Moral Hazard and Lack of Commitment in Dynamic Economies

Alexander Karaivanov
Simon Fraser University

Fernando Martin
Federal Reserve Bank of St. Louis

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Introduction

We study insurance contracts with limited commitment and private information in a dynamic risk-sharing setting.

- **Limited commitment**: contracting parties (risk-averse agent, risk-neutral insurer) cannot commit beyond the current period

- **Private information**: moral hazard due to unobservable effort which affects the probability distribution of stochastic output

- **Dynamic setting**: agent can self-insure through observable savings which affect his outside option

Our focus: Markov-perfect (MP) insurance contracts.
What we do

• We want to understand:
  – how limited commitment by each party matters in the best possible Markov-perfect insurance contract
  – the effect of the rate of return differential between contract parties
  – the role of savings contractibility

• and assess quantitatively:
  – welfare gains from resolving commitment, information and/or contractibility frictions
  – implications for wealth inequality
Markov-perfect insurance contracts – properties

- preserve standard features of optimal insurance – full insurance with full information; ‘inverse Euler equation’ with moral hazard
- easy to characterize and solve numerically – single scalar state variable
- equivalent to a one-sided commitment contract under certain conditions
- agent savings are integral part of MPE in contrast to in one-sided or full commitment contracts
Related literature

• **optimal contracts with commitment** – Townsend (1982), Rogerson (1985); Green (1987); Spear and Srivastava (1987); Phelan and Townsend (1991); Atkeson and Lucas (1992); Cole and Kocherlakota (2001); Doepke and Townsend (2006) among many others

• **limited commitment** – Thomas and Worrall (1988, 1994); Ligon, Thomas and Worrall (2002); Phelan (1995); Kocherlakota (1996); Krueger and Uhlig (2006); Sleet and Yeltekin (2006); Kovrijnykh (2010) plus many others

  – **markets vs. mechanisms/governments** – Bisin and Rampini (2006); Acemoglu, Golosov and Tsyvinski (2008a,b); Sleet and Yeltekin (2008)

• **short-term vs. long-term contracts** – Malcomson and Spinnewyn (1988); Fudenberg et al. (1990)
Model

Agent – risk-averse; with period utility $u(c) - e$ over consumption, $c$; effort, $e \in E$ and discount factor $\beta$.

Insurer – risk-neutral; discounts future profits with factor $1/R$

Technology – agent’s effort $e$ produces output, $y^i$, with probability $\pi^i(e)$ where $0 \leq y^1 < \ldots < y^n$ and $\pi^i(e)$ satisfy MLRP

- Agent may carry observable assets $a \in \mathbb{A} \equiv [0, \bar{a}]$ at a fixed gross return $r$ starting from an initial endowment $a_0 \in \mathbb{A}$

Assumptions: $u_c > 0, u_{cc} < 0; r < 1/\beta$ and $0 < r \leq R \leq 1/\beta$; $\pi^i(e)$ are such that FOA is valid

- for most of the talk we set $r = R$ (equal rates of return)
Limited commitment in this paper

- one-period contracts are fully binding

- parties cannot commit to future agreements extending beyond the current period

- thus, we do not study “opportunistic/strategic default” (i.e., reneging after $y^i$ is realized)

- instead, we focus on the parties’ ability to freely leave/rescind a contract each period before output uncertainty is resolved.
Timing

1. the agent is offered a contract for the period and decides whether to accept or not

2. the agent decides on effort, $e$

3. output $y^i$ is realized

4. (output exchanged for transfers $\tau^i$ if under insurance contract)

5. the agent consumes $c^i$ and saves $a^i$, $i = 1, ..., n$
Markov-perfect insurance

- benchmark: perfectly competitive insurer (free entry)

- free entry drives insurer to zero expected profits per period

- effort $e$ unobservable; assets $a$ observable and contractible

- in a MPE (to be formally defined), insurance contracts $\{T^i(a), A^i(a)\}_{i=1}^n$ specify transfers and future asset holdings as functions of agent’s current assets, $a \in \mathbb{A}$ and the output state, $i = 1, \ldots, n$

- future contracts induce continuation value $\mathcal{V}(A^i(a))$
Incentive compatibility

- given contract \( \{ T^i(a), A^i(a) \} \) the agent’s effort choice satisfies

\[
\sum_{i=1}^{n} \pi^i_e(e)[u(c^i) + \beta V(A^i(a))] - 1 = 0 \quad (IC)
\]

where \( c^i = ra + T^i(a) - A^i(a) \).
Insurer’s problem with free entry

Problem P1

\[
\max_{\{\tau^i, a^i\}_{i=1}^n, e} \sum_{i=1}^n \pi^i(e)[u(c^i) + \beta V(a^i)] - e
\]

subject to incentive-compatibility and zero per-period profits,

\[
\sum_{i=1}^n \pi^i(e)[u(c^i) + \beta V(a^i)] - 1 = 0 \tag{IC}
\]

\[
\sum_{i=1}^n \pi^i(e)[y^i - \tau^i] = 0 \tag{ZP}
\]

where \(c^i = ra^i + \tau^i - a^i\).
Markov-perfect equilibrium

Definition 1

A Markov-perfect equilibrium (MPE) is a set of functions \( \{\{T^i, A^i\}_{i=1}^n, \mathcal{E}, \mathcal{V}\} : \mathbb{A} \rightarrow \mathbb{R}^n \times \mathbb{A}^n \times \mathbb{E} \times \mathbb{R} \) such that for all \( a \in \mathbb{A} \):

\[
\{\{T^i(a), A^i(a)\}_{i=1}^n, \mathcal{E}(a)\} = \text{argmax}_{\{\tau^i, a^i\}_{i=1}^n} \sum_{i=1}^n \pi^i(e)[u(c^i) + \beta \mathcal{V}(a^i)] - e
\]

subject to (IC) and (ZP) and where

\[
\mathcal{V}(a) = \sum_{i=1}^n \pi^i(\mathcal{E}(a))[u(C^i(a)) + \beta \mathcal{V}(A^i(a))] - \mathcal{E}(a),
\]

where \( C^i(a) = ra + T^i(a) - A^i(a) \) and \( c^i = ra + \tau^i - a^i \).
Markov-perfect contracts

A Markov-perfect contract for any given \( a \in \mathbb{A} \) consists of the transfer and asset choices \( \{\tau^i = T^i(a), a^i = A^i(a)\}_{i=1}^n \) associated with a MPE as defined in Definition 1.
MPE – characterization

Proposition 1: A MPE with perfectly competitive insurers and moral hazard is characterized by:

(i) $C^i(a)$ non-decreasing in $i$, with $C^1(a) < C^n(a)$, for all $a \in \mathbb{A}$;

(ii) ‘inverse Euler equations’:

\[
\frac{1}{u_c(C^i(a))} = \frac{1}{\beta r} E \left[ \frac{1}{u_c(C(A^i(a)))} \right]
\]

for all $a \in \mathbb{A}$ and $i = 1, \ldots, n$.

• MP insurance contracts preserve standard features of risk-sharing contracts with private information.
MPE without perfect competition

• general outside option for the agent – function of his assets, \( B(a) \)

• we allow any \( B(a) \) from \( \Omega(a) \) (the autarky value) up to \( \mathcal{V}(a) \) (the agent’s value with free entry), that is, \( \Omega(a) \leq B(a) \leq \mathcal{V}(a) \) for all \( a \in \mathbb{A} \)

• assume \( B(a) \) is differentiable, strictly increasing, strictly concave

• can endogenize \( B(a) \) by introducing bargaining
Insurer’s problem with general outside option

Problem P2

\[ \Pi(a) = \max_{\{\tau^i, a^i\}_{i=1}^n} \sum_{i=1}^n \pi^i(e) \left[ y^i - \tau^i + \frac{\Pi(a^i)}{r} \right] \]

subject to

\[ \sum_{i=1}^n \pi^i(e)[u(c^i) + \beta B(a^i)] - 1 = 0 \] \hspace{1cm} (IC)

\[ \sum_{i=1}^n \pi^i(e)[u(c^i) + \beta B(a^i)] - e \geq B(a) \] \hspace{1cm} (PC)

where \( c^i = ra + \tau^i - a^i \).
Results

- MPE defined analogously to Definition 1 with (PC) taken as equality
- the same properties as in Proposition 1 obtain
Equivalence of MPE and one-sided commitment contract

- compare our MP contract with a long-term contract to which only the insurer can commit (“one-sided commitment”, OSC)

- For any $t = 0, \ldots, \infty$ and any output state history $s^t$, let $\alpha(s^t)$ denote beginning-of-period $t$ agent assets obtained using the MPE policy rule $A^i(a)$. That is, $\alpha(s^t) = A^s_t(\alpha(s^{t-1}))$ with $\alpha(s^{-1}) = a_0$.

**Proposition 2:** Given $\alpha(s^{-1}) = a_0 \in \mathbb{A}$ and any output state history $s^\infty$, a one-sided commitment contract with full commitment by the insurer yields consumption and effort sequences $\{c(a_0, s^t), e(a_0, s^t)\}_{t=0}^\infty$ identical to the sequences $\{C^s_t(\alpha(s^{t-1})), E(\alpha(s^{t-1}))\}_{t=0}^\infty$ in a Markov-perfect equilibrium.
Equivalence of MPE and one-sided commitment contract

• **Intuition:** key to the equivalence result is that the agent and insurer have the same intertemporal rate of return \((R = r)\)
  
  – in the one-sided commitment problem future promised utility and assets are fully interchangeable in our setting
  
  – in contrast, if \(R > r\) (Karaivanov and Martin, 2012) the insurer can generate more surplus; in addition the time profiles of consumption (Euler equations) differ in MPE vs. OSC

• asset accumulation by the agent
  
  – indeterminate in the one-sided contract
  
  – determinate and key part of MPE

*Note: the limited commitment by the agent matters irrespective of \(r, R\) – the insurer cannot drive agent’s continuation value below \(B(0)\)
Asset contractibility

- Asset holdings by the agent important in MPE since they determine the value of his outside option

- So far we have assumed that agent’s assets, $a$ are observable and contractible

- If assets are not contractible, an incentive constraint reflecting the agent’s saving decision must be added to Problems P1 or P2 to solve for the MP contract

$$-u_c(c^i) + \beta B_a(a^i) = 0$$

- We use Abraham and Pavoni’s (2006) verification approach to check validity of the FOA in $e$ and $a^i$ jointly.
Asset contractibility (cont.)

Proposition 4:

For any given outside option $B(a)$ satisfying our assumptions, MPE does not depend on asset contractibility if $\Pi_a(a) = 0$ for all $a \in A$ and only if $\Pi_a(A^i(a)) = 0$ for all $a \in A$ and all $i = 1, \ldots, n$.

- **Intuition**: expected profits $\Pi$ depend non-trivially on assets, since the latter affect the agent's demand for insurance and outside option.
  
  - in general, the agent wants to save more than the amount preferred by the insurer since this enables the agent to raise his outside option, $B(a^i)$ and secure higher future utility
  
  - this misalignment of incentives is not present in the perfect competition case in which all surplus goes to the agent, $\Pi(a) = 0$ for all $a \in A$
Numerical analysis

- compare MP insurance contracts with different sets of frictions to each other and to self-insurance

- the agent’s self-insurance (autarky) problem can be written recursively as

\[ \Omega(a) = \max_{\{a^i\}_{i=1}^n} \sum_{i=1}^n \pi_i(e)[u(ra + y^i - a^i) + \beta\Omega(a^i)] - e \]

where \( \Omega(a) \) is the agent’s autarky value function.

- properties: \( \Omega(a), c^i \) and \( a^i \) all increasing in \( a \)
Numerical analysis – parametrization

• generalized CRRA parameterization for preferences,

\[ u(c) = \frac{\alpha(c^{1-\sigma} - 1)}{1 - \sigma} \]

with \( \alpha, \sigma > 0 \)

• consider an economy with \( n = 3 \), “low”, “medium” and “high” output levels, labeled \( y^L, y^M \) and \( y^H \) where

\[
\pi^M(e) = \frac{\varphi e^\nu}{1 + e^\nu}, \quad \pi^H(e) = \frac{(1 - \varphi)e^\nu}{\gamma + e^\nu}
\]

\[ \pi^L(e) = 1 - \pi^M(e) - \pi^H(e) \]

with \( \gamma, \nu > 0 \) and \( \varphi \in (0, 1) \)
Numerical analysis – parametrization

• to pick parameter values and calibration targets, we follow Castañeda, Díaz-Giménez, and Ríos-Rull (2003) who match earnings, the wealth distribution and other aggregates for the US economy

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<tbody>
<tr>
<td>$\alpha$</td>
<td>$\beta$</td>
<td>$\sigma$</td>
<td>$r = R$</td>
<td>$\nu$</td>
<td>$\varphi$</td>
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<tr>
<td>4.000</td>
<td>0.924</td>
<td>1.500</td>
<td>1.061</td>
<td>0.500</td>
<td>0.450</td>
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INCOME: AUTARKY (DASHED) & MPE (SOLID)
Numerical analysis – findings

Table 2: Statistics for the median-wealth agent (long-run)

<table>
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<tr>
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<th>(a)</th>
<th>(e)</th>
<th>(E_y)</th>
<th>(a/E_y)</th>
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<tbody>
<tr>
<td>Autarky</td>
<td>1.119</td>
<td>1.031</td>
<td>0.380</td>
<td>2.948</td>
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<tr>
<td>MPE</td>
<td>0.247</td>
<td>0.942</td>
<td>0.321</td>
<td>0.772</td>
</tr>
</tbody>
</table>

*Note: expected income, \(E_y = \sum_{i=1}^{n} \pi^i(e)y^i + (r - 1)a\)*
Consumption smoothing: autarky (dashed) & MPE (solid)
MP contracts may explain a non-trivial part of wealth inequality.

Wealth Gini: Autarky = 0.35; MPE = 0.45; U.S. = 0.80
Numerical analysis – welfare

For all $a \in \mathbb{A}$ we compute the consumption-equivalent compensation $\Delta(a)$ defined by

$$
\sum_{i=1}^{n} \pi^i(\hat{E}(a)) \left\{ u(\hat{C}^i(a)[1 + \Delta(a)]) + \beta \Omega(\hat{A}^i(a)) \right\} - \hat{E}(a) = V(a)
$$

where $\{\hat{C}^i(a), \hat{A}^i(a), \hat{E}(a)\}_{i=1}^{n}$ are the optimal policy functions in autarky, $\Omega(a)$ is the autarky value function and $V(a)$ is the agent’s value in MPE with free entry.
Welfare gains: Autarky to MPE
WELFARE GAINS: PRIVATE INFO VS COMMITMENT

MPE with full information / MPE with private information

Commitment with private information / MPE with full information
Welfare gains – summary

• Sizeable gains from MP contracts, especially at low asset levels

• Two opposing forces when resolving the private information friction:
  – demand for insurance is decreasing in assets
  – cost of inducing higher effort is increasing in assets

• For our parameterization, the gains from commitment are higher than those from resolving the moral hazard problem at low asset levels, while the opposite holds for high asset levels.
Numerical analysis – asset contractibility

- define $B(a) = (1 - \theta)\Omega(a) + \theta V(a)$
  - $\theta = 1$ is perfect competition;
  - $\theta = 0$ is monopolist insurer holding the agent to autarky

- welfare gains from asset contractibility can be large (see figure)

- the higher the insurer’s market power (the lower $\theta$), the larger the profits from being able to control agent’s assets
Welfare gains: asset contractibility

Profits ratio

θ

a=0

a=1

a=median
Conclusions

The Markov-perfect dynamic insurance contracts we analyze have:

- simple recursive representation without curse of dimensionality including when agents can (observably) save on the side
- determinate asset dynamics
- non-degenerate long-run wealth distribution
- numerically sizeable effects when varying key environment assumptions such as “market power” and asset contractibility
Thank you
One-sided commitment problem – 1st stage

\[ \Pi^C(a_0) \equiv \max_{\{c^i_0, w^i\}_{i=1}^n, e_0} \sum_{i=1}^n \pi^i(e_0) \left[ u(c^i_0) + \beta \tilde{\Pi}^C(w^i_0) \right] \]  \hspace{1cm} (2)

subject to

\[ \sum_{i=1}^n \pi^i(e_0) [u(c^i_0) + \beta w^i_0] - 1 = 0 \]

\[ \sum_{i=1}^n \pi^i(e) [u(c^i) + \beta w^i_0] - e = B(a_0) \]

\[ w^i_0 \geq B(0), \forall i \]
One-sided commitment problem – 2nd stage

\[
\tilde{\Pi}^C(w) = \max_{\{c^i, w^i\}_{i=1}^n} \sum_{i=1}^n \pi^i(e) \left[ y^i - c^i + r^{-1} \tilde{\Pi}^C(w^i) \right] \tag{3}
\]

subject to

\[
\sum_{i=1}^n \pi^i(e) \left[ u(c^i) + \beta w^i \right] - 1 = 0
\]

\[
\sum_{i=1}^n \pi^i(e) \left[ u(c^i) + \beta w^i \right] - e = w
\]

\[
w^i \geq B(0), \quad \forall i
\]