DEPOT
A DECENTRALIZED AUTONOMOUS PENSION SYSTEM

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Abstract

Pension systems play a crucial role in the economic and political development of countries and help to maintain purchasing power for decades. Nevertheless, many people do not have access to good pension systems. That's why we propose the development of a blockchain-based, decentralized and globally available pay-as-you-go pension system. We show how redistribution of contributions towards pension payments works and how voluntary participation in the pension system is incentivized through transparent, fair and unchangeable processes. Creating a premium for the last generation of the pay-as-you-go system ensures that all participants receive a pension and, in addition, creates an incentive to participate in the pension system.

Note: This work is still under active research and new versions of this paper will appear at http://asure.network. For comments and suggestions, contact us at `research@asure.io`.

Keywords

Blockchain; Decentralization; Cryptocurrencies; Pension; Retirement

1 Introduction

Development over the last 150 years have led to a shift in old-age provision from the kinship networks to larger groups (collectives of the insured community, states). Pension systems today are an essential part of the economic development of states and yet, there are 4.1 billion people without access to social security. [4]

There are a variety of pension systems. For instance, in Germany pension systems are categorized into the three pillars of old-age provision. The three pillars include statutory, occupational and private pension systems. Many countries use a similar classification. As a general rule, the more pension systems a person participates in, the better he/she is protected against old-age poverty due to risk diversification.

Financing. Occupational and private pension systems finance themselves through the funding method and generally follow the performance principle: those who contribute a lot to the pension system also get paid a lot when they get old.

Statutory pension systems finance themselves through the funding method, the pay-as-you-go method or a hybrid of the funding and the pay-as-you-go methods. In addition to the performance principle, many statutory pension insurance policies also follow the principle of solidarity. In Germany, for example, parental leave can be counted as contribution years in pension insurance.

Both the funding method and the pay-as-you-go method have proven their worth in the past. Both financing methods have their strengths and weaknesses, and opinions differ widely as to which financing method is the better one.

1.1 Challenges of old-age provision:

Good old-age provision is hard to build. In the following we will discuss some of the challenges of old-age provision and existing pension systems.

Demographic change. Life expectancy is increasing all over the world, and especially in industrialized nations, the proportion of people over the age of 60 is growing and the problem of retirement provision is becoming more pressing. The burden on pension systems, and in particular PAYG-funded pension schemes, is rising sharply as fewer contributors become available to provide pension payments. The population of developing countries will increase in the future, and thus the problem of retirement provision. For example, the United Nations estimates that by 2050, approximately two billion people will be over 60 years of age, of which as many as 80% live in developing countries [5].

Inflation. In economics, inflation refers to a general and sustained increase in the price level of goods and services (inflation), equivalent to a reduction in the purchasing power of money. The consumer price index (CPR) is most frequently used to measure inflation. The index is calculated with the help of a shopping basket, which is determined in a certain year (base year) representative of an average household. [6] At an inflation rate of 2% per year, this means that if you have a $ 1,000 today, in 2040 this amount of money has only a purchasing power of $ 672.97 in 2040. For this reason, it is important not to store the values, but to try to systematically preserve purchasing power by means of a pay-as-you-go system.

Mismanagement and fees. Compared to pay-as-you-go systems, funded systems are very strongly subject to inflation. For this reason, different investment options are used, these have a higher workload and resulting administrative costs the customer must bear. Another variable is the higher volatility, it increases the chance that the investments are made well as well as the risk that bad investments can be made.

Instrumentalization by politics. Social security funds are in the hands of politicians and public servants. Politicians can use social insurance funds for electoral promises by redistributing them in favor of a group of voters, thus ensuring the next re-election. In addition, governments obviously benefit from more money and power hence they try to improve their image through social security administration. [10]

Last generation. With pay-as-you-go systems, it is important to ensure that there is a next generation, if this is not the case, the last generation will lose the most in the system as nobody is left to pay their pensions.

Residual risk. We do not want to go into detail about other risks such as economic risk, credit risk, interest rate risk, volatility, currency risk, psychological market risk, liquidity risk, tax risks, information risk, country and transfer risk. Different pension schemes entail major risks, this is in the nature of risk-oriented systems. The solutions to that are based on risk minimization through various approaches such as risk diversification, risk taking by the country, alternative pensions such as real estate and passive income.

1.2 Our approach: Decentralized pension

The invention of the Ethereum blockchain with its built-in Turing complete programming language, made it possible to write smart contracts and decentralized applications that create their own arbitrary rules of ownership, transaction formats and state transition functions. [7] Since Ethereum, many more blockchains ([2], [3], [1]) with built-in Turing complete programming languages and different trade-offs are available.

Our approach of a decentralized pension is to provide a state transition function of a **pay-as-you-go** financed pension system as a smart contract and therefore inherit many existing properties of the underlying blockchain-technology.

Through our **preliminary work** and engagement with pension systems, we've created the **requirements** to a decentralized pension model that define **target audience** and use the **pay-as-you-go** basis and the **incentivation** methods and the resulting **benefits** are described in this chapter.

1.2.1 Requirements

We talked to experts from insurance and pension systems fields to develop a model that works decentrally.

We create incentives in order to assist people who are paying contributions. With the contribution value we lead a reference contribution rate representative of members which dynamically adapts to the behaviour of the members.

The most important requirement was to enable the storage of purchasing power. Another important factor is to make risk sharing in the community as fair as possible for the target groups for whom it is suitable.

1.2.2 Target group

The target groups for a decentralized pension system are people:

- without pension access
- there is a pension system available, but
  - it is corrupt
  - it is intransparent
  - the country suffers from high inflation
  - too high administrative costs
  - no good investment strategies in the pension system available
  - less trust in the government, politics and pension system
- who would like to have a supplementary pension, these include:
  - first adopters, technology lovers
  - those wanting to spread their risks over several risk classes
  - those wanting to use a decentralized pension solutions
  - those living as digital nomads
  - those looking for alternatives

1.2.3 Pay-as-you-go system

Pay-as-you-go systems have great advantages in that they can be introduced quickly and no capital needs to be built up.

The goal of pay-as-you-go is to store the purchasing power of the system in the economic sense, to the pension points per deposit are stored as a representation of the contribution and not the contribution value. At retirement, the pension contribution is calculated on the basis of these points at the reference value[1].

[1] Example: In Germany, it is linked to 18.6% of the salary in 2019.

1.2.4 Incentives

Decentralized solutions such as decentralized pensions can only grow organically over the years thanks to a well thought-out incentive structure. Since the use is left to a user, it is comparable with Bitcoin [9], as the system is only controlled by trust and incentives.

1.3 Our contribution

As a reference for our model we took the German pay-as-you-go system. Only after having implemented the German pension system on Ethereum in advance, have we seen the challenges that needed to be solved.

In addition to the challenges, we also saw opportunities to improve the system, such as the inheritability, the degree of automation and the creation of new incentives that are not dependent on middlemen.

There are many advantages that a decentralized pension system can offer, the most important of which we will discuss here.

Decentralized and Autonomous. With the help of blockchain technology, the decentralized system becomes available 24/7 access. There are no employees required to operate the system and this reduces administration costs enormously.

Reduces costs. Due to the automation and decentralized operation, there is no additional cost apart from the transaction fees [2].

Transparent. It is open-source and anyone can view the transactions and check the validity of the processes in the system.

Permissionless. Access is available to everyone and worldwide unconditionally. Access to this system is available to anyone with Internet access.

[2] Except for the Tx fees, these charges may differ depending on the network used, such as Ethereum.

Without any intermediaries. There is no organization or middleman who have money access, the system is a closed economy in itself.

Corruption free. There's no way one can steal the money from the system.

Tamper-proof. The permitted changes of the system are left to the members.

Fraud free. Fraud is avoided by the fact that we do not need external information for the operation.

100 years life cycle. The system is designed to last 100 years, with a 20-year system start and a 40-year payment period [3].

Base points limit. Pension points are limited to 2 per pension period as no one may have an incalculable claim in the later redistribution.

Fully inheritable. The total pension entitlement can be inherited by passing on the private key.

GDPR compliant [8]. We do not use any external data sources such as age, death certificate and average salary as reference values.

Incentive system. Several incentives ensure the sustainability and adoption of the system in the community.

2 Decentralized pension

The decentralized pension is essentially based on the pay-as-you-go system and the performance principle. The longer a contributor pays into the pension system, the longer benefits are paid out in old age and the higher the contributions, the higher the pension payments in old age.

[3] Different products with different running times can be created.

Generic currency unit. The design of the pension system is not tied to a specific currency unit such as ETH or BTC; instead, it uses the generic currency unit "**unit**". The unit must be replaced by a specific currency for the concrete implementation.

Periods. The pension system is divided into periods, which are defined as P. Each action within the pension system takes place in a period $P[p]$. The duration of a period ($P_{duration}$) is freely selectable. Within the following calculations we consider $P_{duration} = 1month$.

Users. All users of the pension system are defined as U and individual users are defined as $U[u]$. Each user has a state $U[u]_{state}$ which can be either **UC** (Contributor), **UP** (Pensioner), or **UD** (Done). The initial state of all users is $U[u]_{state} = UC$

Accounts. The decentralized pension has two accounts: Savings ($W_{savings}$) and Laggards ($W_{laggarts}$). Contributions and pension payments will be charged using these. The savings account contains the total amount of the managed contributions and is used for the monthly processing of deposits and withdrawals. The laggards account manages a reserve, which is paid to the last generation of the pension system.

2.1 Payment of contributions

Contributors can contribute in a period $P[p]$. The total amount per period and user is defined as $U[u]_{units[p]}$. The total number of periods in which a contributor has paid is defined as $U[u]_{contrib}$.

$$U[u]_{contrib} = \sum_{p=0}^{|P|} \begin{cases} 1 & ifU[u]_{units[p]}>0 \\ 0 & otherwise \end{cases} \tag{1}$$

All contribution payments of a period $P[p]$ are credited to the savings account $W_{savings}$. Entries from contributors who do not have any pension entitlement periods ($U[u]_{pensionperiods} = 0$) will also be credited to the $W_{laggarts}$ account.

$$W_{savings} = W_{savings} + \sum_{u=0}^{|U|} U[u]_{units[p]} \tag{2}$$

$$W_{laggarts} = W_{laggarts} + \sum_{u=0}^{|U|} \begin{cases} U[u]_{units[p]} & ifU[u]_{pensionperiods}=0 \\ 0 & otherwise \end{cases} \tag{3}$$

2.1.1 Pension entitlement periods

The pension entitlement periods ($U[u]_{pensionperiods}$) determines the number of periods, in which a pension payment is made. The higher the number of contribution periods $U[u]_{contrib}$, the higher the number of pension entitlement periods.

To incentivize a large number of contribution periods, a target value (P_{target}) is used for the number of contribution periods.

$$P_{target} = 40years \cdot 12months \tag{4}$$

If the number of contribution periods corresponds to the target value, the number of pension entitlement periods should correspond exactly to the target value. If the number of contribution periods below or above the target value, the number of pension entitlement periods are correspondingly disproportionately smaller or larger.

The number of pension entitlement periods is defined as follows:

$$U[u]_{pensionperiods} = \frac{U[u]^2_{contrib}}{P_{target}} \tag{5}$$

2.1.2 Decentralized pension points

For the contributions paid for a period ($U[u]_{units[p]}$), a contributor receives decentralized pension points in the form of decentralized pension tokens (DPT). The total number of DPT of a contributor at retirement age is used to calculate the amount of the pension payable.

$$U[u]_{dpt[p]} = DPT(u,p) \tag{6}$$

$$DPT(u,p) = DPT_{base}(u,p) \cdot DPT_{bonus}(p) \tag{7}$$

Purchasing Power Index: The purchasing power index (PPI) is calculated at the beginning of each period $P[n]$ and defined as $P[p]_{ppi}$. The PPI is the reference value for a DPT of the corresponding period.

To calculate the PPI of the $P[p]$ period, the PPI of the previous period $P[n-1]$ is used. If the difference between PPI and the average contribution for the period $P[n-1]$ is greater than 10%, the PPI of the period $P[n]$ is increased or decreased by 10% accordingly. If the average contribution fluctuates sharply, the PPI slowly feeds on the new average and large jumps are avoided.

$$P[p]_{units} = avg(\sum_{u=0}^{|U|} U[u]_{units[p]}) \tag{8}$$

$$P[p]_{ppi} = \begin{cases} P[p]_{ppi} \cdot 1.1 & if P[p]_{units} \cdot 1.1 > P[p-1]_{ppi} \\ P[p]_{ppi} \cdot 0.9 & if P[p]_{units} \cdot 0.9 < P[p-1]_{ppi} \\ P[p]_{ppi} & otherwise \end{cases} \tag{9}$$

Decentralized pension points basis: The pension points is the ERC20 tokenization of purchasing power in blockchain systems and is an abstraction to purchasing power where the PPI value represents the reference as to how the willingness to pay was present in past periods. For a deposit equal to PPI, 1.0 DPT points are credited to the sender. Anything above the PPI value will be credited with a maximum of 2.0 DPT, it is possible to pay more than twice the PPI value. If the PPI value is lower than the PPI value, less DPT will be credited proportionally to the min value.

$$DPT_{base}(u,p) = \begin{cases} min(\frac{U[u]_{units[p]}}{P[p]_{ppi}}, 2) & if U[u]_{units[p]} > P[p]_{ppi} \\ \frac{U[u]_{units[p]} - min}{P[p]_{ppi} - min} & if U[u]_{units[p]} < P[p]_{ppi} \\ 1.0 & otherwise \end{cases} \tag{10}$$

Decentralized pension points bonus: Up to the period $P_{bonus} = 480$ additional bonus DPT (DPT_{bonus}) will be issued to contributors. Bonus DPT are intended to create an incentive for the first users of the pension system and thus reward the users who believed in and invested in the system at an early stage. The concept of Bonus DPT is based on the reduction of mining rewards known from the Bitcoin protocol.

$$DPT_{bonus}(p) = \begin{cases} 1 + \frac{(P_{bonus} - P[p] + 1)^2}{2 \cdot P_{bonus}^2} & if P[p] < P_{bonus} \\ 1 & otherwise \end{cases} \tag{11}$$

2.2 Pension payment

Contributors are free to choose when they retire. If a contributor retires, no more contributions can be made and, depending on the contributions paid, pension payments can be made instead. The transition from contributor to pensioner is marked by the change of state $U[u]_{state} = UP$.

The pension to be paid is calculated on the basis of the total number of DPTs of a pensioner ($U[u]_{dpt\_total}$).

$$U[u]_{dpt\_total} = \sum_{p=0}^{|P|} U[u]_{dpt[p]} \tag{12}$$

The pension entitlement periods $U[u]_{pensionperiods}$ determine in how many periods a pension is paid out. In which periods a pensioner claims his pension payments is left to the pensioner and can be freely chosen. If all pension payments have been claimed, the state will be replaced by $U[u]_{state} = UD$.

If a pensioner has always paid the average contribution into the pension system in his contribution periods, his pension payment should also correspond to the average contribution payments of the current period and thus the purchasing power stored in DPT should be restored.

The amount of a pension payment results from the following three components: Contribution pension, reserve pension and latecomer pension. For each component, a conversion rate is calculated that determines per period $P[p]$ how much a DPT from the corresponding component is worth.

The pension payment is therefore defined as follows:

$$\begin{aligned} U[u]_{pension[p]} = U[u]_{dpt\_total} \cdot (CPR(p) \\ + SPR(p, W_{savings} - W_{laggarts}) \\ + LPR(p, W_{laggarts})) \end{aligned} \tag{13}$$

2.2.1 Contribution pension rate (CPR)

All contributions for a contribution period ($P[p]units$) are collected and paid out proportionately to pensioners. The contribution pension rate $CPR(p)$ defines the conversion rate from DPT to contributions.

$$P[p]_{units} = \sum_{u=0}^{|U|} U[u]_{units[p]} \tag{14}$$

The pensions to be paid are determined by the average contribution payment of the period ($avg(P[p]units)$) is capped. If there are more contributors than pensioners in the system, any surpluses are used as a reserve and are not paid out directly. If the contribution payments are not sufficient to pay the average contribution payment for the respective period, the contributions are distributed proportionally to all pensioners and pension payments using the DPT.

$$\begin{aligned} P[p]_{dpt\_pensioner} \\ = \sum_{u=0}^{|U|} \begin{cases} U[u]_{dpt\_total[p]} & if U[u]_{state} = UP \\ 0 & otherwise \end{cases} \end{aligned} \tag{15}$$

$$CPR_a(p) = \frac{avg(P[p]_{units})}{P_{target}}$$

$$CPR_b(p) = \frac{P[p]_{units}}{P[p]_{dpt\_pensioner} \cdot avg(P[p]_{units}))}$$

$$CPR(p) = min(CPR_a(p), CPR_b(p)) \tag{16}$$

2.2.2 Reserve pension rate (SPR)

Surplus contributions are reserved as a reserve and $P[p]$ is paid out proportionately in each period. The reserve is paid out in such a way that it is distributed evenly over all active users ($P[p]_{auc}$), their DPT and all active pension entitlement periods of the pension system ($P[p]_{top}$). The reserve pension rate $SPR(p, units)$ thus defines the conversion rate from DPT to reserves.

$$P[p]_{auc} = \sum_{u=0}^{|U|} \begin{cases} 0 & ifU[u]_{state}=DP \\ 1 & otherwise \end{cases} \quad (17)$$

$$P[p]_{active\_dpt} = \sum_{u=0}^{|U|} \begin{cases} 0 & ifU[u]_{state}=DP \\ U[u]_{dpt\_total} & otherwise \end{cases} \quad (18)$$

$$TOPP(u) = \sum_{p=0}^{|P|} \begin{cases} 1 & ifU[u]_{pension[p]}>0 \\ 0 & otherwise \end{cases}$$

$$P[p]_{top} = \sum_{u=0}^{|U|} \begin{cases} P_{target} - TOPP(u) & ifU[u]_{state}=DP \\ P_{target} & ifU[u]_{state}=DC \\ 0 & otherwise \end{cases} \quad (19)$$

$$SPR(p, units) = \frac{units}{P[p]_{active\_dpt} \frac{P[p]_{top}}{P[p]_{auc}}} \quad (20)$$

2.2.3 Laggards pension rate (LPR)

The laggards pension is paid only to the last generation of the pension system. This component ensures that the last generation of the pension system also receives a pension and is intended to create an additional incentive for joining the pension system. The idea is that the laggards pension is so large that every user wants to be part of the last generation. The laggards pension rate $LPR(p, units)$ defines the conversion rate from DPT to reserves. In the case that it is the last generation, the calculation of the Defaulter pension rate $LPR(p, units)$ analogous to the calculation of the reserve pension rate $SPR(p, units)$.

$$total\_pensioners = \sum_{u=0}^{|U|} \begin{cases} 1 & ifU[u]_{state}=DP \\ 0 & otherwise \end{cases} \quad (21)$$

$$LPR(p, units) = \begin{cases} SPR(p, units) & if \frac{total_pensioners}{P[p]_{top}}=1 \\ 0 & otherwise \end{cases} \quad (22)$$

3 Simulations

As part of our research, we performed several simulations of the decentralized pension model. The goal is to simulate different user behavior and to further optimize the incentives and the model and to check its carrying capacity. Another aim of the simulations is to identify user groups who benefit from the pension system, as well as the ones who suffer losses.

All simulations were developed in the programming language *Rust* and published on Github [4] under the MIT license.

3.1 Simulation: Zero-Win

The first simulations try to determine that there will be no losses in the system, if all users behave in a constantly fair manner.

Sim01: 100 users pay 1.0*unit* into the pension system and retire at the same time.

Sim02: 90 users pay 1.0*unit* and 10 users pay 2.0*units* into the pension system and retire at the same time.

Sim03: 90 users pay 1.0*unit* and 10 users pay 0.1*units* into the pension system and retire at the same time.

[4] Git Repository: `https://github.com/AsureNetwork/asure-pension-core`

	Sim01		
User	Periods	Contributions	Result
1..10	1..480	$1.0 \cdot 480 = 480_{Units}$	480_{Units}
20..100	1..480	$1.0 \cdot 480 = 480_{Units}$	480_{Units}

	Sim02		
User	Periods	Contributions	Result
1..10	1..480	$2.0 \cdot 480 = 960_{Units}$	960_{Units}
20..100	1..480	$1.0 \cdot 480 = 480_{Units}$	480_{Units}

	Sim03		
User	Periods	Contributions	Result
1..10	1..480	$0.1 \cdot 480 = 48_{Units}$	48_{Units}
20..100	1..480	$1.0 \cdot 480 = 480_{Units}$	480_{Units}

Outcome: The simulation shows that with the constant and fair behavior and no influence of inflation and deflation there are no winners and no losers, everyone just gets their deposits back without any influence of inflation or deflation in economics. As the first generation also participates in the last payout, the laggards assets are also redistributed and the system is in its original state.

3.2 Simulation: Inflation/Deflation

This simulation series simulates the behavior of inflation and deflation of the units. It is the devaluation and revaluation of the units that has an influence on the user. If the units were devalued, the users would pay more and if the units were revalued, the purchasing power would remain the same. By PPI this is automatically absorbed and the pension payment and payout behavior is adjusted accordingly.

Sim14: With an inflation of 5% the value of the units is missing and accordingly the user numbers more units. If we take 2 generations with 100 users each and let them pay into the system at 5% annual inflation, the first generation pays $1 Unit$ at the beginning and $21,725 Units$ at the end.

	Sim14		
User	Periods	Contributions	Result
1..100	1..480	$\sum_{j=0}^{39} 12 \cdot PPI \cdot 1.05^j = 1450_{Units}$	3831_{Units}
100..200	480..960	$\sum_{j=40}^{79} 12 \cdot PPI \cdot 1.05^j = 10165_{Units}$	7783_{Units}

Outcome: With this result we see that in the case of inflation the units are devalued and in the case of existing inflation the user receives from the system the number of units matching the purchasing power.

Sim15: In a deflation, where the value of units increases, the user will pay correspondingly less into a system. If we take 2 generations with 100 users each and let them pay into the system at 5% annual deflation, the first generation pays $1 Unit$ at the beginning and $0.046 Units$ at the end.

	Sim15		
User	Periods	Contributions	Result
1..100	1..480	$sum(PPI \cdot 1.05^n) = 217_{Units}$	150_{Units}
100..200	480..960	$sum(PPI \cdot 1.05^{40}) = 31_{Units}$	98_{Units}

Outcome: With this result, we see that in the case of deflation the units have a higher value and purchasing power, and when the deflations exist, the user receives from the system the purchasing power appropriate number of units.

3.3 Simulation: Long-term

Long-term simulation tries to reproduce the behavior of the system over several generations. It should show how the system behaves over several generations, during the increase and behold decline in user numbers.

Sim20: We simulate that every year 10 users come in and constantly pay $1 unit$, after 40 years every generation retires and we simulate 190 years and 1120 users.

Outcome: With this result, it is easy to see that if the number of payers is smaller than retirees, at that moment pensioners start to get less out of the system.

	Sim20		
User	Periods	Contributions	Result
1..10	1..480	$1.0 \cdot 480 = 480_{Units}$	952_{Units}
10..20	12..492	$1.0 \cdot 480 = 480_{Units}$	937_{Units}
⋮	⋮	⋮	⋮
420..430	12..984	$1.0 \cdot 480 = 480_{Units}$	484_{Units}
430..440	12..996	$1.0 \cdot 480 = 480_{Units}$	477_{Units}
⋮	⋮	⋮	⋮
1100..1110	1320..1800	$1.0 \cdot 480 = 480_{Units}$	233_{Units}
1110..1120	1332..1812	$1.0 \cdot 480 = 480_{Units}$	2585_{Units}

The penultimate generations lose in this system. In the last generation, which we call laggards, a reward has been paid as planned. There is room for improvement for the last but one generations to make the system even fairer.

4 Conclusion

This paper proposes the development of a decentralized, globally available pension system using the redistribution scheme and to use a public blockchain infrastructure to operate it.

We showed that the redistribution of contributions and pension payouts can be implemented without depending on personal information of the insured person (e.g. age, identity, etc.). Also, we proposed a redistribution scheme with voluntary participation and proper incentivation to guarantee a steady number of new contributors. Contributors have an incentive to participate in the pension system as they are rewarded with a higher pension if they play by the rules of the pension system. Due to its decentralized design, the pension system is not controlled by anybody, is globally available, and open for everyone to participate. The rules of the proposed pension system are immutable and transparently saved onto the blockchain.

The pension system stores purchasing power through the use of pension points which represent the amount of a contribution relative to all other contributions. Pension payouts are based on the amount of pension points a pensioner has and result in a pension that is worth the purchasing power a pensioner was willing to contribute. Therefore there is no profit and no loss and the value retention was being kept over the years. [5]

Due to its global availability, the proposed pension system can provide a pension system to people that currently don't have access to transparent and fair pension systems. Also, it could provide a useful addition to existing pension systems in a portfolio as it is tied to a different class of risks and therefore provides enhanced risk diversification.

We believe that the blockchain technology will play an important role in the design of future pension systems and in solving the problem of old age provisioning.

5 Future work

The present work aimed to develop a concept of a decentralized pension. In closing, it can be noted that there are still open issues to be discussed.

SmartContract system. The next step is to implement the specification of the proposed pension system as a SmartContract system using a blockchain (Ethereum) and make it available to the community for review.

Use of stablecoins. The system still lacks an evaluation of the effects of the volatility of cryptocurrencies like ETH and BTC and if the use of stablecoins would be beneficial.

Release unused pensions. It is assumed that some users will opt for an earlier pension, even if it means partial loss for a user. Some users will lose full access to the system because e.g. the private key is lost, the pension contributions are not inherited and not

[5] The only costs incurred will be the transaction costs, in case of a private network, these can be further minimized.

collected. After some time, the paid-in values could be released, which will benefit the other users in the system. Further research of these conditions has to be done.

Liability, Governance. The question of the liability and control of the system is not yet fully clarified.

Asset management. In addition to a pure pay-as-you-go system, deposits can be made directly into the system, which involves both risks and reward opportunities, and for those who are more interested in risks, such research and results would be of great interest.

Scalable network. In order operate a global pension system or any other social security system, it is necessary to have a scalable blockchain network at hand which could handle a large amount of transactions and supports further requirements that those these system need.

Reset. It would be interesting to reset the pension system in case it runs into a dead end (e.g. no new contributors are joining the system and all pensions are paid).

Other use cases. In addition to decentralized pension, other social insurances may also be decentralized, such as: health insurance, accident insurance, unemployment insurance etc. In addition to the well-known social insurance, the future and unconditional basic income can be organized decentrally.

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