Citizens in energy transition: Highlighting the role played by spatial preference heterogeneity in public acceptance of biofuels

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An example of DCE methods applied to the development of biofuels in the transportation sector.

- **Results** of an **article** written with:
  - Anthony Paris (IFPEN, Univ. Paris-Nanterre);
  - Pascal GASTINEAU (Univ. Gustave Eiffel)
  - Pierre-Alexandre MAHIEU (Univ. Nantes)

- This paper investigates the **acceptance to pay a new tax** dedicated to the **development of new biofuels** in order to **reduce greenhouse gas** (GHG) emission in the transportation sector.
  - Revealing preferences for different biofuels characteristics & development policies

- A **survey** has been conducted with a ***Discrete Choice Experiment (DCE),*** a particular methodology:
  - in march 2018
  - among **1000 respondents**, representative of the **French** population

Citizens in energy transition: Highlighting the role played by spatial preference heterogeneity in public acceptance of biofuels

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Abstract

Renewable fuels development is an integral part of the public policies mix highlighted by policy makers to decarbonize the transportation sector. Widespread deployment of energy transition technologies will largely depend on the attitudes of consumers and citizens. This paper investigates the acceptance by the French population to pay a new annual tax to finance the development of new biofuels in order to reduce greenhouse gas (GHG) emission in this sector. With a Discrete Choice Experiment conducted among about 997 French citizens in 2018, we analyze preferences for different biofuel development policies. Using a two-stage method, we are particularly interested in the heterogeneity of these preferences. The first stage uses a random parameters logit model. It highlights the heterogeneity of preferences for the attributes within our sample. The means of marginal willingness to pay stemming from the random parameter model are 71, 105 and 142 euros for 20%, 30% and 50% reduction in GHGs emissions compared to 5% reduction. In addition, the support to agricultural sector and the avoidance of food price increase are valued, in mean, respectively at 60 euros and 39 euros. The second stage model uses a panel random-effect regression to estimate the influence of socioeconomic and spatial characteristics on marginal willingness to pay for each of the choice experiment attributes except for emissions reduction. We show that French citizens can be split into two categories depending on the agricultural specialization of its localization.

JEL Classification: C35; C83; Q01; Q42
Keywords: Biofuels; Discrete choice experiment; Social acceptance; Willingness to pay

- Introduction
- The *Discret Choice Experiment* approach
  - The survey: an example of a choice card
  - Choice of attributes and levels
  - Experimental design
  - The questionnaire and data collection
- A two-stage estimation procedure
  1. *Random Parameter Logit model*
  2. *Panel data analysis of the WTP (Random-effects model)*
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INTRODUCTION
INCREASING THE USE OF BIOFUELS ?

- An example of Discrete Choice Experiment methods applied to the development of biofuels in the transportation sector.

- **In France, transportation sector accounts for:**
  - **34%** of the final energy consumed (92 % petroleum products)
    - ➔ diversification
  - **26 %** of national GHG
    - ➔ biggest emitter

- **Renewable fuels are one of the solution** to decarbonize the transportation sector(SP95-E10 for instance):
  - incorporated in fuels with various blend rates:
    - Agricultural raw material (wheat, corn)
    - Vegetable oil (rapeseed, sunflower, palm)
    - Microalgae
    - Energy crops (switchgrass, jatropha), wood or agricultural residues

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- **Questionnable:**
  - The « *food vs. fuel* » debate
    - large increase in agricultural commodity prices during the 2000's
    - competition on the uses of arable land
    - deforestation (ILUC)

- **Second-generation biofuels as a solution ?**
  - lignocellulosic biomass
    - Energy crops (switchgrass, jatropha), wood or agricultural residues
  - better score in GHG emissions reduction from LCA studies

➔Lower impact on agricultural prices

➔Less opportunities for agricultural sector

INTRODUCTION
LITERATURE REVIEW

- **US studies:**
  - Li et al. (2009); Solomon and Johnson (2009); Petrolia et al. (2010); Jensen et al. (2010, 2012); Susaeta et al. (2010); Farrow et al. (2011); Marra et al. (2012); Aguilar et al. (2015); Li and McCluskey (2017); Baral and Rabotyagov (2017); Pouliot et al. (2018).
- **EU studies:**
  - Giraldo et al. (2010); Gracia et al. (2011); Loureiro et al. (2013); Kallas and Gil (2015);
  - Savvanidou et al. (2010); Lanzini et al. (2016).
- **Other countries :**
  - Bae (2014); Lim et al. (2017); Mamadzhanov et al. (2019); Shin and Hwang (2017).

- No SP studies on the **french case.**
- Analysis of consumers choices but **citizen preferences.**
- **heterogeneity** in preferences:
  - socioe-economic determinants;
  - **spatial preference heterogeneity.**

- **A two-stage estimation procedure (Campbell, 2007; Scarpa et al., 2011; Abildtrup et al., 2013; Yao et al., 2014, etc.)**
  1. ***Random Parameter Logit model;***
  2. ***Panel data analysis of the WTP (Random-effects model).***

A QUANTITATIVE ANALYSIS OF CITIZENS' PREFERENCES

- **This article investigates the factors influencing citizens (not consumers) motivations and obstacles to finance biofuels development :**
  - We estimate the relative weight of various biofuels characteristics influencing citizens' acceptance.
  - Same criteria than policy makers (climate change, energy security)?
  - Spatial heterogeneity ?

- **We measure citizens' valuation of these characteristics in monetary terms :**
  - Willingness To Pay (WTP) for these factors.
  - Non-market valuation : ***Discrete Choice Experiment (DCE).***

- **Our survey** is the first in **France** and the first using main biofuels characteristics to distinguish between feedstocks

1. **The survey begins** with some information about biofuels in terms of actual use, political determination to develop them, their advantages and disadvantages.

2. **Various successive choices** are then proposed between two scenarios – A and B – and a status quo option.
   ➔ Fictional choices made by respondents among several options

3. Respondents **finish survey** by responding to social and economic questions allowing us to analyze impact of these citizens' characteristics on their preferences structure.

4. **Econometric analysis**

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METHOD:
THE DISCRET CHOICE EXPERIMENT (DCE)

Theorical framework in microeconomics :

Lancaster (1966) and Mc Fadden (1974)

Environmental Economics:

Stated Preference Methods

1/ DESIGN

- Bridges et al. (2013) ,
- Johnson et al. (2019)

- **Attributes and levels:**
  - Nb : Marshall et al. (2011)
  - Content: *Qualitative phase* (Coast et al., 2012; Kløjgaard et al., 2012; Louvier and Lancsar, 2009)

- **Experimental design** to build the scenarios

2/ SURVEY

- **# of respondents**

- **Type of survey :**
  - Interviews /
  - Auto-administered (online or paper) /
  - Survey institute

- **Content:**
  - DCE module + other questions

3/ ANALYSIS

- Hauber et al. (2016)

- **Statistics on choices and Dominant preferences:**
  - Difficulty of choice or lexicographic preferences (Scott, 2002)

- **Conditional logit**
  - ➔ Average preferences

- **Mixed logit** (Train, 2009) or **Latent Class**
  - Heterogeneity of preferences

OVERVIEW OF THIS DCE

- This study investigates the acceptance by the French population of a new annual tax to finance the development of biofuels in order to reduce GHG emissions in the transportation sector.
- It analyses preferences for the main characteristics of biofuels.

1/ DESIGN

- **Attributes and levels:**
  - #: 4 attributes, 2 to 4 levels.
  - Content: 5 choices between 2 unlabelled alternatives + opt-out (status quo).
- **Experimental design**
  - two different blocks (versions) containing five choices cards.
  - D-optimality criterion.

2/ SURVEY

- **~ 1000 of respondents**
  - March 2018
  - Representative of the French population
- **Web survey**
- **Content:**
  - DCE module + additional questions

3/ ANALYSIS

- **Descriptive analysis**
- **Two-stage method**
  - **1/ RPL model**
    - ➔ *Heterogeneity*
  - **2/ Panel data estimates (RE)**
    - ➔ to estimate the influence of socioeconomic and spatial characteristics on mWTPs.

OVERVIEW OF THIS DCE

- Respondents have to make choices between three options.
- In our case, respondents are citizens who choose between conserving actual biofuels level (status quo) or developing additional biofuels.
- Each option is defined by a set of attributes taking different values.
- One of these attributes is the monetary contribution of the respondents ; the others include environmental or economic implications of the issue.

THIS DCE : EXAMPLE OF A CHOICE CARD

- In the following choice card, which scenario do you prefer between:
  - **scenario A**;
  - scenario B;
  - Statu Quo

	Scénario A	Scénario B	Statu Quo
Contribution monétaire : Montant payé par chaque ménage par an pendant 5 ans	100 €	15 €	0 €
Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Oui	Non	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-5%	-20%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

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In the scenario A:

- Each household have to pay a contribution of 100 euros per year during 5 years.
- There will be an increase of agricultural activities.
- The GHG emissions of this new biofuel will decrease by 5% compared to the Statu Quo.
- There will be an increase in some food prices.

	Scénario A	Scénario B	Statu Quo
Contribution monétaire : Montant payé par chaque ménage par an pendant 5 ans	100 €	15 €	0 €
Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Oui	Non	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-5%	-20%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

In the scenario B:

- Each household have to pay a contribution of 15 euros per year during 5 years.
- No increase of agricultural activities.
- The GHG emissions of this new biofuel will decrease by 20% compared to the Statu Quo.
- No increase in food prices.

Statu Quo
The current situation remains: no development of a new biofuel

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THE CHOICE OF THE ATTRIBUTES

- The number of attributes must be limited to avoid the cognitive burden / without omitting any fundamental attribute.

- Choice of the attributes and levels based on :
  - The literature,
  - Discussions with fuel and biofuels experts,
  - Discussions with fuel users having knowledge of biofuels or not.

ATTRIBUTES AND LEVELS

- **Annual contribution during five years** (0 € (only SQ) ; 15 €; 50 €; 100 €; 150 €) :
  - Amount can vary depending on the new biofuels developed, the quantity needed...
  - Minimal amount (15 €) corresponds to 1.25 € per month,
  - Maximal amount (150 €) based on the audiovisual contribution.

- **Support for agricultural sector** (Yes ; No (SQ)):
  - Existence of an agricultural support depends on the source of new biofuels developed.

- **GHG emissions variation** (0% (only SQ) ; -5% ; -20% ; -30% ; -50%).
  - Variations depend on the source of the new biofuels and the blend rate in traditional fuel,
  - Amount of emissions based on *LCA* analysis (Edwards et al., 2014).

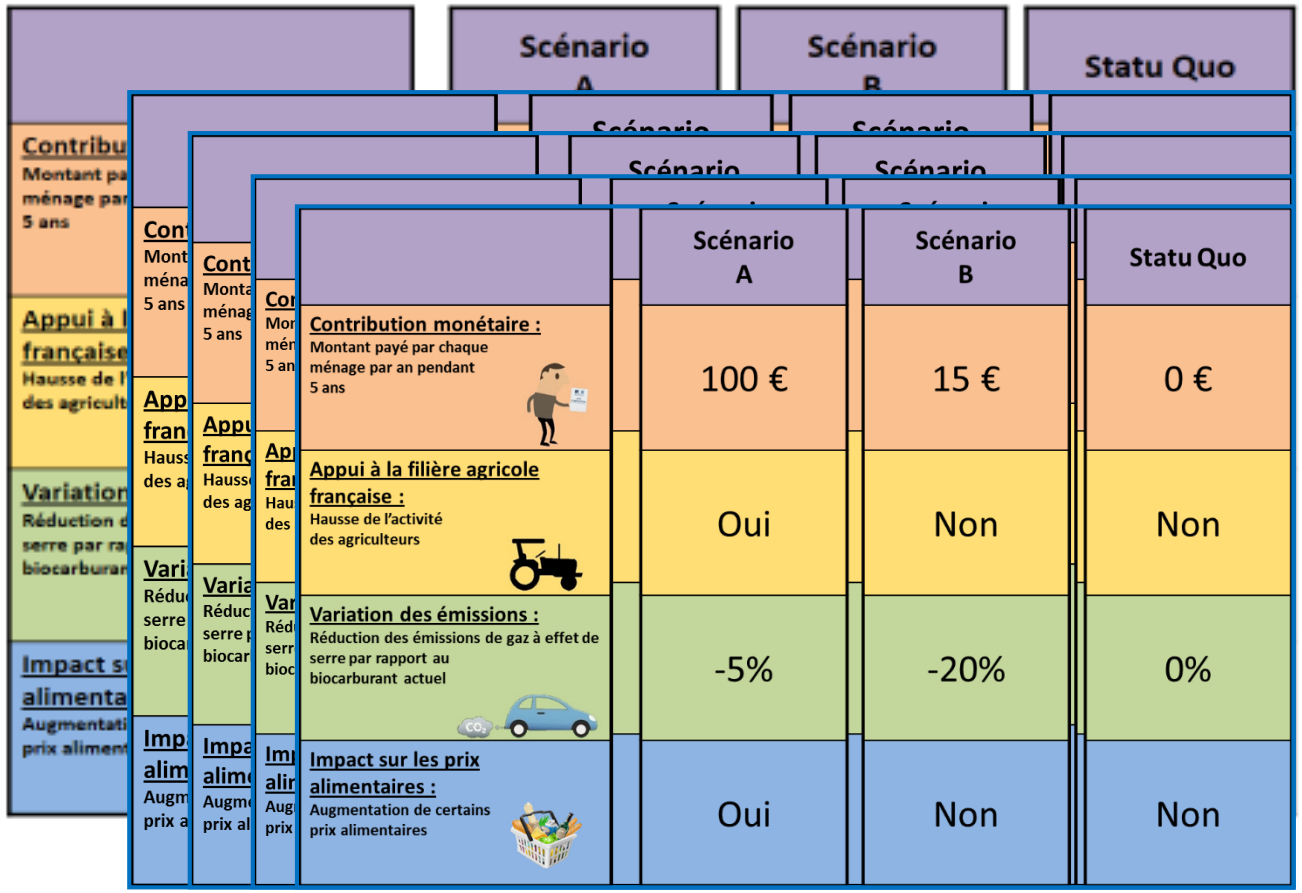
- **Impact on food prices** (Yes ; No (SQ)).
  - Existence of food prices impact depend on the source of the new biofuels.

THE DCE APPROACH: A BLOCK OF CHOICE SET

Five different choices cards are randomly attributed to each respondent

➔ **stated preference method**

Attributes	Levels
Monetary contribution	0€ (only SQ) ; 15€ ; 50€ ; 100€ ; 150€
Support for agricultural sector	Yes ; No (SQ)
Emissions variation	0% (only SQ) ; -5% ; -20% ; -30% ; -50%
Impact on food prices	Yes ; No (SQ)



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THE AIM OF THE EXPERIMENTAL DESIGN

- With four attributes and two to four levels each, $4^2 * 2^2 = 64$ scenarios exist and the questionnaire would be far too heavy if all combinations of attributes' levels were presented.
- How to select the options that are submitted to respondents ?

THE EXPERIMENTAL DESIGN

- Experimental design using the D-optimal criterion.
- Minimize the size of the variance-covariance matrix of parameters given a prior for \beta.
- We obtain a first version with 10 choice sets which were blocked into two blocks : 5 choice sets per respondent.
- This first version has been administrated to a test sample comprising 42 respondents to estimate priors.
- Estimations used in a second efficient design.

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PRESENTATION OF THE QUESTIONNAIRE

- < 15 minutes.
- General questions regarding the citizens' characteristics (to achieve the sample representativeness).
- Description of the survey (biofuels actual use, advantages and disadvantages, example of a choice task).
- **5** choice sets.
- Additional questions to respondents choosing the status quo in all choice sets.
- Final questions on socio-demographic situation, transport and environmental behaviors.

LIMITATIONS OF STATED PREFERENCE METHODS
➔HYPOTHETICAL BIAS (1/2)

- **Two related criticisms:**
  1. Some respondents are not fully involved in the task
  2. Responses may differ from people's real choices
  - ➔ **Hypothetical bias**

- **Causes :**
  - Choice tasks are difficult to complete
  - Choices are not incentive-compatible

- **Consequences :**
  - May overestimate WTP and predicted uptake rates
  - Noisy and less precise estimates

- **Objective**: design experiments to
  i. decrease hypothetical bias and
  ii. improve precision of welfare estimates.

LIMITATIONS OF STATED PREFERENCE METHODS
➔HYPOTHETICAL BIAS (2/2)

- **Classical solutions:** *Ex-ante* survey designs
  - **Origines: contingent valuation method (CVM)**
    1. ***"Oath statements"*** (Jacquement et al, 2013)
    2. ***"Cheap talk"*** (Cumming and Taylor, 1999; Morrison and Brown, 2009):
       - *Ex: Remind the negative impact of a new tax on respondent's available income.*
    3. **Emphasize *consequentiality*** of the choices (Loomis, 2014)
       - ➔ *Remind political determination to develop new biofuels and the impact of responses on political choices.*
         - Zawojska et al. (2019):
           - Policy consequentiality : *respondents believe their survey responses can influence decisions related to the outcome in question.*
           - Payment consequentiality : *respondents are aware they will have to bear their share of the coercive cost if the outcome is implemented.*
- **Other solutions:**
  - *Ex-post calibration with follow-up certainty scales*
    - *Ex: Indicate certainty level on a 0-10 scale (Champ et al., 1997).*

DATA COLLECTION

- Survey in March 2018.
- Web-survey.
- 997 answers.
- 23 protesters removed and 2 surveys with errors.
- 972 respondents (sample).

DESCRIPTIVE STATISTICS (1/2)

Characteristics	Sample	2014 Survey
Size	972	-
Gender (% female)	51.0%	51%
Age		
Young (18 to 29)	20.7%	20,6%
Young adult (30 to 44)	28.3%	27,9%
Adult (45 to 59)*	26.1%	28,6%
Old (60 and older)	24.9%	22,9%

T-tests test shows significant differences * at 10% significance level; ** at 5% significance level, and *** at 1% significance level.

DESCRIPTIVE STATISTICS (2/2)

Characteristics	Sample	2014 Survey
Professional activity		
Top socio-professional category**	16.2%	13,7%
Middle socio-professional category**	16.2%	13,7%
Low socio-professional category***	32.2%	27,5%
Retired***	23.1%	32,6%
Inactive	12.2%	12,5%

T-tests test shows significant differences * at 10% significance level ; ** at 5% significance level, and *** at 1% significance level.

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THEORETICAL FRAMEWORK

- **Three axioms**
  1. **Revealed preference** theory
     - B>A if U(B) > U(A)
  2. **Characteristics demand** theory
     - V = f (X,b)
  3. **Random Utility** theory
     - U = V + e

Econometric models:

- Conditional Logit (CL) model
- Random Parameter Logit (RPL) model

	Scénario A	Scénario B	Statu Quo
Contribution monétaire : Montant payé par chaque ménage par an pendant 5 ans	15 €	0 €	0 €
Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Non	Oui	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-20%	-50%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

A two-stage estimation procedure

1. *Random Parameter Logit model*

$$U_{n,i} = \eta SQ + X_i \beta_n + \epsilon_{n,i} \tag{2}$$

$$U_{n,i} = \begin{cases} V_{n,i} + \epsilon_{n,i} = V(X_i, \beta_n, \mu_n) + \epsilon_{n,i} = X_i \beta_n + \mu_n + \epsilon_{n,i}, & \forall\, i = A, B \\ V_{n,i} + \epsilon_{n,i} = V(ASC, X_i, \beta_n) + \epsilon_{n,i} = \eta SQ + X_i \beta_n + \epsilon_{n,i}, & i = SQ \end{cases} \tag{3}$$

2. *Panel data analysis of the WTP (Random-effects model)*

Campbell, 2007; Scarpa et al., 2011; Abildtrup et al., 2013; Yao et al., 2014.

$$W_{n,k} = -\frac{dx_{cost}}{dx_k} = -\frac{dU/dx_k}{dU/dx_{cost}} = -\frac{\partial V/\partial x_k}{\partial V/\partial x_{cost}} = -\frac{\beta_k}{\beta_{cost}} \tag{4}$$

$$W^l_{n,k} = -\frac{\beta^l_k}{\beta_{cost}} \tag{5}$$

$$W^l_{n,k} = \psi_n + \gamma D^l_{n,k} + \lambda Z_n + \xi^l_{n,k} \tag{6}$$

Figure 1: Example of a choices card for survey

	Scenario A	Scenario B	Status Quo
Monetary contribution: Amount paid by each household in Euros per year during five years	15 €	100 €	0 €
Support for agricultural sector: Increase agricultural activities	Yes	No	No
Variation in GHG emissions: Reduction in GHG emissions compared to actual biofuels	-20%	-50%	0%
Impact on food prices: Increase in some food prices	Yes	No	No

Used to:

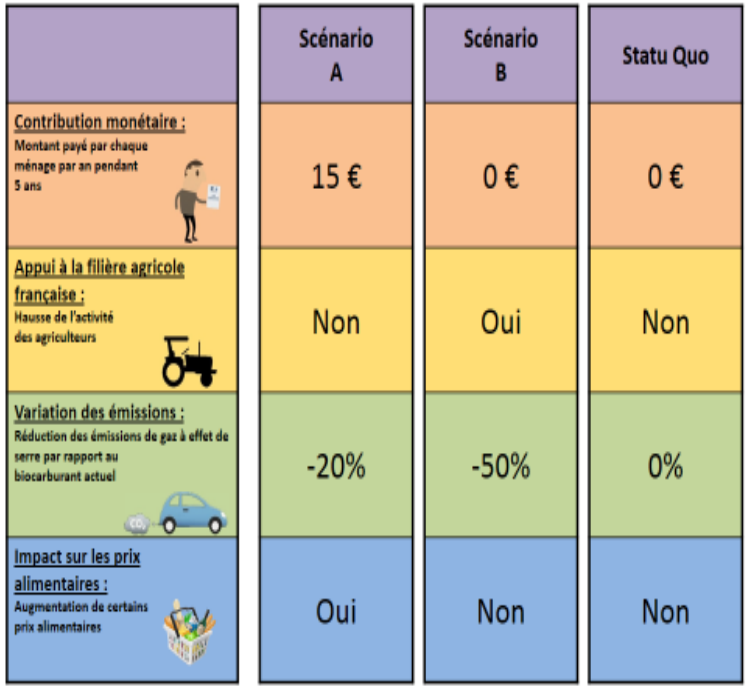
1/ tackle down the endogeneous problem

2/ **socio-economic variables**

RESULTS OF THE RPL MODEL

	CL model	RPL model	
	Coef. (S.E.)	Coef. (S.E.)	Std. Deviation (S.E.)
Alternative Specific Constant	-0.251***	-2.143***	-
	(0.057)	(0.185)	-
Monetary contribution	-0.012***	-4.008***	1.737***
	(0.001)	(0.087)	(0.090)
Agricultural support	0.509***	0.742***	0.662***
	(0.044)	(0.084)	(0.137)
No impact on food prices	0.453***	1.113***	1.130***
	(0.041)	(0.090)	(0.116)
Emissions variation			
20% reduction	0.336***	0.675***	1.732***
	(0.063)	(0.125)	(0.193)
30% reduction	0.856***	1.458***	1.380***
	(0.073)	(0.145)	(0.204)
50% reduction	0.985***	1.693***	2.476***
	(0.041)	(0.162)	(0.210)
Error Component	-	-	3.481***
	-	-	(0.223)
N (Ind.)	972	972	
N (Obs.)	14,580	14,580	
McFadden R^2	0.0679	0,2669	
Log Likelihood	-4,976.61	-3,914.10	

Note: For each variables, the first line concerns the estimated coefficient and the second line (in brackets) mentions the standard errors. The number of stars, i.e., one, two and three, refers to the 10%, 5% and 1% significance level, respectively. For the Random Parameter Logit model, the coefficient of the monetary contribution follows a log-normal distribution.



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Intuitive:

Monetary contribution: −

Agricultural support: +

Emissions variation: +

Impact on food prices: +

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  2. ***Panel data analysis of the WTP (Random-effects model)***
- Results of the second step: analysing spatial preference heterogeneity
- Conclusion

COMPUTING THE WILLINGNESS TO PAY (WTP) FOR EACH ATTRIBUTE

- The RPL coefficients are estimated for each respondent

$$U_{n,i} = \eta SQ + X_i \beta_n + \epsilon_{n,i}$$

Deducing the WTP for each respondent

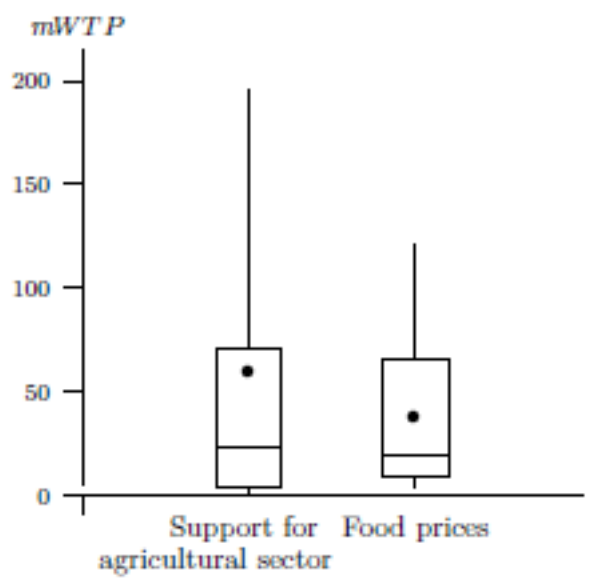
$$W_{n,k} = -\frac{dx_{cost}}{dx_k} = -\frac{dU/dx_k}{dU/dx_{cost}} = -\frac{\partial V/\partial x_k}{\partial V/\partial x_{cost}} = -\frac{\beta_k}{\beta_{cost}}$$

	Scénario A	Scénario B	Statu Quo
Contribution monétaire : Montant payé par chaque ménage par an pendant 5 ans	15 €	0 €	0 €
Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Non	Oui	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-20%	-50%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

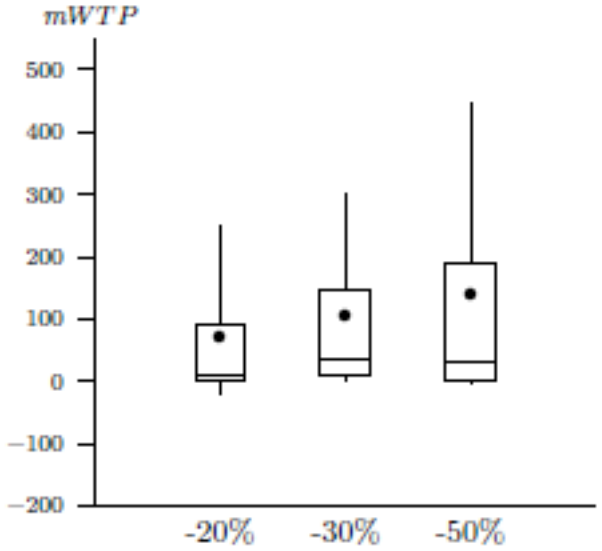
- WTP for agricultural support
- WTP for reducing the GHG emissions
- WTP for avoiding an increase in food prices

WTP ESTIMATES

Figure 2: Distribution of the marginal willingness to pay

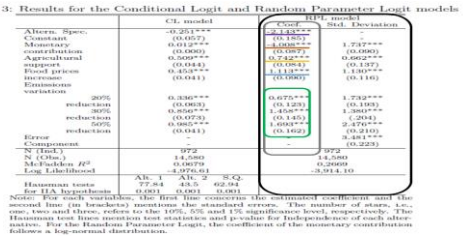


(a) Box plots for the marginal willingness to pay for the support for agricultural sector and avoidance of food prices increases



(b) Box plots for the marginal willingness to pay for the GHGs emissions reduction compared to -5% level

RESULTS OF THE RPL MODEL



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Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Non	Oui	Non
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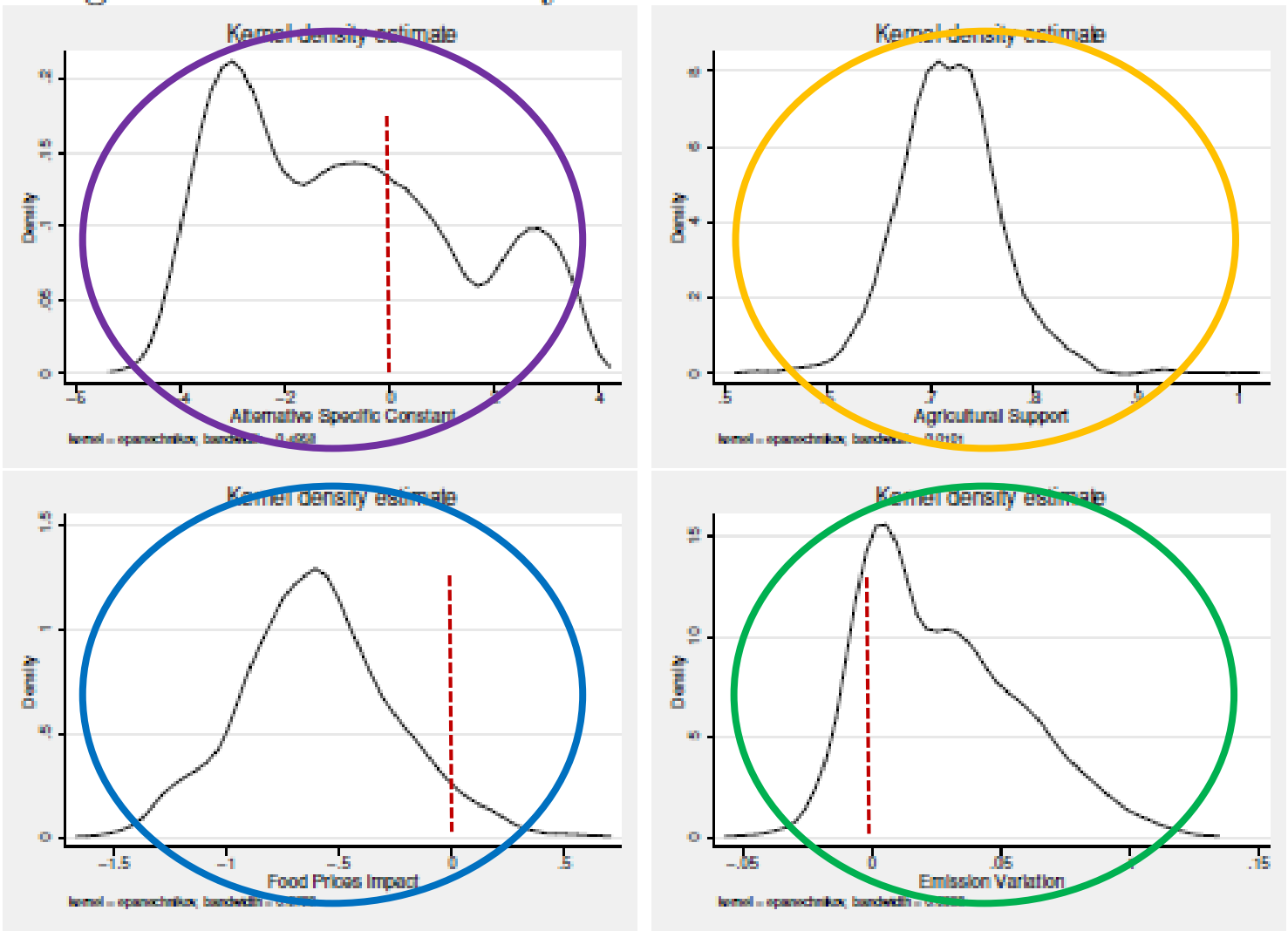
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

Figure 2: Kernel density of coefficients with RPL model



COMPUTING THE WILLINGNESS TO PAY (WTP) FOR EACH ATTRIBUTE

- The RPL coefficients are estimated for each respondent

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Deducing the WTP for each respondent

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Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

- **WTP for agricultural support**
- **WTP for reducing the GHG emissions**
- **WTP for avoiding an increase in food prices**

$$W^l_{n,k} = \psi_n + \gamma D^l_{n,k} + \lambda Z_n + \xi^l_{n,k}$$

Panel data analysis (Random-effects model)

- Introduction
- The *Discret Choice Experiment* approach
  - The survey: an example of a choice card
  - Choice of attributes and levels
  - Experimental design
  - The questionnaire and data collection
- A two-stage estimation procedure
  1. *Random Parameter Logit model*
  2. *Panel data analysis of the WTP (Random-effects model)*
- **Results of the second step: analysing spatial preference heterogeneity**
- Conclusion

2ND STEP OF OUR ANALYSIS

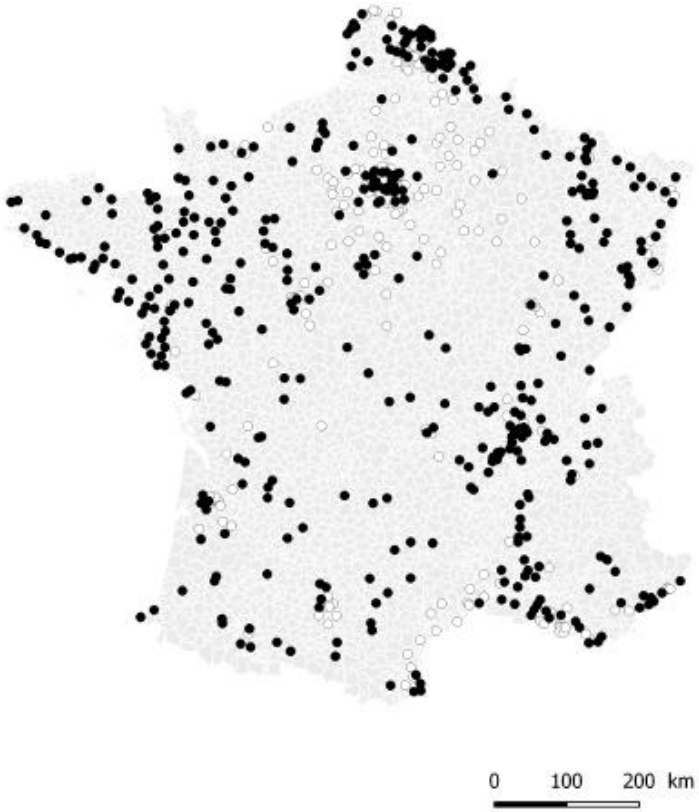
$$W_{n,k}^{l} = \psi_n + \gamma D_{n,k}^{l} + \lambda Z_n + \xi_{n,k}^{l}$$

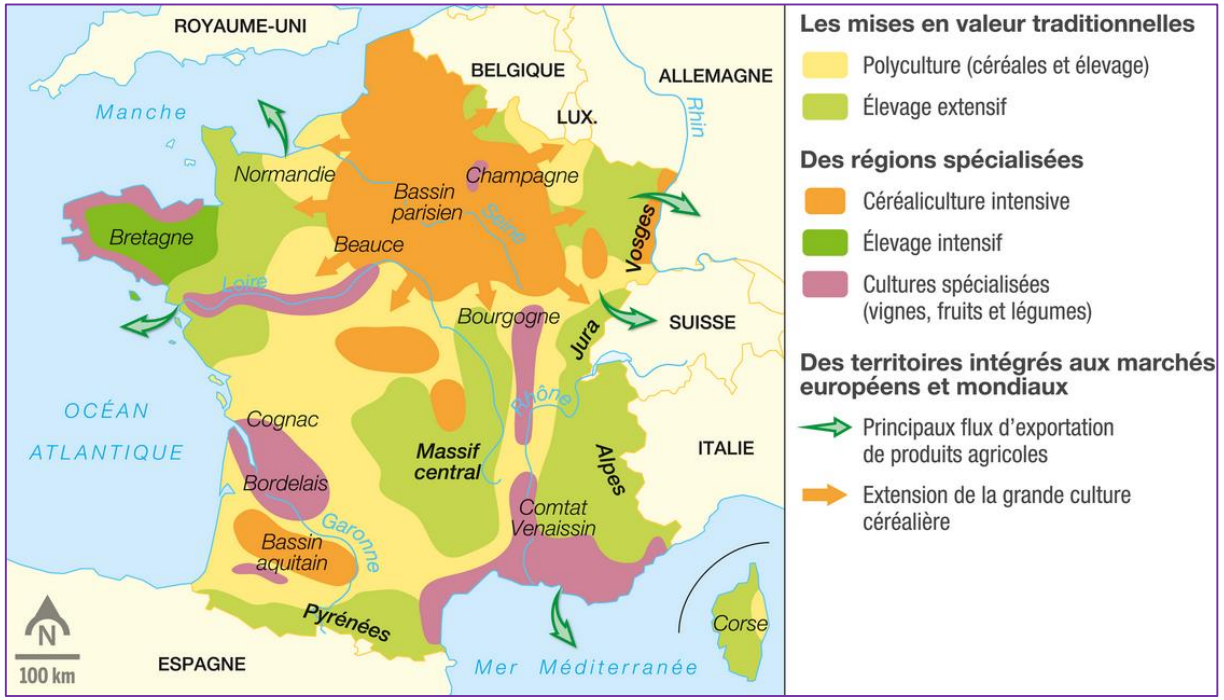
	Scénario A	Scénario B	Statu Quo
Contribution monétaire : Montant payé par chaque ménage par an pendant 5 ans	15 €	0 €	0 €
Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Non	Oui	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-20%	-50%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

Citizens in energy transition: Highlighting the role played by spatial preference heterogeneity in public acceptance of biofuels

Anthony Paris*[a], Benoît Chèze[a, b, c], Pascal Gastineau[d], and Pierre-Alexandre Mahieu[e]

French citizens can be split into two categories depending on the agricultural specialization of their location





 |

2ND STEP OF OUR ANALYSIS

$$W_{n,k}^{l} = \psi_n + \gamma D_{n,k}^{l} + \lambda Z_n + \xi_{n,k}^{l}$$

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Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Non	Oui	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-20%	-50%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

2 clusters

Table 4: Marginal WTP panel regression model

Indicator for attribute level			
Constant	92.53***	85.71***	40.52**
	(8.677)	(7.287)	(19.78)
30% reduction	34.62***	35.46***	34.62***
	(4.432)	(6.527)	(4.432)
50% reduction	71.58***	82.59***	71.58***
	(4.432)	(6.527)	(4.432)
Agricultural support	-10.42**	-18.82***	-10.42**
	(4.432)	(6.527)	(4.432)
Food price impact	-32.11***	-45.82***	-32.11***
	(4.432)	(6.527)	(4.432)
Indicator for agricultural specialization			
No agricultural area	ref.		
	-		
Biofuel crops area	-19.86		
	(13.15)		
Livestock farming area	-43.02***		
	(13.89)		
Market gardening area	-30.67*		
	(15.87)		
Poly-culture area	-28.96***		
	(10.90)		
Viticulture area	-16.88		
	(18.95)		

2ND STEP OF OUR ANALYSIS

$$W^l_{n,k} = \psi_n + \gamma D^l_{n,k} + \lambda Z_n + \xi^l_{n,k}$$

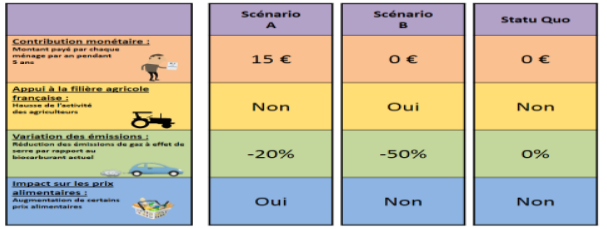

Table 5: Marginal WTPs panel regression model

	(1)	(2)	(3)
	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)
Attributes			
Constant	92.53***	85.71***	40.52**
	(8.677)	(7.287)	(19.78)
30% reduction	34.62***	35.46***	34.62***
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Agricultural specialization			
No agricultural area	ref.		
	-		
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	(10.90)		
Viticulture area	-16.88		
	(18.95)		
Agricultural specialization subgroups		-27.58***	-14.57*
		(9.896)	(8.818)
Interaction terms			
30% reduction × Agr. spec. subgroups		-1.543	
		(8.864)	
50% reduction × Agr. spec. subgroups		-20.30**	
		(8.864)	
Agricultural support × Agr. spec. subgroups		15.49*	
		(8.864)	
No impact on food prices × Agr. spec. subgroups		25.28***	
		(8.864)	
Socioeconomic and locational variables			
Income			0.008***
			(0.003)
Tax burden			-20.65*
			(12.07)
Dptmt. agricultural surface share			0.566**
			(0.234)
Local population density			0.002***
			(0.001)
N (Ind.)	972	972	972

Livestock farming, market gardening and poly-culture areas…

… compared to crops, viticultures and non agricultural areas

2ND STEP OF OUR ANALYSIS

$$W^l_{n,k} = \psi_n + \gamma D^l_{n,k} + \lambda Z_n + \xi^l_{n,k}$$

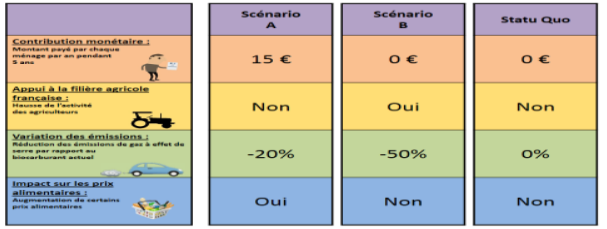

Table 5: Marginal WTPs panel regression model

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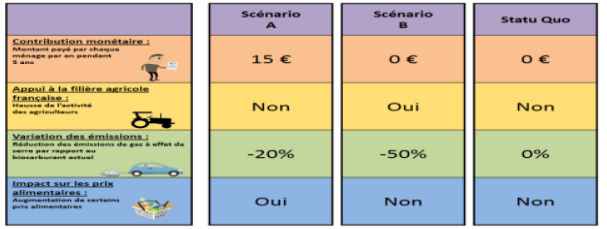

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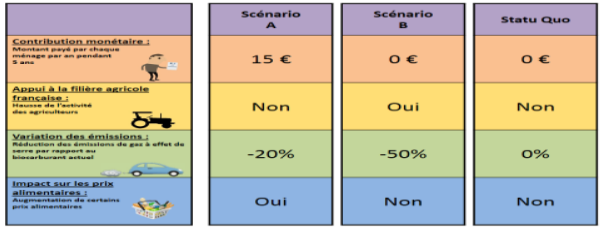

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Table 5: Marginal WTPs panel regression model

	(1) Coef. (S.E.)	(2) Coef. (S.E.)	(3) Coef. (S.E.)
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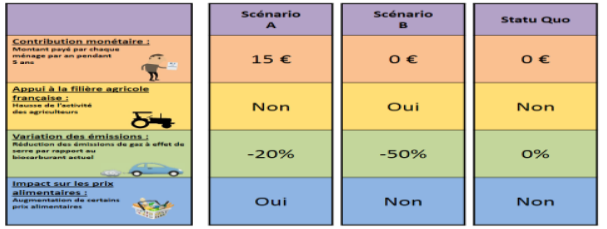
Socioeconomic and locational variables			
Income			0.008*** (0.003)
Tax burden			-20.65* (12.07)
Dptmt. agricultural surface share			0.566** (0.234)
Local population density			0.002*** (0.001)
N (Ind.)	972	972	972

2ND STEP OF OUR ANALYSIS

$$W^l_{n,k} = \psi_n + \gamma D^l_{n,k} + \lambda Z_n + \xi^l_{n,k}$$



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			(12.07)
Dptmt. agricultural surface share			0.566**
			(0.234)
Local population density			0.002***
			(0.001)
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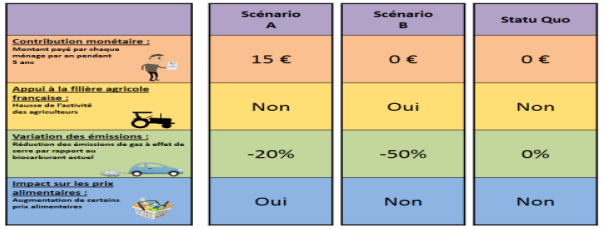
ANALYSIS BY CLUSTERS

$$W_{n,k}^{l} = \alpha_n + \gamma D_{n,k}^{l} + \lambda Z_n + \epsilon_{n,k}^{l}$$



	Scénario A	Scénario B	Statu Quo
Contribution monétaire : Montant payé par chaque ménage par an pendant 5 ans	15 €	0 €	0 €
Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Non	Oui	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-20%	-50%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

Table 5: Panel regression for both area

		Livestock farming, market gardening and poly-culture areas			Biofuel crops, viticulture and non agricultural areas		
Indicator for attribute level							
	30% reduction	33.92***	33.92***	33.92***	35.46***	35.46***	35.46***
		(5.397)	(5.397)	(5.395)	(7.225)	(7.225)	(7.215)
	50% reduction	62.29***	62.29***	62.29***	82.59***	82.59***	82.59***
		(5.397)	(5.397)	(5.395)	(7.225)	(7.225)	(7.215)
	Agricultural support	-3.330	-3.330	21.04	-18.82***	-18.82***	-10.76
		(5.397)	(5.397)	(14.45)	(7.225)	(7.225)	(8.27)
	Food price impact	-20.54***	-20.54***	3.497	-45.82***	-45.82***	-35.22***
		(5.397)	(5.397)	(14.45)	(7.225)	(7.225)	(8.27)
	Constant	35.91	55.16**	88.47***	32.99	47.95***	54.48***
		(26.03)	(22.70)	(16.03)	(28.73)	(14.68)	(14.28)
Socioeconomic variables							
	Tax burden	-33.37**	-32.84**	-33.86**	-10.47		
		(16.58)	(16.54)	(16.56)	(17.70)		
	Dptmt. agricultural surface share	0.720**	0.625**		0.423		
		(0.311)	(0.304)		(0.352)		
In interaction with	Agricultural support			-0.470*			
				(0.259)			
	Food price impact			-0.463*			
				(0.259)			
	Income	0.005			0.011**	0.011**	0.012***
		(0.004)			(0.004)	(0.004)	(0.004)
	Local population density	0.003			0.002**	0.001**	
		(0.003)			(0.001)	(0.001)	
In interaction with	Agricultural support						-0.001**
							(0.001)
	Food price impact						-0.001***
							(0.001)
	N (Ind.)	527	527	527	445	445	445
	N (Obs.)	2,625	2,625	2,625	2,225	2,225	2,225

ANALYSIS BY CLUSTERS

$$W_{n,k}^{l} = \alpha_n + \gamma D_{n,k}^{l} + \lambda Z_n + \epsilon_{n,k}^{l}$$

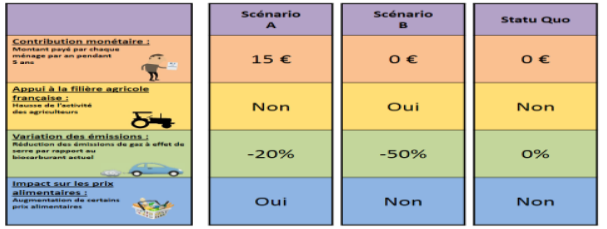


Table 5: Panel regression for both area

		Livestock farming, market gardening and poly-culture areas			Biofuel crops, viticulture and non agricultural areas		
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	30% reduction	33.92***	33.92***	33.92***	35.46***	35.46***	35.46***
		(5.397)	(5.397)	(5.395)	(7.225)	(7.225)	(7.215)
	50% reduction	62.29***	62.29***	62.29***	82.59***	82.59***	82.59***
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	Constant	35.91	55.16**	88.47***	32.99	47.95***	54.48***
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	Dptmt. agricultural surface share	0.720**	0.625**		0.423		
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				(0.259)			
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	Income	0.005			0.011**	0.011**	0.012***
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Scénario A	Scénario B	Statu Quo
15 €	0 €	0 €
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The more agricultural is the Département, the less supportive

City dwellers are less supportive

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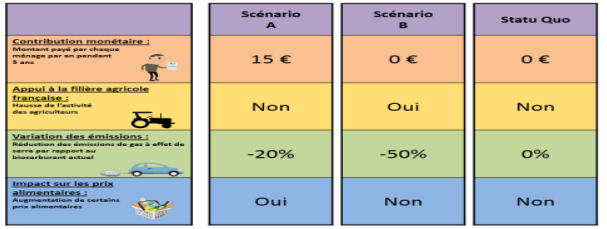

	Scénario A	Scénario B	Statu Quo
Contribution monétaire : Montant payé par chaque ménage par an pendant 5 ans	15 €	0 €	0 €
Appui à la filière agricole française : Hausse de l'activité des agriculteurs	Non	Oui	Non
Variation des émissions : Réduction des émissions de gaz à effet de serre par rapport au biocarburant actuel	-20%	-50%	0%
Impact sur les prix alimentaires : Augmentation de certains prix alimentaires	Oui	Non	Non

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The more agricultural is the Département, the less sensitive

City dwellers are less sensitive

- Introduction
- The *Discret Choice Experiment* approach
  - The survey: an example of a choice card
  - Choice of attributes and levels
  - Experimental design
  - The questionnaire and data collection
- A two-stage estimation procedure
  1. *Random Parameter Logit model*
  2. *Panel data analysis of the WTP (Random-effects model)*
- Results of the second step: analysing spatial preference heterogeneity
- Conclusion

GRAPHICAL CCL

$$W_{n,k}^{l} = \alpha_n + \gamma D_{n,k}^{l} + \lambda Z_n + \epsilon_{n,k}^{l}$$

	Scénario A	Scénario B	Statu Quo
	15 €	0 €	0 €
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2 CLUSTERS
spatial preference heterogeneity between & within groups

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- **Not the same explanatory variables**
- **Not the same explanation of the agricultural support**

CONCLUSION

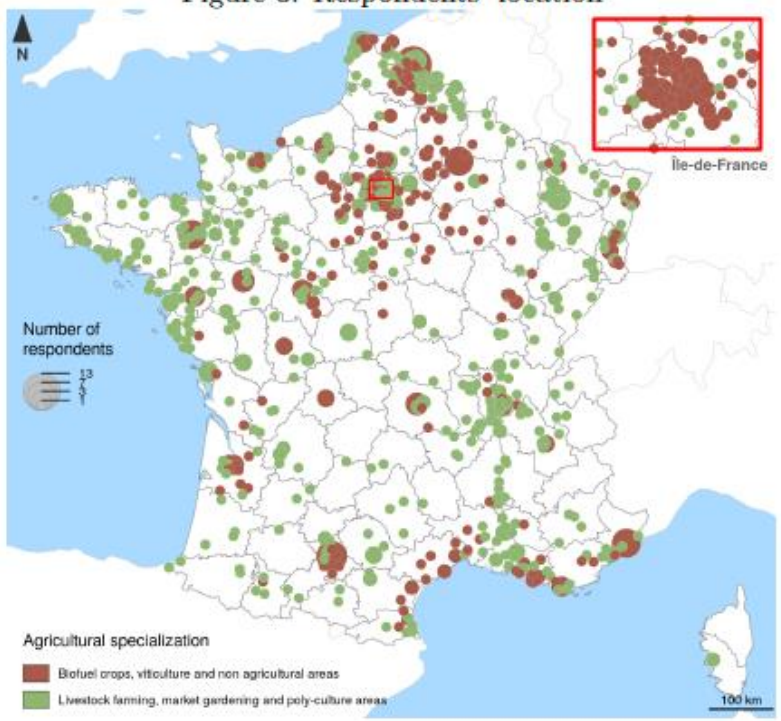
- Renewable fuels development is an integral part of the public policies mix highlighted by policy makers to decarbonize the transportation sector.
- We believe that wide-spread deployment of energy transition technologies will largely depend on the attitudes of consumers and citizens.

- This article investigates **French population's motivations** and obstacles **to finance new biofuels development** in the transportation sector.
- It uses a **two-step approach** based on a **nation-wide discrete choice experiment** to
  - (i) identify the influencing factors in individual preferences concerning a new biofuel development; and
  - (ii) analyze the determinants of the **spatial heterogeneity of preferences**, with a special attention to the types and importance of agricultural activities around respondents location.

CONCLUSION

- On the whole, there is a relative equality in the parameter linked to the GHG emissions reduction. **Reduction in GHG emissions impacts all respondents' utility in a similar way.**
  - The mean of mWTP are 71, 105 and 142 euros per year for a reduction of respectively 20%, 30% and 50% in GHG emissions.
- We show that **French citizens can be split into two categories** depending on the **agricultural specialization** of their location.

Figure 3: Respondents' location



Heterogeneity in respondents' behavior is more linked to biofuel characteristics than to the fight against climate change through reduction in GHG emissions.

CONCLUSION

- Respondents living in area specialized in livestock farming, poly-culture and market gardening (**54%**) have greater mWTPs to **support agricultural sector** and to **avoid food price increase** compared to French citizens coming from area with crops or viticulture specialization or without agricultural activity (**46%**).

- They are :
  - less willing to pay for a reduction of 50% in GHG and
  - negatively impacted by the perception of tax burden.

- **Insights for policy makers:**
- Our results confirm a **strong preference for second-generation biofuels** (no impact on food prices) **allowing agricultural support**, whatever the cluster under consideration.

  ➔ **biofuels from wheat straw* > wood residues > food crops**

  *co-products without any impact on food prices.

- Caution on the way to finance the energy transition (tax burden).

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ÉCHANTILLON REPRÉSENTATIF

Statistiques descriptives de l'échantillon

Table 2: Selected characteristics of study sample

Characteristics	French population	Sample
Size	-	972
Gender (% female)	51.1%	51.0%
Age		
Young (18 to 29)	19.8%	20.7%
Young adult (30 to 44)	26.8%	28.3%
Adult (45 to 59)	28.6%	26.1%
Old (60 to 75)	24.8%	24.9%
Professional activity		
Top socio-professional category	15.7%	16.2%
Middle socio-professional category	16.4%	16.2%
Low socio-professional category	33.7%	32.2%
Retired	20.0%	23.1%
Inactive	14.2%	12.2%

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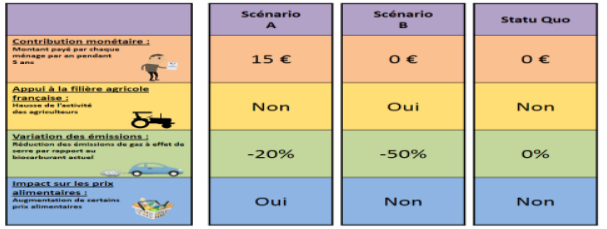

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