Managing the Costs of Informational Privacy: Bundling as a Strategy in the Individual Health Insurance Market

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"Genetic testing has tremendous potential in the world of medicine. As the science develops, so will the public's concern over its impact on society. As the legislation develops, so will our industry's interest in its effect on our business. Our challenge becomes learning how to manage the issue, helping people get the protection they need at a fair price, while ensuring the future viability of the insurance industry." [14, p. 63]

Abstract

Advances in genetic testing and data mining technologies have increased the availability of genetic information to insurance companies and insureds (applicants and policy holders) in the individual health insurance market (IHIM). Regulators, concerned that insurance companies will use this information to discriminate against applicants who have a genetic risk factor but who are still healthy, have implemented genetic privacy legislation in at least 18 states. However, in previous work we have demonstrated that such legislation will have unintended consequences – it will reduce consumer participation in the market without making those remaining better off. This paper identifies a mechanism, a ***bundling strategy****, that insurance companies may implement in this regulatory environment to restore (or maximize) consumer participation in the market and to discourage such discrimination among insureds. This problem is examined through simulation modeling. The results will have significant implications for policy designs implemented by insurance companies, for legislation implemented by industry regulators, and therefore, for the insurability of the individuals that rely on this market for health insurance coverage.*

1. Introduction

Recent advances in information technology (IT) have had a significant impact on the information conditions in the individual health insurance market (IHIM), and therefore a significant impact on the insurability of individuals that rely on this market for health insurance coverage. Advances in biological research and ***genetic testing*** continue to provide applicants and their doctors with more accurate assessments of their personal riskiness for a growing number of medical conditions. Alternatively, advances in ***data warehousing*** and ***data mining*** technologies continue to enable insurance companies to gain access to more accurate assessments of applicant riskiness as well.

However, industry regulators are concerned that health insurance companies will use applicants' genetic information, acquired through genetic testing or data mining efforts, to discriminate against those who are at higher risk for developing specific medical conditions, but who are presently in good health. In response to this concern, state and federal legislators have proposed and implemented ***genetic privacy legislation*** that prevent insurance companies from denying coverage to, or setting higher rates for, applicants who are genetically predisposed to certain medical conditions. This informational privacy legislation is intended to accomplish two goals – ***increase consumer participation*** in the IHIM and ***improve the equity of premiums*** paid by individuals in the market. Our previous research demonstrates that these regulations, while well-intended, will actually reduce market participation and product affordability in this market [6]. These results are counter-intuitive, and therefore counter to social trends, as we will see in Section 3.

This paper addresses the social costs imposed upon an IHIM when applicants for health insurance coverage possess private information regarding their personal riskiness for a large number of medical conditions. This work then examines a strategy that insurance companies may implement: to mitigate these costs, to maximize the extent to which the population is insured, and to ensure premium equity across insureds, all without adversely affecting the viability of the insurance industry. The

methodology used to explore these issues is Industrial Dynamics, a simulation-based modeling technique. The findings demonstrate that insurance companies may be able to maximize consumer participation and attain premium equity in the IHIM despite the presence of extreme information asymmetries (i.e., genetic privacy legislation) by having individuals' valuations for a large bundle of medical coverages (i.e., a comprehensive insurance policy) converge to a single value; this is referred to as a ***bundling strategy***. The sensitivity of this result to various assumptions will also be explored.

The structure of this paper is as follows. Section 2 presents a more detailed overview of the problem. Section 3 reviews relevant literature in the area of insurance economics and information technology. Section 4 provides a brief explanation of a bundling strategy and explains its relevance to this problem. Section 5 and Section 6 present the measures and methodology used to model this research problem, respectively. Section 7 presents the model and Section 8 presents the results. Finally, Section 9 concludes the paper.

2. Problem overview

While most Americans obtain their health insurance coverage through employee-sponsored group plans or government-sponsored programs such as Medicare and Medicaid, a significant minority purchase their insurance individually for themselves and their family[1] [12]. In addition, structural changes in the workforce [11] and changes in demographics [8] suggest that a growing proportion of the population will come to rely primarily on the IHIM for their health coverage in the future.

Within this growing market, there are two costs that threaten the insurability of individuals and the viability of the industry: 1) the ***public cost of private information*** and 2) the ***distributional cost of public information***. This paper examines the trade-offs between these two costs and identifies a strategy for eliminating both from the market.

The public cost of private information is the decrease in consumer participation in the IHIM due to adverse selection in the presence of informational asymmetries between insurance providers and insurance applicants. When regulators forbid insurance companies from engaging in precise differential pricing, the alternative is uniform pricing across non-identical populations called pools or communities. When individuals possess private information regarding their personal riskiness for incurring medical costs and insurance companies are forced to engage in community rating individuals who are at lower risk will determine that they are being overcharged and will choose to remain uninsured.

The public cost of private information may be eliminated in this market by making applicants' private information publicly available and by allowing insurance companies to engage in differential pricing strategies (or risk classification). However, such risk classification introduces an adverse ***distributional effect*** into the market. That is, by making information public, premiums across applicants are no longer equitable since each applicant is now paying a premium based on his own risk status. This inequity may be considered unfair by regulators in the IHIM, especially if the inequity is based on factors over which individuals have no control (e.g., genetic predisposition). This inequity represents the ***distributional cost of public information***.

IT is rapidly increasing the genetic information available to individuals and insurance companies in the IHIM. Advances in biological and genetic research have helped to identify genetic components of various diseases such as Alzheimer's, breast cancer, cystic fibrosis, Huntington's, and Tay Sachs, as well as those associated with non–traditional diseases such as mental illness, obesity, and alcoholism [13]. This growing knowledge of human genetics, combined with rapid advances in technology, has enabled researchers to develop tests, based on DNA and chromosome analysis, that can determine if individuals possess genetic mutations that may increase their chances of developing certain medical conditions [3]. These tests may help individuals more accurately assess their propensity for acquiring certain medical conditions and therefore of incurring the associated medical costs.

In the absence of state or federal regulation, insurance companies will attempt to price policies based on such genetic information. In fact, through ***data mining*** efforts insurance companies may be able to infer individuals' riskiness based on genetic factors such as family history, medical history, and genetic test results [5]. However, such differential pricing strategies (referred to as ***medical underwriting***) introduce a distributional cost into the market, since individuals may be charged different premiums (or offered different coverage) based solely on their genetic dispositions, over which they have no control.

Regulators in the IHIM are concerned with promoting ***fairness*** in the IHIM by eliminating the distributional cost associated with medical underwriting based on genetic information. Their intuition is to accomplish this goal by denying insurance companies access to

[1] In a survey performed by the United States General Accounting Office (GAO) in 1996, it was estimated that 10.4 million individuals under 65 years of age (about 4.5 percent of the non-elderly population) relied on the IHIM as their only source of health coverage during 1994.

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individuals' genetic information. In fact, regulators from at least 18 states (including New Jersey, New York, Vermont, Arizona, and Georgia) have passed genetic privacy legislation that prevents health insurance companies from denying coverage to, or setting higher rates for, applicants who are genetically predisposed to certain medical conditions, but who are presently in good health [12, 13, 16, 17].

Unfortunately, this genetic privacy legislation substitutes one form of unfairness for another. That is, this legislation eliminates the distributional cost of public information, but it simultaneously introduces a public cost of private information. It will encourage individuals at lower risk, who are now unable to signal their risk status to insurance companies, to opt out of the market, without providing any incremental benefit to those remaining in the market. This is explored more fully in our previous paper [6]. The problem addressed in the remainder of the paper is to identify a strategy that will eliminate both costs from the market.

3. Literature review

Work in the area of insurance economics has acknowledged that the presence of private information (or asymmetric information) in a market may lead to an adverse selection problem and, in the worst case, complete market collapse. Much of this literature has focused on the development of pricing strategies and policy designs to mitigate the costs of adverse selection in insurance markets where insurance applicants possess private information about their propensity to incur a ***single***, specified loss. One stream of literature suggests that insurance companies can use price-quantity contracts (i.e., contracts that specify both the premium rate for the policy and the amount of coverage provided by the policy) as a screening mechanism to reduce the public cost of private information [15, 19, 20, 26]. In these models, insurance companies typically induce individuals to sort themselves in risk classes by their choice of contracts. High risks select full insurance coverage at actuarially fair rates (calculated for the pool of high-risk individuals) while low risks select partial insurance coverage but at a lower average premium than that of high risks. The lower premium for low risk individuals reflects both the lower degree of coverage and the lower average riskiness of applicants. Another stream of literature suggests that insurance companies can reduce the public cost of private information by offering tailored products to individuals based on individual characteristics (e.g., demographics such as age or consumption patterns such as smoking) that are correlated with individuals' risk [4, 7, 22]. Unfortunately, both policy designs examined in these literatures mitigate the public cost of private information by introducing a distributional cost into the market. Therefore, their use in the IHIM may violate commonly held norms about fairness, especially if this discrimination is based on genetic information.

A third stream of literature is concerned with designing mechanisms that balance economic efficiency and equity within an insurance market. Tabarrok [24] examines genetic testing in the context of health insurance markets. He identified a mechanism, ***genetic insurance***, that may eliminate the distributional effect of public information. In his model, all individuals purchase genetic insurance at a single premium and then undergo genetic screening; their genetic insurance policies will pay them the expected increase in health insurance premiums that would result from the conditions detected during their genetic screening. The fully public results of their testing would then determine the actual cost of their health insurance in an efficient market. Of course, this form of genetic insurance only works if participation in the market can be made mandatory and universal; otherwise it is prone to the same adverse selection effects of the IHIM that it is intended to correct. Thus it is infeasible in today's IHIM.

4. Bundling as a strategy

The goal of this paper is to develop a model that more accurately portrays the characteristics of the IHIM and to examine a mechanism that will eliminate the need for the screening and signaling mechanisms discussed in previous literature, and the associated costs and loss of equity described above. In particular, we explore the likelihood of attaining a ***pooling equilibrium*** in a ***regulated IHIM*** in which applicants for health insurance coverage possess ***private information*** about their propensity to acquire a ***large number*** of medical conditions.

The mechanism introduced to accomplish this goal is termed a ***bundling strategy***. Under a ***pure bundling*** strategy, a seller of a set of products would offer to sell to buyers the entire set of products at a fixed price. Pure bundling essentially represents a "take it or leave it" offer in which buyers either decide to purchase the complete bundle of products at that fixed price or decide to purchase no products at all. The idea behind pure bundling is that it may be possible, under certain conditions, to make individuals who are heterogeneous in their valuations for a single product homogeneous in their valuations for a large bundle of products[2].

[2] This results by applying the law of large numbers and the Central Limit Theorem.

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Recent IT literature has focused on the use of bundling strategies to maximize profits of a monopoly seller of multiple goods with zero marginal costs. Bakos and Brynjolfsson find that when marginal costs are very low, when consumer valuations for the goods are of comparable value, and when the correlation in demand for different goods is low, a multi-product monopolist can use a bundling strategy to increase profits, reduce consumer surplus, and reduce dead weight losses[3] [2]. However, these authors acknowledge that regulators in the digital goods industry may be opposed to the implementation of any bundling strategy that is designed to maximize profits by minimizing consumer surplus.

The problem addressed by Bakos and Brynjolfsson is complimentary to, but very different from, the problem addressed in this paper. The problem addressed in this paper has important strategic implications for the IHIM and other markets characterized by ***regulated competition*** (i.e., marginal profits to sellers is zero) for the provision of multiple goods with ***high marginal costs***[4].

In the following sections, we attempt to solve the problem of ***maximizing market participation*** in a regulated IHIM by having applicants' valuations for a large number of goods (i.e., coverages for medical costs) converge to a single value.

The conditions to be considered include:

- The ***number of diseases*** to be included in the bundle to make individuals who are heterogeneous in their valuations for specific medical conditions sufficiently homogenous in their valuations for a large bundle of medical conditions to entice them to purchase the complete bundle (i.e., the pooled policy)
- The impact of varying the ***distribution of risk types*** for each medical condition on the sustainability of the bundling solution.
- The impact of the presence of coverage for ***catastrophic medical conditions*** on the sustainability of the bundling solution[5].

[3] These authors suggest that this setting is consistent with the selling of digital information goods, which are essentially costless to reproduce and distribute and can be sold easily in large bundles.

[4] In the IHIM the marginal cost for health coverage is the consumer's expected medical costs. Consumers' willingness to pay (or valuation) for this coverage will be only slightly higher due to the presence of risk aversion.

[5] Catastrophic diseases, defined as those diseases that have a low prior probability of occurrence but very high consequences (treatment costs) when acquired, presently pose a difficult problem to insurance companies. These companies are attempting to identify strategies that will allow them to provide health coverage to individuals for these catastrophic diseases in the presence of growing adverse selection. This analysis will provide some guidance.

5. The market participation measure

In order to evaluate the effectiveness of a bundling strategy in meeting the stated objectives, we must develop an appropriate measure. Consumers purchase products because they perceive that the purchase makes them better off. In our context, consumers purchase individual health insurance policies to off-load their financial risk (i.e., the potential treatment costs associated with acquiring poor health) to a neutral third party – the insurance company. In the traditional economics literature, the measure used to assess the aggregate benefit (net of costs) that consumers obtain from the purchasing of products in a market is ***consumer surplus***.

However, the purchase of insurance coverage generates a ***positive externality*** within the IHIM, which is not captured by modeling consumer surplus. That is, individuals that choose to remain uninsured may be less able, or less willing, to receive appropriate treatment for medical conditions in the future; this would be of particular concern for regulators if these medical conditions were contagious and could be spread throughout the population if not treated. This could have a very adverse effect on overall health care costs. However, universal coverage reduces the threat of epidemic by allowing all individuals to have access to necessary medical treatment[6].

Since the consumer surplus measure does not account for the positive externalities associated with universal health insurance coverage, we introduce an alternative measure, ***market participation***, which does. Market participation is defined as the percentage of outcome risk present in the population (or potential market) that is actually covered by health insurance. The market participation measure provides ordinal rankings of alternatives consistent with those implied by the consumer surplus measure (as we will see later). However, it also accounts for the positive externalities discussed above and gives a clear and unambiguous metric for determining how closely we approach the

[6] In fact, [9] discussed the public value, and social desirability, of universal inoculations. The article claimed that:

> Mass vaccination is without a doubt the greatest public-health triumph of the century. It has saved millions of lives, and prevented the crippling of countless others... mass vaccination is among the cheapest and most effective ways to improve public health suggests that there are positive externalities associated with universal inoculations.

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goal of full participation. This therefore provides insurance companies and regulators with a more meaningful interpretation on which to base their decisions.

6. Methodology

Previous work in the area of insurance economics typically uses closed-form analytics to examine methods to manage the cost of private information in an insurance market in which individuals face a single risk. However, it is not feasible to derive closed-form analytical solutions when considering a more realistic insurance market in which individuals face a large number of risks for which they seek coverage. Due to the complexity of the problem and the inability to produce tractable closed-form solutions, we use simulation techniques to examine the issues presented in this paper.

The IHIM belongs to a class of social systems that Jay Forrester calls multi-loop nonlinear feedback loops [10]. He introduces an approach, termed Industrial (or System) Dynamics, which can lead to a better understanding of these dynamic social systems and to more effective development of corporate and governmental policies for the future [10]. Industrial Dynamics is essentially a simulation modeling technique that begins with populations or pools, transitions among pools, and determinants of rates of flow of populations among pools. Rates of flow can be based upon any information in the model, including previous rates of flow or size of pools and perceived differences among them. It is this ability to have flows influence pools, which in turn influences flows, that allows Industrial Dynamics to capture complex and nonlinear behavior of systems over time[7]. We use this simulation technique to develop and test models of the IHIM and explore the impact of bundling strategies.

7. The Model

7.1. Model Assumptions

Individuals are potential consumers of health care products and services. Initially, there are n types of simulated diseases in this simulated world, the risks of which are independently and identically distributed (i.i.d.). Each of the n diseases has a genetic component. The treatment costs for each disease are known and constant.

Initially, individuals are endowed with either a high risk status or a low risk status for each of the n diseases[8]. Individuals are endowed according to a series of Bernoulli trials (i.e., for each medical condition each individual is genetically endowed either as high risk or as low risk for that condition). It is assumed insurance companies cannot observe the individuals' risk types, but that the population distribution of risk types is common knowledge. Initially, it is also assumed that individuals are identical in every aspect except in their probability of developing each disease (and of therefore incurring the treatment costs associated with each). In addition, it is assumed that individuals are risk averse. It is also assumed that each individual is perfectly informed, through a set of free and perfectly accurate genetic tests, about his risk type for each disease. Therefore, individuals have a complete information advantage over the insurance company. The probability of a low risk (LR) individual developing disease i is represented by $P(i \mid LR_i)$, the probability of a high risk (HR) individual developing i is represented by $P(i \mid HR_i)$, where $0 < P(i \mid LR_i) < P(i \mid HR_i) < 1$. It is assumed that these probabilities are fixed and not altered by individuals' behaviors, eliminating the need to address moral hazard in this model.

Initially, applicants for private health insurance all possess the same underlying von Neumann - Morgenstern utility function for wealth, specified as $U(W) = -e^{rW}$, where r is the risk aversion parameter and W represents wealth. The exponential utility function exhibits constant absolute risk aversion (CARA) as defined by Arrow [1]. Individuals make insurance purchase decisions to maximize their own expected utility.

Finally, the simulation considers a single, risk-neutral insurance firm, participating in a regulated insurance market. This company is assumed to engage in a pure bundling strategy; that is, the company offers to the market only one policy, a comprehensive policy providing full coverage for all diseases at a single premium[9]. The insurance company engages in actuarially-fair pricing based on the claims experience for the policy; that is, the insurance company sets the

[7] Forrester uses this technique to examine the dynamics of urban systems; in particular, he demonstrated how industry, housing, and people interact with each other as a city grows and decays and the implications for governmental policies.

[8] The binomial distribution better characterizes consumer valuations in the IHIM than those distributions investigated in previous literature (e.g., Gaussian, uniform, etc.). That is, in the IHIM consumers are generally either high risk or low risk. For example, an individual either has the HIV virus or not; he either has a mutation of the P53 gene or not.

[9] We have completed work that explores insurance companies use of mixed bundling strategies and price-quantity contracts in this environment. However, due to pace limitations we are unable to present these results in this paper.

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premium for the policy in each period to the level that would have enabled the company to break-even in the previous period had that premium been charged.

7.2. Simulation Structure

The structure for the simulation is as follows[10]:

Applicants:

- Enter the IHIM
- Observe a free and perfectly accurate genetic test for each of the *n* diseases, which identifies the individual as either high risk or low risk for that disease
- Observe the premium of the bundled (or comprehensive) insurance policy offered by the insurance company that period
- Based on all available information (realization of their risk status and premium of the policy), decide whether to purchase the policy offered in the market or remain uninsured, based on maximizing their own expected utility
- Remain healthy or experience occurrences of illness during the period, after which, those with both illness and insurance coverage file claims

Insurers:

- Observe the insurable population
- Offer a comprehensive insurance policy to the market based on population probabilities
- Collect revenues from premiums
- Pay claims and adjust premiums as claims are filed

In this model, a steady-state equilibrium is achieved when the policy premium and market participation achieve stability.

8. Results

8.1. Number of Diseases Covered

Table 1 provides a summary of the initial parameters set for exploring the model discussed in Section 7. We first examine the effect of the bundle size (i.e., the number of diseases covered in the insurance policy) on market participation and on the premium under a pure bundling strategy.

Under these conditions, we find that offering comprehensive insurance coverage for a bundle of medical conditions will result in higher market participation and lower premium rates than offering separate insurance policies, each providing coverage for a single medical condition. That is, as the size of the bundle increases, providing coverage for more medical conditions, a greater proportion of applicants chooses to purchase the bundled coverage, a larger proportion of outcome risk is covered in the market, and premiums rates paid by insureds are lower on a per disease basis [see Table 2]. In addition, as the number of diseases covered in the bundle, *n*, becomes "large enough", market participation approaches full participation and the premium rate for the bundle approaches the actuarially fair rate for the population, eventually resulting in a pooling equilibrium. These results will hold even if insureds possess perfect, private information regarding their riskiness for each of those diseases[11]. We suggest that such a pure bundling strategy, which encourages market participation at lower premiums, allows individuals to maintain their privacy, and does not threaten the viability of the insurance industry, will receive regulatory and public encouragement in today's IHIM.

The intuition behind this result is that as the number of diseases covered in the bundle increases, individuals, who are heterogeneous in their risk exposure to each disease, become homogenous in their risk exposure to the entire bundle of diseases. Figure 1 demonstrates that as *n* increases, individuals' expected losses associated with acquiring the *n* diseases converge to a single value, the average expected losses for the population. This suggests that for large bundles individuals' expected losses, and therefore their valuations for bundled insurance coverage, converge (i.e., the variance of these expectations across the population decreases), making individuals more homogenous in their valuations for complete insurance coverage.

[10] This model is implemented using the macro language of Excel 5.0.

[11] In addition, the results do not rely on the assumption that the risk status across diseases are i.i.d.. The general result that the market will converge to a pooling equilibrium as the number of medical conditions covered in the bundled policy increases still holds even if the risks are correlated. However, this convergence occurs at a slower rate than under the i.i.d. assumption (i.e., a larger bundle is required to attain the pooling solution). In addition, the results do not rely on the assumption that risk status for each medical condition is distributed according to a binomial. The Central Limit Theorem and law of large numbers ensure that when considering a sufficiently large applicant-base the results will hold under a wide range of assumptions about the underlying distribution of risk.

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These results suggest that under a wide range of conditions, an insurance company engaging in a pure bundling strategy (i.e., offering comprehensive health insurance coverage for a large number of medical conditions at a fixed price) may improve market participation and reduce premiums in the presence of extreme information asymmetries[12].

8.2. Proportion of risk types in the population

In this section we explore the impact that the proportion of risk types for each disease will have on the results presented in the Section 8.1. The attractiveness of selling large bundles of disease coverages will depend somewhat on the proportion of high risk individuals present in the population for each of the diseases. Table 3 and 4 demonstrate the relationship among the size of the bundle, the proportion of applicants at high risk for acquiring each disease, and the proportion of applicants participating in the health insurance market. These tables show that if the proportion of high risk applicants present in the market is sufficiently small then all applicants will purchase the comprehensive policy regardless of the size of the bundle. The intuition behind this result is that the presence of a very small number of high-risk individuals in the population will adversely affect the premium charged by the insurance company for a pooled insurance contract, but it will do so only slightly. With sufficient (and reasonable) levels of risks aversion, those individuals who are at lower risk will be willing to accept this slightly higher than actuarially fair rate offered by the market for a pooled contract rather than remain uninsured[13].

Alternatively, if the proportion of high-risk individuals is sufficiently high, a pooling solution can again be attained with a relatively small bundle size because, similar to the case above, individuals are already initially very homogeneous in their valuation for insurance coverage. In the extreme case in which everyone in the population is high risk with certainty, individuals' valuations will be identical. Therefore, if the proportion of high-risk individuals is sufficiently high, a pooling result can be generated and sustained even in the presence of a small insurance bundle.

If the proportion of high risk individuals lies in-between these "sufficient" values, then the market participation and the resulting premium will depend heavily on the number of diseases covered in the bundle. However, if the proportion of high risks does lie within this region, the presence of high-risk applicants adversely affects the premium to such an extent that lower risk applicants decide to opt out of the market and remain uninsured rather than pay the premium offered in the market. Should those individuals at lower risk opt out, the premium of the bundled policy prevailing in the market is higher than in the case of pooling, reflecting the riskiness (and the resulting loss experience) of those higher risk individuals that purchase the policy.

Therefore, as the proportion of high risk individuals present in the IHIM tends toward the extreme values (i.e., either 0% high risk or 100% high risk), individuals' valuations for individual disease coverage are initially more homogeneous; therefore, their valuations for a bundle of coverages converge faster, requiring a smaller bundle to encourage a high level of market participation and a lower premium. However, if the proportion of high risks is moderate, then the level of market participation and the level of insurance premiums prevailing in the market will depend heavily on the number of diseases covered in the bundle.

8.3. Presence of catastrophic disease

Up to this point, we have considered a bundled insurance policy that provides coverage for a large number of i.i.d. diseases. However, insurance companies have recently become very concerned about providing insurance coverage for catastrophic diseases – that is, diseases that occur with low probability but that have very high associated treatment costs. AIDS and many types of cancer can be considered catastrophic diseases when compared to other health care coverages such as broken arms and common viral infections. The concerns of insurance companies about providing coverage for catastrophic diseases has been heightened by advances in genetic testing that enable individuals to acquire private information regarding their riskiness for such diseases [21, 23]. One concern is that individuals who know themselves to be at low risk for certain low probability, high consequence diseases may opt out of the insurance market altogether to avoid paying what may be considered unfair

[12] Table 2 also demonstrates the consistency between two measures of market efficiency; that is, as the number of diseases included in the bundle increases both market participation and consumer surplus (normalized to account for the number of diseases included in the bundle) increase monotonically. However, it may be easier for regulators to use the market participation metric for determining how closely the market approaches the goal of universal coverage.

[13] In this section, the risk aversion parameter for the exponential utility function, r, is equal to .005. For this model, this risk aversion parameter implies that applicants are willing to pay between 13% and 18% above actuarially fair rates to avoid uncertain losses. Risk premiums of this magnitude seem reasonable in most insurance markets [18].

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premiums when compared to their overall level of riskiness.

Therefore, in this section we consider a population of applicants that are at risk for acquiring a set of (*n-1*) i.i.d. diseases about which they are perfectly informed as described in Table 1. However, in this section we also assume that each applicant has some risk of acquiring a single, catastrophic disease. The parameters characterizing this catastrophic disease are presented in Table 5.

We observe that the high cost associated with treating the single catastrophic disease does have a significant impact on the results found in Section 8.1; that is, we find that the presence of coverage for a catastrophic disease in the bundle will actually ***encourage*** applicants to purchase the bundle and induce a full market participation pooling equilibrium in which all applicants purchase the complete coverage policy at a common, fixed premium that is actuarially fair for the full population. This result may appear counter-intuitive to many insurance providers that fear private information related to catastrophic diseases will lead to an adverse selection problem. However, to the contrary, this model demonstrates that including such catastrophic diseases in the bundle will actually encourage a bundling solution, not deter it.

The intuition behind this result is that the risk premium that individuals are willing to pay in order to obtain health coverage depends heavily on the size of the potential loss (as well as the probability of incurring this loss). Individuals are typically more willing to pay a higher risk premium to avoid an uncertain catastrophic loss than to avoid an uncertain non-catastrophic loss with the same expected cost. A higher willingness to pay for catastrophic coverage will lead to a higher willingness to pay for a bundle of diseases which includes coverage for the catastrophic disease compared to a bundle that includes a non-catastrophic disease with the same expected loss. As a result, under a pure bundling strategy, including catastrophic diseases in the bundle will increase market participation and will more quickly result in pooling. This result appears to be robust under a pure bundling strategy under a wide range of parameter assumptions.

However, we need to discuss two caveats. The first caveat is that an adverse selection problem may exist in this environment if the difference in riskiness between those applicants at high risk for acquiring the catastrophic disease and those at low risk is extremely large. This adverse selection problem exists in our model when high risk individuals are 750 times more likely to acquire the catastrophic disease than those at low risk. In that case, those individuals at low risk will determine that they are being overcharged so much for comprehensive coverage that they will choose to opt out of the market and remain uninsured while those at high risk for the catastrophic disease will continue to purchase comprehensive coverage.

The second caveat is that an adverse selection problem may exist if insurance companies are able to offer an ***exclusion policy*** – a policy that covers individuals for all medical conditions except for a specified condition or set of conditions – along with the comprehensive policy in this environment. Assume that the regulated insurance company offers two policies in this market – a comprehensive policy and an exclusion policy that covers all medical conditions except for the catastrophic disease. In our model if those individuals at high risk for the catastrophic disease are ***less than*** 450 times riskier than those at low risk (given parameter values), then the pooling solution found in the case of pure bundling still holds. However, if those individuals at high risk for the catastrophic disease are ***more than*** 450 riskier than those at low risk, then the pooling solution will be broken. That is, under these conditions low-risk individuals will purchase the exclusion policy while high-risk individuals continue to purchase the comprehensive policy.

These findings suggests that for some intermediate values (e.g., when high risks are 450 – 750 times more likely to acquire the catastrophic disease), a policy that provides comprehensive coverage will have universal appeal to applicants***, as long as the exclusion policy is not offered***. Therefore, legislation such as the Kennedy-Kassebaum health care reform bill, which restricts insurance companies from offering such exclusion policies, should be encouraged in this environment. That is, legislation that prevents insurance companies from offering policies that exclude coverage may actually benefit consumers and may increase market participation when individuals possess private information regarding their risk status for a large number of medical conditions[14].

9. Conclusions

In this paper we addressed the problem of maximizing market participation in a regulated IHIM in which applicants for health coverage possess private information about their propensity to acquire a large number of medical conditions. We find that it may be possible to attain universal coverage at equitable premiums (i.e., a pooling equilibrium) in the IHIM by

[14] In contrast, our previous research demonstrates such legislation will adversely affect consumers and reduce market participation when consumers face many risks but have private information regarding only one of them [6].

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implementing a pure bundling strategy. More specifically, a pooling result within the IHIM can be strengthened:

- As the number of diseases for which the bundle provides coverage increases
- If the proportion of individuals at high risk for acquiring each disease tends toward the extremes values (i.e., 0% or 100%)[15]
- By including coverage for catastrophic (i.e., low probability, high consequence) diseases in the bundled policy

This problem is becoming increasing important due to recent advances in technology and changes in regulatory policies in the IHIM. This work provides a significant contribution to existing research in the areas of insurance economics and information technology and has significant implications for firm strategy and regulatory policy in the IHIM. We would expect that the use of bundling strategies in the IHIM would, for the most part, receive regulatory encouragement.

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Tables

Table 1. Initial Parameters

P(*high risk*)	10%
P(*acquire disease / high risk*)	5%
P(*acquire disease / low risk*)	1%
Cost(*disease*)	100

[15] Conversely, intermediate values for the proportion of high risks will weaken pooling.

Table 1. Individuals' risk status for each disease is independently and identically distributed according to a binomial distribution. Once an individual's risk status is determined, s/he is endowed with the appropriate probability of acquiring the disease.

Table 2. The Impact of Bundle Size

Number of diseases, *n*, included in bundle

	1	*5*	*10*	*25*	*80*
% Applicants Covered	10%	40%	64%	92%	100%
% Outcome Risk Covered	36%	57%	74%	95%	100%
CS / Disease[16]	1750	3401	4976	6377	6745
Premium / Disease[17]	5.00	1.96	1.61	1.43	1.40

Table 2. This table represents the relationship between the number of diseases covered under a pure bundling strategy, measures of market participation and consumer surplus, and the premium (expressed on a per disease basis to clarify comparisons).

Table 3. Proportion of High Risks, Bundle Size, and % Applicants Covered

Number of diseases, *n*, included in bundle

	5	*10*	*25*	*40*	*50*
.01	100%	100	100	100	100
.05	100	100	100	100	100
.10	40	64	92	94	97
.25	32	70	85	91	98
.50	50	75	95	98	99
.75	80	90	98	100	100
.90	95	99	100	100	100
.95	98	99	100	100	100
.99	100	100	100	100	100

Table 3. The values going down the table represent the proportion of applicants that are at high risk for acquiring each of the diseases. The results hold for the parameter values presented in Table 1.

Table 4. Proportion of High Risks, Bundle Size, and Market Participation
where P(*acquire disease / high risk*) = .10

Number of diseases, *n*, included in bundle

	20	*40*	*50*	*85*	*100*
.01	100%	100	100	100	100
.05	65	82	90	93	96
.10	44	69	75	91	93
.25	58	80	85	94	96
.50	79	94	95	95	98
.75	95	99	100	100	100
.90	99	100	100	100	100
.95	100	100	100	100	100
.99	100	100	100	100	100

[16] This represents the consumer surplus per disease aggregated over all individuals. This is measure is expressed in terms of a Thalers, a theoretical unit of money.

[17] The premium / disease is expressed in terms of Thalers.

Table 4. This table the shows the same trend as Table 3, but it does so for another parameter value, where P(*acquire disease / high risk*) = .10 (as opposed to .05)

Table 5. Initial Parameters for Catastrophic Disease

P(*high risk for catastrophic*)	5.0%
P(*acquire disease / high risk*)	10.0%
P(*acquire disease / low risk*)	.1%
Cost(*disease)*	1000

Table 5. Individuals' risk status for the catastrophic disease is independent of the (*n*-1) diseases and is distributed according to a binomial distribution. Once an individual's risk status is determined, he is endowed with the appropriate probability of acquiring the catastrophic disease.

Figure 1. Distribution of Expected Medical Costs Per Disease Across Individuals

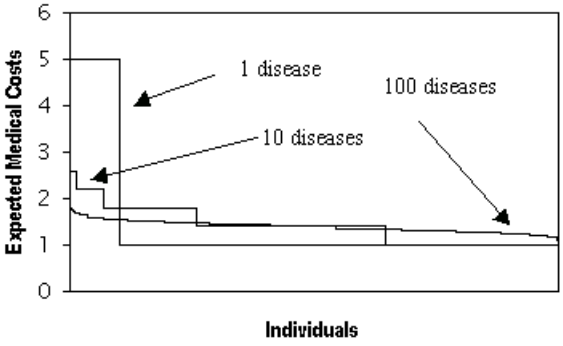

Figure 1. This figures shows the distribution of expected medical costs on a per disease basis across individuals when individuals face the risk of acquiring 1 disease, 25 diseases, and 100 diseases under the model assumptions. This figure demonstrates that individuals' expected costs per disease converge (and the variance in expectations among individuals is reduced) as the bundle of diseases for which they are at risk becomes large. In particular, as ***n*** becomes large, individuals valuations converge to the expected costs per disease for the population, which in this case is Th 1.40.