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Pierre Chiaverina[1] , Emmanuel Raynaud[2], Marie Fillâtre[3], Sophie Nicklaus[4] and Valentin Bellassen[5]

Abstract: Public school food procurement has been identified as a key lever in the transition towards sustainable food systems. In this study, we assess the nutritional quality and the carbon footprint of 2020 school menus served in 101 municipalities in the inner suburbs of Paris. In this sample, school canteens menus meet an average 8.2/15 (min = 4, max = 14) adequacy score to the regulatory nutritional quality frequency criteria and their carbon footprint averages at 1.9 (min = 1.2, max = 2.6) $kgCO_2e$/day. The nutritional and environmental qualities of canteen menus were not correlated with each other. In-house canteens have a significantly higher nutritional quality - 0.7 more points – and so do larger canteens. The carbon footprint significantly decreases with an increasing education level of the population and, for in-house canteens, it also decreases by 0.16 $kgCO_2e$/day with a ten-fold increase in canteen size and by 0.0035 $kgCO_2e$/day per percent of left-wing vote, breaking even with delegated canteens above 3,500 enrolled children and 53% of left-wing vote respectively. The frequency of certified food (mean = 18%, min= 0%, max=51%), a cornerstone of the 2018 national law aiming at more sustainable institutional catering, has no impact on our indicators of nutritional quality and carbon footprint. The substantial variations between canteens in both nutritional and environmental qualities suggests that there is room for improvement on both ends.

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

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[1] UMR MOISA, INRAE Montpellier, Bât. 26, 2 place Pierre-Viala, 34060 Montpellier Cedex 1, France. pierre.chiaverina@inrae.fr (corresponding author)

[2] UMR SADAPT INRAE/AgroParisTech, Université Paris Saclay, AgroParisTech - 16, rue Claude Bernard – 75231 PARIS Cedex 05, emmanuel.raynaud@agroparistech.fr

[3] UMR SADAPT INRAE/AgroParisTech, Université Paris Saclay, AgroParisTech - 16, rue Claude Bernard – 75231 PARIS Cedex 05, m.fillatre94@gmail.com

[4] Centre des Sciences du Goût et de l'Alimentation (CSGA), AgroSup Dijon, CNRS, INRAE, Université Bourgogne Franche-Comté, 17 rue Sully, F-21000 Dijon, France, sophie.nicklaus@inrae.fr

[5] CESAER, AgroSup Dijon, INRAE, Université Bourgogne Franche-Comté, F-21000 Dijon, France valentin.bellassen@inrae.fr

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32 giving us access to Agribalyse 3.0 database and Florent Vieux (MS Nutrition) for giving us access to school
33 canteen dish recipes.

34 All statistical analyses were conducted using R software.

36

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

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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

3

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

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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$_2$e)	Min GHGE value per school meal (kgCO$_2$e)	Max GHGE value per school meal (kgCO$_2$e)	Share of the meat components in the carbon footprint
Eco2 Initiative (2020)	Paris	n=1	/	Primary school	1.8 kgCO$_2$e	/	/	/
Cerutti et al (2018)	Turin	n=1	1 year	Secondary school	1.67 kgCO$_2$e	/	/	39%-51%
Wickramasinghe et al. (2016)	United Kingdom (UK)	n=139	1 week	Primary school	0.72 kgCO$_2$e	0.52 kgCO$_2$e	1.34 kgCO$_2$e	41.5%
Jungbluth et al. (2016)	Switzerland	n=240	1 year	/	4.1 kgCO$_2$e	/	/	48%
Tregear et al. (2019)	Croatia, Greece, Italy, Servia, UK	n=10	1 or 2 weeks	Primary school	/	0.84 kgCO2e	2.14 kgCO2e	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$_2$e	0.9 kgCO$_2$e	5.7 kgCO$_2$e	/
De Laurentiis et al. (2017)	UK	n=136	2 weeks	Primary school	1.02 kgCO$_2$e	/	/	52%
Batlle-Bayer et al.(2021)	Spain	n=7	1 week	High school	/	< 2 kgCO$_2$e	> 12 kgCO$_2$e	/
González-García et al.(2021)	Spain	n=1	2 weeks	Pre-school	1.26 kgCO$_2$e	0.75 kgCO$_2$e	2.95 kgCO$_2$e	/
Martinez et al.(2020)	Spain	Baseline menu based on 88 dishes	/	Pre and primary school	1.2 kgCO$_2$e	/	/	/

2.1.2 Nutritional quality of canteen menus

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

2.1.3 Interactions between nutritional and environmental quality of diets

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

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138 amounts of fibre and phytonutrients (Aleksandrowicz et al. 2016)[6]. 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).

2.2 Potential drivers of nutritional and environmental quality of schools' menus

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2.2.1 Organizational factors

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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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[6] 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).

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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).

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2.2.3 Political affiliation

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

2.2.4 Canteen size

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

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210   (2016) find that large private catering firms provide poorer quality services as they adopt predatory

211   pricing strategies in order to win contracts.

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).

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.

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

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

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

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

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

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

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

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

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

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

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and environmental issues.The procurement of school meals in France

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

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

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[7] 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

13

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[8]. 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.

4   Material and method

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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[8] 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

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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:**

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

346 where Menu Emissions$_j$ are the emissions of the menu on day d in city j, dish_share$_{kijd}$ 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 $Carbon\ footprint\ of\ food\ ingredients_{ki}$ 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 (gCO2/g)	Ingredient 2	Quantity 2 (g)	CFI_2 (gCO2/g)	Ingredient 3	Quantity 3 (g)	CFI_3 (gCO2/g)	Total Quantity (g)	Emissions (gCO2e)	Rounded emissions (gCO2e)
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[9]	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

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

17

	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

4.2.2 Nutritional quality

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

Equation 2:

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

$$RCS_{i,k} = \begin{cases} 1 - \dfrac{\max\left(Obs\_freq_{i,k} - Rec\_freq_k, 0\right)}{Rec\_freq_c} & if\ Rec\_freq_k\ is\ a\ maximal\ frequency\ criterion \\[2mm] 1 - \dfrac{\max\left(Rec\_freq_{i,k} - Obs\_freq_k, 0\right)}{Rec\_freq_c} & if\ Rec\_freq_k\ is\ a\ minimal\ frequency\ criterion \\[2mm] 1 - \dfrac{\left|Obs\_freq_{i,k} - Rec\_freq_k\right|}{Rec\_freq_k} & if\ Rec\_freq_k\ is\ an\ exact\ frequency\ criterion \end{cases}$$

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

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

Alternatively, the same two indicators are computed on a restricted number of four FCs (in bold in Table 5) instead of the whole 15. The four FC are arguably the most important ones because they have the highest nutritional values and concern costly food items often wasted by children (ADEME 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[10] 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

---

[10] 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

22

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

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:**

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

435   where Yi 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

23

438 degree, which is strongly correlated with the median income[11] (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).

5 Results

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")

448 are weakly respected as in Vieux et al. (2018). In addition, the minimal frequency of 8/20 servings of

449 "hard cheese" (25.7% binary and 70.2% relative) and the maximum of 2/20 serving of "fatty protein"

450 (22.8% binary and 37.9% relative) are also poorly met. Substantial (> 30 percentage points)

451 differences are however identified with Vieux et al (2018) on the following six FC: "Raw fruits or

452 vegetables starters", "Pre-processed dishes", "Hard cheese", "Non-cheese dairy products", "Sugary

453 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[12]. 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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[11] Similar results were found when performing OLS regression with the median income rather than the education level.
[12] For most French elementary public schools' children attend school only Wednesday morning.

24

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 ± 0.24 $kgCO_2e$/day, with minimal and

462   maximal monthly averages at 1.2 and 2.6 $kgCO_2e$/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 ($kgCO_2e$)	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)

25

				study)	
Starters containing more than 15% fat	Fatty starters	starter	4/20 max	83,2%	82,5%
Raw vegetable or fruit dishes containing at least 50% vegetables or fruits	**Raw fruits or vegetables starters**	**starter, side dish**	**10/20 min**	**38.6%**	**70%**
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%
Unground beef, veal or lamb, and offal	**Red meat**	**protein dish**	**4/20 min**	**63,4%**	**77,5%**
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%
Vegetables, other than pulses, alone or in a mixture containing at least 50% vegetables	**Vegetable side dishes**	**side dish**	**=10/20**	**22,8%**	**27,5%**
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					
Raw fruit dessert 100% raw fruit without added sugars	**Raw fruit dessert**	**dessert**	**8/20 min**	**93%**	**77,5%**

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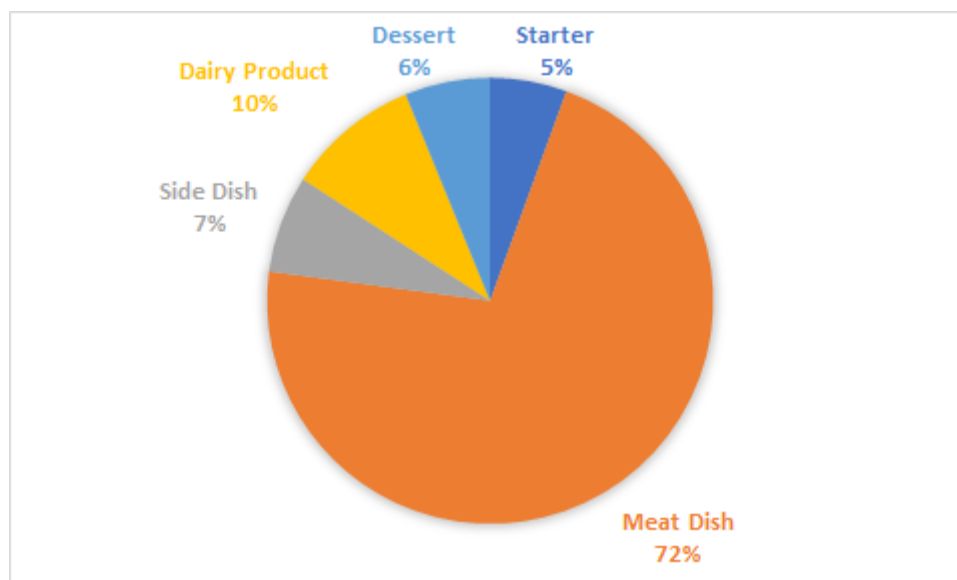

Figure 1: Share of greenhouse gas emissions (in percentage) by food component (average GHG emissons, 1.9 kgCO$_2$e).

5.2 Interactions between nutritional quality and carbon footprint

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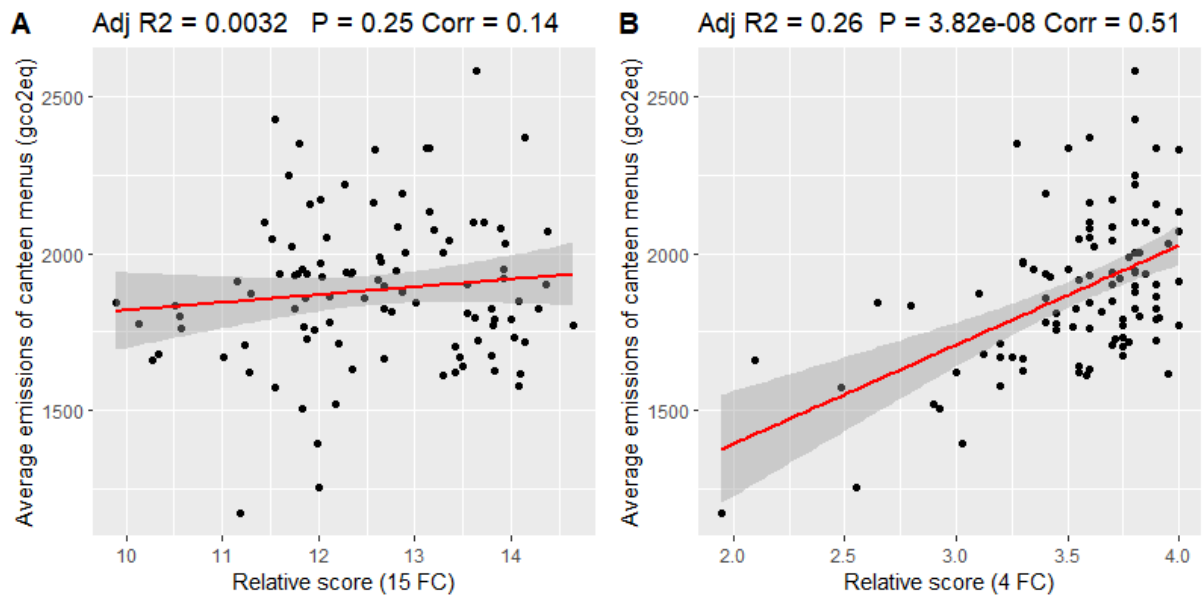
Figure 2: Correlation between carbon footprint and nutritional score

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

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

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

28

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

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

On average, the management model has no impact on the environmental impact of menus (Table 7, column 1). However, this average result hides interactions with canteen size or left-wing vote. In-house canteens serving more than 3,500 pupils[13] indeed have a lower environmental impact (0.16 kgCO$_2$e less when the number of pupils is multiplied by 10, see Table 7, Annex 1. 15 *and* Annex 2. 1 *for* the details of the calculations). Similarly, in-house canteens in left-wing municipalities (with more than 53% of left-wing votes) have a higher environmental quality (0.0035 kgCO$_2$e less with a one percent increase of left-wing votes, see Table 7, Annex 1. 16 and Annex 2. 1). In addition, a lower carbon footprint of canteen menus is observed in municipalities with a better educated population (4,30-4,40 kgCO$_2$ less with a 1% increase of the population with a second-year university level) while the frequency of certified food products has no significant effect (Table 7). This result is confirmed when we restrict the certified food category to organic food (see Annex 1. 17).

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[13] 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)

	Dependent variable:		
	Average emissions of canteen menus (gco2e)		
	(1)	(2)	(3)
In-house provision	64.882	871.630**	216.703**
	(52.015)	(375.443)	(90.860)
Frequency of certified products	6.825	−29.823	−82.943
	(209.036)	(205.771)	(210.451)
Proportion of the population with a high diploma	−434.252**	−442.824**	−443.229**
	(194.544)	(190.900)	(191.507)
Proportion of the left-wing voters during the first round	−159.981	−176.693	59.295
	(113.638)	(111.751)	(155.762)
log(Population of 6-10 years old enrolled)	−56.281	82.260	−56.193
	(63.989)	(89.560)	(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***	1,856.864***	2,235.479***
	(216.053)	(288.540)	(213.836)
Observations	101	101	101
R^2	0.094	0.137	0.132
Adjusted R^2	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
519 Note: *p<0.1; **p<0.05; ***p<0.01

6 Discussion and policy recommendations

6.1 Benchmarking of nutritional and environmental scores

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

30

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$_2$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$_2$e

541 (ADEME 2016). Overall, our average estimate lies within the 0.72-4.1 kgCO$_2$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

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

6.2 Drivers of nutritional quality and carbon footprint

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

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[14] Once this is factored in the econometric analysis, price difference is no longer statistically different.

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

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

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

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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.

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6.3   Policy and Managerial Implications

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

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

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656   1.8 to 1.2 kgCO2e) 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 kgCO2e/day, which is consistent with previous

679   literature. No correlation is found between the nutritional and environmental qualities of canteens

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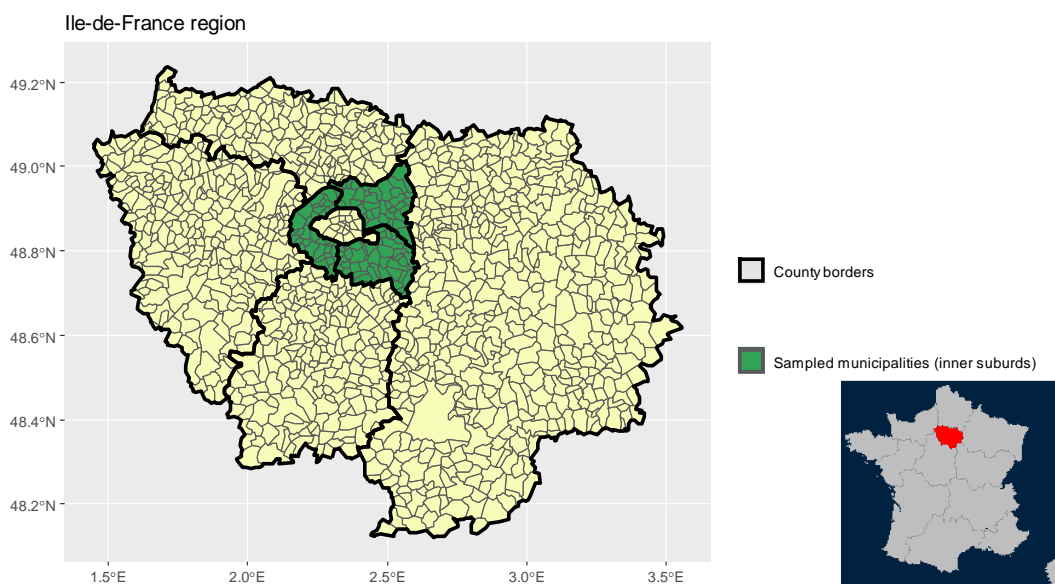
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689   **Annex 1. 2:** Central kitchens of intercommunal associations

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

*517 meat alternatives were proposed out of 2020 menus*
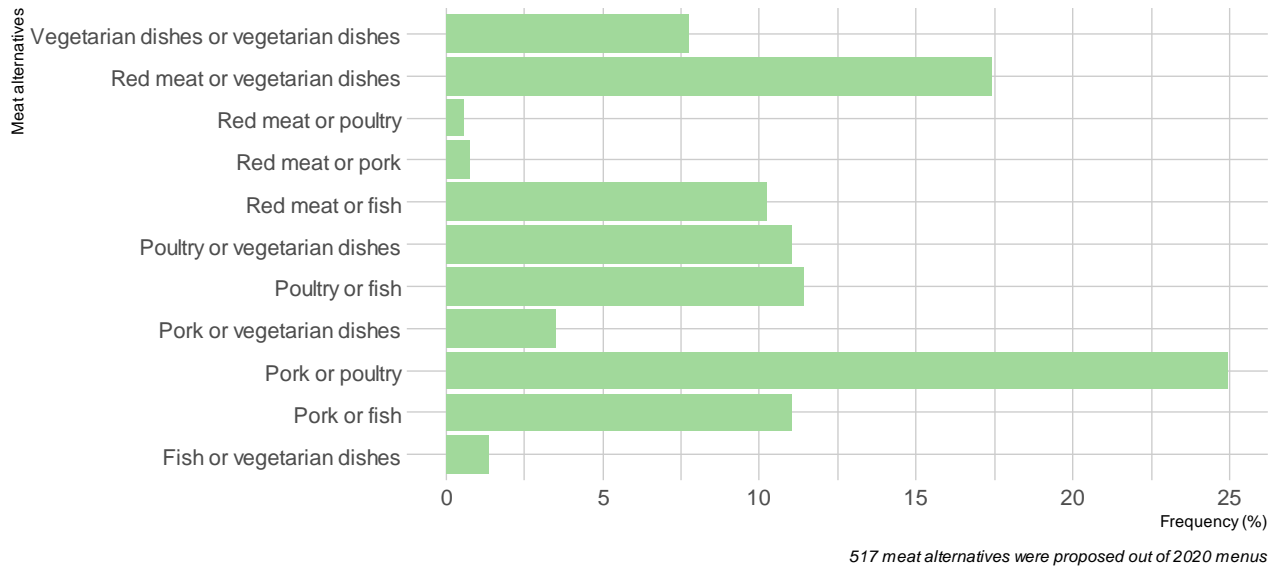
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693 **Annex 1. 4:** Controlling carbon footprint homogeneity of the food categories used based on
694 representative dishes from Agribalyse 3.0

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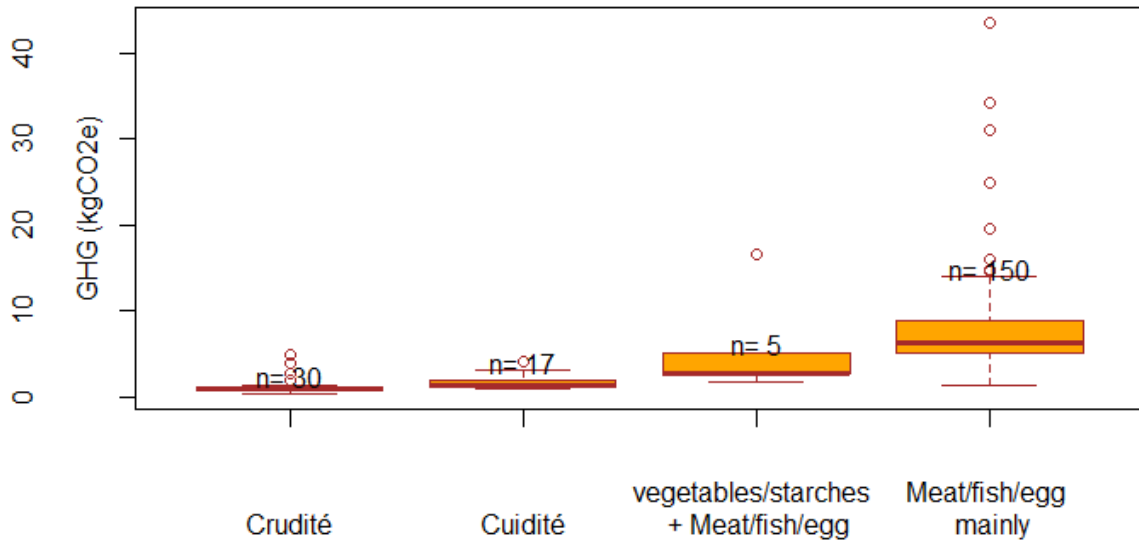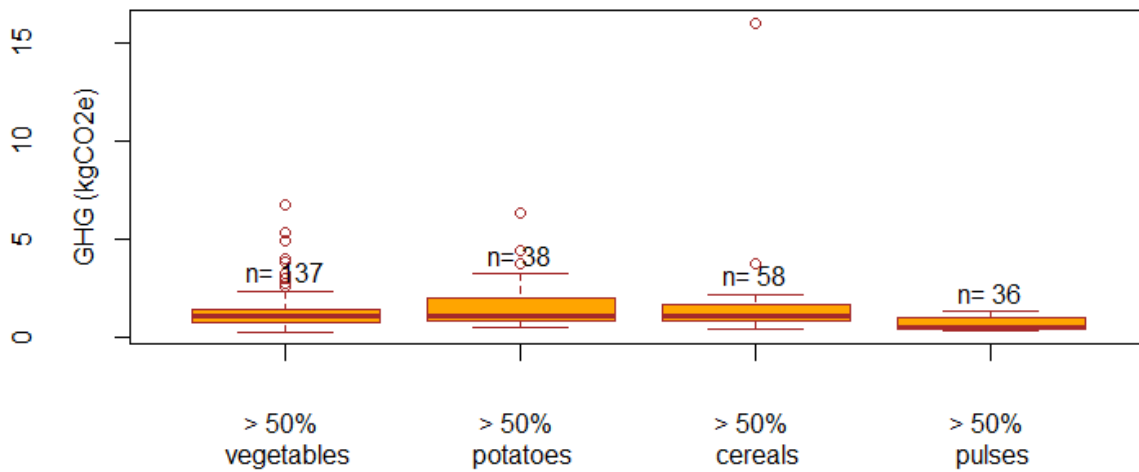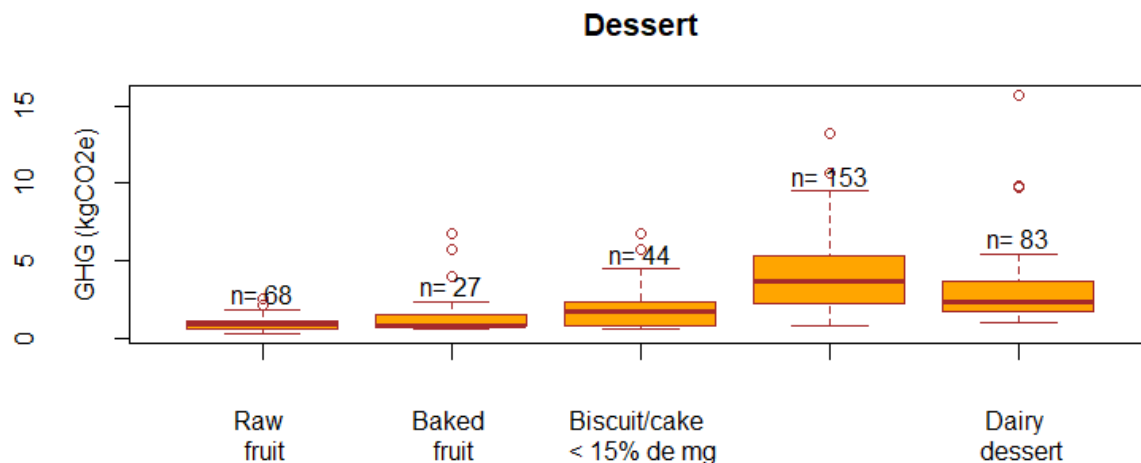696   all dishes belonging to the relevant category in Agribalyse 3.0.

Meta

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Dairy Product
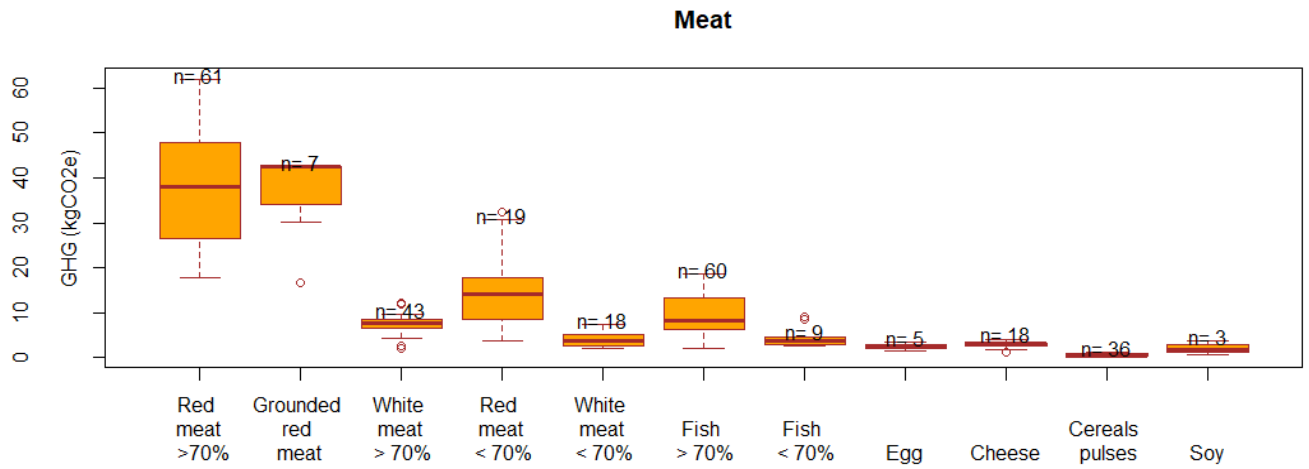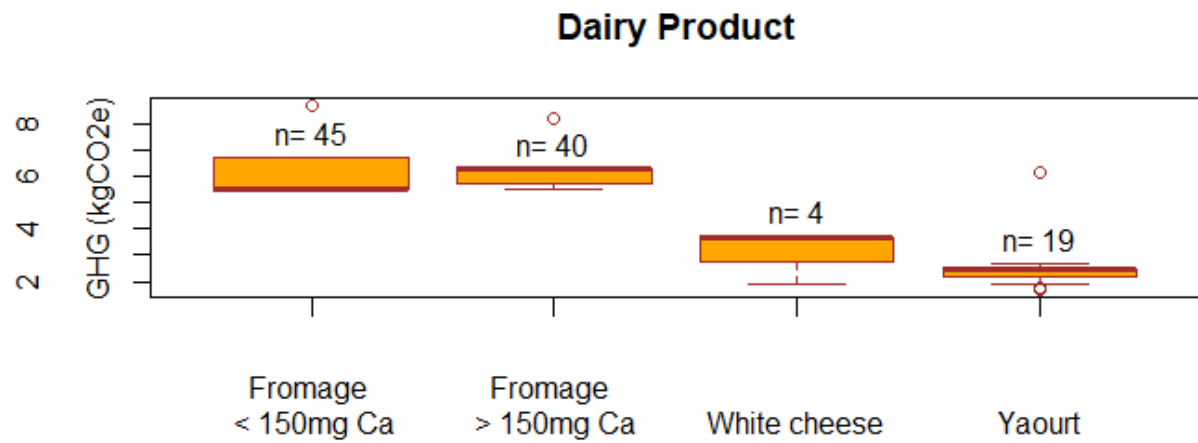
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Starter

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Side dish

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Dessert

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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[15]

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

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[15] 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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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[16]	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%
Raw fruits or vegetables starters	**starter, side dish**	**8/20 min**	**38.6%**	**41,6%**
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%

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[16] See the complete frequency criterion name in Table 3.

Red meat	**protein dish**	**3.2/20 min**	**63,4%**	**20,8%**
Pre-processed dishes	protein dish	3.2/20 max	74,2%	59,4%
Vegetable side dishes	**side dish**	**=8/20**	**22,8%**	**18,8%**
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%
Raw fruit dessert	**dessert**	**6.4/20 min**	**93%**	**83%**

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

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

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[17] See the complete frequency criterion name in Table 3.

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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%
Raw fruit dessert	**dessert**	**6.4/20 min**	**98,8%**	**97,5%**

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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[18]	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%
Raw fruits or vegetables starters	**starter, side dish**	**10/20 min**	**38.6%**	**84,4%**
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%
Red meat	**protein dish**	**4/20 min**	**63,4%**	**87,8%**
Pre-processed dishes	protein dish	4/20 max	74,2%	88,6%
Vegetable side dishes	**side dish**	**=10/20**	**22,8%**	**83,8%**
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%
Raw fruit dessert	**dessert**	**8/20 min**	**93%**	**98,8%**

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[18] 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[1]	Delegated provision, N = 53[1]	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)

[1] Mean (SD)

[2] Welch Two Sample t-test

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

	Dependent variable:		
	Relative Score (15 FC)		
	(1)	(2)	(3)
In-house provision	0.688***	0.581**	0.108
	(0.231)	(0.228)	(1.685)
Frequency of certified products	−0.103	−0.711	−0.689
	(0.911)	(0.916)	(0.923)
Proportion of the population with a high diploma	0.168	0.325	0.330
	(0.875)	(0.852)	(0.857)
Proportion of the left-wing voters during the first round	0.565	0.123	0.133
	(0.481)	(0.498)	(0.501)
log(Population of 6-10 years old enrolled)		0.723**	0.642
		(0.280)	(0.402)
In-house provision * log(Population of 6-10 years old enrolled)			0.144
			(0.509)
Constant	11.988***	9.876***	10.124***
	(0.488)	(0.947)	(1.295)
Observations	101	101	101
R^2	0.133	0.189	0.190
Adjusted R^2	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)

Note: $^{*}p<0.1; ^{**}p<0.05; ^{***}p<0.01$

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

	Dependent variable:		
	Relative Score (4 FC)		
	(1)	(2)	(3)
In-house provision	0.159*	0.139	1.582***
	(0.082)	(0.083)	(0.599)
Frequency of certified products	0.447	0.333	0.268
	(0.325)	(0.336)	(0.328)
Proportion of the population with a high diploma	−0.665**	−0.636**	−0.651**
	(0.313)	(0.312)	(0.305)
Proportion of the left-wing voters during the first round	−0.206	−0.289	−0.318*
	(0.172)	(0.182)	(0.178)
log(Population of 6-10 years old enrolled)		0.135	0.383***
		(0.103)	(0.143)
In-house provision * log(Population of 6-10 years old enrolled)			−0.440**
			(0.181)
Constant	3.753***	3.358***	2.599***
	(0.174)	(0.347)	(0.460)
Observations	101	101	101
R^2	0.096	0.112	0.164
Adjusted R^2	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: $^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

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

| | Dependent variable: | | |
| | Relative Score (4 FC) using bisquare weigthing function | | |
	(1)	(2)	(3)
In-house provision	0.086	0.085	0.608
	(0.064)	(0.065)	(0.479)
Frequency of certified products	−0.201	−0.203	−0.233
	(0.251)	(0.262)	(0.263)
Proportion of the population with a high diploma	−0.099	−0.099	−0.105
	(0.241)	(0.244)	(0.244)
Proportion of the left-wing voters during the first round	−0.052	−0.054	−0.047
	(0.132)	(0.142)	(0.143)
log(Population of 6-10 years old enrolled)		0.003	0.099
		(0.080)	(0.114)
In-house provision * log(Population of 6-10 years old enrolled)			−0.160
			(0.145)
Constant	3.683***	3.675***	3.375***
	(0.134)	(0.271)	(0.368)
Observations	101	101	101
R^2	0.200	0.200	0.224
Adjusted R^2	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

Annex 1. 15: Interaction term between in-house provision and canteen size (min = 129 pupils, max = 25,985 pupils) on GHG ($kgCO_2e$) of canteen menus
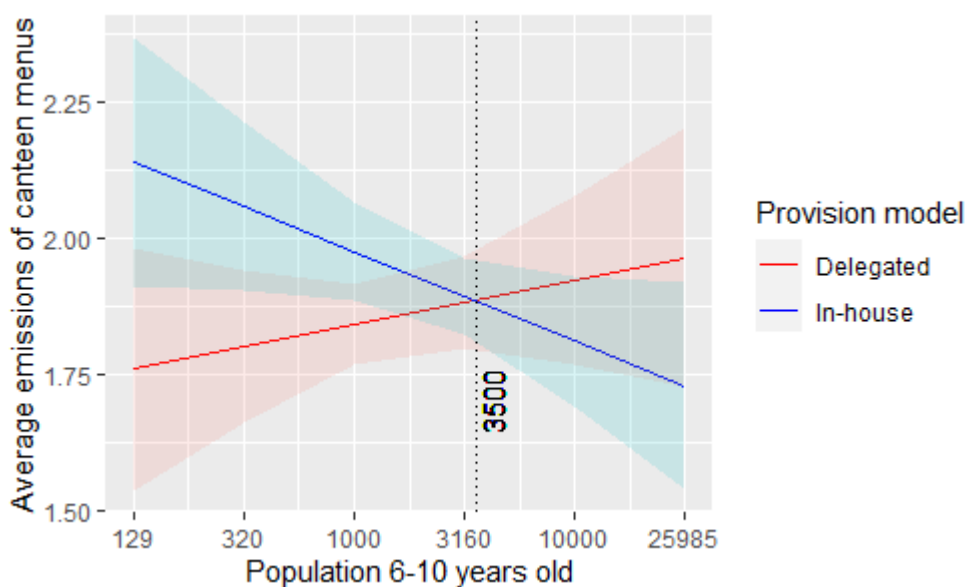
780 **Annex 1. 16:** Interaction term between In-house provision and the proportion of left-wing voters[19]
781 on GHG (kgCO$_2$e) of canteen menus
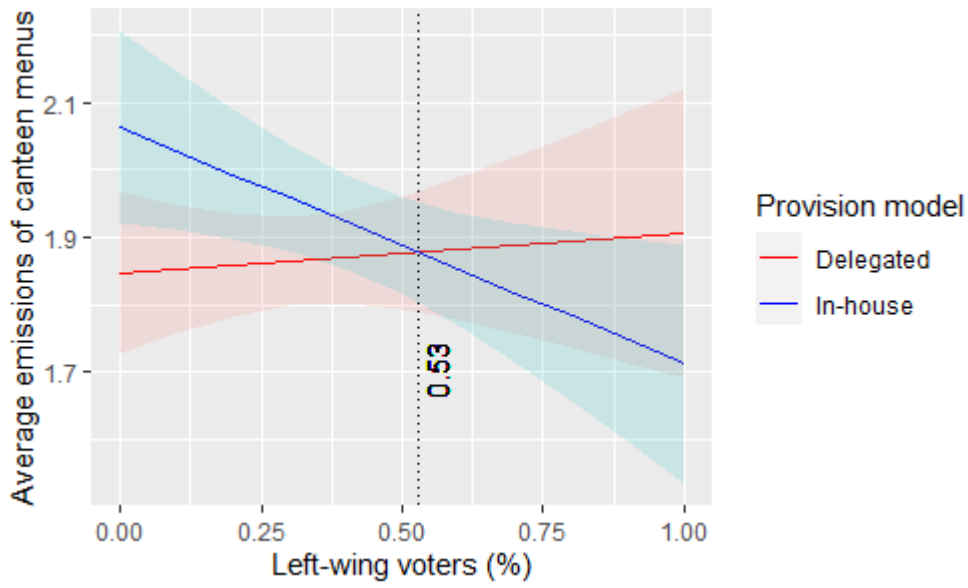
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[19] A 0% share vote is obtained for municipalities without left or right candidates.

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

	Dependent variable:		
	Relative Score (15 FC) using bisquare weigthing function		
	(1)	(2)	(3)
In-house provision	0.801***	0.669***	0.302
	(0.219)	(0.217)	(1.624)
Frequency of organic products	−0.742	−1.155	−1.144
	(0.933)	(0.941)	(0.949)
Proportion of the population with a high diploma	0.515	0.482	0.508
	(0.823)	(0.806)	(0.813)
Proportion of the left-wing voters during the first round	1.187***	0.760	0.784
	(0.458)	(0.479)	(0.484)
log(Population of 6-10 years old enrolled)		0.633**	0.565
		(0.269)	(0.385)
In-house provision * log(Population of 6-10 years old enrolled)			0.113
			(0.490)
Constant	11.729***	9.955***	10.146***
	(0.467)	(0.907)	(1.241)
Observations	101	101	101
R^2	0.354	0.397	0.401
Adjusted R^2	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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Annex 1. 18: Mean GHG value per school meal (gCO2e) and its determinants (including organic labels rather than certified, OLS regression)

	Dependent variable:		
	Average emissions of canteen menus (gco2e)		
	(1)	(2)	(3)
In-house provision	63.356	873.032**	218.169**
	(51.447)	(375.002)	(90.860)
Frequency of organic products	−40.416	−67.190	−122.197
	(223.146)	(219.215)	(223.062)
Proportion of the population with a high diploma	−423.284**	−436.614**	−440.444**
	(191.305)	(187.739)	(188.340)
Proportion of the left-wing voters during the first round	−159.971	−177.068	59.963
	(113.605)	(111.704)	(154.851)
log(Population of 6-10 years old enrolled)	−52.958	84.870	−54.351
	(63.709)	(88.915)	(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***	1,851.517***	2,232.601***
	(215.106)	(286.664)	(212.541)
Observations	101	101	101
R²	0.094	0.138	0.133
Adjusted R²	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

Annex 2.

Annex 2. 1.

Annex 2. 1: Canteen menu and explanatory variable database

See MenuR.xlsx.

Annex 3.

Annex 3. 1: Classification algorithm

See Algorithm.rar

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