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Christian Gollier, TSE

The incredible health and economic shocks of Covid-19 impacted us very unequally. Chefs in restaurants suffered more than public servants. Young working mothers and isolated seniors faced terrible challenges. This reminds us of the key social value creation of risk-sharing mechanisms in our modern society. These shocks are a pure "act of god" and myriads of individual economic losses were incurred to save our community. The collective loss is efficiently smoothed by a massive increase in public debt. Let us recognize that the way we shared risk in this pandemic followed the principles of efficient risk sharing quite well, at least up to now.

The SCOR-TSE partnership has mobilized its scientific forces to work on several issues raised by the crisis. What relative weights should we put on the (often contradictory) health and economic goals of today's policymakers? Given the fragility they have shown during this crisis, how can we better finance our long-term care systems? Should we differentiate the intensity of lockdowns by regions or age classes? This report illustrates that economics is probably as important as epidemiology in shaping public and private policies in the face of a pandemic.

Philippe Trainar, SCOR

Risks for human beings are accumulating. Climate change, terrorism, pandemics, cyber-attacks, liability, public debts, long-term care, and ultra-low interest rates are putting pressures on households, companies, and governments. Ultra-low interest rates distort relative prices, impacting (re)insurance tariffs and resource allocation. These are the ingredients for new economic and financial imbalances. For more than a decade, the SCOR-TSE chair on Risk Markets and Value Creation has been dedicated to understanding these imbalances, their consequences, and their solutions. Its research is innovative, theoretical, and empirical, as an accepted economic rationale has not yet been established for many of these imbalances. Finding this rationale is exactly the kind of research the SCOR Foundation for Science is eager to support.

How to insure long-term care

Pierre Pestieau *received his PhD from Yale. He taught economics at Cornell University and University of Liège, where he has been a professor emeritus since 2008. He is also a member of CORE, Louvain-la-Neuve, and a fellow at CEPR and CESIfo.*

His main research interests are pension economics, social insurance, inheritance taxation, redistributive policies, and tax competition.

Most of us will need long-term care at the end of our lives, yet it is one of the largest uninsured risks facing the elderly. Pierre Pestieau (University of Liège) regularly collaborates with TSE economists. His recent work examines the reasons for the surprisingly narrow market for long-term care insurance, and advocates the introduction of a private or public deductible.

Why is the funding of long-term care so important?

The rise in long term care (LTC) needs is a major demographic challenge. The number of Europeans in need of LTC is expected to grow from 27 million in 2013 to 35 million by 2060. According to a recent US study, more than half of 65-year-olds will ultimately have a high need of LTC (see Table 1). The poorest – especially women – are most at risk. For example, 22% of those in the highest income quintile will require care for more than two years; for the lowest quintile, this increases to 31%.

About two thirds of LTC is generally provided by informal caregivers; recent figures show that about 80% of dependent individuals in the US receive informal care from relatives and friends. However, it is expected that the role of this informal LTC provision will decrease and it is not clear that the state, or the market, will be able to fill the gap. Financial risks associated with meeting LTC needs will then grow, increasing the urgency for the development of mechanisms to absorb these risks.

> **One would expect private insurance markets to expand to insure individuals against the - quite likely – substantial costs of LTC. However, markets for private LTC insurance remain thin**

Table 1	Length of dependence for US citizens aged 65+						
	% with LTC need	Average year of high LTC need	Distribution of need (% of cohort)				
			None	< 1 year	1 - 1.99 years	2 - 4.99 years	≥ 5 years
Men	46.7	1.5	53.3	18.4	7.4	11.1	9.8
Women	57.5	2.5	42.5	19.4	8.1	12.3	17.8

Source: Nordman (2018)

What explains the 'long-term care insurance puzzle'?

Given that each person has a large probability to enter a nursing home in later life and given the large costs related to LTC, one would expect private LTC insurance markets to expand, in order to insure individuals against the - quite likely - substantial costs of LTC. However, although markets for private LTC insurance exist in most countries, they remain thin.

On the supply side, high prices and the reimbursement formula are among the explanatory factors. Financial frictions and statutory regulations affect the profitability of insurance companies and may explain their relatively high loading costs they apply.

The two main LTC reimbursement formulas are not attractive for those who fear to incur a too long period of dependence. Reimbursement policies pay for the actual cost of care. For example, if the chosen daily benefit is $100 and the actual cost of care is $90, the insurer will pay $90. If the daily cost of care is $120, the policy will pay $100 per day and the insured must pay the difference. However, this formula has a ceiling for both the amount and duration of the benefits. Cash indemnity policies pay the dependent the chosen daily benefit as soon they qualify, regardless of actual expenses. This benefit may cover the dependent for their lifetime but the amount is generally low.

Neither formula meets the concern of those who fear becoming penniless or being forced to depend on their children because of an extended and costly dependency.

On the demand side, government-provided care may be crowding out private insurers with means-tested programs impacting both poor and affluent households. In the US, Medicaid imposes a high implicit tax on self-insurance via saving and, as a secondary payer, on the purchase of LTC insurance. Family solidarity can also reduce demand: parents might refuse to buy insurance if it reduces children's incentives to provide care.

Alternative explanations involve behavioral bias. Ignorance or lack of self-control can cause our choices about buying insurance to be based on how we perceive the risk of old-age dependency, rather than the actual risk. Old-age dependency is also a singular event in one's life, so insurance against LTC costs cannot be treated like standard insurance (e.g. against domestic fires). Dementia, disability, and death generate anxiety, and this may encourage a refusal to face reality.

Which solution does your research support?

Concerns about the risk of a long and costly dependency could be dealt with by a system in which individuals' contributions to their LTC costs are capped at a certain amount, with full coverage for all further expenditures. Under the system proposed in the UK by the Dilnot Commission (2011), only around a third of dependents would reach the proposed cap of about £35,000, but everyone would benefit from knowing that they were covered, avoiding the fear and uncertainty of the current system.

We argue that this formula could be justified as an efficient insurance policy, applying Arrow's (1963) theorem on insurance deductibles. Addressing the issue of health care, Arrow's theorem states: "If an insurance company is willing to offer any insurance policy against loss desired by the buyer at a premium which depends only on the policy's actuarial value, then the policy chosen by a risk-averting buyer will take the form of 100% coverage above a deductible minimum."

Compared to health care, the random and costly nature of LTC introduces two specific dimensions: the risk of becoming dependent and the length of dependency. My research with Jacques Drèze and Erik Schokkaert (2016) shows that Arrow's theorem holds for LTC, implying that policies should offer full self-insurance for the first years of dependency followed by full insurance thereafter. In other words, it is optimal to focus insurance coverage on the states with largest expenditures. My paper with Justina Klimaviciute (2020) shows that this result also holds with ex post moral hazard.

> **Concerns about the risk of a long and costly dependency could be dealt with by a system in which individuals' LTC contributions are capped at a certain amount, with full coverage for all further expenditures**

Can the deductible also be applied to the optimal design of social insurance?

In another paper with Justina, we analyze a setting with a non-linear scheme of income taxation and LTC insurance and explore how the optimal deductible amounts should be designed for individuals with different productivities. We show that the optimal deductibles for high- and low-productivity individuals are not always the same and that their comparison depends on absolute risk aversion and on whether both individual types have the same or different LTC needs. We also find that when the probability of dependence is negatively correlated with income, this strengthens the case for social insurance and might result in the optimal level of deductible being equal to zero or even negative.

SUMMING UP

In our aging societies, individuals face significant late-in-life risks with an increasing need for LTC. Yet, they hold little LTC insurance. The goal of Pierre's recent paper is to survey the standard causes of the LTC insurance puzzle and to suggest a way to make the reimbursement formula more attractive to those who fear a lengthy period of dependence. He proposes the adoption of insurance policies with deductibles, offering full coverage for the dependent beyond a certain number of months.

FURTHER READING

'Arrow's theorem of the deductible and long-term care insurance' (Drèze et al, 2016, *Economics Letters*) presents Pierre's main argument. 'Insurance with a deductible: a way out of the long term care insurance puzzle' (Klimaviciute and Pestieau, 2020, *Journal of Economics*) extends it to cope with the issue of moral hazard.

For a non-technical overview in French, see 'Dépendance et franchise', (Klimaviciute and Pestieau, 2019, *Revue d'économie financière*).

Fair innings: Whose lives should be saved first?

Nicolas Treich *is a research associate at INRAE and TSE. His work focuses on risk and decision theory, environmental economics, benefit-cost analysis and, more recently, on animal welfare.*

He has published scientific papers on subjects including the precautionary principle, the value of statistical life, and climate policy. He has organized several international conferences and written numerous articles for the general public, as well as reports on risk policy issues.

The Covid-19 pandemic has shone a harsh light on the life-and-death tradeoffs that all societies regularly confront. To guide such decisions about our health, environment, and economies, governments often evaluate regulations using benefit-cost analysis. However, the standard use of this tool to measure policy impact often ignores crucial differences such as age and income. In a new paper coauthored with economists at Duke and Harvard, TSE's Nicolas Treich shows that the social welfare function can help policymakers make fairer choices.

How can we measure policy impacts in terms of their ability to save lives?

The dominant tool used by governments to assess fatality risk-reduction policies is benefit-cost analysis (BCA). The method relies on the estimation of how much individuals are willing to pay if the policy has a positive impact, or to accept for a negative impact. The social value of a policy is calculated as the sum of these monetary equivalents.

When valuing fatality risk reduction using BCA, governments generally attribute the same willingness to pay – or value per statistical life (VSL) – to everyone. This approach avoids prioritizing richer individuals who are willing to pay more for lifesaving measures such as ventilators. But this methodology fails to prioritize the young. BCA is also indifferent to whether the costs of a policy are borne by the poor or the rich.

In contrast, the social welfare function (SWF) measures policy impacts in terms of interpersonally comparable wellbeing, using "utilities" rather than monetary equivalents. An individual's utility is a measure of their strength of preference for goods such as longevity, income, and health. The simplest utilitarian version of this framework assigns a social value to a policy by summing expected utilities across age and income groups. "Prioritarian" versions give extra weight to the worse off.

The SWF approach is widely used by economists studying optimal tax theory and climate change. However, little research has been undertaken to apply it to fatality risk reduction.

Is it more important to save the lives of the young?

The notion that the young should receive priority with respect to lifesaving measures is reflected in the academic literature and in surveys of citizen preferences regarding health policy. To the extent that age inversely correlates with life expectancy remaining, this idea seems hard to dispute. If Anne is similarly situated to Bob, except for being younger, and a reduction in Anne's current mortality risk produces a larger increase in her life expectancy than the same reduction in Bob's, the risk reduction for Anne seems socially more valuable.

> **Our paper takes the position that a policy that improves expected lifetime wellbeing for a younger person is ethically better than an otherwise-identical policy that produces the same gain in an older person**

> **Which Covid-19 patients should receive scarce medical equipment? Which uninfected individuals should get vaccinated? The SWF framework provides a systematic methodology for answering such questions**

Beyond such utilitarian arguments, it has been suggested that the health and lives of the young should also take priority on fairness grounds. John Harris (1985) introduced the idea that everyone is entitled to a "fair innings" up to an appropriate age threshold; the rest of their life can be seen as a bonus which may be canceled to help others reach the same threshold.

Our paper takes the position that a policy that improves expected lifetime wellbeing for a younger person is ethically better than an otherwise-identical policy that produces the same gain in an older person. While fair innings in this sense is an intuitively appealing idea, it is not supported by the current economic literature on the valuation of lifesaving, which generally focuses on BCA.

How do you apply the social welfare function approach to life-saving issues?

In previous work (Adler et al., 2014), we analyzed the application of the SWF framework to risk policies and compared it to VSL. We calculated the social value of risk reduction (SVRR) for different types of SWFs: utilitarian, "ex ante prioritarian," and "ex post prioritarian". Utilitarianism ranks outcomes by summing wellbeing numbers, while prioritarianism does so by summing a strictly increasing and strictly concave transformation of wellbeing, thereby giving priority to those at lower wellbeing levels.

Our current article uses a much richer, multi-period model of individual resources and survival. Each individual is characterized by a lifetime risk profile; a lifetime income profile; and a current age. This setup permits a more nuanced analysis of an individual's SVRR and VSL. In particular, it allows us to compare SVRR and VSL with respect to an individual's age as well as with respect to income and baseline fatality risk.

What were your key findings?

First, we demonstrate that the SWF framework - by contrast with BCA - provides a rigorous basis for the "fair innings" concept. The SVRR, as calculated using an ex ante or ex post prioritarian SWF, gives extra social weight to risk reduction for younger individuals above and beyond the additional weight they receive by virtue of greater life expectancy remaining.

Second, we show that the manner in which BCA values risk reduction is significantly different from the SWF framework, regardless of which SWF is used. These differences are multifold and may be empirically quite significant. In particular, VSL increases much more steeply with income in each age group than the utilitarian SVRR, while the prioritarian SVRRs are flat or decrease with income.

How can this research help us to face the challenges of Covid-19?

Although our article was drafted prior to the current health crisis, the coronavirus pandemic only increased the salience of perennial life-and-death issues such as risk allocation. Which Covid-19 patients should take priority in receiving scarce medical equipment that would reduce the risk of dying from the disease? Which uninfected individuals should get vaccinated, or receive N95 masks and other protective equipment? The SWF framework provides a systematic methodology for answering such questions. It gives guidance in determining the social value of reducing an individual's fatality risk, depending upon age, income, and other characteristics.

SUMMING UP

Nicolas and his colleagues analyze the use of SWFs to value fatality risk reduction, and compares the SWF framework to BCA. Their SWF framework has important advantages over BCA when it comes to risk-income and risk-risk trade-offs. It gives preference to the young in risk-risk tradeoffs, and mitigates the usual preference for the rich. They thus demonstrate that the fair innings concept has a rigorous basis in welfare economics. Their SWF approach is also sensitive to the distribution of costs - preferring that income losses be borne by those higher up the socioeconomic ladder.

FURTHER READING

With Matthew Adler, Maddalena Ferranna, and James Hammitt as coauthors, 'Fair innings? The utilitarian and prioritarian value of risk reduction over a whole lifetime', to appear in *Journal of Health Economics* and is available to read at www.tse-fr.eu. See also Nicolas's 2021 working paper 'Fatality Risk Regulation' with James Hammitt.

Sharing the risk of lockdown

Stéphane Villeneuve and Jessica Martin

Stéphane Villeneuve *is a professor of applied mathematics and former dean of the department of mathematics at University of Toulouse 1 Capitole, where he is affiliated with both Toulouse School of Management and TSE.*

He is also a member of the TSE-Partnership Foundation (TSE-P) where he coordinates the Chair on Market Risk and Value Creation sponsored by SCOR under the aegis of The Risk Foundation. His research focuses on stochastic methods in finance and their applications for dynamic contracting.

In the wake of the unprecedented economic shock of the Covid-19 pandemic, how can we prepare for the risk of similar catastrophes? A new working paper by Toulouse researchers Jessica Martin and Stéphane Villeneuve focuses on the optimal design of contracts, using a model that separates the contractors' incentives from the external risk of a shutdown.

Should contracts include risk-sharing for pandemics?

The Covid-19 crisis has had serious consequences for entire sectors of the economy. Never before has the global economy come to such a standstill due to an external event. But large shutdown risks can also arise during other catastrophic events such as the massive bushfires that ravaged Australia towards the end of 2019, temporarily halting agriculture, construction, and tourism in many areas. As vaccination begins to offer a glimmer of hope for a way out of the pandemic, our research is guided by the perspective that we must learn to live with such risks.

"How can we agree to an incentive contract whose obligations could be made impossible or at least very difficult because of the occurrence of a risk of a similar scale to the Covid-19 pandemic?

Our paper tries to make its contribution by focusing on a simple microeconomic issue. In a world subject to moral hazard, how can we agree to an incentive contract whose obligations could be made impossible or at least very difficult because of the occurrence of a risk of a similar scale to the Covid-19 pandemic?

Including shutdown risk-sharing in contracts seems crucial for at least two reasons. First, it is not certain that public authorities will be able to continue to take significant economic support measures to insure the partners of a contract if the frequency of such global risks were to increase. Second, the private insurance market does not offer protection against the risk of a pandemic which makes pooling too difficult. It therefore seems likely that we will have to turn to an organized form of risk-sharing between the contractors.

How can we design contracts to prepare for such risks?

Economic theory has a well-developed set of tools to analyze incentive and risk-sharing problems using expected-utility theory. The extensive literature related to dynamic contracting through a principal-agent model has, so far, mostly been based on continuously governed (eg. Brownian motion) output processes. However, some recent works have introduced jump processes into continuous time contracting. Biais et al. were the first to do so (in 'Large Risks, Limited Liability, and Dynamic Moral Hazard', 2010) by studying optimal contracting between an insurance company and a manager whose effort can reduce the occurrence of an underlying accident.

Here, we extend the classical framework to include a shutdown risk. We do not claim that this model is general enough to come up with robust economic facts, but it has the remarkable advantage of being explicitly creditworthy, which allows us to find an explicit optimal contract that disentangles the incentives from external risk-sharing and allows us to understand the sensitivity of the optimal contract to the different exogenous parameters of the model.

Our work uses a jump-diffusion process to include the possibility for accidents to negatively affect revenue. In this, it shares some structural similarities with Capponi and Frei ('Dynamic Contracting: Accidents Lead to Nonlinear Contracts', 2015). Both models consider a risk-averse principal and agent with exponential utility and reach an explicit characterization of the optimal wage. However, our framework uses a different form of jump diffusion to enable the shutdown event to completely stop revenue generation in a continuous-time setting. The main novelty is the multiplicative effect of the jump risk: upon the arrival of the risk, the entire output process comes to a halt.

What does the optimal risk-sharing contract look like?

A key feature of our study is that the shape of the optimal contract is linear. More precisely, the agent's compensation is the sum of two functions: the first is linear with respect to the output and serves to give the incentives; the second is linear with respect to the effective duration of the contract and serves to share the default risk. The contract exposes both agents to a risk of exogenous interruption but it has two different regimes that are determined by an explicit relation between the risk aversions and the agent's effort cost.

Under the first regime, the agent is more sensitive to the risk of default than the principal. In this case, the principal deposits on the date 0 a positive amount into an escrow account; the balance of this account will then decrease over time at a constant rate. Note that the later the default arrives, the more the balance decreases to a point where it may even become negative. If default occurs, the principal transfers the remaining balance to the agent.

Under the second regime, the principal is more sensitive to the risk of default. In this case, the agent deposits a positive amount as a deductible into the escrow account, the balance of which declines as time passes and symmetrical reasoning applies. This linearity contrasts with the optimum obtained by Capponi and Frei as the additive contribution of their jump process to revenue generation leads to a sub-linear wage. This result is in line with studies elsewhere which prove that the agent must be rewarded or punished for a risk that is beyond his or her control.

What happens when firms invest in mitigation?

The Covid-19 crisis has highlighted the ability of humans and businesses to react and adapt when faced with adversity. We include such phenomena by allowing the principal to respond to a shutdown by investing in order to continue some form of (possibly disrupted) production. This is quite a natural and realistic variant on our initial model. When faced with lockdown, companies may for example invest in teleworking infrastructure, protective equipment or adapting their organization. Crucially, we find that in many circumstances, investing in mitigation of shutdown effects is not optimal for the principal. When it is, it is only optimal up until some cutoff time related to a balance between the cost of investment, the agent's rents and possible remaining gain.

"Faced with lockdown, companies may invest in teleworking infrastructure or protective equipment. In many circumstances, we find that investing in shutdown mitigation is not optimal for the principal

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SUMMING UP

What type of delegation contract should be offered when facing a risk of the magnitude of the current pandemic? How does the likelihood of shutdown modify the terms? Jessica and Stéphane's model includes a default risk whose origin is independent of the inherent agency problem. They characterize the optimal wage along with the optimal action provided by the agent. The optimal contract is linear by offering both a fixed share of the output which is similar to the standard model and a linear prevention mechanism that is proportional to the random lifetime of the contract. In an extension, they find that investing in shutdown mitigation is often not optimal for the principal.

FURTHER READING

Jessica and Stéphane's paper '*A Class of Explicit Optimal Contracts in the Face of Shutdown*'

Outreach

SCOR Chair rewards risk and insurance economists

The European Group of Risk and Insurance Economists (EGRIE), a non-profit organization, is dedicated to promoting research on risk and insurance.

In December 2020, two awards were granted during the EGRIE annual seminar, organized within the framework of the SCOR Chair on "Risk Markets and Value Creation" at TSE and Paris Dauphine University, sponsored by SCOR and The Risk Foundation. This year we were pleased to award the SCOR-EGRIE Young Economist Best Paper Award to **Richard Peter** and **Pascal Toquebeuf** for *"Separating ambiguity and ambiguity attitude with mean-preserving capacities: Theory and applications"* and the SCOR Geneva Risk and Insurance Review Best Paper Award to **Céline Grislain-Letrémy** and **Bertrand Villeneuve** for *"Natural disasters, land-use, and insurance".* More information is available at *www.egrie.org/awards-grants*

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EGRIE European Group of Risk & Insurance Economists

SCOR / TSE Workshop on Behavioral Insurance Economics

SAVE THE DATE: *April 15, 2021*

Insurance decisions provide a rich ground for identifying the existence and consequences of human behavioral limitations. They involve risk, uncertainty, complexity as well as death-related, long term and passive decisions. In this workshop, researchers will present and discuss some papers using different methods (e.g., theory, experiments, econometrics) and interdisciplinary research. These papers contribute to a small but growing literature at the interface of behavioral and insurance economics. This workshop, by invitation, is reserved for TSE and SCOR personnel.

Philippe Trainar, Stéphane Villeneuve and Nicolas Treich

Scientific contributions

Articles in peer-reviewed journals

- **Christian Gollier**, "Aversion to risk of regret and preference for positively skewed risks", *Economic Theory,* vol. 70, n. 4, November 2020, pp. 913–941.
- **Jihyun Kim** and **Nour Meddahi**, "Volatility Regressions with Fat Tails", *Journal of Econometrics,* vol. 218, n. 2, October 2020, pp. 690-713.
- **Francesca Barigozzi, Helmuth Cremer** and **Kerstin Roeder**, "Having it all, for all: child-care subsidies and income distribution reconciled", *Journal of Economic Behavior and Organization,* vol. 176, May 2020, pp. 188–211.
- **Jean-Charles Rochet, Max Reppen** and **Mete Soner**, "Optimal dividend policies with random profitability", *Mathematical Finance,* vol. 30, n. 1, January 2020, pp. 228–259.

Working papers

- **Chiara Canta** and **Helmuth Cremer,** "Asymmetric information, strategic transfers, and the design of long-term care policies", *TSE Working Paper,* n. 20-1156, November 2020.
- **Chiara Canta, Helmuth Cremer** and **Firouz Gahvari,** "Welfare improving tax evasion", *TSE Working Paper,* n. 20-1121, July 2020.
- **Christian Bontemps, Jean-Marie Dufour** and **Nour Meddahi,** "Optimal Moment-based Tests for Distributional Assumptions", 2020.

The TSE research team moved to a new building at the end of 2019. The architects were awarded the Pritzker prize and l'Equerre d'Argent in 2020.

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