The role of supply chains in today's agricultural production: how relevant is proximity?

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1. Agglomeration economies, economies of scope and ecosystem services

2. Econometric specifications for crop location in Burgundy

3. Preliminary results: significant supply chain effect for common crops, less clear for diversification crops

Distribution of crop location and non-linearity of ecosystem services provision

(Davis et al., 2012)

Agglomeration economies vs economies of scope

- **Assuming that only profit matters**, what drives producer choice?
- Agglomeration forces
  - ✓ « Natural » Ricardean comparative advantage (Chakir, 2009; Garrett et al., 2013; Kempen et al., 2005; Wu and Segerson, 1995)
  - ✓ Economies of scale (Holmes and Lee, 2012; Mafakheri and Nasiri, 2014)
  - ✓ Informational and technological externalities (Gallaud et al., 2012; Krugman, 1991; Porter, 1998)
  - ✓ Supply/demand pecuniary externalities (Bleakley and Lin, 2010; Krugman, 1991; Porter, 1998)
  - ✓ Upstream transportation costs (Alexander et al., 2013; Charrier et al., 2013; Garrett et al., 2013; Kilkenny, 1998; Mafakheri and Nasiri, 2014; van der Hilst et al., 2010)
- Economies of scope
  - ✓ Decreased output and price variability
  - ✓ Agronomic synergies (Carrouée et al., 2012; Davis et al., 2012)

Farm-scale profit: agglomeration and scope can balance out

(Davis et al., 2012)

(Lechenet et al., 2014)

Nevertheless, agglomeration forces dominate

% of farms with at least 4 different crops

(CGDD, 2012)

Distribution of crop sequences types in Burgundy.

Group	Crop sequence types	Frequency
1	Oilseed rape/winter wheat/winter barley; winter cereals	51.4%
2	Crop sequences based on maize and winter cereals	20.4%
3	Oilseed rape/winter cereals/sunflower or peas	15.7%
4	Pasture associated with maize, winter cereals and oilseed rape	5.4%
5	Maize monoculture	2.6%
6	Crop sequences with sugar beet	2.5%
7	Diversified crop sequences	1.9%

27 %

(Aouadi et al., 2015)

→ Farmgate profit maximization is not a satisfactory simplification

❖ Hypothesis: vertically integrated « plantgate » profit maximization has a stronger explanatory power

Same problem from a modeler's prospective

- Downscaling region-level data is key when ecosystem services are studied (Cantelaube et al., 2012)

- Aggregation is underestimated when only pedo-climatic drivers of crop location are considered (Chakir, 2009)

Model residuals
Cumulated share of wheat, barley and rapeseed in Picardie region

(Chakir, 2009)

- Hypothesis: this under-estimation is (partly) due to the absence of agro-industrial and institutional drivers

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Two common crops, two diversification crops, four spatial patterns

Descriptive statistics of dependent variables				
	Barley	Rapeseed	Proteaginous	Hemp
N	2,017	2,017	2,017	2,017
Min	0	0	0	0
Mean	0.19	0.16	0.01	0.0003
Median	0.19	0.18	0	0
Max	0.78	0.41	0.19	0.09
% zeros	2.58	15.02	56.42	96.63
Gini coefficient	0.30	0.36	0.79	0.99
Moran's I	0.63	0.72	0.22	0.08

Common hypothesis: agro-industrial and institutional factors partly drive crop location

- Specification 1: barley
- Quasi-gaussian distribution

- Classical « share model »

$$log\left(\frac{share_{barley}}{1-share_{barley}}\right) = \alpha Pedoclim_i + \beta Instit_i + \gamma Agroindus_i + \varepsilon_i$$

Common hypothesis: agro-industrial and institutional factors partly drive crop location

- Specification 2: rapeseed
- Truncated quasi-gaussian distribution

- « share model » with selection (Heckit)

$$P\left(share_{rapeseed} > 0\right) = \alpha_1 Pedoclim_i + \beta_1 Instit_i + \gamma_1 AgroIndus_i + \varepsilon_{1i}$$

$$log\left(\frac{share_{rapeseed}}{1 - share_{rapeseed}}\right) = \alpha_2 P_i + \beta_2 I_i + \gamma_2 AI_i + \delta \times \lambda\left(\hat{\alpha}_1 P_i + \hat{\beta}_1 I_i + \hat{\gamma}_1 AI_i\right) + \varepsilon_{2i}$$

Common hypothesis: agro-industrial and institutional factors partly drive crop location

- Specification 3: proteaginous, hemp
- High frequency of zeroes, small mean

- Probit model

$$P(share_j > 0) = \alpha Pedoclim_i + \beta Instit_i + \gamma Agroindus_i + \varepsilon_i$$

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Barley: dominant role of agro-industrial drivers

- Partial r2 of economic and institutional variables three times higher than pedo-climatic ones
- Agro-industrial drivers alone have a larger partial r2 than pedo-climatic drivers

OLS, barl_1012/(1-barl_1012) = f(BX)	
	Model 1
(Intercept)	-1.85 (0.14)***
rugmean	0.01 (0.01)
IGP_beef	-0.26 (0.13)*
grani_UGB_per_ha	-0.20 (0.18)
herbi_UGB_per_ha	-0.14 (0.07)*
awc_mean	0.00 (0.00)
EDF: s(Soufflet)	6.21 (7.41)***
EDF: s(malt)	2.35 (2.97)***
EDF: s(preliq)	3.69 (4.33)***
EDF: s(hr)	1.47 (1.82)
EDF: s(tmoy)	3.65 (4.62)**
R^2	0.32
Num. obs.	2017
***p < 0.001, **p < 0.01, *p < 0.05	

Partial r2	
Pedo-climatic variables	0.049
Economic and institutional variables	0.169
malt	0.024
Soufflet	0.045

Barley: evidence for vertical integration

Moran's I = 0.18 , p.value = 0

Moran's I = 0.14 , p.value = 0

Barley: quantification of vertical integration

- At the average, the proximity to Soufflet silos can increase barley's share from 5% to 30%

Partial effect at the average of distance (in minutes) to malt plants and Soufflet silos
The red dotted line indicates the average value of the variable over our sample. The share is given as a proportion of municipal arable crops area.

Rapeseed: signficant role of proximity to transformation plant

- Proximity to transformation plant has a significant effect in both models
- Animal density has a significant negative effect (rapeseed is not eaten directly by animals)

Non-random selection, P(colz_1012=1) = f(BX) & share_trans(colz_1012) = g(B'X')		
	Selection model	Share model
(Intercept)	3.32 (0.89)***	-1.62 (0.05)***
rugmean	-0.08 (0.03)*	0.03 (0.01)**
IGP_poultry	-0.41 (0.39)	-0.39 (0.10)***
IGP_dairy	0.38 (0.17)*	
grani_UGB_per_ha	0.37 (0.39)	-0.26 (0.12)*
herbi_UGB_per_ha	-0.34 (0.12)**	-0.26 (0.05)***
EDF: s(oi10231)	3.94 (4.08)***	4.51 (4.88)***
EDF: s(flour)	4.26 (4.77)***	3.52 (4.19)***
EDF: s(animal_food)	1.52 (1.90)***	2.43 (3.03)
EDF: s(preliq)	2.77 (3.33)**	4.35 (4.79)*
EDF: s(hr)	1.00 (1.00)**	4.02 (4.56)
EDF: s(tmoy)	3.01 (3.70)	4.86 (4.99)***
EDF: s(invmills)		2.40 (3.05)***
R^2	0.67	0.40
Num. obs.	2017	1714
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$		

Biodiesel plants drain rapeseed over long distances

Partial effect at the average of distance (in minutes) to biodiesel plants (*oi10213*), flour plants and animal food plants

Left pane: probability that rapeseed is present in the municipality. Right pane: rapeseed's share of arable crops in municipality. The red dotted line indicates the average value of the variable over our sample. The share is given as a proportion of municipal arable crops area.

Proteaginous: no clear role of available processing plants

- Proximity to animal food plants, biodiesel plants and malt plants is significant
- Yet, removing these variables does not affect goodness-of-fit

Probit, P(prot_0709)=1) = f(BX)		
	prob1	prob2
(Intercept)	0.55 (0.18)**	0.58 (0.18)***
rugmean	-0.09 (0.02)***	-0.07 (0.02)***
otex6aucun	-1.01 (0.48)*	-1.01 (0.48)*
otex6ffm	-0.36 (0.13)**	-0.44 (0.13)***
otex6grani	-0.47 (0.23)*	-0.48 (0.23)*
otex6herbi	-0.52 (0.12)***	-0.60 (0.11)***
otex6poly	-0.10 (0.08)	-0.07 (0.08)
herbi_UGB_per_ha	-0.28 (0.09)**	-0.39 (0.08)***
grani_UGB_per_ha	0.37 (0.24)	0.39 (0.23)
awc_mean	0.00 (0.00)	-0.00 (0.00)
EDF: s(I(animal_food_farm + animal_food_pet))	2.77 (3.39)***	
EDF: s(malt)	1.00 (1.00)***	
EDF: s(oi10231)	1.00 (1.00)***	
EDF: s(dli)	4.83 (4.98)*	4.77 (4.97)**
EDF: s(hr)	2.38 (3.03)	3.25 (3.89)***
EDF: s(preliq)	1.00 (1.00)	3.83 (4.39)**
EDF: s(tmoy)	1.00 (1.00)*	1.00 (1.00)
logLik	-1174.94	-1202.99
AIC	2397.84	2451.68
Proportion correctly predicted	0.69	0.69
***p < 0.001, **p < 0.01, *p < 0.05		

Hemp: two collectors close to Burgundy

- Proximity to Interval major silos has a significant effet
- Proximity to Chanvrière de l'Aube does not: mediated by contracts with other collectors?

Probit, P(hemp_0709)=1) = f(BX)	
	prob3
(Intercept)	-2.74 (0.53)***
rugmean	-0.02 (0.04)
herbi_UGB_per_ha	-0.30 (0.23)
grani_UGB_per_ha	0.04 (0.44)
awc_mean	0.00 (0.00)
EDF: s(chanv_aube)	3.90 (4.71)
EDF: s(Interval)	4.34 (5.30)*
EDF: s(dli)	3.50 (4.08)
EDF: s(hr)	1.76 (2.22)
EDF: s(preliq)	1.00 (1.00)*
EDF: s(tmoy)	3.39 (4.00)*
logLik	-233.15
AIC	512.07
Cut-off	0.09
Proportion correctly predicted	0.90
***p < 0.001, **p < 0.01, *p < 0.05	

Conclusion

- The agro-industrial drivers of common crops (barley, rapeseed) can be detected and quantified at regional scale
- The method's applicability to diversification crops (proteaginous, hemp) is still questionable, in particular at national scale

Possible improvements

- Soils: soil type tested but coarse resolution & may be more relevant to focus on a given characteristic
- Collectors: multicollinearity => need for precise hypothesis and/or better data (minor silos, legal collecting areas)
- Proximity to fluvial ports (low cost of fluvial transport)
- Other potential drivers?
- …

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