CEBRA Project 1404C: Testing Compliance-Based Inspection Protocols

Final Report

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Approach rate: An estimate of the likelihood of entry of pests and diseases determined through inspection results.

Biosecurity risk material: Material that has the potential to introduce a pest or disease to Australia. This could include, but is not limited to: live insects, seeds, soil, dirt, clay, animal material, and plant material such as straw, twigs, leaves, roots, bark, food refuse and other debris.

Clearance number: A key parameter of the CSP-1 and CSP-3 algorithms. It represents the number of consecutive clean lines that must be reached before a target's goods can be switched to a reduced inspection rate (i.e. switched to monitoring mode).

CSP (continuous sampling plan): A technical rule for determining whether or not to inspect a consignment, based on the recent inspection history of the pathway and some parameters the pathway manager sets. (Dodge and Torrey, 1951).

Consignment: In general, a consignment consists of all the goods for a single consignee that arrives on the same voyage of a vessel; a single consignment can consist of many container loads of goods.

Economics experiment: An economics experiment can refer to several related research methods used to collect data for scientific purposes so as to understand the factors that influence people's decisions in economically relevant situations, either as individuals or in a group setting. A key commonality of these approaches is that the researcher maintains some control over the environment of interest and/or the allocation of participants to treatments (see below). A *conventional laboratory experiment* is conducted in a computer laboratory with university students, while a *field experiment* is characterised by augmenting the laboratory experiment with elements from the natural context for studying interactions with rules and institutions.

(Experimental) treatment: Each treatment represents a specific combination of the collection of characteristics analysed in the experiment. In this experiment, the characteristics include: the type of inspection rule (CSP-1 or CSP-3); the clearance number and monitoring fraction of the inspection rule; the level of information provided to participants about the rule; the nature of feedback given to participants; the costs incurred in being inspected or treated; and whether the participant has a choice over the rule they follow. The results from different treatments can be compared only where one of these characteristics is varied at a time, with all others held constant.

Framing: Relates to the presentation of information that shifts the perspective of decision-makers in ways that can change the way they evaluate alternative options. (Weber, 2013, 387).

Heuristic (technique): A mental shortcut applied in problem solving, learning or discovery to help arrive at a decision in a context where finding the optimal solution is challenging, impractical or impossible. Practical methods drawing on selected salient features of the problem are usually employed, though these are not guaranteed to be optimal or perfect.

Implied approach rate: An estimate of the approach rate for consignments in the main experimental task. This is a weighted average of the biosecurity risk material approach rates of the available suppliers, weighted by the number of choices of that supplier made by participants in each treatment.

$$\textit{Implied approach rate (\%)} = \frac{\sum_{i=A,B,C,D} \text{Choices for supplier i} \times \text{Approach rates for supplier i (\%)}}{\text{Total supplier choices}}$$

The number of choices in the above formula can be either taken at a particular time point (period) or aggregated across periods in the multi-period task.

Inspection: Examination of product or systems for the biosecurity of animal, plant, food and human health to verify that they conform to requirements (Beale, 2008).

Inspection failure: In general, an inspection failure occurs when there is a non-compliance detected at inspection. The possible types of non-compliance include the incorrect declaration of goods, packaging failures and the presence of biosecurity risk material in consignments. For the purposes of the experiment, it is assumed all inspection failures are due to the presence of biosecurity risk material in consignments.

Inspection game: A mathematical model of a situation where an *inspector* verifies that another party (the *inspectee*) adheres to certain legal requirements (Avenhaus et al., 2002, 1949).

Institution: The set of rules or procedures that govern how different agents can interact in an economic system.

Intervention: Legally enforceable obligations (through legislation or regulations) imposed by government on business and/or the community, together with government administrative processes that support the obligations. In the biosecurity context, this includes requirements related to:

- prescribing specific actions that must be completed before goods can be brought into Australia;
- giving notice of goods to be unloaded in Australian territory;
- providing information, including documents, about the goods if requested by biosecurity officers;
- allowing for the goods to be physically inspected;
- allowing for samples of the goods to be taken; and
- prescribing treatments for rectifying the presence of biosecurity risk material in a consignment.

Monitoring fraction: A parameter in the CSP-1 and CSP-3 rule used to determine the frequency of inspection once an importer has demonstrated sufficient compliance with biosecurity requirements in the monitoring mode of the CSP algorithm. This parameter governs the reduced rate of inspection (MF) to be applied that enables inspection of less than 100% of consignments imported.

Natural framing: Refers to the experimental instructions (or script) being prepared in a way that describes the real-world context underpinning the experimental study. The opposite of abstract framing, where the instructions are devoid of the real-world context for the experiment.

Period: The unit of time for a sequence of repeated decision processes in an experiment. In multi-period tasks, experimental subjects make choices based on the same set of rules and/or parameters as part of the replication process.

Power (statistical power): For a binary test of hypotheses, the power is the probability that the test correctly rejects the null hypothesis (H_0) when the alternative hypothesis (H_1) is true. Where the null hypothesis is that there is no treatment effect, or a covariate has no effect on the choices made by experimental subjects, the power represents the ability of a statistical test to detect an effect if the effect actually exists.

Tight census: A parameter in the CSP-3 algorithm which governs the number of consignments inspected at a rate of 100% following an inspection failure when the importer is in monitoring mode.

Treatment: Refers to actions required to rectify consignments found to contain biosecurity risk material during an inspection so they can be brought into Australia.

Treatment cost: The costs incurred by an importer resulting from treatments required by the biosecurity regulator to address the presence of biosecurity risk material in a consignment and allow the consignment to enter Australia.

1. Executive Summary

This report forms part of the evidence base to support the Commonwealth Government Department of Agriculture and Water Resources (the department) in reforming the design and implementation of Australia's regulatory framework for biosecurity assurance. It builds on the findings of *CEBRA Project 1304C: Incentives for Importer Choices* (Rossiter et al., 2016), which developed proposals for regulatory frameworks that could provide appropriate incentives for participants to reduce the likelihood of biosecurity risk material entering Australia. CEBRA Project 1404C tests the appropriateness of candidate mechanisms and scopes alternative approaches to the way they are implemented using a series of *economic experiments* conducted with university students in a computer laboratory.

Much of the department's focus on resource allocation in the context of biosecurity risk management, including the Risk-Return Resource Allocation model, does not formally incorporate or model the likely response of stakeholders (e.g. importers and suppliers) to changes in biosecurity control strategies employed by the department. Recent investigations in Rossiter et al. (2016) and Rossiter and Hester (2017), however, highlight that departmental assessments of biosecurity control strategies need to take these behavioural responses into account. This is because, under some circumstances, the incentive structures inherent in certain processes and strategies could encourage stakeholders to behave very differently under new protocols, relative to the established ones.

Imposing regulatory changes without carefully considering stakeholder responses could introduce inappropriate incentive structures for compliance and deliver unintended policy consequences, potentially undermining the maintenance of Australia's high biosecurity status. In this context, the experiments conducted in this project are novel because their focus is on the behaviour of stakeholders, namely importers, in response to different protocols applied by a biosecurity regulator. In turn, this provides a complementary, but distinct, approach to guide how trade-offs associated with meeting the department's biosecurity policy objectives could be managed.

This report documents the design and results from the experiments, where experimental subjects (students) assumed the role of importers and were required to make choices about their supplier over time. The experiments sought to mimic the interactions between the department and importers relating to biosecurity inspections. Rather than testing <u>all</u> aspects of importer decision-making under different candidate rules, the experiments examined particular aspects of the rules likely to be more difficult to assess in the field. The experimental treatments tested were constructed to inform the department about implementing compliance-based protocols and identify how current practices may be fine-tuned to better support departmental objectives.

The project investigated how the following aspects affect an importer's choice of supplier:

i. different inspection rules from the continuous sampling plan (CSP) family;
ii. the level of information provided to stakeholders about the inspection rule;
iii. feedback on an importer's performance under the inspection rule;
iv. costs of being inspected and of failing inspection;
v. allowing rule-choice from a limited set of options; and
vi. an importer's understanding of the rule.

1.1 Key findings

1. CSP-1 and CSP-3 algorithms appear to yield similar importer behaviours.

There appeared to be no systematic differences in supplier choices between directly comparable CSP-1 and CSP-3 treatments. However, we acknowledge that a laboratory experiment is unlikely to be able to discriminate between these algorithms with reasonable statistical power. This ability to discriminate is further undermined by the relatively flat payoffs facing importers under "realistic" cost parameters that reflect constraints around the department being able to provide sizeable rewards for compliance and/or punitive punishments for non-compliance. Given the CSP-1 algorithm's relative simplicity and that theory suggests its application is more likely to be in the regulator's interests, the CSP-1 algorithm could form part of the wider roll-out of compliance-based inspection protocols across the department.

2. Providing more information about inspection rule parameters and the consequences of failing inspection tends to support importer choices more consistent with government biosecurity objectives.

The evidence of the potential benefits of providing more information about the rules was most noticeable in the CSP-3 algorithm treatments. In other treatment comparisons, the results were less clear, but at least suggested no significant adverse effects from providing more information about the rule. As suggested in CEBRA Project 1304C, the department can retain some flexibility around the rule parameters by providing clear guidance to stakeholders on the circumstances under which inspection rules can change.

3. Providing targeted feedback to importers could support behaviour consistent with improved compliance.

The evidence from the feedback comparison treatments supports the notion that giving appropriately framed feedback could assist with importer decision-making around biosecurity risk options. The potential benefits of this were the largest when feedback was provided around the inspection cost savings achieved.

4. Pathways or importers where the cost of being inspected and/or the cost of failing inspection are high are likely to be more suitable for compliance-based inspection protocols.

This finding accords with theoretical predictions from the inspection game model of Rossiter and Hester (2017). The experimental results suggest that a higher cost of failing inspection seems to induce a larger reduction in the average approach rate than an increase in the cost of being inspected by a similar multiple.

5. Allowing importers a choice of inspection rule, where eligibility is unrestricted and the different rules are based only on having different parameters, may not encourage behaviours supportive of enhanced compliance.

The experimental results suggested offering a choice of inspection rules tended to encourage subjects to choose suppliers with higher approach rates of biosecurity risk material. As discussed later in this report, the CSP family of rules may not provide strong incentives to encourage compliance, as the payoff functions tend to be relatively flat. This makes it difficult to calibrate menus of regulatory contracts based on the situation where menu options are driven only by having different parameters for the rules.

These experimental results, when combined with the theoretical arguments raised in Rossiter et al. (2016), suggest that a better strategy may be where access to “lighter-touch” regulatory options is based on importers providing evidence that they, and/or their suppliers, have undertaken specific biosecurity risk mitigation measures. This would still require the structure of the menu of regulatory contracts to be appropriately calibrated, but may provide greater assurance to the department that those experiencing less intervention at the border can demonstrate superior biosecurity risk management on the pathway. This would allow the department to better target its inspection effort across different pathways and importers while still providing appropriate incentives for compliance.

6. Subjects who reported understanding the inspection rule better tended to make choices consistent with government biosecurity objectives.

The inspection sequence following an inspection failure in monitoring mode under the CSP-3 algorithm involves several possible options, dependent on an importer’s compliance history. This complexity could result in even experienced biosecurity system stakeholders being unclear about the consequences of failing an inspection and motivated the project team to investigate the effect of understanding the rules on supplier choices in the experiment.

This finding suggests a potential role for providing alternative ways to explain the inspection rules to which importers are subject as a strategy for encouraging them to make “better” supplier choices. While providing a diagram for the CSP-3 treatments did not seem to improve rule understanding, there could be scope for the department to present inspection rules in an alternative manner or offer training to importers and customs brokers as part of a broader strategy to improve biosecurity compliance.

2. Introduction

This report forms part of the evidence base to support reform of Australia's regulatory framework for biosecurity assurance of internationally traded goods.
CEBRA Project 1304C laid the groundwork for the Department of Agriculture and Water Resources (the department) to develop a greater understanding of how to design or modify biosecurity intervention protocols to improve compliance. The main goal was to better understand the issues around protocol design using the incentive structures inherent in regulatory interventions to:

- encourage biosecurity risk mitigation activity through the import-supply chain;
- decrease the level of intervention required by the department at the border; and
- reduce the regulatory burden associated with border inspections for compliant biosecurity system stakeholders.

CEBRA Project 1404C continues the department's focus on importer and supplier behaviour in response to inspection rules and is the next step in determining how to apply compliance-based protocols in practice. The project draws on insights from CEBRA Project 1304C, which advised on potential ways to design or modify inspection protocols on two plant-product pathways, and lays the groundwork for a proof-of-concept trial for adaptive sampling protocols (CEBRA Project 1608C).

The project involves testing and refining specific aspects of proposed inspection protocols using *economics experiments* conducted with university students in a computer laboratory. This type of testing in a controlled environment enables an examination of whether specific changes to protocols and the way they are implemented, as suggested by economic analysis and interviews with stakeholders in CEBRA Project 1304C, are likely to be appropriate mechanisms to assess in the field. The experiments provide a partial evidence base on which to assess potential protocol changes to help guide the broader rollout of compliance-based regulation across the department.

As part of the policy development process, laboratory experiments offer government departments and agencies significant benefits as a safe, low-cost environment to assess and refine potential changes to policy in a relatively quick manner. These experiments can be used as a "test-bed" for new ideas and provide an opportunity to test policy in a safe environment before wider implementation. For instance, it is possible to assess stakeholder responses to regulatory changes to avoid introducing changes that could be counterproductive to the department's policy goals.

More generally, carefully designed experiments can form part of a broader approach to risk management within the public service. Investigations in the laboratory can mitigate implementation risks by providing an opportunity to scrutinise policy and process changes before their wider rollout. Evidence from the way in which behavioural responses are influenced by specific components of the policy or process can help identify potential issues with how policies are designed, particularly if it appears that things may not be operating as intended in the laboratory environment. Approaches that do not seem to work as intended in the laboratory can subsequently be modified, or otherwise not pursued in the field. It is in this vein that the project seeks to assess specific aspects of biosecurity inspection rule design before they are employed as part of a prospective field trial (CEBRA Project 1608C).

This report documents the design and results from the experiments, where experimental subjects (students) assumed the role of importers and were required to make choices about their supplier of plant-based products over time. The experiments sought to mimic the interactions between the department and importers relating to biosecurity inspections. Rather than testing all aspects of importer decision-making under different candidate rules, the experiments examined specific aspects of the rules, including those likely to be more difficult to assess in the field. The experimental treatments tested were also constructed to inform the department about implementing compliance-based protocols in practice and to identify how current practices may be fine-tuned to better support departmental objectives.

The construction of experimental treatments is discussed in Chapter 3, with Chapter 4 summarising the key results and Chapter 5 outlining the implications of the experimental findings for Australian biosecurity operations. A separate *Supplementary Report* discusses the technical background underpinning aspects of the report, such as the framework underpinning the experiments and a fulsome statistical analysis of the experimental data.

2.1 Objectives

The objective of this study was to undertake experimental testing of key components of potential compliance-based inspection protocols to inform the department on how to develop tailored approaches for a wider roll-out of these types of protocols. It also provided an opportunity to refine particular aspects of inspection protocols in a safe, low-cost environment before their implementation in the field.

2.2 Methodology

This section sketches the approach adopted in this project to address the research questions of interest. More extensive discussion of these research methods is provided in the *Supplementary Report*, particularly Chapter 2, and the references contained therein.

2.2.1 Laboratory economics experiments

This project followed a standard process developed as part of the broader approach to test markets and other institutions, such as regulatory frameworks, drawing upon well-established procedures in the experimental economics literature. These included:

- running the experiment according to a precise script, where the experimental instructions described the subject's role/s, the actions they could choose and the associated payoffs. This helped to ensure consistency between experimental sessions and the ability to replicate the experiments;
- repeating the main task of interest (the biosecurity inspection game) to allow participants to learn about the experimental environment and task;
- providing salient financial incentives, where participants were paid in cash at the end of the experiment based on clearly defined performance criteria related to the decisions they make in the experimental task;
- randomising the allocation of subjects to treatments within each laboratory session; and

- taking steps to ensure the privacy of individual choices in the experiment and when subjects receive their cash payments.

The experiments in this project were conducted during September and October 2015 in the Monash University Laboratory for Experimental Economics (MonLEE).[1] In total, 275 students from different disciplines at Monash University took part in the experiments over 12 sessions, with two or four experimental treatments conducted in each session. Each session included between 19 and 24 individuals and lasted for around 75 to 90 minutes. The experiments consisted of four tasks, one of which was paper-based. These were, in order:

1. an abstract task to elicit the attitudes of subjects to risk;
2. the task where the subjects played the role of an importer of plant-products to Australia who had to choose their supplier over multiple periods;
3. a post-experiment questionnaire to elicit other characteristics of the subjects, including attitudes to the environment and government interventions; and
4. a paper-based incentivised task to assess how well the experimental subjects understood the inspection rules they experienced as part of the second task.

Task 2 is the main focus of this report. The other tasks provide additional information to assess the robustness of findings relating to the biosecurity inspection game using sophisticated statistical methods and are discussed in more detail in Chapters 3, 4 and 6 and Appendix A of the *Supplementary Report*.

2.2.2 Improving institution performance through behavioural economics

As an adjunct to insights from CEBRA Project 1304C which drew largely upon “standard” economic theory, the project team sought to use aspects from *behavioural economics* to assist in developing options for ways in which biosecurity inspection frameworks could be improved. Over the past decade, there has been considerable interest using insights from behavioural economics to improve the operation of various government policies, including regulatory frameworks; see, for example, Lunn (2014). Some of the experimental treatments considered in this project draw upon concepts from behavioural economics, such as:

- providing feedback to subjects that focuses on particular consequences of their decisions so as to influence future choices;
- offering the ability to participate in the regulatory process by choosing the inspection rule to follow, which could encourage improved compliance; and
- using decision aids such as diagrams, with the aim of improving subjects’ comprehension of the CSP-3 algorithm’s complex penalty structure.

The project team also sought to construct our experimental tasks carefully to avoid “known” decision-making phenomena affecting the interpretation of our results. For example, in the task designed to elicit subjects’ risk preferences, the project team adapted the widely used task by Eckel and Grossman (2008) so that no options could involve subjects losing money. This reflects the notion that people can behave quite differently in response to losses relative to gains.

[1] This research project was approved by the Monash University Human Research Ethics Committee as a low-risk project in August 2015.

2.2.3 Translating laboratory experiments outcomes to policy problems

Carefully crafted laboratory experiments, where potential confounding elements have been adequately controlled for or eliminated, should allow researchers to attribute differences in outcomes to treatments in a causal manner. However, the ability to generalise results from laboratory experiments beyond the experimental setting has been the subject of significant debate.[2]

As noted earlier, the project team has used laboratory experiments in this context as both a risk management tool to mitigate potential implementation risks in the field and an opportunity to assess policy options that would not be readily available for testing in the natural regulatory environment. The stylised laboratory environment, which enables a focus on specific aspects of regulatory design and implementation, means that it is highly unlikely the experiment's results will fully replicate the behaviour of experienced biosecurity system stakeholders. The project team does not purport to make such claims of laboratory outcomes translating to the field; indeed, what the experiment aims to achieve is much more modest in terms of informing policy design.

In considering how laboratory experiments can be used to inform biosecurity inspection arrangements, the project team considers the following principles, based on views articulated by Kessler and Vesterlund (2015), as reasonably conservative and appropriate for the policy development context.

1. Laboratory experiments can help uncover principles of behaviour, which are themselves general. These principles enable an understanding of how biosecurity regulations can be reformed to improve how they operate.
2. *Qualitative* findings around the direction of treatment effects from laboratory experiments *should* be generalisable to the field.
3. The use of simplifying assumptions to enable causal attribution of treatment differences in the laboratory setting implies the magnitude of observed treatment effects *will likely differ* from those expected in other environments.

In keeping with the second and third principles, our discussion of experimental results in Chapter 4 largely focuses on the direction of treatment effects rather than their magnitudes.

[2] See Chapter 2.5 of the *Supplementary Report* for a more extensive discussion of how the results of laboratory experiments can be translated into policy practice.

3. Structuring the biosecurity inspection experiment to inform regulatory design

Two of the critical requirements in formulating economics experiments are to:

- understand the key influences expected to affect behaviour; and
- determine which of those aspects are feasible (and worthwhile) to test in the laboratory before applying in the less controlled field setting.

The influences on the biosecurity system are many and complex, so theoretical economic models can be used to help translate the real-world interactions between importers and the regulator into the laboratory setting. Since importer behaviour is the focus of these experiments, the key elements of interest to the department include:

- the ability for designed inspection protocols to encourage importers to reduce the biosecurity risk material approach rate of their consignments;
- the circumstances under which protocols may encourage behaviours that raise the likelihood of biosecurity risk material being present;
- the influence of inspection rule parameters in encouraging different behaviours; and
- the importance of the total costs incurred by importers in being inspected, and the costs associated with changing behaviour.

This chapter outlines the practical policy issues for which we seek to provide evidence through these laboratory experiments. In translating the real-world interactions with the biosecurity system to the experimental setting, the chapter also reviews the factors influencing decision-making by the regulator and importers and describes some of the choices made in designing the main experimental task of interest. In closing this methodology chapter, we describe the 18 treatments used for the main experimental task and how the treatments can be compared to infer how particular implementation options may affect regulatory compliance.

3.1 Policy issues governing rule implementation

The aspects investigated as part of these experiments are strongly aligned with policy options available to the department as part of designing and implementing rules governing the importing processes for consignments of biosecurity concern. They stem from observations made by project team members based on the predecessor project, CEBRA Project 1304C, as potential opportunities to improve how compliance-based inspections are administered by the department. Most importantly, they relate to aspects that are under the direct control of the department. The policy rationale for the aspects relating to incentive structures and implementation features assessed in the experiments are outlined below.

3.1.1 Type of inspection rule structure – CSP-3 or CSP-1?

The department's Compliance-Based Inspection Scheme (CBIS) predominantly uses the CSP-3 algorithm to determine inspections. This rule was adopted and introduced following recommendations in Robinson et al. (2012) based on a statistical analysis of the department's administrative data for several plant-product pathways.

Subsequent analysis of the CSP rules in the game-theoretic context in CEBRA Project 1304C, including the analysis of Rossiter and Hester (2017), suggested that the CSP-1 algorithm would be preferable from the biosecurity regulator's perspective, particularly where the consequences of biosecurity risk material leakage are perceived to be relatively large. From a practical perspective, the CSP-1 algorithm is simpler and more easily able to be communicated to stakeholders, with stakeholders also likely to develop a clearer understanding of the incentive properties of the inspection rule. As the project team was recommending the CSP-1 algorithm be used in a subsequent field trial, department officers requested that the performance of the CSP-1 and CSP-3 algorithms be compared in the laboratory setting.

The CSP-1 and CSP-3 algorithm are outlined in the box below. These algorithms differ in terms of what happens to an importer following an inspection failure in "monitoring mode", with the CSP-3 algorithm being slightly more forgiving than the CSP-1 algorithm for one-off failures but involving significantly more complexity.

Continuous sampling plan algorithms

In this box, we introduce the two continuous sampling plan (CSP) algorithms considered in the experiments. The most basic of the CSP family rules is the CSP-1 algorithm, which was introduced in Dodge (1943) and is illustrated in Figure 1.

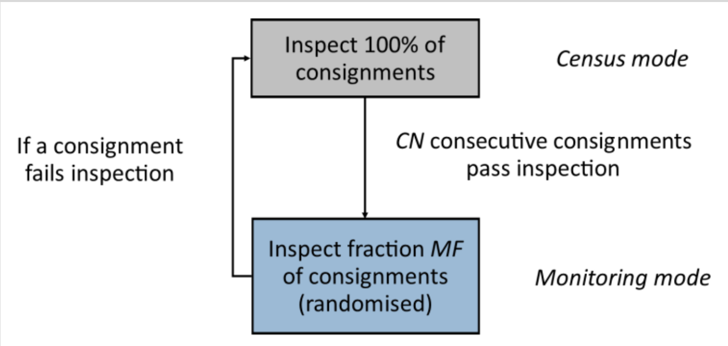

Figure 1. Schematic representation of the CSP-1 algorithm.

When a new importer starts on this algorithm, they are usually subject to mandatory inspections (in "census mode") until they build up a good compliance record. Two key parameters for the regulator to choose in this rule are:

- the clearance number (*CN*) – the number of successive consignments that must pass inspection for the importer to be eligible for a reduced inspection frequency; and
- the monitoring fraction (*MF*) – the reduced inspection frequency and probability that a given consignment is inspected in "monitoring mode".

If an importer's consignment fails inspection when the importer is in "monitoring mode", their subsequent consignments are subject to mandatory inspection in "census" mode. The importer only receives the reduced inspection frequency again after another *CN* successive consignments pass inspection.

The CSP-3 rule documented in Dodge and Torrey (1951) has less severe consequences for occasional non-compliance when an importer is on the reduced inspection frequency *MF* relative to the CSP-1 rule. In the CSP-3 algorithm

(Figure 2),[3] if an importer's consignment fails inspection in monitoring mode, the next four consignments following a failure subject to mandatory inspection in what is referred to as "tight census mode". This is designed to protect against a sudden systematic problem that would significantly raise the likelihood of a consignment failing inspection. However, unlike the CSP-1 algorithm, the importer does not need to demonstrate *CN* consecutive passes to return to a lower inspection frequency.

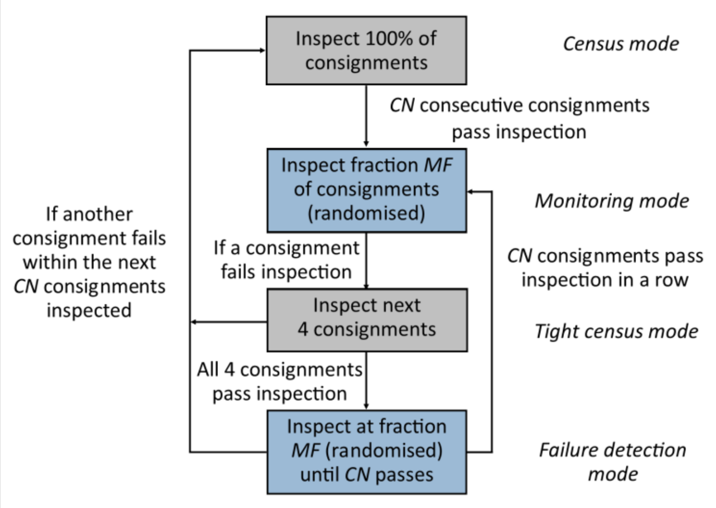

Figure 2. Schematic representation of the CSP-3 algorithm.

If the next four consignments following a failure pass inspection, the importer's consignments go back to being inspected at the reduced rate (*MF*) while the regulator keeps track of the number of inspections passed since the last recorded failure. This part of the algorithm is usually referred to as "failure detection mode". Provided the importer passes inspection *CN* times since their last failure, the importer remains eligible to be inspected at the reduced rate of inspection; otherwise, on recording another failure within *CN* consignments of the previous one, the importer's consignments revert to mandatory inspection until they pass inspection *CN* times in a row. Intuitively, this provides less of a "cost" to the importer if recording a failure in one inspection does not increase the probability that future consignments will be more likely to fail.

3.1.2 Level of information provided about the rule to importers

The experiment is assessing an aspect key to implementing incentive regulation – how much information about the incentive structures should be disclosed to stakeholders. CEBRA Project 1304C flagged that providing more specific information about the inspection protocols to stakeholders could encourage them to seek out ways to reduce the likelihood of biosecurity risk material being present in consignments.

Extracts from the department's website at the time[4] highlight the way in which the inspection protocol was vaguely described.[5]

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[3] The version of the rule used in this paper follows the practical simplification suggested by Robinson et al. (2012).

[4] This was found from an archived copy of the department's website available through the Internet Archive Wayback Machine: https://web.archive.org/web/20160102061626/http://www.agriculture.gov.au:80/import/goods/plant-products/risk-return.

To qualify for reduced inspections, importers must initially pass a defined number of consecutive document assessments and inspections on the eligible products. This number ranges from 5 to 10, depending on the risks associated with the commodity.

Once an importer has qualified for reduced inspections, future consignments will be inspected at a reduced rate (which currently ranges from 10 to 50 per cent depending on the commodity).

If non-compliance is detected at inspection or documentation assessment, that importer will return to 100 per cent inspection for several consignments until their product meets the number of clean consignments required.

The number of consecutive clean consignments required and the reduced intervention rate applied are determined for each commodity based on the biosecurity risk posed and may change over time.

Based on this advice, the potential rule structures facing importers could range from one with CN = 5 and MF = 10 per cent to one with CN = 10 and MF = 50 per cent. This spectrum of rule parameters provides a large range of cost savings available to importers from reduced inspections at the border from complying with biosecurity requirements. However, stakeholders will be ambiguous as to the rule that currently applies to them and could therefore underestimate the potential benefits of risk mitigation approaches.

In the extract above, the CSP-3 algorithm's penalty mechanism applied on failing an inspection is also not clearly described. Furthermore, the prospect of the rule parameters changing without being informed creates further ambiguity around the inspection scheme to which importers are subject. In the face of this level of confusion and with established "defaults" around suppliers and/or technologies, stakeholders may choose to maintain current arrangements and be less likely to undertake costly measures, such as introducing new technology or switching to suppliers with better biosecurity control practices, that could reduce the approach rate of biosecurity risk material.

In the experiment, we assessed the impact on importer choices of different levels of precision about specified components of the rule. As a preview of the experimental findings, there was some evidence that treatments with a more precise description of the rule had subjects making choices that resulted in a lower approach rate of biosecurity risk material. Based on the findings of these experiments, the department has since decided to publish the clearance number and monitoring fraction parameters for each CBIS pathway on the website.

[5] Previous discussions with department staff involved in rolling out the CBIS indicated that a reason behind describing the rules in this way was to allow the department to change the CSP-3 rule parameters in responses to changes in the risk profile of certain commodities. As discussed in Rossiter et al. (2016), flexibility can still be retained by the department by disclosing the circumstances under which rule parameters or eligibility may be changed to biosecurity system stakeholders. This has the advantage of not impeding the application of incentives for compliance embedded within compliance-based inspection protocols as well as a communication mechanism that can be used to improve stakeholder understanding of biosecurity risk management issues.

3.1.3 Importer feedback on performance under the inspection rule

CEBRA Project 1304C identified that providing more targeted feedback to importers about their inspection performance in general, as well as the causes of inspection failures, could help importers improve their compliance with biosecurity requirements. The idea is that importers could pass on this information to improve compliance within their existing supply chain, or provide them with intelligence to enable them to switch to suppliers with lower failure rates.

At present, the department provides reports listing the directions and outcomes for individual consignments to importers through their customs broker representatives. While it would be possible for stakeholders to build a consolidated history of their compliance based on these reports, their current format makes it a time-consuming task to extract salient information. An alternative approach would be for the department to generate consolidated feedback reports and provide them to stakeholders at regular intervals. This has the added benefit that the department can frame the information in the reports to support its aim of reducing approach rates for biosecurity risk material. Furthermore, it would make further use of the department's planned expansion of its advanced analytics capability flagged in the *Agricultural Competitiveness White Paper*.[6]

The experiment goes some way towards assessing how importer behaviour can be influenced through providing and framing targeted feedback on performance through the inspection process. As a preview of the experimental findings, there was some evidence that targeted feedback helped subjects make choices that afforded a lower biosecurity risk material approach rate. Based on these experiments and subsequent development and refinement of performance report templates, the department agreed to trial providing feedback reports to importers both as part of the follow-up field trial (CEBRA Project 1608C) and a separate department-initiated trial of new onshore inspection protocols for lemons and limes sourced from the United States of America.[7] More recently, more structured feedback reports have also been applied to the cut flowers pathway.[8]

3.1.4 Influence of costs on importer choices

Previous work seeking to understand stakeholder behaviour in biosecurity inspections sought to explain the role of costs borne by importers on their choices. The scope of costs considered include both direct costs, such as inspection fees, and indirect costs, such as delay, storage and transport costs. While the former costs are readily observable by the department, indirect costs are of a private nature to the importer. From the perspective of an importer's incentives to comply with biosecurity

6 More details on the measures comprising the biosecurity surveillance and analysis initiative funded through the *Agricultural Competitiveness White Paper* can be found at: http://www.agriculture.gov.au/biosecurity/agwhitepaper-bio-surveillance-analysis.

7 For more details on the compliance-based inspection trial for US lemons and limes see: http://www.agriculture.gov.au/import/goods/plant-products/risk-return/trial-usa-lemons-limes.

8 For more details on the feedback and reporting frameworks used as part of changes to import conditions for fresh cut flowers and foliage see http://www.agriculture.gov.au/import/industry-advice/2018/15-2018 and http://www.agriculture.gov.au/import/goods/plant-products/cut-flowers-foliage/importing-fresh-cut-flowers-into-aus-safely.

requirements, both direct and indirect costs associated with the inspection process are relevant for understanding behavioural responses to different inspection rules.

The theoretical predictions in Rossiter and Hester (2017) on these influences were clear, in that higher costs of being inspected and/or rectifying a consignment following an inspection failure would encourage importers to make choices consistent with a lower biosecurity risk material approach rate. The experiments seek to demonstrate these behavioural tendencies in a safe, low-cost environment to help build confidence in these notions within the department.

The aim of this is to build a more nuanced understanding within the department of how appropriate pathways can be selected for compliance-based inspections. It involves more than a statistical analysis of inspection outcomes under a mandatory inspection scheme and requires a more in-depth understanding of pathway cost structures, mitigation options and consequences for leakage. This brings what can be thought of as “non-statistical intelligence” into considering how best to design biosecurity assurance protocols across a variety of circumstances.

3.1.5 Menus of regulatory contracts

CEBRA Project 1304C highlighted that, by offering a suite of options to importers as to how biosecurity assurance is provided for their consignments, the regulator can use the importer’s information advantage about private costs of compliance and the mitigation measures available to it to extract improved performance. Information would be revealed through the process of selecting an option from the menu and would assist inspection effort to be allocated more efficiently across importers and pathways.

Eligibility for different menu options was originally conceived in terms of stakeholders demonstrating adherence to effective biosecurity control measures through some means that was independently verifiable, such as an audit. However, the potential use of menus can also be demonstrated through comparing actions between different “types” of stakeholders. For this experiment, we seek to assess the suitability of a simple rule-choice environment for importers that differ in terms of the costs they face in the inspection process. This is a more limited investigation of the use of menus, but may still provide some intelligence for the department around the appropriate application of menus in the biosecurity context.

3.2 Translating the biosecurity inspection game into an experiment

3.2.1 Roles of the experimental subjects

As the project’s main focus was to assess the behaviour of importers in response to given inspection rules, the experiment was designed as an *individual-choice task*[9] where subjects took on the role of importers. In this setting, the subjects made decisions about their suppliers in response to a predetermined set of rules imposed (or

[9] Other, less restrictive experimental designs that could be used to assess different research questions are considered in Chapter 3 of the *Supplementary Report*. These potential alternative experimental designs, particularly those that might provide a greater understanding of how compliance-based inspection rules could influence upstream supply-chain decisions, may fulfil future research needs of the department.

offered) in the experiment. This meant the computer took on the role as the biosecurity regulator in the strategic interaction, where the same rule applied for the duration of the experiment regardless of the experimental subject's supplier choices.

While this design is relatively easy to implement and the results straightforward to analyse, it imposes rather restrictive assumptions about the types of decisions the regulator can make in this context. For instance, it assumes that the regulator commits to any action for the duration of the task regardless of the choices made by the importer.

3.2.2 Putting the laboratory experiment in context

Economics experiments in the laboratory setting can either be naturally framed in the particularly policy context or can be subject to some level of abstraction. Consultation with departmental officers and CEBRA colleagues indicated a strong preference for a naturally framed experiment, where the instructions would make it clear to participants that the context for the experiment was biosecurity inspection of plant-based products.

Results from naturally-framed experiments generally allow them to be more easily understood by key organisational decision-makers, given the experimental context is more grounded in the reality of a specific policy application. However, in some situations, the context of the experiment may elicit particular behavioural patterns from experimental subjects because it triggers latent psychological motivations. To control for these potential effects, we use a post-experiment questionnaire[10] to ask about subjects' attitudes to the environment, incursions of pests and diseases, government intervention to resolve environmental problems and political preferences.

3.2.3 Choices available to the regulator and influencing importer behaviour

There are many choices the department can make in designing and implementing compliance-based inspection protocols which may affect importer behaviour, some of which were outlined in the previous section. These can include:

- the form of inspection rule/s applied, including its inherent penalty-reward structure;
- the value/s of key rule parameters;
- the level of information given to importers around the specifics of the inspection rule they will be subject to; and
- the amount and nature of feedback on an importer's performance under the inspection rule.

The regulator may be able to influence, though not completely control, the costs incurred by an importer from having their goods inspected and any treatment-related costs for goods found to contain biosecurity risk material. In practice, the scope for influence in a punitive manner is limited by the requirements of the World Trade Organization *Agreement on the Application of Sanitary and Phytosanitary Measures* (World Trade Organization, n.d.) and the *Australian Government Charging*

[10] See the *Supplementary Report* for more details on the post-experiment questionnaire and the way in which we control for these potential influences through econometric modelling of the experimental data.

Framework (Australian Government Department of Finance, 2015). These limits on the cost structures in turn affect how the reward and penalty mechanisms inherent in compliance-based inspection rules and under the control of the department can influence stakeholder behaviour. Specifically, the lack of punitive punishment options for non-compliance will limit the potential effectiveness of any inspection protocol in this context.

To be in line with current practice under the CBIS and the preferred rule recommended by CEBRA Project 1304C, the CSP-1 and CSP-3 algorithms were the only ones considered in these experiments. For simplicity, these rules are applied based on the importer's performance alone. The clearance number and monitoring fraction parameters chosen for the experiment also aligned with public guidance about the CBIS on the department's website, as outlined earlier in the chapter.

Given the biosecurity regulator makes no "active" choices in the experimental implementation adopted for this project, the regulator's objective function or associated parameters do not need to be specified. To simplify the instructions for the experimental task, we also assume that the regulator is a perfect decision-maker when it comes to inspections. This implies that if a consignment is inspected, the inspector always finds biosecurity risk material if it is present and does not cause "false alarms" if the consignment does not contain this material.

3.2.4 Choices and factors influencing decision-making for importers

Analysis of pathway data as part of CEBRA Project 1304C suggested that importers tend to fall into two broad categories, namely:

- those that are, or act as if they are, vertically integrated. For example, this could be through arrangements such as being the Australian distribution arm of a multinational business; and
- those with the freedom to choose their suppliers and obtain their products from a wide range of sources.

Importers under these supply-chain structures have different actions available to them and face different cost structures for the importers. In simulation models developed for that project, it was shown that similar patterns of behaviour could be generated for both types of importers. As importers who are able to choose their suppliers allowed for a simpler set of choices for subjects, the project team decided to use this importer type in these experiments.

From a theoretical standpoint, the principal influences on an importer's supplier choices relate to the profit they can expect to make out of their importing activities. The factors that will influence an importer's profit function include:

- the resale price of imported goods in the domestic market;
- the landed costs of goods into Australia, other than those related to biosecurity inspections, from a particular supplier;
- the likelihood of biosecurity risk material being present in a given supplier's consignments;
- any costs the importer may incur associated with switching suppliers;
- the costs associated with being inspected and consignments being treated if they fail inspection; and

- the likelihood of being inspected, based on the biosecurity regulator's inspection rule.

3.2.5 Further assumptions underpinning the experiment structure

A key consideration of the experimental design is to ensure the experiment allows for the appropriate attribution of causal relationships, or lack thereof, between two variables. In practice, this means eliminating, to the fullest extent possible, any potential factors that could confound inferences about the variables of interest.

As part of translating the theoretical framework into an experimental setting, the project team had to choose a number of parameter values for the experiment. These parameters included aspects such as the costs involved in being inspected, the biosecurity risk material approach rates of suppliers and the CSP rule parameters.

The final parameterisations arrived at by the project team attempted to ensure the payoff functions covered a reasonably wide range to provide an appropriate monetary inducement for students for making "better" choices in the experiment. This was done within the confines of trying to keep many parameters constant across treatments so that the number of treatments remained workable. The parameter values were also chosen to be simple for subjects to understand and relate to, while allowing them to make simple calculations if they chose to do so.

An important lesson from the calibration process[11] was that the simulated payoff function for importers from the CSP rules was relatively flat under what could be considered "realistic" values of the parameters.[12] This made it difficult to find cases where the differences in payoffs between the worst and best supplier-choice strategies were marked, let alone where the optimal strategy providing a significantly larger payoff than the next best strategy. In the context of the laboratory experiments, the relatively flat payoff functions will undermine the ability to discern significant treatment differences

Stakeholder discussions as part of CEBRA Project 1304C provided some intelligence on importers' cost structures under the current charging regime. For many products, importers could receive modest direct and indirect (financial) benefits from avoiding inspections, with usually more marked consequences from failing an inspection. This in part reflects the restrictions on direct penalty and charging structures imposed by international agreements and other Australian Government policy settings.

A practical consequence of these limits on being able to apply sizeable rewards for good compliance and punitive punishments for non-compliance is that CSP-type rules on their own may provide only weak incentives for importers to change their behaviour. This is because the gains available to importers from switching to suppliers with lower biosecurity risk material approach rates are likely to be relatively small.

The simplifying assumptions we make in this context are discussed briefly below.

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[11] Further details on the calibration process, which were also used to generate theoretical predictions of behaviour in the experiment, are provided in Chapter 3 and Appendix B of the *Supplementary Report*.

[12] To avoid the potential for loss aversion to affect how the experimental results can be interpreted, the inspection cost parameters also needed to be chosen in a way that meant losses from failing an inspection occurred only under a limited set of circumstances.

1. Experimental subjects make choices of their suppliers 50 times in a row in time units referred to as "periods".[13] Each period in the experiment's main task involved the subject choosing a supplier for 10 consecutive consignments – also referred to as a shipment. This meant each subject "imported" 500 consignments of plant-based products over the course of the experiment.

   This situation represents a methodological compromise, balancing the need for a large number of consignments achieve sufficient differentiation in payoffs for different strategies under the CSP rules with having a manageable number of choices to avoid subjects getting bored. This structure also enables the experiments to mimic the potential for importers to engage suppliers on the basis of short-term contracts which may be subsequently renewed (or not) depending on that supplier's performance.

2. At the end of each period (that is, choice of supplier for 10 consecutive consignments), the subject is shown the inspection outcomes that related to consignments for that supplier and the "profit" from importing they earned that period. The subject can see for each of the 10 consignments imported:

   a. whether a consignment was inspected; and
   b. if it was inspected, whether or not it was found to contain biosecurity risk material.

   Subjects could then make decisions based on the supplier characteristics plus what they had learned from the outcomes of choices in previous periods.

3. The only aspect that changes over the course of the experiment is where the subject is according to the relevant compliance-based inspection rule (CSP-1 or CSP-3) that applies to their treatment. By the nature of these rules, this depends on previous choices made by the subjects as well as an element of "chance" as to whether a consignment selected for inspection contains biosecurity risk material. The nature of the choices made by experimental subjects, namely the suppliers and their characteristics, are fixed across all 50 periods.

4. The number of potential suppliers is set at four (labelled supplier A, B, C and D). This ensures the choice environment for the experimental subjects is not overly complex, while still allows for sufficient variation in choice outcomes.

5. Consignments offered by different suppliers are taken to be identical in all respects (for example, the amount and quality level) except for their landed cost and the likelihood of biosecurity risk material being present, both of which can affect the profit earned from importing plant-based products into Australia. To this end, the resale price of consignments in the domestic market is assumed to be the same (20 monetary units in the experiment) for all consignments and all suppliers.

   This is a significant simplification of reality, since different brands of the same product may have different attributes that would affect their resale value. However, it enables the experiments to better identify the trade-offs between cost and biosecurity assurance likely to affect importer decisions.

[13] See the Table of Definitions for a more formal definition of the term "period" – terminology which is standard within the economics literature.

6. Importers know suppliers' approach rate for biosecurity risk material, with these values constant across treatments (and periods). In practice, an importer may know very little about the approach rate for particular suppliers, partly reflecting that there is, at present, no formal feedback from the department that could reveal this information to importers.[14]

   The main reason for doing this is to avoid confounding two types of learning that could happen in this experiment, namely learning about how the inspection rule operates and forming beliefs about the "true" biosecurity status of different suppliers. Stating that the approach rate is a fixed value, say 10 per cent, means that variations in observed behaviour can be attributed to subjects learning about the rule, rather than any other learning mechanisms.

7. The landed cost of consignments and the biosecurity risk material approach rate are assumed to be negatively related; that is, more expensive suppliers have lower approach rates and vice versa. This helps rule out supplier choices which would be expected to be "dominated" by other choices.

   The schedule of supplier attributes (Table 1) is held constant across all experimental treatments to remove it as a potential confounding factor for explaining the observed experimental behaviour and is included in the experimental instructions.

Table 1: Supplier options in the biosecurity inspection experiment

Supplier option	**A**	**B**	**C**	**D**
Transportation and purchase costs per good (in monetary units)	**3**	**4**	**6**	**8**
Probability that a good in a shipment contains biosecurity risk material***	**50%**	**30%**	**10%**	**2%**

*** Note that a probability of, for example, 50% does not automatically imply that 5 out of the 10 goods in a shipment contain biosecurity risk material but that there is a 50% probability that each single good contains biosecurity risk material. Thus, it is possible that the number of goods in a shipment containing biosecurity risk material is less than, equal to, or greater than 5.

8. Importers incur no additional costs from changing suppliers. This greatly simplifies the experimental instructions and context for making choices. However, importers interviews in CEBRA Project 1304C perceived there were significant costs associated with changing their suppliers and/or customs brokers to the point that switching could be prohibitively expensive. The assumption of no switching costs means there could be a much higher level of supplier-switching in this experiment than might be expected in other contexts, such as in a field trial. We therefore do not assess switching behaviour in discussing the experimental results in Chapter 4.

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[14] This could involve, for example, publishing inspection failure rates for different suppliers on pathways or providing public notification of inspection failures as is done for imported food products under the Imported Food Inspection Scheme. See, for instance, http://www.agriculture.gov.au/import/goods/food/inspection-compliance/failing-food-reports/ for more details about the reporting framework for food inspection failures.

3.2.6 Attitudes to risk and their influence on biosecurity choices

Individual attitudes to risk form a key part of this experiment. In its most abstract construction, the experiment seeks to understand how people make choices in response to lotteries with different payoffs and different probabilities of outcomes. Hence, it will be important to control for the influence of individual risk preferences when subjects make decisions in this experiment. We seek to obtain independent measures of subjects' risk preferences by:

- conducting a widely used lottery-choice task (Eckel and Grossman, 2008) as the first experimental task to elicit attitudes to risk in an abstract environment; and
- asking about general willingness to take risks in the post-experiment questionnaire.

More details on these procedures and how these are used to analyse choices in the biosecurity inspection game task are contained in Chapters 3 and 4 of the *Supplementary Report*.

3.3 Experimental treatments to assess regulatory options

The five key aspects considered important to understand in designing the experiment, and outlined in Chapter 3.1, were:

1. the influence of different inspection rules, in terms of a rule's in-built penalty for failing inspection and key parameters affecting the rule's operations;
2. the level of information provided to stakeholders about the inspection rule;
3. the amount and framing of feedback on performance under the inspection rule;
4. the influence of costs of being inspected and of failing inspection; and
5. performance under a simple rule-choice environment.

In addition, the project team sought to study some treatments that would provide "bounds" on the types of benefits that may be achieved by pursuing compliance-based inspection protocols.

The 18 treatments[15] that enabled the five key aspects to be addressed, plus provide guidance on the "bounds", are summarised in Table 2. The treatments are presented in five different blocks in this table and the companion results table (Table 7) in Chapter 4. The first block refers to the two "bounds" treatments (treatments M and R), with the second referring to the treatment comparisons useful for determining aspects 1 and 2 in the list above. The third, fourth and fifth blocks provide details of the additional treatments required to investigate aspects 3, 4 and 5 respectively.[16]

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15 The large number of treatments is unusual for an experimental study of this nature; usually, economics experiments focus on up to two dimensions and potentially four to six treatments. The large number of treatments reflected the desire to investigate a range of issues around the inspection process that were of practical relevance to the department. However, using a large number of treatments is not without drawbacks, particularly reduced statistical power and related multiple testing problems (List et al., 2016). The experiments conducted in this context were also more of a "wind-tunnel" format to prepare for a more in-depth field trial. See Chapter 2.4 in the *Supplementary Report* for a discussion of this approach to experimentation in economics.

16 The comparisons in these later blocks also involve comparisons with treatments presented in earlier blocks, such as treatments C1 and C1-I.

Table 2: Subject supplier choices over different time periods in the biosecurity inspection game

Treatment identifier	Rule form	Information disclosed about the inspection rule	Feedback on performance	Monitoring fraction (inspection probability)	Clearance number	Inspection costs	Treatment costs
M	Mandatory	Full information on rule parameters	Results table (last shipment)	1		4	6
R	Randomised	Full information on rule parameters	Results table (last shipment)	0.2		4	6
C1-I	CSP-1	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5)	Results table (last shipment)	0.2	10	4	6
C1	CSP-1	Full information on rule parameters	Results table (last shipment)	0.2	10	4	6
C3-I	CSP-3	Clearance number and tight census number given; monitoring fraction said to lie within a range (0.1 to 0.5)	Results table (last shipment)	0.2	10	4	6
C3-I2	CSP-3	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5); tight census number described vaguely (“a few”)	Results table (last shipment)	0.2	10	4	6
C3	CSP-3	Full information on rule parameters	Results table (last shipment)	0.2	10	4	6
C1-IL	CSP-1	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5)	Results table (last shipment) + loss frame on the costs of being inspected	0.2	10	4	6

Table 2 (continued): Subject supplier choices over different time periods in the biosecurity inspection game

Treatment identifier	Rule form	Information disclosed about the inspection rule	Feedback on performance	Monitoring fraction (inspection probability)	Clearance number	Inspection costs	Treatment costs
C1-L	CSP-1	Full information on rule parameters	Results table (last shipment) + loss frame on the costs of being inspected	0.2	10	4	6
C1-IG	CSP-1	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5)	Results table (last shipment) + gain frame on savings from avoiding inspection	0.2	10	4	6
C1-G	CSP-1	Full information on rule parameters	Results table (last shipment) + gain frame on savings from avoiding inspection	0.2	10	4	6
C1-2.6	CSP-1	Full information on rule parameters	Results table (last shipment)	0.2	10	2	6
C1-2.12	CSP-1	Full information on rule parameters	Results table (last shipment)	0.2	10	2	12
C1-4.12	CSP-1	Full information on rule parameters	Results table (last shipment)	0.2	10	4	12
C1-5.03	CSP-1	Full information on rule parameters	Results table (last shipment)	0.3	5	4	6
C1-5.03.12	CSP-1	Full information on rule parameters	Results table (last shipment)	0.3	5	4	12
Choice6	CSP-1	Full information on rule parameters	Results table (last shipment)	A: 0.2 B: 0.3	A: 10 B: 5	4	6
Choice12	CSP-1	Full information on rule parameters	Results table (last shipment)	A: 0.2 B: 0.3	A: 10 B: 5	4	12

These experimental treatments are constructed to allow pairwise comparisons where only one dimension varies at a time. For example, the only difference between treatment C1 and C1-I is the level of information about the rule parameters that is disclosed to the importer. Under treatment C1, the importer has full information about the monitoring fraction but under treatment C1-I the importer is only given a range of values for the monitoring fraction. By using appropriate procedures in the laboratory and constructing treatments that allow for comparisons where only one dimension varies at a time, the experimenter can attribute differences in observed behaviour to changes in that one dimension of interest. This then allows a causal interpretation of the experimental outcomes.

The tables that follow in this section are designed to present the information from Table 2 in a form that allows for easier identification of the key aspects that change within each comparison group of treatments. This means different aspects of Table 2 will be drawn out in Tables 3 to 6, as warranted as part of the treatment comparisons.

3.3.1 Different inspection rules and level of information about the rule

Table 3 provides the list of relevant treatment comparisons (from Table 2) that may be used to investigate the influence of different inspection rules, and different levels of information about the rules, on importer behaviour and thus the approach rate of biosecurity risk material.

Table 3: Treatment comparisons for different inspection rules and the level of information provided to importers

Treatment identifier	Rule form	Information disclosed about the inspection rule
C1	CSP-1	Full information on rule parameters
C1-I	CSP-1	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5)
C3	CSP-3	Full information on rule parameters
C3-I	CSP-3	Clearance number and tight census number given; monitoring fraction said to lie within a range (0.1 to 0.5)
C3-I2	CSP-3	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5); tight census number described vaguely (“a few”)

In common to all the rules in Table 3 are:

- the clearance number and monitoring fraction for the CSP algorithms are 10 and 0.2 respectively;
- the costs of being inspected and treatment costs are at the baseline levels of 4 monetary units and 6 monetary units respectively; and
- the feedback subjects receive on their performance consists of a table of results based on their previous shipment of 10 goods and their total payoff from that shipment.

To compare the effects of the CSP-1 and CSP-3 algorithms of importer behaviour, the full information treatments (C1 and C3) and treatments where the monitoring fraction is vague (C1-I and C3-I) can be compared in a pairwise manner.[17] While these comparisons can be made as requested by department officers, the main challenge rests in interpreting treatment differences.

The theoretical framework of Rossiter and Hester (2017) showed differences in the predicted optimal behaviour of an importer between the CSP-1 and CSP-3 rule were relatively small, with the CSP-1 rule being better from the biosecurity regulator's perspective in most circumstances. For an experiment, this results in it being nigh impossible to arrive at a set of parameters for the biosecurity inspection interactions where the payoffs for alternative choices differ markedly under the CSP-1 and CSP-3 algorithms. An implication of this is that the CSP-1 and CSP-3 rules are expected to result in the same optimal supplier-choice strategies.[18]

The inability to separate predicted behaviour under the pairwise comparable treatments means, from a statistical perspective, it will be difficult to discern whether an identified difference reflects chance or a "true" difference in observed behaviour. In other words, these comparisons will suffer from low statistical power. Furthermore, if there are differences between subjects' behaviour in comparable CSP-1 and CSP-3 treatments, the experimental results may provide little intuition explaining why these differences have arisen. More generally, this highlights the limits of laboratory experiments, in that they may be less informative than other research methods to provide insights to issues of a fine-scale quantitative nature.[19] From a policy perspective, the "best" experiments can yield is to provide some confirmation that observed behaviours do not differ markedly between the two rule structures where the level of information provided about the rule is the same.

The effect of different levels of information can be assessed by separately comparing the two CSP-1 treatments and the three CSP-3 treatments. For the CSP-3 treatments, the appropriate comparison structure is somewhat hierarchical, with treatment C3-I used as the "benchmark" comparator for treatments C3 and C3-I2. It is unclear whether providing more information about the inspection rules will encourage supplier choices that increase or lower biosecurity risk material approach rates.

[17] Treatment C3-I2 represents the current practice most closely. This treatment is only comparable with treatment C3-I on a pairwise basis, and does not have an equivalent CSP-1 rule treatment.

[18] The main difference between the two rules is that the average payoff for the CSP-3 treatments should be *marginally* higher when compared with the equivalent CSP-1 treatment. This is because the CSP-3 algorithm is slightly more forgiving on inspection failures that the CSP-1 algorithm.

[19] In general, natural or artefactual field experiments, of the kind discussed in Chapter 2.3 of the *Supplementary Report*, are potential research methods that could be used to assess more quantitative considerations. However, in the biosecurity inspection context, opportunities for either type of field experiment where different importers could face different inspection rules is limited. For natural field experiments, this reflects the absence of pathways that would offer "twin studies" as well as ethical concerns about providing a commercial advantage to some firms over others on the same pathway that is not based on identifiable biosecurity-related performance. In the case of artefactual field experiments, it may be difficult to find importers familiar with biosecurity inspection protocols available to participate in laboratory experiments because of their geographic dispersion around Australia.

3.3.2 Framing feedback on rule performance

The relevant treatment comparisons available to assess the feedback on the rule are presented in Table 4. All the rules in Table 4:

- follow the CSP-1 algorithm with clearance number and monitoring fraction of 10 and 0.2 respectively; and
- have common (baseline) inspection and treatment costs of 4 monetary units and 6 monetary units respectively.

Table 4: Treatment comparisons for investigating the role of framed feedback

Treatment identifier	Information disclosed about the inspection rule	Feedback on performance
C1	Full information on rule parameters	Results table (last shipment)
C1-I	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5)	Results table (last shipment)
C1-G	Full information on rule parameters	Results table (last shipment) + gain frame on savings from avoiding inspection
C1-IG	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5)	Results table (last shipment) + gain frame on savings from avoiding inspection
C1-L	Full information on rule parameters	Results table (last shipment) + loss frame on the costs of being inspected
C1-IL	Clearance number given; monitoring fraction said to lie within a range (0.1 to 0.5)	Results table (last shipment) + loss frame on the costs of being inspected

To compare the effects of the additional framed feedback on supplier choices, the full-information rules under the gain and loss frame (treatments C1-G and C1-L) can each be compared pairwise with the baseline treatment C1. Similar comparisons can also be made under the treatments where the monitoring fraction is only vaguely described (treatments C1-IG and C1-IL). The additional targeted feedback from the gain and loss frames may have a larger effect on subject behaviour in the treatments where the inspection rules are not precisely described. Ideally, the additional feedback would encourage subjects to choose suppliers with lower approach rates.

3.3.3 Costs of being inspected and failing inspection

The relevant treatment comparisons are based on a standard two-factor two-level form of experimental comparison, as highlighted in Table 5. The rules in Table 5 are all CSP-1 rules where:

- the clearance number and monitoring fraction for the CSP algorithms are 10 and 0.2 respectively;
- importers know the full specification of the rule; and

- the feedback subjects receive on their performance consists of a table of results based on their previous shipment of 10 goods and their total payoff from that shipment.

The effect of different cost parameters in this setting can be made by making appropriate pairwise comparisons of the treatments in Table 5, with one cost dimension being held constant.

Table 5: Treatments comparing the behavioural influence of inspection cost parameters

Treatment identifier	Inspection cost (monetary units)	Treatment cost (monetary units)
C1	4	6
C1-2.6	2	6
C1-2.12	2	12
C1-4.12	4	12

3.3.4 Regulatory environment with a choice of inspection rule

The way in which importers differ in terms of their innate characteristics (or "type") is based on their costs of inspection and treatment. Creating a meaningful environment for allowing a choice of rule then involves comparing two groups with different levels of one of the cost parameters. We can then compare their behaviour where there is no choice of rule and then when the subject can choose the rule they follow.

It is important to note that the current configuration of the department's information systems will not allow this approach to be implemented via the Q-ruler. However, rule-choice options could be of value for the department as a way of structuring Approved Arrangements with importers. In practice, this could be done by the department constructing several agreement templates that importers could choose from, provided they met the eligibility (pre-qualification) requirements for certain agreements. The eligibility conditions could relate to things such as replacement external audit requirements, additional processing requirements or different certification arrangements and would be entirely at the department's discretion. This type of structure would have the potential to standardise and greatly simplify the administration of these undertakings with importers and/or suppliers.

For the rule-choice environment, we use two CSP-1 rules with different parameters, namely:

- Mechanism A: clearance number 10 and monitoring fraction 0.2; and
- Mechanism B: clearance number 5 and monitoring fraction 0.3.

Note that Mechanisms A and B are unable to be directly compared because there are two parameters that differ between these rules which, in a theoretical sense, would partly offset each other.

Table 6 summarises the different features of the six treatments to be compared in a pairwise manner to understand the influence of rule choice on subject behaviour. In common to all the rules in Table 6 are:

- importers know the full specification of the rule and rule parameters;

- the cost of being inspected is at the baseline levels of 4 monetary units;
- the feedback subjects receive on their performance consists of the table of results of the last shipment of 10 goods and their total payoff from that shipment.

Table 6: Treatment comparisons for generating a rule-choice environment

Treatment identifier	Mechanism	Treatment cost
C1	A	6
C1-4.12	A	12
C1-5.03	B	6
C1-5.03.12	B	12
Choice6	Choice	6
Choice12	Choice	12

For example, the behaviour of subjects in Choice6 who choose Mechanism B can be compared with treatment C1-5.03, since the only dimension they differ across is that one treatment has a choice of rule. The choice treatments (Choice6 and Choice12) were calibrated to ensure it was theoretically optimal for importers with low treatment costs to choose Mechanism B, while those with high treatment costs would prefer Mechanism A.

3.3.5 Boundary treatments

The experimental design included two boundary treatments (treatments M and R) to test for individuals' reactions towards:

- the highest possible inspection probability in the experiment (treatment M); and
- the lowest possible inspection probability in the experiment (treatment R).

Treatment M also mirrors the current mandatory inspection practice that applies to many plant-product pathways. Treatment R, in effect, represents a scheme with randomised inspections, where each consignment has a 20 per cent probability of being inspected. These treatments differ from the others considered in this experiment as the probability of inspection is constant and does not depend on a subject's compliance history. Both of these rules admit analytical solutions for their predicted importer strategies, namely choosing supplier B in treatment M and supplier A in treatment R. For both rules:

- the inspection rules were fully specified in the experimental instructions;
- the costs of being inspected and treatment costs were set at the baseline levels of 4 monetary units and 6 monetary units respectively; and
- the feedback subjects receive on their performance consists of the table of results of the last shipment of 10 goods and their total payoff from that shipment.

4. Experimental results

In this chapter, we investigate the impact on supplier choices of the 18 treatments used in the experiment according to the thematic dimensions of interest described in Chapter 3.2. We then use these results to investigate how particular features of the rules, information and importer characteristics affect decisions that may have implications for the design of regulations for managing biosecurity risks at the border.

The results for each treatment are analysed in terms of changes in the average biosecurity risk material approach rate (henceforth the "implied approach rate") for the experiment's hypothetical plant-product pathway. This measure is of particular interest to the department, given it indicates the extent of non-compliance with biosecurity requirements.[20] The implied approach rate is calculated across experimental subjects (as shown in the plots over time) or both experimental subjects and time periods (as shown in the tables) for each treatment. It is a weighted average of the approach rates of the four supplier options shown in Table 1, with the weights determined by the number of choices participants made of each supplier in the experiment.[21]

This report focuses on simple pairwise comparisons of treatment performance that do not account for information gleaned from the other three tasks conducted in the experiment. A more comprehensive description and analysis of the experimental data is available in Chapters 4 and 5 of the *Supplementary Report*.[22]

Several of the key findings outlined in this chapter appear to deliver potentially economically significant differences from a policy perspective but are not statistically significant at the usual tolerance thresholds. This reflects both significant heterogeneity within treatment groups and the relatively small number of subjects in each treatment group. For these reasons, the findings discussed in this chapter should be interpreted as indicative rather than definitive.

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20 See the Table of Definitions for a more formal description of this metric. The implied approach rate is only one criterion on which to base decisions about the "optimality" of biosecurity inspection rules. For a discussion of other criteria to assess the experimental choices, see Chapter 2.2 of the *Supplementary Report*.

21 To illustrate the calculation of the implied approach rates underpinning Figure 1 and Table 7, the five subjects in treatment M made a total of 250 supplier choices (50 per subject) consisting of 49 (19.6 per cent) for Supplier A, 178 (71.2 per cent) for Supplier B, 20 (8.0 per cent) for Supplier C and 3 (1.2 per cent) for Supplier D. The implied approach rate for treatment M is thus:

$$\textit{Implied approach rate (treatment M)} = \frac{49\times50\% + 178\times30\% + 20\times10\% + 3\times2\%}{5\times50} \approx 28.4\%.$$

22 Chapter 4 of the *Supplementary Report* provides some descriptive comparisons of the experimental data, with Chapter 5 offering a more detailed analysis using sophisticated econometric models. The models assessed in the *Supplementary Report* enable factors, such as attitudes to the environment, government intervention and the level of understanding participants had of the inspection rules, to be accounted for in assessing differences between treatments that are pairwise comparable.

4.1 Treatment comparison overview

Figure 1 below provides an overview of the implied approach rates for all treatments, while Table 7 documents the supplier choices made and the theoretical predictions for each treatment determined through model calibration,[23] together with the number of subjects in each treatment group. Cells shaded in darker hues in Table 7 indicate supplier choices made more frequently by subjects in each treatment group.

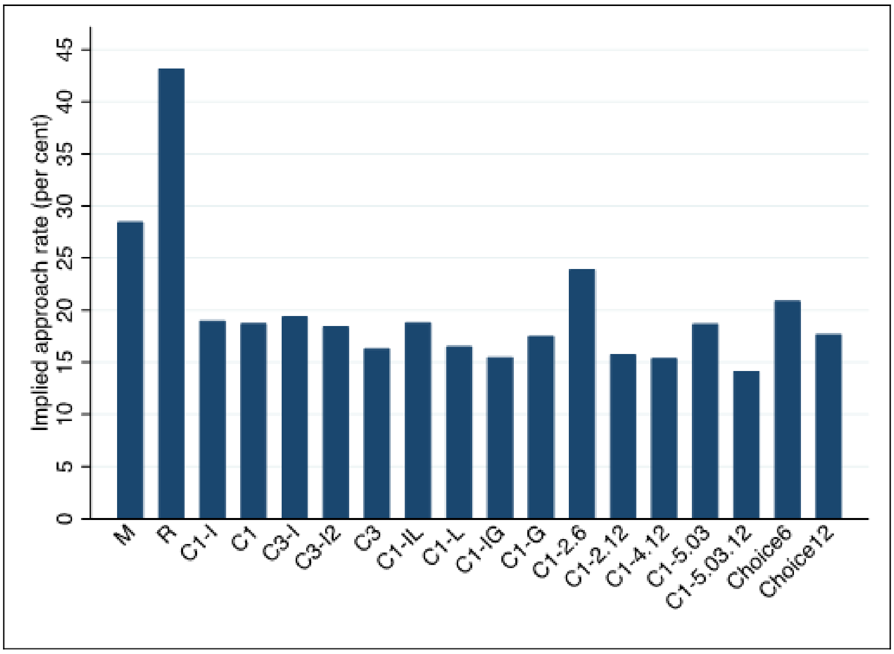

Figure 1: Implied approach rates by treatment, pooled across all periods

The theoretical predictions listed in the final column of Table 7 are derived using simulation methods; see Chapter 3.5 of the *Supplementary Report* for more details. The results are presented in the form of the pair *(x, y)*, where *x* is the "best" supplier choice under census (100 per cent) mode of the relevant CSP rule and *y* is the choice under monitoring mode.[24] For example, the predicted optimal strategy under treatment C1 is to choose supplier D when subject to mandatory inspection and then choose supplier C when subject to the 20 per cent inspection rate in monitoring mode.

[23] See Chapter 3.5 of the *Supplementary Report* for more details about the model calibration process for generating theoretical predictions.

[24] In the context of making theoretical predictions, it is also important to realise that the payoff differences between the "optimal" and several "near-optimal" strategies are small for many treatments. Where optimal and near-optimal strategies overlap between pairwise comparable treatments, the ability to discern significant treatment effects may be hampered in light of a relatively flat payoff function. Indeed, this challenge with the experimental design may well have contributed to there being relatively few treatment effects that can be established as being significantly different from zero in a statistical sense.

Table 7: Supplier choices by treatment and comparison with theoretical predictions

Treatment identifier	Subjects	Implied approach rate		Relative frequency of supplier choice (%)*				Risk-neutral importer theoretical prediction
		Mean (%)	Standard deviation (pp)	A	B	C	D	
M	5	28.4	11.6	19.6	71.2	8.0	1.2	B
R	6	43.1	12.5	75.7	19.0	5.3	0.0	A
C1-I	12	19.0	14.5	11.7	39.7	27.8	20.8	(D,B) to (C,C)
C1	21	18.7	16.0	15.2	31.1	27.9	25.8	(D,C)
C3-I	18	19.4	15.1	14.6	32.4	36.4	16.6	(D,B) to (C,C)
C3-I2	16	18.4	13.9	11.0	34.5	39.8	14.8	Unclear
C3	23	16.3	13.9	9.6	28.4	39.5	22.6	(D,C)
C1-IL	17	18.8	15.8	15.1	30.8	30.5	23.7	(D,B) to (C,C)
C1-L	17	16.5	14.8	12.2	22.6	42.5	22.7	(D,C)
C1-IG	18	15.5	14.0	9.2	26.6	36.7	27.6	(D,B) to (C,C)
C1-G	18	17.5	16.5	16.0	22.9	31.7	29.4	(D,C)
C1-2.6	12	23.9	18.6	29.2	26.0	23.7	21.2	(C,B)
C1-2.12	12	15.7	14.8	11.2	23.8	36.2	28.8	(D,B)
C1-4.12	9	15.4	12.1	5.6	32.0	41.8	20.7	(D,C)
C1-5.03	17	18.7	13.6	10.2	38.5	36.1	15.2	(C,B)
C1-5.03.12	18	14.1	12.5	7.0	20.6	50.0	22.4	(D,C)
Choice6	18	20.9	15.8	17.6	33.7	33.6	15.2	(C,B) for Mechanism B (D,C) if choose Mechanism A
Choice12	18	17.7	14.1	11.2	29.8	42.8	16.2	(D,C) for Mechanism A (C,C) if choose Mechanism B
Total	275	18.6	15.4	14.3	30.0	35.1	20.7	*

Notes: * Based on choices pooled across all 50 periods of the task. This means the relative frequency is calculated on observations totalling the number of subjects multiplied by a factor of 50. Percentage totals across the rows may not add to 100 per cent due to rounding.

When the monitoring fraction is expressed as a range (10 per cent to 50 per cent) rather than a single value (20 per cent), the optimal strategy for the participant depends on their beliefs as to what is the “true” monitoring fraction used by the biosecurity regulator.[25] In the final column of Table 7, the first pair reflects the optimal strategy if the participant believes the “true” monitoring fraction is 10 per cent, while the second pair reflects the optimal strategy under the belief of a 50 per cent monitoring fraction. For treatment C3-I2, where both the monitoring fraction and tight census number are imprecisely described, the theoretical prediction is unclear because of the uncertainty associated with the vague rule description.

The boundary treatments stand out in Figure 1 and Table 7 as those with approach rates of biosecurity risk material much higher than the compliance-based inspection rule treatments. Somewhat reassuringly, Table 7 shows the actual supplier choices in treatments M and R correspond with the theoretical predictions, with around three-quarters of the choices aligning with predicted behaviour.

In contrast to the boundary treatments, the other 16 treatments with compliance-based inspection rules tend to have subjects choosing suppliers with higher biosecurity risk material approach rates than would be considered “optimal” under the theoretical prediction for a risk-neutral importer. In this sense, subjects appear to be taking on more risk in their choice of suppliers than suggested by theory or suggested by their responses to the experimental tasks that seek to measure risk attitudes, even though this means they would likely receive lower cash payments at the end of the experiment.

Such findings that appear counter to the theory are part of the reason for conducting experiments. The mathematical models used to obtain the theoretical predictions of behaviour require some strong assumptions about how people behave in complex decision environments, such as the biosecurity inspection context. Rather than invalidate the experiment, these types of counterintuitive findings can demonstrate other aspects of behaviour that need to be taken into account in explaining how people make choices in these complex regulatory environments. In some circumstances, the findings may also be instructive for regulators in terms of the approaches they could use to assist decision-making in these contexts.

Figure 2 compares the average biosecurity risks across periods for all the adaptive inspection protocols with identical inspection and treatment costs corresponding to the nine treatments listed in second block of Table 7 (that is, from treatment C1-I to C1-G inclusive). The thick orange line in Figure 2 corresponds to treatment C3-I2, which most closely mirrors the department’s information disclosure practice for inspection rules under the CBIS at the time the experiments were conducted.[26] It is noteworthy that treatment C3-I2 never has the lowest, nor the highest, implied approach rate for biosecurity risk material in any period. On average, treatment C3-I2 entails an above-average biosecurity risk material approach rate compared to the other eight treatments where subjects face similar cost structures.

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[25] From a theoretical standpoint, the participants may be able to estimate the “true” monitoring fraction as the experiment progresses. This could mean that the optimal strategy converges to the same strategy as the situation where there is full information given to participants about the rule parameters.

[26] As noted in Chapter 3.1, the results of this experiment led to the department changing its information disclosure practice in January 2016. The current approach is now closer to, but not the same as, that described in treatment C3.

It is worth noting that Figures 2 and other figures in this chapter suggest that the implied approach rate rose sharply in the last 10 periods of the experiment for several, but not all, treatments. This likely reflects "end-game" effects relating to the experimental task being a finitely repeated interaction with a fixed number of periods,[27] which results in the rewards from compliance decreasing as the interaction approaches its final periods. Overall, care should be taken in interpreting temporal patterns in the implied approach rate in individual treatment groups, since they may be affected by changes to supplier choices by a few individuals.

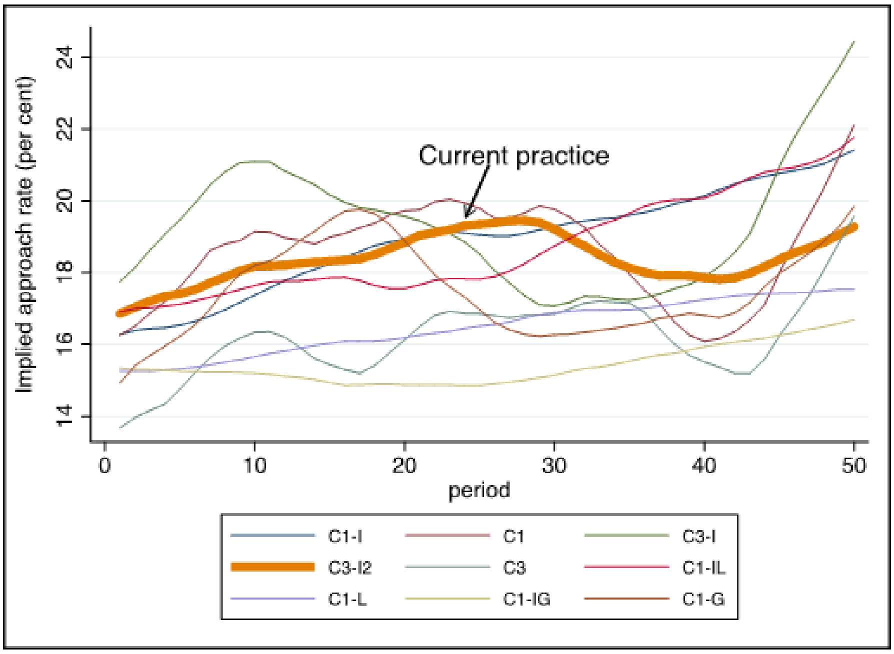


Figure 2: Average biosecurity risk material approach rates by period for comparable adaptive inspection treatments

4.2 Different inspection rules

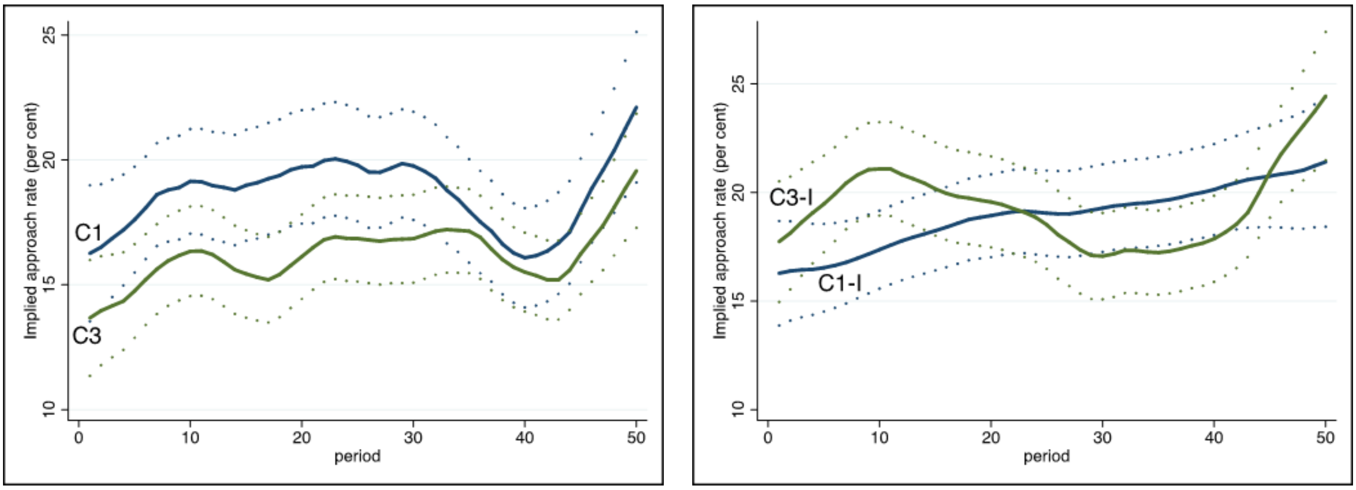
This section compares the CSP-1 and CSP-3 rules under circumstances where the participants have complete information about the rule (treatments C1 and C3) and where there is incomplete information about the probability of inspection in monitoring mode (treatments C1-I and C3-I).

Table 7 indicates that the average approach rate of biosecurity risk material is 2.4 percentage points higher in treatment C1 than in treatment C3 if we do not account for individual characteristics of the experimental subjects. In part, this seems to reflect supplier C being the modal choice of supplier for treatment C3, while subjects in treatment C1 seem to select supplier B most often. However, such pairwise comparisons must be approached with caution. The observed differences may be small relative to the variability with which these raw measures are computed, meaning they could simply reflect chance as opposed to a "true" treatment effect. Furthermore, any differences could be attributed to differences between the measured characteristics in the subjects in the two treatment groups. In this case, we show in

27 See Chapter 2 of the *Supplementary Report* for a more fulsome discussion of the impact of this experimental design on assessing differences between treatments. In general, the reported treatment differences are robust to these end-game effects.

Chapter 5.2 of the *Supplementary Report* that this treatment difference is not statistically significant either without controlling for other factors elicited through the post-experiment questionnaire and risk preference elicitation task. On the other hand, adding in these individual-level controls results in a larger treatment effect (4.2 percentage points) that is statistically different from zero at the 5 per cent level of significance.

The left-hand panel of Figure 3 illustrates the implied approach rate for biosecurity risk material for both treatments over the course of the experiment. The solid lines indicate the average implied approach rate based on a polynomial time-trend,[28] with the dotted lines representing 95 per cent confidence intervals of the average approach rate. The results in the left-hand panel of Figure 3 suggest the temporal patterns in both treatments are very similar, but that the implied approach rate for biosecurity risk material is higher across all 50 periods in treatment C1 than in treatment C3. However, as there is substantial overlap in the regions covered by the 95 per cent confidence intervals for the treatments, it appears this difference may reflect the variability of taking a sample, rather than a "true" measured difference in behaviour.



Complete information about monitoring fraction   Uncertainty about the monitoring fraction

Figure 3: Implied approach rates of CSP-1 and CSP-3 rules

In contrast, the right-hand panel of Figure 3 shows that if importers are provided with "vague" information about the monitoring fraction, the CSP-1 rule seems to fare marginally better in terms of having a lower implied approach rate. Again, the difference between these treatments does not appear to indicate a pronounced treatment effect, with there being significant overlap of the two sets of confidence intervals. This apparent lack of a significant treatment difference, both with and without individual-level controls, is confirmed in the *Supplementary Report*.

Given the opposing implications of the findings relating to whether the CSP-1 or CSP-3 algorithm performs "better" from the perspective of reducing the approach rate

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28 These figures, and similar ones throughout this report and the *Supplementary Report*, are constructed as a univariate analysis of implied approach rates using local polynomials to fit a smoothed curve. Specifically, they use the "twoway" command and the "lpolyci" option in Stata SE Version 14; see https://www.stata.com/manuals/g-2graphtwowaylpolyci.pdf for more details about how these plots are generated.

of biosecurity risk material, a tentative overall assessment could suggest the CSP-1 and CSP-3 algorithms most probably deliver similar results from a biosecurity perspective. Such a finding is unsurprising, given the theoretical predictions under the two treatments shown in Table 7 are identical and the earlier discussion about the challenge with assessing fine-scale, largely quantitative behavioural differences in a laboratory experiment.

4.3 Level of information about the rule

We now turn to investigate the role of providing different levels of information on the rule structure and parameters on the choices of supplier made by experimental subjects. The comparisons presented here focus on the three treatments involving the CSP-3 algorithm. Treatment C3 provides the experimental subjects with the full rule specification, while treatment C3-I provides "vague" information on the monitoring fraction in terms of a range. Treatment C3-I2, which most closely resembles the department's current practice under the CBIS, provides a range for the monitoring fraction and only vaguely describes the tight census number used in the CSP-3 algorithm.

Table 7 shows the implied approach rate is lowest in the full information treatment (treatment C3) and highest in treatment C3-I where the monitoring fraction is vaguely described. Moreover, Figure 4 shows the average approach rate implied by the supplier choices is higher in treatment C3-I than in treatment C3 across all periods of the experiment. Figure 4 also illustrates the performance of treatment C3-I2 relative to the two other treatments, suggesting the biosecurity risk material approach rate implied by the supplier choices for treatment C3-I2 lies between treatments C3 and C3-I for most periods. In particular, the average implied approach rate is higher in treatment C3-I2 than in treatment C3 in all periods except the final period of the task.

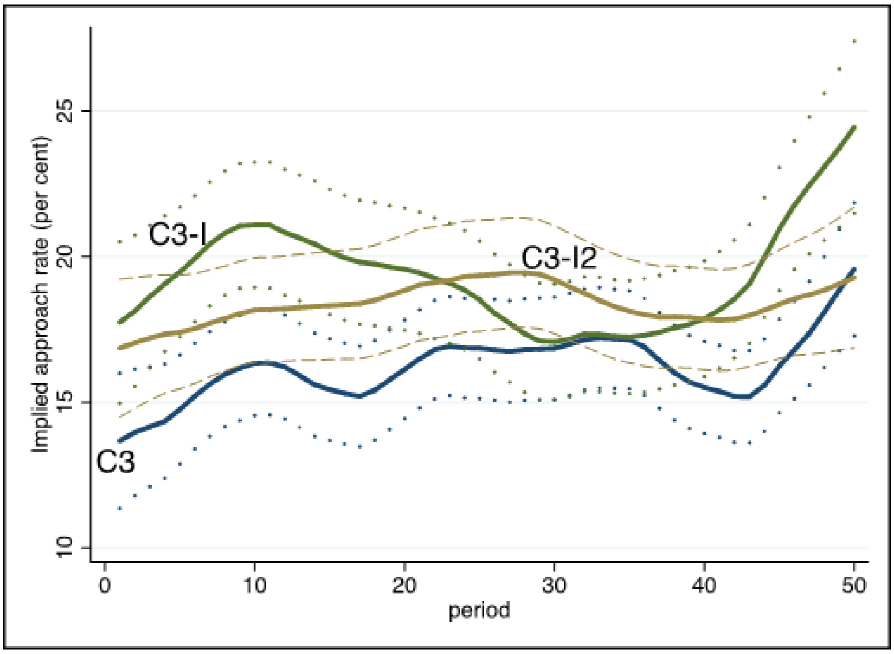

Figure 4: Implied approach rates of CSP-3 rules with different levels of information

Further investigation suggests these observed differences are relatively small and there is limited evidence to support significant treatment effects other than the implied approach rate in treatment C3 being significantly lower than for treatment C3-I.[29] The results provide tentative evidence that giving more information to importers about the parameters used in the rule could encourage them to choose suppliers with lower approach rates of biosecurity risk material.

4.4 Framing feedback on rule performance

We study the role of framing in the feedback provided to our experimental subjects by including a gain frame (treatments C1-G and C1-IG) and a loss frame (treatments C1-L and C1-IL) in our treatments to compare with the CSP-1 treatments with the fully specified rule (treatment C1) and the rule with the monitoring fraction vaguely described (treatment C1-I). The gain frame given in the feedback given to the participants after each period specified the amount saved from not being inspected; the loss frame specified the costs (that is, monetary losses) incurred by the experimental subject due to their consignments being inspected. In both cases, experimental subjects received this additional feedback from an additional statement on the results screen that highlighted these performance measures.

Our conjecture in this experiment was that both frames of feedback could result in lower implied approach rates of biosecurity risk material. As we discuss in this section, the results provide tentative evidence consistent with this intuition.[30] This points to providing tailored feedback to importers on their regulatory performance could encourage them to choose suppliers with lower approach rates in support of the department's overarching biosecurity objective.

4.4.1 Impact of the gain frame

Table 7 suggests that the average implied biosecurity risk material approach rate is lower in the gain-frame treatment under complete rule specification (treatment C1-G) than for the baseline treatment C1. This is also confirmed in the left-hand panel of Figure 5, which demonstrates that the implied approach rate is lower in treatment C1-G relative to treatment C1 across most periods. However, the treatment differences are small in magnitude and not statistically different from zero.

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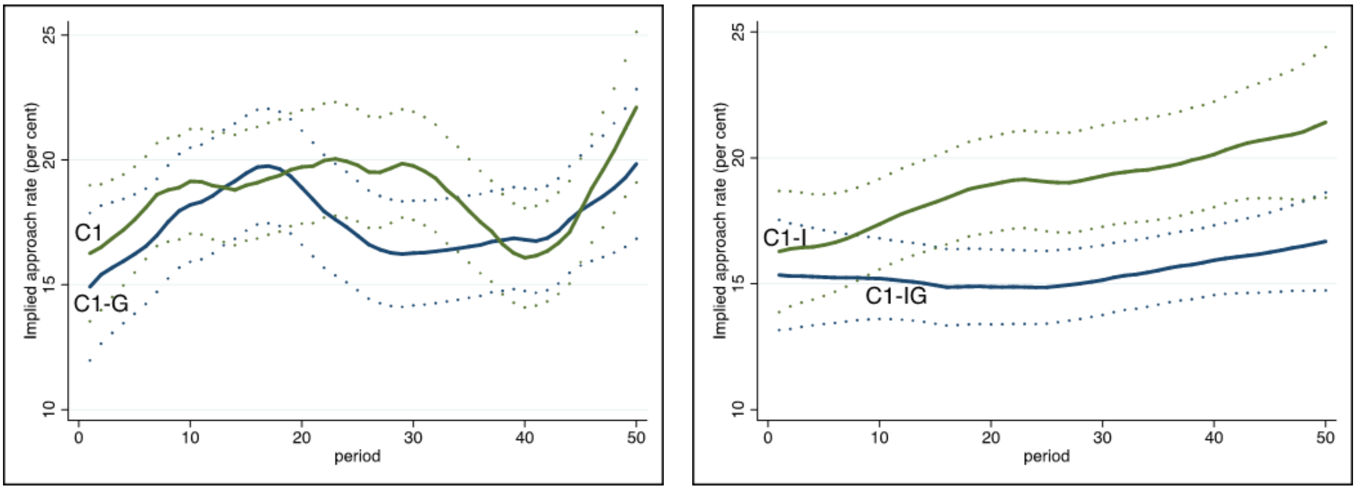
[29] Chapter 5.3 of the *Supplementary Report* points to the implied approach rate being higher in treatment C3-I than treatment C3 once individual-level controls are included, but not if the model only accounts for time (period) effects. On the other hand, further statistical analysis suggests that the implied approach rate for treatment C3-I2 is not significantly higher than that for treatment C3, regardless of whether individual-level controls are incorporated into the model.

[30] Chapter 5.4 of the *Supplementary Report* shows that while the direction of the treatment effects almost always accorded with this intuition, the effects were measured with relatively high standard errors. Consequently, no treatment effects were found to be statistically different from zero, regardless of whether individual-level controls were included.



Complete information about monitoring fraction Uncertainty about the monitoring fraction

Figure 5: Implied approach rates of CSP-1 rules (standard and gain-frame treatments)

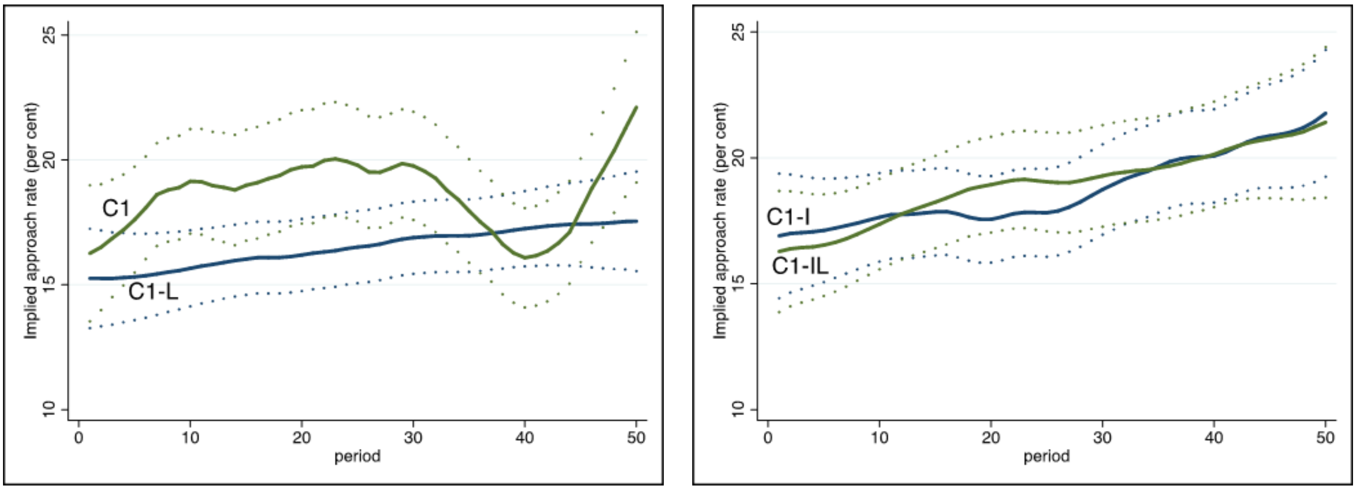
When the monitoring fraction is specified as a range, the impact of the gain frame (treatment C1-IG) becomes more pronounced and apparent across all periods of the experimental task. In the right-hand panel of Figure 5, the 95 per cent confidence intervals for the implied approach rates of the gain-frame treatment (treatment C1-IG) and the standard feedback treatment (treatment C1-I) do not overlap for more than half the periods. Table 7 highlights that the implied average approach rate is 3.5 percentage points lower for treatment C1-IG than for treatment C1-I. While this would appear to be economically significant, the econometric analysis in Chapter 5.4 of the *Supplementary Report* suggests that even this is treatment effect is not statistically different from zero at a 10 per cent level of significance.[31]

4.4.2 Impact of the loss frame

For the situation where subjects know the full rule specification, Table 7 suggests that the implied approach rate is lower on average under the loss-frame treatment (treatment C1-L) than both the baseline CSP-1 rule treatment (treatment C1) and the gain-frame treatment (treatment C1-G). The left-hand panel of Figure 6 illustrates that the implied approach rate is lower across nearly all periods in the complete-information case if a loss frame is included, though formal analysis suggests the difference is not statistically different from zero.

Interestingly, the loss frame appears to be less effective in the environment where there is uncertainty for the subject about the monitoring fraction. Table 7 shows the implied approach rate averaged across all periods for the loss-frame treatment with the monitoring fraction vaguely described (treatment C1-IL) is only marginally lower than for the comparable standard feedback treatment (treatment C1-I), with patterns in the approach rates for the two treatments being closely aligned (right-hand panel of Figure 6).

[31] The *Supplementary Report* demonstrates the lack of statistical significance is robust to estimating the treatment effect based on a subsample of periods of the experiment (periods 11 to 40 inclusive, excluding the first and last ten periods) where the right-hand panel in Figure 5 suggests the treatment difference may be sizeable.



Complete information about monitoring fraction Uncertainty about the monitoring fraction

Figure 6: Implied approach rates of CSP-1 rules (standard and loss-frame treatments)

4.5 Costs of being inspected and failing inspection

These treatment comparisons of the key cost parameters associated with inspection and treatment seek to confirm the theoretical predictions, consistent with the findings of Rossiter and Hester (2017), that higher costs of being inspected and/or failing inspection encourage the choice of lower-risk suppliers. The relevant treatments with different combinations of cost parameters used in this section were shown in Table 5 in Chapter 3, which is restated below as Table 8 for clarity.

Table 8: Treatments comparing the behavioural influence of inspection cost parameters (restated Table 5)

Treatment identifier	Inspection cost (monetary units)	Treatment cost (monetary units)
C1	4	6
C1-2.6	2	6
C1-2.12	2	12
C1-4.12	4	12

The relevant rows in Table 7 for the treatments listed above and Figure 7 below suggest that the direction of treatments effects follow the theoretical predictions. In particular, the implied approach rate is highest across all periods for the treatment with the lowest inspection and treatment costs (treatment C1-2.6) and lowest in the two experimental treatments where failing inspection incurs a treatment cost of 12 monetary units (treatments C1-2.12 and C1-4.12).[32] The results also point to higher

[32] In Chapter 5.5 of the *Supplementary Report*, we show through econometric analysis that the implied approach rate of treatment C1-2.6 is significantly higher than the implied approach rate for treatment C1-4.12. While the approach rate of treatment C1 is also higher than that for treatment C1-4.12, we fail to reject the null hypothesis of no difference at the 10 per cent level of significance. These findings were robust to the inclusion (or exclusion) of individual-level controls.

inspection costs having a more limited impact on supplier choices when treatment costs are already high. This is evident from the negligible difference (0.3 percentage points) in the implied average approach rate of biosecurity risk material between experimental treatments with low (treatment C1-2.12) and high (treatment C1-4.12) costs of inspection when the cost of treating a contaminated consignment is 12 monetary units.

These experimental results confirm our intuition and the theoretical predictions that compliance-based inspection protocols are likely to be most appropriate for plant-based products where the cost of failing inspection is high or, to a lesser extent, where the costs associated with being inspected are high.

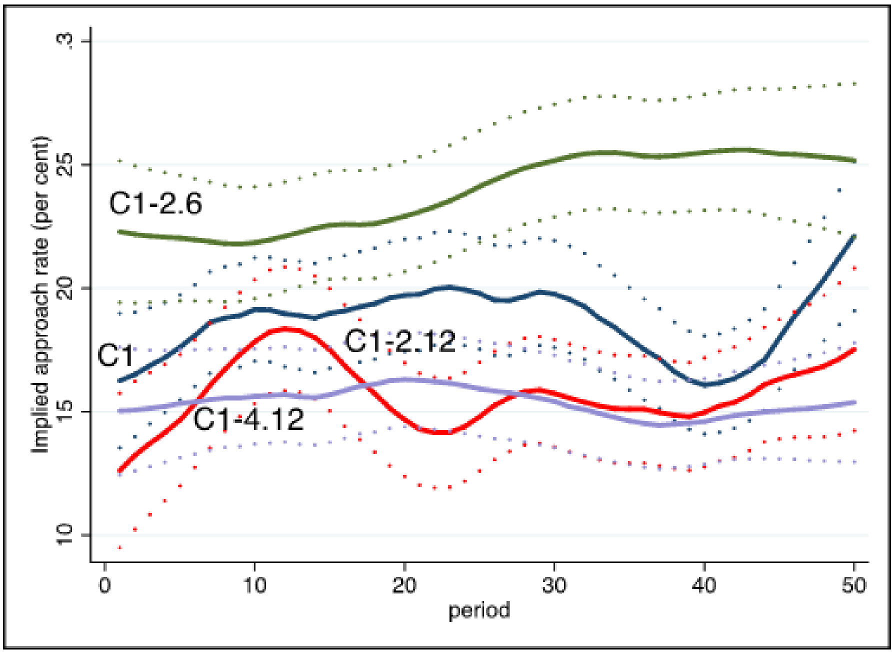


Figure 7: Implied approach rates of CSP-1 rules with different costs of being inspected and failing inspection

4.6 Regulatory environment with a choice of inspection rule

As part of designing a simple menu of regulatory contracts to understand the role that rule choice could play in influencing supplier choices, we constructed a second CSP-1 rule with different parameters (Mechanism B) to use against the standard CSP-1 rule (Mechanism A). For clarity, the two CSP-1 rules are parameterised according to:

- Mechanism A: clearance number 10 and monitoring fraction 0.2; and
- Mechanism B: clearance number 5 and monitoring fraction 0.3.

In the two rule-choice treatments (Choice6 and Choice12), we gave participants the possibility to choose whether they wished to follow the inspection rule given by Mechanism A or Mechanism B. This choice was made once at the start of the experiment and participants had no option to review their choice throughout the 50 periods where they were importing plant-based products.

To investigate the role that the rule-choice environment plays in affecting behaviour, we need to compare subjects according to the choice of rule they made against the behaviour of those who followed the same rule involuntarily. Treatment Choice6 is the rule-choice environment where treating a consignment containing biosecurity risk

material costs the "standard" 6 monetary units. If a subject chose Mechanism A, their supplier choices would be compared against treatment C1; for a subject choosing Mechanism B, the appropriate comparator is treatment C1-5.03. In contrast, treatment Choice12 is the rule-choice environment where the cost of failing an inspection is higher at 12 monetary units. In this environment, a subject who chose Mechanism A would be compared with treatment C1-4.12, while one choosing Mechanism B would be compared with treatment C1-5.03.12. Table 9, which is a modified version of Table 6 from Chapter 3, highlights the way in which appropriate pairwise treatment comparisons can be made in the context of a rule-choice environment, focusing on the dimensions that differ between treatments.

Table 9: Treatment comparisons in the rule-choice environment (modified version of Table 6)

Treatment identifier	Mechanism	Treatment cost
C1	A	6
C1-4.12	A	12
C1-5.03	B	6
C1-5.03.12	B	12
Choice6	Choice: C1 (A) or C1-5.03 (B)	6
Choice12	Choice: C1-4.12 (A) or C1-5.03.12 (B)	12

Interestingly, the large majority of subjects in both choice treatments prefer Mechanism B, even though Mechanism A was constructed to be the "optimal" rule in the rule-choice treatment with a high cost of failing inspection (treatment Choice12). Two-thirds of subjects (12 out of 18) in treatment Choice6 chose Mechanism B, while 16 out of 18 subjects (88.9 per cent) in treatment Choice12 chose Mechanism B. While subjects in these treatments were not asked about how they decided which mechanism to select, one potential explanation for so many participants choosing Mechanism B was that they may have used a mental shortcut (*heuristic*) to compare the clearance numbers and monitoring fractions of the two choices. Since the clearance number in Mechanism B is half that of Mechanism A, while the monitoring fraction of Mechanism B is only 50 per cent higher, a relatively naïve approach comparing the ratios of the two parameters could encourage participants to choose Mechanism B over Mechanism A. Based on the information gleaned from this experiment, this conjecture cannot be proven, but at least highlights some potential issues associated with instituting rule choice based on different rule parameters alone.

Behavioural economics theory and previous experimental research suggests offering rule choice would likely encourage subjects to behave in a manner more consistent with the regulatory objective and choose lower-risk suppliers. However, the observed behaviour in the choice treatments runs counter to this prediction. According to Table 7, introducing rule choice has tended to raise the average implied approach rate of biosecurity risk material by at least two percentage points.

If we take into account the choices in the choice treatments, the differences in the "raw" implied approach rates are particularly pronounced for participants who chose

Mechanism B. For example, Table 7 highlights that participants who chose Mechanism B in treatment Choice6 have an average implied approach rate of 21.4 per cent, compared to an 18.7 per cent implied approach rate for participants in the corresponding treatment C1-5.03. Similarly, participants who chose Mechanism B in treatment Choice12 had an average approach rate of 17.9 per cent, whereas the approach rate in treatment C1-5.03.12 was only 14.1 per cent.[33]

Figure 8 compares patterns in the average biosecurity risk material approach rate over time under rule choice with the corresponding treatments where there was no choice of rule. The top left-hand panel suggests the implied approach rate for subjects who chose Mechanism A in treatment Choice6 does not appear to differ greatly from the corresponding no-choice treatment (treatment C1), as indicated by the number of times the two solid lines cross. However, the top right-hand panel, which comparing those who chose Mechanism B in treatment Choice6 with treatment C1-5.03, points to rule choice having a deleterious impact on the regulatory objective by raising the implied biosecurity risk material approach rate.

The variability in the Choice12 treatment for Mechanism A (bottom left-hand panel of Figure 8) primarily reflects that the time-trend is based on the choices of only two experimental subjects – something also reflected in the substantial width of the 95 per cent confidence intervals around the average implied approach rate. Similar to the findings for treatment Choice6, the approach rate for participants in treatment Choice12 who chose Mechanism B (bottom right-hand panel of Figure 8) is always above that of treatment C1-5.03.12,[34] pointing to rule choice encouraging subjects to favour higher-risk suppliers.

This finding is surprising and suggests that offering a choice of rule based on changing combinations of parameters alone would be ill-advised. Instead, it may be preferable for the regulator to allow some role for rule choice if eligibility to “lighter touch” intervention options are based on import-supply chain participants providing evidence of undertaking activities that reduce the likelihood of biosecurity risk material being found in imported consignments. This has the benefit of ensuring incentives for compliance with biosecurity requirements are more closely linked with stakeholder actions associated with maintaining the stated regulatory objective for biosecurity interventions.

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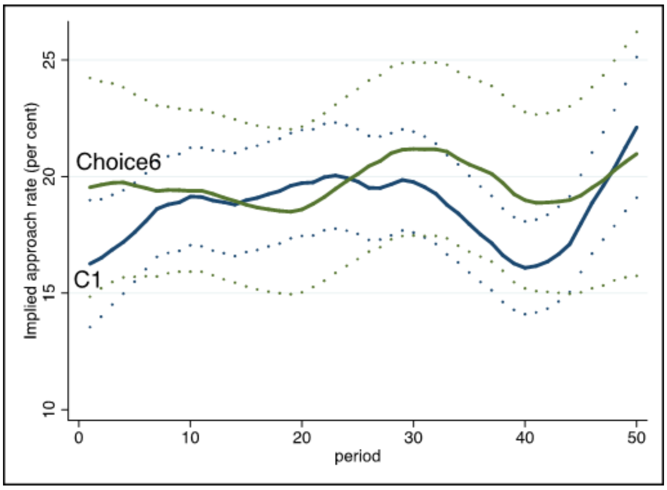
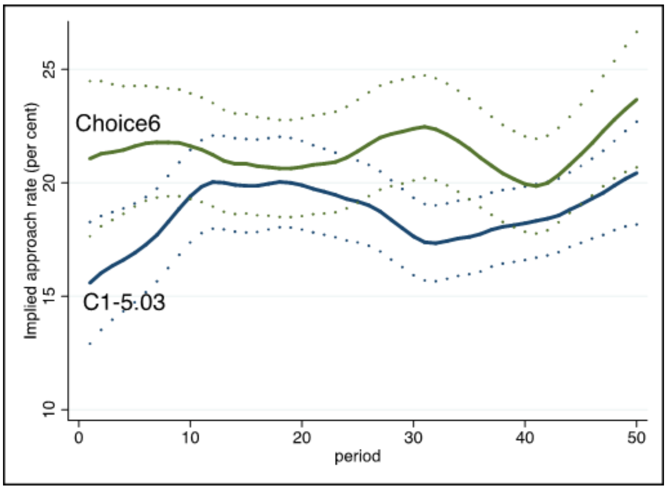
33 While these differences in implied approach rates appear to be large, econometric analysis in Chapter 5.6 of the *Supplementary Report* shows that the only treatment difference statistically significant at the 10 per cent level was that between those who chose Mechanism B in treatment Choice12 relative to the behaviour of those in treatment C1-5.03.12.

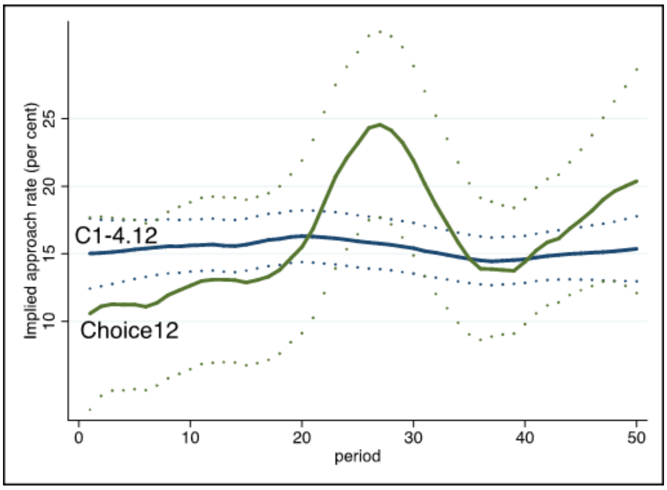
34 Relative to the findings for treatment Choice6, the confidence intervals in the bottom right-hand panel of Figure 8 overlap in only a few periods.



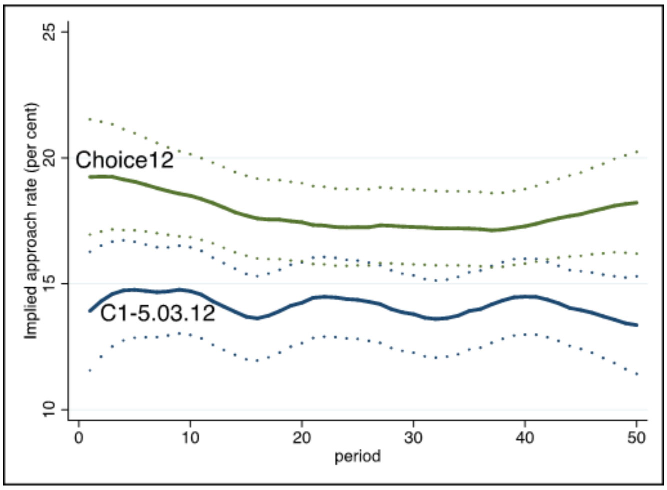
Choice6 (Mechanism A) versus C1



Choice6 (Mechanism B) versus C1-5.03



Choice12 (Mechanism A) versus C1-4.12



Choice12 (Mechanism B) versus C1-5.03.12

Figure 8: Implied approach rates of the choice treatments with the corresponding no-choice treatments

4.7 Role of individual subject characteristics in choosing suppliers

In Chapter 6 of the *Supplementary Report*, we investigate the influence of four sets of characteristics – risk preferences, environmental and political attitudes, subjects' understanding of the rules and demographic characteristics – on supplier choices. The main points of this investigation are summarised below for completeness.

1. Subjects who are more willing to take risks in other settings are more likely to choose suppliers with higher biosecurity risk material approach rates. The regulator is unlikely to be able to change these innate preferences, though some of these strategies around feedback on performance and providing information on the inspection rule may be able to mitigate this influence.
2. Environmental and political attitudes, which may have been associated with the natural framing of the experimental context, did not seem to have a significant influence on subjects' supplier choices.

3. Subjects who reported understanding the inspection rules better tended to choose suppliers with lower approach rates. From a policy perspective, this suggests a role for improving the way in which inspection rules are communicated to stakeholders and that providing alternative ways to present rules may be helpful for improving biosecurity compliance. That said, there was little evidence of the additional diagram in the CSP-3 algorithm treatments performing better in the paper-based task that tested rule understanding.
4. Australian students tended to choose suppliers with lower approach rates relative to overseas students. The difference between these groups of subjects was large and may be indicative of a social norm amongst Australians, over and above environmental or political attitudes, that encourages them to behave differently in response to biosecurity issues. However, we cannot be certain about this attribution, because the post-experiment questionnaire did not explicitly ask questions relating to social norms.

5. Implications for biosecurity operations

This report documents CEBRA Project 1404C, *Testing Compliance-Based Inspection Protocols*, which assessed key aspects of candidate border inspection mechanisms with human subjects under controlled conditions. The experimental design drew upon insights from the theory of incentives and information together with concepts from behavioural economics to understand how the operation of incentive-based frameworks for biosecurity regulation could be improved.

The reforms to regulatory systems and practices investigated as part of this sequence of projects (CEBRA Projects 1304C, 1404C and the prospective 1608C) are part of a multi-stage process involving design, testing and, finally, implementation. The experiments completed as part of this project not only build the evidence base for potential specific changes to biosecurity inspection rules and their implementation, but also demonstrate the value of experiments more generally as a risk management tool when considering policy changes. As part of a carefully managed, iterative process, experiments, such as those conducted as part of this project, can help manage and mitigate implementation risks associated with the development of new or modified frameworks for biosecurity risk management and other public policy applications.

In the context of designing and implementing biosecurity inspection frameworks, this investigation has been constructed to seek insights into *general economic behaviours* in response to different types of inspection rules. In several cases, the experimental treatments were constructed as a cross-check to ensure elements of the inspection protocols that could be adopted in the field appear to work in the *direction* expected from economic theory. As we were able to mimic the incentive structures inherent in inspection rules used by the department, findings about responses to incentives in the experiment are likely to transcend the subject pool (university students) and apply to a significant degree to the target population, namely importers of plant-based products. Furthermore, because of the way in which alternative implementation strategies mirror the natural context, it could also be expected that the *direction* of responses to various behavioural devices are likely to carry over to importers. Whether the direction and/or magnitude of experimentally determined effects carry across to the real-world regulatory environment can only be determined through careful field work – a process envisaged in the prospective CEBRA Project 1608C.

In closing, we summarise the main findings from the economics experiments and explore their potential implications for implementing compliance-based protocols in practice across plant-product pathways. This draws together evidence from the experiments, together with economic theory and qualitative information from stakeholders documented in CEBRA Project 1304C, in a way that seeks to inform the design of the field trial proposed in CEBRA Project 1608C and departmental operations more broadly.

5.1 Structure and communication of inspection rules

Our experiments did not find consistent systematic differences in the supplier choices of subjects between directly comparable CSP-1 and CSP-3 treatments. Given the methodological discussion in Chapter 3, this finding was not unexpected, but also demonstrates that research methods other than laboratory experiments, such as game-theoretic frameworks, are likely to be more suited to addressing these

fine-scale, largely quantitative policy questions. A related finding that was more robust across treatments was that subjects who reported to understand the inspection rules better tended to choose suppliers with lower biosecurity risk material approach rates.

The CSP-1 algorithm has a much simpler structure and is easier to explain to the department's clients. As noted in Rossiter and Hester (2017), the CSP-1 algorithm is also likely to be in the regulator's interests, since it provides slightly sharper incentives for compliance and reduces the likelihood of biosecurity risk material leaking into the Australian environment. As such, there is merit in using the CSP-1 algorithm as part of a wider roll-out of compliance-based inspection protocols across the department.

In addition to choosing inspection rules with simpler structures, there are other ways the department could support stakeholders to understand the operations of the inspections rule, thereby likely encouraging greater regulatory compliance. These relate to the level of information provided to stakeholders about rule parameters and the way in which rules can be explained to stakeholders. As noted in Chapter 3, the department has already used the findings around how it communicates the rule parameters for plant-product pathways so that the clearance numbers and monitoring fractions are now given explicitly in tabular form.[35]

Our experimental results suggest that providing more information to importers about the inspection rule parameters and the consequences of failing inspection could support them choosing lower-risk suppliers. As suggested in CEBRA Project 1304C, the department can retain flexibility around the rule parameters by providing clear guidance to stakeholders on the circumstances under which inspection rules can change. For example, this could be situations where a new pest of disease affecting a particular pathway was found or where a new technology or quality control system became widely available that offered substantial benefits for biosecurity risk mitigation. Such an approach can help build the department's credibility as a regulator with its key stakeholders.

At present, the way in which inspection protocols used in the CBIS are presented to departmental stakeholders is limited to written descriptions on the website. As clients may absorb information in different ways, it may be advantageous to consider alternative mechanisms to encourage understanding. This could include:

- diagrammatic representations of the rule on the website, such as including a simple flow diagram with rule parameters identified as part of the guidance material. This would be along the lines of that shown in the CSP rule box in Chapter 3;[36]
- a simple web-based (or spreadsheet-driven) simulation model that could be used by stakeholders to better understand how the rule operates; and/or

35 See the department's CBIS website (http://www.agriculture.gov.au/import/goods/plant-products/risk-return). Note that for public communication the clearance number is now referred to as the "qualification number" and monitoring fraction as the "risk-based inspection rate".

36 This approach was adopted in the communication strategy as part of the follow-up field trial, CEBRA Project 1608C.

- an online training video describing how the rule operates, which could feature "worked examples".

The efficacy of these alternative presentation mechanisms could always be tested as part of an economics experiment with students and/or with importers and customs brokers as part of refining the way in these features operate in practice.

5.2 Risk profiling and structuring eligibility for high-powered incentive schemes

In an ideal case, inspection rules would be applied on a bespoke basis, accounting for the factors that influence the types and nature of risks posed by each consignment to the government objective of maintaining Australia's high biosecurity status. While applying this type of fine-scale risk assessment to every single consignment at the border, as if it were an insurance model, would be highly impractical, administratively feasible solutions that would capture most of the benefits are available. For well-defined pathways where the risks of non-compliance are reasonably well understood, a system of rules that separated risk categories according to a few key dimensions could be implemented through a menu of inspection rules with a relatively small number of options. Such an approach could offer the department significant reductions in administrative costs associated with designing approved arrangements through being able to provide standardised offerings to importer and supplier clients.

The experimental results discussed in Chapter 4 suggest that constructing menus of inspection rules based solely on different rule parameters may not deliver outcomes consistent with the department's policy objectives. In part, this relates to the relatively flat payoff functions associated with the CSP-1 and CSP-3 algorithms, which implies such rules are not particularly "high-powered" in terms of the incentive structures inherent in them. This reflects not only the structure of the rules, but also the limited ability to provide sizeable (direct financial) rewards for compliance and/or punitive punishments for non-compliance because of other policy considerations, including international agreements. These aspects can make it difficult for the importer to realise substantial benefits from switching to suppliers with a much better history of compliance, or otherwise changing processes and procedures to reduce approach rates. The main classes of products where this may not be the case are those where there are large indirect costs incurred by the importer from being inspected and/or failing inspection.

Under these circumstances, the project team recommends any menus of regulatory contracts be constructed around specific measures known to reduce the approach rate of biosecurity risk material on particular pathways. Such measures should be verifiable to the department through some form of certification, as part of the document lodgement process, or established auditing arrangements. It is envisaged that this type of structured approach with a limited range of choices could be applied in the field-trial phase of this work. Furthermore, it could be an avenue through which particular importers and/or suppliers who demonstrate strong compliance with Australia's biosecurity requirements could become eligible for reduced intervention at the border even if other stakeholders on the pathway remain subject to mandatory inspections.

The approach outlined above can be complemented by a wider roll-out of risk profiling measures available by drawing upon insights from departmental administrative databases. As highlighted in CEBRA Project 1304C, this can involve a standardised descriptive statistical analysis by importer, supplier, country of origin and tariff code using an R script and information available from the department's AIMS and Incident databases.[37] A structured approach to analysing this information, when combined with targeted stakeholder consultation, can help inform the department of ways in which risk "types" can be differentiated, which can ultimately allow for reduced intervention for compliant parties.

5.3 Providing targeted, structured feedback to stakeholders

The evidence from the feedback comparison treatments supports the notion that giving appropriately framed feedback could assist with importer decision-making around biosecurity risk options. The potential benefits of this were the largest when feedback was provided around the inspection cost savings achieved.

While developing an automated feedback system will result in the department incurring costs in the short term, these could well be paid back through being able to reduce interventions on pathways as a result of lower approach rates of biosecurity risk material. Existing departmental systems, such as the Cargo Online Lodgement System (COLS), could always be leveraged as part of this process to provide a single portal for clients to access and report information to the department. Alternatively, the department could develop templates and analysis structures using R and RMarkdown scripts and apply that framework to extracted entries from the AIMS and Incident databases to generate feedback reports that can then be emailed to importers periodically.[38] While the latter approach involves more processing and intervention by department officers, it could be a stepping stone to a more automated system. Furthermore, it would provide an opportunity to experiment with different structures and better incorporate stakeholder views into a more permanent system.

In the experiments conducted in CEBRA Project 1404C, the feedback systems used were very simple structures based on highlighting particular costs incurred or saved. However, a well-designed portal (or report template) could provide a dashboard system that would facilitate clients seeing their own data in a more sophisticated yet structured way. There would be the potential to use insights offered by the field of data visualisation to enable clients to make inferences useful for their operations and support departmental objectives. The potential for these types of approaches to providing more routine stakeholder feedback will be explored further in the field trial (CEBRA Project 1608C); they could also be pre-tested as part of an economics experiment in the laboratory.

5.4 Staging the roll-out of compliance-based protocols

The findings in this experiment aligned with theoretical predictions that pathways where the cost of being inspected and/or the cost of failing inspection are high tend to

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[37] See Chapter 4.1 of Rossiter et al. (2016) for a description of this strategy and some readily available insights.

[38] This has been the approach adopted as part of the CEBRA Project 1608C field trials and the department-initiated US lemons and limes CBIS trial.

be associated with importers choosing suppliers with lower biosecurity risk material approach rates. In these cases, import-supply chain participants already face stronger incentives to comply with Australia's biosecurity requirements. It also means that these pathways are likely to be characterised by low inspection failure rates under the mandatory inspection system that currently applies for many plant product pathways. The department may seek to verify the cost structures related to biosecurity compliance through targeted stakeholder consultation of the type carried out in CEBRA Project 1304C as part of canvassing whether a pathway should be eligible for compliance-based inspection arrangements.

In line with the measured approach the department is adopting in implementing these types of rules, pathways where the costs of inspection and/or treatment are high are likely to be most appropriate candidates for early uptake of compliance based inspection protocols. These pathways may already have widely established control measures used to mitigate biosecurity risks being found in consignments; such control measures can be verified through stakeholder consultation. Such circumstances also provide a useful avenue for offering menus of inspection options to encourage import-supply chain participants whose inspection failure rates are higher to adopt risk-reducing technologies and processes.

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7. List of Figures

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