Redistributional impact of the National Health Insurance System in France:
A microsimulation approach

European Workshop on Dynamic Microsimulation Modelling

Valrie Albouy (INSEE)
Laurent Davezies (INSEE-CREST-IRDES)
Thierry Debrand (IRDES)

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Plan

1. Introduction
2. Estimation of expenditures
3. Micro-simulation with Destinie 2
Context and economic problems

In France, public health insurance can be seen as an insurance over the lifecycle. On the one hand workers have to pay contributions and on the other hand health expenditures are partially or totally reimbursed.

Transfer between ”good health period” and ”bad health period” for each individual ⇒ Intertemporal aspect

Transfer between ”lucky” and ”unlucky” ⇒ Insurance

Contributions not fixed by medical risk evaluation, but by legal rules ⇒ Redistribution
What are the problems?

Difficulties:

- Multiplicity of determinants of health expenditures
- Rules for contributions (ex: several contributions, mainly on wages, but also on pensions, unemployment benefits...)
- Rules of reimbursement (ex: threshold of household income for no co-payment, long-term diseases...)
- Differences of mortality rates between social groups

⇒ Not easy to understand if the legal rules are favorable to a particular group.
Age of death of individual $i$ : $A_i$
Contribuition of individual $i$ at age $a$ : $C_{ia}$
Health care utilization for individual $i$ at age $a$ : $D_{ia}$
Health expenditures of individual $i$ at age $a$ : $M_{ia}$
Reimbursement of individual $i$ at age $a$ : $R_{ia}$, $0 \leq R_{ia} \leq M_{ia}$
Net transfer benefit of individual $i$ at age $a$ : $B_{ia} = R_{ia} - C_{ia}$
Net present value of transfer for individual $i$ with a discount account $r$ : $NPV_i = \sum_{a=0}^{A_i} \frac{R_{ia} - C_{ia}}{(1 + r)^a}$
How to describe transfers over the lifecycle?

A (too) simple framework: 2 groups $G_1$ and $G_2$, and imagine a comparison between the present system and a fictive one, contribution based on risk in *absence of information asymmetry*.

- Evaluate transfers between groups: $\mathbb{E}(NPV_i|G_1)$ and $\mathbb{E}(NPV_i|G_2)$, difference between contribution and a ”pure” risk-based insurance premium for the class of risk $G_1$ or $G_2$.  
  $\Rightarrow$ Measure of the redistribution

- Evaluate dispersion of transfers within groups: $\mathbb{V}(NPV_i|G)$, dispersion of the risk in the group $G$, measure of risk covered within the class of risk $G_1$ or $G_2$.  
  $\Rightarrow$ Measure of the insurance

Questions: who are the ”winners” and the ”losers” in the system? Are the transfers between groups smaller than dispersion of transfers within groups?
"Cross section" and "time-series" dimension

- Terms $\mathbb{E}(NPV_i|G_1)$ can be estimated only with cross-sectional observations:

$$
\mathbb{E}(NPV_i|G) = \sum_{a=0}^{+\infty} \frac{\mathbb{E}(B_{ia}1_{\{a\leq A_i\}}|G)}{(1+r)^a}
$$

$$
= \sum_{a=0}^{+\infty} \frac{\mathbb{E}(R_{ia}1_{\{a\leq A_i\}}|G) - \mathbb{E}(C_{ia}1_{\{a\leq A_i\}}|G)}{(1+r)^a}
$$

- Terms $\mathbb{V}(NPV_i|G_1)$ need longitudinal observations to be estimated:

$$
\mathbb{V}(NPV_i|G) = \sum_{a=0}^{+\infty} \sum_{a'=0}^{+\infty} \frac{\mathbb{Cov}(B_{ia}1_{\{a\leq A_i\}}, B_{ia'}1_{\{a'\leq A_i\}}|G)}{(1+r)^{a+a'}} = \\
\sum_{a=0}^{+\infty} \sum_{a'=0}^{+\infty} \left\{ -\mathbb{Cov}(R_{ia}1_{\{a\leq A_i\}}, C_{ia'}1_{\{a'\leq A_i\}}|G) - \mathbb{Cov}(C_{ia}1_{\{a\leq A_i\}}, R_{ia'}1_{\{a'\leq A_i\}}|G) \right\}
$$
Why microsimulation?

To estimate the statistical distribution of $NPV$, the simplest case is to observe a long panel data with reimbursements and contributions.

- For past generations, these datasets are not available in France.
- For present and future generations, future reimbursements and contributions can not be observed.
Why microsimulation?

We have:

- On the one hand, ESPS-EPAS is a "short" panel (6 years, ≈ 7100 individuals) with $M_{it}$ observed and socio-demographic information $X_{it} \Rightarrow$ statistic law of expenditures $(M_{it})_{t=1...6}|(X_{it})_{t=1...6}$ can be identified.

- On the other hand, microsimulation model DESTINIE of INSEE, gives us good simulation of socio-demographic and contributions trajectories $X_{it}$ over the complete lifecycle. So, we can simulate trajectories of health expenditures over the complete lifecycle and analyze the system. And next, reimbursements and NPV.
Plan

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Estimation of expenditures with ESPS-EPAS panel data

- 2 types of consumption:
  - Ambulatory: 90% of utilisation $D_{it} = 1 \Rightarrow M_{it} > 0$
  - In-patient: 15% of utilisation $D_{it} = 1 \Rightarrow M_{it} > 0$

- Distribution characteristics:
  - Existence of non-consumers ($D_{it} = 0$ vs $D_{it} = 1$)
  - Strong unobserved individual heterogeneity (many things are not explained by covariates $X$)
  - Thick tail of distribution (few people have huge expenditures and many have small)
  - Strong temporal correlation (due to correlation of observed and unobserved heterogeneity in the time-series dimension)
  - Heteroskedasticity
Estimation of expenditures

\[ D_{it} = 1 \{D_{it}^* > 0\} = 1 \{D_{it-1} \gamma D + \ln(M_{it-1}) \gamma \ln(M) + X_{it} \gamma + u_i + \varepsilon_{it} > 0\} \]

\[ \ln(M_{it}) = (D_{it-1} \beta D + \ln(M_{it-1}) \beta \ln(M) + X_{it} \beta + \nu_i + \eta_{it}) \ D_{it} \]

- Thick tails of distribution \( \Rightarrow \) We work in "log": \( \ln(M_{it}) \Rightarrow \)
  heteroscedasticity of \( \eta_{it} \) change the average amount of simulation
  because the exponential retransformation is not linear \( \Rightarrow \) modeling of
  heteroscedasticity.

- Three parts could explain the correlation in the time-series dimension:
  the observed heterogeneity \( X_{it} \gamma \) and \( X_{it} \beta \), the unobserved heterogeneity
  \( u_i \) and \( \nu_i \) and a state dependence \( D_{it-1} \gamma D + \ln(M_{it-1}) \gamma \ln(M) \) and
  \( D_{it-1} \beta D + \ln(M_{it-1}) \beta \ln(M) \)
Estimation of expenditures

\[ D_{it} = \mathbb{1}\{D^*_{it}>0\} = \mathbb{1}\{D_{it-1}\gamma_D + \ln(M_{it-1})\gamma\ln(M) + X_{it}\gamma + u_i + \varepsilon_{it} > 0\} \]

\[ \ln(M_{it}) = (D_{it-1}\beta_D + \ln(M_{it-1})\beta\ln(M) + X_{it}\beta + v_i + \eta_{it}) D_{it} \]

- Impossible to assume that heterogeneity \( u_i \) and \( v_i \) is independent of lag variables \( D_{it-1}, M_{it-1} \), need to treat this problem for estimation and simulation (WP-20 IRDES).

- Given \( X \), number of use and average expenditure per use are correlated \( \Rightarrow u_i \perp \perp v_i \) or \( \varepsilon_{it} \perp \perp \eta_{it} \), \( \Rightarrow \) Take this correlation into account in estimation (avoid bias selection) and in simulation

- 4 estimations: ambulatory and inpatient by gender
### Table: Health expenditures

<table>
<thead>
<tr>
<th>Age</th>
<th>Ambulatory D = 1</th>
<th>Ambulatory</th>
<th>Inpatient D = 1</th>
<th>Inpatient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moy</td>
<td>Q1</td>
<td>Q3</td>
<td>Moy</td>
</tr>
<tr>
<td>0-29</td>
<td>0.89</td>
<td>536</td>
<td>134</td>
<td>656</td>
</tr>
<tr>
<td>30-44</td>
<td>0.93</td>
<td>871</td>
<td>209</td>
<td>1035</td>
</tr>
<tr>
<td>45-59</td>
<td>0.94</td>
<td>1455</td>
<td>371</td>
<td>1697</td>
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<tr>
<td>60-74</td>
<td>0.97</td>
<td>2148</td>
<td>775</td>
<td>2593</td>
</tr>
<tr>
<td>75 +</td>
<td>1.00</td>
<td>2952</td>
<td>1242</td>
<td>3490</td>
</tr>
<tr>
<td>Time to death</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alive</td>
<td>0.93</td>
<td>1151</td>
<td>231</td>
<td>1371</td>
</tr>
<tr>
<td>death in 2 years</td>
<td>0.94</td>
<td>3620</td>
<td>780</td>
<td>4498</td>
</tr>
<tr>
<td>death in 1 years</td>
<td>0.96</td>
<td>4391</td>
<td>952</td>
<td>5299</td>
</tr>
</tbody>
</table>
Estimation of expenditures

Covariates $X$:

- Age (flexible form: linear spline in this version)
- Age of schooling
- Status on the labor market
- Time to death: dummy variables that catch increase of expenditure at the end of the life
- For the young people:
  - Status on the labor market of their father
  - Current level of education
Plan

1. Introduction

2. Estimation of expenditures

3. Micro-simulation with Destinie 2
Destinie 2

- Complete rewriting, begin in 2005.
- Keep the main initial choices of Destinie 1:
  - based on the asset survey of INSEE (2003), survey in cross section with retrospective information
  - closed population
- But new programming structure in two steps, more modular
Destinie 2

- First step (generator of biography): simulation of biographic and professional trajectories excluding transitions to retirement: the theoretical carriers are fictively prolonged since 70 years old.
- Second step (retirement and pension simulator): read the result of the first module and add the simulation of choice of retirement and compute pensions.
  - This second step is not a unique and complete program
  - but a library of modules that we use to construct small specific programs of simulation.
The differential mortality

A important issue in the analyze of transfers induce by the national health system concern the date of death.

- Use of projections of mortality of Insee. However these projections are not differentiate by social groups.
- Use of life tables by social class in 1999, after 30 years old.
- Problem: age of schooling $S$ is the variable of social stratification in Destinie, and not the social class $SC$.

\[
P(\text{Death} = a | S, T = 1999) = \sum_{SC} P(\text{Death} = a | S, SC, T = 1999) P(SC|S, T = 1999)
= \sum_{SC} P(\text{Death} = a | SC, T = 1999) P(SC|S, T = 1999) \text{ if } S \perp \perp \text{Death}|SC
\]

- Life tables by schooling age for the year $T$ are calculated by changing the mortality rate of year $T - 1$ to align mortality on the projection of Insee without changing the relative risks between schooling ages.
At this step of our work, we have simulate ambulatory and in-patient expenditures under the assumption that "shocks" that affect ambulatory expenditures are independent of "shocks" that affect in-patient expenditures.

This is probably wrong ⇒ this bias downward the dispersion of NPV within the groups but not the mean transfer between group.

For the final version, we will estimate and simulate correlated "shocks" between ambulatory and in-patient.
Simulation of reimbursements

Under a threshold (≈ 7 000 € per unity of consumption) of income there is no co-payment. Advantages of Destinie

- Wages, pensions, of individual $i$
- Family links, household structures to compute unity of consumption
- Wages and pensions of members of household of individual $i$

Easy to compute the threshold!

Over the threshold: reimbursement depends on many unobserved factors, mainly the type of care. So, we use a statistical flexible regression (on the amount of expenditures and age) to impute a rate of reimbursement.
Reimbursements by gender (simulation in "cross section")

- Ambulatory men
- Inpatient men
- Ambulatory women
- Inpatient women
Assumption on economic trends

We simulate socio-demographic and salary trajectories for a cohort born between 1994 and 2003.

- productivity growth : 1.8% that drives evolution of real wages and administrative threshold (usual assumption in Destinie model)
- mortality : forecast of National Statistic Institute
- evolution of active population : forecast of National Statistic Institute
2 types of contributions are taken into account:

- **First type** is based on wages and only affects workers: 9.7% of wages for civil servants and 13.9% for the private sector.
- **Second type** is based on incomes, like CSG and CRDS affect workers and retired ~ 6% on wages and ~ 4% on pensions (in short!).

So, contributions are not difficult to determine when we know the status on the labor market, the wages, unemployment benefits and pensions. All these variables are presents in DESTINIE.
Reimbursements and contributions by gender

- Ambulatory men
- Inpatient men
- Contribution men
- Ambulatory women
- Inpatient women
- Contribution women

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Redistributional impact of the National Health Insurance System in France:

Introduction

Estimation of expenditures

Micro-simulation with Destinie 2

Probability of use and survival rate

![Graph showing probability of use and survival rate vs. age with lines for ambulatory, inpatient, and survival rate categories.](image-url)
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Redistributional impact of the National Health Insurance System in France:

Positive expenditures and survival rate

Expenditures in euro
Survival rate

Ambulatory
Inpatient
Survival rate
Introduction

Estimation of expenditures

Micro-simulation with Destinie 2

Difference between reimbursements and contributions
(multiplied by survival rate)

<table>
<thead>
<tr>
<th>Age</th>
<th>Amount in euro 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-15000</td>
</tr>
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<td>75000</td>
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<tr>
<td>96</td>
<td>80000</td>
</tr>
</tbody>
</table>

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Redistributional impact of the National Health Insurance System in France:
Estimation of expenditures

Micro-simulation with Destinie 2

Difference between reimbursements and contributions (multiplied by survival rate)

Age

Amount in euro 2006

> 21 ans
< 19 ans
> 19 ans
> 23 ans

Redistributional impact of the National Health Insurance System in France:
Introduction

Estimation of expenditures

Micro-simulation with Destinie 2

Difference between reimbursements and contributions
(multiplied by survival rate)

<table>
<thead>
<tr>
<th>Age</th>
<th>Amount in euro 2006</th>
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<td>75000</td>
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<td>100</td>
<td>80000</td>
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Introduction

Estimation of expenditures

Micro-simulation with Destinie 2

Difference between reimbursements and contributions (multiplied by survival rate)

<table>
<thead>
<tr>
<th>Amount in euro 2006</th>
<th>men</th>
<th>women without child</th>
<th>women with 1 child</th>
<th>women with 2 children</th>
<th>women with 3 children</th>
<th>women with 4 children or more</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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</table>

Age

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Redistributional impact of the National Health Insurance System in France:
Remarks on the inference

\[ \theta_0 = \mathbb{E}(NPV|G) = f(\beta_0, \gamma_0) \] (or \[ \theta_0 = \nabla(NPV|G) = f(\beta_0, \gamma_0) \])

If \( f(x, y) \) could be easily analytically calculated, \( \hat{\theta} = f(\hat{\beta}, \hat{\gamma}) \) would be a consistent estimator of \( \theta_0 \) and
\[ \nabla(\hat{\theta}) = \nabla f(\beta_0, \gamma_0)' \nabla(\hat{\beta}, \hat{\gamma}) \nabla f(\beta_0, \gamma_0). \]

Microsimulation is used to approximate \( f \) by a random variable having a decreasing variance with the number of simulations, \( \hat{\theta} = \hat{f}(\hat{\beta}, \hat{\gamma}) \) consistent and
\[
\begin{align*}
\nabla(\hat{\theta}) &= \mathbb{E}[\nabla(\hat{\theta}|\hat{\beta}, \hat{\gamma})] + \nabla[\mathbb{E}(\hat{\theta}|\hat{\beta}, \hat{\gamma})] \\
& \text{"simulation"} + \text{"estimation"} \\
\text{variance} & + \text{variance}
\end{align*}
\]

First term is close to 0, when the number of simulation is large, but the second is currently not computed (work in progress)
Results (preliminary)

prod. growth: 1.8%; tech. prog.: 1.8%; discount factor: 0

**TAB:** NPV (1994-2003 cohort)

| $G$         | $N_{sim}$ | $\hat{E}(\text{NPV}|G)$ | $\sqrt{\hat{V}(\text{NPV}|G)}$ | $\hat{E}(\sum_{a=0}^A C_{ia}|G)$ |
|-------------|-----------|--------------------------|---------------------------------|----------------------------------|
| All         | 187       | 870                      | 449                             |
| Sch. age $\leq 19$ | 2127     | 132                      | 890                             | -126                             |
| Sch. age $\leq 21$ | 2161     | 30                       | 764                             | -47                              |
| Sch. age $\leq 23$ | 1962     | -32                      | 821                             | 31                               |
| Sch. age $> 23$   | 1812     | -157                     | 982                             | 170                              |

Note: in K € 2006, $1.018^{50} \approx 2.4$, $1.018^{75} \approx 3.8$, $1.018^{100} \approx 6$

*: probably under estimate because unobserved heterogeneity is uncorrelated in the simulation of ambulatory and inpatient expenditures.
Results (preliminary)

prod. growth: 1.8%; \(\uparrow\) tech. prog.: 1.8%; discount factor: 0

**TAB:** NPV (1994-2003 cohort)

| \(G\)          | \(N_{sim}\) | \(\hat{E}(NPV|G)\) | \(\sqrt{\hat{V}(NPV|G)}\) | \(\hat{E}\left(\sum_{a=0}^{A} C_{ia}|G\right)\) |
|----------------|-------------|----------------------|-----------------------------|-----------------------------------|
| All            | 4118        | -52                 | 990                         | 77                                |
| \(\sigma\)    | 689         | -1                  | 809                         | -57                               |
| \(\varphi\) no child | 582         | 72                  | 778                         | -64                               |
| \(\varphi\) 1 child | 1414        | 27                  | 657                         | -69                               |
| \(\varphi\) 2 child. | 910         | 86                  | 702                         | -98                               |
| \(\varphi\) 3 child. | 349         | 158                 | 703                         | -158                              |

Note: in K \(\in\) 2006, 1.018^{50} \approx 2.4, 1.018^{75} \approx 3.8, 1.018^{100} \approx 6

\(\ast\): probably under estimate because unobserved heterogeneity is uncorrelated in the simulation of ambulatory and inpatient expenditures.
Results (preliminary)

prod. growth: 1,8%; \(\uparrow\) tech. prog.: 2,5%; discount factor: 0

**TAB:** NPV (1994-2003 cohort)

|                | \(N_{sim}\) | \(\widehat{E}(NPV|G)\) | \(\widehat{V}(NPV|G)^{\ast}\) | \(\widehat{E}(\sum_{a=0}^{A} C_{ia}|G)\) |
|----------------|-------------|--------------------------|-------------------------------|--------------------------------|
| All            | 590         | 1386                     | 449                           |
| Sch. age \(\leq\) 19 | 2127        | 132                      | 1487                          | -126                        |
| Sch. age \(\leq\) 21 | 2161        | 20                       | 1217                          | -47                         |
| Sch. age \(\leq\) 23 | 1962        | -31                      | 1298                          | 31                          |
| Sch. age > 23   | 1812        | -145                     | 1522                          | 170                         |

Note: in \(K \in 2006, 1.018^{\text{75}} \approx 3.8, 1.025^{\text{75}} \approx 6.4\)

\(\ast\) : probably under-estimate because unobserved heterogeneity is uncorrelated in the simulation of ambulatory and inpatient expenditures.
Results (preliminary)

prod. growth: 1.8%; ↑ tech. prog.: 2.5%; discount factor: 0


| G     | $N_{sim}$ | $\hat{E}(NPV|G)$ | $\sqrt{\hat{V}(NPV|G)}$ | $\hat{E}(\sum_{a=0}^{A} C_{ia}|G)$ |
|-------|-----------|-------------------|-------------------------|----------------------------------|
| All   | 590       | 1386              | 449                     |
| ♂     | 4118      | -43               | 1597                    | 77                               |
| ♂ no child | 689   | -24               | 1230                    | -57                              |
| ♂ 1 child. |      582 | 93                | 1235                    | -64                              |
| ♂ 2 child. | 1414 | 7                 | 1007                    | -69                              |
| ♂ 3 child. | 910   | 85                | 1143                    | -98                              |
| ♂ 4+ child. | 349   | 151               | 1065                    | -158                             |

Note: in K € 2006, $1.018^{75} \approx 3.8$, $1.025^{75} \approx 6.4$

*: probably under estimate because unobserved heterogeneity is uncorrelated in the simulation of ambulatory and inpatient expenditures.
Disclaimers before conclusions

- Work in progress
- Needs of robustness checks
- Estimation of precision due to estimation on the ESPS-EPAS (bootstrap on the ESPS-EPAS)
Conclusions

- Distribution between social groups but represents only a small part of the explained variance of transfers, vertical redistribution more important (≈ 20% of the variance of transfers), the system is principally an insurantial system.
- Redistribution mainly explained by the contribution system (and not by the behaviors of expenditures)
- Insurance mainly explained by generosity of the reimbursement
- Open questions: What about the change of behaviors in case of reform:
  - on the reimbursements ⇒ renunciation to health-care? unsustainable out-of-pocket?
  - on the contributions ⇒ labor supply?
  - on the link between health and work