Innovation propensity of Tunisian firms: the central role of external knowledge sources

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- Following the accession of Tunisia to the GATT (1990), to the WTO (1996) and to a Free Trade Union with E.U. (1995)
- $\rightarrow$ Industry and innovation policies to foster competitivity of Tunisian firms
  - The *Upgrade* Program (1995)
  - The first Law on Research and Technological Development (1996)

- 2005: the first (and only) innovation survey carried out in this country,
  - by the Ministry of Scientific Research, Technology and Competency Development (MSRTCD, 2005)
  - based on the Community Innovation Surveys **(CIS)** methodology.
- $\rightarrow$ A photography of innovation in manufacturing sectors after a decade of effort to enhance the technological development in Tunisia

- **Our objective:** Analyzing the characteristics of innovative manufacturing firms in a developing country (Tunisia)
- Starting from a survey of other articles on the innovation processes in developing countries,
- and the economics of innovation,

- An econometric and statistical analysis of the survey, using mainly
  - Probit estimations to qualify the global relations between the characteristics of the firms and their propensity to innovate,
  - and non-parametrical regression trees to analyze the interactions between these characteristics (complementarity/substitution)
  - (We also check our econometric model for sampling problems (selection bias) and sensitivity towards unobserved heterogeneity)

Remarks

- Relative rarity of CIS surveys on developing countries
- Necessity of a broader definition of innovations
- Innovation: introducing better products and processes that are new for the Tunisian firms, without being necessarily new at the international level.
- $\rightarrow$ Including all firms that rely on the introduction of novelty to face the market competition and demand.

Literature

- We survey 31 papers that analyze innovation processes in developing countries
- The main common determinants of innovation that arise from this survey can be summarized in the following table:

Innov. type	Size	R&D	PartForeign	Export	Collaboration	Sector
Prod.	$++, 0$	$+++$	$+, 00$	$+, 0$	$++$	Yes
Proc.	$+++$	$+++$	$+, 0$	$+, 0$	$++, -$	Yes

Legend: for $x \in \{+, 0, -\}$, x : more than 25% of studies; xx : more than 50%; xxx : more than 75%.

Research questions

1. Motivations of firms to innovate? Do product and process innovations obey to similar motivations?
2. Characteristics of innovating firms? And, more specifically
    1. Role of exportations
    2. and of different external knowledge sources in the innovativeness of the firms

Main results 1/2

- Motivations of firms significantly differ between product and process innovations
- external knowledge sources play a prominent role in the propensity to innovate (for both types of innovation, but differently)
- firms must benefit from at least one type of these sources to attain a significant innovation propensity
- internal R&D plays a role only for product innovations

Main results 2/2

- export orientation is not significant in itself but,
- serving both foreign and domestic markets plays a positive role in product innovations
- firm size plays a positive role for both type of innovations
- and the participation of the State a negative role
- sectoral effects are negligible (a yet immature sectoral innovation system?)
- $\rightarrow$Globally, the profile of Tunisian firms differ from the countries analyzed in other articles

Our data set 1/3

- First innovation survey (CIS type) in Tunisia, by the MSRTCD $\rightarrow$ firms innovation activity from 2002 to 2004.
- Objective: to cover the maximum of firms likely to have an innovative and/or R&D activity
  - manufacturing firms with high technological intensity and/or strong added value;
  - firms having manpower higher than 10 people;
  - firms filed by the Industry Promotion Agency and the National Institute of the Statistics.
  - $\rightarrow$ Sampling bias and heterogeneity problems (checked in the paper)
- 739 firms $\rightarrow$ 586 firms answered the survey (79%).

Our data set 2/3

- Many [Yes/No] type questions $\rightarrow$ binary variables
- Innovation questions have this type: "Have you introduced a new product or process during the three years preceding the survey [Y/N]?"
- Several shortcomings: many qualitative variables, subjective questions difficult to interpret, etc., common to all CIS surveys, but also some specific ones.
- $\rightarrow$ Only one year of survey (not repeated yet); no data on the intensity of innovations; some questions propose items difficult to interpret; etc.
- No possibility of causal or dynamic analysis
- Table 1 in the paper gives the summary of the innovation variables.

Our data set 3/3

Proportion of innovators in the database

	All firms	
Variable	**mean**	**sd**
innovall	0.61	0.49
innovproc	0.49	0.50
innovprod	0.41	0.49
Observations	586	

- Global relationship between characteristics of the firms, knowledge source (explanatory variables), and firms' innovative capacity
- $\rightarrow$ **Probit estimations**$\rightarrow$ a simple baseline model where the binary dependent variable is innovprod/innovproc/innovall, and the explanatory variables are:
  - Usual suspects: Internal R&D department; firm size (sales)
  - + export behavior ($multiMarket = 1 \rightarrow$ the firm serves both the domestic and foreign markets)
  - + participation of the State to the capital of firms
  - + channels of external technical knowledge: Universities; technical agencies; public research centers; other firms; national and international organisms

Probit results, Part 1/2: Firm characteristics

(bold coefficient/$(*)$ $\rightarrow$ significant at 5%)

	Prod. innov.	**Proc. innov.**
R&D dept.	**0.47**$(*)$ (3.64)	0.23 (1.79)
log(Sales)	**0.08**$(*)$ (2.06)	**0.12**$(*)$ (3.34)
multiMarkets	**0.34**$(*)$ (2.59)	0.10 (0.75)
partState	$-$**0.01**$(*)$ ($-$3.74)	$-$**0.01**$(*)$ ($-$2.65)

The $z-$ *values* are given below coefficients, between parentheses.

Remarks:

- Serving both domestic and foreign markets favors only product innovations
- State's role is clearly negative for both types of innovation
- Internal R&D is necessary only for product innovations

Probit results, Part 2/2: External knowledge channels

	Prod. innov.	Proc. innov.
collUniv.	**0.57**(∗) (2.60)	0.24 (1.15)
collRecCent	−0.25 (−0.95)	−0.11 (−0.44)
collLabUnit	−0.27 (−1.12)	−0.37 (−1.62)
collNatOrg	0.26 (1.54)	**0.51**(∗) (2.99)
collInternatOrg	**0.87**(∗) (4.33)	**0.57**(∗) (2.86)
collOtherFirms	0.29 (1.54)	0.30 (1.61)
consultTech	**0.49**(∗) (3.84)	**0.64**(∗) (5.09)
constant	−**2.21**(∗) (−3.74)	−**2.45**(∗) (−4.39)
Nb. obs.	538	538
Pseudo R^2	0.19	0.15

Remarks:

- Technical consultants, international organizations → both types of innovations,
- Collaboration with national organizations → only for process innovations
- Collaboration with universities → only for product innovations.

- We also test more complete models including the foreign participation (not significant) and sectors (negligible significance). The results of bi-variate Probit estimations are also given.
- The rest of the paper
  - tries to shed more light on the content of the collaborations and
  - analyzes the interactions between these variables

Text based variable about the object of the collaborations (very partial, only 86 answers)

Universities (*Prod.*)	Resolution of technical problems for the firm (Ph.D. and master theses)
National organizations (*Proc.*)	Technical assistance Certification Training Improving quality Product and process update

International organizations (*Both*)	Certification (ISO and others)
	Training
	Main branch of the society
	Design of products
	Technical assistance
	Foreign partners
	Marketing of patents

Collaborations with universities

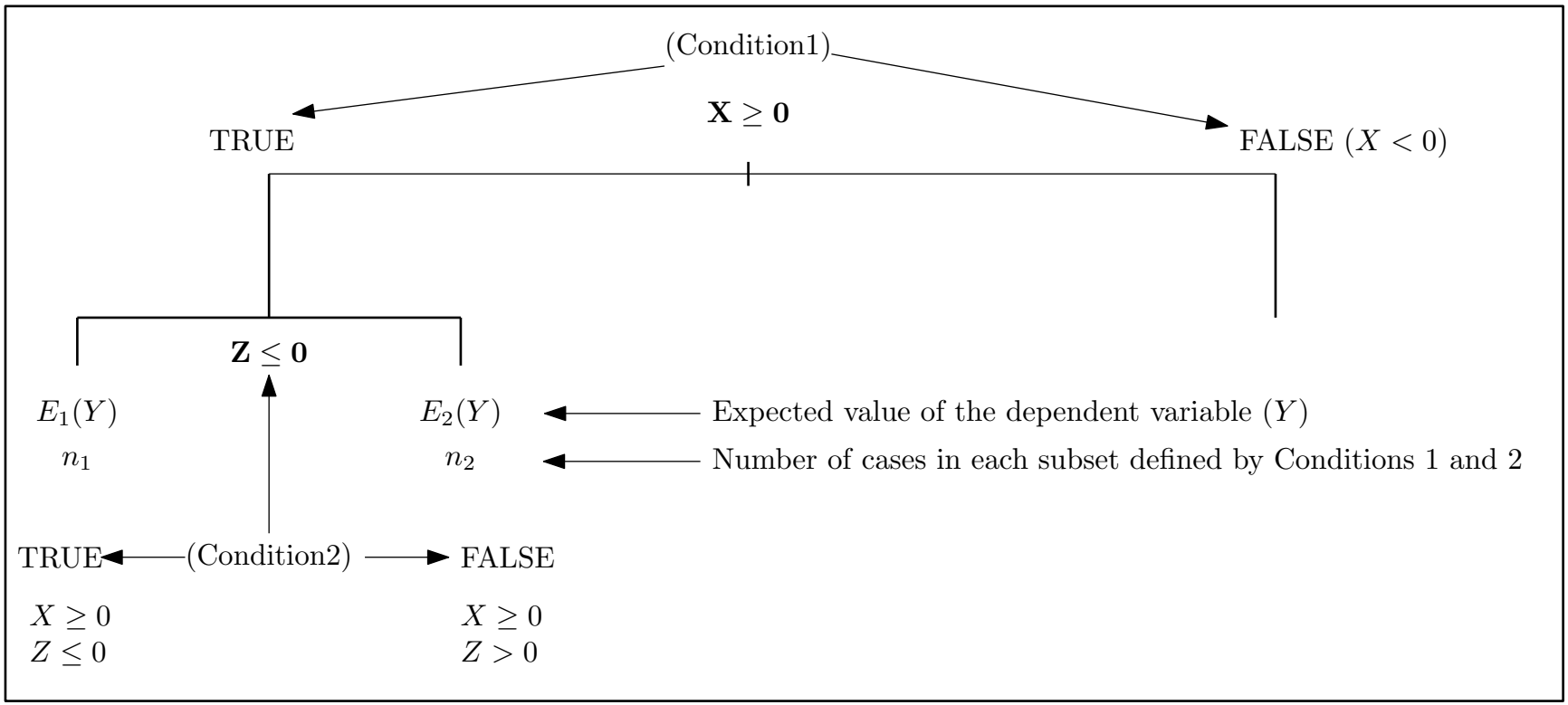
Collaborations with national organizations

Collaborations with international organizations

Collaborations with other firms

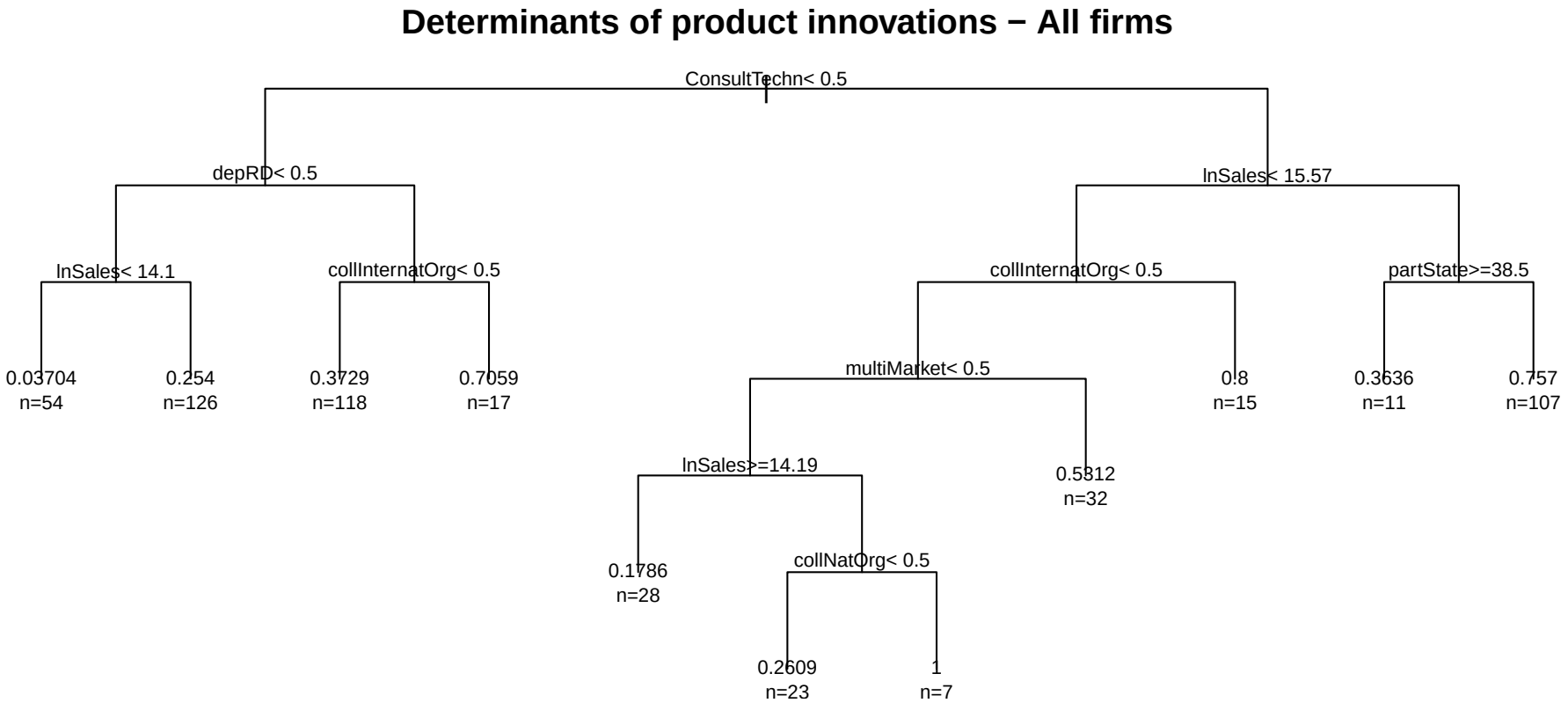
Interpreting regression trees

One dependent variable (Y) and two explanatory variables (Z, X) :



- Regression trees $\rightarrow$ analysis of complementary/substitutable interactions between variables.
- Hierarchical relation between variables.
- $(cp = 1\%)$

Product innovations 1/3



Product innovations 2/3

Two sets of conditions are favorable to product innovations

- For the biggest firms:

$$\left.\begin{array}{c} consultTechn = 1 \\ log(Sales) \geq 15.57 \\ partState < 38.5\% \end{array}\right\} \Rightarrow E\left(P[innovProd]\right) = 0.76, n = 107.$$

- and for smaller ones:

$$\left.\begin{array}{c} consultTechn = 1 \\ log(Sales) < 15.57 \\ collInternatOrg = 1 \end{array}\right\} \Rightarrow E\left(P[innovProd]\right) = 0.80, n = 15.$$

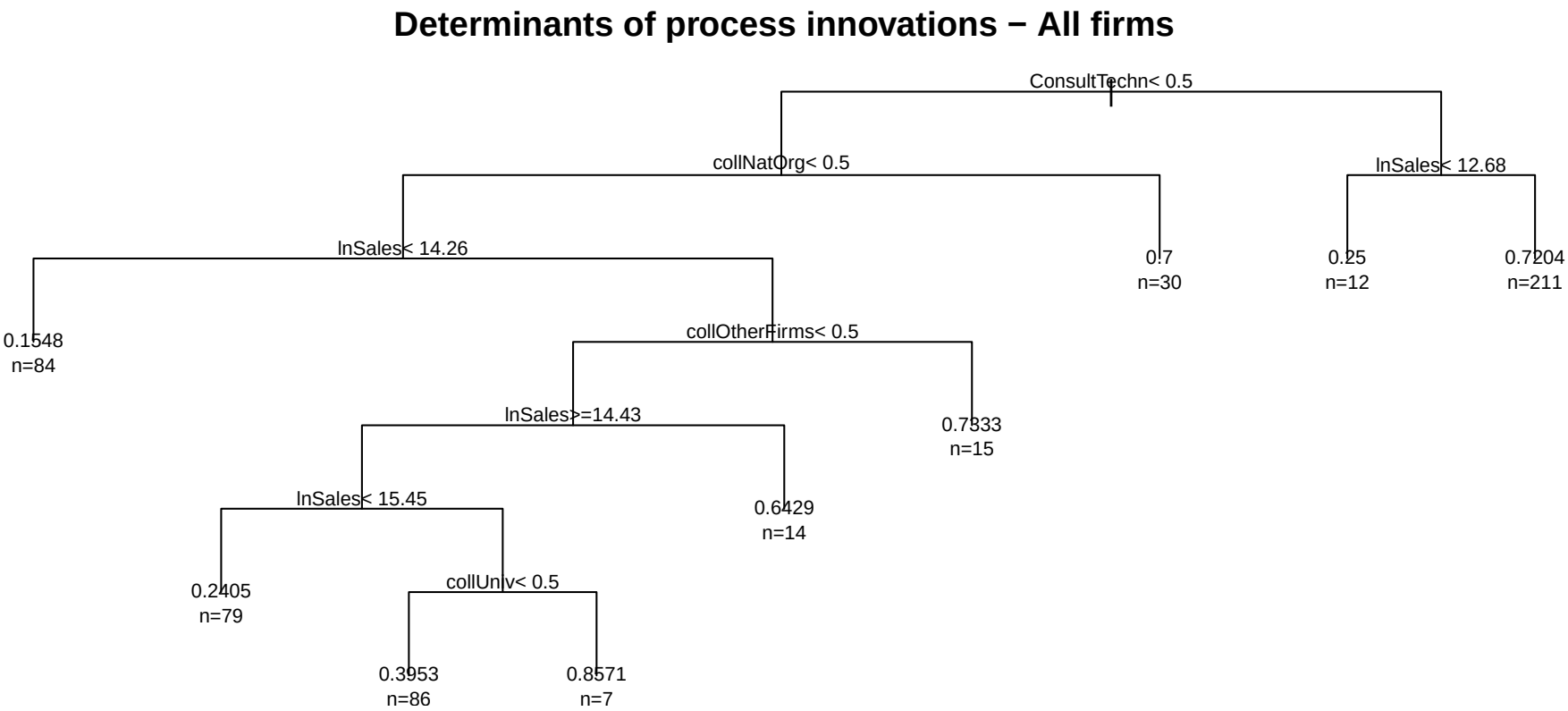
Product innovations 3/3

- Internal R&D plays an important role only for firms that do not appeal to external consultants.

$$\left.\begin{array}{c} consultTechn = 0 \\ depRD = 1 \end{array}\right\} \Rightarrow E\left(P[innovProd]\right) = 0.71, n = 180.$$

- External technical consultants play the most prominent role
- $\rightarrow$ their intervention is necessary (but not sufficient) to attain the highest propensities to innovate.

Process innovations 1/2



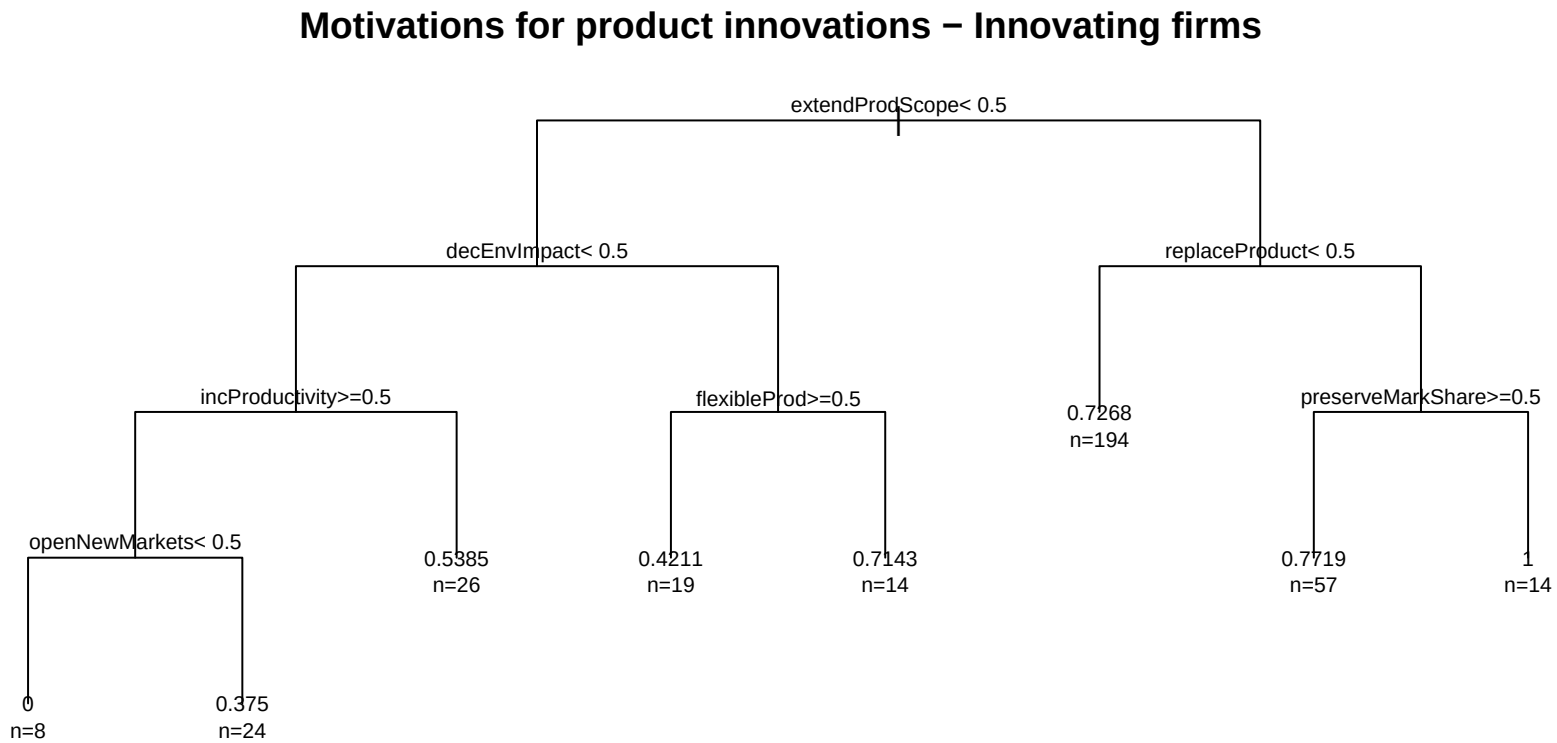
Process innovations 2/2

- Size and external knowledge sources are the only elements connected to process innovations.
- External technical consultants play again the most prominent role
- 211 large firms that appeal to technical consultants are able to attain a high innovative propensity

$$\left.\begin{array}{c} consultTechn = 1 \\ log(Sales) > 12.68 \end{array}\right\} \Rightarrow E\left(P[innovProc]\right) = 0.72, n = 211.$$

- We also observe some substitution between sources of knowledge when $consultTechn = 0$.
- Large firms can compensate it's absence by collaborating with national organizations ($E[P] = 0.7$), other firms ($E[P] = 0.73$) or universities ($E[P] = 0.86$).

Motivations of Product innovations



The most favorable set of motivations:

$$\left.\begin{array}{c} extendProductScope = 1 \\ replaceProduct = 1 \\ preserveMarkShare = 0 \end{array}\right\} \Rightarrow E\left(P[innovProd]\right) = 1, n = 14.$$

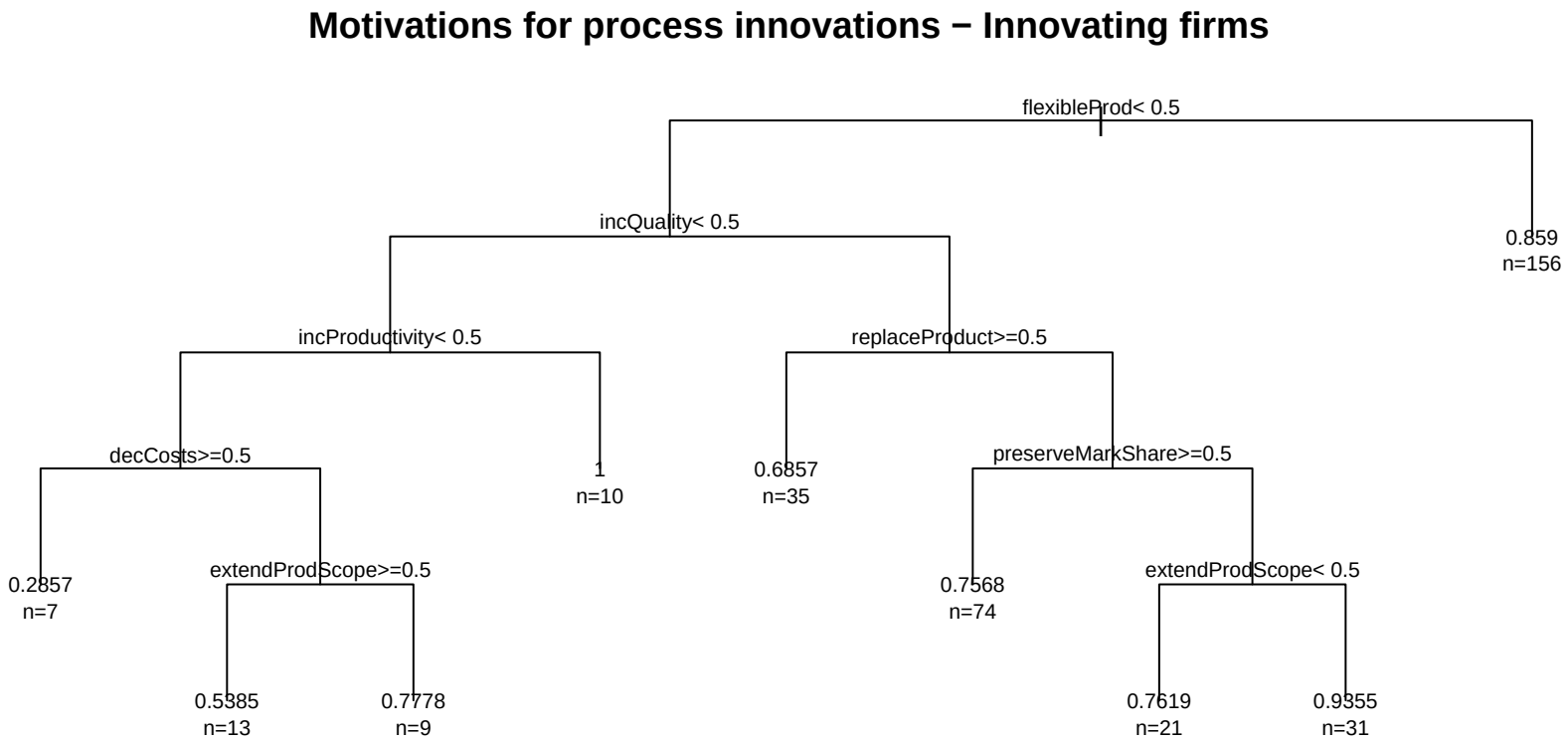
$\rightarrow$ Proactive product strategy (Coherent!)

The most unfavorable one:

$$\left.\begin{array}{c} extendProdScope = 0 \\ decEnvImpact = 0 \\ \mathbf{incProductivity = 1} \\ openNewMarkets = 0 \end{array}\right\} \Rightarrow E\left(P[innovProd]\right) = 0, n = 8.$$

$\rightarrow$ Process oriented defensive strategy ($\rightarrow$ Motivations more favorable to process innovations?)

Motivations of Process innovations



Effectively.

The most favorable set of motivations for process innovations is based on productivity increases:

$$\left.\begin{array}{c} \mathit{flexibleProduct} = 0 \\ \mathit{incQuality} = 0 \\ \mathbf{incProductivity = 1} \end{array}\right\} \Rightarrow E\left(P[\mathit{innovProc}]\right) = 1, n = 10.$$

The next favorable set $\rightarrow$ complementarity between process innovations and proactive product innovations:

$$\left.\begin{array}{c} \textit{flexibleProduct} = 0 \\ \textbf{incQuality} = \textbf{1} \\ \textit{replaceProduct} = 0 \\ \textit{preserveMarkShare} = 0 \\ \textbf{extendProdScope} = \textbf{1} \end{array}\right\} \Rightarrow E\left(P[\textit{innovProc}]\right) = 0.94, n = 31.$$

Except in this last case $\rightarrow$ Product and process innovations obey different motivations.

Differentiated analysis of their determinants.

Checking for sampling problems and heterogeneity

- Selection bias:
  - Survey-Weighted Probit Regression (number of observations in the sample drawn from that sector divided by the number of observations in the population of the sector, as observed in 2004.
- Unobserved heterogeneity:
  - Robust standard error (RSE) estimations
  - Markov chain Monte Carlo Probit regression
- Our baseline model stays robust in the face of these corrections.