Autonomous pension funds on the blockchain

Peter Sestoft

IT University of Copenhagen, sestoft@itu.dk
Dagstuhl seminar, 2017-03-27

Abstract: We propose that life-based pension funds, such as those that pay a whole life annuity, can be fully autonomous and operate without a central trusted pension fund. In particular, payments and benefits, asset management, and estimation of liabilities (reserves, discounted future cash flows) can in principle be implemented using self-executing contracts, for instance on a blockchain infrastructure such as Ethereum.

1 Core activities of a pension fund

We consider life-based insurance-style pension funds, such as those that pay a whole life insurance: a guaranteed income stream to the insured person from retirement age until his or her death.

A pension fund comprises the following activities: (a) Enter contracts with pension customers; (b) receive a stream of payments from active, eg. working, pension customers; (c) pay a stream of benefits to retired and disabled pension customers; (d) regularly send forecasts to pension customers of their expected future benefits based on the contracts and the payments made; (e) invest and manage the assets that result from payments minus benefits; (f) regularly report to regulators to demonstrate that assets are sufficient to cover liabilities, namely, the obligations to pension customers; (g) pay taxes on the payments and benefits streams; (h) in general, react to life events, notably disability, retirement and death, of the pension customers.

2 Autonomous pension funds

We propose that all of these activities may be implemented using self-executing contracts on a distributed ledger such as Ethereum, and discuss some of the concerns raised by and requirements for implementing this idea.

We might call an organization, or distributed algorithm, along these lines an autonomous pension fund (APF). We argue that it is technically feasible to create such an entity as an autonomous organization:

- Activities (b), (c) and (g) are mainly processing of contract-regulated payments and seem clearly implementable using self-executing contracts and a cryptocurrency.

- Activities (d) and (f) can be based on the highly developed actuarial mathematics in the Scandinavian/German tradition, typically formalized with stochastic state models and Thiele's differential equations. This approach can be implemented and operationalized in software in a very general form, as evidenced by eg. Edlund's Actulus Portfolio Calculator.

- Activity (e) could be run in the manner of TheDAO on Ethereum (though preferably without the mistakes and vulnerabilities). How to invest the assets can be decided by voting, with automatically imposed limits on composition (expected return, risk, maturity, ...) of the investments, to match them to the liabilities as forecast using actuarial mathematics.

- Activity (h) depends on insurance-related life status and events being reportable in a trustworthy and automated way, so that self-executing contracts can act on them. This is very nearly the case in much of northern Europe. Life status includes gender, age, marital status, citizenship and tax status; and life events include retirement, becoming unemployed, becoming disabled, retiring, recovering from these events, and death.

- The life-based pension contracts mentioned in (a) can be formalized in a domain-specific language, that is then used in (b), (c), (d), (f), (g) and (h), and in constraining the investment decisions in (e) so that the asset composition matches the expected obligations. Namely, given such formal pension contracts, one can compute expected future cashflows, discounted expected obligations (reserve) and risk of default (as per EU Solvency 2 requirements); and one can generate pension forecasts, distribute monthly payments (into the fund) on pension products, compute monthly benefits, and more.

  A prototype of such a domain-specific language has developed, though not for blockchain use, in a collaboration between the company Edlund A/S, Copenhagen University, and the IT University of Copenhagen.

- Life-based insurance and pension operate on more "objective" states (active, disabled, retired, dead) of the insured than most property insurance, where more human work is needed to assess the degree of damage, counter insurance fraud, and so on. Hence life-based insurance and pension are amenable to a larger degree of automation than is property insurance.

3 Challenges and advantages

Some crucial questions and concerns about the practical feasibility of an autonomous pension fund include:

- Pension promises are extremely long-term obligations. A 25-year old woman entering the labor market in 2017 may retire in 2062 and may expect to rely on her pension income until 2087 or even longer. What reasons does she have to trust that the autonomous pension fund keeps it promises, or even exists, over such a long time span? Clearly, regulation plays a role here, but so does trust in the technology.

- Pension funds are heavily regulated, nationally (in highly country-specific ways) and internationally (eg. EU Solvency 2). This is both to reassure pension customers the pension funds are able to fulfil their promises, and to ensure that the pension products they sell agree with tax regulation.

- What pension products are preferred by customers is considerably influenced by what tax deductions they offer, and by what pension products are mandated eg. in general labor market agreements ("overenskomster"). Thus products offered by the autonomous pension should be certified by tax authorities to allow for expected deductions and to satisfy the general requirements.

- An autonomous pension fund would avoid many of the costs of commercial pension funds, such as those owned by banks whose shareholders expect a return on their investments. Even the many Danish pension funds that are customer-owned (such as most labor market funds, PFA, ...) and in general very efficient, have non-negligible costs. Danish pension funds manage approximately 500 billion Euro, corresponding to 1.6 times annual GDP, and with such large amounts of money under management, even small inefficiencies translate into large absolute costs.

4 References

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