Endogenous Information, Adverse Selection, and Prevention: Implications for Genetic Testing Policy

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Abstract: We examine public policy toward the use of genetic information by insurers. Individuals engage in unobservable primary prevention and have access to different prevention technologies. Thus, insurance markets are affected by moral hazard and adverse selection. Individuals can choose to take a genetic test to acquire information about their prevention technology. Information has positive decision-making value, that is, individuals may adjust their behavior based on the result of the test. However, testing also exposes individuals to uncertainty over the available insurance contract, so-called classification risk, which lowers the value of information. In our analysis we distinguish between four different policy regimes, determine the value of information under each regime and associated equilibrium outcomes on the insurance market. We show that the policy regimes can be Pareto ranked, with a duty to disclose being the preferred regime and an information ban the least preferred one.

Keywords: adverse selection, information value, insurance, moral hazard, prevention

JEL-Classification: D11, D61, D82, G22, G28, I13, I18

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1 Introduction

In this paper, we examine public policy toward the use of information from genetic tests by insurers. Individuals engage in primary prevention, which is not observed by insurers, and we study a wide range of policy approaches toward genetic information. Our results show that a duty to disclose Pareto dominates all other regimes, whereas an information ban is Pareto dominated by all other regimes. Unobserved prevention does not lend itself to an economic efficiency rationale for the current regulatory practice in many legislations. What’s more, an information ban, which is the policy viewed as most favorably in general discussions, results in the lowest level of social welfare.

Our results inform public policy decisions about the use of test information in insurance markets. Genetic information is most relevant in the markets for health insurance, life insurance, annuities, and long-term care insurance. There is evidence of adverse selection in U.S. employer provided health insurance (Bundorf et al., 2010; Handel, 2013; Bajari et al., 2014), in the U.S. Medigap and non-group health insurance market (Finkelstein, 2004; Lo Sasso and Lurie, 2009), in the U.K. private health insurance market (Olivella and Vera-Hernández, 2013), and in annuity (Finkelstein and Poterba, 2002, 2004) and life insurance markets (He, 2009). Genetic information can be a strong contributor to risk-based selection. For example, Zick et al. (2005) find that individuals who had a positive predictive test for Alzheimer’s disease substantially increased their purchase of long-term care insurance. Oster et al. (2010) report "strong evidence of adverse selection" (p. 1048) in the sense that asymptomatic individuals who have tested positive for Huntington’s disease are five times more likely to own long-term care insurance than comparable individuals without a positive test result. The increasing availability of mail-order genetic tests for a wide range of conditions is likely to in-

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1 The broader evidence on adverse selection is mixed. In addition to risk-based selection, there is evidence of selection on other dimensions. See Cohen and Siegelman (2010) and Chiappori and Salanié (2013) for surveys of empirical research on adverse selection in insurance markets.
crease the degree of private information in these insurance markets. Public policy can either exacerbate or mitigate the resulting adverse selection problems and has therefore a major impact on the efficiency of insurance markets and social welfare.

Regulation varies widely across jurisdictions and insurance markets, ranging from bans on the use of genetic test results, to voluntary restrictions, to no regulation.² To cover the broad array of legislation, we consider four policy regimes and determine the incentives for individuals to take genetic tests and implied insurance market outcomes. We analyze a duty to disclose or mandatory disclosure regime under which individuals must provide the results of any genetic tests to insurers. In the U.K., applicants must disclose positive test results for Huntington’s disease when applying for a life insurance policy over £500,000. Canada has no specific legislation governing the use of genetic information. While Canadian insurance companies do not require genetic tests, they may request the results of any tests that have been performed. The situation is similar in Australia and New Zealand. In South Africa, insurers have agreed to a Code of Conduct under which they may not require genetic tests. Previous tests, but not their results, must be disclosed to the insurer. We also consider a consent law or voluntary disclosure regime under which individuals can choose whether or not to reveal test results. U.K. insurers have agreed to a moratorium on the use of genetic tests.³ Individuals are still allowed to disclose favorable genetic test results to rebut family history information.

A ban on the use of genetic tests by insurers seems to be the most widely adopted policy. In the U.S., the Health Insurance Portability and Accountability Act (HIPAA) of 1996 and the Genetic Information and Nondiscrimination Act (GINA) of 2008 together effectively prohibit the use of genetic information (including family health history) in determining coverage or premiums in both group and individual health insurance for asymptomatic individuals. The Oviedo Convention, which is binding on the members of the European Community

² See Joly et al. (2010) and Otlowski et al. (2012) for surveys of regulation on the use of genetic information.
³ The U.K. moratorium has been in place since 2001 and has been extended until at least 2019.
that have signed it, prohibits discrimination against a person on the basis of their genetic herita-
tage. Austria, Belgium, France, Germany Portugal, Sweden and Switzerland have passed leg-
islation that effectively prohibits the use of genetic tests by insurance companies.⁴ Many ju-
risdictions have no explicit legislation on the use of genetic tests. In the U.S., HIPAA and
GINA do not apply to life insurance, annuities or long-term care insurance. Most Asian and
African countries have not enacted legislation regulating the use of genetic information by
insurers.

Our paper contributes to the literature on risk classification and the private and social
value of information in insurance markets.⁵ Crocker and Snow (1986) show that the inclu-
sion of costless categorical variables in the pricing of insurance increases welfare. This result
also holds when categorization is costly by allowing the government to offer partial social
insurance (Rothschild, 2011). Endogenous information and genetic testing is examined in
Tabarrok (1994) who proposes genetic insurance to protect revealed high risks who might
otherwise be unable to afford coverage. Crocker and Snow (1992) find that the private value
of information is negative if insurers can observe whether individuals are informed or not
and if consumers do not have prior information. Furthermore, the private value of inform-
ation is non-negative only if insurers are unable to observe the consumers’ informational
status or if individuals are able to conceal it (Doherty and Thistle, 1996).

Whereas the aforementioned papers assume risk types to be exogenous, other authors
have studied situations where individuals can take actions to mitigate risk. Doherty and Pos-
ey (1998) consider primary prevention for revealed high risks and find that testing is encour-
aged when informational status and test results can be concealed by the individual. In Bardey
and De Donder (2013) test results have to be revealed and high risks can engage in preven-

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⁴ Belgium makes an exception for life insurance policies above approximately $150,000. In Germany, there is an
exception for life insurance policies with a sum insured exceeding €300,000.

⁵ See Crocker and Snow (2013) and Dionne and Rothschild (2014) for recent surveys. The papers mentioned are
most applicable to health and long-term care insurance where contracts are exclusive. For the welfare effects
of genetic testing in life insurance, see Hoy and Polborn (2000) and Polborn et al. (2006).
tion, which is either observed or not. Neither of these papers compares policies in terms of social welfare, so their conclusions are conditional on a specific regulation.

Barigozzi and Henriet (2011) and Crainich (2016) study observable self-insurance (secondary prevention). Whether individuals choose the level of self-insurance that maximizes social welfare, depends on whether genetic information can or cannot be disclosed and on the proportion of high risks in the latter case (Crainich, 2016). Barigozzi and Henriet (2011) rank the policy alternatives discussed above according to social welfare and find that a duty to disclose weakly dominates all other regimes, whereas an information ban is strictly dominated. Given the stark differences between self-protection and self-insurance, it is not clear to what extent the welfare results in Barigozzi and Henriet (2011) can be generalized. We fill this gap in the literature and analyze social welfare under all four relevant policy regimes towards genetic testing, when individuals can engage in unobservable primary prevention.

Primary prevention is a central determinant of genetic risks. These risks are mostly multifactorial in the sense that the interaction of risk-relevant behavior with endowed genetic factors determines the likelihood of onset of disease. A good example that is widely used in the literature, is a mutation of the genes BRCA1 and 2, which leads to an elevated risk of breast and ovarian cancer (Thompson et al., 2002). Besides genetic determinants there is a variety of behavioral factors that are associated with breast cancer risk.6 We argue that individuals’ engagement in prevention reflects their information about risk. Similarly, there are genetic tests that indicate an increased risk of heart attack, hypertension and type 1 and 2 diabetes, as well as other diseases, where lifestyle choices affect the overall risk of developing the disease. Against this background, we argue that prevention is at least as important as self-insurance when studying genetic testing policy.

6 Typical risk factors are nutrition habits, alcohol consumption, smoking before the age of 16 and exercising habits amongst others (Colditz and Frazier, 1995; Thune et al., 1997). In general, any habits that disturb the hormonal balance can lead to an increase in breast cancer risk.
The global incidence of monogenic diseases at birth is estimated at 1 in 100.\(^7\) Hemoglobin disorders (e.g., alpha- and beta-thalassemia, sickle-cell trait, hemophilia) are the single most common, estimated to affect nearly 3 percent of conceptions. Cystic fibrosis is estimated to affect 1 in 2-3000 live births in the EU and about 1 in 3500 in the U.S. Fragile X syndrome is the most common mental impairment, affecting 1 in 3600 males and 1 in 4-6000 females worldwide. Huntington’s disease is estimated to affect 5-7 people per 100,000 in western countries. The most common genetic tests are for fragile X syndrome, factor V Leiden thrombophilia (a blood clotting disorder), cystic fibrosis, hereditary hemochromatosis (iron overload disorder) and Huntington’s disease (Genome News Network, n.d.). Common inherited cancers for which genetic tests are available include breast and ovarian cancer (BRCA1 and 2 gene), Li-Fraumeni syndrome, Cowden syndrome, Lynch syndrome, familial adenomatous polyposis, and retinoblastoma (National Cancer Institute, 2013).

Our analysis also applies to other medical tests, such as tests for HIV and STIs. From a purely economic perspective, a genetic test is not qualitatively different from any other predictive test that might be used as part of the insurance underwriting process. From an ethical perspective, this assertion is debatable. While ethical issues are beyond the scope of this paper, they are also important considerations in developing public policy regarding genetic testing.\(^8\) Regardless of the weight given to ethical considerations, understanding the economic merits of the different policy options is clearly important in policy making.

The paper proceeds as follows. The next section outlines the basic model and incorporates unobservable prevention. Section 3 contains the analysis of equilibrium under the various policy alternatives. Section 4 analyzes social welfare and ranks the policy alternatives. Section 5 provides extensions of the basic analysis. Section 6 discusses public policy implications and concludes.

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\(^7\) Population incidence rates are obtained from WHO (2017) and from Modell and Darlinson (2008) for hemoglobin disorders.

\(^8\) See Nill et al. (2017) for a recent analysis of ethical considerations in public policy toward genetic testing.
2 The Basic Model

2.1 Preliminaries

There is a continuum of individuals in our model and each one has an endowment of wealth \( w \) and a von Neumann-Morgenstern utility function \( u \), which is increasing and concave \( (u' > 0, u'' < 0) \). Agents face a fixed possible loss \( l \), where \( 0 < l < w \). This loss is incurred with probability \( p \) and individuals can choose an effort level \( x \geq 0 \) to reduce the probability of loss (primary prevention). Effort is costly and reduces expected utility by \( \gamma(x) \). The cost of effort is increasing and convex \( (\gamma' > 0, \gamma'' > 0) \) and is measured in utils, consistent with our motivating examples.

Individuals have different prevention technologies. They may be high risk, with prevention technology \( p_H(x) \), or low risk, with prevention technology \( p_L(x) \). Both \( p_H(x) \) and \( p_L(x) \) are decreasing and convex, and for any effort level \( x \geq 0 \) high-risk types have a higher probability of loss than low-risk types, \( p_H(x) > p_L(x) \). Furthermore, we assume that \( \lim_{x \to 0} p_i'(x) = -\infty \), for \( i = H, L \). The population proportions of high- and low-risk types are \( \theta_H \) and \( \theta_L = (1 - \theta_H) \), where \( 0 < \theta_H, \theta_L < 1 \). These parameters are common knowledge.

To focus on endogenous information acquisition, we assume that an agent’s informational endowment does not include her risk type. Then, due to rational expectations, the prevention technology for uninformed individuals, denoted by subscript \( U \), is given by \( p_U(x) = \theta_H p_H(x) + \theta_L p_L(x) \). We use the term *informational status* to distinguish uninformed consumers who do not know their risk type, from informed consumers who have acquired information about their risk type via a costless genetic test. Unlike in Hoy et al. (2014), the genetic test is perfect, that is there are no false positives or false negatives.\(^{10}\)

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\(^9\) Hoy (1989) introduces the positive difference function, \( \delta(x) = p_H(x) - p_L(x) \), to distinguish between constant, decreasing, and increasing difference, \( \delta' = 0, \delta' < 0, \text{ and } \delta' > 0 \), respectively.

\(^{10}\) The simplifying assumption of a perfect test can be relaxed. It is sufficient that consumers and insurers agree on the post-test loss probabilities given the rates of false positive and negative results. In our model all individuals are ex ante identical and take the same testing decision at equilibrium. For a study of genetic testing in a situation where agents differ ex ante, see Hoel et al. (2006) and Section 5.2.
2.2 Insurance Contracts under Moral Hazard and Value of Information

Insurance contracts are denoted by $c$ and consist of a premium $\pi$ and a net indemnity $\beta$, that is $c = (\pi, \beta)$. We assume that individuals cannot buy more than full coverage, $\pi + \beta \leq l$, which is known as the “principle of indemnity” in the insurance literature (see Harrington and Niehaus, 2004, p. 194). The main purpose of this legal doctrine is to mitigate moral hazard because an insurance contract where the insured is better off after the loss than prior to the loss would obviously preclude her from exerting any effort. The expected utility from buying contract $c$ is given by

$$U_i(c, x) = (1 - p_i(x))u(w - \pi) + p_i(x)u(w - l + \beta) - \gamma(x)$$

for a type $i$ individual. We let

$$V_i(c) = \max_{x \geq 0} [(1 - p_i(x))u(w - \pi) + p_i(x)u(w - l + \beta) - \gamma(x)]$$

denote the individual’s indirect utility function and $\bar{x}_i$ denote the unique solution to the maximization problem so that $V_i(c) = U_i(c, \bar{x}_i)$. The second-order condition for optimal effort holds at any contract $c$ due to the convexity of $p_i(x)$ and $\gamma(x)$. We obtain that $\partial \bar{x}_i / \partial \pi < 0$ and $\partial \bar{x}_i / \partial \beta < 0$ from the implicit function theorem because a higher premium reduces wealth in the no-loss state and a higher net indemnity increases wealth in the loss state, both of which lower the marginal benefit of prevention. We assume that $p_H(\bar{x}_H) > p_L(\bar{x}_L)$ at any contract $c$, which rules out the implausible case that high risks exert so much more effort than low risks that their probability of loss is smaller than that of low risks.\footnote{This assumption holds automatically under constant or increasing difference, see Footnote 9. It also holds under decreasing difference if $\delta$ does not decrease too quickly or if we assume that the low-risk probability of loss is fixed and that only high risks exert effort.}

Insurers cannot observe the individual’s choice of effort and need to anticipate policyholder behavior when pricing their contract offerings. We consider the feasible set, which is the set of insurance contracts that earn a non-negative expected profit if bought by a type $i$ individual, $\Pi_i(c) = (1 - p_i(\bar{x}_i))\pi - p_i(\bar{x}_i)\beta \geq 0$. The zero profit line is the locus where this constraint is binding and one can show that it is upward sloping in $(\beta, \pi)$-space. Ligon and Thistle (2008) show that that the feasible set is convex and compact under the principle of
indemnity. Then, we can maximize the individual’s indirect utility function over the feasible set and know from Weierstrass’ extreme value theorem that it attains its maximum as a continuous function on a compact set. We denote the maximizer by \( \hat{c}_i \) and the associated effort level by \( \hat{x}_i \). The “hatted” contracts maximize expected utility subject to the feasibility and incentive compatibility constraint. The “hatted” effort levels are the ones associated with these contracts. Obviously, the expected profit for each of these contracts is zero because otherwise individuals can be made better off. The \( \hat{c}_i \) are second-best efficient because prevention is not observed but they are obtained under the assumption that insurers know the individual’s informational status and their risk type if informed. Therefore, moral hazard is the only informational friction that is reflected in the “hatted” contracts.

Whether consumers decide to become informed depends on the value of information, which is given by the change in expected utility from taking the test. If the uninformed choose contract \( c_U \), and informed high and low risks choose contracts \( c_H \) and \( c_L \), respectively, the value of information is

\[
I = \theta_H V_H(c_H) + \theta_L V_L(c_L) - V_U(c_U).
\]

We let \( z \) denote the individual’s informational status, where \( z = 1 \) if the individual is informed and \( z = 0 \) if the individual is uninformed. We assume individuals choose to become informed if the value of information is non-negative. That is, \( z = 1 \) if and only if \( I \geq 0 \). In those regimes where insurers observe the consumers’ informational status (duty to disclose and code of conduct), they will condition their contracts to the taking of the genetic test. When informational status is not observable (consent law and information ban), insurer’s will

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12 The assumption \( \lim_{x \to 0} p_i'(x) = -\infty \) is important here since it implies that effort will be strictly positive for less than full coverage (Arnott and Stiglitz, 1988). If this assumption does not hold and effort is zero at less than full coverage, then the feasible set is compact but not convex.

13 We can find at least one such contract but it might not be unique. In case of multiple solutions, say \( c_1 \) and \( c_2 \), it holds that \( V_i(c_1) = V_i(c_2) \) such that neither the value of information nor the welfare comparisons are affected by the choice of the solution.

14 Notice the tie-breaker rule of becoming informed when the value of information is zero. This is consistent with prior literature (e.g. Doherty and Thistle, 1996), but our policy conclusions generalize to the case of a cost associated with taking the genetic test, see Section 5.1.
form beliefs about consumers’ informational status, \( b(z) \). These beliefs must be confirmed for the market to be in equilibrium, \( b(z) = z \). The underlying notion of consistency is of the Bayes-Nash type (\textit{sequential rationality}).

### 2.3 Adverse Selection and Insurance Market Equilibrium

In all cases, where insurers cannot access individual test results when consumers decide to become informed (code of conduct and information ban), offering \( ĉ_H \) and \( ĉ_L \) might not be sustainable. The reason is that \( ĉ_L \) could be more attractive than \( ĉ_H \) to high risks, resulting in losses for the insurance company because \( \Pi_H(\hat{c}_L) < \Pi_L(\hat{c}_L) = 0 \). To address this issue insurers can set up self-selecting contracts in the sense of Rothschild and Stiglitz (1976).

To formalize this idea, we define a \textit{perfectly competitive equilibrium} as a set of contracts such that (i) no contract makes strictly negative expected profits, and (ii) no contract outside this set makes strictly positive profits. It is well-known, that a perfectly competitive equilibrium may fail to exist when the proportion of high risks is less than an endogenously determined threshold value. A \textit{locally competitive equilibrium} is a set of contracts such that (i) no contract makes strictly negative expected profits, and (ii) no contract within a certain neighborhood would make strictly positive profits (see Sandroni and Squintani, 2007). A locally competitive equilibrium always exists, is unique, and the equilibrium contracts coincide with those of the perfectly competitive equilibrium.\(^{15}\)

In Appendix A we write out all the relevant information and feasibility constraints explicitly and provide a formal derivation of the locally competitive equilibrium in our set-up. We are able to implement self-selecting contracts due to the single-crossing property. With the help of the envelope theorem, the marginal rate of substitution in \((\beta, \pi)\)-space, allowing effort to vary optimally, is given by

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\(^{15}\) Riley (1979) defines a “reactive” equilibrium where firms anticipate new contract offerings by competitors and shows that it coincides with the locally competitive equilibrium. An alternative solution to the equilibrium non-existence problem are cross-subsidized Wilson (1977)-Miyazayki (1977)-Spence (1978) contracts or fixed contracts (see Peter et al., 2016). For any definition where the existence of equilibrium depends on the population proportion of risk types, take up rates of genetic tests influence whether equilibrium exists or not.
for a type $i$ individual at contract $c$. $M_i(c)$ is positive so that indifference curves are upward sloping, $M_i' = P'R + R'P$, where $PR' < 0$ captures the effect of risk preferences and $P'R > 0$ the effect of moral hazard. Indifference curves can be convex or concave depending on which effect is stronger. They are more likely to be concave (1) the more risk-averse the agent, (2) the lower the productivity of effort and (3) the greater the curvature of the loss probability as a function of effort. We assume that the indifference curves are concave (see Ligon and Thistle, 2008, for a graphical illustration). Then, $p_H(\bar{x}_H) > p_L(\bar{x}_L)$ implies $M_H(c) > M_L(c)$ at any contract $c$ so that the high-risk indifference curve crosses the low-risk indifference curve from below, which together with concavity ensures that they cross precisely once (single-crossing property).

We denote by $c^*_H$ and $c^*_L$ the contracts for high and low risks in a locally competitive equilibrium and by $x^*_H$ and $x^*_L$ the associated optimal effort levels. Contracts notated with a “star” satisfy feasibility, incentive compatibility and the self-selection constraints, and maximize low-risk expected utility subject to these constraints. As in the classical Rothschild and Stiglitz (1976) model it holds that $c^*_H = \hat{c}_H$ and $x^*_H = \hat{x}_H$ such that high-risk utility is not affected by adverse selection.\footnote{In microeconomic jargon, we are in a situation of no distortion at the top. If $\hat{c}_H$ is not uniquely determined, the choice of the contract is irrelevant because the indirect utility of high risks does not depend on it.} For the low risks, we have to distinguish between two cases. First, the high-risk self-selection constraint can be binding such that $V_H(c^*_H) = V_H(c^*_L)$ and $V_L(c^*_L) < V_L(\hat{c}_L)$. This is the case when contract $\hat{c}_L$ attracts high risks, resulting in losses for the insurance company. In equilibrium, the low-risk contract $c^*_L$ is characterized by sufficient risk sharing to be unattractive for high risks at the margin. The other possible case is that the low-risk contract under moral hazard does not attract high risks. Then, $c^*_L = \hat{c}_L$ and $x^*_L = \hat{x}_L$ and adverse selection does not induce further distortions on the market, besides those already present due to moral hazard (see also Cromb, 1990). In this case, both self-selection constraints are slack, that is $V_H(c^*_H) > V_H(c^*_L)$ and $V_L(c^*_L) > V_H(c^*_H)$.
3 Equilibrium Analysis of Alternative Policies

For convenience, we summarize the policy alternatives in Table 1. Under all of these policy alternatives individuals may choose whether or not to take a genetic test.

Table 1: Description of Policy Alternatives

<table>
<thead>
<tr>
<th>Policy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duty to Disclose (dd)</td>
<td>Individual must disclose the results of any test taken</td>
</tr>
<tr>
<td>Code of Conduct (cc)</td>
<td>Individual must disclose that a test has been taken, but not the result</td>
</tr>
<tr>
<td>Consent Law (cl)</td>
<td>Individual may disclose the results of a test that has been taken</td>
</tr>
<tr>
<td>Information Ban (ib)</td>
<td>Individual may not disclose that a test has been taken nor test results</td>
</tr>
</tbody>
</table>

3.1 Duty to Disclose

We consider a duty to disclose (in short: dd) or mandatory disclosure policy first. Under this regime, the insurer must be informed about whether a genetic test has been conducted and, if so, what the results were. For example, the insurance company might have paid for the test, perhaps as part of a more general medical examination. Then, insurers will offer contracts that depend on informational status and risk type, that is $\hat{c}_U$ to uninformed, $\hat{c}_H$ to informed high risks, and $\hat{c}_L$ to informed low risks.

Under a duty to disclose, the value of information is:

$$I_{dd} = \theta_H V_H(\hat{c}_H) + \theta_L V_L(\hat{c}_L) - V_U(\hat{c}_U).$$

None of the insurance contracts offer full coverage due to moral hazard and we denote by $\rho_i$ the risk premium associated with the level of risk sharing that contract $\hat{c}_i$ entails for a type $i$ individual. It is defined such that

$$V_i(\hat{c}_i) = U_i(\hat{c}_i, \hat{x}_i) = u(w - p_i(\hat{x}_i)l - \rho_i) - \gamma(\hat{x}_i).$$

Against this background, the value of information rewrites as follows:

$$I_{dd} = \theta_H u(w - p_H(\hat{x}_H)l - \rho_H) + \theta_L u(w - p_L(\hat{x}_L)l - \rho_L) - u(w - p_U(\hat{x}_U)l - \rho_U) - (\theta_H \gamma(\hat{x}_H) + \theta_L \gamma(\hat{x}_L) - \gamma(\hat{x}_U)).$$

The first line compares the risk of getting informed and facing a lottery between obtaining contract $\hat{c}_H$ with probability $\theta_H$ or contract $\hat{c}_L$ with probability $\theta_L$ to remaining unin-
formed and obtaining contract $\hat{c}_U$ with certainty. The individual’s risk aversion allows us to define the positive risk premium $\rho > 0$ associated with this risk. Similarly, the second line compares the effect of getting informed on the expected disutility of effort. When taking the test, the individual will exert effort $\hat{x}_H$ with probability $\theta_H$ or effort $\hat{x}_L$ with probability $\theta_L$, compared to exerting effort $\hat{x}_U$ with certainty when abstaining from the test. Because the disutility of effort is convex, it holds by Jensen’s inequality that the expected disutility of effort when taking the test exceeds the disutility of the expected effort level, which motivates the definition of $\sigma > 0$ as follows:

$$\theta_H \gamma(\hat{x}_H) + \theta_L \gamma(\hat{x}_L) = \gamma(\theta_H \hat{x}_H + \theta_L \hat{x}_L + \sigma).$$

$\sigma$ measures in units of effort by how much classification risk increases the expected disutility of effort. In a sense, it facilitates a risk-free comparison between the current effort level $\hat{x}_U$ and the lottery of effort levels when taking the test. Equipped with these notations, the value of information becomes:

$$I_{dd} = u(w - \theta_H p_H(\hat{x}_H)l - \theta_L p_L(\hat{x}_L)l - \theta_H \rho_H - \theta_L \rho_L - \rho) - u(w - p_U(\hat{x}_U)l - \rho_U)$$

$$- \gamma(\theta_H \hat{x}_H + \theta_L \hat{x}_L + \sigma) - \gamma(\hat{x}_U).$$

In general, this may be positive or negative, and jointly sufficient conditions for $I_{dd}$ to be non-negative are:

$$p_U(\hat{x}_U)l \geq \theta_H p_H(\hat{x}_H)l + \theta_L p_L(\hat{x}_L)l + \rho,$$

$$\hat{x}_U \geq \theta_H \hat{x}_H + \theta_L \hat{x}_L + \sigma,$$

$$\rho_U \geq \theta_H \rho_H + \theta_L \rho_L.$$  \hfill (1)

The first inequality states that the insurance premium of uninformed agents exceeds the expected insurance premium of informed agents, plus a constant accounting for the aversion to classification risk. The second inequality says that the prevention effort of uninformed individuals is larger than the expected prevention effort of informed individuals, plus a different constant accounting for the aversion to classification risk. The last inequality is a result of moral hazard and compares how the different levels of risk sharing in the various contracts affect expected utility. We summarize our observations in the following proposition.
Proposition 1. Under a duty to disclose the value of information can be positive or negative. The inequalities in (1) are jointly sufficient for the value of information to be non-negative.

This result extends some of the results in Doherty and Posey (1998), Barigozzi and Henriet (2011), Bardey and De Donder (2013), and Bajtelsmit and Thistle (2014). The central trade-off is between classification risk and the decision-making value of information. From the perspective of the uninformed, taking the test comes at the risk that the feasible set will either expand or contract, depending on whether test results are favorable or unfavorable. However, information allows the consumer to adjust effort accordingly. Depending on which effect prevails, the equilibrium is either that uninformed individuals do not acquire information and receive contract \( c_{U} \) if \( I_{dd} < 0 \), or that all individuals become informed and receive either \( c_{H} \) or \( c_{L} \) if \( I_{dd} \geq 0.19F \). In general, it is not possible to say whether moral hazard makes it more or less likely for individuals to take the test. This is because moral hazard affects the expected utility of different risk types to a different degree, see also Section 5 in Bardey and De Donder (2013).

3.2 Code of Conduct

Under a code of conduct (in short: cc), insurers can observe whether individuals took a test or not but do not have access to individual test results. In South Africa, for example, insurers may not ask or coerce the applicant to undergo any genetic test in order to obtain insurance, but the taking of any previous tests must be disclosed. Similarly, if the insurance company pays for the test, it knows that the individual has private information, but the specific test results could have been sent to the individual’s private physician for interpretation. A code of conduct might appear as a compromise because consumers retain some privacy but

\[ I = \theta_{H} u(w - p_{H}l) + \theta_{L} u(w - p_{L}l) - u(w - p_{U}l) = u(w - p_{U}l - \tau) - u(w - p_{U}l) \]

for a positive risk premium \( \tau > 0 \), and is unambiguously negative.

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17 In the absence of prevention, information has no clinical value and its only effect is that it exposes individuals to classification risk. Then the private value of information is given by
still their informational advantage is less than under a complete ban of genetic information.

In terms of our model, insurers are able to discriminate between informed and uninformed individuals and will offer $\hat{c}_U$ to the latter. They cannot distinguish between high and low risks among the informed, which requires them to offer the self-selecting contracts $c^*_H$ and $c^*_L$ to the group of informed consumers. The value of information is given by:

$$I_{cc} = \theta_H V_H(c^*_H) + \theta_L V_L(c^*_L) - V_U(\hat{c}_U).$$

As explained in Section 2.3 it holds that $V_H(c^*_H) = V_H(\hat{c}_H)$ (no distortion at the top). For informed low risks, we either obtain $V_L(c^*_L) < V_L(\hat{c}_L)$ or $V_L(c^*_L) = V_L(\hat{c}_L)$ depending on whether the high-risk self-selection constraint is binding or slack. This demonstrates that

$$I_{dd} - I_{cc} = \theta_L [V_L(\hat{c}_L) - V_L(c^*_L)] \geq 0$$

with a strict inequality as soon as adverse selection imposes an ex-ante efficiency cost on low risks. Intuitively, informed low risks cannot use favorable information under the code of conduct, which discourages consumers from taking the test relative to a duty to disclose. Still, depending on the relative size of the decision-making value of information, both the cost of classification risk and the efficiency cost might be outweighed in equilibrium. We summarize our findings in the following proposition.

**Proposition 2.** Under a code of conduct the value of information can be positive or negative. It does not exceed the value of information under a duty to disclose.

Besides the trade-off between classification risk and the decision-making value of information, there is a potential efficiency cost associated with the code of conduct, which arises because consumers can no longer use favorable test results to escape rationing imposed by self-selection. As a result, it is more likely for individuals to forego the test under a code of conduct than under a duty to disclose. Two equilibria are possible; if $I_{cc} < 0$, individuals do not take the test and receive contract $\hat{c}_U$. If $I_{cc} \geq 0$, uninformed agents acquire information and the equilibrium contracts are $c^*_H$ and $c^*_L$.\(^{18}\) Under both, a code of conduct and a duty to

\(^{18}\) In the absence of prevention, similar arguments show that the value of information under a code of conduct...
disclose, prevention has the effect to expand the set of possible equilibria because, if the decision-making value of information is sufficiently large, situations arise where agents take the test and become informed. This can never happen in the absence of prevention.

### 3.3 Consent Law

When there is a consent law (in short: cl), results from genetic testing can only be revealed with the consent of the consumer. Consequently, individuals will only choose to disclose results if they are favorable. Notice that only low-risk consumers have an incentive to reveal their test results because doing so expands their feasible set, which allows them to obtain a better insurance contract.

In terms of our model, insurers cannot directly observe informational status and need to correctly anticipate consumers’ decisions. If they expect consumers to become informed \( b(z) = 1 \), insurers will offer \( c_L \) to consumers who provide verification of a negative test result and \( c_H \) to everyone else. Individuals will choose to be tested since a positive result does not make them worse off and a negative result makes them better off. This relies on the fact that uninformed individuals cannot provide verification of a negative result, so the only contract they can obtain is \( c_H \). The value of information is then

\[
I_{cl} = \theta_H V_H(c_H) + \theta_L V_L(c_L) - V_U(c_H) = \theta_H U_H(c_H, \bar{x}_H) + \theta_L U_L(c_L, \bar{x}_L) - U_U(c_H, \bar{x}_H)
\]

\[
= \theta_H [U_H(c_H, \bar{x}_H) - U_H(c_H, \bar{x}_U)] + \theta_L [U_L(c_L, \bar{x}_L) - U_L(c_H, \bar{x}_U)],
\]

where the last equality follows from \( p_U(\bar{x}_U) = \theta_H p_H(\bar{x}_U) + \theta_L p_L(\bar{x}_U) \). As explained in Section 2.2, \( \bar{x}_U \) is the optimal effort level for an uninformed individual, in our case with contract \( c_H \). Therefore, the first square bracket is non-negative because \( \bar{x}_H \) is the optimal level of effort for a high-risk individual with contract \( c_H \), whereas \( \bar{x}_U \) may not be optimal for high risks with this contract. The second square bracket is positive because \( c_L \) is the utility-maximizing contract in the feasible set for low risks, whereas \( c_H \) is feasible but leaves a

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is strictly smaller than under a duty to disclose, and is therefore always negative.
positive profit for the insurer when bought by low risks, making them strictly worse off.\textsuperscript{19} The value of information is strictly positive, the insurers’ belief is confirmed, and the market is in equilibrium.

From the perspective of an uninformed individual, $\hat{c}_U$ is the utility-maximizing contract whereas $\hat{c}_H$ is feasible but leaves a positive profit for the insurer so that uninformed agents are strictly worse off. Therefore, $V_U(\hat{c}_H) < V_U(\hat{c}_U)$ which results in $I_{cl} > I_{dd}$. Informational incentives under a consent law are strictly larger than under a duty to disclose and also strictly larger than under a code of conduct, as per Proposition 2. Under a consent law, the expectation of consumers staying uninformed can never be part of an equilibrium. If insurers expected consumers to remain uninformed ($b(z) = 0$), they would only offer $\hat{c}_U$, in which case the value of information would be given by:

$$\theta_H V_H(\hat{c}_U) + \theta_L V_L(\hat{c}_U) - V_U(\hat{c}_U) = \theta_H [U_H(\hat{c}_U, \bar{x}_H) - U_H(\hat{c}_U, \bar{x}_U)] + \theta_L [U_L(\hat{c}_U, \bar{x}_L) - U_L(\hat{c}_U, \bar{x}_U)].$$

Now $\bar{x}_H$ is optimal for a high-risk individual with contract $\hat{c}_U$ and $\bar{x}_L$ is optimal for a low-risk individual with contract $\hat{c}_U$ whereas $\bar{x}_U$ is not necessarily optimal for any of the two types of consumers at contract $\hat{c}_U$. As a result the value of information would be non-negative and consumers would become informed ($z = 1$), contradicting the insurers’ belief ($b(z) \neq z$).\textsuperscript{20} Clearly, this cannot be an equilibrium. We summarize our results in the next proposition.

\textbf{Proposition 3.} Under a consent law the value of information is positive. It is strictly larger than under a duty to disclose or under a code of conduct.

The fact that informational status is not observable under a consent law increases the value of information to the point where it is always positive. The reason is that uninformed individuals are worse off because there is no specific insurance contract for them and all they

\textsuperscript{19} Notice that $U_L(\hat{c}_H, \bar{x}_H) \leq U_L(\hat{c}_H, \bar{x}_L)$ so the fact that $\bar{x}_U$ is not necessarily optimal for a low-risk individual with contract $\hat{c}_H$ reinforces our argument. Likewise, if uninformed individuals prefer remaining uninsured over contract $\hat{c}_L$, a similar argument as provided in the text establishes $I_{cl} > 0$.

\textsuperscript{20} The same argument applies to a situation where informed low risks would prefer to remain uninsured over taking contract $\hat{c}_U$. If $e^0 = (0,0)$ denotes the “contract” representing no insurance, such a case would result in $V_L(e^0) > V_L(\hat{c}_U) = U_L(\hat{c}_U, \bar{x}_L) \geq U_L(\hat{c}_U, \bar{x}_U)$ and the second square bracket is still non-negative.
can do is to obtain the high-risk contract. They have nothing to lose from testing and if the results are favorable, they will decide to reveal them and receive a better contract. The only equilibrium is for consumers to become informed resulting in the equilibrium contracts \( \hat{c}_H \) and \( \hat{c}_L \). Prevention does not give rise to new equilibria under a consent law because the value of information is positive in the absence of prevention too (Doherty and Thistle, 1996). A similar equilibrium arises when consumers can engage in observable secondary prevention, see Lemma 2 in Barigozzi and Henriet (2011). We conclude that the value of information is positive under a consent law, regardless of the mechanism through which prevention operates and whether it is observable or not. We notice that, if there is a cost to testing, an equilibrium can exist in which consumers remain uninformed. We consider this possibility in the welfare analysis and show that our conclusions are robust to this extension, see Section 5.1.

### 3.4 Information Ban

Finally, we analyze an information ban (in short: ib), in which case insurers do not know whether consumers are informed and consumers cannot reveal any test results even if they are favorable. Such a situation corresponds to a complete ban of genetic information in insurance, and insurance companies are neither allowed to inquire whether tests have been taken, nor are they allowed to use existing genetic information in the underwriting process. In some countries, there are voluntary moratoria on the use of genetic information and in other countries there is an explicit government ban in place that completely prohibits the use of genetic information.

Under an information ban insurers need to anticipate consumers’ decisions. If insurers expect consumers to become informed \( b(z) = 1 \), they offer the separating contracts \( c_H^* \) and \( c_L^* \), which are purchased by informed high and low risks, respectively. The preference of the uninformed over these two contracts is not clear. If they choose \( c_H^* \), the value of information is:

\[
I_{ib} = \theta_H V_H(c_H^*) + \theta_L V_L(c_L^*) - V_U(c_H^*) = \theta_H U_H(\hat{c}_H, \bar{x}_H) + \theta_L U_L(c_L^*, \bar{x}_L) - U_U(\hat{c}_H, \bar{x}_U)
\]

\[
= \theta_H [U_H(\hat{c}_H, \bar{x}_H) - U_H(\hat{c}_H, \bar{x}_U)] + \theta_L [U_L(c_L^*, \bar{x}_L) - U_U(\hat{c}_H, \bar{x}_U)].
\]
We utilize the fact that \( c_H^* = \hat{c}_H \) and \( x_H^* = \hat{x}_H \) (no distortion at the top), whereas \( c_L^* \) can be different from \( \hat{c}_L \) due to adverse selection, see Section 2.3. The first square bracket is non-negative because \( \hat{x}_H \) is optimal for a high-risk agent at contract \( \hat{c}_H \) whereas \( \hat{x}_U \) is not necessarily optimal for a high-risk agent with this contract. The second term in square brackets is positive when \( c_L^* = \hat{c}_L \) because \( \hat{c}_L \) is the utility-maximizing contract for low risks in the feasible set. If \( c_L^* \neq \hat{c}_L \), the high-risk self-selection constraint is binding, \( V_H(\hat{c}_H, \hat{x}_U) < U_L(c_L^*, x_L^*) \), where the first inequality holds by definition of \( \hat{x}_L \) and the second results from single-crossing. Hence, the second term in square brackets is positive in either case so that the value of information is always positive.

Now assume that the uninformed prefer \( c_L^* \) over \( c_H^* \). Then, the value of information is:

\[
I_{ib} = \theta_H V_H(c_H^*) + \theta_L V_L(c_L^*) - V_U(c_L^*) = \theta_H U_H(\hat{c}_H, \hat{x}_H) + \theta_L U_L(c_L^*, x_L^*) - U_U(c_L^*, \hat{x}_U) \\
= \theta_H [U_H(\hat{c}_H, \hat{x}_H) - U_H(c_L^*, \hat{x}_U)] + \theta_L [U_L(c_L^*, x_L^*) - U_L(c_L^*, \hat{x}_U)].
\]

The first term in square brackets is non-negative due to the self-selection constraint on high risks, \( U_H(c_L^*, \hat{x}_U) \leq U_H(c_L^*, \hat{x}_H) \leq U_H(\hat{c}_H, \hat{x}_H) \). The second term in square brackets is non-negative due to the optimality of \( x_L^* \) for low risks with contract \( c_L^* \). The value of information is non-negative, the insurers’ belief is confirmed, and the market is in equilibrium.\(^{21}\)

The value of information under an information ban can be larger or smaller than under a duty to disclose or a code of conduct. However, we obtain a clear ranking between the value of information under an information ban and under a consent law. If the uninformed prefer \( c_H^* \) over \( c_L^* \), \( I_{cl} \) and \( I_{ib} \) only differ by \( \theta_L [V_L(\hat{c}_L) - V_L(c_L^*)] \), which is non-negative. If the uninformed prefer \( c_L^* \) over \( c_H^* \), it follows that \( I_{ib} \leq \theta_H V_H(c_H^*) + \theta_L V_L(c_L^*) - V_U(c_H^*) \), and we are in the first case. As a result, \( I_{cl} \geq I_{ib} \) with a strict inequality unless the second-best contracts under moral hazard already satisfy the self-selection constraints and the uninformed prefer the high-risk over the low-risk contract. Finally, the expectation of consumers staying uninformed can never be part of an equilibrium with the same argument as under a consent law. We collect these results in the following proposition.

\(^{21}\) A very similar argument shows that the value of information is positive if the uninformed prefer to remain uninsured over obtaining either contract \( c_H^* \) or \( c_L^* \).
Proposition 4. Under an information ban the value of information is non-negative. It does not exceed the value of information under a consent law.

Optimal contracts under adverse selection satisfy the self-selection constraints and individuals select effort optimally. This results in a non-negative value of information, which is strictly positive as soon as any of the comparisons involved in signing $I_{ib}$ is strict. Intuitively, whichever contract is preferred by the uninformed, they have nothing to lose from testing, even if they test positive and obtain the high-risk contract due to the self-selection constraint, and can only gain because they can adjust effort according to the new information they obtain from the test. The only equilibrium is for consumers to become informed resulting in the equilibrium contracts $c_H^*$ and $c_L^*$. In the absence of prevention, the value of information is zero (see Doherty and Thistle, 1996) because it does not have any decision-making value. If consumers can engage in observable secondary prevention, the equilibrium is for consumers to become informed, too (Lemma 3 in Barigozzi and Henriet, 2011). As under a consent law, an alternative equilibrium can arise if there is a cost associated with the taking of the test. We show that our welfare results continue to hold in such a situation, see Section 5.1.

4 Informational Incentives and Welfare Implications

4.1 Comparing the Value of Information

Having analyzed the various equilibria under the alternative policies, we now collect the results from the previous section about the value of information and rank the different policies by the incentive they provide for consumers to get tested. This will later inform the welfare analysis because it provides an overview of the different cases that can arise. We formalize this comparison in the following proposition.

Proposition 5. A consent law provides the strongest incentive for individuals to become informed ($I_{cl} > I_{da} \geq I_{cc}$ and $I_{cl} \geq I_{ib} \geq 0$ where the latter has at least one inequality strict) and is the only policy that always provides a positive incentive to become informed.
The reason for a consent law to provide such strong incentives is that the uninformed, being unable to provide verification of a negative test result, receive the high-risk contract under a consent law. If they test positive, they remain with this contract but adjust effort according to their new information about risk, and if they test negative, they have access to a more attractive contract. We also observe that informational incentives under a duty to disclose are larger than under a code of conduct \( (I_{dd} \geq I_{cc}) \) and that those under a consent law are larger than under an information ban \( (I_{cl} \geq I_{ib}) \). In both cases, informed low risks can use favorable results under the former policy but not under the latter resulting in potential adverse selection, which reduces the attractiveness of taking the test ex-ante. As our comparison shows this holds whether informational status is observed or not. Not surprisingly, allowing informed low-risk consumers to reveal favorable test results increases the value of information from taking the test. On the other hand, conditional on the use of test results, the inclusion of informational status in the underwriting process lowers the value of information \( (I_{dd} < I_{cl}) \). The reason is that uninformed consumers are better off if they are able to receive a contract that is fair for them, than if they can only obtain the high-risk contract for lack of a favorable test result. Then, they will have less of an incentive to become informed.

### 4.2 Welfare Comparison of the Alternative Policies

As we have seen, the use of information by insurers critically influences the value of information and the resulting equilibrium contracts on the market. We have also found that prevention expands the set of possible equilibria under those policies where the consumers’ informational status is observed. We will now proceed to Pareto rank the four policy regimes by evaluating social welfare. These welfare comparisons are \textit{ex ante}, that is, from the perspective of an uninformed individual.

Consider, for example, the comparison of a duty to disclose and a code of conduct. There are three cases depending on whether the value of information is positive or negative under each regime, which we summarize in Table 2. From Proposition 5 we know that \( I_{cc} > I_{dd} \) is not possible and does not have to be considered. The first column in Table 2 labels the different
cases, the second column specifies the case by comparing the value of information under each policy to zero, the third and fourth column provide the expected utility under each policy and the last column determines which policy is preferred based on a comparison of the expected utilities in columns three and four. If the value of information is negative under both policies (Case A), they yield the same market outcome and individuals are equally well off under either policy. If the value of information is non-negative under a duty to disclose and negative under a code of conduct (Case B), individuals are better off under a duty to disclose because \( I_{dd} \geq 0 \) rewrites as \( \theta_H V_H(\hat{c}_H) + \theta_L V_L(\hat{c}_L) \geq V_U(\hat{c}_U) \), with a strict inequality as soon as \( I_{dd} > 0 \). Finally, if the value of information is non-negative under both regimes (Case C), high risks are equally well off under both policies (no distortion at the top) and low risks are better off under a duty to disclose than under a code of conduct due to \( V_L(\hat{c}_L) \geq V_L(c_L^*) \), with a strict inequality as soon as adverse selection distorts the low-risk contract. Hence, market outcomes under a duty to disclose are at least as good in terms of social welfare as market outcomes under a code of conduct and strictly better in some cases. As a result, a duty to disclose is Pareto-preferred over a code of conduct.

Table 2. Comparison of a Duty to Disclose and a Code of Conduct.

The first column labels the different cases, the second one defines them based on the value of information, the third and fourth column state expected utility under each policy, and the last column provides the Pareto-preferred policy in terms of social welfare.

<table>
<thead>
<tr>
<th>Case</th>
<th>Welfare under a Duty to Disclose</th>
<th>Welfare under a Code of Conduct</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>( 0 &gt; I_{dd} \geq I_{cc} )</td>
<td>( V_U(\hat{c}_U) )</td>
<td>( V_U(\hat{c}_U) )</td>
</tr>
<tr>
<td>B</td>
<td>( I_{dd} \geq 0 &gt; I_{cc} )</td>
<td>( V_H(\hat{c}_H), V_L(\hat{c}_L) )</td>
<td>( V(\hat{c}_U) )</td>
</tr>
<tr>
<td>C</td>
<td>( I_{dd} \geq I_{cc} \geq 0 )</td>
<td>( V_H(\hat{c}_H), V_L(\hat{c}_L) )</td>
<td>( V_H(c_H^<em>), V_L(c_L^</em>) )</td>
</tr>
</tbody>
</table>

Duty to Disclose

The other policy alternatives can be compared in a similar fashion and the case-by-case analysis of the remaining pairs of policies is provided in Appendix B. We summarize our results in the following proposition.
Proposition 6. The policy regimes can be ex-ante Pareto ranked, with a duty to disclose preferred to a code of conduct and a consent law which are in turn preferred to an information ban. The code of conduct and the consent law regime are non-comparable.

Let us compare this result with the outcome in a situation where genetic testing does not have clinical value \((p_H \text{ and } p_L \text{ are fixed}).\) Crocker and Snow (1992) and Doherty and Thistle (1996) analyze the value of information in such a case and show that it depends on whether insurers are able to observe the consumers’ informational status. Under a duty to disclose and a code of conduct, the consumers’ informational status is observable, the value of information is negative \((I_{cc} < I_{dd} < 0),\) and consumers remain uninformed and realize expected utility of \(V_U(\hat{c}_U).\)\(^{22}\) Hence, a duty to disclose and a code of conduct induce the same level of social welfare. Under a consent law and under an information ban regime, consumers’ informational status is not observable. Under a consent law, the value of information is positive \((I_{cl} > 0),\) and individuals realize expected utility of either \(V_H(\hat{c}_H)\) or \(V_L(\hat{c}_L).\) Finally, under an information ban, the value of information is zero \((I_{ib} = 0).\) Individuals then become informed and realize expected utility of either \(V_H(\hat{c}_H)\) or \(V_L(\hat{c}_L).\) Now \(c_L^*\) offers only partial coverage and \(c_H^*\) coincides with \(\hat{c}_H,\) such that the market outcome under a consent law dominates the market outcome under an information ban. Furthermore, \(I_{dd} < 0\) rewrites as \(V_U(\hat{c}_U) > \theta_H V_H(\hat{c}_H) + \theta_L V_L(\hat{c}_L)\) so that the market outcome under a duty to disclose or a code of conduct each Pareto dominate the market outcome under a consent law. The overall conclusion is that, in the absence of prevention, both a duty to disclose and a code of conduct provide the highest level of social welfare, whereas an information ban is the worst policy.

Prevention alters this conclusion. An information ban still ranks lowest, but only a duty to disclose will always provide the highest level of social welfare. The reason is that the decision-making value of information allows for equilibria to arise where uninformed individuals become informed under a duty to disclose (Cases B and C in Table 2). If they decide to forego the test under a code of conduct (Case B), the decision not to test is inefficient and driven by

\(^{22}\) We abuse notation slightly here because in the absence of prevention there is, of course, no effort level.
the fact that informed low risks cannot use favorable results under a code of conduct. Similarly, if they decide to get tested (Case C), the testing decision is efficient but informed low risks realize a loss in expected utility due to the adverse selection cost imposed on them by unidentified high risks. Clearly, this efficiency cost is not incurred in the absence of prevention because staying uninformed is the optimal choice under both regimes.

We point out that the welfare ranking established in Proposition 6 coincides with that in Barigozzi and Henriet (2011), who consider an observable binary self-insurance activity. We conclude that the welfare economics of insurance markets with endogenous information, which has decision-making value, does neither depend on the channel through which this decision-making value operates (i.e., primary or secondary prevention) nor on whether it is observable by insurers or not. Given the broad variety of genetic diseases and the many different ways individuals can react to information about risk, our results broaden the applicability of previous findings considerably.

5 Some Extensions and Further Results

5.1 Costly Testing

Our focus so far was on costless genetic testing. If we introduce a cost associated with the taking of the test, new equilibria are possible but the welfare ranking of the different policies is robust. With a positive cost, the value of information under a duty to disclose and a code of conduct can be positive or negative, depending on the magnitude of the cost. Under a consent law or an information ban, the value of information is no longer uniformly non-negative because the cost of the test can lead to equilibria where it is rational to remain uninformed. The following paragraph discusses the implications of these new equilibria on the welfare ranking between the alternative policies.

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23 The cost of a genetic test is highly variable. For many tests, the cost can range from under $100 to $2,000 (NIH, 2017). The test for breast cancer can cost from $300 to $5,000 depending on the complexity of the test (breastcancer.org, 2017). The costs of tests for hereditary colon cancer range from under $400 to over $5,000 (hcctakesguts.org, 2017).
A duty to disclose still dominates a code of conduct, a consent law and an information ban. The argument between a duty to disclose and a code of conduct is the same as in Table 2. Also, whenever the value of information is non-negative under a consent law or an information ban, the argument to show that a duty to disclose dominates is identical to before. So we only need to compare a situation where the equilibrium is to remain uninformed under a consent law or an information ban, in which case all individuals receive contract \( \hat{c}_U \). If the value of information is negative under a duty to disclose (\( I_{dd} < 0 \)), the outcome on the insurance market is identical because everybody remains uninformed with expected utility of \( V_U(\hat{c}_U) \). If the value of information is non-negative (\( I_{dd} \geq 0 \)), individuals get tested under a duty to disclose because it makes them better off compared to staying uninformed and realizing expected utility of \( V_U(\hat{c}_U) \). Hence, a duty to disclose dominates the alternative equilibrium under a consent law or an information ban. A very similar argument shows that a code of conduct dominates the alternative equilibrium of consumers remaining uninformed under a consent law or an information ban. Finally, one can show with the same reasoning that a consent law dominates an information ban. We point out that the last comparison requires the assumption that the market settles for the equilibrium with the highest level of social welfare in those cases where more than one equilibrium is possible, consistent with the Nash equilibrium refinement of payoff dominance. This shows that the welfare ranking established in Proposition 6 extends to the case where there is a cost associated with the taking of the test.

5.2. Ex-ante Heterogeneity

The equilibria considered so far all share the property that uninformed individuals take the same testing decision at equilibrium. Although common in the literature on genetic test-

\footnote{For example, if \( \psi > 0 \) denotes the cost of testing, it is possible that both \( \theta_H V_H(\hat{c}_H) + \theta_L V_L(\hat{c}_L) - V_U(\hat{c}_H) - \psi \geq 0 \) and \( \theta_H V_H(\hat{c}_U) + \theta_L V_L(\hat{c}_U) - V_U(\hat{c}_U) - \psi < 0 \) hold simultaneously. Then, a consent law admits two equilibria, one in which consumers become informed and one where they do not. Under payoff dominance, we assume the market to settle on the outcome that yields the highest level of social welfare.}
ing, this property is not descriptive. One way to allow for different testing decisions at equilibrium is to introduce ex-ante heterogeneity in the cost of testing. Assume that a fraction \( \eta \in (0,1) \) of the uninformed faces a positive cost of testing, \( \psi > 0 \), whereas testing is costless for the remainder of the uninformed. Such an assumption can be motivated by anxiety or fear of testing, whose level can vary across individuals (see Caplin and Eliaz, 2003, Kőszegi, 2003, and Caplin and Leahy, 2004, for models along these lines).

To compare a duty to disclose and a code of conduct, we can analyze the two subgroups of uninformed consumers separately and infer from Table 2 and the discussion in Section 5.1 that a duty to disclose dominates a code of conduct. Under a consent law, if the equilibrium is for everybody to become informed, we know that a duty to disclose dominates whereas a code of conduct and a consent law are non-comparable. However, due to ex-ante heterogeneity, an equilibrium is possible under a consent law where only a fraction of the uninformed decides to get tested. Then, insurers are unable to distinguish informed high risks from uninformed individuals and have to set up self-selecting contracts between the two groups of consumers, resulting in potential rationing for the uninformed. Uninformed individuals for whom testing is costless decide to become informed under a consent law. It is possible they would not do so under a duty to disclose due to the better insurance contract they receive under the latter regime. Also, uninformed individuals for whom testing is costly remain uninformed under both regimes but also receive a better insurance contract under a duty to disclose. Hence, a duty to disclose dominates a consent law. Similar arguments show that a duty to disclose and a code of conduct dominate an information ban, even in cases where the testing decision is heterogeneous at equilibrium under an information ban. Likewise, a consent law dominates an information ban independent of whether the testing decision is heterogeneous at equilibrium or not. We conclude that, at least based on the simple extension developed in this section, the welfare ranking over the different policies is not sensitive to the property that uninformed consumers take a uniform testing decision at equilibrium.
5.3 Prevention Efforts

Finally, we wonder how the different policy alternatives affect the prevention effort undertaken by individuals. This is an important issue and we will show in the sequel that the comparison of effort levels hinges on the marginal productivity of effort for the different risk types. We reiterate the definition of the positive difference function $\delta(x) = p_H(x) - p_L(x)$. There is decreasing (constant, increasing) difference if $\delta'(x)$ is negative (zero, positive). Thus, in the decreasing difference case, the marginal product of effort is higher for high risks than low risks and preventive efforts carried out by high risks have a greater effect reducing the risk of disease than preventive efforts carried out by low risks. As it turns out, this leads the high risks to exert greater effort in equilibrium.

**Proposition 7:** Under decreasing difference, we have $\hat{x}_H > \hat{x}_U > \hat{x}_L$. Under constant (increasing) difference, we have $\hat{x}_H = \hat{x}_U = \hat{x}_L$ ($\hat{x}_H < \hat{x}_U < \hat{x}_L$).

The technical proof is provided in Appendix C. Consider the decreasing difference case. Under a duty to disclose with $I_{dd} > 0$ and a consent law, everybody becomes informed and high and low risks receive contracts $\hat{c}_H$ and $\hat{c}_L$, respectively, resulting in high risks exerting more effort than low risks. Under a duty to disclose with $I_{dd} < 0$ and a code of conduct with $I_{cc} < 0$, individuals remain uninformed, obtain contract $\hat{c}_U$, and exert an intermediate level of effort $\hat{x}_U$. Under a code of conduct with $I_{cc} > 0$ or an information ban, everybody becomes informed but, due to the adverse selection problem, the equilibrium contracts are $(c_H^*, c_L^*)$. The high-risk contract is unaffected by adverse selection such that high risks exert effort level $\hat{x}_H$. The high-risk self-selection constraint may or may not be binding. If it is, then low risks receive a lower net indemnity and pay a lower premium than under the contract that only reflects moral hazard. Due to the fact that $\partial \hat{x}_i / \partial \pi < 0$ and $\partial \hat{x}_i / \partial \beta < 0$, it follows that low-risk effort is higher under the contract $c_L^*$ than under the contract $\hat{c}_L$, that

---

25 Intuitively, the decreasing difference case is more realistic because it reflects a situation in which informed high risks have a higher decision-making value associated with the information than informed low risks. For example, if the low-risk probability is fixed and only high risks can exert effort, we are in a situation of decreasing difference. Ultimately, the sign of $\delta'(x)$ is an empirical question.
is $x^*_L \geq \hat{x}_L$. As stated in Proposition 7, the ranking over the effort levels with the moral-hazard contracts reverses under increasing difference, and similarly, low risks exert more effort whenever adverse selection results in further coverage rationing relative to contract $\hat{c}_L$.

6 Discussion and Conclusion

We analyze alternative public policies toward insurers’ use of genetic tests. The increasing availability and falling cost of genetic tests for a wide variety of different conditions will change the informational environment within which insurance markets operate. Some fear widespread “genetic discrimination” if insurance companies are allowed to use genetic test results for underwriting. On the other hand, insurance companies fear “regulatory adverse selection” if they cannot use genetic information but individuals make opportunistic insurance purchase decisions based on genetic test results. There is some evidence that both phenomena are occurring. There is a wide variety of regulatory regimes regarding the use of genetic test information depending on the jurisdiction and on the insurance market. We consider four policy alternatives, a duty to disclose, a code of conduct, a consent law and an information ban, all of which are in use in at least some insurance markets in some jurisdictions.

We analyze these policies in an economic environment where individuals can take unobservable preventive action (self-protection or primary prevention) to reduce the probability of becoming symptomatic. Other researchers have considered the case where precautions (self-insurance or secondary prevention) reduce the severity of the disease (Barigozzi and Henriet, 2011) and the case where prevention is not possible (Crocker and Snow, 1992, Doherty and Thistle, 1996). These analyses consistently lead to two conclusions.

First, a consent law provides the strongest incentive for individuals to become informed. The observability of consumers’ informational status and the decision-making value of information are the two main factors that determine the value of information. If informational status is observable, as under a duty to disclose and a code of conduct, then insurance companies can condition their contract offerings based on whether the consumer is informed or not, exacerbating the problem of classification risk. As a result, the value of information is
negative unless the information has sufficient decision-making value. If informational status is not observable, as under a consent law and an information ban, insurers cannot condition their contract offerings based on whether the individual is informed or not. Then the value of information is non-negative whether or not information has decision-making value. Under a consent law, uninformed individuals are treated as if they were high risks because they cannot provide verification of a negative test result; consequently, a positive test result cannot make individuals worse off.

Second, and more importantly, we are able to ex-ante Pareto rank the policy regimes based on the level of social welfare associated with the insurance market outcome they induce. We show that a duty to disclose Pareto dominates all other policy regimes whereas an information ban is Pareto dominated by all other regimes. Our results generalize existing findings considerably. The ultimate policy recommendation is the same for genetic tests where prevention is not possible as well as for genetic tests that allow for unobservable primary prevention or observable secondary prevention. The Pareto ranking of the different policy regimes emerges as a very robust property of insurance markets with endogenous information acquisition. Against the background of this conclusion, arguments in favor of an information ban must be based on the judgement that other, non-economic, considerations outweigh the economic efficiency cost of this policy. Whether the value of information is positive or negative, the equilibrium outcome under a duty to disclose is the best information-feasible policy under a very broad variety of circumstances.
References


Appendix A: Construction of a Locally Competitive Equilibrium

We formalize the notion of a locally competitive equilibrium as applied to our set-up and show rigorously that it can be characterized as explained in Section 2.3. A locally competitive equilibrium is a set of contracts $C$ such that when each $c \in C$ is offered on the market, (i) no contract $c \in C$ makes strictly negative expected profits, and (ii) there is an $\varepsilon > 0$ such that any $c'$ for which $\|c - c'\| < \varepsilon$ for any $c \in C$, would not make strictly positive profits (see Sandroni and Squintani, 2007).

Pooling can never be a locally competitive equilibrium. Assume that $C$ is a singleton, $C = \{\bar{c}\}$. Insurers must break even such that $\theta_H \Pi_H(\bar{c}) + \theta_L \Pi_L(\bar{c}) = 0$.\footnote{If aggregate profit was strictly positive, both risk types could be made better off and competitors would undercut insurers that offer $\bar{c}$.} If $\bar{x}_H$ and $\bar{x}_L$ denote the optimal effort levels for high and low risks at contract $\bar{c}$, then $p_H(\bar{x}_H) > p_L(\bar{x}_L)$ such that $M_H(\bar{c}) > M_L(\bar{c})$ and $\Pi_L(\bar{c}) > 0 > \Pi_H(\bar{c})$. It follows that we can find a local deviation of contract $\bar{c}$, which attracts low risks, does not attract high risks and still makes a positive profit on low risks. To construct such a local deviation, select $\alpha \in (M_L(\bar{c}), M_H(\bar{c}))$ and define $c' = \bar{c} - \varepsilon \cdot (1, 1/\alpha)$, i.e., reduce the premium of $\bar{c}$ by $\varepsilon$ and its net indemnity by $\varepsilon \cdot 1/\alpha$. Then, due to the envelope theorem it holds that

$$\frac{dV_i(c')}{d\varepsilon} \bigg|_{\varepsilon=0} = (1 - p_i(\bar{x}_i))u'(w - \bar{\pi}) \left[ 1 - \frac{M_i(\bar{c})}{\alpha} \right]$$

for a type $i$ individual where $\bar{\pi}$ denotes the premium of contract $\bar{c}$. From the choice of $\alpha$ it follows that high risks are locally worse off whereas low risks are locally better off. Due to continuity, we can also find a neighborhood of $\varepsilon = 0$ in which $c'$ is profitable when purchased by low risks only, which completes the argument.

Hence, we can focus on separating equilibria where low risks and high risks choose different contracts. For the sake of completeness we write out all relevant constraints and analyze which ones are binding in a locally competitive equilibrium. Let $c_L^* = (\pi_L, \beta_L)$ and $c_H^* = (\pi_H, \beta_H)$ be the contract for low and high risks, respectively, and $x_L^*$ and $x_H^*$ the associated effort levels. The contracts need to satisfy the principle of indemnity (PI) and the
non-negativity (NN), incentive compatibility (IC), non-negative profit (NP) and self-selection constraints (SS). These are given by:

\[ \pi_i + \beta_i \leq l_i, \ i \in \{H, L\} \]  
\[ \pi_i, \beta_i \geq 0, i \in \{H, L\} \]

\[ x_i^* = \text{arg max}_x U_i(c_i^*, x), \ i \in \{H, L\} \]

\[ \Pi_i(c_i^*) \geq 0, i \in \{H, L\} \]

\[ V_i(c_i^*) \geq V_j(c_j^*), i, j \in \{H, L\}, i \neq j \]

The constraints PI_H, PI_L, NN_H and NN_L are slack because full insurance is never optimal under moral hazard and some insurance is optimal even in the presence of moral hazard (see Winter, 2013). If \((\pi_i, \beta_i) = (0,0)\) and \(\tilde{x}_i\) denotes the optimal effort level for a type \(i\) individual at no insurance, we can increase the premium by \(\epsilon p_i(\tilde{x}_i)/(1 - p_i(\tilde{x}_i))\) and the net indemnity by \(\epsilon\), resulting in a local increase in expected utility due to

\[ \frac{dV_i(0,0)}{d\epsilon} \bigg|_{\epsilon=0} = p_i(\tilde{x}_i)[u'(w - l) - u'(w)] > 0. \]

If \((\pi_i, \beta_i) = (p_i(0)l, (1 - p_i(0))l)\), which is the utility maximizing full-insurance contract for a type \(i\) individual, then the marginal rate of substitution at this contract for a type \(i\) individual is given by \(M_i(\pi_i, \beta_i) = p_i(0)/(1 - p_i(0))\), which coincides with the slope of the ray that connects \((p_i(0)l, (1 - p_i(0))l)\) to the origin. Then, due to convexity of the feasible set, there is a local deviation that makes the individual strictly better off. The intuition is that the first marginal units of effort are very productive \(\lim_{x \to 0} p_i'(x) = -\infty\), which makes full insurance unattractive for lack of incentives. The constraints IC_H and IC_L hold because individuals chose effort optimally for a given contract. The constraints NP_H and NP_L must be binding because if there was a strictly positive profit, at least one of the two types of agents could be made better off by a local deviation. If both constraints, SS_H and SS_L, were binding, we would be in a situation with \(V_H(c_H^*) = V_H(c_L^*)\) and \(V_L(c_H^*) = V_L(c_L^*)\), which violates single-crossing.

Consequently, a locally competitive equilibrium is a pair of distinct contracts \(c_H^* = (\pi_H, \beta_H)\) and \(c_L^* = (\pi_L, \beta_L)\), such that \(c_L^* \in \text{arg max}_c V_L(c)\) subject to \(\Pi_L(c) = 0, V_H(c_H^*) \geq \).
$V_H(c)$; and $c^*_H \in \arg \max_{c'} V_H(c')$ subject to $\Pi_H(c') = 0, V_L(c^*_L) \geq V_L(c')$. Any other pair of contracts admits locally profitable deviations. Now assume that the low-risk self-selection constraint binds, that is $V_L(c^*_L) = V_L(c^*_H)$. Contract $c^*_H$ cannot be profitable if bought by low risks. If it were profitable such that $\Pi_L(c^*_H) > 0$, we can find a local deviation that makes low risks better off, contradicting with the fact that $c^*_L$ maximizes low-risk expected utility. As a result, $\Pi_L(c^*_H) \leq 0$ and $\Pi_H(c^*_H) = 0$. However, every contract that makes zero profits on high risks is profitable if bought by a low risk so that the only contract satisfying both conditions is the null contract, $c^*_H = (0,0)$. But then both high and low risks achieve the level of expected utility as induced by the null contract, which contradicts expected utility maximization as explained earlier. Therefore, the low-risk self-selection constraint is slack and the high-risk contract maximizes high-risk expected utility subject only to the non-negative profit constraint. In other words, $c^*_H = \hat{c}_H$ and $x^*_H = \hat{x}_H$, and adverse selection does not further distort the high-risk contract. Whether the high-risk self-selection constraint is binding or slack depends on the extent that moral hazard distorts the low-risk contract. If $\hat{c}_L$ attracts high risks, insurers would make losses when offering $\hat{c}_L$ and therefore the high-risk self-selection constraint binds in equilibrium, $V_H(c^*_H) = V_H(c^*_L)$ and $V_L(c^*_L) < V_L(\hat{c}_L)$. If $\hat{c}_L$ does not attract high risks, then $c^*_L = \hat{c}_L$ and $x^*_L = \hat{x}_L$ and adverse selection does not induce further distortions on the market besides those already present due to moral hazard (see also Cromb, 1990). Then, both self-selection constraints are slack, that is $V_H(c^*_H) > V_H(c^*_L)$ and $V_L(c^*_L) > V_H(c^*_H)$.

**Appendix B: Proof of Proposition 6**

The remainder of the proof consists of the pairwise comparison of the other alternative policies. We present the analysis in tables that cover all possible cases. The first column in each table labels the different cases, the second column specifies the case by comparing the value of information under each policy to zero, the third and fourth column provide the expected utility under each policy and the last column determines which policy is preferred based on a comparison of the expected utilities in columns three and four.
Table B1 compares social welfare under a duty to disclose and under a consent law. In Case A, individuals are better off under a duty to disclose than under a consent law because the fact that $I_{dd} < 0$ implies that $V_U(\hat{c}_U) > \theta_H V_H(\hat{c}_H) + \theta_L V_L(\hat{c}_L)$. The testing decision under a consent law is inefficient in this case and merely driven by the fact that the uninformed cannot obtain a contract tailored for them. In Case B, individuals are equally well off under both regimes. As a result, social welfare under a duty to disclose is at least as high as under a consent law and strictly higher in some cases. A duty to disclose is Pareto-preferred over a consent law.

Table B1. Comparison of a Duty to Disclose and a Consent Law

<table>
<thead>
<tr>
<th>Case</th>
<th>Welfare under a Duty to Disclose</th>
<th>Welfare under a Consent Law</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$I_{cl} &gt; 0 &gt; I_{dd}$</td>
<td>$V_U(\hat{c}_U)$</td>
<td>$V_H(\hat{c}_H),V_L(\hat{c}_L)$</td>
</tr>
<tr>
<td>B</td>
<td>$I_{cl} &gt; I_{dd} \geq 0$</td>
<td>$V_H(\hat{c}_H),V_L(\hat{c}_L)$</td>
<td>$V_H(\hat{c}_H),V_L(\hat{c}_L)$</td>
</tr>
</tbody>
</table>

Table B2 compares social welfare under a duty to disclose and under an information ban. In Case A, individuals are better off under a duty to disclose than under an information ban because $I_{dd} < 0$ implies that $V_U(\hat{c}_U) > \theta_H V_H(\hat{c}_H) + \theta_L V_L(\hat{c}_L) \geq \theta_H V_H(c_H^* \hat{c}_H) + \theta_L V_L(c_L^* \hat{c}_L)$. In Case B, individuals are better off under a duty to disclose because $V_L(\hat{c}_L) \geq V_L(c_L^* \hat{c}_L)$. Only if the second-best contracts under moral hazard already satisfy the self-selection constraints, then market outcomes under both regimes are identical in Case B. Social welfare under a duty to disclose is at least as high as under an information ban and strictly higher in some cases. A duty to disclose is Pareto-preferred over a consent law.

Table B2. Comparison of a Duty to Disclose and an Information Ban

<table>
<thead>
<tr>
<th>Case</th>
<th>Welfare under a Duty to Disclose</th>
<th>Welfare under an Information Ban</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$I_{ib} \geq 0 &gt; I_{dd}$</td>
<td>$V_U(\hat{c}_U)$</td>
<td>$V_H(c_H^<em>,V_L(c_L^</em>)$</td>
</tr>
<tr>
<td>B</td>
<td>$I_{dd}, I_{ib} \geq 0$</td>
<td>$V_H(\hat{c}_H),V_L(\hat{c}_L)$</td>
<td>$V_H(c_H^<em>,V_L(c_L^</em>)$</td>
</tr>
</tbody>
</table>
Table B3 compares social welfare under a code of conduct and under a consent law. In Case A, we cannot determine whether individuals are better off under a code of conduct or a consent law. The reason is that $I_{cc} < I_{dd}$ as long as $c_L^* \neq \hat{c}_L$ so that $I_{cc} < 0$ does not imply that $V_U(\hat{c}_U) > \theta_H V_H(\hat{c}_H) + \theta_L V_L(\hat{c}_L)$. In Case B, individuals are better off under a consent law than under a code of conduct due to $V_L(\hat{c}_L) \geq V_L(c_L^*)$. As a result, a code of conduct and a consent law are Pareto non-comparable.

Table B3. Comparison of a Code of Conduct and a Consent Law

<table>
<thead>
<tr>
<th>Case</th>
<th>Welfare under a Code of Conduct</th>
<th>Welfare under a Consent Law</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$I_{cl} &gt; 0 &gt; I_{cc}$</td>
<td>$V_U(\hat{c}_U)$</td>
<td>$V_H(\hat{c}_H), V_L(\hat{c}_L)$ Indeterminate</td>
</tr>
<tr>
<td>B</td>
<td>$I_{cl} &gt; I_{cc} \geq 0$</td>
<td>$V_H(c_H^<em>), V_L(c_L^</em>)$</td>
<td>$V_H(\hat{c}_H), V_L(\hat{c}_L)$ Consent Law</td>
</tr>
</tbody>
</table>

Table B4 compares social welfare under a code of conduct and under an information ban. In Case A, individuals are better off under a code of conduct because $I_{cc} < 0$ implies that $V_U(\hat{c}_U) > \theta_H V_H(c_H^*) + \theta_L V_L(c_L^*)$. In Case B, individuals are equally well off under both regimes. Social welfare under a code of conduct is at least as high as under an information ban and strictly higher in some cases. A code of conduct is Pareto-preferred over an information ban.

Table B4. Comparison of a Code of Conduct and an Information Ban

<table>
<thead>
<tr>
<th>Case</th>
<th>Welfare under a Code of Conduct</th>
<th>Welfare under an Information Ban</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$I_{ib} \geq 0 &gt; I_{cc}$</td>
<td>$V_U(\hat{c}_U)$</td>
<td>$V_H(c_H^<em>), V_L(c_L^</em>)$ Code of Conduct</td>
</tr>
<tr>
<td>B</td>
<td>$I_{cc}, I_{ib} \geq 0$</td>
<td>$V_H(c_H^<em>), V_L(c_L^</em>)$</td>
<td>$V_H(c_H^<em>), V_L(c_L^</em>)$ Code of Conduct</td>
</tr>
</tbody>
</table>

Finally, Table B5 compares social welfare under a consent law and under an information ban. Individuals are better off under a consent law due to $V_L(\hat{c}_L) \geq V_L(c_L^*)$. Only if the second-best contracts under moral hazard already satisfy the self-selection constraints, then
market outcomes under both regimes are identical because adverse selection between in-
formed high and low risks does not lead to further distortions in this case. Consequently, social welfare under a consent law is at least as high as under an information ban and strictly higher in some cases. A consent law is Pareto-preferred over an information ban.

Table B5. Comparison of Consent Law and Information Ban

<table>
<thead>
<tr>
<th>Case</th>
<th>Welfare under a Consent Law</th>
<th>Welfare under an Information Ban</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$I_{cl} \geq I_{lb} \geq 0$</td>
<td>$V_H(\hat{c}_H), V_L(\hat{c}_L)$</td>
<td>$V_H(c_H^<em>), V_L(c_L^</em>)$</td>
</tr>
</tbody>
</table>

In conjunction, the results in the text and the analyses in Tables B1 and B2 imply that a duty to disclose is Pareto superior to the other policy regimes. Tables B2, B4 and B5 show that an information ban is Pareto dominated by the other policy regimes. Finally, Table B3 demonstrates that the comparison of a code of conduct and a consent law is indeterminate. Overall, a duty to disclose is the best information-feasible policy whereas an information ban is the worst information-feasible policy.

Appendix C: Proof of Proposition 7

The strategy of the proof is to compute and sign $\frac{d \hat{x}_U}{d \theta_H}$. If we can show that $\hat{x}_U$ is mono-
tonic in $\theta_H$, we can use the fact that $\hat{x}_U = \hat{x}_H$ if $\theta_H = 1$ and that $\hat{x}_U = \hat{x}_L$ if $\theta_H = 0$ to infer the ranking over the different effort levels. The computation of $\frac{d \hat{x}_U}{d \theta_H}$ is complicated by the fact that the terms of the contract are endogenous, that is

$$\frac{d \hat{x}_U}{d \theta_H} = \frac{\partial \hat{x}_U}{\partial \theta_H} + \frac{\partial \hat{x}_U}{\partial \pi} \frac{d \pi}{d \theta_H} + \frac{\partial \hat{x}_U}{\partial \beta} \frac{d \beta}{d \theta_H}.$$

We first carry out the optimization to identify $\hat{c}_U$ explicitly and determine the effect of a marginal variation of $\theta_H$ on the terms of the insurance contract $(\pi, \beta)$. This will allow us to conclude how the optimal level of effort is affected at the margin. Due to compactness, the local result holds globally, enabling us to make the desired comparison of effort levels.
Contract $c_U$ maximizes the expected utility of an uninformed consumer subject to the incentive compatibility and the non-negative profit constraint. The first-order approach is valid because the first-order condition for optimal effort uniquely identifies the optimal behavior conditional on a given insurance contract. Furthermore, the non-negative profit constraint is binding due to competitive pressure. If $\lambda$ and $\mu$ denote the Lagrangian multipliers for the two constraints, the Lagrangian is given as follows:

$$\mathcal{L}(\pi, \beta, \lambda, \mu) = \left(1 - p_U(x)\right)u(w - \pi) + p_U(x)u(w - l + \beta) - \gamma(x) - \lambda \left[\left(1 - p_U(x)\right)\pi - p_U(x)\beta\right] - \mu \left[-p_U'(x)(u(w - \pi) - u(w - l + \beta)) - \gamma'(x)\right].$$

To compress notation, we use $w_L$ for wealth in the loss state, $w_N$ for wealth in the no-loss state, and $p$ for the probability of loss of an uninformed individual. The associated first-order conditions are given by:

- $\mathcal{L}_\pi = -(1 - p)u'(w_N) - \lambda (1 - p) - \mu p' u'(w_N) = 0$,
- $\mathcal{L}_\beta = p u'(w_L) + \lambda p - \mu p' u'(w_L) = 0$,
- $\mathcal{L}_\lambda = -(1 - p)\pi + p\beta = 0$,
- $\mathcal{L}_\mu = p' \left(u(w_N) - u(w_L)\right) + \gamma'(x) = 0$.

The third and fourth equation give the zero expected profit and the incentive compatibility constraints. The Hessian matrix of $\mathcal{L}$, denoted by $\mathcal{H}$, is given by:

$$\mathcal{H} = \begin{pmatrix}
(1 - p)u''(w_N) + \mu p' u''(w_N) & 0 & -(1 - p) & -p' u'(w_N) \\
0 & pu''(w_L) - \mu p' u''(w_L) & p & -p' u'(w_L) \\
-(1 - p) & p & 0 & 0 \\
-p' u'(w_N) & -p' u'(w_L) & 0 & 0 
\end{pmatrix}.$$  

Its determinant is $\det \mathcal{H} = (p')^2 \left(p u'(w_N) + (1 - p) u'(w_L)\right)^2 > 0$ and as a result, $\mathcal{H}$ is invertible.

We are interested in how marginal changes in $\theta_H$ affect the premium and the net indemnity of the optimal contract under moral hazard. With the help of the positive difference function, we can rewrite the probability of loss of the uninformed as follows:

$$p_U(x) = \theta_H p_H(x) + \theta_L p_L(x) = p_L(x) + \theta_H(p_H(x) - p_L(x)) = p_L(x) + \theta_H \delta(x).$$

This enables us to determine the following marginal effects on the first-order conditions:
\[ L_{\pi \theta_H} = \delta u'(w_N) + \lambda \delta - \mu \delta' u'(w_N), \]
\[ L_{\beta \theta_H} = \delta u'(w_L) + \lambda \delta - \mu \delta' u'(w_L), \]
\[ L_{\lambda \theta_H} = \delta (\pi + \beta), \]
\[ L_{\mu \theta_H} = \delta' (u(w_N) - u(w_L)). \]

To apply the implicit function rule, we only need the first and second row of the inverse of \( \mathcal{H} \) to determine how \( \pi \) and \( \beta \) react to changes in \( \theta_H \). Let \( \mathcal{H}^{-1} = \frac{1}{\det \mathcal{H}} (h_{ij})_{1 \leq i,j \leq 4} \). Then, with the help of the adjugate matrix of \( \mathcal{H} \) it follows that
\[
\begin{align*}
h_{11} &= h_{12} = 0, h_{13} = -(p')^2 u'(w_L) (pu'(w_N) + (1 - p)u'(w_L)) \quad \text{and} \\
h_{14} &= -p'p(u'(w_N) + (1 - p)u'(w_L)).
\end{align*}
\]

Therefore, the overall effect of a change in \( \theta_H \) on the premium \( \pi \) is given by
\[
\frac{d\pi}{d\theta_H} = -\frac{p'(pu'(w_N) + (1 - p)u'(w_L))}{\det \mathcal{H}} \left[ \delta(\pi + \beta)p'u'(w_L) + p\delta'(u(w_N) - u(w_L)) \right],
\]
which is sign ambiguous. It is negative under constant or decreasing difference. The second row of \( \mathcal{H}^{-1} \) is obtained as follows:
\[
\begin{align*}
h_{21} &= h_{22} = 0, h_{23} = (p')^2 u'(w_N) (pu'(w_N) + (1 - p)u'(w_L)) \quad \text{and} \\
h_{24} &= -p'(1 - p)(pu'(w_N) + (1 - p)u'(w_L)).
\end{align*}
\]
As a consequence, the overall effect of a change in \( \theta_H \) on the net indemnity \( \beta \) is
\[
\frac{d\beta}{d\theta_H} = -\frac{p'(pu'(w_N) + (1 - p)u'(w_L))}{\det \mathcal{H}} \left[ -\delta(\pi + \beta)p'u'(w_N) + (1 - p)\delta'(u(w_N) - u(w_L)) \right],
\]
which is sign ambiguous. It is positive under constant or increasing difference.

We are now in a position to determine the effect of a change in \( \theta_H \) on the optimal effort level. To this end we differentiate the first-order condition for optimal effort with respect to \( \theta_H \), which yields:
\[
-\delta'(u(w_N) - u(w_L)) - p' \left( u'(w_N) \left( -\frac{d\pi}{d\theta_H} \right) - u'(w_L) \frac{d\beta}{d\theta_H} \right).
\]
The first term measures how a stronger weight on the high-risk prevention technology effects prevention efficacy whereas the second term measures how a stronger weight on the high-risk probability of loss impacts the degree of risk sharing in the optimal insurance contract, which in turn modulates the marginal benefit of prevention. Using the expressions for
\[ \frac{d\pi}{d\theta_H} \text{ and } \frac{d\beta}{d\theta_H} \text{ and the expression for } \text{det } \mathcal{H}, \text{ we can simplify the second term as follows:} \]

\[ -p' \left[ u'(w_N) \left( -\frac{d\pi}{d\theta_H} - u'(w_L) \frac{d\beta}{d\theta_H} \right) \right] = -\delta' \left( u(w_N) - u(w_L) \right). \]

The total effect of a change in \( \theta_H \) on the first-order condition for optimal effort is then given by:

\[ -2\delta' \left( u(w_N) - u(w_L) \right). \]

This is positive (zero, negative) if we have decreasing (constant, increasing) difference such that optimal effort increases (stays constant, decreases). The result holds in a small open neighborhood of \( \theta_H \), but for any \( \theta_H \in [0,1] \). From the compactness of the unit interval, it follows that the optimal level of effort is uniformly increasing (constant, decreasing) in \( \theta_H \) if we have decreasing (constant, increasing) difference. This completes the proof.
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