Duplicate, Split, and Ineligible Payment Detection in Federal Grant and Healthcare Reimbursement: A Critical Review

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Abstract

Improper payment remains a continuing financial control problem in public expenditure. Three schemes are repeated across programs – paying the same obligation more than once, dividing an obligation in order to bypass a control threshold, and paying an obligation prohibited under the program rules. The current paper conducts a critical review of how these schemes are conceptualized, detected, and evaluated in federal grants and healthcare reimbursement, two contexts that are ordinarily considered in isolation. Our literature search is confined to peer-reviewed papers, government audit and evaluation reports, program integrity guidance and statutory language from 1986 to 2018. This review is not systematic, nor does it rely on a coded corpus, and therefore the comparisons we offer are qualitative. We propose a typology of these schemes that distinguishes them by the invariant that is violated rather than the artefact that is produced. We explain why detection performance differences between the two settings result from payment architecture: healthcare reimbursement is claim-based and pre-payment adjudicated, and thereby mechanically duplicate detectable, but grants are aggregate and post-payment adjudicated. We review detection methodologies across four generations – exact match, semi-supervised learning, supervised learning, and relational learning – and highlight how few of the evaluations distinguish test from training data or quantify the investigative costs assumed by the methodology. We conclude with an agenda for four deficits: denominator, label, architecture, and capacity.

Keywords: improper payment; duplicate payment; split payment; ineligibility; federal grants; healthcare reimbursement; program integrity; audit analytics

DOI: 10.21590/ijtmh.4.04.06

1. Introduction

1.1 The problem in kind

Government and health insurance companies pay claims, while grantees draw down grants. In addition, there is a great volume of payments, a wide variety of payment amounts, complicated and evolving program eligibility criteria, and the payer is not typically the beneficiary. This

combination makes improper payments structurally possible in both situations. A report on the Medicare program integrity efforts reveals the diversity of the efforts (Binder, 2011). In the current paper, we focus on three types of improper payment that can be found across program integrity efforts.

The duplicate payment discharges an obligation which is already paid, either because the same invoice was sent through two different channels or due to system failure. Split payment divides an obligation into several payments, each of which does not exceed control threshold, hence the whole obligation avoids control. Finally, ineligible payment discharges an obligation which is not permitted according to the program rules, e.g., an uncovered service, unenrolled beneficiaries on the day of service or allowable cost according to applicable principles. Improper payment in accounts payable context is examined as a systems problem (Einkamerer, 2017).

1.2 Why the two literatures should be read together

There is some difference between grant and healthcare reimbursement literatures – the former mostly consists of audit and evaluation reports and auditing is often viewed as a system of verification rather than of detection (Power, 2013). There is an extensive amount of analytical literature in the latter case including in-patient stay prediction in Medicare and Medicaid and recovery audit contracting program (Kirk, 2017).

This is a worthwhile exercise in that the two institutions are institutionally different yet formally the same. They both involve one party claiming funds from another according to a rule set with the latter bearing the loss. Their institutional difference may then be seen as an observational comparative payment system architecture study. Comparison of the two cases will not reveal any causal effect because they differ legally and in terms of available data. However, the comparison raises a question that neither literature considers by itself: is the level of a payment adjudication scheme a determinant of its performance in detection?

1.3 Scope and method

This study is a critical narrative literature review. It includes all English-language publications in peer reviewed journals, government audits and evaluations, program integrity documents and statutes from 1986 to 2018 on the detection, prevention and measurement of duplicate, split or ineligible payments in the US federal grant programs and publicly funded healthcare reimbursement systems. This literature was selected to support the argument of the paper without any systematic search being performed. There is no coding of literature in this review. Comparative peer-reviewed work on financial statement fraud detection (Perols, 2011) provides an example of such literature.

2. A Typology Grounded in Invariants

2.1 The inadequacy of signature-based definitions

Current definitions classify schemes according to their operational appearance. Duplicate looks like a repeated invoice, split – like a series of small purchases and an ineligible claim – like a service with an unusual code. Such definitions are helpful for training and designing screen queries, yet they refer to an artefact rather than a condition making a payment improper. Most fraud examination literature bases its advice on operational signs (Albrecht, 2012; Singleton, 2010). This attitude extends to program integrity practice.

Consider three economically equivalent cases: a hospital submits the same claim twice using different claim identifiers; a grantee reports the same allowable costs in two consecutive drawdowns; a state agency pays the same vendor twice using two purchase orders based on one blanket agreement. Each of these cases involves discharge of the same obligation twice, while operational signature is different. A definition of a scheme based on the signature would classify these three situations as unrelated, while the definition based on obligation would classify them the same way.

2.2 The invariant formulation

A payment is duplicative if it discharges an obligation that has already been discharged. The invariant is a one-to-one correspondence between the discharged obligations and payments. In accounts payable, this means that the main question is whether each invoice corresponds to at most one settlement (Einkamerer, 2017).

Fractionation occurs when the obligation being discharged is part of an overall obligation that would, if viewed as a whole, have been controlled by some control that the part was able to escape. The invariant in this case is that of maintaining the threshold for control based on economic substance of the transaction and not on the administrative dissection. Continuous auditing systems operate at a transactional level where this is revealed (Kogan, 2014).

A payment is considered ineligible if the obligation being discharged violates at least one condition of the eligibility criteria as specified on the date and context of the claim. The invariant here is the fulfillment of all conditions at the time of processing. This invariant has the closest relation with the rule base described in section 5 since each condition is a predicate and must be articulated and maintained.

2.3 Duplication and its four mechanisms

Duplicate claims arise through four mechanisms each having a different form of detection. The first mechanism is resubmission whereby the same document is submitted repeatedly either using the same or different identifiers. Here detection is the collision of a normalized identifier and the biggest problem lies in normalization rather than analytics.

The second method is that of dual channel submission whereby the same claim is submitted through two payment channels; for instance, through both paper and electronic claims, or through a grant drawdown and direct reimbursement. The problem here is that of linking the systems in cases whereby they do not share a common key. This problem is also discussed in literature regarding e-invoicing (Ali, 2016). The third mechanism is double counting whereby a single cost is counted twice in one submission for instance as an item and then in a bundled rate. Here, there needs to be a mapping between billing and cost accounting granularity which is usually held in a look-up table and not learned from the data.

The final mechanism is illegitimate after legitimate; here, a legitimate payment is made followed by a second claim whose purpose is to create a legitimate new claim but refers to the previous discharged obligation. This is the hardest form of duplicate to detect because the second claim is internally valid and can only be detected in comparison with the discharged obligation.

2.4 Fractionation and predicate satisfaction

A definition of fractionation is made relative to a control and the number of thresholds a program must maintain to be exposed to the risk of fractionation. Some examples include competitive bidding, threshold for approval authority, threshold for single transaction review, and diagnostic grouping thresholds for healthcare. There are three main features of fractionation that differentiate it from duplication. First, each individual payment is not necessarily invalid; it is the pattern that may be improper. Second, detection needs a temporal window of a correct length, which cannot be derived from the rule itself. Third, detection relies on entity resolution across documents that differ in dates, order numbers, and descriptions.

Ineligibility is defined by a conjunction of predicates, whose applicability is different for services, populations, providers, and dates. Four sets of predicates are used repeatedly. Coverage predicates identify whether the item or service is a covered benefit. Population predicates establish eligibility of the beneficiary on the date of the service. Provider predicates indicate whether the provider is qualified and in good standing. Allowability predicates determine whether the cost is allowable according to the applicable cost principles. Ineligible payment can be detected only through linking payments with eligibility determinations stored in another system, and contested determinations are resolved via appeal processes (Donley, 2018).

3. The Federal Grant Setting

3.1 Payment architecture and its consequences

There are differences between federal grant disbursements and commercial procurement that impact detection opportunities. The recipient of the grant is reimbursed for incurred cost rather than payed for deliverables delivered. Money is either drawn from a letter of credit or claimed using the reimbursement request, hence making a periodic aggregate a unit of payment. Since payments are aggregates, the presence of two payments representing the same underlying cost

results in no key collision. To detect a double-count, the general ledger of the grantee needs to be used, which is not usually available to the funding agency. Monitoring capabilities of continuous auditing of enterprise systems make the same point: monitoring is only as effective as transaction data can reach (Kuhn, 2010).

3.2 The audit regime

Detection capacity of the grant setting is determined mainly by its audit scheme. Single audit obliges recipients that spend more than a certain amount of federal assistance in a fiscal year to get an audit of their federal programs, and findings are compiled in a government-wide repository. Single audit has broad reach since it covers sub-recipients through the pass-through chain, but it is retrospective and sample-based. Sample designed to test allowable costs is not likely to reveal a duplicate drawdown. Computer-assisted audit tools, studied for many years in the audit literature, have the same constraints of sampling and retrospective review (Braun, 2003).

3.3 Where grant duplication concentrates

Grant findings identified four areas where duplications tend to occur. First, there is a case of cost transfers where a cost is transferred between awards retroactively to clear an overrun or spend remaining money before the deadline. Transfers are valid if documented and prompt, and they are invalid when discharging a cost that has been charged. The second is a case of indirect cost recovery where a negotiated rate is applied to a base, which includes already recovered costs using a direct charge. This rate agreement reconciles actual charges only during audit.

Thirdly, there is sub-recipient duplication, where a sub-recipient receives payment for the same deliverable twice, or uses two prime awards for the same cost. Here, entity resolution becomes crucial. Finally, there is period-of-performance straddling, whereby a cost incurred after the end of the period is charged or charged to the last period of an award and the first period of its successor. While it appears as an issue of eligibility, it functions as a duplication issue. Transaction mining of ERP data has been used in fraud detection for these types of issues (Khan, 2010).

3.4 Fractionation in grants

Fractionation of grants is done most likely at the micro-purchase and simplified acquisition thresholds, where a number of acquisitions made in a short span of time from one supplier are made just under the threshold. It involves clustering whereby the acquisitions are clustered according to supplier, description normalization is done, and the sum total is assessed to see whether it is above the threshold. Process mining of transactions has been used in fraud detection of this type of transaction, and event sequences in this process become useful (Jans, 2014). However, there are few evaluations of the grant split detection discussed in the sources reviewed. One reason for this could be that funders often lack the purchasing documents of the grantees. Hence, the review does not seek to test this hypothesis.

3.5 The measurement infrastructure

Improper payment measurement in grants has developed from the early 2000s through the requirement of statutory reporting. The agencies estimate improper payments based on statistical samples of payments based on program rules. There are two aspects that make such estimation constrained in terms of the information provided. Firstly, the sample provides an estimated rate rather than actual schemes, meaning that low rate of duplication can go hand-in-hand with high rate of ineligibility without saying anything about the latter. Secondly, such testing is done using grantee documentation, hence misclassification can occur in both directions. Computer-aided fraud detection practice guidance has some relevance in this regard (Coderre, 2009).

By reporting sample design and the rate of documentation failure along with the estimation, it will be known how much of misclassification results from documentation rather than program itself.

4. The Healthcare Reimbursement Setting

4.1 The claim architecture

In healthcare reimbursement, the architecture is inverted relative to grants. Payments are made based on claims, and are determined based on coverage, eligibility, coding, and pricing prior to any payments being made. This means that duplication is mechanically determinable. The identity of a claim is given as a combination of beneficiary, provider, date of service, procedure code and modifier, and hence duplicate claim collides with this identity. Fractionation is detectable at the claim level by application of bundling rules that deny the second component of the pair treated as one.

Ineligibility is testable at the adjudication stage, since eligibility, coverage dates, and provider standing are stored in the payer's system. The payer can implement these predicates prior to the actual payment, and this is the key difference between the architecture of healthcare reimbursement and grants funding.

4.2 Edit systems and their logic

There is a mature field of edit systems, that is, the rules applied at adjudication that either reject or flag the claims that fail the stated predicate. These are not statistical results but encodings of expert knowledge. Service coverage is an encoding of the predicate set for a service, and provider and price edits are used to enforce enrollment, sanction status, and fee schedule logic. Prepayment automated payment systems have been suggested as one of the vulnerability sources of fraud in the United States healthcare (Sparrow, 2008). That is why the way they are designed is equally important as the fact of being designed.

The takeaway from that experience is that much of improper payment detection in healthcare is a knowledge encoding problem, rather than machine learning problem. The scarcity is in expertise needed to specify a rule, as well as in the institutional mechanism to update it.

4.3 Post-payment review and recovery

Only claim-level predicates can be enforced through prepayment edits. The residue of potential impropriety will need to be discovered post-payment. The main technique of post-payment discovery in healthcare is recovery audits – the process where contractors discover overpayments and the payer requests their recovery. Changes in CMS's recovery audits program and management practices have been proposed based on federal reviews (King, 2015). The recovery process is the place where overpayment disputes arise, and there is guidance on how to contest the CMS overpayment demands (Haney, 2014).

After identification, there are several other stages that should be completed, and all of them can be contested as well.

4.4 Peer comparison and its limits

Peer comparison is the analytic kernel of the post-payment architecture. For each provider, utilization and coding statistics are compared to those of a peer distribution, and providers falling into the tail are sent for review. Peer comparison does not need any labels, and this characteristic makes the approach suitable when fraudulent cases are infrequent. The weakness of the approach is that the tail contains both proper and improper providers. In the case of the rarity of impropriety, the precision is poor. Statistical fraud detection reviews this trade-off between screening and classification without labels (Bolton, 2002).

Another point of weakness is the definition of the peers. If grouping is done based solely on the specialty, the high-acuity practice falls next to the routine practice; therefore, a rule referring the tail refers the former in connection with non-impropriety.

4.5 Ineligibility in healthcare

Ineligible payments in healthcare result from the failure of four predicates: the services are not covered, the beneficiaries are not enrolled at the date of service, providers are excluded or not qualified, and the services are not medically necessary. Three predicates above are adjudicable and mostly adjudicated. The fourth predicate is not adjudicable since medical necessity is a clinical issue and not a claim predicate. Adjudication dispute results in appeals, and appeals are themselves subject to review (Donley, 2018). Since the necessity question is outside the scope of the described edit systems in Section 4.2, it is a gap in terms of the prepayment edits.

Consequently, three adjudicatable predicates may be applied as edits, while the necessity predicate requires clinical review after the payment.

4.6 Comparative assessment

Adjudication of the healthcare reimbursement occurs before the payment on the level of the single claim with the internal predicate set and codified rules. Adjudication of the grant disbursement occurs after the payment on the level of the aggregate drawdown with the external

predicate set. Health care organizations' internal control systems are considered in the aspects of control and accountability (Reginato, 2012). Table 1 provides a summary of the consequences for three schemes, and rows of the table become the base of the architectural argument in Section 7.

The comparison is also temporal. When a payer denies a claim during adjudication, the result is no recovery, but when a funder discovers a duplicate after drawdown, the funder has to recover the money from the grantee. Section 8.1 revisits the problem of recovery.

Table 1. Implications of the payment architecture for the three schemes, by setting

Dimension	**Federal grants**	**Healthcare reimbursement**
Unit of payment	Aggregate drawdown or reimbursement	Itemized claim
Timing of control	Post-award audit, retrospective	Prepayment adjudication, prospective
Duplicate detection	Inference over ledgers; no transaction key	Key collision on the claim composite; deterministic for exact matches
Split detection	Requires grantee purchasing data, which the funder often does not hold	Code bundling edits; rule-encoded and automatic
Eligibility predicate set	External, distributed across agencies, often stale	Internal to payer systems, current at adjudication
Principal analytic mode	Sampling and extrapolation	Rule encoding plus peer comparison
Principal binding constraint	Data access and payment architecture	Rule maintenance and investigative capacity
Literature maturity	Descriptive, with audit reports prominent	Larger empirical and methods literature in the sources reviewed

5. Detection Methods: Four Generations

5.1 Generation one: exact matching and linkage

First generation technologies consist of exact match de-duplication. A key is built using the identification field values, the records are sorted and duplicates are flagged. Its efficacy depends on the quality of the key construction, which is a domain problem, not an algorithmic problem. In grants, the best possible key is far worse, since different costs can validly have identical identifying attributes.

The next generation consists of fuzzy match de-duplication. The generation is extended into near duplicates via normalized descriptions, tolerances on amounts and date, and so forth. Probabilistic theory is provided by the record linkage literature on how to assess whether two records pertain to the same entity (Fellegi, 1969); string comparator algorithms have been around a long time for the purposes of record linkage (Jaro, 1989; Winkler, 2006). Fuzzy matches generate false positives that consume investigation resources as well as false negatives that cost the organization money.

5.2 Generation two: rule and edit systems

Generation number two incorporates domain knowledge in the form of rules: coverage limits, bundling prohibitions, frequency caps, price caps, provider restrictions and aggregation thresholds. Rules seem ubiquitous in both domains in practice; the literature about rule systems tends to be descriptive. Rule systems are a component of the fraud classification frameworks found in the literature alongside data mining (Ngai, 2011). The substance of the literature is the maintenance of rules, as the coding system changes.

Rules are transparent, hence manipulable. A provider who knows that the maximum frequency limit is ten units per month can charge nine. Publishing rules becomes a map of what is not detected. There is no consensus answer to the question in the sources reviewed.

5.3 Generation three: statistical screening and unsupervised learning

Third-generation techniques use methods that do not involve labeling – peer comparison, statistical tests for outliers in distributions, analysis of the distribution of digits, clustering and density-based anomaly scores. Peer comparison is the most commonly used of these techniques in healthcare, and there are high standards for using it. Peer groups have to be homogeneous enough for differences to show the behavior, and the peer groups defined by specialty alone may end up ranking providers by their case complexity instead of the degree of their impropriety. General surveys of anomaly detection provide the theoretical background for it (Chandola, 2009).

Digit-distribution analysis detects the absence of natural variation, and its use in audits is based on the tradition of Benford's law (Nigrini, 2012; Drake, 2000). Use of digit-distribution analysis in audits is explained in the literature on digital analysis (Ashcroft, 2002). This technique fires on legitimate constraints like per diem rates and fee schedule maxima, which do not have any natural digit distribution. Clustering and density-based anomaly scoring detect points that lie in areas of low density. Low density is not necessarily an indicator of impropriety, and such techniques cannot distinguish between a novel legitimate pattern and an improper one easily.

5.4 Generation four: supervised and relational learning

Fourth-generation techniques train classifiers on the labeled data, and increasingly, they analyze relational structure among providers, beneficiaries, grantees, and payments. Supervised

techniques have an urgent problem with labeling – reviewers mark only the claims selected by existing screens, so the model trained on the result of the screening learns only screens. Moreover, class distributions are usually imbalanced, and the techniques for handling them are reviewed in the imbalanced learning literature (He, 2009).

Graph-based anomaly detection analyzes the payment system as a graph. Collusive schemes leave structural signatures that feature vectors of entities cannot discover, such as shared addresses and bank accounts, and graph-based anomaly detection is designed to handle such structures (Akoglu, 2015). Relational approach is mostly used in the reviewed sources for modeling provider networks in healthcare and sub-recipient networks in grants. Structural features complement behavioral features.

5.5 Prevention versus detection

One of the main arguments of this review is that prevention is the more cost-effective leverage wherever it can be measured. Prepayment edits and threshold aggregation avoid losses and use no investigation resources. The economics of continuous assurance delivers a similar message from the other end: the cost of monitoring must be balanced against its benefits (Alles, 2002).

Prevention creates no recoveries and therefore no visible performance, while detection creates both; and agencies tend to be evaluated based on the latter. As a result, there is often an underinvestment in prevention, while the investment in detection is driven by the need for recoveries.

6. Appraisal of the Evidence Base

6.1 Evaluation design

An approach to detection is only credible if it is backed by a credible evaluation. A statement about the performance of an approach implies a number of elements: the existence of a held-out evaluation dataset, separation of that dataset from the training data temporally or through the entity dimension, reporting of precision in addition to recall, and reporting of the base rate of the phenomenon of interest. Precision, recall and ROC analysis are standard measures of the above (Fawcett, 2006); and the decision-making approach of data science textbooks requires the same things (Provost, 2013).

The vast majority of the evaluations in the literature fail to meet all of those criteria. When the evaluation set is not separated from the training data temporally or by entity, the reported performance can be due to memorization of the population used for evaluation, rather than generalization to the population of providers or grantees. And when precision is not reported in addition to recall, one has no idea how many valid cases have been flagged.

6.2 The denominator problem

Most detection approaches in this literature measure the number of frauds found or recovered or the value of that amount. However, they often fail to provide the population from which that sample was taken and the number of flags generated. The former allows computing precision and the latter – recall. Data mining textbooks emphasize the importance of having the base rate and the flagged population known for proper interpretation of any result (Provost, 2013).

The gap between recoveries and costs is an artifact of the institution. Detection teams are evaluated based on recoveries, while unsuccessful investigations do not typically feature in performance evaluation. Thus, it would be possible to make a case for a hypothetical approach that doubles the rate of detected improper payments but at the cost of creating twenty times as many flags on a report limited to recoveries alone. Section 9.1 outlines a framework for comparing such detection approaches.

6.3 Reported effectiveness by setting and scheme

A qualitative assessment of reported detection effectiveness for different settings and schemes is provided in Table 2. The bands capture our interpretation of the relevant sources, and should not be considered any kind of pooled estimates, since the denominators vary and comparable figures cannot be derived across the literature. The analytical procedures used in external audits are described as a separate body of practices (Kogan, 2018).

Table 2. Qualitative assessment of reported detection effectiveness by setting and scheme

Scheme	**Grants**	**Healthcare**
Duplicate	Moderate where keys exist; otherwise low	High for prepayment; moderate post-payment
Split / fractionated	Low; rarely evaluated	Moderate through bundling edits; low for cross-episode patterns
Ineligible	Moderate for allowability; low for coverage	High for coverage and enrollment; moderate for necessity

It is noteworthy that one of the most important cells in Table 2 corresponds to poor detection of grant duplications, which can have a high dollar exposure and yet show relatively low detection effectiveness. The reason is more architectural than analytical – see Section 7.

6.4 The label problem

Supervised models require labels for training, and in the sources considered, those are obtained through completed investigations. There are two problems associated with this choice. Labels are

selective: they provide information about claims selected by a screen for analysis. Thus, a model trained on them inherits the biases of the screen and cannot detect schemes that were not selected by the screen. Labels are also contaminated: a claim may be rejected as being not an improper payment due to lack of documentation, and a model is taught to recognize the absence of the scheme. In reviews of data mining applications to fraud detection, labelled cases are viewed as the scarce input into supervised learning.

Labels also become obsolete. Schemes evolve their defenses against detection; the labels collected using one screen describe the population not visible to the next screen. Concept drift refers to this kind of change in the distribution (Gama, 2014).

6.5 Nature of the evidence base

The reviewed sources include mostly government audit and evaluation reports, peer-reviewed journals in accounting and health services, and statutory and guidance documents. Audits provide more information about mechanisms than methods. Methods, where provided, are usually described in insufficient detail to duplicate. The literature on audit analytics has defined research areas that include more empirical research on the use of analytics in practice (Appelbaum, 2017).

The sources are skewed towards the latter half of the 1986-2018 period. This is appropriate given the expansion of program integrity activities from the 2000s. The review does not quantify that expansion and does not take into account the expansion as an indicator of progress in the field. Research on obstacles to use of big data analytics in audit is a branch of this recent literature (Alles, 2016).

7. Why the Two Settings Diverge

7.1 The architectural explanation

The divergence is explained by three architectural features. Each feature establishes the potential detectability of the scheme. The first feature is the granularity of the payment unit. When the payment unit is the discrete obligation, duplication becomes a major collision. When the payment unit is an aggregate, duplication becomes an inference over the accounts which no longer preserves the mapping to obligations. Any analytics method generates only the information contained in the payment records.

The second feature is the timing of adjudication relative to disbursement. When adjudication is prior to disbursement, detected improprieties can be intercepted before the occurrence of any loss. When adjudication is after disbursement, detection retrieves a fraction of the loss, and even the retrieval of this fraction is subject to additional attrition through a legal process. Continuous auditing has been observed in individual organizations and provides a hint of transaction monitoring (Hardy, 2015). The third feature is the location of the predicate set. When the eligibility predicates reside at the payer, they can be applied at adjudication. When they reside

elsewhere, a request is made, which is often slow, incomplete, and sometimes legally constrained.

7.2 What follows for method transfer

The transfer implication is awkward for the machine learning literature. Using a healthcare-style analytics stack for a grant program will result in a model that lacks the information necessary to determine the most valuable grant scheme, as that data will be in the books of the grantee. The intellectual groundwork of continuous auditing research has been well documented, and the issue of transferring it elsewhere has been one it has consistently asked (Chiu, 2014; Kiesow, 2016).

Thus, the transfer is one of architecture rather than analysis. This implies moving the payment unit closer to the obligation, moving adjudication close to the prepayment, and incorporating the predicate set into the payer. The argument is one of design, and does not assert that some particular analytical technique would be effective in grants.

7.3 The counterargument and its limits

A logical counter argument is that expenditure on grants is too heterogeneous for claim level adjudication. That argument carries weight, as grants' costs cannot be expected to come in consistent units. However, its strength depends on the particular scheme in consideration. Cost duplication requires persistent identification of the cost, but does not require standardized categories. Split purchases require aggregation by vendor and window, and do not need standardization of claims at all. Big data usage inhibitors in audits align with this counter argument (Alles, 2016).

The argument thus implies that there should not be claim-level adjudication but rather obligation-level tracking. The second is the more specific and realistic option, and is the suggested reform in lieu of full claim-level payment.

8. Data Infrastructure, Law, and Recovery

8.1 The recovery problem

Recovery is not simply an inverse of payment. A duplicate payment has to be recovered from someone who might dispute the payment, is insolvent, or can recover that money as offset against other payments. Overpayment demands recovery guidance explains the dispute process (Haney, 2014). Appeal process for Medicare determinations raise the same issue (Donley, 2018).

Studies which quantify identified overpayments as a benefit of a detection method are quantifying a potential recovery, not a realized one. The economic value of a detection method is its realized recovery net of the investigative cost. Therefore, the value of a detection method estimated through the stopping criterion of identified overpayments is overestimated by an amount which cannot be estimated by the study itself.

8.2 Capacity as the binding operational constraint

Investigative capacity is finite and costly. Nurse reviewers, auditors, and program analysts are skilled workers, and in many cases their cost exceeds the computational cost of a detection method. Several studies within the audit profession investigate the drivers and barriers of big data (Alles, 2015).

These sources make few remarks about the investigative capacity. Almost no paper provides the size of the flagged queue at the recommended operating point, and almost none mentions the investigative effort required by a method. A method that increases the recall at a considerably higher flagged queue size can be useless for an organization that already faces a capacity problem with its current size. Such case may be theoretical, but this test is the one a deployable method must pass.

8.3 Incentive compatibility

In case of grant programs the motive to detect overpayment may be less important than the motive to disburses money since the latter is the actual purpose of the program while the former is its cost. In case of health care payer organizations with stronger motives for investing into detection are those who are facing the financial loss. Incentives of agents that diverge from the incentives of principals are a general feature of any organization (Jensen, 1976).

It seems that the lack of discussion of the incentive compatibility is the major drawback of the existing literature. In order to estimate the value of a method we need to know how it will be used, and it will be used according to its incentives. As argued in section 5.5 the reporting system rewarding recoveries will motivate organizations to invest in detection rather than prevention.

9. Research Agenda

9.1 The denominator standard

The agenda consists of four deficits: denominator, label, architecture, and capacity. The field needs to adopt an analytic reporting standard that requires four numbers for every claimed detection result: the sampled population, the volume of flags at the claimed operating point, the investigative cost of resolving that volume, and the recovered volume net of that cost. Those are the bare minimum numbers necessary for computing precision and comparing methods at a specified workload. The principles of analytic monitoring for continuous assurance provide a starting point for the reporting of analytic results in operational terms (Vasarhelyi, 2004).

Every number answers a distinct question. Population sampled enables estimating recall, flag volume demonstrates workload, investigative cost demonstrates whether this workload could be resourced, and realized recovery demonstrates whether the result was worth the effort.

9.2 Label improvement through designed exploration

The label deficit could be partially addressed by dedicating a portion of investigative capacity to randomly selected items as opposed to only model-ranked ones. Items randomly selected provide labels describing the population rather than the screen, thus breaking the feedback loop in which a model learns the screen. This approach does come at a cost, as some investigative capacity is spent on items a model does not rate highly, and this cost needs to be stated in the analytic reporting standard above. Probability estimates produced by classifiers need to be calibrated in order to enable the decision of allocation (Zadrozny, 2002). Cost-sensitive decision rules provide a framework for this trade-off (Elkan, 2001).

9.3 Architecture experiments

The architectural claim made in Section 7 needs to be verified directly. Two approaches are possible. The first one is a staged introduction of the obligation-level identifiers into a grant program with duplication detection being compared before and after such an introduction. The second approach is a comparison of duplication detection between lines of business in healthcare with and without shared claim keys. Neither of these two approaches is a randomized experiment, yet they will be more capable of separating architecture and method than the current comparison is. The evaluation of continuous data-level auditing systems provides a precedent for design and measurement here (Kogan, 2014).

The outcome needs to be defined in advance. Duplication detection needs to be scored against a common set of confirmed duplicates with flag volumes documented in both conditions, so that the comparison would be based on difference in architectures rather than in reporting practices.

9.4 Obligation identity as a first-class construct

Neither setting possesses an identifier of the economic obligation separate from the documents asserting it. Research of that identifier would get to the heart of the problem of both duplication and splitting. The theory of record linkage provides a framework for establishing when two documents represent the same economic obligation (Fellegi, 1969), and data matching literature considers duplicate detection the problem of entity resolution (Christen, 2012). What is lacking is an identifier maintained by both payer and payee through the life cycle of the economic obligation through the payment process.

Such an identifier needs to survive the transitions that economic obligation experiences. A purchase order transforms into an invoice, an invoice into a payment, a claim into an adjustment, a reverse, or a re-submission. Such an identifier would transform the mapping defined in section 2.2 into an observable process.

9.5 Scheme-specific evaluation

Metrics of aggregate performance of schemes should be abandoned in favor of scheme-level stratification, since aggregate performance masks what schemes a method works on. A

hypothetical improvement of 30 points in duplicate detection and 2 in ineligibility detection is a fundamentally different improvement from the one providing 15 points of improvements in each category. Review of statistical fraud detection methods organized by application area (Bolton, 2002) is a long-established practice and scheme-level stratification of results extends it to program payments.

Scheme-level reporting would also reveal what setting a method can be applied to. If the method works well in duplicate detection and poorly in ineligibility detection, then it can be used where it works well and combined with rules-based detection elsewhere. Aggregate reporting masks that choice.

9.6 Capacity-constrained benchmarking

Benchmarks should report comparison of methods on fixed volume of flags generated, rather than fixed score threshold. Fixed threshold gives an opportunity to make the method with a different distribution of scores look good or bad depending on the load an organization can handle. This would bring research closer to the real-world operational problem. It would also mask the higher variance of the method. As concept drift leads to a change in the population, period-separated comparison is required (Gama, 2014).

The logic also holds for the assessment period. Performance in one period could reflect a condition which won't continue, and a split in the periods will show if the method's strength persists in a different scheme population.

10. Conclusion

Duplicate, split, and ineligible payments are one challenge seen in light of three invariants: the cardinality of the obligation to payment map, the resilience of a control threshold to administrative decomposition, and the satisfaction of coverage predicates during adjudication. Healthcare adjudicates discrete itemized claims prior to payment, against predicates stored within the payer. Grants adjudicate aggregated drawdowns post-payment, against predicates stored elsewhere. According to the reading outlined here, the disparity in performance between the two has less to do with analytic sophistication and everything to do with architecture.

Among all the literature surveyed, the commonest points raised are the relative cost-effectiveness of prevention, that good rules have as much significance as good models, and that relations contain data beyond that of behavior.

Three changes would alter the course: a denominator standard for reporting detection results, designed exploration of the investigative queue to disrupt the label feedback loop, and obligation identity as a first-class construct. None of these is a modelling breakthrough, yet all are expected to contribute more to loss reduction than another round of classifiers.

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