MANAGED CARE INSURANCE AND HEALTH COST INFLATION: AN EVOLTUIONARY GAME APPROACH

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No. 272
March 2000

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March 2000

Discussion Paper No 272

ISSN 1033-4661

* The authors would like to thank Stuart McDonald, Jason Potts and another anonymous referee for their help in regards to this paper.

1 Introduction

The effect of managed care (MC) insurance contracts, such as health maintenance organizations (HMOs) and preferred provider organizations (PPOs), on health costs is controversial. For some areas and time periods, there is a strong negative relationship between MC penetration in a market and health costs (see, *e.g.*, Gaskin and Hadley 1997). Other researchers have found a positive relationship between MC penetration and health costs (see, *e.g.*, Feldman *et al.* 1993).[1] Still another finds that traditional fee for service (FFS) insurance premiums in a market area decline as MC penetration increases when MC market share is low, only to increase as MC penetration increases when MC market share is high (Baker and Corts 1996; See Table 1 below for a summary of the literature on this issue.)

There exist theoretical explanations for both health cost inflation and deflation when MC penetration is increasing. For instance, on the inflation side, MC penetration can lead to negative "adverse selection" for FFS insurers, where sicker patients buy FFS insurance. Because they are more likely to need health services, sicker consumers are less likely to accept restrictions on health care use and provider choice that MC insurers impose (see, *e.g.* Baker and Corts 1996 or Feldman, Dowd, and Gifford 1993). As a consequence, FFS plans attract less healthy patients so that FFS premiums will increase. Given imperfect markets, MC insurers must only slightly under-bid FFS insurers to gain the healthy patients. Therefore, health cost inflation occurs.

[1] In their study, firms which offer optional HMO plans to employees wind up with higher health premiums overall.

The adverse selection literature, as it relates to MC, assumes that there is a fixed number of MC and FFS insurers that are restricted to their respective strategies for the duration of the analysis (see *e.g.* Feldman and Dowd 1991, 1982). However, if FFS insurers find themselves with an unprofitable set of customers, "switching" to the MC strategy is a reasonable response. The ability to switch strategies would certainly affect the competition in both the MC and FFS insurance markets, which would change the effect of adverse selection on health cost inflation. As in Feldman-Dowd, we are interested in entry by insurers with a fundamentally new strategy.

Other theories predict health cost deflation under high MC penetration. As a MC insurer's market share increases over time, it can leverage price cuts from health care providers (Dranove *et al.*, 1998). In a process known as selective contracting, MC insurers use "steering mechanisms" to lower costs by offering financial incentives for consumers to use hospitals and doctors that have been willing to offer lower prices (see, *e.g.*, Brown and Morrisey 1999).[2] MC insurers may opt to then lower prices, which will attract more consumers in future periods. The loss of market share and/or profits may force FFS insurance insurers to lower premiums, thus lowering overall costs.[3] Health CPI figures for the US during the 1990's, when MC became popular, appear in Table 2 in the Appendix.

In the health insurance market, the insurer and consumer markets are intertwined so that the payoffs for insurers depend on the strategies adopted by the consumers and vice-versa. Therefore, even though the benefits appear to favor insurers adopting the

[2]Another explanation is that MC's physician oversight and review, especially in HMOs, can also lower health costs because of lower utilization (see *e.g.* Manning, Leibowitz, Goldberg, *et al.* 1985). However, this paper will abstract from this effect.

[3]However, "cost shifting" could lead to health cost inflation. Cost shifting occurs, if it occurs, whenever cuts in provider fees are passed along to other payers (Dranove 1988). Therefore, even if MC premiums decline, overall health costs could increase or remain stable.

MC strategy, this depends on the decisions made by consumers. MC insurers need large numbers of customers in order to negotiate lower prices with health care providers. Further, if MC insurers attract only small numbers of customers, the effects of adverse selection on FFS insurers will be small. Whether MC can attract customers depends on, among other things, the strength of preference for unrestricted access to health care providers.

This paper seeks to provide a theoretical explanation for the various health cost/premium inflation patterns found at different levels of market share for MC insurers. It also seeks to describe the evolution of MC penetration. MC penetration is described in a evolutionary game theoretic setting with a replicator dynamics model. There are two types of players which switch type over time. First, insurers switch between MC and FFS according to *endogenous* payoffs. Buyers of insurance, who are sick or healthy in type, also switch between MC or FFS insurance over time according to *endogenous* payoffs. Switching behavior for all insurers and consumers occurs according to differential equations.

With a modest set of differential equations and assumptions, the results of our model are similar to the periods of health premium inflation and deflation that occurred in the U.S. during the 1990's. The emergence of MC insurers in our model reflects the US experience.

Section 2 provides a brief literature review. Section 3 presents the model. Section 5 provides discussion.

2 Literature Review

Baker and Corts find that FFS insurance premiums fall by 13.8 when HMOs have 0-10 percent of the market share; fall by 1.8 when HMOs have 10-20 percent of the market

share; and *increase* by 20.3 percent when HMOs have 20-30 percent of the market share (1996).

Table 1 summarizes Miller and Luft's literature review of the effect of MC's effects on health costs (1994). Clearly the effects of MC penetration on costs is mixed for reasons

Table 1: Number of papers examining the effects of MC costs by type of health cost

	Health Cost		
Cost Type	Lower	Higher	Uncertain
Physician/outpatient per enrollee	2	1	2
Total per enrollee	1	1	1
Hospital Costs	2	0	0
Premium levels	0	1	0
Growth of premiums	0	0	0

that our model will attempt to highlight. Most studies of utilization confirm the results from the Rand experiment, where they decline for holders of MC insurance (Manning, Leibowitz, Goldberg *et al.* 1985).

Feldman, Dowd, and Gifford show that firms which offer HMO coverage to their employees face increases in average premiums in comparison to firms where only FFS is offered (1993). While they concede that HMO plans lower utilization, they suggest that adverse selection *within the firm* where the employees work, explains most of the HMO cost savings. Profit-maximizing HMOs "shadow price" their FFS competitors, so that average premiums paid within the firm increase.

We extend the Feldman-Dowd model to a replicator dynamics setting (1991, 1982).[4] In their model, adverse selection leads to health cost inflation. However, the inflation does not "spiral" because MC insurers will not want to insure the sickest patients. Therefore, an equilibrium MC market share emerges which halts the adverse selection inflation spiral.

[4]Weibull gives an advanced textbook treatment of evolutionary game theory (1995).

3 The Model

In this section, we extend Feldman-Dowd to a dynamic setting with a multi-population replicator dynamics model. The model presented here differs somewhat from traditional replicator dynamics models in that the payoffs are not fixed over time. In addition to other static parameters, they depend on the population proportions in the two markets.

In a replicator dynamics setting, players do not instantly switch type in response to payoffs. If one strategy has a higher payoff than the other, there is movement over time towards that strategy. Normally, the explanation is bounded rationality (Weibull 1995). However, in the health insurance market, there are many reasons to believe that insurers and consumers do not switch strategies instantly independent of bounded rationality. In the case of consumers, switching insurance type may necessitate choosing a new health care provider. The information problems associated with selecting health care providers is well-known (see *e.g.* Holmstrom (1985)). Further, employers may offer a limited set of insurance plans that are infrequently changed. In the case of insurers, switching strategies can mean losing clientele.

Let us first consider insurers. We distinguish a population of FFS player (insurer) strategies and a population of MC player strategies. FFS players are passive in negotiating with health care *providers*, such as doctors and hospitals. On the other hand, MC players restrict their customers to health care providers whom have offered lower prices for their services. Both player populations set community rated premiums, which means they do not price discriminate by health status or otherwise *within* a insurer. Insurers within each population are symmetric in size, face the same provider costs, have customers with the same average sickness, and set the same premiums. We abstract from strategic behavior on the part of health care providers.

Consumer health insurance choices are also modeled as populations of player strategies, FFS or MC. Recall that sicker patients will prefer FFS, *ceteris paribus*. As explained below, the healthiest consumers will tend to join MC plans first.

Again, note that we abstract from the issue of employers buying health insurance for their workers.

The profit of a representative MC insurer is

$$\Pi_H = (C_H - P_H(S_H))S_H$$

where C_H is the community rated health care premium, P_H the provider costs faced by the MC insurers, and S_H the aggregate market share of MC insurers. C_H is assumed fixed in this version of the model. Feldman-Dowd assume $P_H(S_H) = S_H$, where costs increase as more consumers join MC due to adverse selection (each successive patient joining MC is sicker). In our model, $P_H(S_H) = 1 - S_H = S_F$, where S_F is the market share of FFS. Thus, provider costs decline as MC (FFS) share increases (decreases), after accounting for adverse selection. We note that other functional forms would be consistent with selective contracting.

The profit of a representative FFS insurer is given by

$$\Pi_F = (P_B - C_B(S_H))S_F$$

where $P_B = 100 + S_H$ is the FFS premium (following Feldman-Dowd) and $C_B(S_H) = (1 - S_F) = S_H$ are the costs of providers to FFS. FFS insurers raise premiums as their market share declines to account for their customer's increasing sickness due to adverse selection. Further, C_B varies inversely with their market share, also reflecting a sicker

clientele. One could also think of this as cost shifting.

We follow Feldman-Dowd in representing consumer preferences for FFS over MC insurers using a monetary index Ψ. Let $\Delta = P_B - C_H$ be the differential between FFS and MC premiums. Also, let $\Psi = -20 + 35S_H$, which is again similar to Feldman-Dowd.[5] When $\Delta > \Psi$, consumers prefer MC; when $\Delta < \Psi$, consumers prefer FFS; and when $\Delta = \Psi$, consumers are indifferent.

Suppose that the consumer on the continuum from healthiest to sickest is indifferent between MC and FFS at point S_H^*. Then the S_H^* consumers who use MC are healthier than the indifferent consumer; the $1 - S_H^*$ consumers who use FFS are sicker than the indifferent consumer. Note that for many low values of S_H, consumers have a monetized preference for MC. Also note that in a replicator dynamics setting, individuals do not instantly switch to the strategy with highest payoff.

The dynamics of player strategy proportions X_H, X_F for insurers and for consumers S_H, S_F are modeled using the *standard* two population replicator dynamics. The insurer population movements are

$$\dot{X}_H = (\Pi_H - X_H\Pi_H - \Pi_F X_F)X_H$$

and

$$\dot{X}_F = (\Pi_F - X_H\Pi_H - \Pi_F X_F)X_F.$$

[5]Feldman-Dowd also model the healthiest consumers as preferring MC, although the preference is stronger in our model.

Note that $X_H\Pi_H - \Pi_F X_F$ represents average insurer profits at a given point in time. Thus for Π_H greater than average insurer profits, the proportion of MC insurers increases and the proportion of FFS insurers falls.

The consumer population movements are

$$\dot{S}_H = (\Delta - \Psi - S_H(\Delta - \Psi) + S_F(\Delta - \Psi))S_H$$

$$\dot{S}_F = -(\Delta - \Psi + S_H(\Delta - \Psi) - S_F(\Delta - \Psi))S_F.$$

Note that $S_H(\Delta - \Psi) - S_F(\Delta - \Psi)$ is the average payoff for consumers of either type at any point in time. Thus for $\Delta - \Psi$ average payoff for consumers, the proportion of consumers patronizing MC insurers increases and the proportion patronizing fee for service insurers falls.

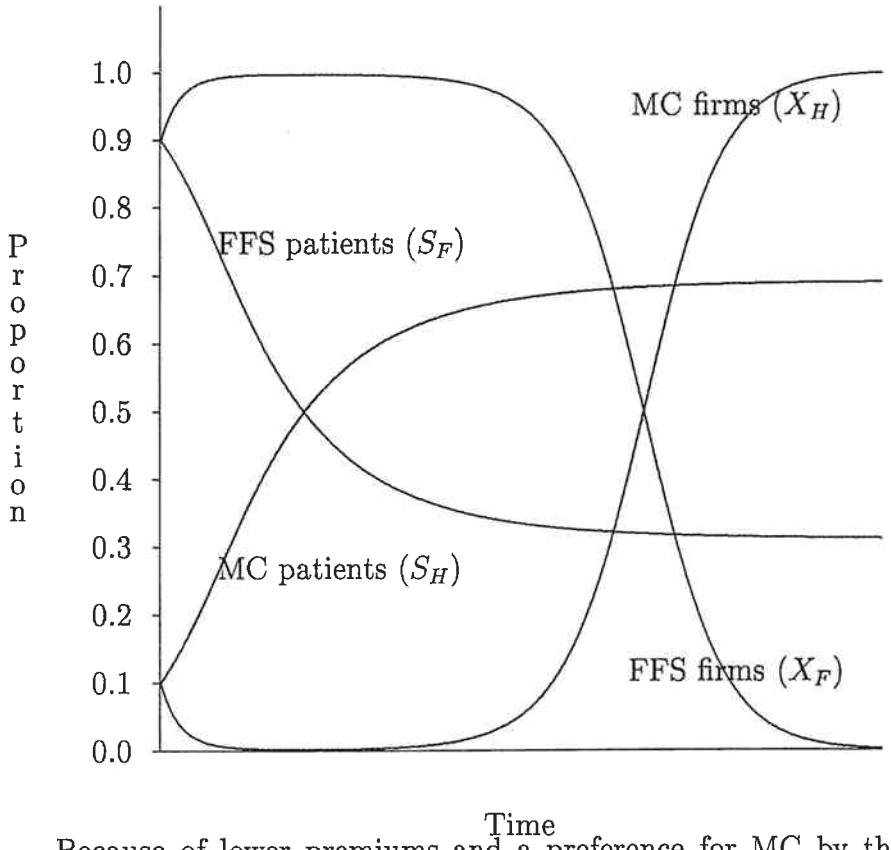
The system of four equations are solved numerically using a first-order Euler method.

4 Results

4.1 Fixed MC Premium

The replicator dynamics results are shown in figure 1. We assume MC begins with 10% of both markets; that is, 10% of consumers use MC insurance and 10% of insurance insurers use the MC strategy. Note that this means $P_B = 100.1$ initially. We set $C_H = 100$. Initially, MC insurers switch to the FFS strategy. FFS is more profitable initially because MC insurers do not have enough market power to negotiate lower provider costs relative to FFS. Further, FFS premiums and consumer market share are initially higher by assumption.

Figure 1: Replicator Dynamics



Because of lower premiums and a preference for MC by the healthiest, customers begin switching to MC in the first periods. As S_H increases, MC is able to negotiate lower provider costs through selective contracting, after accounting for a progressively sicker clientele. At the same time, FFS provider costs increase because of adverse selection. Therefore, they must increase premiums to remain profitable. At this point, many begin switching to the MC strategy. This occurs at the left-most, lower inflection point in figure 1.

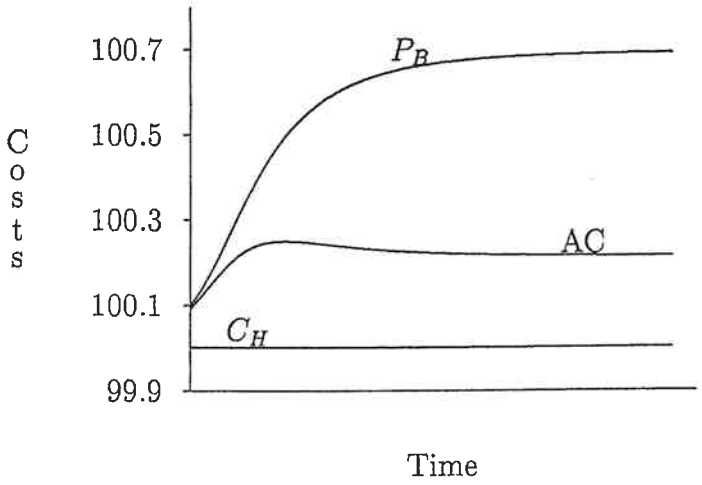
MC winds up with just under 70% of the patients. This corresponds well with the experience in the US. However, in contrast to our results where MC takes over, many US insurers use the FFS strategy. In our results, we would have a few large FFS insurers with low marginal revenue.

Average premiums (AC) are shown in figure 2. While C_H is fixed, P_B increases in

a concave manner. Because most consumers use the increasingly more expensive FFS insurance initially, AC increases over the first few periods. As more consumers switch to the cheaper MC insurance, AC begins to fall even as P_B increases. Comparing the first period to the last period, health premiums increase.

Adverse selection increases P_B. However, this effect is not that important in terms of inflation because consumers switch towards MC, which has a lower premium.

Figure 2: Average Premiums Under Replicator Dynamics



For comparison, health cost inflation for most of the 90's appear in table 2.

4.2 Price Competition

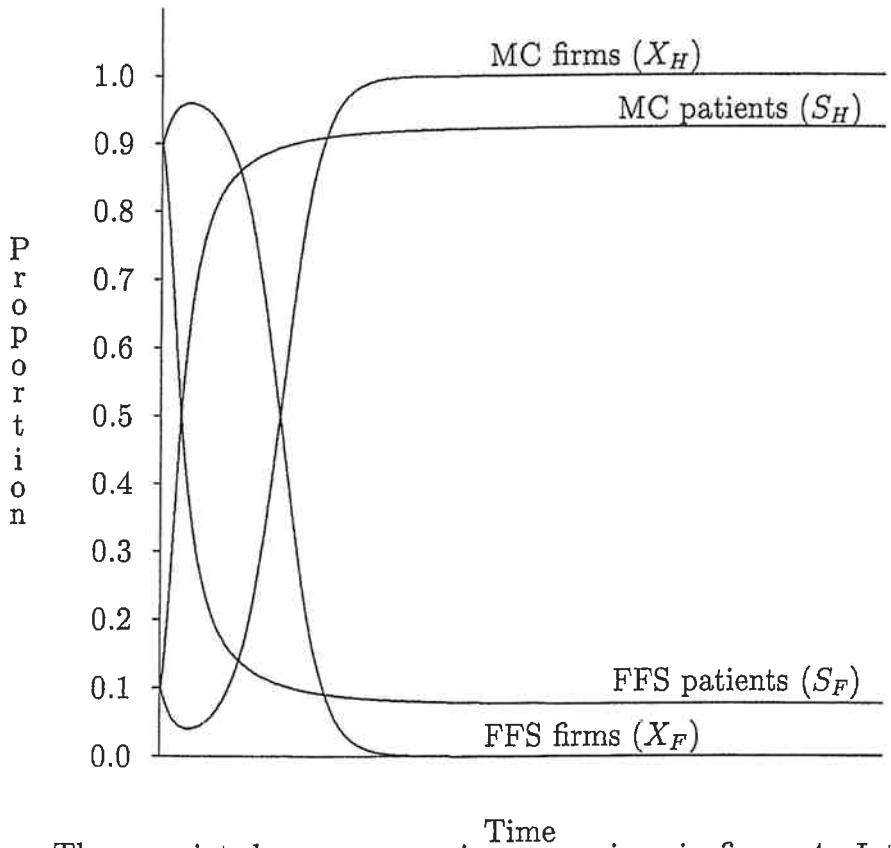
In this section, we allow MC insurers to vary their premium. We let

$$C_H = .95 \cdot X_H \cdot P_B,$$

so that as MC insurers gain market share, they increase their price to match the increase in P_B. If their are few MC insurers, their premiums will be low in order to attract customers.

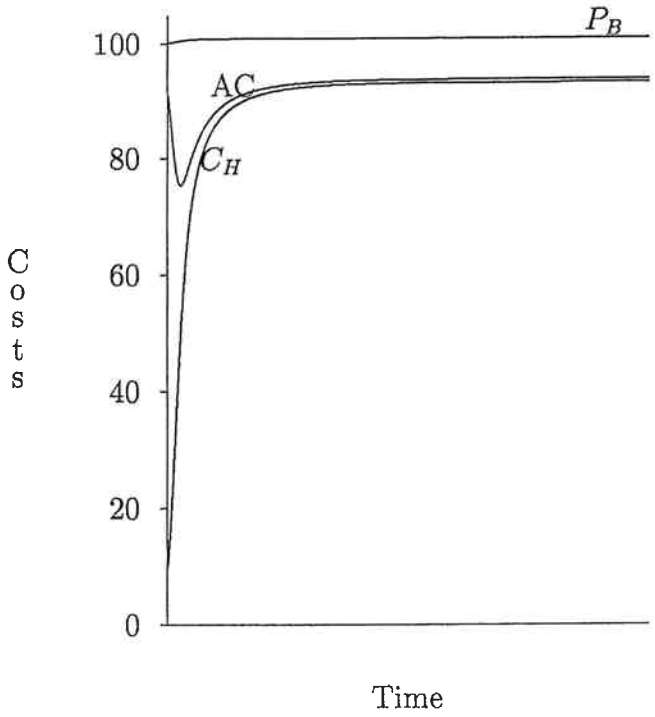
The results are given in figure 3. Notice that they are similar to those in figure 1, except that both consumers and insurers switch to the MC strategy quicker. This is at first surprising because MC premiums are initially quite low in comparison to the previous section so that MC profits are initially lower. However, keep in mind that this attracts consumers, which lowers costs because of selective contracting. Note that a larger proportion of consumers use MC under price competition.

Figure 3: Replicator Dynamics



The associated average premiums are given in figure 4. Interestingly, they are U-shaped, which some have predicted.

Figure 4: Average Premiums Under Replicator Dynamics



5 Conclusion

In this paper, we have modeled two intertwined markets with a replicator dynamics model patterned after Feldman-Dowd (1991). Using US market shares in the early 1990s as starting values, the market evolution in our model is similar to the US case over the 1990s. Similarly, the inflation pattern in our model is nonlinear as in the US case.

As MC insurers gain market share, adverse selection leads to health premium inflation under fixed MC premiums. However, as more and more consumers join the lower priced MC, inflation tops out and then declines. Thus, our results take Feldman-Dowd further (1982,1991). That is, not only does inflation cease to spiral under adverse selection, under the parameters of our model they also begin to decline. Under price competition, the average premiums are U-shaped.

Virtually all insurers end up adopting selective contracting. The few insurers which retain the FFS strategy have very small margins on very large market shares. Our paper

is the first that we know of which allows health care insurers to switch strategy according to endogenous payoffs.

Although it is clear that MC has a role in containing health care premiums, our model highlights its limits in terms of *reducing* health care premiums in the US to world standards.

We concede that other starting values and assumptions about parameters would lead to other equilibria. This is especially true of Ψ, the preference for FFS over MC. However, the complex intertwined dynamics of these two markets means that several scenarios could occur.

6 Appendix

Table 2: CPI medical cost inflation for urban consumers

Year	Inflation
1991-1992	7.4
1992-1993	5.9
1993-1994	4.8
1994-1995	4.5
1995-1996	3.5
1996-1997	2.8
1997-1998	3.2
First quarter 1999	2.6
Source: *US Bureau of Labor Statistics*	

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