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# 1 The drivers of the nutritional quality and carbon footprint of school menus in 2 the Paris area

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4

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7 **Abstract:** Public school food procurement has been identified as a key lever in the transition towards  
8 sustainable food systems. In this study, we assess the nutritional quality and the carbon footprint of 2020  
9 school menus served in 101 municipalities in the inner suburbs of Paris. In this sample, school canteens menus  
10 meet an average 8.2/15 (min = 4, max = 14) adequacy score to the regulatory nutritional quality frequency  
11 criteria and their carbon footprint averages at 1.9 (min = 1.2, max = 2.6) kgCO<sub>2</sub>e/day. The nutritional and  
12 environmental qualities of canteen menus were not correlated with each other. In-house canteens have a  
13 significantly higher nutritional quality - 0.7 more points – and so do larger canteens. The carbon footprint  
14 significantly decreases with an increasing education level of the population and, for in-house canteens, it also  
15 decreases by 0.16 kgCO<sub>2</sub>e/day with a ten-fold increase in canteen size and by 0.0035 kgCO<sub>2</sub>e/day per percent of  
16 left-wing vote, breaking even with delegated canteens above 3,500 enrolled children and 53% of left-wing vote  
17 respectively. The frequency of certified food (mean = 18%, min= 0%, max=51%), a cornerstone of the 2018  
18 national law aiming at more sustainable institutional catering, has no impact on our indicators of nutritional  
19 quality and carbon footprint. The substantial variations between canteens in both nutritional and  
20 environmental qualities suggests that there is room for improvement on both ends.

21 **Keywords:** green public procurement, public school food procurement, food sustainability, school canteen  
22 menus, nutrition.

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36

## 37 **1 Introduction**

38 Current food systems have unsustainable impacts on both climate change and human health. With  
39 regard to climate change mitigation, the global food system is responsible for 28 % of global  
40 emissions, two thirds of which stem from animal products (Rogissart, Foucherot, and Bellassen  
41 2019). Concerning human health, half of Europeans over 18 years of age were overweight (36%) or  
42 obese (16%) in 2014 (Eurostat 2016), increasing morbidity, mortality as well as loss of self-esteem  
43 and self-confidence.

44 There is a growing interest from policy makers to address these environmental and nutritional  
45 challenges through public food procurement strategies. This is particularly salient within the EU with  
46 regulatory initiatives developed by public authorities at various administrative levels (European,  
47 national, local) to drive food procurement towards more sustainable supply and demand patterns.  
48 Public procurement – representing 14% of EU GDP in terms of government spending – is an  
49 important instrument for promoting sustainable policy goals owing to its buying power (European  
50 Commission 2016). Public school food procurement accounts for 31% of the total value of food  
51 purchased by catering services in Europe (Boyano et al. 2019). In France, nearly 3 billion meals are  
52 served each year in schools, amounting to 7 billion euros of food purchases (Institut de la gestion  
53 déléguée 2019). These numbers demonstrate the pivotal potential of public-school food  
54 procurement in fostering sustainable food systems in Europe.

55 Policies promoting healthier environment in schools and pre-schools are already the cornerstone of  
56 the EU action plan looking for halting the rise of overweight and obesity among children (European  
57 Commission 2014). By 2017, all EU member states had implemented some policies with this purpose

58 (European Commission 2017). Successful strategies to improve children’s nutrition in school are the  
59 results of many reinforcing policies from voluntary to mandatory aiming at reducing unhealthy food  
60 availability while favouring healthy food provision and protecting schools from marketing activities  
61 (Kovacs et al. 2020). In addition, centralized school systems managed by national governments  
62 providing early compulsory education offer the highest potential thanks to their ability to set national  
63 standards and to reach all crucial ages for shaping food habits, from childhood and adolescence  
64 (Kovacs et al. 2020). On the environmental aspects, the European Commission introduced in 2004 a  
65 green public procurement (GPP) scheme as a tool to reduce the environmental impacts of public  
66 procurement (European Commission 2016). GPP is able to influence both the production and  
67 consumption sides by stimulating the demand for more environmental-friendly goods and services  
68 (Testa et al. 2012). While GPP in public school food procurement is not yet widespread in Europe,  
69 pioneer initiatives in some municipalities have shown that reducing meat consumption and requiring  
70 a shift from conventional to organic products or integrated production system are promising ways to  
71 reduce the carbon footprint (Cerutti et al. 2016; 2018; Tregear et al. 2019).

72 In France, recent policy instruments have been designed to enhance the sustainability of public food  
73 procurement. In 2011, a decree set up mandatory nutritional quality criteria for school meals,  
74 establishing for instance a minimal frequency to serve vegetables and fruit (Décret n° 2011-1227). A  
75 2015 law committed canteens to fight against food waste (LOI n° 2015-992) and in 2018, the EGALIM  
76 law incentivized experimental vegetarian menus once per week. In addition, this law set specific  
77 targets on food purchase in public collective catering, including public schools. By 2022, the food  
78 procured must contain 50% of products certified by a public label (PDO/PGI, “Label Rouge” certifying  
79 higher quality products, etc. ) with a minimum of 20% of organic products (LOI n° 2018-938).

80 Because canteen menus are so pivotal in policies aiming at improving the sustainability of diets,  
81 identifying which factors help canteens in designing more sustainable menus becomes a key  
82 question. The contribution of this paper towards answering it is twofold. First, it develops a method  
83 to measure the carbon footprint and nutritional quality on the sole basis of school menus. While less

84 accurate than the list of ingredients and the quantity used for each meal, it allows us to substantially  
85 enlarge sample size compared to comparable studies and is more easily replicable. The other main  
86 innovation of the present study is to investigate for the first time the determinants of the nutritional  
87 quality and carbon footprint of contemporary school menus. In particular, we assess the relative  
88 merits of the two main governance modes for school catering management: direct management by  
89 municipalities (*in house* provision) versus outsourcing the catering service (delegated provision)..

90 The paper is structured as follows. The first two sections present the literature background on the  
91 school canteen meal quality enabling us to formulate hypotheses on its determinants. The following  
92 two sections describe the data and methodological approach used to evaluate both nutritional  
93 quality and carbon footprint of canteen meals. The results of the analysis are then presented and  
94 discussed. In a last section, recommendations for procurement policies are drawn from our findings.

## 95 **2 Literature Review**

### 96 **2.1 Nutritional nutritional quality and carbon footprint of canteen menus**

#### 97 **2.1.1 Carbon footprint of canteen menus**

98 In the studies identified, the agricultural production step is responsible for 60-70% of the carbon  
99 footprint of canteen menus (Table 1). Most studies highlight the presence of animal products and  
100 especially red meat in canteen menus as the main determinant of their carbon footprint (between  
101 40% and 50% on average, see Table 1). Substituting plant-based ingredients for animal products is  
102 therefore considered as an effective way to reduce GHG emissions (Takacs and Borrion 2020).  
103 Introducing food from organic practices does not necessarily reduce the carbon footprint of canteen  
104 menus: while the carbon emissions per hectare are undisputedly lower in organic systems, the  
105 impact per kilogram of product is often similar to conventional production due to lower yields in  
106 organic systems (Bellassen et al. 2021; Meier et al. 2015; Mondelaers, Aertsens, and Van

107 Huylenbroeck 2009; Tuomisto et al. 2012). Interventions addressing other food processing stages  
108 (food storage, preparation and waste management) such as cooking methods prioritizing a cook-  
109 warm system (Fusi, Guidetti, and Azapagic 2016), technologies saving water and energy (Mudie and  
110 Vadhati 2017) and low carbon disposal methods such as anaerobic digestion, composting and animal  
111 feed (Tregear et al. 2019) have lower mitigation potentials (Takacs and Borrion 2020). Accordingly,  
112 these levers are not considered here.

113 **Table 1:** Mean GHGE value school meal in previous studies

Authors	Places	Sample size	Period	School level	Mean GHGE value per school meal (kgCO <sub>2</sub> e)	Min GHGE value per school meal (kgCO <sub>2</sub> e)	Max GHGE value per school meal (kgCO <sub>2</sub> e)	Share of the meat components in the carbon footprint
Eco2 Initiative (2020)	Paris	n=1	/	Primary school	1.8 kgCO <sub>2</sub> e	/	/	/
Cerutti et al (2018)	Turin	n=1	1 year	Secondary school	1.67 kgCO <sub>2</sub> e	/	/	39%-51%
Wickramasinghe et al. (2016)	United Kingdom (UK)	n=139	1 week	Primary school	0.72 kgCO <sub>2</sub> e	0.52 kgCO <sub>2</sub> e	1.34 kgCO <sub>2</sub> e	41.5%
Jungbluth et al. (2016)	Switzerland	n=240	1 year	/	4.1 kgCO <sub>2</sub> e	/	/	48%
Tregear et al. (2019)	Croatia, Greece, Italy, Serbia, UK	n=10	1 or 2 weeks	Primary school	/	0.84 kgCO <sub>2</sub> e	2.14 kgCO <sub>2</sub> e	21%-43%
ADEME. (2016)	France	n=14	3 days	Primary school (n=1), secondary school (n=2), high school (n=2), university (n=1), other (mass catering in the health and private sector, n=8)	2,65 kgCO <sub>2</sub> e	0.9 kgCO <sub>2</sub> e	5.7 kgCO <sub>2</sub> e	/
De Laurentiis et al. (2017)	UK	n=136	2 weeks	Primary school	1.02 kgCO <sub>2</sub> e	/	/	52%
Battle-Bayer et al.(2021)	Spain	n=7	1 week	High school	/	< 2 kgCO <sub>2</sub> e	> 12 kgCO <sub>2</sub> e	/
González-García et al.(2021)	Spain	n=1	2 weeks	Pre-school	1.26 kgCO <sub>2</sub> e	0.75 kgCO <sub>2</sub> e	2.95 kgCO <sub>2</sub> e	/
Martinez et al.(2020)	Spain	Baseline menu based on 88 dishes	/	Pre and primary school	1.2 kgCO <sub>2</sub> e	/	/	/

### 114 **2.1.2 Nutritional quality of canteen menus**

115 Food nutritional guidelines are often only partly implemented by canteen managers (Brennan et al.  
116 2019; Woods et al. 2014; Vieux et al. 2018). The complexity of guidelines, lack of human resources  
117 and knowledge are often identified as significant barriers: classifying food products and dishes into  
118 food groups is a necessary step which is reported to be challenging (Ardzejewska, Tadros, and Baxter  
119 2013; Downs et al. 2012; Girona et al. 2019; Pettigrew et al. 2014). In addition, the absence of strong  
120 legal sanctions or monitoring mechanisms does not provide incentives to canteen managers to  
121 modify canteen menus (Girona et al. 2019; Woods et al. 2014). Socio-economic factors - e.g. pupils'  
122 demands, religious or cultural food habits, lack of parental support, and psychological resistance, e.g.  
123 food neophobia, etc. - can generate additional barriers (Ardzejewska, Tadros, and Baxter 2013; Cho  
124 and Nadow 2004; Downs et al. 2012; Pettigrew et al. 2014). Finally, financial constraints on canteen  
125 budgets have been shown to negatively affect nutritional quality, because healthy food tends to be  
126 more expensive (Bell and Swinburn 2004; Billich et al. 2019; Downs et al. 2012).

### 127 **2.1.3 Interactions between nutritional and environmental quality of diets**

128 Studies based on optimized diets or *ad hoc* change in diets show that adopting healthier diets can  
129 also lead to a reduction in GHG emission (Doro and Réquillart 2020; Macdiarmid et al. 2012; Tukker  
130 2011; Westhoek 2014; Kesse-Guyot et al. 2020). However, reduction in GHG emissions while  
131 sustaining nutritional adequacy requires significant changes in diet composition: substitutions  
132 between food product categories (substituting animal with plant-based products) and within food  
133 product categories (substituting red meat with other animal products) (Doro and Réquillart 2020).  
134 Substituting plant-based products for animals should however be cautiously implemented as the  
135 health consequences of the shift are equivocal. On the one hand, low-meat meals reduce the risks of  
136 disease associated with protein and fats from animal products such as colorectal cancers (Chan et al.  
137 2011; Pan et al. 2012), cardiovascular diseases and stroke (Westhoek 2014) and provide higher



138 amounts of fibre and phytonutrients (Aleksandrowicz et al. 2016)<sup>6</sup>. On the other hand, plant-based  
139 diets in school canteens can pose serious nutritional challenges for some key nutrients (e.g., vitamin  
140 B12, vitamin D and DHA) which must be addressed when composing plant-based menus (Poinsot et  
141 al. 2020; Vieux et al. 2018).

142 To the best of our knowledge, only one study has assessed empirically the interaction between  
143 nutritional quality and carbon footprint in the specific case of canteen menus (K. K. Wickramasinghe  
144 et al. 2016). It showed that reducing greenhouse gas (GHG) emissions in canteens can compromise  
145 nutritional quality of school meals. Other studies using optimization methods manage to design  
146 optimal canteen menus ensuring nutritional adequacy while reducing carbon footprint (Benvenuti et  
147 al. 2016; Ribal et al. 2016; Eustachio Colombo et al. 2019).

## 148 **2.2 Potential drivers of nutritional and environmental quality of schools' menus**

### 149 **2.2.1 Organizational factors**

150 Previous economic literature on the relative performance of “in-house” versus delegated public  
151 service provision provides mixed results (O. Hart, Shleifer, and Vishny 1997; Hirsch 1995). Private  
152 firms produce goods more efficiently (in terms of production costs) than “in-house” mode because  
153 outsourcing provides high-powered incentives to cut costs (Andersson, Jordahl, and Josephson 2019)  
154 and private caterers can more easily reach economies of scale because they simultaneously serve  
155 several clients. However, this cost-efficiency can be counteracted by transaction costs in the design,  
156 implementation and monitoring of contractual arrangement (Andersson, Jordahl, and Josephson  
157 2019; O. Hart 2003). In addition, the selection of contractors is complex, exposing public bodies to  
158 the “winner’s curse” (Engel, Fischer, and Galetovic 1997) or aggressive bids (Guasch and Straub  
159 2009); adapting the initial contract to unforeseen contingencies and the resulting renegotiation can

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<sup>6</sup> In addition, a reduction in livestock production has indirect health benefits such as lower use of antibiotics (Marshall and Levy 2011), improved water quality (nitrates) (Powlson et al. 2008) and also air quality (particulate matter)(Moldanová et al. 2011).

160 also be costly (Saussier, Staropoli, and Yvrande-Billon 2009). Finally, Hart et al. (1997) suggested that  
161 the incentive power linked to the delegation decision may have detrimental effects on the quality of  
162 the good provided, in particular when this quality cannot be fully specified in the initial contract.  
163 When applied to institutional catering, this literature is inconclusive. Poor delegated contract  
164 performances explained by adverse selection, moral hazard and contract incompleteness, leading to  
165 poor quality of school catering service delivered by large private companies has been reported  
166 (Maietta and Gorgitano 2016). Similarly, in-house provision of catering services can be plagued by  
167 lack of financial and human resources, and administrative rigidities. The lack of staff with knowledge  
168 and skills is a key barrier to implement nutritional guidelines (Downs et al. 2012; MacLellan, Taylor,  
169 and Freeze 2009) and small in-house canteens are less likely to have enough resources to hire a full-  
170 time nutritionist (Cour des comptes 2020).

### 171 **2.2.2 Certified products frequency**

172 As mentioned previously, introducing food from organic practices does not necessarily reduce the  
173 carbon footprint of canteen menus because of lower yields in organic systems (see Section 2.1.1).  
174 However, the literature highlights that organic food sourcing of school canteens is connected with  
175 healthier and less carbon intensive dietary patterns by driving changes in meal composition (less red  
176 meat and more fruits and vegetables). Treagear et al. (2019) finds a lower carbon footprint of school  
177 canteen menus where school procurement encourages local or organic sourcing. Moreover, canteens  
178 providing a great quantity of organic food have been reported to provide menus with a higher  
179 nutritional quality (He, Løes, and Mikkelsen 2010; He and Mikkelsen 2014; Lassen et al. 2019; B.  
180 Mikkelsen et al. 2006). One reason was that “green” caterers were more conscious about the  
181 nutritional composition of their menus because they offered significantly more in-service training to  
182 implement organic foods successfully. This additional training was needed to successfully process  
183 organic food and increase the share of vegetarian dishes so that savings from lower meat purchases  
184 balance the price premium of organic products (B. Mikkelsen et al. 2006).

### 185 **2.2.3 Political affiliation**

186 Political affiliation refers to both the political sensitivity of individual citizens, or related pressure  
187 groups, and the political affiliation of the elected officials. Citizens who consider themselves close to  
188 the left are more likely to support environmental positions (Neumayer 2004) and have a higher  
189 willingness-to-pay for environmental good improvements (Li et al. 2009; Solomon and Johnson  
190 2009). Hence, it is more likely that the parents (or parental associations) in left municipalities  
191 pressure local public officers and caterers to reduce GHG emissions. Similarly, the commitments and  
192 priorities of public officials at the municipal level are identified as a key determinant in overcoming  
193 the constraints of green public procurement (Brammer and Walker 2011; Filippini et al. 2018; B. E.  
194 Mikkelsen and Sylvest 2012). We can therefore presume that left-oriented public officials could be  
195 more inclined to commit to green public procurement by allocating more resources and relying on  
196 other criteria than price during tendering processes. The effect of political affiliation can interact with  
197 the management mode: right-wing individuals express a higher willingness-to-pay for environmental  
198 goods only when public procurement is outsourced, possibly due to a higher trust in private  
199 organisation/market solutions (Dupont and Bateman 2012).

### 200 **2.2.4 Canteen size**

201 Thorsen et al. (2009) show that the larger the canteens in terms of number of lunches served, the  
202 healthier the menus they provide due to better access of employees to health promotion  
203 programmes. Similarly, Wagner et al. (2007) highlight the key role of staff training enabling canteens  
204 to provide healthy foods without additional costs. Finally, large municipalities have potentially more  
205 staff to organize the catering services and dedicate resources to improve its sustainability. During the  
206 interviews conducted for this study, caterers and nutritionists indicate that larger in-house canteens  
207 are also more likely to hire a nutritionist to design their menus thanks to economies of scale while  
208 delegated canteens employ nutritionists in their headquarters which then interact with decentralized  
209 canteen managers in various ways (Canteen managers 2020). However, Maietta and Gorgitano

210 (2016) find that large private catering firms provide poorer quality services as they adopt predatory  
211 pricing strategies in order to win contracts.

### 212 **2.2.5 Parent's educational level**

213 Parents influence the food habits and dietary behavior of pupils by providing healthy food and high  
214 quality diet at home (van Ansem et al. 2013; Birch and Davison 2001; Haines et al. 2019). This role  
215 requires knowledge and motivation that parents with higher socio-economic status and higher  
216 educational attainment are more inclined to fulfil (K. H. Hart et al. 2003). They demonstrate a  
217 stronger environmental awareness (Aminrad, Zakaria, and Hadi 2011) and a lower consumption of  
218 red and processed meat in affluent countries (Gossard and York 2003). Families with higher  
219 education levels also more often opt for letting their children eat at school (Decataldo and Fiore  
220 2018). In addition, they have a higher propensity to get involved in a pressure group (like parental  
221 associations) influencing both the nutritional (Ardzejewska, Tadros, and Baxter 2013; Cho and Nadow  
222 2004; Clelland, Cushman, and Hawkins 2013; Downs et al. 2012) and environmental quality of meals  
223 in canteens (Cho and Nadow 2004; Dědina, Šánová, and Kadeřávková 2014; Filippini et al. 2018).  
224 Parents with higher socio-economic status are more likely to push toward a healthy diet at school for  
225 their children (K. H. Hart et al. 2003).

## 226 **2.3 Empirical hypotheses**

227 Based on this literature review, five key hypotheses are spelled out and tested.

### 228 ***Hypothesis 1.A – In-house school canteen management provides menus of higher nutritional quality***

229 As mentioned in section 2.2.1, the literature on the impact of the management mode on the  
230 nutritional and environmental quality of school menus is equivocal. High incentives to save costs at  
231 the expense of quality and poor contract performances could drive down the nutritional and  
232 environmental quality of delegated canteens but this could be balanced by lack of trained personnel  
233 in smaller “in-house” canteens. We assume that the first effect is strongest.

234 **Hypothesis 1.B** – *Delegated canteens management provide menus of lower carbon footprint*

235 High incentives to save production and procurement costs in outsourced situations may incite  
236 caterers to substitute expensive meat products with cheaper plant-based products.

237 **Hypothesis 2** – *A higher frequency of certified foods in school menus is associated with a lower  
238 carbon footprint and better nutritional quality*

239 Procurement contracts favoring certified foods are associated with more service training efforts  
240 improving nutritional quality and reducing meat products (and waste) to balance the price premium  
241 of certified products such as organic foods.

242 **Hypothesis 3** – *Left-wing votes in municipal elections are associated with a lower carbon footprint of  
243 school canteen menus, in municipalities with in-house provision.*

244 Left-wing voters represent a higher support for local policy-makers to introduce environmental-  
245 friendly initiatives in canteens, especially in municipalities with “in-house” canteens.

246 **Hypothesis 4** – *Municipalities with a population of higher education level provide school canteen  
247 menus associated with a higher nutritional quality and a lower carbon footprint*

248 Higher education level is related to healthier eating habits, higher environmental and health  
249 awareness, lower meat consumption and a higher use of school canteen which can lead to higher  
250 parental support to introduce more sustainable food in canteens.

251 **Hypothesis 5** – *Larger in-house canteens are associated with higher nutritional quality and lower  
252 carbon footprint*

253 **3 Municipalities with a larger number of pupils in elementary**  
254 **schools can dedicate more resources to organize the food**  
255 **catering service. In particular, they are more likely to hire**  
256 **nutritionists and to provide their staff with training on health**

## 257 **and environmental issues.The procurement of school meals in** 258 **France**

259 In France, institutional catering for pre and primary schools (pupils between 3-11 years old) is under  
260 the administrative responsibility of municipalities. However, 11 % of municipalities, mostly the  
261 smallest ones, chose to transfer this responsibility to an intercommunal association where several  
262 municipalities cooperate to provide meals to their public schools (Institut de la gestion déléguée  
263 2019). Two management modes exist to organize the catering service. First, municipalities adopting  
264 in-house provision manage the entire school meal service themselves. They elaborate the menus,  
265 organize food procurement, hire and manage the personnel and build and maintain facilities  
266 necessary for cooking and serving food. Food suppliers are selected through awarding procedures  
267 complying with the national Code of Public procurement, involving public tender<sup>7</sup>. In 2019, 52% of  
268 French canteens were operated in-house (Institut de la gestion déléguée 2019). Second,  
269 municipalities can choose to delegate the catering service to, most of the time, a private contractor  
270 through competitive tenders where the contractor's remuneration is linked to its activity.  
271 Sometimes, delegated provision is further subdivided into delegated provision where the  
272 contractor's remuneration is linked to its activity and bears the risk of fluctuating numbers of meals  
273 and public market provision where the contractor is remunerated by the municipality according to its  
274 cost. Municipalities have an indirect influence on the quality of canteen menus by designing the call  
275 for tender thereby defining the set of criteria used to assess the various bids received from the  
276 potential suppliers (the price being only one of them), and through negotiating specific contractual  
277 provisions with the selected operator.

278 French school canteen management is the subject of various recommendations and regulations. On  
279 the nutrition side, the entire institutional catering sector (both public and private) is the subject of  
280 national guidelines elaborated since 1999 by the *Groupe d'Etude des Marchés Restauration Collective*

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<sup>7</sup> National regulation in public procurement is derived from the European Union directive 2014/24. The main principles are transparency of the procedures, equal and free access to public markets. For more details, see: [https://ec.europa.eu/environment/gpp/eu\\_public\\_directives\\_en.htm](https://ec.europa.eu/environment/gpp/eu_public_directives_en.htm)

281 *et Nutrition* (GEM-RCN, public catering and nutrition market study group). This group is made of  
282 representatives of various relevant stakeholders involved in the catering sector under the auspice of  
283 the French Ministry of Economy. The broad goal is to promote healthy eating behaviors and to  
284 prevent obesity. GEM-RCN defines the general format of meals and sets adequate portion sizes of  
285 the dishes according to three different age classes<sup>8</sup>. It also sets the maximal and minimal frequency  
286 of a set of 15 food groups in a series of 20 consecutive lunches. For example, canteens must serve  
287 fruits or vegetables as starters or side dishes at least 10 times and red meat as a protein dish at least  
288 4 times (Table 5). This voluntary guidance became mandatory in 2011 (Décret n° 2011-1227). On the  
289 environmental side, the food procured must contain 50% of products certified by a public label with  
290 a minimum of 20% of organic products by 2022 (LOI n° 2018-938). In addition, the EGALIM law  
291 incentivized experimental vegetarian menus once per week.

## 292 **4 Material and method**

### 293 **4.1 Sample and data gathering**

294 Primary school canteen menus were downloaded from the web sites of the 123 municipalities of the  
295 inner suburbs of Paris (Ile-de-France region) over a period of 20 days at school in November 2018  
296 (see map in Annex 1. 1). For 33 municipalities, we identified at least one other municipality offering  
297 similar menus on the same days, thereby indicating an intercommunal cooperation in charge of  
298 school canteens (Annex 1. 2). These municipalities were therefore regrouped into one of the  
299 corresponding 11 intercommunal associations, reducing the sample size to 101 municipalities or  
300 intercommunal associations (hereafter municipalities). For these intercommunal associations, the  
301 simple average over their constitutive municipalities of the independent variables – left-wing vote,  
302 educational attainment, ..., was used. The database thus includes the name of 10,816 different dishes  
303 belonging to one of the five meal components: starter, protein dish, side dish, dairy product, and

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<sup>8</sup> The three age classes correspond to pre-school, primary school and both secondary and high school levels. This study is based on guidelines designed for elementary schools.

304 dessert (full database available in Annex 2. 1). All menus also indicate the presence of products with  
305 a public certification (organic, protected designation of origin (PDO), protected geographical  
306 indication (PGI) and label rouge products (a public certification on the high quality of the product)) as  
307 well as the non-certified “local” origin of dishes. Sometimes, canteens offer a choice between two or  
308 three dishes for the same component. This kind of alternative occurred on 20% of days for the main  
309 course, most often with a choice between pork or poultry, or a vegetarian option or fish alternative  
310 to meat (Annex 1. 3). Alternatives are seldom offered for the other meal components.

## 311 **4.2 Dependent variables**

312 Our dependent variables are continuous measures that capture the nutritional and environmental  
313 quality of canteen meals. The environmental impact of school menus is assessed through their  
314 carbon footprint for two reasons. First because climate change is arguably one of the most pressing  
315 environmental challenges of the 21st century and second because GHG emissions are correlated with  
316 most environmental impacts such as eutrophication, acidification and energy use (Röös et al. 2013).  
317 The nutritional quality of canteen menus is assessed through their conformity to the 2011 national  
318 nutritional guidelines, namely, the extent to which each of the 15 GEM-RCN’s frequency criteria (FC,  
319 see section 3) are fulfilled, as in Vieux et al (2018).

### 320 **4.2.1 Carbon footprint**

321 The carbon footprint of canteen menus is assessed in three steps. First, a list of 38 categories of  
322 dishes with homogeneous carbon footprint is designed (Table 2). The 38 categories and the carbon  
323 footprint of each of their ingredient (Table 2) are based on the Etiquettable tool developed by ECO2  
324 initiative. The categories were designed to be both relevant to canteen managers and homogeneous  
325 in terms of carbon footprint (eg. main dish with more than 70 % of red meat, starter with more than  
326 50 % of raw vegetable or fruit, ...). In particular, they either coincide with - or can be merged into - a  
327 nutritional category as specified by GEM-RCN (Table 2). We control their homogeneity by ensuring,  
328 based on Agribalyse 3.0, that the standard deviation of a given category did not exceed 25 % of its



329 average (Annex 1. 4). For each category, a typical composition – types of ingredients and associated  
 330 quantities – has been determined based on the detailed ingredient lists of dishes served in school  
 331 canteens from the 9th and 10th districts of Paris. For example, a typical dish of the category “raw  
 332 vegetable and cheese with less than 150 mg of calcium per portion” is estimated to contain 40 g of  
 333 raw vegetable, 20 g of cheese and 14 g of dressing (Table 2). The carbon footprint of each ingredient  
 334 type is then estimated by selecting a set of representative actual ingredients (e.g. raw vegetables are  
 335 represented by an equal share of tomatoes, carrots, and lettuce), and computing their average  
 336 carbon footprint from the Agribalyse 3.0 database (Agribalyse 3.0 2020). The GHG emissions from  
 337 the transportation step were reassessed by Eco2 initiative according to the actual provenance of  
 338 food in the Parisian canteens they surveyed and are also used for the present analysis. Second, each  
 339 dish is assigned to a single category based on its name, resulting in the “activity data”, here the  
 340 number of times a given category is served in each municipality. Finally, the average carbon footprint  
 341 of school menus is estimated from the combination of the carbon footprint of food ingredients and  
 342 activity data (Equation 1). Equation 1 shows that average carbon footprint of school menus sums the  
 343 carbon footprint of the food ingredients multiplied by the mass of food served (dish share) for the 38  
 344 categories.

345 **Equation 1:**

$$Menu\ Emissions_{d,j} = \sum_{k=1}^5 \sum_{i=1}^{38} dish\_share_{kij_d} \times Carbon\ footprint\ of\ food\ ingredients_{ki}$$

346 where Menu Emissions<sub>j</sub> are the emissions of the menu on day d in city j, dish\_share<sub>kij<sub>d</sub></sub> is the share of  
 347 food category i in dishes category k served on day d (either 0 or 1, except when the canteen offers  
 348 alternatives for a given dish, see Annex 1. 3 and Annex 1. 5), and finally  
 349 Carbon footprint of food ingredients<sub>ki</sub> is the carbon footprint of food ingredients of food  
 350 category i of dish category k.

351

352

353 **Table 2:** Carbon footprint of ingredients (CFI), GEM-RCN equivalence and portion size for each of the 38 food categories served in school canteen, based on  
 354 their three main ingredients

Component	GEM-RCN equivalence (Simplified FC name)	Categories used in the environmental classification	Ingredient 1	Quantity 1 (g)	CFI 1 (gCO <sub>2</sub> /g)	Ingredient 2	Quantity 2 (g)	CFI 2 (gCO <sub>2</sub> /g)	Ingredient 3	Quantity 3 (g)	CFI 3 (gCO <sub>2</sub> /g)	Total Quantity (g)	Emissions (gCO <sub>2</sub> e)	Rounded emissions (gCO <sub>2</sub> e)
Starter	Raw fruits or vegetables starters	Raw vegetables	Vegetables	70	0,92				Sauce	14	2,06	84	93	90
	Raw fruits or vegetables starters	Raw vegetables + cheese < 150 mg Ca <sup>9</sup>	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Raw fruits or vegetables starters	Raw vegetables + cheese > 150 mg Ca	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Other starters	Cuidité	Vegetables	70	0,92				Sauce	14	2,06	84	93	90
	Other starters	Cuidité + cheese < 150 mg Ca	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Other starters	Cuidité + cheese > 150 mg Ca	Vegetables	40	0,92	Cheese	20	5,68	Sauce	14	2,06	74	179	180
	Other starters	Cereals or pulses	Cereals / pulses	30	1,36				Sauce	14	2,06	44	70	70
	Other starters	Cereals or pulses + cheese < 150 mg Ca	Cereals / pulses	25	1,36	Cheese	20	5,68	Sauce	14	2,06	59	176	180
	Other starters	Cereals or pulses + cheese > 150 mg Ca	Cereals / pulses	25	1,36	Cheese	20	5,68	Sauce	14	2,06	59	176	180
	Fatty starters	vegetables/starches + Meat/fish/egg	Vegetable / starches	30	1,14	Meat / fish / egg	20	5,12	Sauce	14	2,06	64	165	170
Fatty starters	Meat/fish/egg mainly	Meat / fish / egg	35	5,12				Sauce	14	2,06	49	208	210	
Main dish	Red Meat	Ungrounded red meat >70%	Red meat	100	32,1				Sauce	20	3,25	120	3277	3280
	Other main dish	Grounded red meat >70%	Red meat	100	32,1				Sauce	20	3,25	120	3277	3280
	Other main dish	White meat > 70%	White meat	100	6,5				Sauce	20	3,25	120	720	720

<sup>9</sup>Despite they share similar emissions, we separate raw fruits or vegetables starters including cheese with more and less than 150 mg Ca

	Fish	Fish > 70%	Fish	90	6,2				Sauce	20	3,25	110	624	620
	Pre-processed dishes/Fatty protein dishes/ Fried dishes	Red meat < 70%	Red meat	70	32,1				Sauce	30	3,25	100	2346	2350
	Pre-processed dishes/Fatty protein dishes/ Fried dishes	White meat < 70%	White meat	70	6,5				Sauce	30	3,25	100	556	560
	Pre-processed dishes/Fatty protein dishes/ Fried dishes	Fish < 70%	Fish	60	6,2				Sauce	30	3,25	90	470	470
	Other main dish	Egg	Egg	90	2,6				Sauce	20	3,25	110	299	300
	Other main dish	Cheese	Cheese	70	5,7				Sauce	20	3,25	90	463	460
	Other main dish	Cereals/pulses association	Cereals / pulses	60	1,4				Sauce	20	3,25	80	147	150
	Other main dish	Soy	Soy	60	1,4				Sauce	20	3,25	80	147	150
	Other main dish	Cereals + eggs and/or dairy products	Cereals	30	1,4	Eggs and/or dairy products	50	4,62	Sauce	20	3,25	100	337	340
	Other main dish	Pulses + eggs and/or dairy products	Pulses	30	1,4	Eggs and/or dairy products	50	4,62	Sauce	20	3,25	100	337	340
Side dish	Pre-processed dishes	> 50% vegetables	Vegetables	83	0,9	Starches	17	1,4	Sauce	11	3,25	110	134	130
	Pulses or starches	> 50% potatoes	Vegetables	83	0,9	Starches	17	1,4	Sauce	11	3,25	110	134	130
	Pulses or starches	> 50% cereals	Starches	53	1,4	Vegetables	17	0,9	Sauce	11	3,25	80	122	120
	Pulses or starches	> 50% pulses	Starches	53	1,4	Vegetables	17	0,9	Sauce	11	3,25	80	122	120
Dairy product	Soft cheese	Cheese < 150 mg Ca	Cheese	25	5,7							25	142	140
	Hard cheese	Cheese > 150 mg Ca	Cheese	25	5,7							25	142	140
	Non-cheese dairy product	White cheese	Yaourt and dairy desert	125	2,5							125	317	320
	Non-cheese dairy product	Yoghurt	Yaourt and dairy desert	125	2,5							125	317	320

Dessert	Raw fruit dessert	Raw fruit	Fruit	110	0,8							110	87	90
	Other dessert	Baked fruit	Fruit	110	0,8							110	87	90
	Sugary low-fat dessert	Biscuit/cake < 15% de mg	Dessert	40	2,6							40	105	100
	Fatty dessert	Biscuit/cake/pastry > 15% of fat	Dessert	40	2,6							40	105	100
	Non-cheese dairy product	Dairy desert	Yaourt and dairy desert	125	2,5							125	317	320
Bread	Bread	Bread	Bread	40	0,7							40	30	30

355 **4.2.2 Nutritional quality**

356 Four scores are used to evaluate the level of compliance with the FC. First, a “Global Compliance  
 357 Score” is defined as the sum of 15 binary sub-scores corresponding to compliance with each of the  
 358 15 FC. If the series of 20 meals complied with one criterion, a sub-score of 1 was assigned for these  
 359 criteria; if it did not comply, the sub-score was 0. The series of 20 school canteen menus for a given  
 360 municipality can therefore obtain a score ranging from 0 to 15 (Table 4). Second, the “Relative  
 361 Compliance Score” (RCS), which is used in our regression model, is proportional to the distance to  
 362 the FC, with a maximum of 1 when the criterion is met (Equation 2).

363 **Equation 2:**

$$RCS_i = \frac{\sum_{k=1}^{15} RCS_{i,k}}{15}$$

$$RCS_{i,k} = \begin{cases} 1 - \frac{\max(Obs\_freq_{i,k} - Rec\_freq_k, 0)}{Rec\_freq_c} & \text{if } Rec\_freq_k \text{ is a maximal frequency criterion} \\ 1 - \frac{\max(Rec\_freq_{i,k} - Obs\_freq_k, 0)}{Rec\_freq_c} & \text{if } Rec\_freq_k \text{ is a minimal frequency criterion} \\ 1 - \frac{|Obs\_freq_{i,k} - Rec\_freq_k|}{Rec\_freq_k} & \text{if } Rec\_freq_k \text{ is an exact frequency criterion} \end{cases}$$

364 where  $Rec\_freq_k$  and  $Obs\_freq_{i,k}$  are the GEM-RCN frequency criterion and the observed frequency in  
 365 municipality  $i$  respectively for food category  $k$ ,  $RCS_{i,k}$  is the Relative Compliance Score for food  
 366 category  $k$  in municipality  $i$  and  $RCS_i$  is Relative Compliance Score in municipality  $i$ .

368 For example, the category “starter containing more than 15% fat” should not be served more than  
 369 four times out of 20 meals (Table 5). A series containing four starters of this type thus scores 1 on the  
 370 two scores. However, a series that contained 5 starters of this type scores 0 in the “global  
 371 compliance score” and 0.75 in the relative compliance score.

372 Alternatively, the same two indicators are computed on a restricted number of four FCs (in bold in  
 373 Table 5) instead of the whole 15. The four FC are arguably the most important ones because they  
 374 have the highest nutritional values and concern costly food items often wasted by children (ADEME  
 375 2016). They are also the most reliable when detailed nutritional information is not available – as is

376 our case: for example, raw fruits to be crunched are unequivocally classified into the category « Raw  
377 fruit dessert » on the sole basis of the menu. By contrast, beef lasagne or moussaka is classified into  
378 «protein dishes with a ratio of protein over fat lower than 1» based on their typical nutritional  
379 content, but misclassification is possible if the actual recipe of the canteen differs from the typical  
380 recipe.

381 Dish frequency is obtained from the classification described above for the carbon footprint (Table 5).  
382 For example, the nutrition-based category “pulses, starches or grains, alone or in a mixture  
383 containing at least 50% pulses, starches or grains” (GEM-RCN frequency criterion) is obtained by  
384 summing the carbon emission-based categories “more than 50% potatoes”, “more than 50% cereals”  
385 and “more than 50% pulses”. Only three additional categories not considered in the environmental  
386 part were required to assess the 15 FC (fatty starters, fatty protein dishes and fried dishes). Note that  
387 some dishes do not count towards any of the 15 FC such as *cuidité*<sup>10</sup> or meat dishes with more than  
388 70% of white meat.

### 389 **4.2.3 Classification algorithm**

390 In order to assess the nutritional and environmental quality of the large number of dishes, a  
391 dedicated algorithm was developed using the R software to automatically classify them. Its rationale  
392 is based on the presence or absence of keywords in the names of dishes. First, the existence of  
393 alternatives is detected through the presence of “or”. Second, dish names are broken down into  
394 single words. These words were then “cleaned” (no upper case and no plural) and compared to two  
395 types of word lists for each category: one or two lists containing words that must be present and the  
396 other containing words that must be absent. For example, a main dish containing the word “beef”  
397 but not “lasagne” or “ground” is classified in the category “Unground beef, veal or lamb and offal”.  
398 As in this example, many of these rules are intuitive. However, some word combinations could not be  
399 intuitively classified. For example, classifying in “Vegetables, other than pulses, alone or in a mixture  
400 containing at least 50% vegetables” a “poêlée forestière” with potatoes, green beans and

---

<sup>10</sup> Cooked vegetable served cold as a starter.

401 mushrooms required the portion of potatoes with respect to green beans and mushrooms to be  
402 established. Similarly, the presence of “sausage” and the absence of any poultry-related word  
403 indicates the presence of red meat but whether it has a protein/fat ratio lower than one is not  
404 intuitive. In these ambiguous cases, we relied on the 2,500 technical files of school canteen dishes  
405 collected by Vieux et al. (2018) as a reference. The technical files were screened for possible  
406 correspondences with the ambiguous word combinations, and the word combinations were sorted in  
407 the most frequent category among the corresponding technical files. The code is provided in *Annex*  
408 *3. 1.*

409 Overall, this method enables us to substantially increase sample size at the cost of a few possible  
410 misclassifications of dishes into nutritional and environmental categories. Two quality checks were  
411 implemented to minimize the risk of classification error. A first automatic step consisted in checking  
412 that each dish was sorted into a single category. A second manual step consisted in checking that  
413 each category contained dishes which intuitively belong there.

### 414 **4.3 Explanatory variables**

415 Our sample of municipalities has similar socio-economic characteristics to the Ile-de-France NUTS2  
416 region to which it belongs, except for a slightly more pronounced left-wing orientation (Table 3). It is  
417 however substantially richer and better educated than the rest of France. Data on the management  
418 mode for school canteens (“in house” provision vs. outsourcing) and on the frequency of certified  
419 products were collected from the municipalities’ websites (propositions 1 and 2). To test proposition  
420 3, the vote shares for the first round of the 2014 municipal elections were aggregated into left (left-  
421 oriented: from diverse left to far left also including the Greens) and right (right-oriented: from the  
422 centrists to the far right, see Annex 1. 6 for details). For proposition 4, we relied on data from the  
423 National Statistical Institutes (INSEE). The educational level was measured as the proportion of the  
424 population with at least a second-year university level. Finally, for proposition 5, canteen size was  
425 approximated by the population of children enrolled in school between 6 and 10 years old (absolute

426 number). We cannot compare directly the average population aged between 6-10 years old with the  
 427 France and Ile-de France level because the different municipalities in intercommunal associations  
 428 were summed rather than averaged to capture the size effect of central kitchens.

429 **Table 3:** Descriptive characteristics of the involved municipalities and comparison with larger areas

Statistic	Mean	St. Dev.	Min	Max
In-house provision model	0.475			
Population aged between 6-10 years old (2017)	2,973	3,259	129	25,985
Average population aged between 6-10 years old (2017), Metropolitan France	116			
Average population aged between 6-10 years old (2017), Ile-de-France region	614			
Proportion of the population with a higher diploma (2017)	0.425	0.142	0.137	0.688
Average proportion of the population with a higher diploma (2017), Metropolitan France	0.299			
Average proportion of the population with a higher diploma (2017), Ile-de-France region	0.426			
Proportion of left-wing voters (2014)	0.386	0.246	0.000	1.000
Average proportion of left-wing voters (2014), Metropolitan France	0.332			
Average proportion of left-wing voters (2014), Ile-de-France region	0.290			

430

#### 431 **4.4 Model specification**

432 To test our propositions on the drivers of nutritional and environmental quality, an OLS specification  
 433 is used (Equation 3).

434 **Equation 3:**

$$Y_i = B_0 + B \cdot X_i + \varepsilon_i$$

435 where  $Y_i$  is either the nutritional quality (15 or 4 FC global or relative score) or the average carbon  
 436 footprint of menus in municipality  $i$ , and  $X_i$  is a vector of characteristics of municipality  $i$  used to test  
 437 the previously described propositions. The proportion of the population with a higher education



438 degree, which is strongly correlated with the median income<sup>11</sup> (Annex 1. 7), is used as a proxy of  
439 socio-economic level for Proposition 4. Where residuals are heteroskedastic (Breusch-Pagan test), a  
440 robust model using the bisquare weighting function is estimated in addition to the ordinary least  
441 squares (e.g. see Table 6 and Annex 1. 13).

## 442 **5 Results**

### 443 **5.1 Descriptive statistics of nutritional quality and carbon footprint**

444 On average, a municipality in our sample fulfilled 8.2 (min = 4, max = 14) out of the 15 FC (Table 4). A  
445 maximum frequency of 4/20 serving of “fried dishes” and a minimum of 8/20 serving of “Raw fruit  
446 dessert” are the FC most often met (Table 5). Criteria expressed by a strict equality (eg. 10 dishes  
447 containing at least 50% pulses, starches or grains or 10 dishes containing at least 50% vegetables”) are weakly respected as in Vieux et al. (2018). In addition, the minimal frequency of 8/20 servings of  
448 “hard cheese” (25.7% binary and 70.2% relative) and the maximum of 2/20 serving of “fatty protein”  
449 (22.8% binary and 37.9% relative) are also poorly met. Substantial (> 30 percentage points)  
450 differences are however identified with Vieux et al (2018) on the following six FC: “Raw fruits or  
451 vegetables starters”, “Pre-processed dishes”, “Hard cheese”, “Non-cheese dairy products”, “Sugary  
452 low-fat desserts” and “Fatty desserts” (Table 5).

454 According to interviews with kitchen managers and public caterers, the attendance of school  
455 canteens on Wednesday is six times lower than for the rest of the week<sup>12</sup>. We therefore tested the  
456 sensitivity of our results by removing the 4 Wednesdays of the 20-day period of analysis. We  
457 recalculate the expected frequency on the basis of 16 days. The compliance with the adjusted  
458 minimum frequency of 3.2 serving of red meat decreases dramatically with respect to the 20-day

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<sup>11</sup> Similar results were found when performing OLS regression with the median income rather than the education level.

<sup>12</sup> For most French elementary public schools’ children attend school only Wednesday morning.

459 period (Annex 1. 8 and Annex 1. 9), binary score: -43%, relative score: -12%) suggesting that caterers  
 460 are more inclined to serve expensive red meat on Wednesdays when fewer children eat at school.

461 The carbon footprint of canteen menus averages at  $1.9 \pm 0.24$  kgCO<sub>2</sub>e/day, with minimal and  
 462 maximal monthly averages at 1.2 and 2.6 kgCO<sub>2</sub>e/day respectively (Table 4). Meat dishes add up to  
 463 72% of the carbon footprint (Figure 1), which is higher with respect to the 40%-50% found in the  
 464 previous studies (Table 1) while no French comparisons exist.

465 Based on descriptive statistics, in-house canteens offered menus with a slightly better nutritional  
 466 quality than delegated canteens for the 15 FC relative score but not for the 4 FC scores (see Annex 1.  
 467 11). In-house and delegated canteens have a similar carbon footprint and delegated canteens serve  
 468 certified products slightly more often (21% against 15%, see Annex 1. 11).

469  
 470 **Table 4:** Nutritional quality and carbon footprint of school canteen menus

School canteen menu quality score	N	Mean	St. Dev.	Min	P25	P75	Max
Relative score (15 FC)	101	12.6	1.1	9.9	11.8	13.6	14.7
Binary score (15 FC)	101	8.2	1.9	3	7	9	13
Relative score (4 FC)	101	3.5	0.4	2.0	3.4	3.8	4.0
Binary score (4 FC)	101	1.4	0.8	0	1	2	4
Average emissions of canteen menus (kgCO <sub>2</sub> e)	101	1.88	0.243	1.17	1.72	2.02	2.59
Frequency of certified products	101	0.18	0.12	0.000	0.09	0.26	0.51

471  
 472  
 473 **Table 5:** The 15 frequency criteria for nutritional quality and the percentage of municipalities fulfilling  
 474 each criterion (global compliance score)

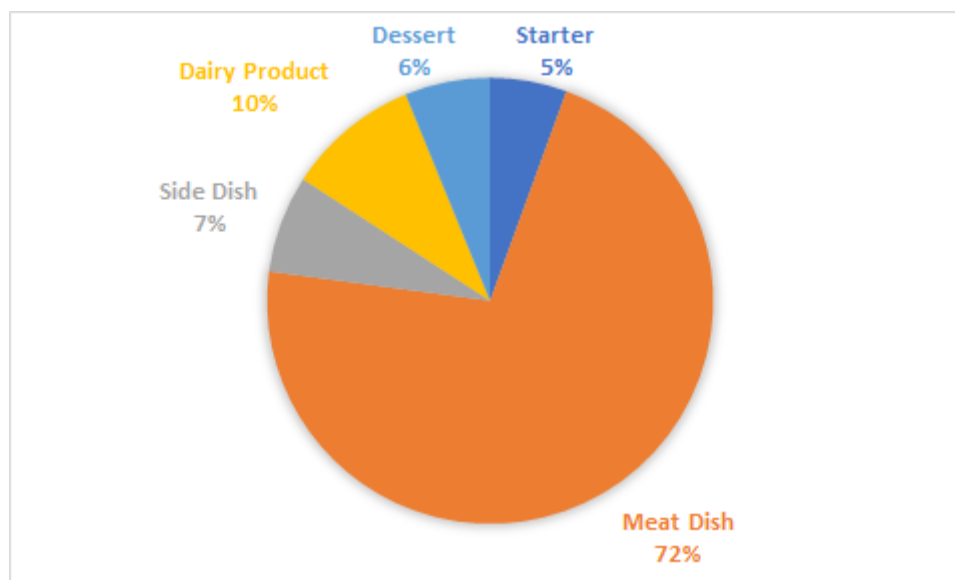
Frequency criterion (FC)	Simplified FC name	Component(s) concerned	Expected frequency	% of series fulfilling the criterion in the Paris Area (this	% of series fulfilling the criterion in France (Vieux et al., 2018)
--------------------------	--------------------	------------------------	--------------------	--	---

				<b>study)</b>	
Starters containing more than 15% fat	Fatty starters	starter	4/20 max	83,2%	82,5%
<b>Raw vegetable or fruit dishes containing at least 50% vegetables or fruits</b>	<b>Raw fruits or vegetables starters</b>	<b>starter, side dish</b>	<b>10/20 min</b>	<b>38.6%</b>	<b>70%</b>
Dishes to fry or pre-fried dishes containing more than 15% fat	Fried dishes	protein dish, side dish	4/20 max	98%	100%
Protein dishes with a protein/fat ratio lower than 1	Fatty protein dishes	protein dish	2/20 max	22,8%	55%
Fish or fish-based dishes containing at least 70% fish and having a protein/fat ratio higher than 2	Fish	protein dish	4/20 min	86%	60%
<b>Unground beef, veal or lamb, and offal</b>	<b>Red meat</b>	<b>protein dish</b>	<b>4/20 min</b>	<b>63,4%</b>	<b>77,5%</b>
Preparations or ready-to-eat dishes containing less than 70% of the recommended weight for the portion of meat, fish or eggs	Pre-processed dishes	protein dish	4/20 max	74,2%	25%
<b>Vegetables, other than pulses, alone or in a mixture containing at least 50% vegetables</b>	<b>Vegetable side dishes</b>	<b>side dish</b>	<b>=10/20</b>	<b>22,8%</b>	<b>27,5%</b>
Pulses, starches or grains, alone or in a mixture containing at least 50% pulses, starches or grains	Pulses or starches	side dish	=10/20	20,8%	27,5%
Cheese containing at least 150 mg of calcium per portion	Hard cheese	starter, dairy product	8/20 min	25,7%	77,5%
Cheese with a calcium content of more than 100 mg and less than 150 mg per portion	Soft cheese	starter, dairy product	4/20 min	73,3%	57,5%
Dairy (fresh dairy products, dairy-based desserts) containing more than 100 mg of milk calcium and less than 5 g of fat per portion	Non-cheese dairy product	dairy product, dessert	6/20 min	77,2%	40%
Desserts containing more than 15% fat	Fatty dessert	dessert	3/20 max	61,4%	95%
Desserts or dairy products containing more than 20 g of total	Sugary low-fat dessert	dairy product, dessert	4/20 max	41,6%	100%

simple sugars per portion and less than 15% fat					
<b>Raw fruit dessert 100% raw fruit without added sugars</b>	<b>Raw fruit dessert</b>	<b>dessert</b>	<b>8/20 min</b>	<b>93%</b>	<b>77,5%</b>

475 Legend: in bold, the 4 FC with a particular nutritional importance

476

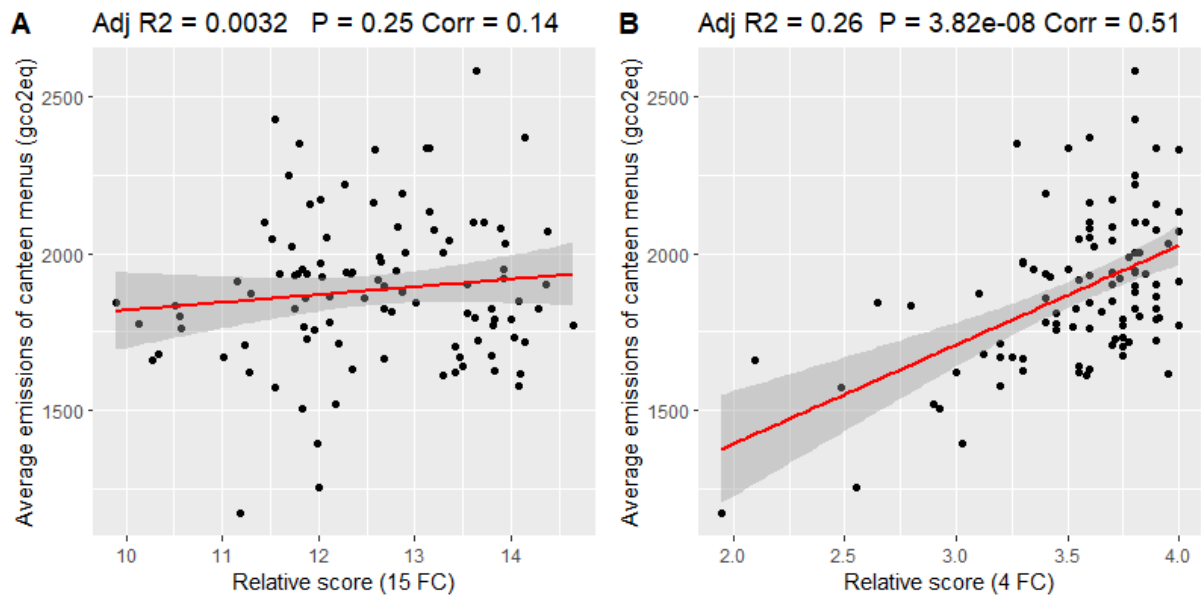


477 **Figure 1:** Share of greenhouse gas emissions (in percentage) by food component (average GHG  
478 emissions, 1.9 kgCO<sub>2</sub>e).  
479

480

## 481 5.2 Interactions between nutritional quality and carbon footprint

482 There is no correlation between nutritional quality and carbon footprint (Figure 2.A). However, when  
483 nutritional quality is restricted to the 4 FC score, nutritional quality and environmental performance  
484 are antagonistic (Figure 2.B.). This antagonism is mainly driven by the FC requesting a minimal  
485 frequency of four red meat dishes per cycle, which is less diluted in the 4 FC score. Interestingly,  
486 there is substantial variability in the carbon footprint of the menus with the highest nutritional  
487 quality (e.g. higher than 13, see Figure 2),



488

489 **Figure 2:** Correlation between carbon footprint and nutritional score

490

491 **5.3 Higher nutritional quality in municipalities with large and in-house canteens**

492 Only propositions 1.a and 5 on the management model and the canteen size are verified as  
 493 determinants of nutritional quality (Table 6, column 2): the nutritional quality of meals is significantly  
 494 higher in in-house municipalities – partial effect at the average (PEA) of 0.66-0.8 more points  
 495 compared to an average relative 15 FC score of 12.6 – and larger canteens (0.62 more points when  
 496 the number of pupils is multiplied by 10). Left-wing vote also seems to be associated with higher  
 497 nutritional quality but with a lower significance level, in particular when canteen size is controlled  
 498 for. The effects of parental education level and the frequency of certified products are not  
 499 significant. When nutritional quality is assessed by the 4 FC score instead of the 15 FC score, none of  
 500 the independent variables has a significant effect (Annex 1. 14).

501 **Table 6:** 15 FC relative score and its determinants (robust regression using Bisquare weighting  
 502 function; the table reports regression coefficients)

	<i>Dependent variable:</i>		
	Relative Score (15 FC) using bisquare weighting function		
	(1)	(2)	(3)
In-house provision	0.794*** (0.221)	0.666*** (0.221)	0.290 (1.635)
Frequency of certified products	-0.524 (0.873)	-0.924 (0.886)	-0.903 (0.896)
Proportion of the population with a high diploma	0.496 (0.838)	0.504 (0.825)	0.523 (0.831)
Proportion of the left-wing voters during the first round	1.171** (0.461)	0.804* (0.482)	0.808* (0.487)
log(Population of 6-10 years old enrolled)		0.617** (0.271)	0.552 (0.390)
In-house provision * log(Population of 6-10 years old enrolled)			0.116 (0.494)
Constant	11.719*** (0.468)	9.966*** (0.916)	10.157*** (1.256)
Observations	101	101	101
Residual Std. Error	0.955 (df = 96)	0.875 (df = 95)	0.880 (df = 94)
R <sup>2</sup>	0.347	0.400	0.399
Adjusted R <sup>2</sup>	0.319	0.369	0.361
F Statistic	7.0906*** (df = 4; 96)	6.9168*** (df = 5; 95)	5.6693*** (df = 6; 94)

Note:

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

503

#### 504 **5.4 Lower carbon footprint in municipalities with a higher education level and in-** 505 **house canteens of larger size**

506 On average, the management model has no impact on the environmental impact of menus (Table 7,  
507 column 1). However, this average result hides interactions with canteen size or left-wing vote. In-  
508 house canteens serving more than 3,500 pupils<sup>13</sup> indeed have a lower environmental impact (0.16  
509 kgCO<sub>2</sub>e less when the number of pupils is multiplied by 10, see Table 7, Annex 1. 15 and Annex 2. 1  
510 for the details of the calculations). Similarly, in-house canteens in left-wing municipalities (with more  
511 than 53% of left-wing votes) have a higher environmental quality (0.0035 kgCO<sub>2</sub>e less with a one  
512 percent increase of left-wing votes, see Table 7, Annex 1. 16 and Annex 2. 1). In addition, a lower  
513 carbon footprint of canteen menus is observed in municipalities with a better educated population  
514 (4,30-4,40 kgCO<sub>2</sub> less with a 1% increase of the population with a second-year university level) while  
515 the frequency of certified food products has no significant effect (Table 7). This result is confirmed  
516 when we restrict the certified food category to organic food (see Annex 1. 17).

<sup>13</sup> This number refers to the total number of pupils in the school. Based on interviews with canteen managers, among them, an average two thirds of pupils have lunch in the canteen.

517 **Table 7: Average GHG footprint per school meal and its determinants (OLS regression)**

	<i>Dependent variable:</i>		
	Average emissions of canteen menus (gco2e)		
	(1)	(2)	(3)
In-house provision	64.882 (52.015)	871.630** (375.443)	216.703** (90.860)
Frequency of certified products	6.825 (209.036)	-29.823 (205.771)	-82.943 (210.451)
Proportion of the population with a high diploma	-434.252** (194.544)	-442.824** (190.900)	-443.229** (191.507)
Proportion of the left-wing voters during the first round	-159.981 (113.638)	-176.693 (111.751)	59.295 (155.762)
log(Population of 6-10 years old enrolled)	-56.281 (63.989)	82.260 (89.560)	-56.193 (62.973)
In-house provision * log(Population of 6-10 years old enrolled)		-246.055** (113.446)	
In-house provision * Proportion of the left-wing voters during the first round			-410.507** (202.976)
Constant	2,281.486*** (216.053)	1,856.864*** (288.540)	2,235.479*** (213.836)
Observations	101	101	101
R <sup>2</sup>	0.094	0.137	0.132
Adjusted R <sup>2</sup>	0.046	0.082	0.076
Residual Std. Error	233.709 (df = 95)	229.282 (df = 94)	229.998 (df = 94)
F Statistic	1.971* (df = 5; 95)	2.491** (df = 6; 94)	2.378** (df = 6; 94)

518 *Note:*

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

519

## 520 **6 Discussion and policy recommendations**

### 521 **6.1 Benchmarking of nutritional and environmental scores**

522 Our results confirm that nutritional guidelines are only partially met. Similar results are found by  
 523 Vieux et al (2018) when comparing FC suggesting that potential misclassification of dishes into  
 524 nutritional categories is limited. However, some caution is warranted on the six FC where substantial  
 525 differences are identified. There are at least two elements which can explain these differences. First,  
 526 Vieux et al. (2018) had access to the “technical files” (indicating the composition of each dish, namely  
 527 the ingredients and the quantities used). Without this information, our method based on the sole  
 528 menus could suffer from a few misclassifications, especially in GEM-RCN’s categories that explicitly  
 529 refer to nutritional content or ingredient proportion. This likely explains part of the difference in the

530 “hard cheese” category, which can easily be misclassified into “soft cheese” when the exact calcium  
531 content is unknown. Second, the two samples do not cover the same period and location and data  
532 were collected differently. The higher compliance score in Vieux et al. (2018) may be partly explained  
533 by social desirability bias as their canteen menus were provided by canteens on a voluntary basis  
534 whereas we exhaustively sampled our target area.

535 Our average monthly carbon footprint of 1.9 kgCO<sub>2</sub>e/day is close to the averages reported by Eco2  
536 Initiative (2020) for Parisian canteens. To a certain extent, this similarity confirms the robustness of  
537 our classification despite the absence of detailed dish composition. The misclassification risk is  
538 intrinsically reduced for the environmental indicator by the fact that all cheeses have the same  
539 emissions factor, no matter whether their calcium content is higher or lower than 150 mg. Our  
540 estimate is also close to the average carbon footprint of a French meal estimated at 2.3 kgCO<sub>2</sub>e  
541 (ADEME 2016). Overall, our average estimate lies within the 0.72-4.1 kgCO<sub>2</sub>e range from the existing  
542 literature. However, this robustness assessment relying on previous literature is limited given that  
543 carbon footprint is strictly dependent on a set of factors that we cannot control (e.g. food  
544 consumption patterns in each country reviewed, the amount of food served, food ingredients  
545 geographical origin and the agricultural method used to its production, as well as the conservation  
546 methods used for food ingredients). Large differences have nevertheless been identified between  
547 studies evaluating the mean GHG value per school meal. Exploring the drivers of these gaps such as  
548 the country's food culture or GHG calculation method can provide a valuable source of information  
549 to improve either the methods or the environmental quality of the meals.

550 Overall, we find that nutritional and environmental quality are not correlated. This echoes the  
551 previously stressed finding that a synergy between environmental and nutritional qualities is possible  
552 but not systematic (Doro et al, 2020). Some studies suggest antagonism between the two goals  
553 (Vieux et al. 2013; K. Wickramasinghe et al. 2017) while most found synergies (Behrens et al. 2017;  
554 van Dooren et al. 2014; Irz et al. 2016; Kesse-Guyot et al. 2020). Note however that the potential



555 antagonism between nutritional quality and carbon footprint tends to arise with very specific micro-  
556 nutrients, e.g. vitamin B12 and D, omega 3, calcium which are mainly found in animal products,  
557 largely out of the reach of our menu-based estimation of nutritional quality (Vieux et al. 2013; K. K.  
558 Wickramasinghe et al. 2016). The high variability in the carbon footprint of the menus with the  
559 highest nutritional quality suggests that it is possible to identify high quality school meal series with  
560 low carbon footprint, despite the importance given by GEM-RCN criteria to animal products.

## 561 **6.2 Drivers of nutritional quality and carbon footprint**

562 In-house provision is associated with both higher nutritional quality and lower carbon footprint in  
563 larger canteens. This may be explained by a stronger cost constraint in delegated canteens,  
564 incentivizing canteen managers to cut healthy but expensive food items such as fruits and vegetables  
565 although the reverse could have been expected for polluting and expensive food items such as red  
566 meat. Indeed, profitability was reported to be negatively affected by the introduction of healthier  
567 options (Jaworowska et al. 2013) due to a reduction of meal palatability and therefore customer  
568 satisfaction (Cohen et al. 2012). Outsourcing can also be plagued with difficulties in contracting, in  
569 particular on quality (Andersson et al., 2019; Hart et al., 1997; Saussier et al., 2009), explaining lower  
570 nutritional quality in delegated canteens. The endogeneity of the canteen management model is  
571 likely the most important limit of our study, preventing any strong causal interpretation of our results  
572 related to the management model. Indeed, previous research on public-private partnerships for  
573 other public services, like water management, has shown that this bias is not negligible (Chong et al.  
574 2006; Ménard and Stéphane 2003). For instance, a simple comparison on the price of water paid by  
575 taxpayers between cities that delegate the water provision and those that run the system in-house  
576 shows that this price is lower under in-house provision. But this simple comparison tends to ignore  
577 the fact that municipalities mostly outsource the water provision when water treatment is complex  
578 and therefore intrinsically more costly<sup>14</sup>. More generally, the decision to delegate the provision of  
579 public service can be motivated by a lack of in-house competencies, financial constraints, or the

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<sup>14</sup> Once this is factored in the econometric analysis, price difference is no longer statistically different.

580 substantial investments required for in-house provision (Ménard and Stéphane 2003). Our results  
581 show that the management model is not correlated with any other observed municipality  
582 characteristics, which reduces the risk of bias (Annex 1.7). However, endogeneity can be caused by  
583 variables affecting meal quality that we cannot control for such as a lack of an adequate place (Abery  
584 and Drummond 2014; Girona et al. 2019) or equipped kitchens (Wagner, Senauer, and Runge 2007),  
585 both requiring investments. Overall, a better understanding of the reasons that both motivate  
586 outsourcing and affect nutritional and environmental quality of canteen meals is crucial to make finer  
587 conclusions on the provision model impact.

588 Our finding that canteen size is associated with higher nutritional quality is consistent with the  
589 qualitative literature. This size effect may be caused by the higher staff training permitted by  
590 economies of scale in larger canteens (Thorsen et al., 2009). Indeed, canteen managers emphasize  
591 the paramount importance of dieticians in the design of nutritionally balanced menus and that  
592 access to this competence is likely challenging in small canteens (Cour des comptes 2020). A similar  
593 rationale could apply to environmental quality, although we have shown that it then depends on the  
594 management model: large in-house canteens offer menus with a lower carbon footprint than large  
595 delegated canteens. We can presume that higher staff training access in larger in-house canteens  
596 facilitates the substitution of meat products with plant-based products, for which recipe creation  
597 might be challenging and time-consuming.

598 Parents strongly influence the nutritional quality of their children's diet (Ardzejewska, Tadros, and  
599 Baxter 2013; Clelland, Cushman, and Hawkins 2013; Downs et al. 2012), as well as its environmental  
600 quality (Cho and Nadow 2004; Dědina, Šánová, and Kadeřávková 2014; Filippini et al. 2018). Our  
601 results show that this influence can extend to canteen menus on environmental quality, but not  
602 nutritional quality (*Table 4*). One explanation may be that parents are more inclined to put pressure  
603 on policy makers and caterers to reduce canteen meal GHGEs because of their higher environmental  
604 awareness (Aminrad, Zakaria, and Hadi 2011) and lower meat consumption (Gossard and York 2003).

605 There again, one must remain cautious on the causal interpretation. An alternative explanation could  
606 be that canteen managers are keener to serve red meat in poor neighborhood where this expensive  
607 food item may be less frequently offered in children's homes. This hypothesis would call for a further  
608 exploration of food choices of canteen managers, which is beyond the objective of this study.  
609 Overall, further research on the possible lines of action of parents about canteen manager decisions  
610 as well as additional factors which would enhance parental involvement is required to interpret  
611 these results.

612 The introduction of certified food in canteen meals is independent from the nutritional and quality  
613 and carbon footprint of canteen menus. This finding contradicts previous research showing that  
614 organic food in canteens improve the nutritional quality (Lassen et al. 2019; B. Mikkelsen et al. 2006)  
615 and carbon footprint (Tregear et al. 2019) of canteen menus. This contradiction may stem from the  
616 differing motivations for introducing certified food by canteen managers. In our context, their  
617 motivation is partly an anticipation of the recent EGALIM law (LOI n° 2018-938) which requires public  
618 institutional catering to serve at least 20% organic food and 50% certified food (including organic  
619 products) by January 2022 and may therefore be disconnected from broader nutritional or  
620 environmental concerns.

621 The left-wing vote only has an effect when interacting with the management mode: canteens with in-  
622 house provision in leftist municipalities have lower environmental impact than canteens with  
623 delegated management. This could be related to the emphasis put by left parties – and in particular  
624 the Green party – on school catering during the municipal campaigns. Once in charge of  
625 municipalities, left-wing parties may have more difficulties to implement their electoral promises  
626 when school catering is delegated, since the delegation may have been contracted before the  
627 elections or catering companies may not respect this contracted commitment in the absence of  
628 strong control capability. That would mean costly renegotiations with private providers, in particular  
629 if the contract has been recently agreed. Unfortunately, we did not have access to this information.

### 630 **6.3 Policy and Managerial Implications**

631 Our results confirm those found in the literature showing that canteens are far from fulfilling  
632 nutritional guidelines (Brennan et al. 2019; Woods et al. 2014; Vieux et al. 2018) calling into question  
633 their usefulness. Guideline's complexity, lack of human resources and knowledge and the absence of  
634 strong legal sanctions or monitoring mechanisms are identified in the literature as significant barriers  
635 to their implementations. For example, managing fifteen frequency criteria as defined by the French  
636 regulations, some of which require the detailed nutrient content of dishes, is both complex and  
637 constraining when also trying to reduce the environmental footprint of meals. This is especially true  
638 for small municipalities unable to have enough dedicated staff to follow this guideline. One way to  
639 facilitate the fulfillment of nutritional guidelines would be to adapt them to the size of municipalities  
640 (as measured for instance by the number of meal served), larger municipalities being for instance  
641 compelled to fulfill more nutritional criteria. While harsh penalties for non-compliance would likely  
642 be counter-productive, their total absence does not provide incentives to canteen managers to  
643 improve meal quality.

644 The presence of a minimal frequency of red meat in nutritional guidelines may be seriously  
645 questioned in light of its environmental aftermaths. Alternative meat types with lower carbon  
646 footprint (e.g. poultry) or dishes based on vegetal proteins (e.g. pulse-based) can provide similar  
647 nutritional benefits without the environmental downside. However, introducing vegetarian meals  
648 with lower environmental impact requires both cooking know-how and a good understanding of  
649 their nutritional quality. For example, vegetarian dishes containing eggs and/or dairy products other  
650 than cheese have a better nutritional quality than vegan dishes and vegetarian dishes containing  
651 cheese (Poinsot et al. 2020). Alternatively, portion size of meat-based dishes could also be  
652 questioned, since average protein intake by French children is currently exceeding nutritional  
653 guidelines (e.g., INCA3, Anses). More broadly, the leeway allowed by the nutritional guidelines to  
654 reduce the carbon footprint of canteen meals must be further explored: in less than 2 years, a few  
655 Parisian school canteens have succeeded in reducing by 30% GHG emissions of canteen meals (from

656 1.8 to 1.2 kgCO<sub>2</sub>e) while complying with the GEM-RCN (Eco2 Initiative 2020). They mainly modified  
657 the frequencies and portion sizes of food, two actions which require staff training, children's  
658 awareness and commitments from local public officers but no additional costs. Our results point out  
659 however that reducing the frequency of red meat quickly runs into the minimal frequency  
660 recommended by the GEM-RCN.

661 The compliance with the adjusted minimum frequency of 3.2 serving of red meat decreases  
662 dramatically when removing the Wednesday of the 20-day period of analysis. It suggests that  
663 caterers are more inclined to serve expensive red meat on Wednesdays when fewer children eat at  
664 school. This peculiarity should be considered, for example by excluding Wednesdays from the  
665 accounting of frequency criteria while maintaining minimal nutritional requirements (e.g., 5  
666 component meal).

667 The introduction of more publicly certified food products (like PDO and PGI) is a cornerstone of the  
668 recent French EGALIM law on public institutional catering. However, we found no significant impact  
669 of the frequency of these products on nutritional quality or carbon footprint. Their goals are to  
670 certify a geographical origin or a higher quality that are not necessarily related to health and  
671 environmental issues. While these results should be interpreted cautiously due to limited precision  
672 of our measurement of certified food frequency, they certainly call for more research on the  
673 environmental impact of mandatory procurement of certified food.

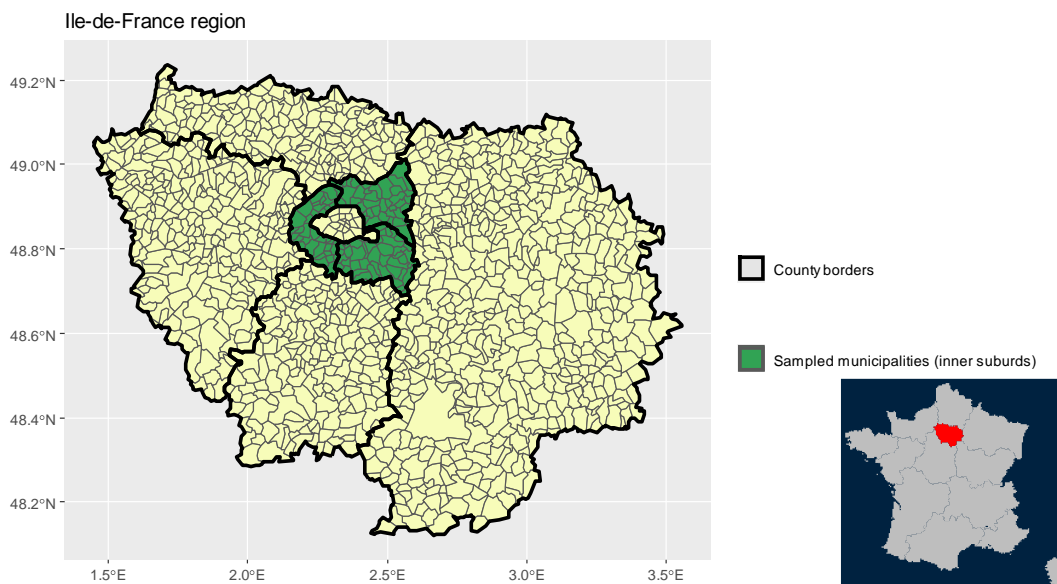
## 674 **7 Conclusion**

675 The present study evaluates simultaneously the nutritional quality and the carbon footprint of  
676 canteen meals of municipalities in the inner suburbs of Paris and their determinants. We find that  
677 canteens meet an average 8.2 nutritional frequency criteria out of 15 as defined by national  
678 regulation and that their menus average 1.9 kgCO<sub>2</sub>e/day, which is consistent with previous  
679 literature. No correlation is found between the nutritional and environmental qualities of canteens

680 menus. In-house canteens have a significantly higher nutritional quality and so do larger canteens.  
 681 The carbon footprint is significantly lower in municipalities with a higher educational level and, for in-  
 682 house canteens, it is also significantly lower in larger canteens and where left-wing vote is higher,  
 683 breaking even with delegated canteens above 3,500 enrolled children and 53% of left-wing vote  
 684 respectively. Further research based on a larger and more diverse sample, applying a different  
 685 sampling method, would overcome some of the limits of the present study.

686 **ANNEXES 1.**

687 **Annex 1. 1: Sampled municipalities within the Ile-De-France region**



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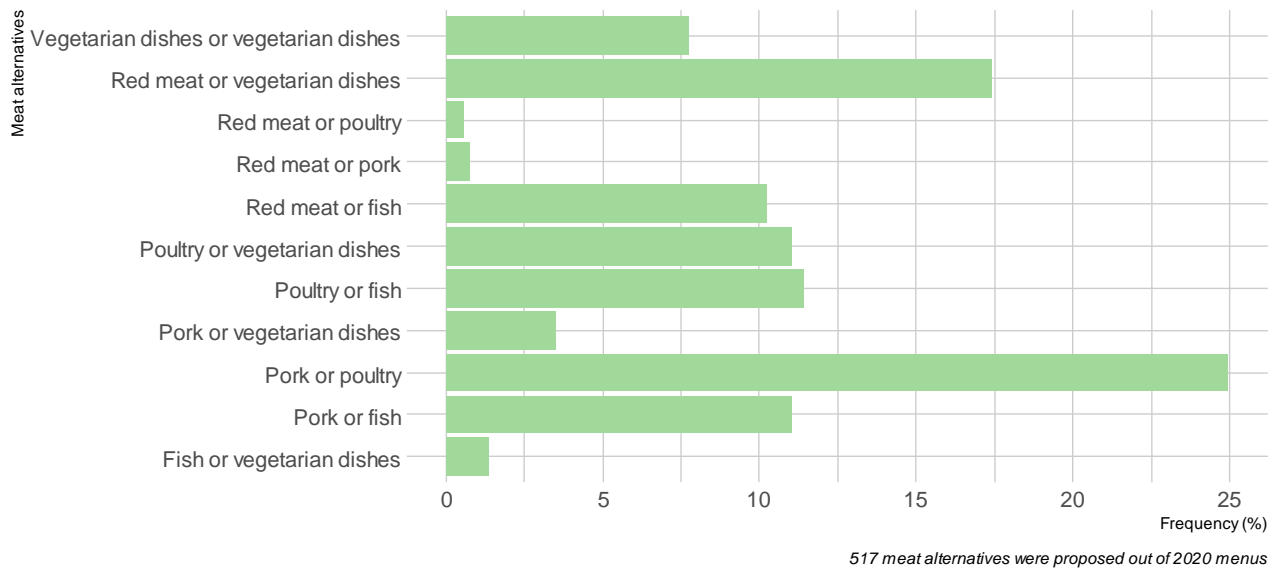
689 **Annex 1. 2: Central kitchens of intercommunal associations**

Central kitchen	Municipalities in the intercommunal association
COCLICO	Clichy, Colombes
cantine de Bagneux	Bagneux, Cachan
SIPLARC	Bondy, Noisy-le-Sec
SIRESCO	Bobigny, Aubervilliers, La Courneuve, Romainville, Tremblay-en-France, Arcueil, Champigny-sur-Marne, Ivry-sur-Seine, La Queue-en-Brie
SIVURESC	Le Blanc-Mesnil, Pantin
SIVOM	Pierrefitte-sur-Seine, Stains
SYREC	Saint-Ouen, Villepinte, Gennevilliers

SIRM	Boissy-Saint-Léger, Villeneuve-Saint-Georges, Bonneuil-sur-Marne
Central kitchen of the Grand Paris Sud Est Avenir	Alfortville, Limeil-Brévannes et Créteil
Sidoresto	Gentilly, Vitry-sur-Seine
Communauté Bourget	Dugny, Le bourget, Drancy

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691 **Annex 1. 3:** Type of alternative when a choice is offered on protein dishes

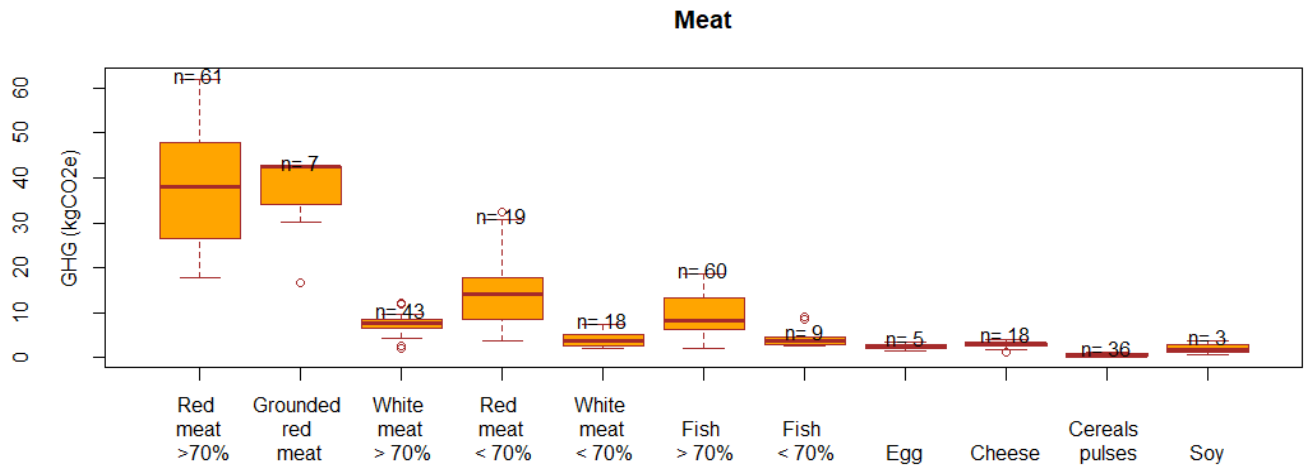


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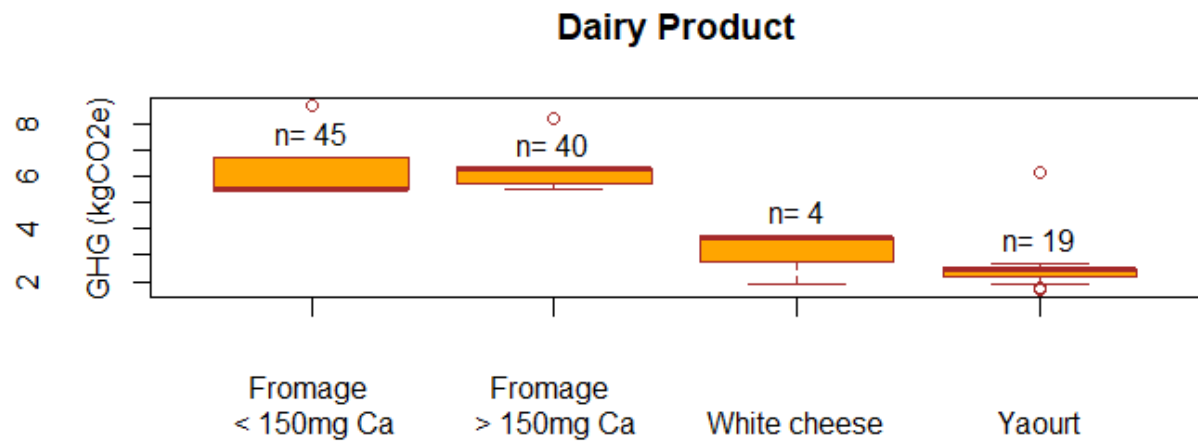
693 **Annex 1. 4:** Controlling carbon footprint homogeneity of the food categories used based on

694 representative dishes from Agribalyse 3.0

695 Each of the following figures represents the mean (median?), first and third quartiles, and XX of the  
 696 all dishes belonging to the relevant category in Agribalyse 3.0.



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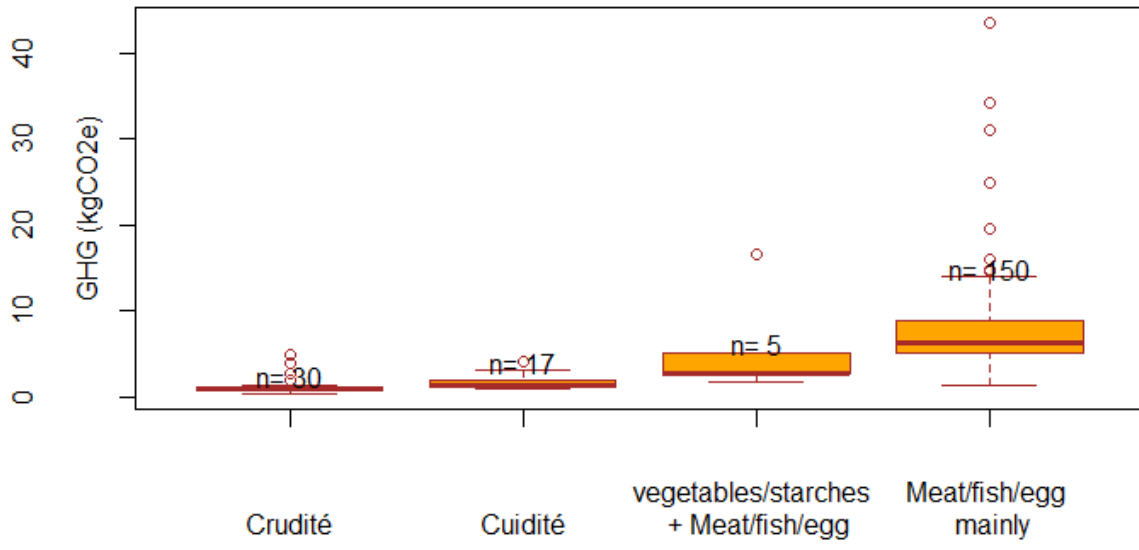
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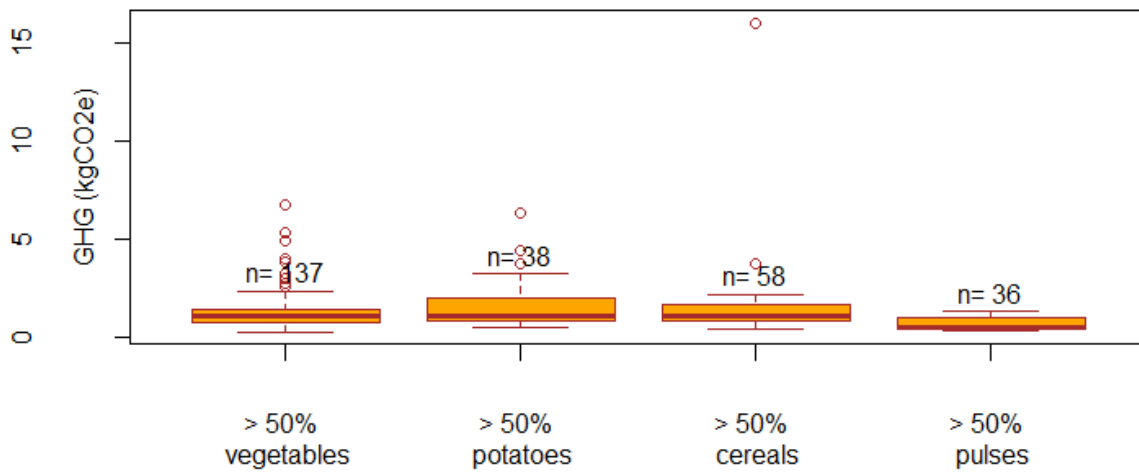


### Starter



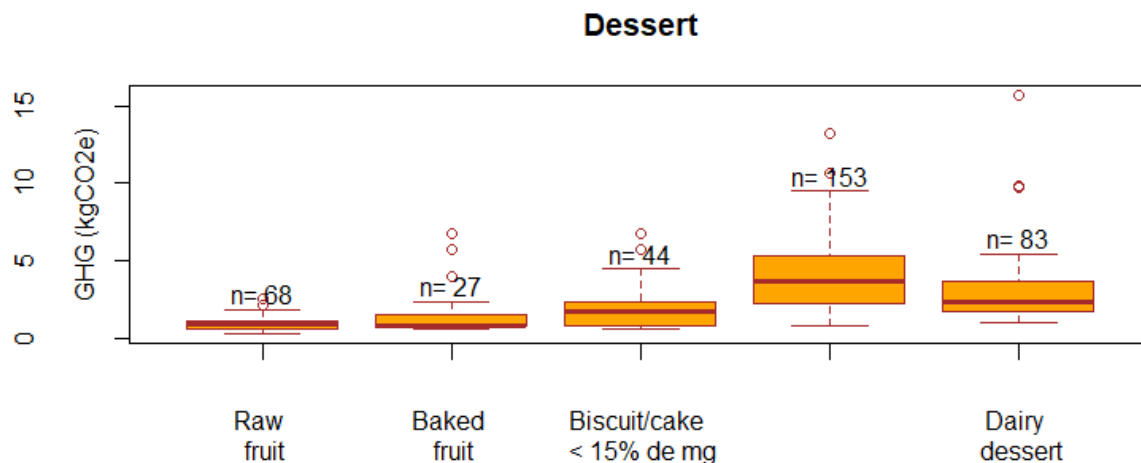
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### Side dish



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705 **Annex 1. 5:** Weightings applied in the case of alternative choices

	Fish dish	Meat dish	Vegetarian dish
Meat dish	Meat: 0.8 Fish: 0.2		
Vegetarian dish	Vegetarian: 0.05 Fish: 0.95	Vegetarian: 0.05 Meat: 0.95	

706 For example, when an alternative is offered between fish and meat, we assume that 80% of pupils  
707 get a meat dish and 20% get a fish dish.

708 **Annex 1. 6:** Classification of the political nuances between right and left affiliations<sup>15</sup>

Abbreviation	Political nuance	Affiliation
LDVG	Liste divers gauche	Left
LDVD	Liste divers droite	Right
LUMP	Liste de l'UMP	Right

<sup>15</sup> The "Liste diverse" (LDIV) political nuance was not ranged because it contains disparate parties, difficult to classify between right and left.

LSOC	Liste du Parti Socialiste	Left
LEXG	Liste d'extrême gauche	Left
LVEC	Liste Europe Écologie Les Verts	Left
LUG	Liste Union de la gauche	Left
LUDI	Liste Union des Démocrates et des Indépendants	Right
LFG	Liste Front de Gauche	Left
LCOM	Liste du Parti communiste français	Left
LPG	Liste du Parti de Gauche	Left
LUD	Liste Union de la Droite	Right
LMDM	Liste Modem	Right
LUC	Liste Union du Centre	Right
LFN	Liste Rassemblement National	Right
LEXD	Liste Extrême droite	Right

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718 **Annex 1. 7:** Correlation matrix of municipality descriptive variables

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	Left-wing voters	In-house	Pop high degree diploma	children 6-10	Median Income
Left-wing voters	1	0.31	-0.4	0.33	-0.57
In-house	0.31	1	-0.34	0.28	-0.37
Pop high degree diploma	-0.4	-0.34	1	-0.23	0.91
children 6-10	0.33	0.28	-0.23	1	-0.36
Median Income	-0.57	-0.37	0.91	-0.36	1

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722 **Annex 1. 8:** The 15 frequency criteria for school meal service and the percentage of series fulfilling  
 723 each criterion among the 101 observed series of 16 meals (binary scores without Wednesdays)

Simplified FC name <sup>16</sup>	Component(s) concerned	Expected frequency	% of series fulfilling the criterion in Paris Area (binary score)	% of series fulfilling the criterion without Wednesdays (binary)
Fatty starters	starter	3.2/20 max	83,2%	80,2%
<b>Raw fruits or vegetables starters</b>	<b>starter, side dish</b>	<b>8/20 min</b>	<b>38.6%</b>	<b>41,6%</b>
Fried dishes	protein dish, side dish	3.2/20 max	98%	96%
Fatty protein dishes	protein dish	1.6/20 max	22,8%	13,9%
Fish	protein dish	3.2/20 min	86%	73,3%

<sup>16</sup> See the complete frequency criterion name in Table 3.

<b>Red meat</b>	<b>protein dish</b>	<b>3.2/20 min</b>	<b>63,4%</b>	<b>20,8%</b>
Pre-processed dishes	protein dish	3.2/20 max	74,2%	59,4%
<b>Vegetable side dishes</b>	<b>side dish</b>	<b>=8/20</b>	<b>22,8%</b>	<b>18,8%</b>
Pulses or starches	side dish	=8/20	20,8%	18,8%
Hard cheese	starter, dairy product	6.4/20 min	25,7%	19,8%
Soft cheese	starter, dairy product	3.2/20 min	73,3%	59,4%
Non-cheese dairy product	dairy product, dessert	4.8/20 min	77,2%	79,2%
Fatty dessert	dessert	2.4/20 max	61,4%	49,5%
Sugary low-fat dessert	dairy product, dessert	3.2/20 max	41,6%	32,7%
<b>Raw fruit dessert</b>	<b>dessert</b>	<b>6.4/20 min</b>	<b>93%</b>	<b>83%</b>

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**Annex 1. 9:** The 15 frequency criteria for school meal service and the percentage of series fulfilling each criterion among the 101 observed series of 16 meals (relative scores without Wednesdays)

<b>Simplified FC name<sup>17</sup></b>	<b>Component(s) concerned</b>	<b>Expected frequency</b>	<b>% of series fulfilling the criterion (relative Score)</b>	<b>% of series fulfilling the criterion without Wednesdays (relative score)</b>
Fatty starters	starter	3.2/20 max	94,4%	92,5%
<b>Raw fruits or vegetables starters</b>	<b>starter, side dish</b>	<b>8/20 min</b>	<b>84,4%</b>	<b>84,8%</b>
Fried dishes	protein dish, side dish	3.2/20 max	99,5%	99%
Fatty protein dishes	protein dish	1.6/20 max	37,9%	40,5%
Fish	protein dish	3.2/20 min	95,7%	94,5%
<b>Red meat</b>	<b>protein dish</b>	<b>3.2/20 min</b>	<b>87,8%</b>	<b>75,9%</b>
Pre-processed dishes	protein dish	3.2/20 max	96,7%	79%
<b>Vegetable side dishes</b>	<b>side dish</b>	<b>=8/20</b>	<b>83,8%</b>	<b>80,6%</b>
Pulses or starches	side dish	=8/20	82,2%	79,7%

<sup>17</sup> See the complete frequency criterion name in Table 3.

Hard cheese	starter, dairy product	6.4/20 min	70,2%	67,2%
Soft cheese	starter, dairy product	3.2/20 min	87,2%	86,6%
Non-cheese dairy product	dairy product, dessert	4.8/20 min	95,8%	94,8%
Fatty dessert	dessert	2.4/20 max	80,2%	73,3%
Sugary low-fat dessert	dairy product, dessert	3.2/20 max	72,6%	69,7%
<b>Raw fruit dessert</b>	<b>dessert</b>	<b>6.4/20 min</b>	<b>98,8%</b>	<b>97,5%</b>

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728 **Annex 1. 10:** The 15 frequency criteria for school meal service in Paris area and the percentage of  
729 municipalities fulfilling each criterion among the 101 series of 20 meals (binary vs relative scores)

Simplified FC name <sup>18</sup>	Component(s) concerned	Expected frequency	% of series fulfilling the criterion in Paris Area (binary score)	% of series fulfilling the criterion in Paris Area (relative Score)
Fatty starters	starter	4/20 max	83,2%	94,4%
<b>Raw fruits or vegetables starters</b>	<b>starter, side dish</b>	<b>10/20 min</b>	<b>38.6%</b>	<b>84,4%</b>
Fried dishes	protein dish, side dish	4/20 max	98%	99,5%
Fatty protein dishes	protein dish	2/20 max	22,8%	37,9%
Fish	protein dish	4/20 min	86%	95,7%
<b>Red meat</b>	<b>protein dish</b>	<b>4/20 min</b>	<b>63,4%</b>	<b>87,8%</b>
Pre-processed dishes	protein dish	4/20 max	74,2%	88,6%
<b>Vegetable side dishes</b>	<b>side dish</b>	<b>=10/20</b>	<b>22,8%</b>	<b>83,8%</b>
Pulses or starches	side dish	=10/20	20,8%	82,2%
Hard cheese	starter, dairy product	8/20 min	25,7%	70,2%
Soft cheese	starter, dairy product	4/20 min	73,3%	87,2%
Non-cheese dairy product	dairy product, dessert	6/20 min	77,2%	95,8%
Fatty dessert	dessert	3/20 max	61,4%	80,2%
Sugary low-fat dessert	dairy product, dessert	4/20 max	41,6%	72,6%
<b>Raw fruit dessert</b>	<b>dessert</b>	<b>8/20 min</b>	<b>93%</b>	<b>98,8%</b>

<sup>18</sup> See the complete frequency criterion name in Table 3

730 **Annex 1. 11:** Nutritional and environmental quality of school canteen menus for municipalities by the  
 731 provision model (including a student t-test)

Variable	Overall, N = 101 <sup>1</sup>	Delegated provision, N = 53 <sup>1</sup>	In-house provi
Relative score (15 FC)	12.59 (1.11)	12.22 (0.98)	12.99 (1.11)
Binary score (15 FC)	8.16 (1.93)	8.32 (1.96)	7.98 (1.90)
Relative score (4 FC)	3.55 (0.39)	3.57 (0.38)	3.52 (0.40)
Binary score (4 FC)	1.38 (0.82)	1.45 (0.85)	1.29 (0.80)
Average emissions of canteen menus (kgCO2e)	1.88 (0.239)	1,85 (0.254)	1.9 (0.218)
Frequency of certified products	0.18 (0.12)	0.21 (0.13)	0.15 (0.12)

<sup>1</sup> Mean (SD)

<sup>2</sup> Welch Two Sample t-test

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752 **Annex 1. 12: 15 FC relative score and its determinants (OLS)**

	<i>Dependent variable:</i>		
	Relative Score (15 FC)		
	(1)	(2)	(3)
In-house provision	0.688*** (0.231)	0.581** (0.228)	0.108 (1.685)
Frequency of certified products	-0.103 (0.911)	-0.711 (0.916)	-0.689 (0.923)
Proportion of the population with a high diploma	0.168 (0.875)	0.325 (0.852)	0.330 (0.857)
Proportion of the left-wing voters during the first round	0.565 (0.481)	0.123 (0.498)	0.133 (0.501)
log(Population of 6-10 years old enrolled)		0.723** (0.280)	0.642 (0.402)
In-house provision * log(Population of 6-10 years old enrolled)			0.144 (0.509)
Constant	11.988*** (0.488)	9.876*** (0.947)	10.124*** (1.295)
Observations	101	101	101
R <sup>2</sup>	0.133	0.189	0.190
Adjusted R <sup>2</sup>	0.097	0.147	0.138
Residual Std. Error	1.054 (df = 96)	1.024 (df = 95)	1.029 (df = 94)
F Statistic	3.672*** (df = 4; 96)	4.441*** (df = 5; 95)	3.678*** (df = 6; 94)

753 *Note:*

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01

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757 **Annex 1. 13:** 4 FC relative score and its determinants (OLS)

	<i>Dependent variable:</i>		
	Relative Score (4 FC)		
	(1)	(2)	(3)
In-house provision	0.159* (0.082)	0.139 (0.083)	1.582*** (0.599)
Frequency of certified products	0.447 (0.325)	0.333 (0.336)	0.268 (0.328)
Proportion of the population with a high diploma	-0.665** (0.313)	-0.636** (0.312)	-0.651** (0.305)
Proportion of the left-wing voters during the first round	-0.206 (0.172)	-0.289 (0.182)	-0.318* (0.178)
log(Population of 6-10 years old enrolled)		0.135 (0.103)	0.383*** (0.143)
In-house provision * log(Population of 6-10 years old enrolled)			-0.440** (0.181)
Constant	3.753*** (0.174)	3.358*** (0.347)	2.599*** (0.460)
Observations	101	101	101
R <sup>2</sup>	0.096	0.112	0.164
Adjusted R <sup>2</sup>	0.058	0.065	0.111
Residual Std. Error	0.377 (df = 96)	0.375 (df = 95)	0.366 (df = 94)
F Statistic	2.538** (df = 4; 96)	2.392** (df = 5; 95)	3.082*** (df = 6; 94)

Note:

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

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774 **Annex 1. 14:** 4 FC relative score and its determinants (robust regression using Bisquare weighting  
 775 function)

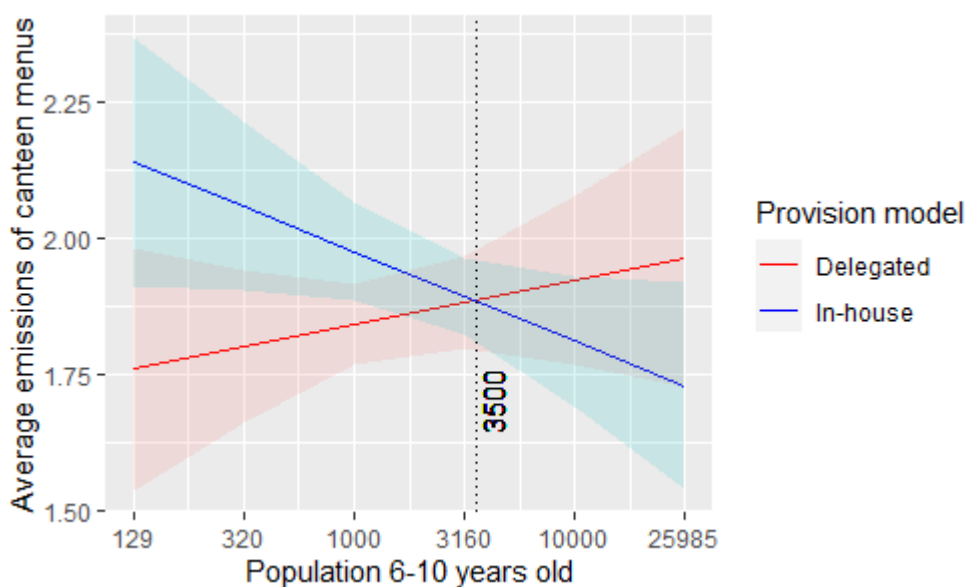
	<i>Dependent variable:</i>		
	Relative Score (4 FC) using bisquare weighing function		
	(1)	(2)	(3)
In-house provision	0.086 (0.064)	0.085 (0.065)	0.608 (0.479)
Frequency of certified products	-0.201 (0.251)	-0.203 (0.262)	-0.233 (0.263)
Proportion of the population with a high diploma	-0.099 (0.241)	-0.099 (0.244)	-0.105 (0.244)
Proportion of the left-wing voters during the first round	-0.052 (0.132)	-0.054 (0.142)	-0.047 (0.143)
log(Population of 6-10 years old enrolled)		0.003 (0.080)	0.099 (0.114)
In-house provision * log(Population of 6-10 years old enrolled)			-0.160 (0.145)
Constant	3.683*** (0.134)	3.675*** (0.271)	3.375*** (0.368)
Observations	101	101	101
R <sup>2</sup>	0.200	0.200	0.224
Adjusted R <sup>2</sup>	0.167	0.158	0.174
Residual Std. Error	0.281 (df = 96)	0.281 (df = 95)	0.270 (df = 94)
F Statistic	1.0543 (df = 4; 96)	0.82948 (df = 5; 95)	0.90347 (df = 6; 94)

Note:

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

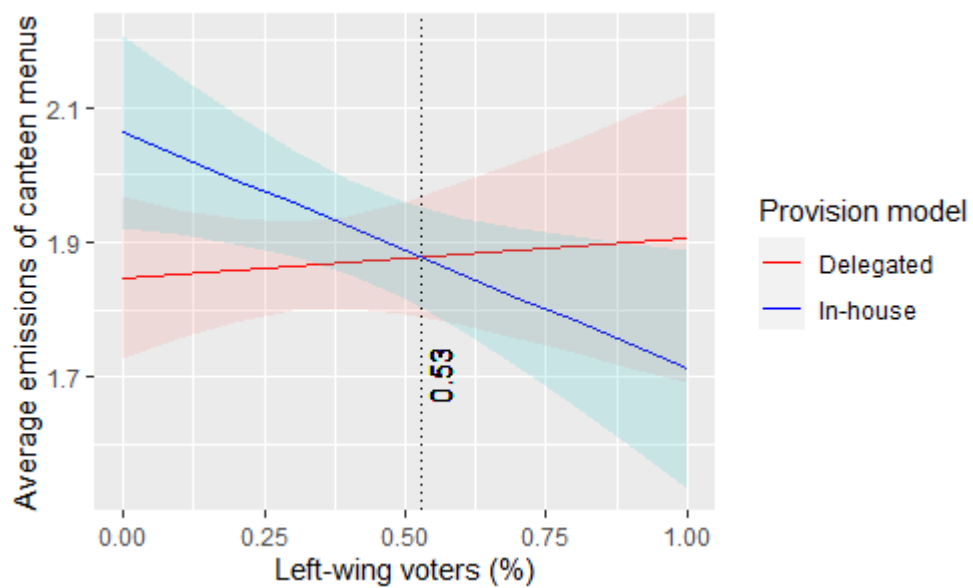
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777 **Annex 1. 15:** Interaction term between in-house provision and canteen size (min = 129 pupils, max =  
 778 25,985 pupils) on GHG (kgCO<sub>2</sub>e) of canteen menus



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780 **Annex 1. 16:** Interaction term between In-house provision and the proportion of left-wing voters<sup>19</sup>  
781 on GHG (kgCO<sub>2</sub>e) of canteen menus



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<sup>19</sup> A 0% share vote is obtained for municipalities without left or right candidates.

785 **Annex 1. 17:** 15 FC relative score using bisquare weighting function and its determinants (including  
 786 organic labels rather than certified, using bisquare weighting function)

	<i>Dependent variable:</i>		
	Relative Score (15 FC) using bisquare weighting function		
	(1)	(2)	(3)
In-house provision	0.801*** (0.219)	0.669*** (0.217)	0.302 (1.624)
Frequency of organic products	-0.742 (0.933)	-1.155 (0.941)	-1.144 (0.949)
Proportion of the population with a high diploma	0.515 (0.823)	0.482 (0.806)	0.508 (0.813)
Proportion of the left-wing voters during the first round	1.187*** (0.458)	0.760 (0.479)	0.784 (0.484)
log(Population of 6-10 years old enrolled)		0.633** (0.269)	0.565 (0.385)
In-house provision * log(Population of 6-10 years old enrolled)			0.113 (0.490)
Constant	11.729*** (0.467)	9.955*** (0.907)	10.146*** (1.241)
Observations	101	101	101
R <sup>2</sup>	0.354	0.397	0.401
Adjusted R <sup>2</sup>	0.327	0.365	0.363
Residual Std. Error	0.943 (df = 96)	0.900 (df = 95)	0.890 (df = 94)
F Statistic	7.2838*** (df = 4; 96)	6.9587*** (df = 5; 95)	5.7592*** (df = 6; 94)

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

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802 **Annex 1. 18:** Mean GHG value per school meal (gCO<sub>2</sub>e) and its determinants (including organic labels  
 803 rather than certified, OLS regression)

	<i>Dependent variable:</i>		
	Average emissions of canteen menus (gco2e)		
	(1)	(2)	(3)
In-house provision	63.356 (51.447)	873.032** (375.002)	218.169** (90.860)
Frequency of organic products	-40.416 (223.146)	-67.190 (219.215)	-122.197 (223.062)
Proportion of the population with a high diploma	-423.284** (191.305)	-436.614** (187.739)	-440.444** (188.340)
Proportion of the left-wing voters during the first round	-159.971 (113.605)	-177.068 (111.704)	59.963 (154.851)
log(Population of 6-10 years old enrolled)	-52.958 (63.709)	84.870 (88.915)	-54.351 (62.663)
In-house provision * log(Population of 6-10 years old enrolled)		-246.649** (113.197)	
In-house provision * Proportion of the left-wing voters during the first round			-413.364** (201.502)
Constant	2,274.376*** (215.106)	1,851.517*** (286.664)	2,232.601*** (212.541)
Observations	101	101	101
R <sup>2</sup>	0.094	0.138	0.133
Adjusted R <sup>2</sup>	0.047	0.083	0.078
Residual Std. Error	233.670 (df = 95)	229.193 (df = 94)	229.821 (df = 94)
F Statistic	1.978* (df = 5; 95)	2.505** (df = 6; 94)	2.405** (df = 6; 94)

Note:

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

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## 806 **Annex 2.**

### 807 **Annex 2. 1.**

#### 808 **Annex 2. 1:** Canteen menu and explanatory variable database

809 See MenuR.xlsx.

## 810 **Annex 3.**

### 811 **Annex 3. 1:** Classification algorithm

812 See Algorithm.rar

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