The Effects of Financial Structures to Increase SDH Investments: A Simulation Approach

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Overview of Project

- Social Determinants of Health (SDH) are conditions in peoples' environments that affect their health and well-being
 - SDoH has been recognized to impact health equity and drive a large fraction of avoidable adverse health outcomes and healthcare costs¹
 - *Examples*: Food insecurity, housing instability, education, transportation, safety, employment, structural racism, and other socioeconomic and environmental factors
- SDH interventions especially important for state Medicaid programs because Medicaid population has complex and extreme SDH complications that interfere with care²
 - Medicaid covers over 70 million individuals in the U.S., and accounts for 20% of healthcare spending
- Managed Care Organizations (MCOs) compete to serve state Medicaid population, and are enthusiastic about implementing SDH interventions³⁻⁵
 - Initiatives cost-effective with positive ROI

- However, challenges in bringing such interventions to scale:
 - Benefits (cost savings) accrue over a long time, but interventions require substantial funding upfront
 - Volatile Medicaid enrollment patterns (coverage changes, eligibility, switching of plans, churn) make cost savings risky ("wrong-pocket problem")
- Thus, *underinvestment* in SDH interventions

Overview of Project

 In prior work, we proposed a social bond that could be issued to investors in capital markets jointly by MCOs, thus providing capital for SDH investments⁶



• In this project, we provide evidence for the economic feasibility of such a financial structure using a **simulation** approach

Overview of Project

• We construct a Monte Carlo simulation model of a market with MCOs and patient populations with evolving health conditions

• Key Takeaways:

- Benefits of Investments
 - \circ With a single MCO, health improvements lead to cost savings over time
 - *Example*: Diabetes patients and transportation costs
 - A number of time periods required to offset initial investments

• Wrong-pocket Problem

- With multiple MCOs, patient switching makes investments risky: financial performance can be worse when investments are made
- Non-investing MCOs benefit from the savings made from other MCO investments: free-rider problem
- Introduction of SDH Bond
 - Ensures continuous investments for all patients, and improves overall health of patients
 - \circ Solves the wrong-pocket problem caused by patients switching MCOs
 - $\,\circ\,$ Long-term profits higher than no-investment case

• High-level setup

- m = 3 MCOs in a healthcare market with t = 5 periods
- Each MCO has patients whose health evolves over time
- Patients can fall into severe illness \Rightarrow higher cost for MCO
- MCO can make costly SDH investments in each period that improve patient health, reduce likelihood of severe illness
- We then introduce a simple social bond that commits MCOs to making investments

Setup of Simulation Model: Details

- We generate a hypothetical healthcare market with m = 3 MCOs and initial market shares of patients, each of which has a random health score
- In each period:
 - Based on the current health score h, each patient has a probability p_1 of light illness or p_2 of severe illness—cost to MCO higher with severe illness
 - Each MCO makes an SDH investment decision
 - Individual health score *h* is adjusted (goes up with SDH investment)
 - Retained premiums are calculated
 - Patients are allowed to switch to a different MCO or stay at the same MCO
- In the next period, the patients and MCO repeat this process until the end date (t = 5)

Setup of Simulation Model: Details

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<u>Parameter</u>	<u>Value</u>	<u>Source</u>
Health score <i>h</i> initial value	random number \in [0,1] for each patient from Normal(μ = 0.8, σ = 0.2)	AHQR, self-reported health status
Probability of severe illness	$p_2 = 0.3 \times [(1 - h) + Normal(\mu = 0.005, \sigma = 0.003)]$	
Probability of minor illness	$p_1 = 1 - p_2$	
Cost of severe illness	Random number ~ $Normal(\mu = 19,158, \sigma = 2,419)$	AHQR, based on health buckets
Cost of minor illness	Random number ~ $Normal(\mu$ = 5,482 , σ = 331)	AHQR, based on health buckets
Premium per patient/year	\$7,000/period	Medicaid spending/enrollment
SDH Investment per patient	\$350/period	5% of premiums, assumed
Health score change each period	h + 0.02 with investment, h – 0.01 without investment	
Number of MCOs	<i>m</i> = 3	
Initial MCO market share	$I_{1 \times i} = \{0.5 0.3 0.2\}$	
MCO transition Markov Process	$T = \begin{cases} 0.9 & 0.03 & 0.07\\ 0.07 & 0.85 & 0.08\\ 0.08 & 0.08 & 0.87 \end{cases}$	
Number of Simulation runs	1,000	
Number of patients	10,000	
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Setup of Simulation Model: Details

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- Retained premium per patient for MCO *i* in period *t*:
 - $RP_{it} = Premium p_{2,it}Cost_{si} p_{1,it}Cost_{mi} [Investment Cost| Investment]$
- Three different Monte Carlo simulation scenarios:
 - 1. No MCO makes an SDH investment
 - 2. MCO 1 Always invests , MCO 2 Sometimes invests, MCO 3 Never invests
 - 3. All MCOs invest using Social Bond structure

Simulation Results: No MCO Investment

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##	mco1	mco2	mco3
## 1	"560.11(11.68)"	"558.69(17.67)"	"560.33(14.29)"
## 2	"519.24(11.88)"	"517.62(17.62)"	"519.47(14)"
## 3	"478.16(11.86)"	"476.78(17.89)"	"478.47(14.05)"
## 4	"436.99(11.9)"	"436.32(17.94)"	"437.33(13.76)"
## 5	"396.29(12.11)"	"395.84(18.3)"	"395.58(13.97)"

Retained Premiums Per Patient

mcol mco2 mco3
1 "0.7733(0.0025)" "0.7731(0.0039)" "0.7734(0.0031)"
2 "0.7634(0.0025)" "0.763(0.0039)" "0.7635(0.0031)"
3 "0.7534(0.0025)" "0.753(0.0039)" "0.7534(0.003)"
4 "0.7433(0.0025)" "0.7432(0.0039)" "0.7434(0.003)"
5 "0.7334(0.0026)" "0.7333(0.004)" "0.7333(0.003)"

Patients' Average Health

##		mcol			mco3		
##	"1934.27	(11.89)"	"1929.67	(17.88)"	"1934.69	(14.01)"	

Discounted Retained Premiums Per Patient

- *Note:* Discount rate = 8%
- Patient health scores decrease over time without any SDH investments

Simulation Results: MCO 1 Always, MCO 2 Sometimes, MCO 3 Never Invests

mco3

##		mco1	mco2	mco3
##	1	"420.04(12.06)"	"419.54(18.58)"	"560.28(15.1)"
##	2	"482.57(11.81)"	"479.56(17.92)"	"537.19(15.14)"
##	3	"538.39(11.44)"	"670.87(17.36)"	"526.93(14.8)"
##	4	"585.37(11.41)"	"626.54(17.4)"	"519.15(14.46)"
##	5	"624.65(11.23)"	"450.92(17.4)"	"513.44(14.25)"

Retained Premiums Per Patient

Patients' Average Health

1 "0.7999(0.0026)" "0.7999(0.004)" "0.7734(0.0033)"
2 "0.8148(0.0025)" "0.8142(0.0038)" "0.7678(0.0033)"
3 "0.828(0.0024)" "0.8005(0.0038)" "0.7652(0.0032)"
4 "0.839(0.0024)" "0.7896(0.0038)" "0.7633(0.0031)"
5 "0.8482(0.0023)" "0.8104(0.0038)" "0.762(0.0031)"

mco2

##		mco1		mco2	mco3			
##	"2085.43	(11.59)"	"2099.58	(17.73)"	"2128.66	(14.75)"		

##

mco1

Discounted Retained Premiums Per Patient

- Patient health scores reflect SDH investment, but MCO 3 still benefits because of churn between MCOs
- "Wrong pocket" problem MCO 3 has no incentive to invest, has higher retained premiums compared to Scenario 1
 - MCO 2 also benefits more than MCO 1

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Simulation Results: All MCOs Invest, Social Bond

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##		mcol	mco2	mco3
##	1	"420.13(11.21)"	"418.88(17.88)"	"420.29(14.87)"
##	2	"488.09(11.28)"	"487.09(17.68)"	"488.62(14.18)"
##	3	"553.93(10.96)"	"553.14(17.34)"	"554.38(13.55)"
##	4	"617.21(10.7)"	"616.8(16.37)"	"618(13.03)"
##	5	"677.78(10.37)"	"678.3(16.24)"	"678.9(12.59)"

Retained Premiums Per Patient

mco1 mco2 mco3
1 "0.7999(0.0024)" "0.7998(0.0038)" "0.7999(0.0031)"
2 "0.8159(0.0024)" "0.8159(0.0037)" "0.8161(0.003)"
3 "0.8314(0.0023)" "0.8314(0.0037)" "0.8315(0.0029)"
4 "0.8462(0.0022)" "0.8462(0.0034)" "0.8464(0.0027)"
5 "0.8603(0.0022)" "0.8605(0.0033)" "0.8606(0.0026)"

Patients' Average Health

mcol mco2 mco3 ## "2162.15 (10.9)" "2159.56 (17.1)" "2164.45 (13.64)"

Discounted Retained Premiums Per Patient

- All MCOs invest due to social bond: raise upfront money for investment, and repay bond over time
- Increase in discounted premiums versus no investment by roughly 12%
 - Discounted premiums higher for MCO 3 versus Scenario 2
 - Greatest % increase in total premiums for MCO 3
- Retained premiums highest out of all scenarios, as is patient health
 - Average IRR of investment: 8.9%, positive NPV

Extensions

• Various extensions/robustness:

• Different changes in health scores due to SDH investment: threshold for necessary health increase for return on investment (ROI) to be positive

		health score increase(if invested)												
Year	No Investment	0.000	0.005	0.010	0.013	0.015	0.020	0.025	0.030	0.035	0.040	0.045	0.050	
1	46	46	46	46	45.99	45.99	45.99	46	45.98	46.01	45.98	45.98	45.98	
2	44.97	46	46.51	47.01	47.37	47.45	48.03	48.54	49.04	49.58	50.06	50.59	51.1	
3	43.94	46	47.01	48.04	48.65	48.9	50.07	51.09	52.1	53.13	54.11	55.14	56.17	
4	42.91	46	47.52	49.07	49.97	50.35	52.11	53.64	55.14	56.65	58.14	59.66	61.16	
5	41.9	46	48.04	50.07	51.28	51.8	54.13	56.16	58.14	60.14	62.11	64.09	66.05	
NRP(in U	Jnit)	-14.72	-9.64	-4.53	-1.46	-0.23	5.61	10.71	15.68	20.79	25.68	30.74	35.74	
ROI		-0.5888	-0.3856	-0.1812	-0.0584	-0.0092	0.2244	0.4284	0.6272	0.8316	1.0272	1.2296	1.4296	
AnnualR	eturns	-0.11776	-0.07712	-0.03624	-0.01168	-0.00184	0.04488	0.08568	0.12544	0.16632	0.20544	0.24592	0.28592	
AR(in %)	-11.78%	-7.71%	-3.62%	-1.17%	-0.18%	4.49%	8.57%	12.54%	16.63%	20.54%	24.59%	28.59%	
Hea	lth Increased	0.000	0.005	0.010	0.013	0.015	0.020	0.025	0.030	0.035	0.040	0.045	0.050	
	ROI	-0.5888	-0.3856	-0.1812	-0.0584	-0.0092	0.2244	0.4284	0.6272	0.8316	1.0272	1.2296	1.4296	
	AR(in %)	-11.78%	-7.71%	-3.62%	-1.17%	-0.18%	4.49%	8.57%	12.54%	16.63%	20.54%	24.59%	28.59%	

• Heterogenous effects of SDH investments by patient—some patients more sensitive to investments

• Heterogenous effects of SDH investments by MCO—some MCOs better at implementing investments

Concluding Remarks

- We develop a simulation model of Managed Care Organizations (MCOs) that serve Medicaid populations
- We show that the "wrong pocket" problem can provide a disincentive to engage in SDH investments
- We provide evidence that a "social bond", which raises funds from investors and commits MCOs to use the funds for SDH investments, can improve patient health and increase profits for MCOs due to cost-savings
- To be done:
 - Show how effects differ under different assumption for market shares
 - Show the difference compared to market with two MCOs
 - Provide evidence of differential effect if there is no churn of patients
 - Compare rate of return of bond to investors compared to other similar investments
 - Analyze how government guarantees can affect incentives

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