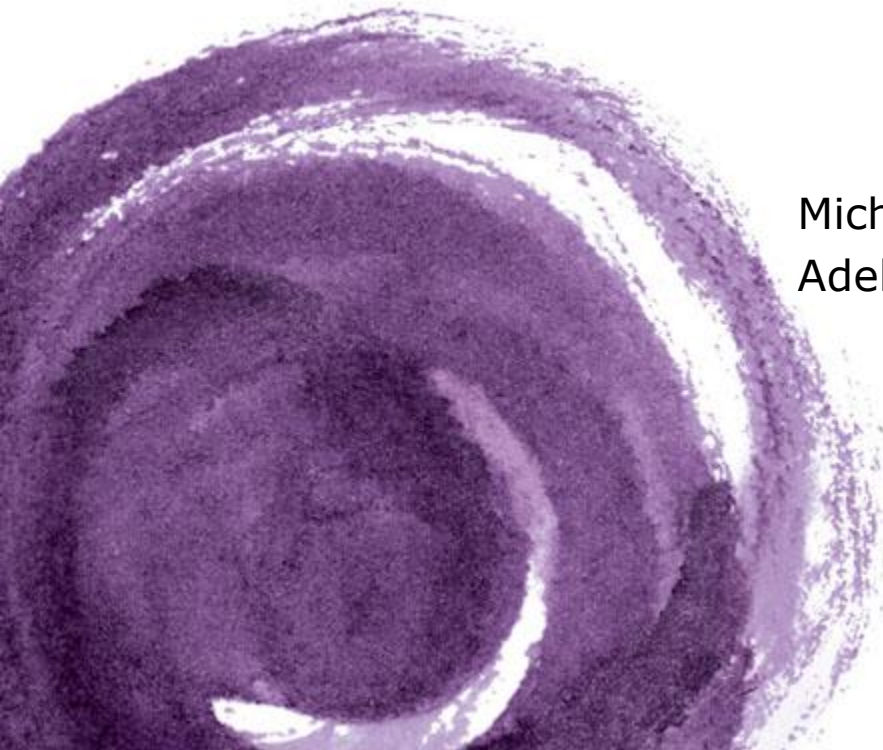




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# **Modelling and measuring bank's business risk: a distance function approach**

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# Introduction: Business risk concept

- Business risk is the risk of adverse, and unexpected changes in banks' revenues and costs
- These changes are the consequence of uncertainty in volumes, margins, and unit costs which come from changes of clients preferences, demands of banking products, competition in banking markets, or banks' environment.
- However, there is no common agreement on a definition of this risk, on risk drivers of business risk, and on measurement methodologies.

# Introduction: Business risk measure

- Two approaches to compute business risk
  - EaR approach.
  - Benchmark approach: consists finding a panel of specialized banks and taking information about their earnings volatility as a proxy for the profit volatility of the corresponding business line in an universal bank.
- This paper proposes a new approach founded on efficiency frontier methodology
  - Using “distance function” allows to compute banks’ profitability (duality between distance function and profit function);
  - The distance to the frontier of “best practices” provides a measure of profit inefficiency, i.e. losses related to underperformance;
  - Shifts of the efficiency frontier induced by adverse shocks on banks’ volumes serve as a measure of profit volatility and business risk.

# Agenda

- 1. The directional distance function**
- 2. Using the directional distance function to measure business risk**
- 3. Data and results**

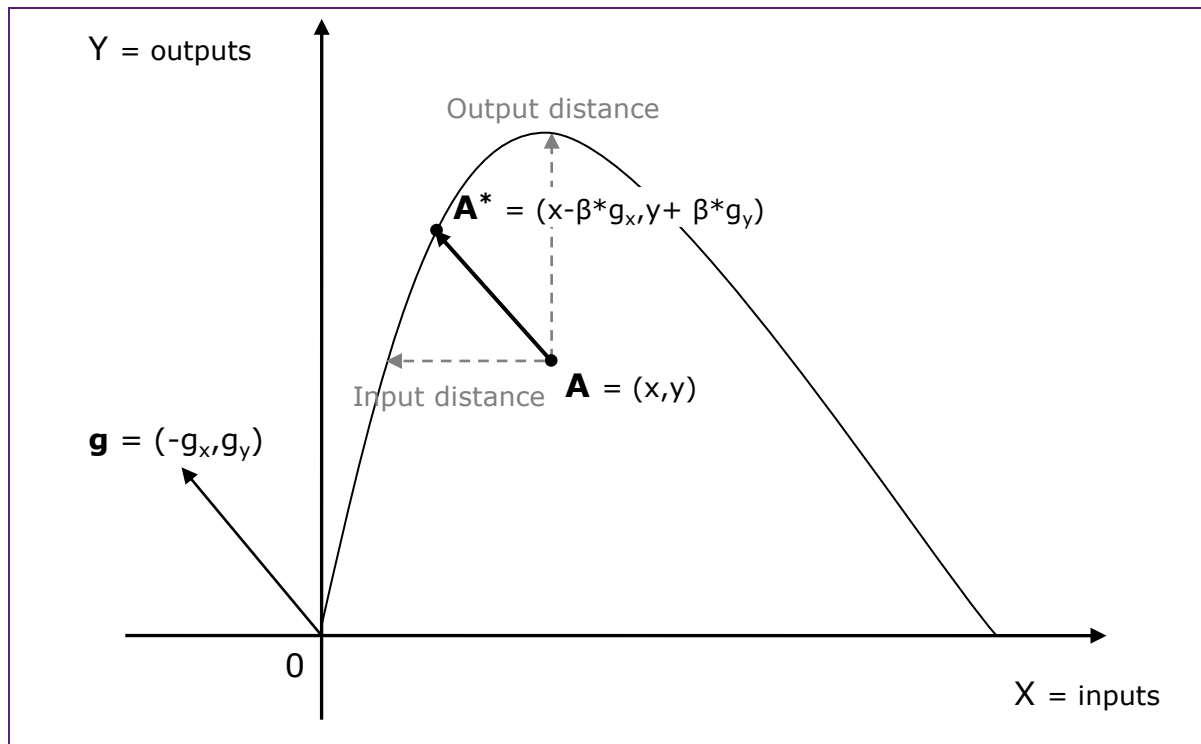
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# 1. The directional distance function

- Directional distance function - Definition
  - Distance from some observed input-output combination to the frontier of technology in a given direction
  - Measure of profit inefficiency



# 1. The directional distance function

- Directional distance function – Mathematically

- Inputs:  $X=(x_1, \dots, x_k)$
- Outputs:  $Y=(y_1, \dots, y_p)$
- Technology (production possibilities):  $T$
- Direction vector :  $g=(-g_x, g_y)$

- **Directional distance function**

$$\vec{D}(X, Y; -g_x, g_y) = \text{Max}_{\beta} \left\{ (X - \beta g_x, Y + \beta g_y) \in T \right\}$$

- Interpretation of  $\beta$  : measure of the maximum outputs expansion and inputs contraction technically possible (when  $g_x$  and  $g_y$  positive)

# 1. The directional distance function

- Advantages of the directional distance function
  - Duality with the profit function (Färe and Grosskopf 1997)
    - A fundamental link between profit and distance function
    - Allows a simultaneous contraction of the inputs and expansion of outputs in constructing the efficiency frontier
  - Less information required
    - Only volume of inputs and outputs
    - Prices not required - that avoids a problematic issue in banking applications
  - Additivity
    - Allows to sum banks' distances to determine inefficiency of a group of banks

# 1. The directional distance function

- The approach – Form of the function
  - Choice of a quadratic directional distance function
    - A parametric form to have a decomposition of the distance
    - Function that respects the properties of the distance function

$$\begin{aligned}\vec{D}(X, Y; -g_x, g_y) &= \alpha_0 + \sum_{j=1}^p \alpha_j Y_j + \sum_{h=1}^k \gamma_h X_h + \frac{1}{2} \sum_{h=1}^k \sum_{h'=1}^k \gamma_{hh'} X_h X_{h'} \\ &+ \frac{1}{2} \sum_{j=1}^p \sum_{j'=1}^p \alpha_{jj'} Y_j Y_{j'} + \sum_{j=1}^p \sum_{h=1}^k \eta_{jh} Y_j X_h\end{aligned}$$

# 1. The directional distance function

- The approach – Estimation of the parameters (1/2)
  - Choice of the **stochastic frontier approach** (Kumbhaker and Lovell 2000)
  - Stochastic specification
    - Idea: distance refers to a certain perturbation that isolates the bank from the frontier of the best practices

$$0 = \vec{D}(X, Y; -g_x, g_y) + \varepsilon$$

- Using the translation property of the distance function...
  - Intuition: if direction vector doubled => value of distance function reduced by 2

$$\vec{D}(X - x_k g_x, Y + x_k g_y; -g_x, g_y) = \vec{D}(X, Y; -g_x, g_y) - x_k$$

- ...To determine model equation
  - One chosen input explained by the combination of the other inputs and the outputs

$$-x_k = \vec{D}(X - x_k g_x, Y + x_k g_y; -g_x, g_y) + \overbrace{(v - u)}^{\varepsilon}$$

# 1. The directional distance function

- The approach – Estimation of the parameters (2/2)
  - Properties of the residual ( $\varepsilon$ )
    - Decomposition into noise disturbance ( $v$ ) and technical inefficiency ( $u$ )
      - $v$ : normal distribution
      - $u$ : half normal distribution
    - Technical inefficiency provides a measure of the distance
  - Maximum likelihood method to estimate parameters

# Agenda

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## 2. Directional distance function and bank's business risk measurement

- The distance is a measure of bank's under-profitability
  - The distance measures the loss of profits associated to inefficient managerial choices of outputs-inputs combinations
  - The distance is featured as a profit-inefficiency score at the bank level
    - A profit efficient bank has a score = 0 (this bank is located on the frontier of "best practices"),
    - A bank getting a score = 0.1 could increase profit by 10%.

## 2. Directional distance function and bank's business risk measurement

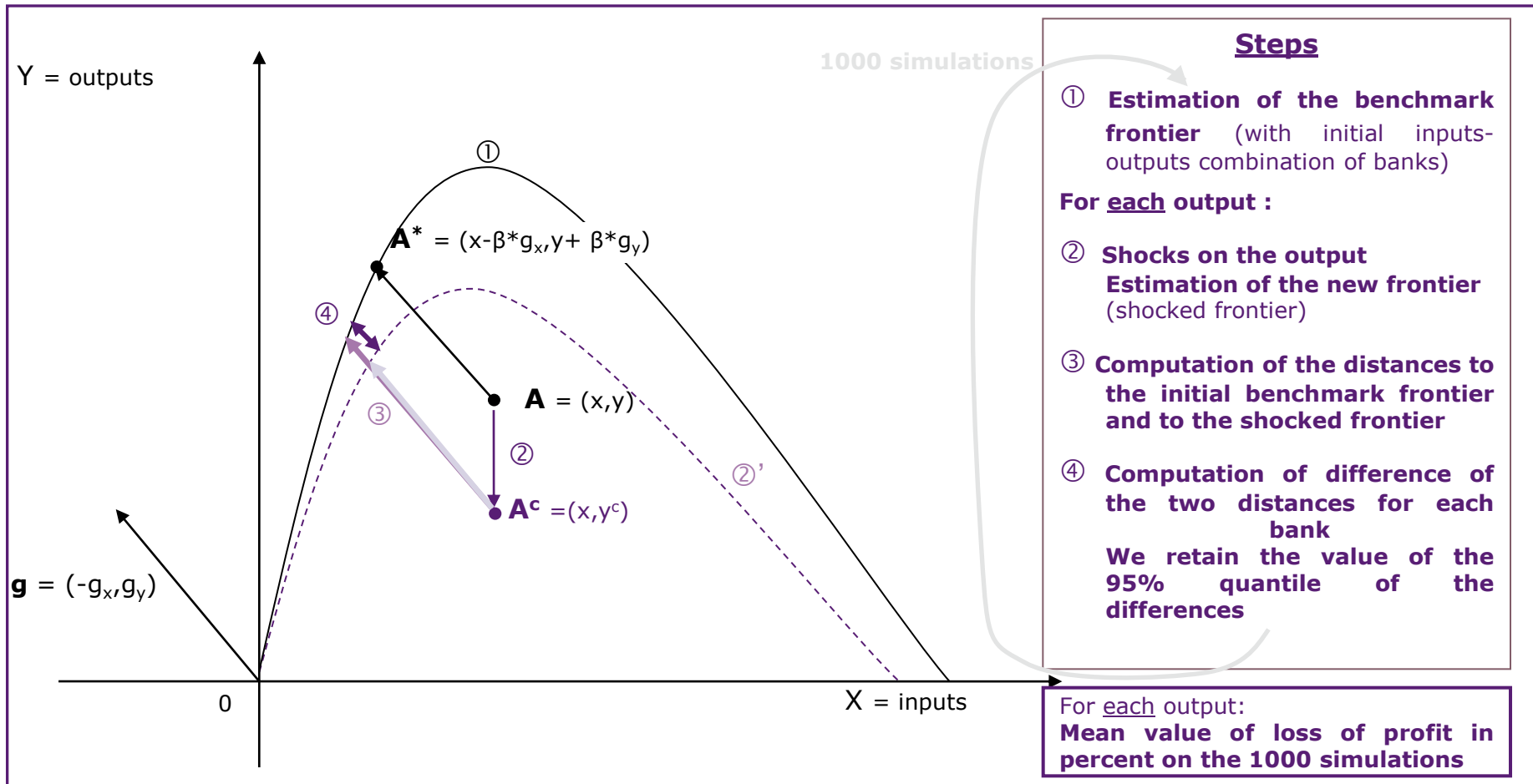
- From distance to business risk
  - Bank's business risk refers to situations where profit losses result from adverse changes in demand of banking products, stronger competitive pressures in banking markets...
  - Such events create uncertainty in volumes, margins and costs, and consequently uncertainty in bank's profit.
  - Here we assume that outputs' uncertainty create volatility in bank's profits
  - Using the framework of directional distance function, business risk for a given bank could be computed using Monte Carlo simulations as follows:
    - by simulating adverse shocks in outputs,
    - by estimating the volatility of each bank's distance (i.e. its profit inefficiency) as a consequence of these shocks,
    - and by taking an extreme value (a higher quantile) of the volatility distribution.

## 2. Directional distance function and bank's business risk measurement

- Simulation procedure to compute business risk :
  - In a first step, we estimated a distance function that will serve as a benchmark for the next-steps comparisons.
  - In a second step, we generated outputs' shocks by drawing in an uniform distribution  $[0; 0.5]$ : each output's volume is modified (reduced) by a certain percentage at each drawing.
    - We re-estimated the new distance function taking into account new shocked values of bank's outputs.
    - If shocks reduce volumes, the profit-inefficiency increases and the new frontier is below the initial one.
  - In a third step, we computed for each bank and each shocked product:
    - the distance to the initial frontier,
    - and the distance to the shocked frontier.
  - In a final step,
    - we computed the difference between the distance to the new estimated frontier (shocked frontier) and the distance to the initial benchmark frontier: this difference measure the profit's reduction generated by the shocks on the outputs' volumes.
    - and we retained for each simulation the value of the 95% quantile of the differences in distances over all sample's banks as the percent of losses of profit in case of one output's shock.

## 2. Directional distance function and bank's business risk measurement

- Illustration of the simulation procedure :



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# 3. Data and results

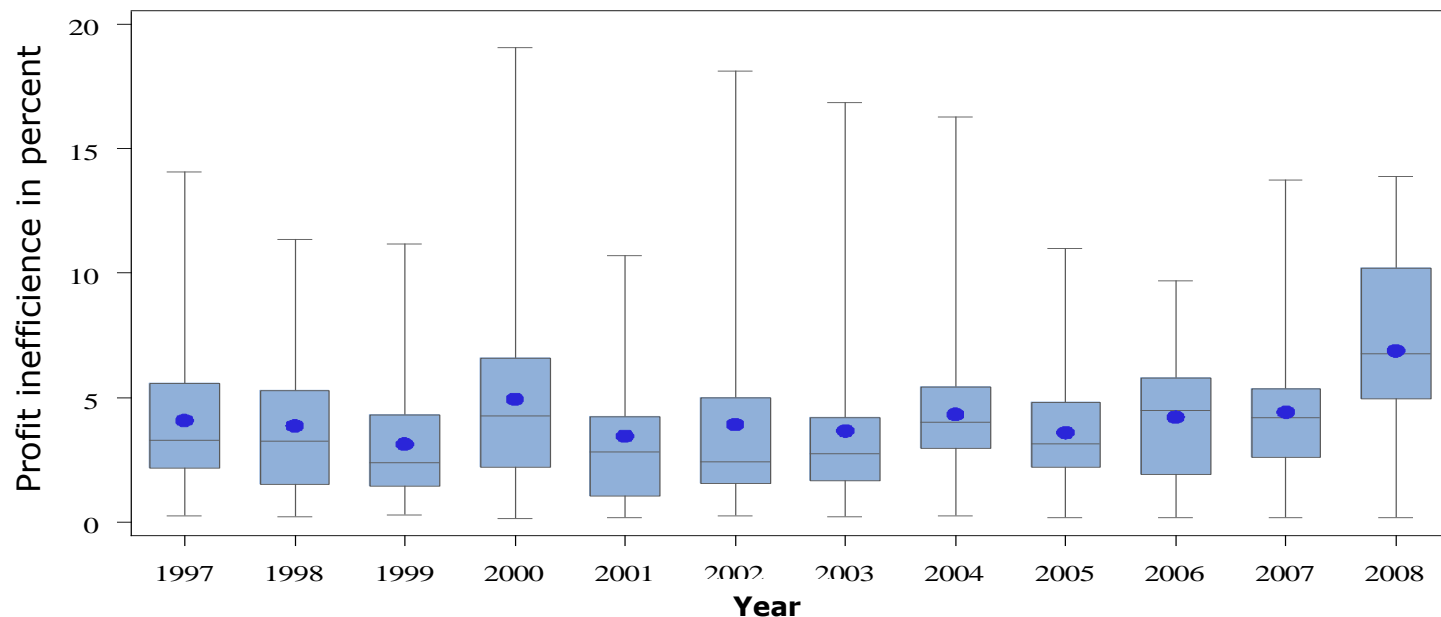
## ● Data

- Data came from supervisory reports (BAFI – Base des Agents Financiers) with accounting information about the banks' activities and results
  - Reliability and homogeneity of data
- Panel
  - 35 regional banks of a large French banking group
  - Period 1997-2008
- Four inputs
  - Labor costs (salaries paid to the employees)
  - Real physical capital costs (office rental and current operating costs)
  - Financial costs of deposits
  - Financial costs of borrowed funds
- Five Outputs
  - Deposits
  - Mortgage loans
  - Other loans (businesses and municipalities)
  - Interbank investments and investments in other financial markets
  - Sale of financial and insurance products

# 3. Data and results

- Results – Profit inefficiency

- Distance that isolates the bank from the frontier of the best practices
- Volatility of the distance
  - Between banks
  - Inter-temporal variability (across the business cycle)



### 3. Data and results

- Results of simulation – Two cases (1/2)

- Results obtained assuming strong shocks of 25% on average
- Business risk
  - In percent of total profit of the all banks of the sample
  - Mean of 95% quantile of the difference of the two distances given by the 1000 simulations
- Case (-1, 1): Bank can reduce costs in face of adverse volumes shocks

	Shocked outputs				
	Deposits	Mortgage loans	Other loans	Interbank investments and investments in other markets	Sale of financial and insurance products
Business Risk	13.0%	9.4%	14.7%	11.3%	3.3%

- Shock on one output: loss of profit between 3.3% and 14.7%
- Shocks on all outputs : loss of profit equal to 51.7%

### 3. Data and results

- Results of simulation – Two cases (2/2)
  - Case (0, 1): costs can not be reduced

	Shocked output				
	Deposits	Mortgage loans	Other loans	Interbank investments and investments in other markets	Sale of financial and insurance products
Business Risk	51.0%	12.1%	8.3%	14.4%	10.1%

- Shock on one output: loss of profit between 8.3% and 51.0%
- Shocks on all outputs : loss of profit equal to 95.9%

# Conclusion

- Directional distance function
  - A new measure of business risk in terms of Earnings-at-Risk
  - A way that takes into account the banking technology and banks business models
  - A data-saving methodology
- Additional research is needed to calibrate more realistic outputs shocks by estimating products demand functions