can be criticised (or, what is the same, dismissed as inapplicable or irrelevant) by pointing to the experimental gap. As Donald MacKenzie has shown in relation to the dynamics of technology testing: "There will always be ways in which test artifacts can be seen as differing from 'the real thing', or test situations from actual use, given sufficient ingenuity in seeing them. No amount of modification of test procedures can wholly remedy this. Hence debates about testing are potentially endless," (MacKenzie, 1989). The wider the gap between experiment and the world at large, the broader this validity challenge can be. Our main point is thus that the design of any regulatory experiment will involve choices and trade-offs, depending on the kind of evidence the regulator wants to produce. These trade-offs can be deduced from the nature of the separation established between the experiment and the world at large, and will usually be a function of how the experiment is expected to fit into the broader regulatory and political context.

The special political relevance of regulatory experiments makes these choices particularly momentous. If questions of validity are always epistemologically complex, in regulatory experiments they are routinely brought to the forefront. Regulatory experiments are after all public demonstrations, which must convince multiple constituencies, not simply the experimentalists and their peers. The ability of experiments to produce consensus, always problematic in the natural sciences (Collins 1985, Shapin and Schaffer 1985), is made even more difficult here by the existence of multiple audiences and forums, with entrenched views and values, always capable of using the 'experimental gap' to dispute the applicability or relevance of the evidence. In the two examples discussed below, we explore this complex relationship between experimentation and the production of assent to regulatory decisions.

But while regulatory experiments might be less than perfect or straightforward in their ability to bring about certainty and consensus, it is undeniable that they are instruments to *alter* the world (Hacking, 1983). We see them as interventions that, of necessity, change the regulatory *status quo*. As trials of strength for emerging policies, they generate a new balance of forces between the regulators, the regulated, and their audiences. This is why, as we will see, regulatory experiments often break regulatory stalemates and legitimise short-term courses of action. They might not clarify all the issues at hand, let alone persuade everybody of the goodness of a particular decision, but they reshape the space of controversy, transforming uncertainties into variables of ignorance, and testing the resilience of novel regulations.

The Farm-Scale Evaluations of Genetically Modified Crops in the UK

The Goals of the Experiment

The Farm-Scale Evaluations (FSEs) were set up by the British government in 1998 to study the effects of GM crops on farmland biodiversity, at a time of intense public opposition to agricultural biotechnology. The FSEs followed the recommendation of the UK nature conservation agencies to halt the release of genetically modified organisms until a better

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Replicability is of little relevance in our two case studies. Both the FSEs and the CBOE options programme were one-off events. Similar tests might be conducted in the future. But their purpose will not be to replicate them in order to verify that the original results were real, but rather to produce knowledge adjusted to new regulatory conditions. The political value of regulatory experiments – their embeddedness in a particular time and place – makes replicability less relevant than it is in scientific research.

assessment of their environmental impact could be produced[4]. To create a space for proper experimentation, biotechnology companies agreed to suspend commercialisation of GM crops for the duration of the trials. As their name indicates, the defining characteristic of the trials was their scale. Larger than any previous experimental release of GM organisms, the FSEs were intended to produce evidence more realistic than what could be obtained in the greenhouses or small plots of land where previous tests had been conducted. The FSEs constituted, it was often repeated: "The largest scientific experiment of their kind anywhere in the world."[5]

After conducting a small pilot program in 1998 to define the parameters of the experiment, several dozen farms were selected across Britain to represent national variations in soil, weather and farming intensity. In each of these farms, a crop of transgenic organisms was grown side by side with a conventional counterpart. The three GM crops under examination were varieties of herbicide-tolerant oilseed rape, beet, and maize. The research question was whether the farm management system required by these three crops, in particular the extensive application of the broad-spectrum herbicides to which the crops are resistant, had a significant impact on the populations of weeds and invertebrates in and around the trial fields. The magnitude of this effect was measured by comparing the biodiversity impact of the transgenic crops with that of the conventional (non-GM) varieties grown side by side in the other half of the split fields.

The results, published in October of 2003, were ambivalent. While transgenic oilseed rape and beet seemed to have a detrimental effect on the population of some weeds and invertebrates, genetically modified maize appeared to benefit the ratio of farmland biodiversity in the fields, as compared to that of conventional maize[6].

Experimental Design

The organisation of the evidence-gathering and assessment activities of the FSEs gives us an indication of what kind of evidence the regulators were after, and in what way the experiment was expected to feature in the final regulatory decision.

The trial sites were managed by farmers, who were told to handle their fields as if the crops were intended for commercial purposes, and were thus expected to follow their usual farming practices. Research on the sites was conducted by researchers from three British public

[4] The decision to halt the commercialisation of GMOs to win time for a re-evaluation of the case for agricultural biotechnology was a European-wide phenomenon. For the duration of the FSEs, the European Union's authorisation process for new GMOs was *de facto* suspended, while the EU Member States hammered out a new regulatory regime.

[5] BBC News, "Q&A: GM Farm-Scale Trials," 9 March 2004. Available at http://news.bbc.co.uk/1/hi/sci/tech/3194574.stm. The FSEs are one of several evaluations of the policy on genetically modified organisms conducted in the United Kingdom in the last few years. Almost in parallel with the FSEs, the government launched an economic review of the case for GM crops, a scientific assessment of the existing evidence on their safety, and the GM Nation? Public Debate, to promote deliberation and gauge public attitudes to biotechnology. The existence of these simultaneous tracks of evaluation and experimentation points to a phase of far-reaching regulatory reconsideration of agricultural biotechnology in the UK following the intense disputes of the late 1990s. The FSEs must be seen in this broader context, as one of several large-scale experiments influencing regulatory decision-making.

[6] On the different impacts on weed populations (and weed seedbank) of maize and beet and oilseed rape see M. S. Heard *et al:* "Weeds in fields with contrasting conventional and genetically modified herbicide-tolerant crops: I Effects on abundance and diversity," *Philosophical Transactions of the Royal Society: Biological Sciences*, 358, 1819-1832.

research institutes – the Centre for Ecology and Hydrology, Rothamsted Research, and the Scottish Crop Research Institute. The researchers were told to concentrate on producing evidence that could be accepted and published by a prestigious peer-review journal. The publication of a series of papers analysing the results of the FSEs in the *Philosophical Transactions of the Royal Society: Biological Sciences* marked the formal conclusion of the FSEs experiment[7].

Throughout the five years of the experiment, a Scientific Steering Committee oversaw its overall scientific integrity. The remit of this committee (or of the field researchers, for that matter) explicitly excluded commenting publicly on the 'regulatory implications' of the experimental results. Once published in the *Philosophical Transactions*, the articles produced by the research team were forwarded to the Advisory Committee on Releases into the Environment (ACRE), the UK statutory advisory body on releases of genetically modified organisms, which then produced a set of regulatory recommendations for the government minister in charge, based solely on evidence published in the scientific journal. Once this process was completed, the government announced its decision.

This organisational fragmentation of different stages in the experimentation-regulation continuum, and especially the clear formal separation between experimental research and regulatory advice, was intended to create a 'buffer zone' between whatever evidence the FSEs may generate, and the final decision the government would eventually make. The duty of the researchers and the experts overseeing the experiments was simply to guarantee the scientific acceptability of the evidence – as measured by its publication in a leading, peer-reviewed journal. From this organisational design we can deduce a desire on the part of the regulator to prioritise the scientific acceptability of the evidence at the expense of its explicit orientation towards policy goals. The perception of scientific soundness was achieved by demarcating clearly the gathering and assessment of the evidence from the formulation of specific regulatory recommendations, as well as from the resulting governmental decision.

Regulatory Consensus and the 'Experimental Gap'

The FSEs were surrounded by controversy from their inception to the final publication of their results, and beyond[8]. When the experiments were announced in 1998, critics of agricultural biotechnology challenged their usefulness by pointing to a variety of fundamental issues that had been explicitly excluded from the remit of the researchers. In particular, the measure of the 'gene flow' arising from transgenic crops, and its consequences for the co-existence of conventional, transgenic and organic agriculture was not addressed by the FSEs. The critics also questioned the release of large amounts of transgenic crops into the environment. Even if this was necessary for research purposes, it might lead to the irreversible contamination of the British countryside[9]. Finally, the very idea of subjecting the acceptability of GM crops to a scientific trial, however realistic that trial might be, was to many an unacceptable abdication of the fundamental ethical and political debate that ought to

[7] See G. R. Squire, D. R. Brooks, D. A. Bohan, *et al:* "On the Rationale and Interpretation of the Farm Scale Evaluations of genetically modified herbicide-tolerant crops," and following articles in the *Philosophical Transactions of the Royal Society: Biological Sciences*, 358, Number 1439, November 29, 2003.

[8] During the period of experimentation some of the test sites were the targets of direct protest action.

[9] There was a suspicion among opponents of GM crops that the very existence of such a large-scale experiment would make the ultimate commercialisation of transgenic crops unavoidable; that the regulatory experiment would indeed make the presence of GM crops in the British environment a *fait accompli*, thereby helping bring their final authorisation about.

guide such a decision. As an environmentalist critic of the FSEs put it at the time, such a way of framing the regulatory process was unacceptable to opponents of agricultural biotechnology: "Misusing science to obstruct democratic questioning of GM crops; hiding behind a set of scientific experiments to avoid the debate and all its complexities is neither rigorous science nor good governance,"[10].

Most of these general and *a priori* criticisms faded away as the FSEs were completed. From then on, the critics increasingly took issue with the 'experimental gap' inscribed into the trials, the multitude of ways in which they had failed to replicate significant features of the real world. When the ambivalent results of the FSEs were published, both critics and proponents of biotechnology pointed to the inadequate representativeness of the trials, albeit for very different reasons. It was now the proponents of biotechnology who began to challenge the relevance of the FSEs *tout court*, arguing that all they had measured was the effects of herbicides on biodiversity, not any effects caused by the transgenic crops themselves, and that no decision on the regulatory status of the latter should be based on a test that did not measure their specific impact.

On the other hand, critics of biotechnology, who in the past had been the most vocal critics of the FSEs, focused now on the evidence they had produced of the environmental harm of GM crops. Their reservations regarding the design and ultimate implications of the trials were secondary to this fact[11]. As a spokesperson for Friends of the Earth put it: "These trials were never enough to give GM crops the green light, but they may provide enough information to give them the red one,"[12].

We observe here an interesting phenomenon. The FSEs failed to produce a definitive consensus on the appropriate regulatory status of GM crops. Different actors in the dispute used particular conclusions from the trials to support their previous positions, while issues of representativeness and relevance provided plenty of arguments to dismiss unwelcome pieces of evidence. Yet, the FSEs limited and narrowed down the space of the technical debate on GM crops. They framed, at least for some time (and time is a critical variable in the regulatory process), the issues under dispute. The FSEs became in this sense an 'obligatory point of passage' (Latour, 1987) for critics and supporters of GM crops alike, re-orienting the strategies of suspicion and justification available to the different participants in the debate.

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[10] Sue Mayer: "Science's Secret Garden," *The Financial Times*, 5th August 1999.

[11] Critics of agricultural biotechnology have paid a great deal of attention to the results for GM maize, which suggested a slight beneficial effect of the crop management system on farmland biodiversity. The challenges to the maize results have centered on the herbicide used in the conventional half of the trials, atrazine, which is well known for its extreme impact and is in the process of being phased out in the European Union. By using such a harsh herbicide on the conventional maize crops, the critics argue, the trial failed to represent (future) realistic farming conditions, and biased the comparison in favor of the GM maize, which was treated with a less effective herbicide. This point was emphasised by Michael Meacher, who, as former environment minister, had been instrumental in setting up the FSEs. "I cannot see that the government could logically, consistently, or morally go ahead when the comparison is exposed to everybody as not being a valid or a real one." Quoted in: "Flawed GM Tests Must Start Over," BBC News (UK Edition), 12th October 2003. Available at http://news.bbc.co.uk/1/hi/sci/tech/3185620.stm. The controversy over atrazine is another example of the ample maneuvering space that the 'experimental gap' provides to those willing to challenge the representability of regulatory experiments.

[12] Pete Riley, Friends of the Earth's campaigner, quoted in: "Flawed GM Tests Must Start Over," BBC News (UK Edition), 12th October 2003. Available at http://news.bbc.co.uk/1/hi/sci/tech/3185620.stm

Regulatory Certainty and Decision-Making

Soon after the publication of the results, the British government announced its decision to authorise, with some unspecified restrictions, the commercialisation of the herbicide-resistant maize, while refusing to grant a similar permit for oilseed rape and beet. This was a cautious decision. The FSEs did not serve to define a long-term and coherent regulatory course for GM crops: they raised at least as many scientific issues as they helped resolve, and the 'scientific debate' on GM crops is far from closed. What the experiments did was to redraw the boundaries of the debate, displacing it towards new issues, sharpening some of the disagreements, and making specific points of dispute more or less significant.

While they served to justify a short-term decision, in so doing the FSEs helped break a long regulatory stalemate. By finding GM maize to have less detrimental environmental effects than the two other transgenic crops under investigation, the FSEs legitimised a partial authorisation of this crop. Politically, this was a very significant fact: it allowed the regulator to disaggregate the category of 'genetically modified crops' into individual organisms, with specific and differential environmental risk profiles, which seemed to call for 'case-by-case' regulatory assessment (the mantra of regulators during the 'GM debate'). Even though it included a series of conditions and restrictions, the authorisation of GM maize functioned as a sort of regulatory bridgehead in a context of protracted and irreconcilable divisions.[13]

Financial Experiments: the pilot program in options trading

Unleashing New Financial Instruments

To reveal more dimensions of regulatory experimentation, let us now examine an example from a very different domain: financial regulation, and the regulatory experiment that accompanied the introduction of stock options in the Chicago Board Options Exchange (CBOE) in the early 1970s.
Options are contracts that give their owners the option to buy or sell a financial asset for a certain price on a certain date, and, not unlike GM crops, for decades they have been a highly controversial regulatory object. The traditional fear of the regulator, in our case the US Securities and Exchange Commission (SEC), was that, by blurring the age-old distinction between investing and gambling, options trading would 'unleash forces' that would be impossible to control and might eventually disrupt the financial system as a whole.

To understand those concerns, we need to take a brief look at the history of derivatives markets. The CBOE was funded by the Chicago Board of Trade (CBT), a leading American commodities market. Funded in 1848, the CBT traded futures contracts - contracts that guaranteed the supply of agricultural commodities for set prices at given dates. In the 1880s, so-called 'bucket shops' began to sell 'secondary' contracts based on the prices of CBT-traded futures. After a protracted legal battle (Ferris, 1988), these contracts were made illegal

[13] The restrictions placed on the cultivation of the GM maize led Bayer, the company that owned the license, to announce that, despite the formal authorisation, it would not try to sell this variety to British farmers. In this sense, the regulatory decision failed to have an immediate impact on the ground – none of the three crops of the FSEs has been commercialised yet. However, we would like to argue that, from the point of view of the regulator, the fundamental change was the lifting of the moratorium, the decision to authorise the cultivation of a GM crop in the UK, regardless of the particular constraints and restrictions placed on its commercialisation. This decision broke the deadlock, and changed the regulatory *status quo* of GM crops. It created a precedent that will in all likelihood be used and expanded in the future.

and terminated, on the basis that contracts that did not include specific conditions for the delivery of goods were betting in disguise, rather than legitimate commercial activity.

Winning the battle with the bucket shops placed the CBT as one of the most influential forces behind the maintenance of a clear distinction between legitimate investment and illegitimate gambling. In fact, in its efforts to demarcate the boundaries between legitimate financial practices and illegitimate and immoral gambling, the CBT spearheaded the growing opposition to gambling in American society. The great crash of 1929, which was attributed to the explosion of purely speculative actions in stock exchanges, re-inforced this dichotomy. The practice that suffered the most as a consequence of the crash was options trading, a financial instrument that was seen as inducing price volatility and risky market conditions[14]. In the early 1930's, during the Congressional discussions that led to the creation of the SEC, the possibility of banning options trading altogether was seriously considered (Falloon, 1998). The resulting Congressional Acts, which established the framework for financial regulation in the US, institutionalised this general suspicion of financial markets generally, and of options trading in particular, as arenas for irresponsible, gambling-like speculation. While the trading of options was not banned officially, for almost four decades no organised exchange chose to trade this type of contract. Thus, when in 1968 the CBT offered to set up an options exchange, the SEC viewed the introduction of these contracts as a threat to the stability of the economic environment. The main concern of the regulator was that the trading of options would, through the obligations embedded in them, create pressures on the securities market as a whole, increasing their volatility. The fear was that options would open the floodgates for other financial derivatives projects. Or, in a paraphrase on the biological processes discussed in our first case, that once options were released into the economic environment, the generic concept of tradable financial contracts would 'mutate' into other markets, thus becoming ungovernable.

Setting up the Experiment

In contrast to the resistance on the part of the regulatory authorities, the idea of exchange-traded options found support in financial circles and among financial economists. As part of their lobbying efforts, the CBT hired a firm of consultants, Robert R. Nathan Associates Inc., to produced, with the help of some of the leading financial economists of the time, a study evaluating the idea of an options exchange and its impact on 'the public interest,' (Nathan, 1969). The fact that strong forces operated for and against the options market ensured that any decision would be controversial. After three years of intensive discussions, a compromise was reached between the SEC and the promoters of the exchange. It was based on the mutual agreement that many aspects of options trading and its consequences were still unknown, and that an empirical examination of the phenomenon at hand – a regulatory experiment – would generate the necessary knowledge about this novel financial instrument.

The experiment was designed as follows. In 1972, the SEC approved the opening of the Chicago Board Options Exchange (CBOE) by authorising 16 types of options contract in the form of a pilot program[15]. The authorisation to launch the CBOE included significant restrictions, which defined the experimental status of the new market. The most important of

[14] Buyers of options are required to pay relatively small prices in advance – the price of the contract, known as 'premium' – while the price of the stocks would be paid only if, and when, the option is exercised. Thus, being a leverage, contracts options could be used to make substantial profits by speculators who would gain from rises or falls in prices, without investing much money in advance.
[15] CBOE itself began trading in April 1973.

these restrictions was that CBOE would be required to report, in advance, on each and every change in procedures that the exchange wished to introduce. Any change would need to be approved by the SEC, giving the regulator the ability to stop the operations of the new market, completely or partially, at any moment in time. The mandatory reports affected every aspect of the organisation of the market: trading hours, responsibilities of the various exchange staff, the spatial positions of employees on the trading floor and many more. The reporting and approval requirement created, in practice, a real time informational link between the exchange and the regulator, much like the continuous monitoring systems that exist in scientific laboratories or highly-technified production facilities.

These restrictions did not go uncontested. The CBOE did not want its development stifled by a generalised obligation to receive prior approval to new market procedures, and it questioned the utility of such a limitation. After all, proponents of options argued, the validity of the experiment – its ability to reproduce real-world conditions – would be greatly compromised by this restriction, since in real market conditions there would be no need to wait for prior regulatory approval. That is, 'realistic' market behavior would be different enough from that of the pilot program to render the results of the latter meaningless for regulatory purposes.

Experimental Results and Regulatory Decision

Despite these criticisms, the pilot program was carried out until its termination in 1976, when the SEC decided to declare a moratorium on the addition of new options contract. This decision was the result of the SEC's realisation that the growth of options in the pilot market was proceeding at such a pace that information about it could not be collected and analysed properly. That is, the regulatory experiment was becoming impossible to monitor and manage with the necessary precision. Does this mean that the experiment had failed? Not necessarily. The justification to declare a moratorium on the authorisation of options contract was directly derived from the experience of the pilot program. Without it, a decision to stop this rapidly growing branch of financial markets would have encountered much stronger resistance than it did. In addition, only an experiment could produce evidence about the size and complexity of the market processes generated by options trading. By showing its own unmanageability, the pilot program met its stated goal of generating *useful* knowledge on the controllability of the new financial instruments. It produced a relative sense of certainty about the eventual uncertainties that an unbridled exchange would create.

In what sense can the pilot program be characterised as a regulatory experiment, and what kind of knowledge was it designed to produce? To answer these questions, let us look at the specific differences vis-à-vis the real world instituted in the experimental setting. This 'experimental gap' was different from that of the FSEs. The CBOE was a life-size experiment, in which the experiment (the 'laboratory') and the world were co-extensive. Once approved by the SEC, stock options trading was open to the public, and the scale of operations was that of a full-scale market. The crucial element that turned the pilot program into an experiment was the SEC's authority to change any aspect of trading, or even to stop trading altogether. This difference would create, the SEC hoped, a regulatory separation between the options market and the rest of the American financial system, allowing the collection of data about market behavior without putting the whole of the system at risk. The 'experimental gap' was created here by applying a higher degree of control than is exercised in other financial markets. While the additional restrictions were resented by proponents of options trading, and could be seen as undermining the validity of the experiment in the abstract, they defined the usefulness of the trial by allowing the regulator to collect

experimental data in real-time, and in a site of realistic scale, without releasing irreversible forces into the market place.

Conclusions

We have described two examples of the uses of experimentation in regulatory policy-making. Despite their obvious differences, here we would like to emphasise the common dynamics at work. In both cases an effort was made to anticipate the effects of particular policies by putting them to the test in an experimental setting. Let us now summarise the key arguments we want to draw from this comparison.

First, regulatory experiments are designed to address uncertainties and bridge gaps in the regulatory knowledge base. Yet, they rarely produce absolute certainty or bring about a conclusive consensus. In this sense, crucial experiments are very rare, in science or in regulation. This is partly due to the necessary separation from the world – what we have described in this paper as the 'experimental gap' – but also to the fact that experiments generate new questions. Experiments are not merely displays of virtuosity (Collins, 1988). They have a generative quality: a capacity to create new knowledge, and to open up new and expected areas of investigation.

What experiments can do, however, is to generate new forms of uncertainty, which may be more amenable to the traditional procedures of risk assessment and management. Experiments translate unknown quantities into variables of ignorance – such as the quantifiable reduction in the number of invertebrates caused by a particular GM crop management system, or practical data on whether financial processes can or cannot be effectively monitored by a regulatory authority. They turn unknowns into specific problems that, while giving rise to new questions (and perhaps to future experiments), can nevertheless be provisionally discussed and deliberated upon on the basis of customary repertoires of justification. Experimentation may not, in and of itself, bring about a final consensus about the issues at hand – critics may not accept the relevance of the trial to begin with, and they will in any case find plenty of space for challenges and reservations in the inevitable 'experimental gap' – but it often contributes to framing complex and open-ended decision-making around a set of measurements, and to propel issues forward by facilitating decisions that can be explicitly referred to the results of the trial at hand. Experiments do not only generate new data but also new strategies of justification and suspicion. They become obligatory points of passage for regulatory decision-making; they are difficult to ignore, and their results, though open to interpretation and challenge, reshape the public debate, make particular courses of action increasingly implausible, and help justify breakthroughs in regulatory stalemates.

Second, the rubric of 'regulatory experiment' includes a range of tests and trials that can be designed to produce quite different kinds of evidence. In our two examples we have seen an experiment designed to produce evidence conforming to the rules of general scientific validity, but relatively inconclusive as far as a particular regulatory decision was concerned, and an experiment generating easily operationalisable data, dubiously representative of the external world but of direct relevance to regulatory decision-making. In the FSEs we observe an experiment organised as a proper scientific investigation – with controlled conditions (the conventional crops grown side by side with the transgenic varieties), statistically representative measurements, etc. In the CBOE, on the other hand, we have an experiment of a different kind, a life-size trial, conducted on the market as a whole, and with no control

variable[16]. We want to keep the notion of regulatory experiment flexible enough to include this variety. Our broad understanding of experimentation, centered on the creation and bridging of the 'experimental gap,' should be understood as the starting point to develop a more taxonomy of experimental tropes in regulation. A taxonomy that should ought to include practices – pilot programs, simulations, Regulatory Impact Assessment, surveys – that present a clear family resemblance and pose comparable political and epistemological questions.

The peculiarities of the design of each individual experiment will give us clues as to what sort of evidence regulators are primarily looking for; what kinds of trade-offs the regulators make between usefulness, validity, and replicability. In the case of the FSEs, the emphasis was on the scientific soundness of the evidence, and the trials were designed to separate (and protect) experimental data from regulatory decision-making. The importance given to scientific validity points to the regulator's desire to produce unassailable evidence in a highly contentious political environment. In the case of options trading and the CBOE pilot program, the regulatory manageability of a new financial instrument was the central concern. The design of the experiment – a one-off, life-size experiment on the financial system as a whole – was geared towards measuring regulatory capacity, rather than producing valid evidence of the consequences of options trading under 'realistic market conditions'.

Finally, in the two cases we have described experiments lent legitimacy to cautious and precautionary decisions. Both experiments were linked to moratoria – the CBOE pilot program justified a formal moratorium on additions of new options, while the British government used the data from the FSEs to maintain the prohibition on two crops, while authorising a third one under strict conditions. In both cases, regulatory authorities were dealing with objects that, once released into their respective environment, may easily evade control. This made the phase of experimentation particularly critical. Anticipatory trials offered what was probably the last chance to obtain knowledge on the behavior of highly mobile entities, be they organisms or financial instruments, under bounded and controlled conditions that would cease to exist as soon as they were released. Our two experiments provided regulators with a trial of strength of their own control powers. Both the release of GM crops in the farm trials and options trading at CBOE were intended to measure the ability of authorities to constrain and keep pace with the movement of new regulatory objects.

We may observe an increasing shift towards regulatory experiments to decide the fate of these kinds of entities: new regulatory objects that can hardly be brought under traditional forms of control once they are let loose in their environments. Much may come to depend on this particular form of regulatory practice, with its hybrid epistemic and political features. We need to pay attention to the particular experimental design of regulatory trials, and to the ways in which such design orients and constrains the course of policy-making.

[16] It would have been impossible to create an alternative American financial system to create a comparison between experiment and control group. The experiment on options trading could have been organised in an economic laboratory, as in the examples of experimental economics studied by Francesco Guala (Guala, 2001). However, an experiment conducted in a laboratory would have been unable to measure the regulator's ability to control a life-size market. Releasing options contracts into the American financial system allowed the SEC to test the resilience of its control mechanisms under 'real world' conditions. Campbell describes these experimental interventions that lack a control group as 'quasi experiments'.

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