

Detecting fraud in public procurement: methodology and application to French Data

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Dec. 6, 2022

1 Introduction

- Forewords
- taxonomy of fraud in public procurement

2 Theoretical issues

- Fraud, favoritism, corruption and rent seeking
- Price-only procurement
- Multi-criteria public procurement

3 Automated detection?

- what really matters?
- red flags
- Public procurement graph analysis

Introduction

Press clippings, but no footprints?

Marchés publics à l'INA : Mathieu Gallet condamné

Accueil / Société

par Jérôme Leflâtre
publié le 15 janvier 2018 à 20h46

Jugé pour «favoritisme» dans l'attribution de marchés publics lorsqu'il était président de l'Institut national de l'audiovisuel (INA) entre 2010 et 2014, Mathieu Gallet a été reconnu coupable lundi par le tribunal de Créteil. L'actuel PDG de Radio France a été condamné à un an de prison avec sursis et 20 000 euros d'amende.

Guillaume Peltier : dons et services rendus, plongée dans ses micropartis

Le député et numéro deux du parti Les Républicains a créé plusieurs mouvements, dont les plus gros donateurs sont des entrepreneurs implantés dans sa circonscription, et auxquels il a parfois rendu des services. Un cas qui illustre l'ambiguïté de ces structures prisées par nombre d'élus et permettant de recevoir des dons anonymes et défiscalisés.

L'élu et l'homme d'affaires se rencontrent rapidement après l'élection de M. Peltier à Neung-sur-Beuvron, en 2014. Ils sympathisent. Selon nos informations, M. Roussel devient rapidement un donateur de l'élu. En 2017, Neung-sur-Beuvron paye 182 000 euros à Girard-Sudron pour réaliser une étude « *technico-économique* » sur le remplacement de l'éclairage public du village par des luminaires utilisant la technologie LED. Dès le début de l'année 2017, M. Peltier a

SOCIÉTÉ - JUSTICE

Procès des sondages de l'Elysée : quand la présidence pensait « échapper au droit commun »

La première semaine d'audience s'est concentrée sur les responsabilités des membres du cabinet de la présidence Sarkozy dans la signature, sans respecter les procédures de marchés publics, de contrats avec les sociétés de Patrick Buisson et Pierre Giacometti.

Par Samuel Laurent

Publié le 22 octobre 2021 à 13h11 - Mis à jour le 22 octobre 2021 à 13h18 - Lecture 4 min.

Article réservé aux abonnés

Édition du jour
Date du mardi 23 février

Le Monde
Ukraine : dernière chance pour la paix

Garde à vue d'Éric Piolle et droit des marchés publics, que comprendre ?

OPINION. Selon la Chambre régionale des comptes (CRC) Auvergne-Rhône-Alpes, les éléments pour déroger aux obligations de mise en concurrence n'ont pas été suffisamment prouvés par l'exécutif grenoblois. Par Jean-Baptiste Vila, Université de Bordeaux (*)



Introduction

Press clippings, but no footprints?

Avis No 13-32047 publié le 22/02/2013 **Date limite de réponse : 27/02/2013**

Dépt. : 94 Institut national audiovisuel - ina.

Prestation de conseil pour le compte de l'INA à Bry-Sur-Marne

Avis de marché Procédure NC

Attribution du marché ou du lot :

- lot 1: Lot unique.

Nom du titulaire/organisme : Roland Berger Strategy Consultants, 11 rue de Prony 75017 Paris.

Date d'attribution du marché : 26 avril 2013.

Nombres d'offres reçues : 5.

Instance chargée des procédures de recours : Tribunal de grande instance de Paris 4 boulevard du palais 7501 Paris tél. : 01-44-32-51-51.

Avis No 10-259855 publié le 04/12/2010

Dépt. : 94 Institut national audiovisuel - ina

Prestation de conseil en développement stratégique pour l'Institut National Audiovisuel de Bry-sur-Marne

Résultat de marché Procédure NC

V.3) *Nom et adresse de l'opérateur économique en faveur duquel une décision d'attribution du marché a été prise :*

Roland Berger Strategy Consultants, 11 rue du Pony, 75017 Paris.

V.4) *Informations sur le montant du marché :*

Estimation initiale du montant du marché :

Valeur : 240 000 EUR.

Marseille : cinq ans de prison pour le haut fonctionnaire corrompu

Renaud Chervet touchait des pots-de-vin contre l'attribution de marchés publics du Département

Par Laurent D'ANCONA



Introduction

Press clippings, but no footprints?

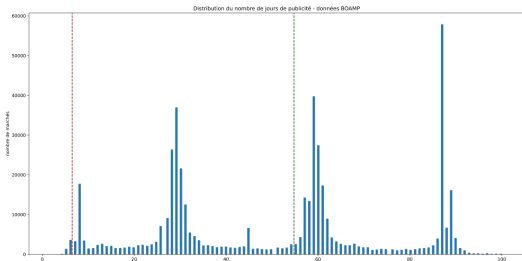


Figure: Publicity FR

publicityDuration	
count	2179.0
mean	46.0
std	11.0
min	15.0
10%	32.0
20%	36.0
30%	42.0
40%	43.0
50%	45.0
60%	49.0
70%	51.0
80%	54.0
90%	59.0
max	101.0

Figure: publicity CD13

Introduction

Press clippings, but no footprints?

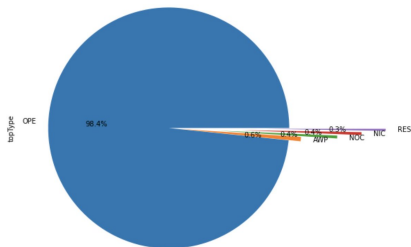


Figure: Type of procedure / CD13

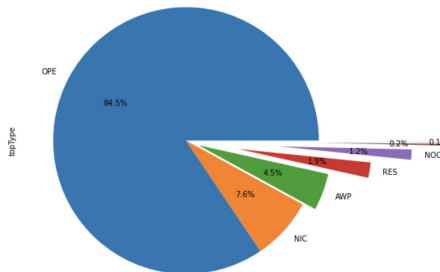


Figure: Type of procedure / FR

Introduction

Press clippings, but no footprints?

Price_weight	
count	2288.0
mean	52.0
std	19.0
min	10.0
25%	40.0
50%	50.0
75%	60.0
max	100.0

Figure: Obj. criteria / CD13

Price_weight	
count	706632.0
mean	47.0
std	17.0
min	0.0
25%	40.0
50%	40.0
75%	60.0
max	100.0

Figure: Obj. criteria / FR

Introduction

Press clippings, but no footprints?

WIN_share	
count	2322.00
mean	26.93
std	29.63
min	0.59
10%	1.69
20%	3.85
30%	6.67
40%	10.00
50%	14.29
60%	23.08
70%	33.33
80%	50.00
90%	83.33
max	100.00

WIN_share	
count	1013410.00
mean	29.05
std	31.78
min	0.03
10%	1.59
20%	3.75
30%	6.58
40%	10.32
50%	16.56
60%	25.00
70%	33.33
80%	50.00
90%	100.00
max	100.00

Figure: Concentration / CD13

Figure: Concentration / FR

Introduction

Press clippings, but no footprints?

DIST	
count	2549.00
mean	141.14
std	234.00
min	0.11
10%	3.13
20%	4.27
30%	7.39
40%	16.23
50%	19.70
60%	28.86
70%	74.32
80%	275.16
90%	657.50
max	950.31

Figure: Dist btw BS / CD13

DIST	
count	34785.00
mean	244.74
std	340.95
min	0.00
10%	3.47
20%	8.79
30%	19.40
40%	29.92
50%	68.41
60%	183.15
70%	336.92
80%	643.56
90%	664.10
max	8821.90

Figure: Dist btw BS / FR

Introduction

Press clippings, but no footprints?

tenderNumber	
count	830043.0
mean	7.0
std	15.0
min	0.0
10%	1.0
20%	2.0
30%	2.0
40%	3.0
50%	3.0
60%	4.0
70%	5.0
80%	6.0
90%	10.0
max	898.0

Figure: Dist btw BS / CD13

tenderNumber	
count	830043.0
mean	7.0
std	15.0
min	0.0
10%	1.0
20%	2.0
30%	2.0
40%	3.0
50%	3.0
60%	4.0
70%	5.0
80%	6.0
90%	10.0
max	898.0

Figure: Dist btw BS / FR

- Supervisor, principal, delegated official... who chooses the procedure implemented?
- Capture or extortion?
- Rent seeking, favoritism or corruption?

Definitions

Capture occurs when a firm bribes a public official to obtain a trading advantage. This corresponds to 'active bribery' as termed in the OECD Convention.

Extortion occurs when a firm complies with a demand for a bribe to avoid being excluded from trade. This type of bribes is referred to as 'facilitation payments' by international legislation.

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What are we looking for?

a mechanism design approach

- The degree $\alpha_i \in [0, 1]$ to which the public buyer takes firm i 's profit, Π_i , into account.
- The public buyer assessment, S_i , of the fact that firm i is carrying out the contract.
- The surplus $V(q_i)$, generated by the fact that the contract is carried out with a quality level q_i .
- When choosing a level of quality q_i , firm i incurs a cost $c(q_i, \theta_i)$, where θ_i represents its private efficiency parameter. $\theta_i \sim F(\cdot)$
- The potential bribe, equal to a fraction, $\gamma_i \geq 0$, of the payment of the contract, given by firm i to the public buyer.

$$[x_i(\Theta), t_i(\Theta)]_{i=1, \dots, n}$$

What are we looking for?

a mechanism design approach

The generic objective function:

$$E_{\Theta} W = \int_{\Theta} \sum_i \left[\left(S_i + V(q_i) \right) x_i - (1 + \lambda) t_i + \alpha_i \left((1 - \gamma_i) t_i - c(q_i, \theta_i) x_i \right) + \gamma_i t_i \right] dF(\Theta)$$

The generic modified objective function (i.e incentives into account)

$$E_{\Theta} W = \int_{\Theta} \sum_i x_i \left[\left(S_i + \hat{V}(q_i) \right) - \frac{1 + \lambda - \gamma_i}{1 - \gamma_i} c(q_i, \theta_i) - \left(\frac{1 + \lambda - \gamma_i}{1 - \gamma_i} - \alpha_i \right) \frac{F_i(\theta_i)}{f_i(\theta_i)} c_{\theta}(q_i, \theta_i) \right] dF(\Theta)$$

Given its parameter θ_i , firm i is induced to choose an optimal quality

$$q^*(\theta_i) = \arg \max_{q_i} V(q_i) - J_i(q_i, \theta_i)$$

with $J_i(q_i, \theta_i) = \frac{1 + \lambda - \gamma_i}{1 - \gamma_i} c_i(q_i, \theta_i) + \left(\frac{1 + \lambda - \gamma_i}{1 - \gamma_i} - \alpha_i \right) \frac{F_i(\theta_i)}{f_i(\theta_i)} c_{\theta}(q_i, \theta_i)$.

What are we looking for?

a mechanism design approach

Firm t e.g. is awarded the contract if

$$S_t + V(q^*(\theta_t)) - J_t(q^*(\theta_t), \theta_t) > S_s + V(q^*(\theta_s)) - J_s(q^*(\theta_s), \theta_s) \quad \forall t, s.$$

from [Maréchal and Morand, 2021]

The mere observation of procedural choices does not theoretically reveal the preferences of the public purchaser.

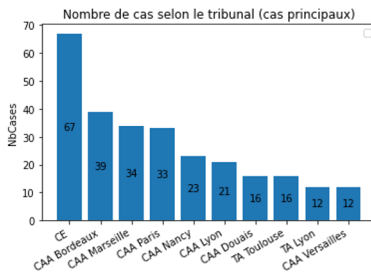
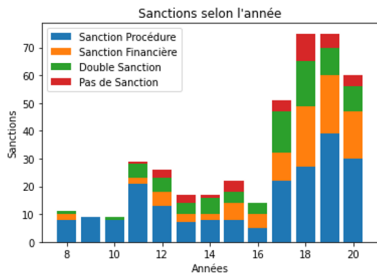
- γ_i VS α_i ?
- lawful or unlawful preferences?
- lawful or unlawful selection rule?

Administrative justice database

- 1 2008-2021
- 2 T.A., C.A.A., C.E.
- 3 435 entries

Manquement à l'obl d'écarter une candidature irrecevable, une offre irrégulière, inacceptable ou inappropriée	81
Manquement à l'obl d'information des candidats	71
Imprécision, erreur ou irrégularité des documents de la consultation ou du marché	38
Avantage d'un candidat ou manquement au principe d'égalité	31
Marché/ DSP passé sans publicité ni mise en concurrence	31
Erreur d'appréciation dans l'évaluation d'une candidature ou d'une offre	29
Méthode de notation irrégulière	29
Méconnaissance des spécifications légales applicables au marché	26
Manquement à l'obl de contrôle des capacités professionnelles, techniques et financières	24
Manquement aux règles de publicité	23
Interdiction d'écarter une candidature ou une offre valide	23
Modification des caractéristiques du marché, modification de l'offre ou du contrat	23
Critère ou sous-critère irrégulier	20

Database of French administrative justice decisions



Database of French administrative justice decisions

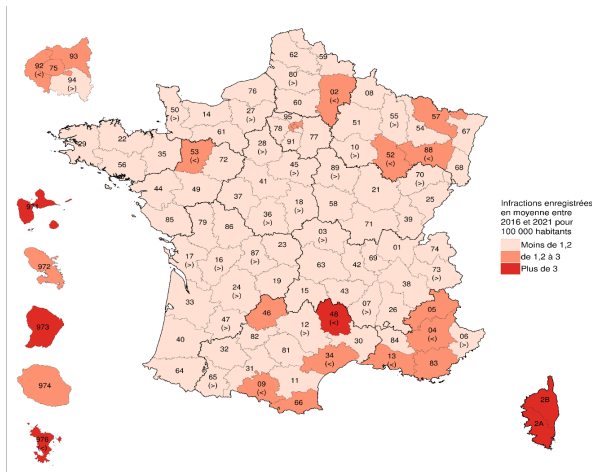


Figure: Atteintes à la probité / 100 000h hab

Price-only procurement

A simple framework

the openness / administrative costs trade-off

- $c_i \sim \mathcal{U}(0, 1) \forall i$
- a first-price sealed bid auction
- the buyer chooses the openness of the procedure ω
- an entry process: $N(\omega), N' > 0$
- an administrative cost $\kappa(\omega), \kappa' > 0$

The benevolent public-buyer

$$\max_{\omega} \mathbb{E}_{\Theta} \sum_i (S - b_{N(\omega)}^i(\theta_i) P(b_i | b_{-i})) - \kappa(\omega)$$

$$\min_{\omega} \underbrace{(b_{N(\omega)}^{(1):N(\omega)})}_{\downarrow} - \underbrace{\kappa(\omega)}_{\uparrow}$$

Price-only procurement

A simple framework

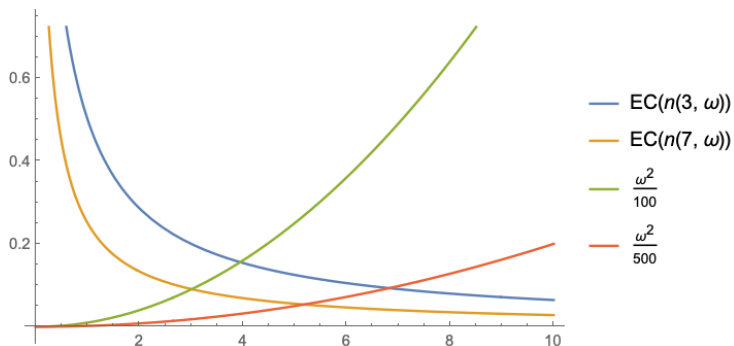


Figure: Benefit and cost of openness

Fraud and sanctions

- Expected fine: $F_{\Omega}(\omega)$, $F'_{\Omega} \leq 0$

- $$b(c_0) = c_0 + \frac{\int_{c_0}^1 (1-s)^{N(\omega)-1} ds}{(1-c_0)^{N(\omega)-1}}$$

$$\max_{\omega} \mathbb{E}\Pi_0 = \frac{1-c_0}{N(\omega)} P(c_0 < c^{(1):N(\omega)}) - F_{\Omega}(\omega)$$

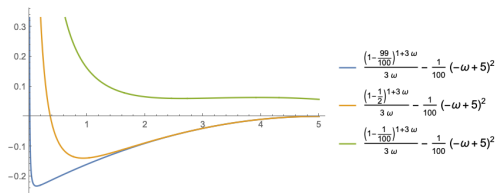


Figure: Expected costs and gains from openness

Price-only procurement

α -corrupted public buyer, publicity delay as a clue?

The generic objective function of the public buyer

- $0 \leq \alpha \leq 1$ the weight of the fraudulent objective in the overall objective of the public buyer.

$$\max_{\omega} \alpha \left(\frac{1-c_0}{N(\omega)} P(c_0 < c^{(1):N(\omega)}) - F_{\Omega}(\omega) \right) + (1 - \alpha) \left(\mathbb{E}_{\Theta} \sum_i (S - b_{N(\omega)}^i(\theta_i) P(b_i | b_{-i})) - \kappa(\omega) \right)$$

Proposition 1:

$$\frac{\partial \omega^*}{\partial \alpha} > < 0?$$

The openness of a public procurement contract does not monotonically evolve with the honesty of the public buyer.

Multi-criteria public procurement

Endogenous and falsifiable quality

- model *à la* [Che, 1993]
- Firms are symmetric and may all produce quality q
- $c(q, \theta) = \theta q$, $\theta_i \sim \mathcal{U}(0, 1) \forall i$
- valuation of the quality: $U(p, q) = V(q) - p$, $V(q) = \log q$
- First score auction with scoring rule $\tilde{S}(\lambda, q, p) = \lambda \log q - p$
- λ : quality manipulation
([Huang and Xia, 2019, Celentani and Ganuza, 2002])

Lemma

The equilibrium quality-price (q, p) bidding strategy is given by:

$$q_E(\theta_i, \lambda) = \frac{\lambda}{\theta_i}$$
$$p_E(\theta_i, \lambda) = \lambda \left(1 + \int_{\theta_i}^1 \frac{1}{s} \left(\frac{1-s}{1-\theta_i} \right)^{(n-1)} ds \right)$$

Multi-criteria public procurement

Endogenous and falsifiable quality

The equilibrium score is given by:

$$\tilde{S}_E(\theta_i, \lambda) = \lambda \left(\log \frac{\lambda}{\theta_i} - \left(1 + \int_{\theta_i}^1 \frac{1}{s} \left(\frac{1-s}{1-\theta_i} \right)^{(n-1)} ds \right) \right)$$

Let us consider the winning firm (the lowest θ_i)
with $H(\theta_1) = 1 - (1 - \theta_1)^n$ $h(\theta_1) = n(1 - \theta_1)^{n-1}$

$$q_W = \lambda \int_0^1 \frac{n(1 - \theta_1)^{n-1}}{\theta_1} d\theta_1$$

$$p_W = 2\lambda$$

$$\tilde{S}_W = \lambda \left(\log \left(\lambda \int_0^1 \frac{n(1 - \theta_1)^{n-1}}{\theta_1} d\theta_1 \right) - 2 \right)$$

Multi-criteria public procurement

Endogenous and falsifiable quality

In order to allow the fraudulent firm to win the contract, the public buyer must falsify its quality score. Let δ represents the miscalculation of fraudulent firm's quality. The higher the δ the bigger the expected fine: $F_{\Delta}(\delta)$ with $F'_{\Delta} > 0$

Naïve intuition

Increasing λ reduces $F_{\Delta}(\delta)$

$$\lambda \left(\log \frac{\delta \lambda}{\theta_i} - \left(1 + \int_{\theta_i}^1 \frac{1-s}{s} \left(\frac{1-s}{1-\theta_i} \right)^{(n-1)} ds \right) \right) > \tilde{S}_W$$

$$\log \delta > \log \theta_i + \left(1 + \int_{\theta_i}^1 \frac{1-s}{s} \left(\frac{1-s}{1-\theta_i} \right)^{(n-1)} ds \right) + \log \left(\int_0^1 \frac{n(1-\theta_1)^{n-1}}{\theta_1} d\theta_1 \right) - 2$$

Multi-criteria public procurement

Openness and quality manipulation interplay

Proposition 2

$\frac{\partial F_{\Delta}(\delta)}{\partial \lambda} = 0$: Increasing the weight given to quality in the scoring rule does not reduce the degree of fraud required to manipulate scores

Let's consider openness once again:

$$\log \delta > \log \theta_i + \left(1 + \int_{\theta_i}^1 \frac{1-s}{s} \left(\frac{1-s}{1-\theta_i}\right)^{N(\omega)-1} ds\right) + \log\left(\int_0^1 \frac{N(\Omega)(1-\theta_1)^{N(\omega)-1}}{\theta_1} d\theta_1\right) - 2$$

Proposition 3

$\frac{\partial F_{\Delta}(\delta)}{\partial \omega} < 0$: Reducing the openness of the market reduces the degree of fraud required to manipulate scores

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what really matters?

Favoritism in Departmental council

	<i>Dependent variable:</i>
	local
Allotment	0.618*** (0.523, 0.713)
Publicity	-0.512*** (-0.627, -0.396)
Accelerated Procedure	-0.249 (-0.669, 0.170)
Negotiated Procedure	-0.263 (-0.601, 0.075)
Competitive Procedure with Negotiation	0.555*** (0.453, 0.658)
Restricted Procedure	-0.395 (-1.281, 0.491)
Social clause	-0.269** (-0.475, -0.064)
Environmental clause	-0.219** (-0.376, -0.061)
Constant	0.107 (-0.047, 0.261)
Observations	7,048
Log Likelihood	-4,747.380
Akaike Inf. Crit.	9,512.760

Note:

*p<0.1; **p<0.05; ***p<0.01



what really matters?

Criteria

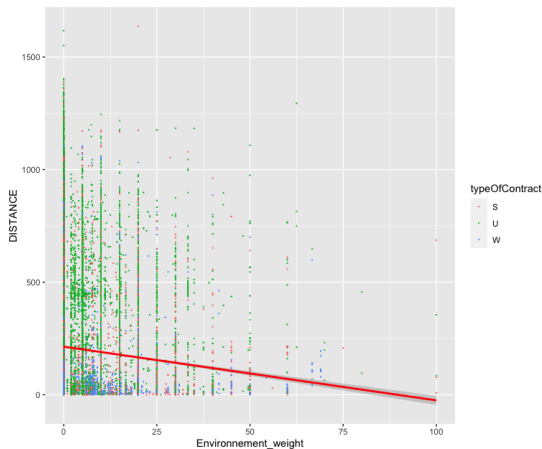


Figure: Impact of envir. crit. weight on proximity

what really matters?

Criteria

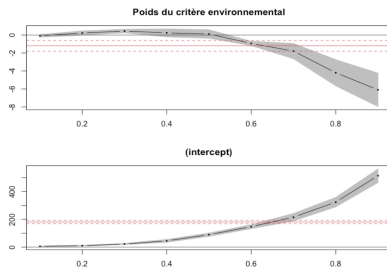


Figure: Impact of envir. crit. weight on proximity

what really matters?

Criteria

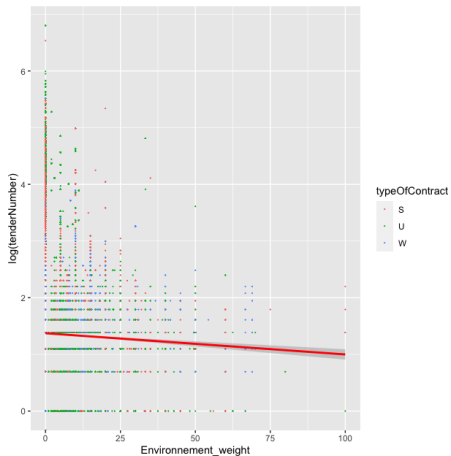


Figure: Impact of envir. crit. weight on openness

what really matters?

Criteria

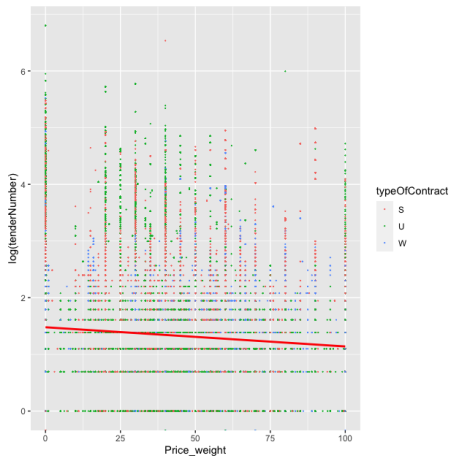


Figure: Impact of price. crit. weight on openness

A priori red flags

Publicity and openness

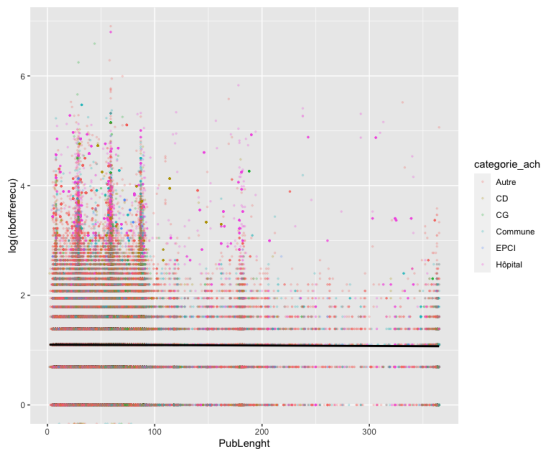


Figure: Impact of pub. length

A priori red flags

Publicity and openness

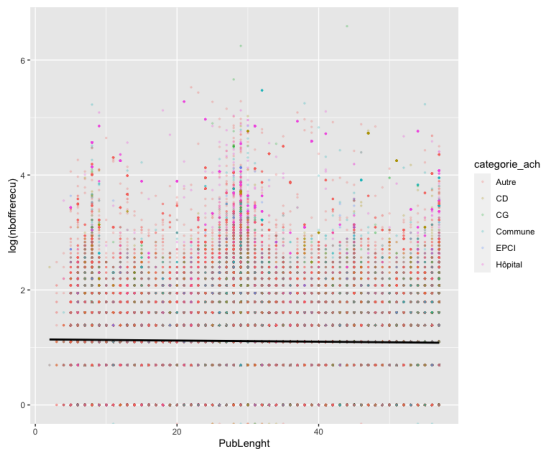


Figure: Impact of pub. length - max = median

A priori red flags

Publicity and openness

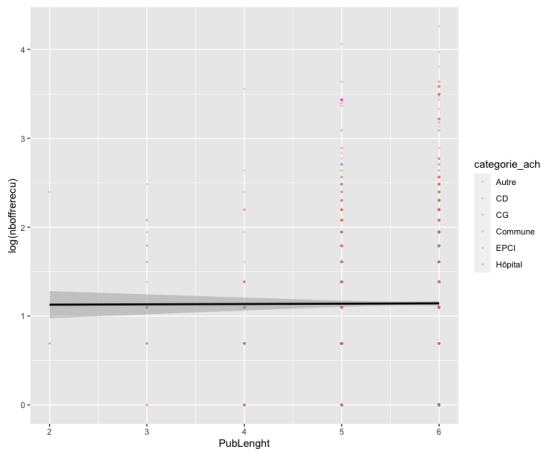


Figure: Impact of pub. length - less than a week

A posteriori red flags

Concentration and openness

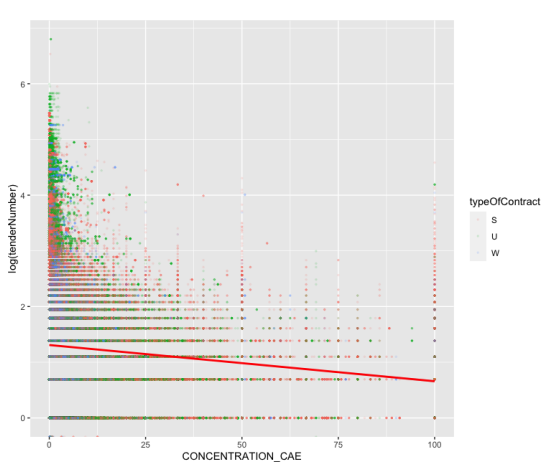


Figure: Concentration index - the public buyer

A posteriori red flags

Concentration and openness

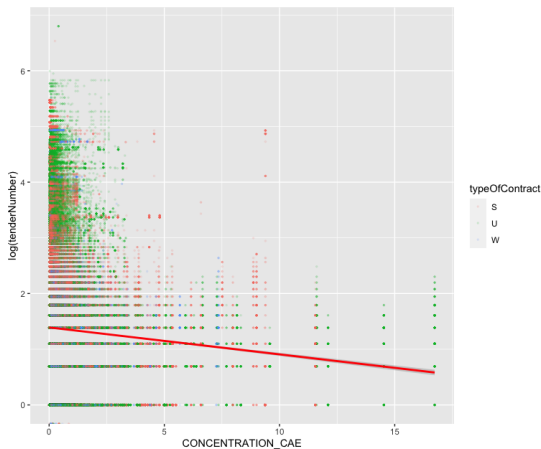


Figure: Concentration index - the large public buyers

A posteriori red flags

Concentration and openness

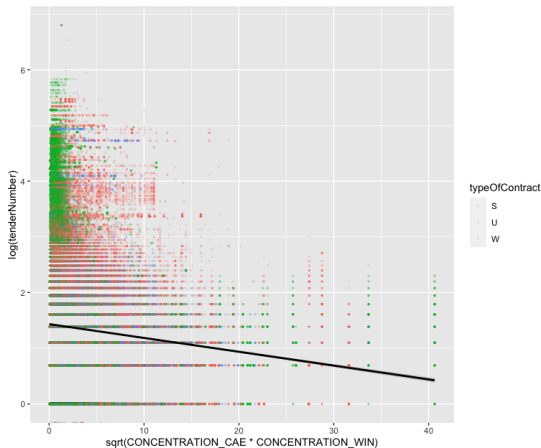


Figure: Cross-concentration

A posteriori red flags

Composite index

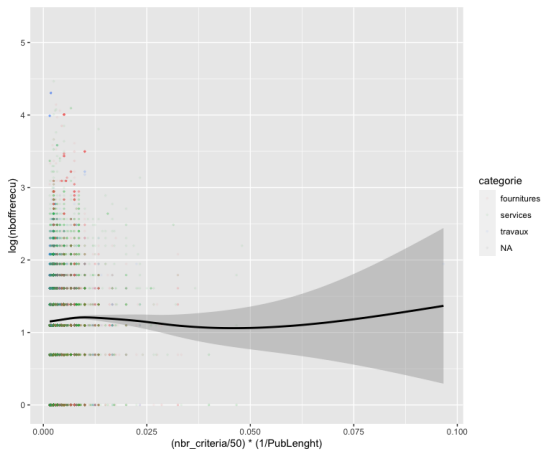


Figure: red flags as composite index

A posteriori red flags

Composite index

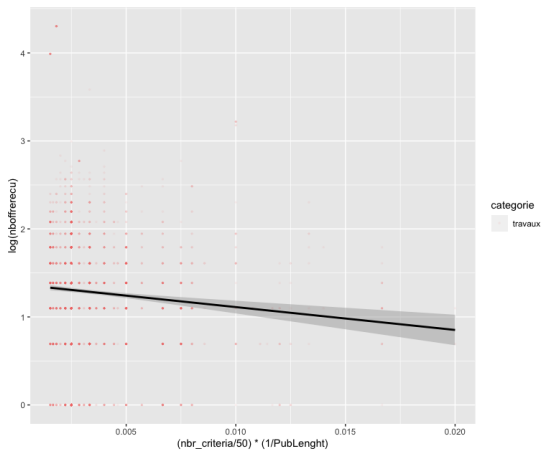


Figure: red flags as composite index

Definition 1 (Hawkins' Definition of Outlier, 1980)

"An outlier is an observation that differs so much from other observations as to arouse suspicion that it was generated by a different mechanism."

Definition 2 (General Graph Anomaly Detection Problem)

Given a (plain/attributed, static/dynamic) graph database, Find the graph objects (nodes/edges/substructures) that are rare and that differ significantly from the majority of the reference objects in the graph.

Graph: Consulting markets graphs in Lucas (2022)

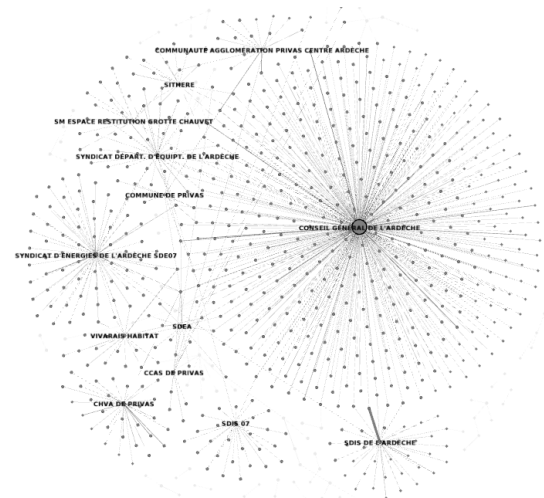


Figure: the network of consulting markets

Graph: Consulting markets graphs in Lucas (2022)

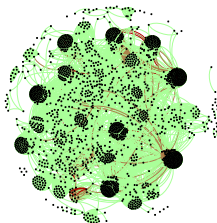


Figure: Red flags in the projected graph

Graph: Consulting markets graphs in Lucas (2022)

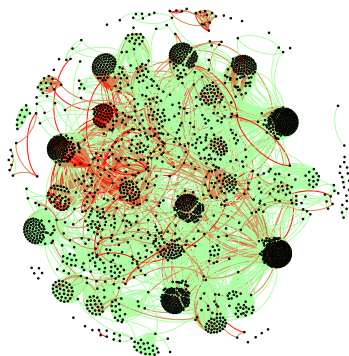


Figure: Global anomalies detected

Graph: Consulting markets graphs in Potin (2022)

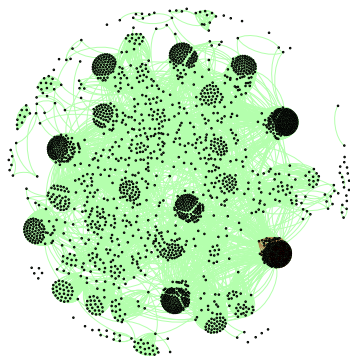


Figure: Structural anomalies detected

Nouvelle approche : trouver des structures dans les graphes liées à des comportements redflags et non redflags

- Construction d'une collection de graphes redflags (\mathcal{G}_r) et non redflags (\mathcal{G}_{nr}).
- Identification des sous graphes discriminants dans chaque collection (\mathcal{P}_r et \mathcal{P}_{nr})
- Représentation des graphes via ces sous graphes
- Classification des graphes en redflags ou non redflags, sans connaissance de l'existence des redflags.

Identification de motifs discriminants:

Entrée: Ensemble de graphe $\mathcal{G} = \mathcal{G}_r \cup \mathcal{G}_{nr}$

Sortie: Ensemble de motifs $\mathcal{P} = \mathcal{P}_r \cup \mathcal{P}_{nr}$

Recherche de motifs:

Entrée: Ensemble de graphe \mathcal{G}

: Ensemble de motifs \mathcal{P}

Sortie: Ensemble de vecteurs booléens \mathcal{X} , tel que $X_{ij} = 1$

: si le motif P_j est présent dans le graphe G_i

Classification:

Entrée: Ensemble de vecteurs booléens \mathcal{X}

Output: Associer à chaque vecteur un label redflag ou non redflag

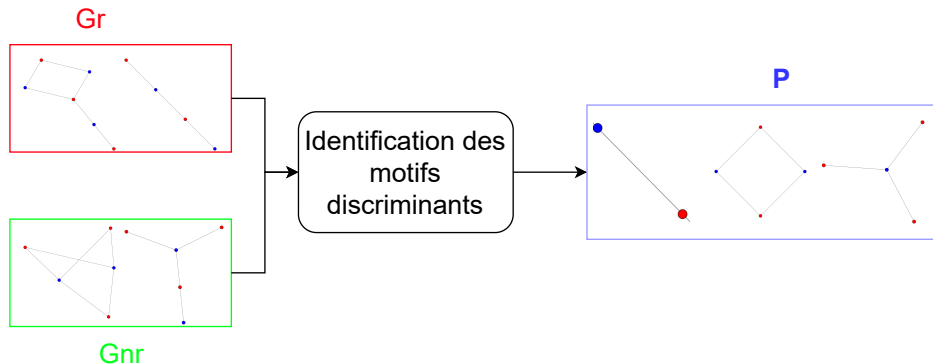
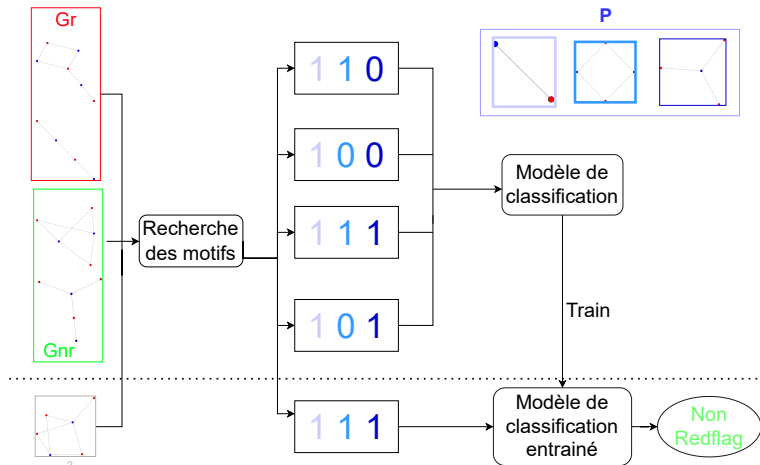


Figure: Partie identification des sous graphes

Work in progress

Predictive model



- Collection de 660 graphes (330 redflags et 330 non redflags)
- Filtrage sectoriel (marché de travaux), temporel (périodes d'un an), et géographique (départemental).
- Méthode de recherche de motifs : TKG.
- Méthode de classification : Random Forest

Work in progress

Predictive model

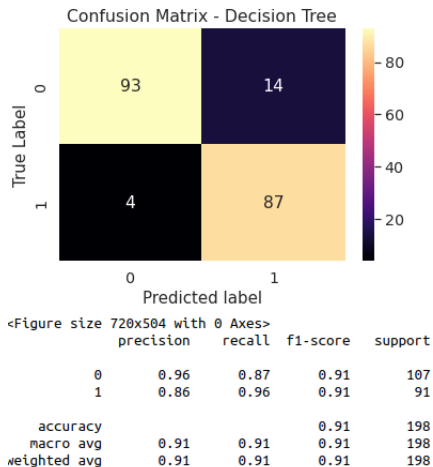





Figure: Résultats

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