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ESTIMATING THE VALUE OF PUBLIC INSURANCE USING COMPLEMENTARY PRIVATE INSURANCE

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ABSTRACT

The welfare associated with public insurance is often difficult to quantify because the demand for coverage is unobserved and thus cannot be used to analyze welfare. However, in many settings, individuals can purchase private insurance to supplement public coverage. This paper outlines an approach to use data and variation from private complementary insurance to quantify welfare associated with counterfactuals related to compulsory public insurance. We then apply this approach using administrative data on disability insurance. Our findings suggests that public disability insurance generates substantial surplus for the sample population, and there may be gains to increasing the generosity of coverage.

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Social insurance programs are ubiquitous and cover many of the largest risks individuals face. To determine the welfare generated by public insurance, it is important to quantify both the benefits and the costs of this insurance. While the costs of public insurance are relatively straightforward to calculate, the benefits of public insurance are often difficult to quantify. A fundamental difficulty is that public insurance is typically compulsory, so the demand for this non-market good is unobserved and thus cannot be used to infer the value individuals place on coverage. While a relatively large literature has worked to quantify welfare in private insurance markets, this difficulty may explain why there have been far fewer studies investigating the welfare associated with public insurance.

Several recent studies investigate welfare within private insurance markets (e.g., Hackmann, Kolstad and Kowalski (2015), Bundorf, Levin and Mahoney (2012), Einav, Finkelstein and Cullen (2010)). Although recent studies investigating welfare in private insurance settings use a range of methods, the commonality among these studies is that they use price variation to identify the demand for insurance and thus the value individuals place on coverage.[1] Perhaps because of the unique challenges that arise in the setting of compulsory public insurance, a recent literature on the welfare generated by compulsory public insurance has evolved independently of the literature on welfare in private insurance settings. A handful of recent studies have analyzed welfare within public insurance settings, such as Medicaid (Finkelstein, Hendren and Luttmer (2015)), unemployment insurance (e.g., Chetty (2008), Gruber (1997)), and disability insurance (Low and Pistaferri (2015), Chandra and Samwick (2005)). While these studies employ a range of approaches across these settings, all of these studies confront the fact that demand for compulsory public coverage is unobserved by making several critical assumptions on the nature of individual utility (or marginal utility), uncertainty, and heterogeneity to estimate welfare, often employing data on consumption or assets.[2] Importantly, these studies make several assumptions that can meaningfully affect the resulting analysis and are often difficult to empirically validate.

In this paper, we propose a complementary approach to analyzing the welfare associated with public insurance that leverages the fact that individuals can often purchase supplemental private insurance to top-up the benefits of compulsory public insurance. The basic idea behind this approach is simple: The existence of complementary private insurance allows us to extend standard willingness-to-pay approaches used in private insurance settings and apply these to welfare questions associated with compulsory public insurance. Relative to other approaches to value compulsory public insurance, the approach outlined in this paper requires minimal assumptions and can be implemented using commonly available data and straightforward variation.

While the existence of parallel private and public insurance is a necessary condition to implement this

[1]See Einav, Finkelstein and Levin (2010) for a review of the literature on welfare analysis in private insurance markets and a discussion of the various empirical methods employed in this literature.

[2]See Chetty and Finkelstein (2013) for a review of the recent literature on social insurance. In addition, see Finkelstein, Hendren and Luttmer (2015) for a discussion of some of the trade-offs between modeling assumptions and data requirements in conducting welfare analysis in compulsory public insurance settings.

approach, it turns out that this is a common feature of many social insurance programs in the United States and abroad.[3] Some of the largest social insurance programs in the United States have this feature including Medicare (private Medigap insurance), Social Security disability insurance (private long-term disability insurance), and Social Security retirement benefits (private annuities). The model of complementary public and private insurance is also very common outside of the United States, particularly in the context of universal public health insurance. Many countries that provide universal public health insurance also allow individuals to purchase complementary private health insurance coverage to top-up the incomplete public health insurance benefits including France, the Netherlands, Canada, Denmark, Japan, Switzerland, New Zealand, Italy, England, Norway, and Sweden.[4]

Intuitively, in settings in which individuals can purchase private complementary insurance, coverage decisions individuals make in the private supplemental insurance market can inform us about individuals' willingness-to-pay for extending the generosity of the compulsory coverage to include the benefits of supplemental insurance, and, in some settings, these decisions can inform us about individuals' underlying valuation of the inframarginal compulsory public coverage. Formalizing this intuition, this paper begins by outlining a framework which illustrates that data and variation from the market for supplemental insurance can be used to quantify welfare associated with several policy-relevant counterfactuals related to compulsory public insurance. We then apply this framework to the context of disability insurance using administrative data on enrollment and claims from one large employer that provides its employees long-term disability insurance that supplements the wage replacement benefits of public disability insurance.

Our modeling approach builds upon prior work by Einav and Finkelstein (2011) and Einav, Finkelstein and Cullen (2010). The key empirical inputs into the welfare analysis are the demand and cost curves associated with the private supplemental insurance market. We describe how these demand and costs curves can be used to evaluate marginal counterfactuals related to the incremental coverage sold in the existing market for supplemental insurance and to bound the surplus provided by the inframarginal compulsory public insurance. For instance, consider the welfare associated with extending the generosity of compulsory public insurance to include the coverage provided by private supplemental insurance. The existence of a private supplemental insurance market provides the opportunity to study the welfare from extending the generosity of public insurance to incorporate the coverage provided by supplemental insurance because we effectively observe a market

[3]Despite that fact that private insurance is often available to top-up compulsory public insurance, most of the prior literature on welfare analysis in compulsory public insurance settings abstracts from opportunities individuals have to purchase private complementary coverage. A notable exception is Chetty and Saez (2010) who characterize the impact of endogenous private insurance on the welfare associated with government intervention under a range of different modeling assumptions. In addition, a few recent papers have characterized the welfare associated with top-up supplemental insurance, including Cabral and Mahoney (2014) in the setting of Medigap coverage and Einav, Finkelstein and Williams (2016) in the setting of coverage for alternative options for breast cancer treatment.

[4]In some of these countries, private supplemental insurance covers the cost-sharing associated with services partially covered by the compulsory public insurance; in other countries, private supplemental insurance covers complementary services not covered by the compulsory public insurance (e.g., drugs, dental, out-of-network doctors/hospitals). For a detailed overview of parallel public and private health insurance internationally, see Thomson et al. (2013).

for the extension of this public coverage. Thus, we illustrate how a simple, straightforward extension of the Einav and Finkelstein (2011) framework can be used to investigate the welfare associated with an expansion of the generosity of compulsory public insurance, where we incorporate key features that can matter in this setting such as externalities induced by the supplemental insurance and crowd-out of the private supplemental insurance market.

Beyond examining a marginal extension of public insurance, we also outline an approach to study the total welfare generated by compulsory public insurance, which relies on the demand and cost curves associated with supplemental insurance (the same objects required to implement the marginal welfare analysis described above). Looking toward the empirical application to disability insurance, we focus attention on the case where public and private insurance provide coverage that is linear in the insured loss. We then derive a lower bound on the total surplus generated by the inframarginal compulsory public insurance coverage in terms of the demand and cost curves that can be estimated within the supplemental insurance market. This derivation relies on minimal assumptions on the nature of individual preferences, and we provide a simple and intuitive sufficient condition applicable when preferences are represented by a univariate utility function: utility exhibits non-increasing absolute risk aversion. Using a numerical example, we discuss the central trade-off between this bounding approach and a more structural approach to analyzing the welfare associated with the compulsory inframarginal public insurance. The bounding approach we outline is more robust in terms of perturbations in the underlying utility, risk distribution, and liquidity; however, this robustness comes at the cost of obtaining a lower bound on welfare rather than a precise welfare number. We note that in some applications this cost may be considerable if the lower bound is too loose to provide valuable insights.

Using administrative data from one large firm on employee long-term disability (LTD) insurance, we then apply this approach empirically to quantify the value of the wage replacement benefits of disability insurance among this population. Disability insurance is a particularly important setting in which to understand the welfare associated with insurance, as the threat of a career-ending disability is one of the largest financial risks many individuals face, and the public Social Security Disability Insurance (SSDI) program is one of the largest social insurance programs in the United States. In 2014, approximately 9 million disabled workers received SSDI benefits, and the total SSDI benefits paid exceeded $140 billion.[5] Despite the large size of this social insurance program, there has been very little research quantifying the welfare provided by disability

[5]Source: https://www.ssa.gov/policy/docs/statcomps/supplement/2015/highlights.pdf.

insurance.[6,7] In addition to the coverage available to workers through SSDI, 34% of US workers have the opportunity to purchase private supplemental LTD coverage through their employer to top-up the benefits of SSDI.[8] A typical empirical challenge to investigating the welfare associated with public SSDI coverage (relative to other social insurance programs) is that it is a national program with little variation in coverage across workers. Thus, disability insurance is a natural context to apply the framework described above as it allows us to use variation within employer-provided private supplemental LTD insurance to overcome this key empirical challenge and analyze the welfare associated with disability insurance.

We apply the welfare framework by leveraging premium variation and the subsequent decisions employees make in the context of LTD insurance at one large firm, Alcoa, Inc. There are several nice features of the setting of this empirical application. First, the firm offers salaried employees three vertically differentiated plans with wage replacement rates of 50%, 60%, and 70% in the event of disability. Second, the basic 50% replacement rate plan is free for employees. This is convenient as no one opts out of the plans, and thus claims data is available for all employees in the estimation population. Third, there is variation over time in the incremental premium for the highest generosity plan. This variation allows us to trace out the relative demand curves for an incremental 10% replacement rate, starting from a baseline 60% replacement rate. Fourth, the administrative data include information on disability claims in addition to disability insurance enrollment, so the demand estimates can be paired with cost data to evaluate welfare. Lastly, the firm's disability plans explicitly require workers to apply to SSDI and, if approved, SSDI benefits crowd-out LTD benefits dollar for dollar. In this way, the LTD plans at this firm top-up the compulsory public insurance, providing a natural interpretation to our estimates.

Using premium variation among the LTD policies available to employees, we find that the demand for supplemental disability coverage is price-sensitive. Our baseline estimates indicate that if the premium for the most generous LTD plan increases by 0.1% of annual earnings, enrollment would decline by 7 percentage points. This is precisely estimated and robust to controlling for time trends and individual fixed-effects. Based on our estimates, the implied mean willingness-to-pay for the incremental 10% replacement rate (starting from

[6]While there has been limited research on the consumption-smoothing benefits of disability insurance, there are a small number of recent related studies. A few recent papers document consumption changes in response to disability onset or major health shocks: Meyer and Mok (2013) document changes in consumption and income that follow a change in self-reported disability status using PSID data; Kostol and Mogstad (2015) document changes in income and consumption among denied and approved disability insurance applicants in Norway; Dobkin et al. (2017) document consumption changes following major hospitalizations, providing indirect evidence on individuals' exposure to disability-induced earnings losses. In addition, a few papers have investigated the ex ante welfare provided by disability insurance using calibrated life-cycle models (see Low and Pistaferri (2015), Chandra and Samwick (2005)). In another recent study, Autor et al. (2017) employ a structural model along with earnings and consumption data to estimate Norwegian disability insurance applicants' implied willingness-to-pay to be approved for disability insurance. In contrast to these few related papers which rely on consumption data and/or calibrated life-cycle models to infer the value of disability insurance, the approach in the present paper employs data and variation from the market for supplemental disability coverage to directly investigate the willingness-to-pay for disability insurance and the welfare associated with this coverage.

[7]While there has been relatively little research on the welfare associated with disability insurance, there has been extensive research on the causes and consequences of the vast growth in disability insurance rolls over time. See Autor and Duggan (2006) and Liebman (2015) for a review of this literature.

[8]These statistics are reported in Table 16 of the U.S. Department of Labor's National Compensation Survey, Employee Benefits in the U.S., March 2015 publication at: `http://www.bls.gov/ncs/ebs/benefits/2015/ownership/civilian/table16a.pdf`.

the baseline of 60% wage replacement) is roughly 0.31% of annual earnings, or $202 annually for a worker earning $65K a year (roughly the mean annual earnings in the estimation population). Based on these estimates, the total surplus generated by public insurance is at least 0.68% of annual earnings, or $440 annually for a worker with annual earnings of $65K. This bound is meaningful, as it indicates that the value individuals place on the compulsory public coverage is more than 2.5 times the cost of providing this coverage. It is important to emphasize that these estimates come from a particular population that is not representative of a broader set of workers. However, based on these estimates, compulsory public disability insurance is associated with benefits that far exceed the costs of this coverage for this employee population, and, for a plausible range of moral hazard elasticities, extending the generosity of compulsory public coverage would result in substantial welfare gains for these employees if they would not otherwise have access to employer-provided supplemental disability coverage. We demonstrate that these results are robust to a wide range of alternative specifications.

While the empirical results are specific to the population we examine, our analysis also highlights some general strengths of this approach for evaluating the welfare generated by compulsory public insurance. First, this method requires straightforward variation and limited data to be implemented empirically. Implementing this approach simply requires sufficient variation in the price of supplemental coverage to estimate the demand curve for supplemental coverage and standard data on prices, insurance enrollment, and costs. In contrast, other approaches to valuing public insurance often require isolating random (or like-random) assignment of benefits within the compulsory public insurance program and often require data on consumption or assets. Second, this approach does not require us to specify many of the underlying primitives of individuals' decisions, in contrast to other approaches of valuing compulsory public coverage which typically rely on fully specifying individual utility (or marginal utility), obtaining data on all the inputs in the utility (or marginal utility), specifying the uncertainty individuals face, and/or assumptions on the nature of individuals' optimization. Third, this approach can accommodate features of complementary public and private insurance in a range of settings. In settings with linear coverage, this approach can also be used to bound the welfare generated by the inframarginal compulsory public coverage under minimal assumptions.

Of course, this approach is not without limitations. A primary limitation of this approach is that it can only be applied in settings in which individuals are permitted to buy supplemental insurance coverage. While there are many public insurance settings in which individuals can buy complementary coverage (e.g., disability insurance, universal health insurance settings such as Medicare, etc.), there are some public insurance settings in which no complementary coverage is typically available (e.g., unemployment insurance, means-tested public insurance such as Medicaid), and in these settings this approach does not provide a constructive alternative to existing approaches for valuing compulsory public insurance.[9] Further, this approach is subject to the same challenges and limitations of welfare analysis based on revealed preference in private insurance markets more broadly. For instance, this approach relies on the notion of revealed preference to use demand estimates to conduct welfare analysis, which is subject to potential criticisms related to behavioral biases or information frictions. Moreover, empirical implementation of this approach requires isolating credible price variation and requires making some parametric assumptions when there is not sufficient price variation to estimate demand non-parametrically.[10]

The remainder of the paper proceeds as follows. Section 1 describes the framework for evaluating welfare. Section 2 describes the background and data for the empirical application. Section 3 describes the empirical strategy, and Section 4 presents the demand estimates and welfare analysis. Lastly, Section 5 concludes.

1 Framework

1.1 Model

Setup and Notation The setup of our framework draws heavily upon prior work by Einav and Finkelstein (2011) and Einav, Finkelstein and Cullen (2010). Suppose there is a population of heterogeneous individuals, indexed by φ. Let $G(\varphi)$ represent the distribution of the population. An important aspect of this approach is that heterogeneity across individuals is unrestricted. Importantly, this means φ may be multi-dimensional to include variation in preferences and risk, and there are no restrictions on G.

Individuals each face some continuous downside risk, where this absolute disposable income risk can vary arbitrarily across individuals.[11] Let w represent an individual's baseline income, which can also vary arbitrarily across individuals. Looking forward to our empirical application, let us consider linear insurance products where the generosity of insurance is indexed by the fraction of the risk covered by the insurance, so that a θ generosity policy covers θ% of the continuous underlying risk.[12] Specifically, consider a supplemental insurance product that provides δ generosity coverage on top of baseline public compulsory insurance coverage of generosity α, so that an individual who holds both the baseline and supplemental insurance has total coverage of generosity $\alpha + \delta$. Let $\pi(w, \theta, \gamma|\varphi)$ represent an individual's willingness-to-pay for coverage of generosity θ relative to the outside option of coverage of generosity γ. In this notation, we can represent the willingness-to-pay for supplemental coverage ($\pi(w, \alpha + \delta, \alpha|\varphi)$) and the willingness-to-pay for the compulsory baseline

[9] While supplemental insurance to top-up the benefits of compulsory public unemployment insurance is uncommon, supplemental unemployment insurance exists in Sweden and thus a similar approach to analyzing welfare could be useful in that setting.

[10] Section 1.3 discusses the advantages and limitations of this approach in greater detail.

[11] Our empirical application focuses on insurance for lost earnings due to disability, which represents a continuous downside disposable income risk. Disability is a continuous risk because disability shocks can vary in severity in terms of the duration of time that an individual is unable to work. Some disability spells are relatively short-lived (e.g., 2-3 years), while many disability spells are of a much longer duration often representing an absorbing state.

[12] While the framework is described in terms of linear contracts, all of the counterfactual welfare analysis related to the marginal coverage sold in the supplemental insurance market can easily be extended to non-linear insurance settings as discussed further below.

coverage ($\pi(w, \alpha, 0|\varphi)$). Throughout, we suppose that the underlying primatives are such that $\pi(w, \theta, 0|\varphi)$ is continuous and differentiable with respect to θ for all φ. Let $c(w, \theta, \gamma|\varphi)$ represent the expected cost borne by insurance providers for an individual with coverage of generosity θ relative to coverage of generosity γ. In this notation, we can describe the expected cost associated with an individual buying supplemental coverage as the sum of two components,

$$c(w, \alpha + \delta, \alpha|\varphi) = c^S(w, \alpha + \delta, \alpha|\varphi) + c^P(w, \alpha + \delta, \alpha|\varphi), \tag{1}$$

where $c^S(w, \alpha + \delta, \alpha|\varphi)$ is the expected cost to the supplemental insurer for providing this incremental coverage of generosity δ to the individual, and $c^P(w, \alpha + \delta, \alpha|\varphi)$ is the expected external cost associated with the individual having this incremental coverage which are borne by the primary insurer.[13] In the special case where the supplemental coverage is not associated with an externality on the primary insurer (with linear contracts, this is equivalent to the case of no moral hazard), then there is no external cost for the primary insurer, $c^P(w, \alpha + \delta, \alpha|\varphi) = 0$, and thus the total expected cost is simply the expected cost to the supplemental insurer, $c(w, \alpha+\delta, \alpha|\varphi) = c^S(w, \alpha+\delta, \alpha|\varphi)$. As will become clear, the framework outlined below accommodates ex post moral hazard that arises after the purchase of supplemental insurance. Importantly, we abstract from moral hazard that takes place prior to the supplemental insurance market decision.[14]

Supplemental Insurance Market: Demand, Costs, and Equilibrium Suppose each individual makes a discrete choice whether to buy supplemental insurance of generosity δ for (relative) price p or go with the outside option of the basic compulsory insurance of generosity α. Define the demand curve for this supplemental coverage as follows:

$$D(p|\alpha + \delta, \alpha) = \int \mathbb{1}\big(\pi(w, \alpha + \delta, \alpha|\varphi) \geq p\big) dG(\varphi), \tag{2}$$

where we assume the underlying primitives in the population are such that demand is decreasing, continuous, and differentiable. Throughout we ignore income effects associated with changes in the price of supplemental insurance.[15] As will become clear, the theoretical framework explicitly accommodates income effects associated with a change in the generosity of the inframarginal coverage.

Define the social marginal cost and social average cost curve for an insurance product that provides δ generosity coverage on top of a baseline coverage of generosity α as follows:

$$MC(p|\alpha + \delta, \alpha) = E[c(w, \alpha + \delta, \alpha|\varphi)|\pi(w, \alpha + \delta, \alpha|\varphi) = p] \tag{3}$$

$$AC(p|\alpha + \delta, \alpha) = \int c(w, \alpha + \delta, \alpha|\varphi)\mathbb{1}\big(\pi(w, \alpha + \delta, \alpha|\varphi) \geq p\big) dG(\varphi) \tag{4}$$

where the cost curves $MC(p|\alpha+\delta, \alpha)$ and $AC(p|\alpha+\delta, \alpha)$ represent the costs inclusive of those incurred by both

[13] Throughout the discussion, the cost of insuring an individual is treated as invariant to the insurer's identity. The model could easily be extended to incorporate systematic cost differences across insurers.

[14] For example, in the empirical application to employer-provided disability insurance, this would rule out that the existence of disability insurance may cause individuals to work in more risky occupations.

[15] Ignoring income effects from supplemental insurance premium variation allows us to use estimates of the Marshallian demand curve for supplemental insurance in the welfare analysis that follows. Abstracting from income effects may be reasonable in settings where the variation in premiums for supplemental insurance is small relative to income (as is the case in our empirical application).

the supplemental insurer and the primary insurer. We can also define the marginal and average cost curves for the supplemental insurer, who is only responsible for the incremental coverage:

$$MC^S(p|\alpha+\delta,\alpha) = E[c^S(w,\alpha+\delta,\alpha|\varphi)|\pi(w,\alpha+\delta,\alpha|\varphi)=p] \quad (5)$$

$$AC^S(p|\alpha+\delta,\alpha) = \int c^S(w,\alpha+\delta,\alpha|\varphi)\mathbb{1}\big(\pi(w,\alpha+\delta,\alpha|\varphi)\geq p\big)dG(\varphi) \quad (6)$$

Consider the benchmark case of perfect competition, where we define the equilibrium price P^{CE}, such that supplemental insurers break even on average,

$$P^{CE}(\alpha+\delta,\alpha) = min\{p : p = AC^S(p|\alpha+\delta,\alpha)\}. \quad (7)$$

1.2 Welfare Measures

Next, we apply the framework above to analyze welfare. First, we consider the welfare associated with the marginal coverage sold in the existing market for supplemental insurance and marginal counterfactuals involving extensions of the compulsory insurance to include this incremental coverage. We illustrate how a simple, straightforward extension of the Einav and Finkelstein (2011) framework can be used to investigate the welfare associated with an expansion of compulsory insurance, where we incorporate key features that can matter in the presence of parallel public and private insurance such as externalities induced by the supplemental insurance and crowd-out of the private supplemental insurance market. Second, we consider the welfare associated with the inframarginal coverage provided by the compulsory public insurance.

1.2.1 Marginal Coverage: Welfare From Extending the Generosity of Compulsory Public Insurance

A basic policy-relevant parameter of interest in social insurance settings is the value of extending the generosity of compulsory public insurance. In a setting in which the only insurance available is the baseline compulsory insurance of generosity α, the welfare from extending the generosity of the compulsory insurance coverage can be described using the notation above as,

$$\int \Big(\frac{\partial}{\partial\theta}\big(\pi(w,\theta,\gamma|\varphi)-c(w,\theta,\gamma|\varphi)\big)\Big|_{\theta,\gamma=\alpha}\Big)dG(\varphi). \quad (8)$$

In settings where individuals have access to complementary insurance, there is a direct empirical analogue to the objects in the expression above. Notice that the surplus generated by supplemental insurance for an individual, $\pi(w,\alpha+\delta,\alpha|\varphi)-c(w,\alpha+\delta,\alpha|\varphi)$, is simply a discretized version of $\frac{\partial}{\partial\theta}\big(\pi(w,\theta,\gamma|\varphi)-c(w,\theta,\gamma|\varphi)\big)\Big|_{\gamma,\theta=\alpha}$. In other words, relative to a benchmark of only compulsory insurance of generosity α, the social surplus associated with increasing the generosity of the compulsory coverage by δ for an individual is simply the social surplus associated with that individual purchasing supplemental insurance, $\pi(w,\alpha+\delta,\alpha|\varphi)-c(w,\alpha+\delta,\alpha|\varphi)$.

Note that equation 8 measures the welfare associated with a marginal extension of compulsory coverage relative to a benchmark scenario where only compulsory coverage exists (i.e., a world with no private supplemental insurance market). More generally, we may be interested in measuring the effect of extending the generosity of compulsory coverage relative to a benchmark scenario in which individuals are able to purchase private supplemental insurance themselves. This alternative benchmark scenario is of particular interest because a necessary condition for empirically implementing this approach is the existence of a private supplemental insurance market.

Let $Welfare\_Extn(p|\alpha+\delta,\alpha)$ represent the per-capita welfare associated with extending compulsory coverage to include the supplemental coverage relative to a benchmark scenario where private supplemental coverage is available for price p:

$$Welfare\_Extn(p|\alpha+\delta,\alpha) \quad = \quad \int \big(\pi(w,\alpha+\delta,\alpha|\varphi) - c(w,\alpha+\delta,\alpha|\varphi)\big)\mathbb{1}\big(\pi(w,\alpha+\delta,\alpha|\varphi) < p\big)dG(\varphi). \quad (9)$$

In words, the above expression for welfare tells us that the value of extending compulsory public insurance comes from aggregating individual values among people who would not have otherwise bought the private supplemental coverage. There are a few important points to highlight about the above expression. First, this expression nests the case in which no supplemental insurance is available (where effectively the price for supplemental insurance is infinite),

$$Welfare\_Extn(\infty|\alpha+\delta,\alpha) \quad = \quad \int \big(\pi(w,\alpha+\delta,\alpha|\varphi) - c(w,\alpha+\delta,\alpha|\varphi)\big)dG(\varphi). \quad (10)$$

Second, this expression provides an intuitive way to characterize how crowd-out affects the value of extending the generosity of public coverage. To see this, note that we can decompose this expression as follows:

$$\begin{aligned} Welfare\_Extn(p|\alpha+\delta,\alpha) \quad &= \quad Welfare\_Extn(\infty|\alpha+\delta,\alpha) \quad (11) \\ &- \quad \int \big(\pi(w,\alpha+\delta,\alpha|\varphi) - c(w,\alpha+\delta,\alpha|\varphi)\big)\mathbb{1}\big(\pi(w,\alpha+\delta,\alpha|\varphi) \geq p\big)dG(\varphi), \end{aligned}$$

where the first term represents the value of the extension if there were no private market available to crowd-out, and the second term represents crowd-out of the voluntary private market for supplemental insurance that would have existed in the absence of the compulsory public insurance extension.

Graphical Illustration We build intuition further through a graphical example in the spirit of Einav and Finkelstein (2011). For the moment let us abstract from moral hazard, meaning that the social and private cost curves are one and the same. Figure 1 Panel (A) plots the demand, marginal cost, and average cost curves where the horizontal axis represents the fraction with supplemental insurance, and the vertical axis is measured in dollars. For the purposes of this example, let us consider a private supplemental insurance market that is characterized by competitive average-cost pricing, and let us assume the market is adversely selected (as depicted in the figure by the downward sloping cost curves). In the absence of moral hazard, full insurance is optimal if individuals are risk averse and administrative costs are negligible.

Consider an extension of the compulsory coverage to include the benefits of the supplemental insurance coverage. It is straightforward to measure the objects of interest in the context of this example. Relative to a benchmark where no supplemental coverage is available, the welfare generated by this extension is: $Welfare\_Extn(\infty|\alpha+\delta,\alpha)$ = Area ABCD − Area EFCD. Relative to a benchmark of a competitive private supplemental insurance market, the welfare generated by extending compulsory coverage is:

$Welfare\_Extn(P^{CE}|\alpha+\delta,\alpha) = Welfare\_Extn(\infty|\alpha+\delta,\alpha) -$ Area AHIE, where this expression makes clear that the term (Area AHIE) represents crowd-out of the private supplemental market that otherwise would have existed.

There are several additional counterfactual scenarios one can consider within this graphical example. For instance, fixing the level of compulsory public coverage, the welfare associated with allowing a private supplemental insurance market relative to banning supplemental coverage is represented by the trapezoid AHIE. Relative to the first-best efficient allocation, a private competitive market for supplemental coverage is associated with welfare losses due to adverse selection represented by the trapezoid HBFI. It is also straightforward to generalize this graphical example along several dimensions. For instance, Figure 1 Panel (B) illustrates a setting with moral hazard, in which the supplemental insurer does not internalize the full cost of the incremental insurance it provides. Thus, a supplemental insurer's cost curves lie below the social cost curves for the incremental coverage, where the vertical distance between these curves represents the externality associated with the supplemental coverage. While the optimal allocation is different than in the situation with no moral hazard, the points have been re-labeled to emphasize that the analogous welfare measures associated with extending the generosity of compulsory insurance are represented as in the discussion above.

1.2.2 Inframarginal Coverage: Welfare Generated by Compulsory Public Insurance

Beyond estimating the welfare associated with extending the generosity of compulsory public insurance, we may also be interested in estimating the welfare associated with the inframarginal compulsory public coverage. Below, we derive a lower bound on the total surplus generated by compulsory public insurance relative to the absence of insurance for this risk using data and variation from supplemental private insurance.[16]

Once again, consider a setting in which compulsory public insurance provides coverage α and supplemental coverage of generosity δ is available for price p. Our primary focus is to investigate the welfare provided by the baseline compulsory coverage relative to a world with no insurance for this risk:

$$Welfare\_Baseline(p|\alpha+\delta,\alpha) = \int \Big\{ \big(\pi(w,\alpha,0|\varphi) - c(w,\alpha,0|\varphi)\big)\mathbb{1}\big(\pi(w,\alpha+\delta,\alpha|\varphi) < p\big) + \big(\pi(w,\alpha,0|\varphi) - \frac{\alpha}{\alpha+\delta}c(w,\alpha+\delta,0|\varphi)\big)\mathbb{1}\big(\pi(w,\alpha+\delta,\alpha|\varphi) \geq p\big)\Big\} dG(\varphi). \quad (12)$$

The first term in the expression above captures the value of compulsory public coverage among individ-

[16] In the interest of investigating counterfactuals requiring minimal assumptions, our primary focus is to investigate welfare provided by the baseline compulsory coverage relative to a world with no insurance for this risk. Note that this welfare measure does not necessarily represent the value of compulsory public insurance relative to a world without this compulsory insurance, as it could be the case that alternative private insurance or alternative public programs providing coverage for this risk would exist in the absence of compulsory public insurance. The welfare measure we focus on may characterize the welfare associated with compulsory public insurance more generally in insurance settings in which there is a large degree of private information, in which we might expect complete (or nearly complete) unraveling of private insurance in the absence of public coverage. For instance, this is arguably the relevant case for disability insurance and long-term care insurance, as Hendren (2013) argues that the large degree of asymmetric information in these settings can explain the almost complete unraveling of private, non-group insurance for these risks. Because nothing about the observed supplemental insurance market can reveal what private or public coverage might exist in the absence of the compulsory public insurance, we avoid making arbitrary assumptions about such a counterfactual and focus instead on the surplus generated by the inframarignal compulsory public insurance relative to a world with no insurance for this risk.

uals who do not buy supplemental insurance, and the second term captures the value of compulsory public coverage among individuals who purchase supplemental insurance at price p.[17] Note that it is relatively straightforward to estimate costs in the expression above. The observed claim costs for those with and without insurance could be used to estimate costs for this bound under the status quo allocation of supplemental insurance (Einav, Finkelstein and Cullen (2010)). If one wanted to estimate the bound under a counterfactual allocation of supplemental insurance, one would need to predict costs leveraging an estimate of (or assumption regarding) moral hazard. The key challenge to estimating the equality above is the fact that the willingness-to-pay for the baseline coverage, $\pi(w, \alpha, 0|\varphi)$, is unobserved. To be able to empirically use this measure of welfare, we need to have a way to connect what we can estimate in the data to the objects in the above expression. The proposition below helps us do this.

Proposition 1. For an individual represented by φ, define the demand for insurance generosity on the intensive margin: $v(w, \theta|\varphi) \equiv \frac{\partial}{\partial\theta}\pi(w, \theta, 0|\varphi)$. Suppose that (i) $v(w, \theta|\varphi)$ is weakly decreasing in θ, and (ii) $v(w, \theta|\varphi)$ is weakly decreasing in w. Then,

$$\pi(w, \alpha, 0|\varphi) \geq \frac{\alpha}{\delta}\pi(w, \alpha + \delta, \alpha|\varphi). \tag{13}$$

Proof. Note that $\pi(w - \pi(w, \alpha, 0|\varphi), \alpha + \delta, \alpha|\varphi) \equiv \pi(w, \alpha + \delta, 0|\varphi) - \pi(w, \alpha, 0|\varphi)$.[18] Under the assumptions in the proposition, we get

$$\begin{aligned}\frac{\pi(w, \alpha, 0|\varphi)}{\alpha} &= \frac{1}{\alpha}\int_0^\alpha v(w, \theta|\varphi)d\theta \geq v(w, \alpha|\varphi) \geq \frac{1}{\delta}\int_\alpha^{\alpha+\delta} v(w, \theta|\varphi)d\theta \\ &= \frac{\pi(w - \pi(w, \alpha, 0|\varphi), \alpha + \delta, \alpha|\varphi)}{\delta} \geq \frac{\pi(w, \alpha + \delta, \alpha|\varphi)}{\delta},\end{aligned}$$

where the first two inequalities follow from assumption (i) and it is straightforward to show the final inequality follows from additionally assuming (ii) holds. □

Proposition 1 provides us a way to empirically bound the welfare provided by the inframarginal coverage. To see this, note that the left-hand-side of inequality 13 is the key unknown in equation 12 , while the right-hand-side of this inequality is a linear transformation of the willingness-to-pay for supplemental coverage, $\pi(w, \alpha + \delta, \alpha|\varphi)$, an object whose distribution one can estimate with sufficient data and variation from the private supplemental insurance market. To make this result concrete, consider the following example: Suppose that compulsory public insurance covers 60% of some risk and supplemental insurance covers an additional 10% of the risk. Applying Proposition 1, we get that an individual's willingness-to-pay for compulsory public

[17]Note that one could use a broader measure of welfare associated with public insurance if one accounted for the indirect value of public insurance through allowing for a supplemental market in which individuals may buy supplemental coverage (as the existence of the supplemental market is an indirect consequence of the public coverage).

[18]The willingness-to-pay for supplemental coverage is implicitly defined as the difference between the willingness-to-pay for $\alpha + \delta$ coverage and the willingness-to-pay for α coverage, with an appropriate shift in the income at which these expressions are evaluated: $\pi(w - \pi(w, \alpha, 0|\varphi), \alpha + \delta, \alpha|\varphi) \equiv \pi(w, \alpha + \delta, 0|\varphi) - \pi(w, \alpha, 0|\varphi)$. Intuitively, this definition follows from the fact that the willingness-to-pay for $\alpha + \delta$ coverage ($\pi(w, \alpha + \delta, 0|\varphi)$), is the sum of the willingness-to-pay for α coverage ($\pi(w, \alpha, 0|\varphi)$) and the willingness-to-pay for the incremental coverage at a lower effective income ($\pi(w - \pi(w, \alpha, 0|\varphi), \alpha + \delta, \alpha|\varphi)$). By ruling out large income effects that operate in the direction of undermining the bounding strategy, assumption (ii) allows us to connect the willingness-to-pay for the supplemental coverage to the marginal willingness-to-pay for the baseline coverage.

insurance is at least six times his/her willingness-to-pay for the incremental coverage sold in the supplemental market. More generally, we get the following natural corollary defining a population-level bound on the welfare provided by the compulsory baseline coverage:

Corollary 1. If $\pi(w,\alpha,0|\varphi) \geq \frac{\alpha}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi), \forall\varphi$, then:

$$Welfare\_Baseline(p|\alpha+\delta,\alpha) \geq \int \Big\{ \big(\frac{\alpha}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi) - c(w,\alpha,0|\varphi)\big)\mathbb{1}\big(\pi(w,\alpha+\delta,\alpha|\varphi) < p\big) + \big(\frac{\alpha}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi) - \frac{\alpha}{\alpha+\delta}c(w,\alpha+\delta,0|\varphi)\big)\mathbb{1}\big(\pi(w,\alpha+\delta,\alpha|\varphi) \geq p\big)\Big\} dG(\varphi). \quad (14)$$

The assumptions behind Proposition 1 have a simple intuitive basis and are related to concepts in the prior theoretical literature related to decisions under uncertainty.[19] The first assumption states that an individual's demand for insurance generosity is weakly downward sloping. The second assumption says that an individual's demand for insurance generosity for a fixed risk is weakly declining with his/her baseline income. In the case that preferences can be represented by a univariate utility function, we obtain an alternative sufficient condition in terms of utility for applying this bound:

Proposition 2. Suppose an individual's utility can be represented by the increasing, thrice differentiable function $u(c)$. Define $\pi(w,\theta,\gamma|\varphi)$ as: $E[u(w+(1-\theta)x - \pi(w,\theta,\gamma|\varphi))] = E[u(w+(1-\gamma)x)]$, where $\theta > \gamma$ and the expectation is taken over $x \leq 0$, representing the uncertain losses the individual faces. Additionally, suppose the individual is risk averse and his/her utility exhibits weakly decreasing absolute risk aversion. Then,

$$\pi(w,\alpha,0|\varphi) \geq \frac{\alpha}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi). \quad (15)$$

and thus we obtain the bound in Corollary 1.

Proof. See Appendix A. □

The propositions above give us two alternative conditions under which we can apply a simple method to bound the welfare generated by compulsory public insurance using information from the associated private supplemental insurance market. There are a few important points to note. First, the key assumption within Proposition 2 is weakly decreasing absolute risk aversion, which is satisfied by most of the common utility functions used by empiricists, including Constant Absolute Risk Aversion (CARA), Constant Relative Risk Aversion (CRRA), and a broader class of empirically relevant Hyperbolic Absolute Risk Aversion (HARA) utility functions.[20] Second, the sufficient condition in Proposition 2 applies when utility is defined over a single

[19] Perhaps because it is so intuitive that an individual's willingness-to-pay to avoid taking on risk should scale with the size of the risk, prior theoretical papers have worked to derive sufficient conditions on utility functions such that the underlying preferences satisfy similar properties to the properties we study here. See Eeckhoudt and Gollier (2001) and Menezes and Hanson (1970) for examples. While much of the related theoretical literature focuses on risks with both positive and negative realizations (as is applicable in a finance setting), we show that in the context of an insurance problem (where all realizations of risk are non-positive), we obtain a simple sufficient condition for the assumptions within Proposition 1 when preferences can be represented by a univariate utility function (see Proposition 2).

[20] The general version of the HARA family is characterized by a utility function of the following form: $u(c) = \xi(\nu + \frac{c}{\gamma})^{1-\gamma}$. The absolute risk aversion for this family is then equal to $r_A = (\nu + \frac{c}{\gamma})^{-1}$, which is clearly weakly decreasing in c for all parameter values for which the individual is risk averse over the entire range of possible consumption values. Note the values for which the individual is risk averse are those that satisfy: $\xi(1-\gamma)\gamma^{-1}(\nu + \frac{c}{\gamma})^{-\gamma-1} \geq 0, \quad \forall c \geq 0$.

argument. Most of the theory surrounding decisions under uncertainty is developed within the setting of univariate utility, and Proposition 2 follows in this spirit. In situations in which consumers face more complicated optimization problems with utility defined over multiple goods, as is the case in insurance models with moral hazard, one would want to directly rely on the assumptions on the demand for insurance within Proposition 1 to obtain the lower bound on the welfare provided by the inframarginal coverage.

Regardless of whether one relies on the conditions within Proposition 1 or Proposition 2 to implement the welfare bound, it is important to emphasize that this bounding approach does not require specifying particular individual utility/demand functions or restricting heterogeneity across individuals. In other words, each individual may have his/her own distinct utility/demand function that varies arbitrarily throughout the population, so long as each individual's preferences exhibit weakly decreasing absolute risk aversion (or more generally, satisfy the conditions on demand for insurance generosity within Proposition 1), the lower bound on welfare described in Corollary 1 above is applicable.

Graphical Illustration Figure 2 illustrates Proposition 1 graphically. Consider a fixed individual indexed by φ. This figure displays the individual's demand for insurance on the intensive margin (e.g., the marginal valuation $v(w, \theta|\varphi) = \frac{\partial}{\partial \theta}\pi(w, \theta, 0|\varphi)$), where the horizontal axis represents the generosity of insurance (θ) and the vertical axis is measured in dollars. As in Proposition 1, suppose that (i) $v(w, \theta|\varphi)$ is weakly decreasing in θ, and (ii) $v(w, \theta|\varphi)$ is weakly decreasing in w. Recall, our goal is to use the observed data to investigate the willingness-to-pay for the inframarginal compulsory coverage: $\pi(w, \alpha, 0|\varphi) = \int_0^\alpha v(w, \theta|\varphi)d\theta$.

Suppose that data and variation within the supplemental insurance market allows us to estimate the individual's willingness-to-pay for supplemental insurance $\pi(w, \alpha + \delta, \alpha|\varphi)$. Under assumptions (i) and (ii), the willingness-to-pay for supplemental coverage scaled by the amount of supplemental coverage, $\frac{\pi(w,\alpha+\delta,\alpha|\varphi)}{\delta}$, provides an (under)estimate of the mean value of $v(w, \theta|\varphi)$ for $\theta \in [\alpha, \alpha + \delta]$, represented by point A in Figure 2. While we have an estimate for point A, we cannot identify the function representing the individual's demand for insurance, $v(w, \theta|\varphi)$, without further assumptions, as the true function could be $v_1(w, \theta|\varphi)$ or $v_2(w, \theta|\varphi)$ or any other function that passes through point A. However, as long as the individual's demand for coverage is downward sloping, we obtain the lower bound on the individual's willingness-to-pay for the inframarginal coverage in Proposition 1: $\pi(w, \alpha, 0|\varphi) \geq \frac{\alpha}{\delta}\pi(w, \alpha + \delta, \alpha|\varphi) =$ Area DEBC.

To fully evaluate the net welfare from the inframarginal coverage for this individual, we must consider the costs associated with this coverage accounting for any moral hazard induced by this coverage. Figure 2 represents a context with moral hazard, where the marginal cost of coverage $\frac{\partial}{\partial \theta}c(w, \theta, 0|\varphi)$ is upward sloping.[21] The efficient generosity level is represented by the intersection of the demand and marginal cost curves. The expected cost associated with the compulsory inframarginal coverage for this individual will depend on whether

[21]If there were no moral hazard, $\frac{\partial}{\partial \theta}c(w, \theta, 0|\varphi)$ would be constant as a function of θ.

the individual has supplemental insurance. If the individual does not have supplemental insurance, the expected cost associated with the baseline coverage is: $c(w, \alpha, 0|\varphi)$ =Area LJBC; if the individual does have supplemental insurance, the expected cost associated with the baseline coverage is: $\frac{\alpha}{\alpha+\delta}c(w, \alpha+\delta, 0|\varphi) = \frac{\alpha}{\alpha+\delta}$ (Area LKMC). Thus, the net welfare associated with the baseline coverage for this individual would be bounded below by $\big($Area DEJL$\big)$ if the individual has no supplemental coverage or $\big($Area DEBC$-\frac{\alpha}{\alpha+\delta}$ (Area LKMC)$\big)$ if the individual does have supplemental insurance.

Figure 2 also illustrates that the tightness of the bound on the surplus associated with the inframarginal coverage will depend on several factors. First, fixing the observed willingness-to-pay for supplemental insurance, the tightness of the bound will depend on the individual's unobserved demand for insurance. For instance, in the graphical illustration the bound would be tighter if the individuals true underlying demand was represented by $v_2(w, \theta|\varphi)$ (where $\pi(w, \alpha, 0|\varphi) =$ Area FHBC) than if his/her demand was as in $v_1(w, \theta|\varphi)$ (where $\pi(w, \alpha, 0|\varphi) =$ Area IGBC). Second, fixing the unobserved demand for insurance, the figure illustrates that the lower bound is tight for low values of α and becomes very loose as α approaches the efficient generosity level (which is 100% absent moral hazard, but lower otherwise).[22] An implication of this is that, all else equal, we would expect to obtain a tighter lower bound in settings where supplemental insurance tops up very incomplete compulsory insurance than in settings where supplemental insurance tops up very generous compulsory insurance. We present a numerical example below that illustrates how the tightness of this bound can vary under a range of assumptions on the underlying utility and decision environment.

Numerical Example Next, we consider a numerical example to compare the bounding approach to a more structural approach that specifies all the underlying primitives to illustrate the trade-offs between these complementary approaches more concretely. Consider an individual indexed by φ who faces some potential loss and has compulsory public insurance that covers 60% of this risk. Further, suppose the individual has the option to purchase private supplemental insurance to cover an additional 10% of the risk on top of the public insurance. Supposing that the conditions within Proposition 1 hold, the individual's willingness-to-pay for the infrmarginal coverage is at least six times his/her willingness-to-pay for the supplemental coverage, and thus the individual's surplus associated with the inframarginal coverage is at least six times the surplus associated

[22] To more precisely characterize the tightness of the bound in our discussion below, we define the surplus ratio as: *surplus ratio*= $\frac{\pi(w,\alpha,0|\varphi)-c(w,\alpha,0|\varphi)}{\text{Bound}\left(\pi(w,\alpha,0|\varphi)-c(w,\alpha,0|\varphi)\right)}$. The surplus ratio describes how tight the lower bound is under a given set of assumptions, with a smaller ratio indicating a tighter bound. As can be seen in Figure 2, the surplus ratio will be close to 1 for small values of α and will be very large as α approaches the efficient generosity level. In the special case of linear demand for insurance generosity and no moral hazard, the surplus ratio is monotonically increasing in α. The surplus ratio need not be monotonically increasing in α for a downward sloping demand function more generally, though we find that the surplus ratio is monotonically increasing in α under the range of assumptions analyzed within the numerical example below (see Appendix Figure A1). In the special case that the demand for insurance generosity is linear and there is no moral hazard, the surplus ratio is equal to $\frac{2-\alpha}{(2-\delta)-2\zeta}$, when α represents the compulsory insurance generosity and the willingness-to-pay for supplemental insurance is measured over the range of coverage $(\zeta, \zeta+\delta)$. The surplus ratio in the special case with linear demand and no moral hazard is equal to 2.4 for $(\alpha, \zeta, \delta) = (0.34, 0.60, 0.10)$, which is the relevant range for the empirical application. Thus, if the demand for insurance generosity were linear and there were no moral hazard, then the lower bound we estimate would capture roughly 40% of the welfare associated with the inframarginal compulsory coverage. While the key advantage of the bounding approach is that we do not need to specify the functional form of the demand for insurance on the intensive margin, this suggests our estimated bound may be fairly conservative.

with the supplemental coverage. This bound is applicable regardless of the distribution of uncertainty, the specific form of utility, and access to liquidity.

Suppose we observe (or have a reliable estimate for) an individual's willingness-to-pay for supplemental insurance and the expected cost associated with this insurance. For a given willingness-to-pay for supplemental insurance, Table 1 reports the calibrated value of the inframarginal coverage under various assumptions on the underlying utility function, liquidity, and risk. For each scenario considered, the table also displays the *surplus ratio*, which we define as the ratio of the surplus from the inframarginal coverage under the stated assumptions to the lower bound on surplus from the inframarginal coverage derived under Proposition 1 (*surplus ratio*= $\frac{\pi(w,\alpha,0|\varphi)-c(w,\alpha,0|\varphi)}{\text{Bound}\left(\pi(w,\alpha,0|\varphi)-c(w,\alpha,0|\varphi)\right)}$). The surplus ratio describes how tight the lower bound is under a given set of assumptions, with a smaller ratio indicating a tighter bound. To ease comparisons across the sets of assumptions, each distribution of risk we consider has the same expected cost: \$8 for each 1 percentage point of insurance coverage.

Fixing the willingness-to-pay for supplemental insurance at \$100, Figure 3 displays the numerical analogue of Figure 2 under the range of assumptions considered in Table 1. Specifically, this figure displays the marginal cost and marginal valuation of insurance generosity on the intensive margin, where units are scaled to represent dollars per 1 percentage point of insurance coverage. Given a willingness-to-pay for supplemental insurance of \$100, an (under)estimate of the individual's mean marginal valuation of insurance for a 1 percentage point increase in coverage is \$10 over the range $\theta \in$[0.6, 0.7]. Based on Proposition 1, the lower bound on the individual's valuation of the inframarginal 60% coverage is \$600 $\left(\pi(w, 0.6, 0|\varphi) \geq 6 \times \pi(w, 0.7, 0.6|\varphi)\right)$ and the lower bound on the net surplus from the inframarginal coverage is \$120 (Area ABCD in Figure 3). For each of the considered sets of assumptions in Table 1 and the associated calibrated parameters, this figure displays the implied marginal willingness-to-pay for insurance on the intensive margin.

Figure 3 and Table 1 illustrate two important points. First, the precise implied valuation for the inframarginal public coverage is very sensitive to the underlying assumptions on the form of the utility, liquidity, and the nature of uncertainty. Comparing the associated values in Table 1 columns (2) and (3) when $\pi(w, 0.7, 0.6|\varphi) = \$100$, we see that the implied net surplus from public coverage is 40% higher under the CRRA specification than under the CARA specification, with the same assumed risk and benchmark income. Comparing Table 1 columns (2), (4), (6), and (8), we see that the implied net surplus from public coverage varies greatly with changes in the assumed risk distribution, even conditional on specifying the same form of utility, benchmark income, and expected cost. A comparison of columns (2), (10) and (11) reveals that the implied valuation of public coverage is very sensitive to the benchmark income; in this example, when $\pi(w, 0.7, 0.6|\varphi) = \$100$, the implied net surplus from public coverage based on CRRA utility increases 71% when the benchmark income is cut by \$14.5K. Second, the lower bound can be quite conservative, and the tightness of the lower bound depends on the underlying risk, utility, and liquidity. Across all the considered scenarios, we see that the implied surplus associated with inframarginal public coverage ranges from 1.79 to 6.29 times the lower bound.[23] This highlights an important limitation of the bounding approach: it provides less precise information about welfare than an approach that fully specifies the underlying primitives.

In summary, this numerical example highlights the central trade-off between these complementary approaches to quantifying welfare. The bounding approach is more robust than a more structural approach in terms of perturbations in the underlying utility, risk distribution, and liquidity; however, this robustness comes at the cost of obtaining a lower bound on welfare rather than a precise welfare number. In some applications, this cost may be considerable if the lower bound is too loose to provide valuable insights.

Empirical Implementation While the propositions above provide a lower bound on the surplus from the inframarginal coverage for a given individual, we empirically implement the population-level bound in Corollary 1 which aggregates across individuals. The key empirical inputs for the population-level welfare bound are: (i) the mean willingness-to-pay for the supplemental coverage and (ii) the mean expected costs associated with the inframarginal coverage given the status quo allocation of supplemental insurance. To estimate (i), we estimate the demand for supplemental insurance and integrate under this demand curve. In settings with rich enough price variation, the demand for supplemental insurance could be estimated non-parametrically. In practice, there is typically a limited range of price variation available, and thus applying either the bounding approach or a more structural approach to quantify the welfare associated with the inframarginal coverage would typically require some extrapolation from the identifying variation to estimate the demand for supplemental insurance. However, in contrast to more structural approach, the bounding approach requires minimal restrictions on the *demand for insurance generosity for a given individual* to relate the willingness-to-pay for supplemental insurance to the willingness-to-pay for the inframaringal coverage.

Following the empirical insurance literature, one can use ex post realized costs to estimate (ii). Note that the observed realized costs are inclusive of any moral hazard induced by the status quo allocation of insurance coverage, meaning that the bound estimated with these observed costs trades off the value associated with the inframarginal coverage and the costs of this coverage inclusive of moral hazard induced by the observed coverage.[24] Putting this all together, empirical implementation of the population-level bound requires lever-

[23] Appendix Figure A1 depicts how the surplus ratio varies with the generosity of the baseline coverage, fixing the underlying utility parameters as calibrated under the assumptions analyzed in Figure 3.

[24] More generally, one might be interested in applying this bounding approach in settings with a counterfactual allocation of supplemental insurance that departs from the observed allocation, and thus rely on the degree to which claims respond as one increases (or decreases) coverage relative to the observed allocation. To do this extrapolation, one would need an estimate of moral hazard induced by marginal coverage changes. To obtain such an estimate, one could either look to the prior literature for an estimate of moral hazard or one could estimate moral hazard in the empirical application itself. In theory, a feature of this approach is that the claims data and price variation required to implement this approach may be sufficient for estimating moral hazard as well. In practice, some empirical applications will provide sufficient power to estimate demand but insufficient power to obtain precise estimates of moral hazard, as is the case in our empirical application to disability insurance. We illustrate how one could proceed if this practical difficulty arises through our approach to incorporating moral hazard in the empirical application.

aging plausibly exogenous variation in premiums to estimate the demand curve for supplemental coverage and standard data on prices, insurance enrollment, and costs.

1.3 Comparison to Alternative Methods

Below, we discuss how the willingness-to-pay approach we outline compares to other approaches used in the prior literature to analyze the welfare associated with compulsory public insurance. There are a few notable strengths of the willingness-to-pay approach. First, this method requires straightforward variation and limited data to be implemented empirically. To estimate all of the inputs of the marginal and inframarginal welfare analysis discussed above, one simply needs sufficient variation in the price of supplemental coverage to estimate the demand curve for supplemental coverage and standard data on prices, insurance enrollment, and costs. In contrast, other approaches to valuing compulsory public insurance often require isolating random (or like-random) variation in compulsory public insurance (which by virtue of the program being compulsory is often difficult to do). In addition, alternative approaches often require data on consumption or assets, data which is often not available and can suffer from considerable measurement error when it is available.

Second, an advantage of this approach is that it allows us to remain largely agnostic as to the underlying primitives of individuals' decisions (similar to Einav and Finkelstein (2011)). It is possible to investigate a wide range of marginal welfare questions (welfare analysis in the spirit of the sufficient statistics literature on social insurance (e.g., Chetty, 2008)) without making restrictions on the form of individual utility or individuals' underlying optimization problem. In settings with linear insurance coverage, going beyond marginal welfare questions and bounding the welfare provided by the compulsory inframarginal coverage requires only minimal assumptions on individual preferences. Further, because the framework does not restrict heterogeneity across individuals, this approach could be applied without restricting heterogeneity in settings with rich enough variation to estimate demand non-parametrically.[25] The fact that this approach requires few assumptions is in contrast to other approaches of valuing compulsory public coverage which rely on fully specifying utility (or marginal utility), specifying the nature of uncertainty individuals face, restricting heterogeneity across individuals, obtaining data on all the inputs in the utility (or marginal utility), and/or assumptions on the nature of the individual's optimization.

Third, this approach can accommodate features of complementary public and private insurance in a range of settings. It is straightforward to show that this approach can accommodate features that may be present

[25]Other approaches in the prior literature analyzing welfare associated with compulsory public insurance often require making assumptions to extrapolate along two margins: (i) extrapolate from a LATE estimate to a broader population by making parametric restrictions on heterogeneity (similar in spirit to the parametric demand extrapolation in our application) and (ii) extrapolate to connect the estimated elasticities to an expression for welfare through specifying underlying primitives (e.g., an optimization model for decision-making, budget constraint, marginal utility, etc). In theory, if there were rich enough variation that one could estimate demand non-parametrically, the approach we outline would not require much extrapolation on either margin. In practice, given the typical scope of variation available to estimate demand, the approach we outline will often require parametric extrapolation along margin (i), but will require minimal assumptions to connect the parametric demand estimates to welfare (i.e., no substantial extrapolation on margin (ii)).

in the supplemental insurance market, such as imperfect competition, administrative costs, multiple contract options, and pricing regulations. Importantly, while the framework above is discussed in the context of linear insurance (which is the relevant case in the empirical application that follows), the general approach to valuing a marginal extension of compulsory coverage to include benefits covered by supplemental insurance can be applied to any setting with complementary private insurance provided sufficient data and variation exist, even settings with highly non-linear coverage. For example, if compulsory public insurance includes a deductible and supplemental insurance fills in this deductible, an individual's willingness-to-pay for supplemental insurance reveals his/her valuation of extending public insurance to fill in this deductible.[26] In settings with linear coverage, this approach can be used to go beyond marginal welfare questions and bound the welfare generated by the inframarginal compulsory coverage under minimal assumptions.

Of course, an important limitation of this approach is that it can only be applied in settings in which individuals can purchase complementary private insurance to top-up the compulsory public coverage. While there are many public insurance settings in which individuals can buy complementary coverage (e.g., disability insurance, universal health insurance settings such as Medicare, etc.), there are some public insurance settings in which no complementary coverage is typically available (e.g., unemployment insurance, means-tested public insurance such as Medicaid), and in these settings this approach does not provide an alternative to existing approaches to valuing public insurance. In addition, applying the inframarignal welfare bound requires that the public and private insurance provide linear coverage for the same financial risk. Implicit in this requirement is that the public and private insurance be of the same quality aside from the definition of generosity.[27] In settings where this additional requirement is not met, the applicable analysis would be limited to analyzing marginal extensions of the compulsory public insurance to include coverage comparable to that offered by the supplemental insurance.

It is also important to note the interpretation of the welfare analysis discussed above. Because this approach draws upon the demand for supplemental insurance, any information realized before the purchase of supplemental insurance is considered pre-determined at the time of evaluating welfare. In this way, the welfare from public coverage discussed above is the welfare of this coverage based on the information known at the point in time of the observed supplemental insurance market decisions. Thus, the lower bound on the value of public coverage described above may be conservative from the perspective of ex ante welfare as it does not capture any additional welfare from insurance against risk type revelation over time before the supplemental

[26] Or alternatively, in the setting of health insurance, if private supplemental insurance improves upon basic compulsory public insurance by providing access to a broader group of health care providers, an individual's willingness-to-pay for supplemental insurance reveals his/her valuation of an extension of the compulsory public insurance coverage to include this broader group of health care providers. To the extent that the available supplemental insurance fills the obvious gaps in the compulsory public insurance coverage in a given setting, expanding compulsory public coverage to include the benefits of supplemental insurance may be one of the most policy-relevant marginal expansions to consider.

[27] There may be instances where supplemental insurance is of higher or lower quality than the compulsory public coverage. In such cases, the public and private insurance may be covering slightly different financial risks, and thus the linear insurance assumption fails and the inframarginal welfare bound is not applicable.

insurance purchase decision.[28]

More broadly, this approach is subject to the same limitations and challenges of welfare analysis in private insurance markets. For instance, this approach relies on the notion that individuals' decisions to buy or forgo insurance can be used within a revealed preference framework to do welfare analysis. While this is a common approach to evaluating welfare in private insurance settings, there are potential criticisms and drawbacks to relying on revealed preference as individuals may suffer from behavioral biases or may face informational frictions. Additionally, as in typical analyses within private insurance markets, this approach relies on estimating demand, which requires isolating price variation that is plausibly exogenous and typically requires making parametric assumptions when there is not sufficient price variation to estimate demand non-parametrically.[29] Despite the non-trivial challenges associated with using revealed preference for welfare analysis, researchers conducting welfare analysis in private insurance settings typically opt to employ demand estimates and rely on revealed preference (as opposed to employing methods similar to those used in the prior compulsory public insurance literature). In this way, the framework described above provides a constructive illustration of how to extend this revealed preference style analysis often employed in settings with private insurance to investigate questions related to compulsory public insurance.

2 Empirical Application: Background and Data Description

The remainder of the paper applies the framework discussed in the prior section to evaluate welfare in the context of public and private disability insurance. Specifically, we leverage price variation in the private supplemental long-term disability (LTD) policies offered by one large employer to quantify the value of disability insurance among workers in this population. While the empirical setting is interesting in its own right, the empirical application also illustrates some of the strengths and challenges associated with this willingness-to-pay approach for analyzing the welfare associated with compulsory public insurance. This section begins by briefly describing some relevant background on public and private disability coverage. We then proceed to discuss the data and identifying variation.

2.1 Brief Background on Public and Private Disability Coverage

In the United States, the public disability insurance program, Social Security Disability Insurance (SSDI), is one of the largest social insurance programs. In 2014, approximately 9 million disabled workers received SSDI ben-

[28]While much of the literature analyzing welfare in private insurance markets follows a similar approach taking heterogeneity underlying the demand for insurance as pre-determined, there are some notable recent exceptions that consider broader ex ante measures of welfare. Hendren (2017) describes a method to estimate the ex ante value of insurance behind the veil of ignorance before individual risk types are realized. His approach similarly draws on estimated demand and cost curves from an existing private insurance market. Similar issues regarding a divergence between the point in time at which demand and welfare are measured arise in Handel, Hendel and Whinston (2015) and Einav, Finkelstein and Williams (2016).

[29]As discussed above, most empirical applications of this approach will require some parametric extrapolation to identify the demand curve across the population because a key input in the welfare analysis described above is an estimate of the mean willingness-to-pay for the supplemental coverage (i.e., the integral under the demand curve across the population).

efits, and the total SSDI benefits paid exceeded \$140 billion.[30]. Eligible workers may apply for public disability insurance benefits in the event of a disability. The applicant then goes through an evaluation of his/her case that includes an assessment of the severity of his/her disability and an assessment of his/her residual work capacity.[31] If an individual's SSDI case is approved, the individual receives a monthly benefit that is a function of his/her prior earnings history. In particular, the Social Security Administration (SSA) calculates the individual's Average Indexed Monthly Earnings (AIME), which is defined as the average inflation-adjusted monthly earnings in the individual's 35 highest earning years of employment (or all years of employment if the beneficiary has worked fewer than 35 years).[32] The monthly benefit for the beneficiary, the Primary Insurance Amount (PIA), is then determined by a piece-wise linear function of the AIME. Since SSDI pays a benefit for each month the individual is out of the labor force due to disability, from an individual's perspective SSDI insurance provides coverage that is linear in the risk (lost wages due to time out of work with disability), where the effective replacement rate for individual i in the event that he becomes disabled in terms of his/her current annual earnings, w_i, is: $\gamma_i = \frac{\text{Annual SSDI Benefit}_i}{w_i}$, where Annual SSDI Benefit$_i = 12 \times PIA(AIME_i)$. Among US workers, the mean pre-tax replacement rate for public disability insurance through SSDI is roughly 45%.[33] Throughout the following discussion, we focus on the welfare generated by the primary wage-replacement benefits of SSDI abstracting from additional benefits associated with the SSDI program (e.g., Medicare coverage, survivor benefits, etc).[34]

Many employers offer LTD insurance to supplement the wage replacement benefits of SSDI. Approximately 34% of all workers have the option to buy LTD coverage through their employer to top-up the coverage from SSDI.[35] While on average 34% of all workers have access to LTD coverage, the percent of workers with access to LTD is much higher among particular subgroups: 44% of full-time workers, 53% of managerial and professional workers, and 57% high income workers (workers in the top 25% of earners). The median replacement rate of employer-provided LTD coverage is 60%, with only 1% of plans providing coverage in excess of 67% and 24% of plans providing coverage less than 60%.[36]

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[30]Source: `https://www.ssa.gov/policy/docs/statcomps/supplement/2015/highlights.pdf`.

[31]The following SSA publication contains a basic description of the evaluation criteria: `http://www.ssa.gov/pubs/EN-05-10029.pdf`.

[32]A calculator on the SSA website describes the disability benefit formula: `https://www.ssa.gov/planners/retire/AnypiaApplet.html#&sb=-1`.

[33]This statistic is based on authors' calculations using employees in the CPS, as described in Table 3. Note this replacement rate is calculated before considering the tax treatment of wages and SSDI benefits.

[34]Some SSDI beneficiaries have access to additional benefits beyond the wage-replacement benefits described above. For example, after two years of SSDI coverage, beneficiaries receive health insurance through Medicare. Additionally, in some circumstances, SSDI provides additional financial benefits to beneficiary dependents (i.e., young children or elderly spouses). Throughout the following discussion, we focus on the welfare generated by the primary wage-replacement benefits of SSDI abstracting from these additional features. Note that the estimated lower bound on the welfare provided by the SSDI wage replacement benefits would be a conservative characterization of welfare of the entire SSDI program to the extent that these additional features generate positive surplus.

[35]These statistics are reported in Table 16 of the U.S. Department of Labor's National Compensation Survey, Employee Benefits in the U.S., March 2015 publication at: `http://www.bls.gov/ncs/ebs/benefits/2015/ownership/civilian/table16a.pdf`.

[36]These statistics are reported in Table 30 of the U.S. Department of Labor's National Compensation Survey, Employee Benefits in the U.S., March 2015 publication at: `http://www.bls.gov/ncs/ebs/benefits/2015/ownership/civilian/table30a.pdf`.

2.2 Data Description and Identifying Variation

In this paper, we use data from one large employer that offers LTD coverage. The data comes from Alcoa, Inc., a large, multinational manufacturing firm that annually employed roughly 48,000 employees within the United States residing within 24 different states during our sample period. Approximately half of the the firm's employees are offered LTD benefits. The data include information on LTD benefit menus, enrollment decisions, wages, employment status, basic demographics, and LTD claim payments.

As is typical with employer-provided LTD policies, the policies offered by this employer guarantee a stated replacement rate in terms of annual earnings, with the explicit stipulation that LTD claimants must apply for SSDI, and, if approved, SSDI benefits crowd-out LTD benefits dollar-for-dollar.[37] The LTD policies at this firm insure relatively long duration disability spells, as workers cannot place an LTD claim until he/she has been disabled for at least six months.[38] In this way, LTD policies at this firm largely operate as a means to top-up the replacement rate of the public program. For the remainder of the empirical application, we make the simplifying assumption that the LTD plans provide pure top-up insurance for SSDI. While this simplification is helpful in interpreting the lower bound on the value of the inframarignal coverage, the simplification is not necessary to have a meaningful interpretation of the marginal coverage welfare analysis.[39]

Estimation Setting For the empirical application, we focus on employees offered the most common LTD benefit menu containing three vertically differentiated plans with replacement rates of 50%, 60%, and 70%, which we denote as Plan L, Plan M, and Plan H, respectively. We focus on the years in which this menu is consistently available, 2003-2006. Employees choose a LTD plan during the annual open enrollment period in November.[40] The selected plan is effective for the following calendar year, where disabilities that originate within that calendar year are covered if the disability results in time out of work in excess of six months.

[37]Based on notes in the LTD claims data regarding SSDI application status, the requirement to apply to SSDI seems to be enforced. The crowd-out of SSDI benefits is in terms of pre-tax monetary benefits (not post-tax benefits), which is an important consideration when incorporating the differential tax treatment of LTD benefits and SSDI benefits. We discuss this further in the robustness analysis in Section 4.

[38]This required period of disability before applying for benefits is often referred to as the "elimination period". Autor, Duggan and Gruber (2012) analyze data from a large LTD insurer covering policies offered by nearly ten thousand unique employers, and they report that nearly two-thirds of beneficiaries have LTD insurance with a shorter elimination period than the firm we study, with the most common elimination period being 90 days.

[39]In our empirical context, the LTD plans offered by the firm only vary with respect to the replacement rate. Since the identification relies on comparing different LTD plans, the comparability of LTD and SSDI coverage in terms of quality is not important for identification. Though LTD and SSDI appear to be of similar quality in this setting, it is important to think about how any differences in quality would affect the interpretation of our analysis. The interpretation of some of our welfare analysis is largely unchanged by the comparability of SSDI and LTD coverage. For instance, our estimate of the welfare associated with the observed market for a 70% LTD plan relative to a 60% LTD plan (in Table 6 Panel A row 1) is the same regardless of the degree of comparability. However, if LTD and SSDI coverage are not comparable, we would need to interpret the inframarginal welfare bound as more narrowly representing a bound on the value of inframarginal disability coverage of quality comparable to LTD insurance. Similarly, if LTD and SSDI coverage are not comparable, we would want to interpret our analysis of counterfactuals related to extending the generosity of disability insurance as more narrowly applying to an insurance extension of comparable quality to LTD coverage (e.g., mandating the purchase of the marginal LTD coverage).

[40]In the event that an employee does not actively select a LTD plan, the employee is assigned to a default level of coverage. Plan M is the default coverage for new employees, and the default for continuing employees is their coverage choice from the previous year. Importantly, individuals in plans consistent with these default options could have actively chosen these plans. In Section 4, we analyze the robustness of our results to excluding individuals who appear to not be active choosers based on their insurance allocations across the range of employee benefits offered by this firm.

Table 2 describes the menu of LTD policies offered during our sample period, displaying the plan premiums by year both in levels and relative to the plan of adjacent quality. In this setting, both benefits and premiums are described in terms of an individual's annual earnings. To ease interpretation, Table 2 also displays the premiums scaled by $60K, which is roughly the median annual earnings in the estimation sample. From this table, one can see that there are several nice properties of the data for this empirical application. First, the basic 50% replacement rate plan is free for all employees. This is convenient as no one opts out of the plans, and thus claims data are available for all employees in the sample. Second, there is variation over time in the incremental premium for the highest generosity coverage. For a worker with earnings of $60K annually, the premium for Plan H (relative to Plan M) falls by $33 on a baseline of $98, representing a one third price decline relative to the baseline premium. Thus, while the Plan H relative price change is modest in absolute terms, it is fairly large in relative terms.[41]

In this setting with vertically differentiated plans, the demand for a plan is determined by the premium relative to the premiums for the adjacent plans, provided that no plans are dominated in the observed range of premiums. Consistent with this intuition, the bottom panel of Table 2 illustrates that the decline in the Plan H premium between 2003 and 2004 is associated with a sharp increase in Plan H enrollment and a sharp decline in Plan M enrollment, while Plan L enrollment is largely unaffected. The primary estimation focuses on the demand and costs associated with the incremental 10% replacement rate moving from Plan M to Plan H. That is, the estimation focuses on estimating the demand for a 10 percentage point increase in the replacement rate starting from a baseline replacement rate of 60%. Although there is a small amount of variation in the Plan M premium that could be used to investigate the demand for Plan M (relative to Plan L), there are two key reasons why we focus on the Plan H demand for our baseline estimation. First, from inspecting Table 2, one can see that the relative premium for Plan H (compared to Plan M) varies more than five times as much as the relative premium for Plan M (compared to Plan L) varies; thus, we obtain more precise estimates by focusing on the demand for Plan H coverage. Second, under the assumptions used to derive the bound in Section 1, focusing on the demand for Plan H provides a more conservative lower bound on the welfare provided by public insurance.[42]

Measuring Variables for Analysis The primary data needed for the analysis are cost data, premium data, and coverage data. While measuring premiums and coverage are straightforward, there are a few subtle issues that arise when measuring costs in this setting. The ideal cost data would follow all realized disability spells through their entire duration to calculate the cost measures used in the welfare analysis. Because the dis-

[41] Another way to benchmark the price change is to compare it to the mean insurer costs for this coverage. In these terms, the magnitude of the Plan H relative price drop is 35% of the mean cost for the incremental coverage among those enrolled in Plan H.

[42] Appendix C provides suggestive evidence on the validity of the assumptions used to derive the bound by comparing the baseline Plan H demand estimates to Plan M demand estimates that we obtain by leveraging the modest amount of available variation in the price for Plan M (relative to Plan L).

ability spells we focus on originated relatively recently (our sample period is 2003-2006), many of the disability spells are still unfinished, and thus, this ideal information following each spell through its entire duration is not available.[43] In practice, we have data on LTD claims paid through 2011, which means that all disability spells originating during the period of coverage (2003-2006) are observed through at least the first five years of the spell. Although complete data is not available for censored spells, we can construct proxies for the total realized costs using the data that is available. In our baseline analysis, we use a conservative measure of costs where we calculate the maximum potential costs by extending those spells truncated at five years to their maximum possible duration and imputing the lost wages.[44] Because our aim is to estimate a lower bound on the welfare provided by disability insurance, this conservative measure is appropriate. However, we also repeat the welfare analysis with alternative (less conservative) cost measures and display the results in Appendix D for comparison. The primary cost measure used in the welfare analysis is the mean present discounted value of the realized costs relative to annual earnings associated with the incremental 10 percentage point increase in the replacement rate. The baseline cost measure is constructed using an interest rate of 4%, and additional analysis in Appendix D illustrates that the results are robust to a range of alternative interest rates.

One aim of the welfare analysis is to estimate a lower bound on the wage replacement benefits of public disability insurance. In this analysis, we focus on bounding the surplus generated by compulsory disability insurance coverage of generosity equal to the mean SSDI replacement rate in the estimation sample, where we calculate an individual's SSDI replacement rate using the SSA formula replacing the AIME with the monthly wage rate according to the firm's human resources records. We note this is an imperfect calculation because the data does not contain each worker's full work history which would be needed to precisely calculate the AIME following the SSA formula.

Summary Statistics and Identifying Variation The estimation sample is restricted to salaried employees who are actively employed in the previous calendar year, who are subject to the relevant LTD benefit menu, and who have an SSDI replacement rate less than 50%.[45] This final restriction ensures that for all the employees in the sample, the LTD plans offered by the firm all provide coverage that goes beyond SSDI's coverage. To ensure the workers in the estimation sample are comparable over time, we exclude workers at job sites that open or close during the period of analysis (2003-2006), and we exclude workers at job sites that experience very large fluctuations in employment during the period of analysis (job sites at which the percent change in

[43]Notice that this is not just a data availability issue. Many of the disability spells originating during the period of coverage (2003-2006) are currently still unfinished. Thus, even with the most up-to-date data available to claims administrators, there would still be a censoring issue.

[44]Specifically, regardless of when the disability spell originated, we use the cost data to measure the length of the spell over the first five years and extend spells that continue through the end of this five year window to their maximum possible duration. The maximum possible duration of benefits is set by the LTD insurance policies and depends on the age at disability. For those disabled before age 60, benefits may be paid until the individual turns age 65. For those disabled after age 60, the benefits may continue for a maximum of five years.

[45]The restriction that workers be "actively employed" means that the workers were employed continuously at the firm and were not on leave, paid or unpaid, during the previous calendar year.

employment from the minimum to the maximum employment year exceeded 75%).[46]

Figure 4 describes the public and top-up private disability coverage available to employees at the firm. The horizontal axis displays the monthly earnings, and the right vertical axis displays the associated pre-tax monthly potential disability benefit. The solid line displays the SSDI public disability benefit formula for the year 2003 (the first year of our sample), while the remaining three lines display the benefit formula for those who have one of the firm's three available top-up private LTD plans in addition to SSDI public disability insurance. The estimation sample focuses on individuals with an SSDI replacement rate less than 50% (the Plan L replacement rate). In terms of this figure, these are the individuals whose monthly earnings lie to the right of the intersection of the "with Plan L top-up" line and the "SSDI" line. This level of monthly earnings based on the 2003 benefit formula is roughly $2,020 which is indicated in the figure by the vertical reference line. In addition to displaying the public and private potential disability benefits, this figure also displays a histogram of the monthly earnings for all salaried employees.[47] As can be seen in this figure, the vast majority of salaried employees at the firm have high enough earnings that their implied SSDI replacement rate lies below the 50% threshold used to define the estimation sample.

Table 3 compares employees in the estimation sample (column 3) to the entire employee population at the firm (column 1) and to all salaried employees at the firm (column 2). From inspecting Table 3, one can see that the mean employee tenure is approximately 13 years. The majority of employees are male, and the median age is 45. The estimation sample contains roughly 23% of the overall employee population. Those in the estimation sample differ from the wider employee population at the firm along a couple of dimensions: those in the estimation sample are salaried employees (as opposed to hourly employees) and earn higher wages on average. The median wage is roughly $60K in the estimation sample, while the median wage is approximately $36.5K across the entire firm. Along several other dimensions such race, age, sex, and company tenure, the estimation sample and the overall employee population look quite similar.

For comparison, Table 3 columns (4) through (7) report analogous summary statistics for employees in the Current Population Survey (CPS), pooling data across 2004-2007. Comparing columns (1) and (4), we see that employees in the firm and a nationally representative sample of employees in the CPS appear broadly similar in terms of mean age and mean annual earnings, but quite different in terms of gender composition. The difference in gender composition can be explained by industry, as the employees at the firm (column 1) and manufacturing employees in the CPS (column 5) look very similar along this dimension. Examining the table further, we can see that the salaried employees at the firm (column 2) look similar in terms of observable characteristics to manufacturing employees in the CPS with white collar occupations (column 6).[48] Lastly,

[46]Because the identification strategy leverages over time variation, we make this restriction to ensure the sample is relatively homogeneous year-to-year.

[47]In this figure, monthly earnings are censored at ($200,000/12).

[48]The definition of white collar occupations used here encompasses individuals who report professional or managerial occupations.

comparing the estimation sample (column 3) to the sample in the CPS that meets an analogous selection criteria (column 7), one can see that they look broadly similar on observables such as age, gender, race, and annual earnings. Overall, it is important to emphasize that neither the firm's overall employee population nor the estimation sample are representative of employees in the United States as a whole, so one should exercise appropriate caution in interpreting the estimates. That being said, along the lines of observable attributes, the employees in the estimation sample look similar to manufacturing, white collar employees more broadly.

To identify the demand for Plan H, we utilize a straightforward over-time identification strategy exploiting the sharp decrease in Plan H premiums between 2003 and 2004. Importantly, we have three years of data after the price change to trace out any underlying time trends. The key identification assumption is that absent the price change, the take-up of Plan H would not have changed discontinuously between 2003 and 2004. While we cannot test this assumption directly, we can provide several pieces of evidence in support of this assumption. First, the aggregates reported in Table 2 provide some support for this assumption. We see that coincident with the sharp drop in premiums between 2003 and 2004 there is a sharp increase in the take-up of Plan H, and this increase in Plan H market share comes at the expense of Plan M, as expected if the change in market share was due to the relative price change. Moreover, we see that both the Plan H market share and the relative premium for Plan H are stable thereafter, from 2004 to 2006. Second, as we discuss further below, our analysis in Table 4 indicates that the identifying variation is unrelated to observable employee characteristics that may be important determinants of the demand for disability insurance. Third, we demonstrate that the welfare analysis is robust to the inclusion/exclusion of covariates in the demand estimation (e.g., a time trend, demographic controls, individual fixed effects, etc.).

Table 4 explores whether the identifying variation is related to observable characteristics of employees. Since the identifying variation stems from a sharp change in premiums between 2003 and 2004, it is important to demonstrate that the estimation sample is comparable across years in all other ways. Column (1) summarizes demographic information for employees in the sample during 2003 (the year in which the relative price for Plan H was the highest), while columns (2) through (4) display summary statistics for the subsequent three years, during which the relative price for Plan H was lower and quite stable. Across these columns, the table summarizes observable employee information by year, along with the overall mean predicted probability of the worker claiming LTD based on the worker's observable characteristics (denoted by "predicted LTD claims"). This predicted probability is simply the fitted value from regressing an indicator for having a disability claim on all the observable attributes summarized in Table 4, where we control flexibly for age and wage using indicators for deciles of these distributions. Inspecting this table, we see the sample looks very similar across the four years in terms of age, job tenure, fraction male, earnings, and predicted LTD claims. In particular, there is no evidence of a problematic break in observables coincident with the Plan H price decrease between 2003 and 2004. We also investigate this in a slightly different way, relating the continuous (relative) price for Plan H to each of these worker characteristics including a time trend. The coefficients and p-values associated with these pair-wise regressions, reported in columns (5) and (6), collectively illustrate that the identifying variation is unrelated to the observable characteristics. In addition, we cannot reject that all of these observables are jointly unrelated to the premium variation (p-value 0.34). Overall, the evidence from Table 4 illustrates that the identifying premium variation is unrelated to observable characteristics.

3 Empirical Strategy and Connection to Welfare Framework

Applying Framework To apply the framework outlined in Section 1, we make the following assumption:

Assumption 1. For an individual represented by φ, define the demand for insurance generosity: $v(w,\theta|\varphi) \equiv \frac{\partial}{\partial\theta}\pi(w,\theta,0|\varphi)$. For all individuals (i.e., for all φ), suppose that (i) $v(w,\theta|\varphi)$ is weakly decreasing in θ , and (ii) $v(w,\theta|\varphi)$ is weakly decreasing in w .

We implement this analysis by estimating the demand and costs associated with a 10 percentage point increase in the replacement rate starting from a baseline of 60% wage replacement in the event of disability (moving from Plan M to Plan H among the plans offered by the firm). Thus, the empirical application departs from the initial basic framework in Section 1 in that there is a wedge between the willingness-to-pay we estimate (moving from a 60% to 70% replacement rate) and the replacement rate of compulsory public insurance (on average 34% in our estimation sample). Under Assumption 1, $\pi(w,\alpha+\delta,\alpha|\varphi)$ is decreasing in α, and we apply Proposition 1 to obtain a lower bound (analogous to that in Corollary 1) on the welfare associated with compulsory disability insurance of generosity α_{Public} relative to no insurance coverage in the presence of the status quo allocation of supplemental insurance:

$$Welfare\_Public = \int \big(\pi(w,\alpha_{Public},0|\varphi) - c(w,\alpha_{Public},0|\varphi)\big)dG(\varphi)$$
$$\geq \int \Big\{\big(\frac{\alpha_{Public}}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi) - \frac{\alpha_{Public}}{\alpha_{obs}(\varphi)}c(w,\alpha_{obs}(\varphi),0|\varphi)\big)dG(\varphi), \quad (16)$$

where $\alpha_{obs}(\varphi)$ is the observed aggregate replacement rate across public and supplemental insurance for individual φ.[49] In addition to calculating this bound, we also analyze the welfare generated by the marginal coverage moving from a 60% to a 70% replacement rate. Under the assumption used to calculate the inframarginal welfare bound (Assumption 1), the value of the incremental coverage, $Welfare\_Extn(\infty|\alpha+0.1,\alpha)$, is decreasing in the baseline coverage α. Thus, under Assumption 1, we can interpret the welfare associated with the marginal coverage as a lower bound on the welfare obtained by a 10 percentage point increase in the replacement rate, starting from the lower replacement rate of public disability coverage.

[49]Because the counterfactuals we consider allow for moral hazard, we leverage Proposition 1 to derive the population-level bound we implement rather than Proposition 2. See Section 1 for further comparison of these propositions.

Demand To analyze welfare, we estimate the demand for supplemental coverage. In the disability insurance setting, an individual's coverage and an individual's premium are defined relative to the individual's annual earnings, and the variation used to identify the demand curve is in the relative premium for supplemental coverage. Thus, we estimate the demand curve in relative terms and then discuss how this demand curve is used in the welfare analysis below. Let p_{it}^H and p_{it}^M represent the premium (relative to annual earnings) faced by individual i in year t for Plan H and Plan M, respectively. Let $r_\pi(\theta,\gamma|\varphi) = \frac{\pi(w,\theta,\gamma|\varphi)}{w}$ denote the relative willingness to pay for generosity θ coverage over the outside option of γ coverage. The focus of the empirical analysis is on estimating demand for Plan H relative to Plan M: the distribution of $r_\pi(0.7, 0.6|\varphi)$. To recover this relative demand curve from the empirical setting, we assume that none of these vertically differentiated products are dominated in the ranges of prices observed in the data, so that the relevant price for tracing out the relative demand curve for a product is the price compared to that of the adjacent products. Under this assumption, we can use variation in the relative price for Plan H over Plan M, $(p_{it}^H - p_{it}^M)$, to trace out the distribution of $r_\pi(0.7, 0.6|\varphi)$.

Given rich enough variation in relative prices, one could in principle estimate a nonparametric demand curve for the incremental coverage, giving one an almost fully nonparametric bound on welfare generated by the compulsory insurance (under the minimal conditions within Assumption 1 above). Though we leverage a fairly large relative price change for Plan H compared to Plan M, this price variation translates into a modest change in the quantity of individuals insured through Plan H, moving the share insured under Plan H from 60% to 64% of employees. Given a primary aim of our analysis is to estimate the mean willingness-to-pay for the incremental coverage (i.e., the integral under the demand curve across the population), we must rely on a parametric specification of demand. In the face of these practical constraints, we conduct our baseline welfare analysis leveraging a linear demand specification and then show the key findings from the welfare analysis are robust to several alternative demand specifications.[50] In our baseline specification, we estimate the demand for Plan H coverage using the following estimation equation:

$$PlanH_{it} = I(r_\pi(0.7, 0.6|\varphi) \geq p_{it}^H - p_{it}^M) = \alpha_0 + \alpha_1(p_{it}^H - p_{it}^M) + \rho X_{it} + \epsilon_{it}, \tag{17}$$

where $PlanH_i$ indicates if individual i selected Plan H and $(p_{it}^H - p_{it}^M)$ is the price of Plan H relative to Plan M. The baseline demand estimation includes a time trend to control for any unrelated trends in insurance enrollment that may be correlated with the identifying variation. Further analysis presented in Section 4 demonstrates that the welfare analysis is robust to several other alternative specifications of demand, including alternative included/excluded covariates (e.g., no controls, individual fixed effects, etc.) and alternative demand forms (e.g., probit demand, logit demand, linear-log demand, log-log demand, etc.).

[50] Although the shape of the demand curve certainly varies across alternative functional form extrapolations, the implied mean willingness-to-pay for supplemental insurance is less sensitive to the specific extrapolation. Thus, the resulting lower bound on the value of the inframarignal coverage is in the same general range across the functional form extrapolations for demand that we investigate. See Table 7 for this robustness analysis.

Costs While cost data is not necessary to measure the willingness-to-pay for disability insurance, to fully evaluate welfare it is necessary to have data on costs. We use individual-level data on disability claims to analyze costs, where we use realized costs as a proxy for expected costs. As is the case with demand, costs are measured relative to annual earnings. Let c_{it} represent the present discounted value of the realized costs relative to annual earnings associated with providing individual i in year t an incremental 10% replacement rate paid in the event of disability. We use an interest rate of 4% in the baseline estimation.[51] Our focus throughout is on the wage replacement costs for disability insurance, abstracting from administrative costs.[52]

With regard to analyzing costs, the empirical environment has both strengths and weaknesses. A strength of the empirical environment is that there is individual-level administrative cost data. While in principle one could use the very same price variation used to estimate the demand curves to estimate moral hazard and selection, a practical limitation is that it is difficult to obtain precise estimates of selection and moral hazard within the context of disability insurance because realized costs are noisy proxies for expected costs given the low incidence of disability.[53] In the face of these strengths and weaknesses, we take the following approach. First, our baseline welfare analysis focuses on estimating welfare in the status quo allocation of insurance. Since this estimation draws on observed realized costs, this analysis fully incorporates moral hazard and selection within the status quo insurance allocation. Second, we analyze welfare within counterfactuals that depart from the status quo allocation of insurance under a wide range of assumptions on the moral hazard elasticity.[54] Overall, we find that the key lessons of the counterfactual welfare analysis are not very sensitive to the amount of incremental moral hazard within a plausible range of elasticities.

4 Empirical Application: Estimates and Welfare Analysis

Estimates Table 5 displays the demand and cost estimates. Panel A columns (1) and (2) display linear demand estimates for Plan H coverage, without individual fixed effects (column 1) and with individual fixed effects (column 2). Across these specifications, we see that an increase in the relative premium for Plan H is associated with a statistically significant decline in the share of individuals with this disability plan. Drawing on the estimates from column (1), the magnitude implies that an increase in the premium for Plan H by 0.1% of annual earnings would lead the share of individuals enrolled in Plan H to decline by 7 percentage points (or 11% of the mean value). Table 5 Panel A also displays the mean implied willingness-to-pay for the incremental coverage based on these regression estimates, along with the associated bootstrapped standard error. Using

[51] Additional analysis presented in Appendix D illustrates that our results are robust to a range of alternative interest rates.

[52] While we have no data on administrative costs and thus abstract from such costs here, it would be straightforward to calculate alternative welfare measures incorporating administrative costs. Because the welfare analysis discussed below illustrates that the marginal disability coverage generates substantial surplus, incorporating even quite large administrative costs would not affect the qualitative findings.

[53] While our baseline welfare analysis does not depend on estimating moral hazard or selection, we exploit the available price variation to investigate these and report the results in Appendix B. As noted in the text, this analysis has limited statistical power due to the low incidence of disability claims.

[54] As will become clear, the counterfactuals we focus on do not require estimating the degree of selection.

these estimates from column (1), the implied annual mean willingness-to-pay for the incremental coverage provided by Plan H is 0.31% of annual earnings, or $202 for an individual earning $65K annually (roughly the mean annual earnings in the sample population). The 95% confidence interval allows us to rule out estimates less than 0.25% of annual earnings or more than 0.37% of annual earnings.[55] The implied valuation of the incremental coverage is similar when employing estimates from a specification with individual fixed effects (column 2). Table 5 Panel B displays the mean observed costs scaled to represent a 10% replacement rate for all and separately for those who do and those who do not purchase supplemental coverage. Comparing Panels A and B, the mean willingness-to-pay for incremental coverage in the population is large relative to the mean observed costs among the insured or among the sample population overall.

Implied Welfare Analysis Next, we present the welfare analysis based on these estimates. For each scenario considered, Table 6 reports the mean willingness-to-pay and welfare per dollar of annual earnings using the demand estimates from Table 5 column 1. The table reports the associated bootstrapped standard errors, and reported per-capita mean values are evaluated over the entire sample population.[56] In addition, we also present two scaled versions of these measures to ease interpretation. The table reports the mean willingness-to-pay and welfare as a percent of the mean per-capita cost associated with the counterfactual. To contextualize the relative estimates in terms of dollars, the table also reports the mean willingness-to-pay and welfare measures scaled by $65K, approximately the mean annual earnings in the sample. Note that scaling the estimates by the mean annual earnings provides an unbiased estimate of these welfare measures in dollar terms if earnings are uncorrelated with the relative willingness-to-pay for disability coverage.[57]

Table 6 Panel A presents our baseline welfare analysis analyzing the welfare associated with the marginal and inframarginal coverage under the observed allocation of supplemental insurance in the status quo. Row (1) displays welfare associated with the incremental coverage evaluated at the mean observed allocation of supplemental coverage. Because the mean observed allocation of the incremental coverage is very close to the allocation under a competitive equilibrium for this coverage, these welfare measures approximate the welfare associated with a competitive market for the incremental coverage.[58] The per-capita mean willingness-to-pay associated with the observed market for the incremental coverage is 0.36% of annual earnings, or $233 annually when scaled by $65K. The implied per-capita welfare associated with the market for incremental coverage is 0.26% of annual earnings, or $170 annually when scaled by $65K. Row (2) presents the implied lower bound on

[55]This confidence interval is based on the bootstrapped standard error on the mean willingness-to-pay reported in Table 5, where we utilize 10,000 bootstrap samples.

[56]The bootstrapped standard errors are calculated using 10,000 bootstrap samples.

[57]Note that this scaling will underestimate the value of disability coverage in dollar terms if instead the relative surplus from disability coverage is positively correlated with annual earnings.

[58]Comparing the estimates within Table 5 Panel B, the mean relative price for the incremental Plan H coverage is very close to the average cost of those individuals willing to pay for the incremental coverage. In other words, the predicted competitive equilibrium in the market for the incremental coverage would be close to the observed pair of average prices and quantities regardless of the shape of the average and marginal cost curves far outside of the variation in the data. Thus, we can think of the mean observed allocation as an approximation of the competitive equilibrium. See Appendix B for more details.

the welfare associated with the inframarginal disability insurance providing a 34% replacement rate, the mean public disability replacement rate among individuals in the sample. The mean willingness-to-pay for public disability coverage is at least 1.05% of annual earnings, or 279% of the per-capita cost of this coverage. The implied per-capita welfare of this coverage is at least 0.68% of annual earnings, or $440 when scaled by $65K. Overall, there are two key findings. First, the observed market for supplemental insurance coverage generates substantial surplus. Second, the observed demand and costs within the supplemental insurance market provide a meaningful lower bound on the value of the inframarginal public disability insurance coverage, indicating that individuals highly value the public coverage relative to the costs of providing it.

It is important to emphasize that our baseline welfare measures in Table 6 Panel A fully incorporate moral hazard, and thus implicitly the trade-off between risk protection and moral hazard (e.g, Chetty (2008), Baily (1978)). To see this, note that the observed costs in the supplemental insurance market are inclusive of any moral hazard induced by the status quo allocation of insurance coverage. This means that the observed costs are the relevant costs for calculating the welfare associated with the observed supplemental insurance market and the lower bound on the welfare associated with the inframarginal public coverage in the presence of the observed supplemental insurance market. Thus, the lower bound in Row (2) Panel A indicates that public disability coverage is highly valued relative to the costs of this coverage inclusive of moral hazard induced by the public coverage and the observed allocation of LTD supplemental coverage.

Next, we consider welfare under counterfactual allocations of insurance that depart from the observed allocation. To evaluate welfare under these counterfactual insurance allocations, we will need an estimate of moral hazard—the degree to which costs respond as one increases or decreases coverage relative to the observed allocation. In theory, an advantage of this general approach is that the same data and variation used to estimate demand could be used to explore moral hazard. In practice, there is limited power to detect moral hazard in our empirical setting given the observed range of variation and the low incidence of disability claims.[59] Thus, we analyze welfare in counterfactual allocations of insurance under a range of moral hazard elasticities to illustrate how these welfare estimates vary with the degree of moral hazard.

Table 6 Panel B presents estimates of welfare under a hypothetical compulsory insurance extension from a baseline 60% replacement rate to a 70% replacement rate relative to a setting where individuals do not have access to this incremental coverage.[60] Each column displays these estimates under the stated assumed moral hazard semi-elasticity: the percentage change in the PDV of lost earnings due to disability with respect to a change in the replacement rate. There are a few key take-aways from this additional analysis. First, the in-

[59] Appendix B exploits the available price variation to investigate moral hazard in this setting. As noted in the text, this analysis has limited statistical power due to the low incidence of disability claims.

[60] For employees on Plan H, we observe costs inclusive of any moral hazard associated with the incremental coverage. However, for individuals on Plan M and Plan L we need to project what their costs would have been under Plan H. If there is no moral hazard, this is simply the costs associated with a 10% replacement rate applied to their observed mean per-unit of coverage costs. If there is moral hazard, we inflate these costs by the appropriate moral hazard semi-elasticity in the calculations in Table 6.

cremental disability coverage is associated with substantial surplus if moral hazard is in the range of prior estimates. Prior studies in other disability settings have found that a 10 percentage point increase in the replacement rate leads to approximately an 8-10% increase in disability (e.g., Gruber (2000), Autor, Duggan and Gruber (2012)).[61] If the moral hazard elasticity is in the range of these prior estimates, the net welfare from extending the generosity of disability insurance is at least 78% of the cost of providing this coverage. Second, the incremental disability coverage is associated with positive surplus for a much broader range of moral hazard elasticities; in this population, the incremental disability coverage is associated with positive surplus provided that a 10 percentage point increase in the replacement rate leads to less than a 38% increase in lost earnings due to disability. Third, comparing Panel A and Panel B, we see that mandating the incremental coverage does not increase surplus relative to a private voluntary market for this coverage.

It is important to emphasize that the estimates come from a particular population that is not representative of workers more broadly. However, based on these estimates, workers in this population seem to highly value the inframarginal disability coverage offered by public disability insurance, and, if it were not for the fact that this firm offers fairly priced supplemental coverage, there would likely be significant welfare gains from extending the generosity of public coverage for these workers. Below, we demonstrate that the key findings are robust to a wide range of alternative specifications. The general qualitative result— that individuals highly value disability insurance on the margin— is in line with the findings from prior studies related to disability insurance. Prior studies by Low and Pistaferri (2015) and Chandra and Samwick (2005) employ calibrated life-cycle models to quantify the welfare associated with disability insurance. While the approach in these studies is quite different from our willingness-to-pay approach, these calibration studies provide similar qualitative findings as they predict that extending the generosity of SSDI would improve welfare.[62]

Robustness Next, we illustrate the robustness of the welfare analysis to a variety of alternative specifications. In the interest of brevity, the discussion focuses on the robustness of the estimated lower bound on the value of public coverage. For each alternative specification considered, Table 7 Panel A displays the implied lower bound on the mean willingness-to-pay and welfare generated by public insurance, and Table 7 Panel B displays the underlying parameter estimates corresponding to each alternative specification. The first rows of each panel of Table 7 display the baseline welfare measures and linear demand estimates for reference.

Because the welfare analysis requires us to extrapolate outside the empirical variation in premiums, the

[61]Gruber (2000) estimates the effect of benefit generosity on labor force participation using variation in public disability insurance generosity in Canada. Autor, Duggan and Gruber (2012) estimate the effect of benefit generosity on the probability of claiming LTD using variation across employers in LTD offerings, focusing on plans that typically have much shorter elimination periods than the plans in our setting. Though these prior studies estimate slightly different elasticities than the elasticity of interest in the present setting, we use these prior estimates to contextualize the results in Table 6 Panel B.

[62]Given the large stakes associated with disability risk and the incomplete coverage available from other sources, it is perhaps not surprising that individuals would highly value an incremental increase in coverage for this risk. The threat of a career-ending disability is arguably the largest adverse financial shock faced by many individuals. Prior work by Dobkin et al. (2017) has found that while individuals tend to have close to complete coverage for the medical costs associated with health shocks, individuals have relatively little coverage for the earnings losses associated with severe health shocks.

functional form of the demand curve could meaningfully influence the welfare estimates. Thus, we assess the robustness of our findings by considering alternative demand forms. Rows (2) and (3) present estimates from alternative probit and logit demand specifications, respectively. An undesirable property of the linear demand estimates is that the implied willingness-to-pay for those with the lowest willingness-to-pay is below zero. To address this concern, we consider several additional alternative specifications. Row (4) displays alternative welfare measures based on the baseline linear demand curve truncated at an implied valuation of zero. Row (5) displays a linear-log specification, while Row (6) displays a log-log specification where both quantity and premiums enter in logs. Because unconstrained linear-log and log-log specifications yield somewhat unrealistically high valuations of LTD in the upper tail and our aim is to obtain a lower bound, we constrain the estimated demand curves in Rows (5) and (6) such that the maximum willingness-to-pay for Plan H incremental coverage is 1% of annual earnings. Overall, we obtain a meaningful lower bound on the value of public coverage across all of these demand specifications, ranging from 0.5% to 0.9% of annual earnings.

Next, we consider the robustness of the analysis with respect to the variation used to estimate demand. Because the identification relies on over-time variation, it is important that individuals in the sample in different years are comparable to one another. In addition to the evidence in Table 4 that observable characteristics look similar across time, we illustrate that our results are robust to the inclusion/exclusion of a wide range of controls. The baseline specification estimates Equation 17 where we include a time trend to control for any unrelated trends in coverage that could be correlated with the identifying variation. Row (7) displays the results associated with estimating Equation 17 with no controls, and Row (8) displays the results associated with estimating Equation 17 with additional controls for demographic characteristics.[63] Row (9) displays the results of the individual fixed effects specification, and Row (10) displays the results from a propensity score re-weighted regression, where observations are re-weighted to look demographically alike to individuals in the first year of the sample. Taken together, the results in Table 7 rows (7) through (10) illustrate that the welfare bounds are qualitatively and quantitatively similar with the inclusion of more or fewer controls.

We also consider robustness with respect to the tax treatment of premiums and benefits. For the LTD plans offered at this employer, premiums are paid by employees with pre-tax dollars, and the benefits individuals receive from their LTD policy in the event of a disability are taxable. In contrast, SSDI benefits are largely exempt from tax.[64] Because it is not clear that employees know the differential tax treatment of each of these, premiums and the benefits are treated symmetrically in the baseline specification. Row (11) reports the results from an alternative specification that reflects the tax treatment of premiums and benefits, where we assume LTD premiums are paid with pre-tax dollars, LTD benefits individuals receive are taxable, and public SSDI benefits are not taxable (effectively raising the mean SSDI replacement rate from 34% to 52%). For simplicity,

[63]Specifically, the demographic covariates included in this specification are age, sex, and race.

[64]See this SSA website describing the tax treatment of SSDI benefits: `https://www.ssa.gov/planners/taxes.html`.

we assume that the same marginal tax rate is applicable to premiums and benefits, and we use a marginal tax rate of 35%, roughly the average marginal tax rate among individuals in this sample accounting for state and federal income taxes. While accounting for the tax treatment of LTD premiums and benefits leads to a lower implied surplus for a fixed extension of LTD coverage, accounting for the tax treatment of public SSDI benefits (and the effectively higher after-tax replacement rate) exactly offsets this giving us the same lower bound on the welfare of public disability insurance as in the baseline specification.[65]

Lastly, drawing upon a strategy in prior work by Einav et al. (2012), we analyze the robustness of our results to excluding employees who appear to be "passive" choosers.[66] Row (12) reports the demand estimates and associated welfare measures excluding the roughly 13% of employees in our sample who appear to be passive choosers, where we characterize an individual as a passive chooser if at any point during the sample period his/her insurance selections are completely consistent with all the default options across the range of employee benefits offered by the firm including health insurance, prescription drug insurance, dental insurance, and disability insurance.[67] The results for the sub-sample of individuals who appear to be active choosers in each year are very similar and statistically indistinguishable from the results for the baseline sample.

5 Conclusion

This paper outlined an approach to analyze welfare associated with compulsory public insurance relying on data and variation from the private market for complementary insurance. This approach has several nice properties as it requires straightforward variation, commonly available data, and minimal assumptions to evaluate a wide range of welfare questions. Specifically, we described how the demand curve and costs from the private market for complementary insurance can be used to investigate counterfactuals associated with a marginal extension of the compulsory public coverage (a counterfactual that is within the set of observed contracts), as well as estimate a lower bound on the welfare provided by compulsory public insurance.

We illustrated this framework by applying it to the setting of disability insurance, employing administrative data from one large employer. Based on our estimates, compulsory public disability insurance is associated with benefits that far exceed the costs of this coverage for this employee population, and, for a plausible range of moral hazard elasticities, extending the generosity of compulsory public coverage would result in substantial welfare gains for these employees if they would not otherwise have access to employer-provided supplemental disability coverage. While one should exercise caution in extrapolating from the specific estimates, the fact that some workers highly value disability insurance beyond the incomplete compulsory public coverage is interesting given that only a third of workers nationwide have access to employer-provided sup-

[65] See Appendix E for a more detailed description.

[66] As shown by Handel (2013), inertia can bias the results of welfare analysis based on estimated demand curves.

[67] We create the individual-level measures of passive choice by comparing insurance selections to defaults for the range of employee benefits from 2004-2006, the time period for which we know the default options across all the other employee benefits (e.g., dental insurance, health insurance, prescription drug insurance, etc).

plemental disability insurance. More generally, the analysis highlights that individuals' willingness-to-pay for supplemental coverage can provide useful insights into the value of compulsory public insurance.

References

Autor, David, Andreas Ravndal Kostol, Magne Mogstad, and Bradley Setzler. 2017. "Disability Benefits, Consumption Insurance, and Household Labor Supply." National Bureau of Economic Research Working Paper 23466.

Autor, David H., and Mark G. Duggan. 2006. "The Growth in the Social Security Disability Rolls: A Fiscal Crisis Unfolding." *Journal of Economic Perspectives*, 20(3): 71–96.

Autor, David, Mark Duggan, and Jonathan Gruber. 2012. "Moral Hazard and Claims Deterrence in Private Disability Insurance." National Bureau of Economic Research Working Paper 18172.

Baily, Martin Neil. 1978. "Some aspects of optimal unemployment insurance." *Journal of Public Economics*, 10(3): 379 – 402.

Bundorf, M. Kate, Jonathan D. Levin, and Neale Mahoney. 2012. "Pricing and Welfare in Health Plan Choice." *American Economic Review*, 102(7): 3214–3248.

Cabral, Marika, and Neale Mahoney. 2014. "Externalities and Taxation of Supplemental Insurance: A Study of Medicare and Medigap." National Bureau of Economic Research Working Paper 19787.

Chandra, Amitabh, and Andrew A. Samwick. 2005. "Disability Risk and the Value of Disability Insurance." National Bureau of Economic Research Working Paper 11605.

Chetty, Raj. 2008. "Moral Hazard versus Liquidity and Optimal Unemployment Insurance." *Journal of Political Economy*, 116(2): 173–234.

Chetty, Raj, and Amy Finkelstein. 2013. "Social Insurance: Connecting Theory to Data." *Handbook of Public Economics*, 5: 111.

Chetty, Raj, and Emmanuel Saez. 2010. "Optimal Taxation and Social Insurance with Endogenous Private Insurance." *American Economic Journal: Economic Policy*, 2(2): 85–114.

Dobkin, Carlos Dobkin, Amy Finkelstein, Raymond Kluender, and Matthew J. Notowidigdo. 2017. "The Economic Consequences of Hospital Admissions." *forthcoming in American Economic Review*.

Eeckhoudt, Louis, and Christian Gollier. 2001. "Which Shape for the Cost Curve of Risk?" *The Journal of Risk and Insurance*, 68(3): 387–401.

Einav, Liran, Amy Finkelstein, and Heidi Williams. 2016. "Paying on the Margin for Medical Care: Evidence from Breast Cancer Treatments." *American Economic Journal: Economic Policy*, 8: 52–79.

Einav, Liran, Amy Finkelstein, and Jonathan Levin. 2010. "Beyond Testing: Empirical Models of Insurance Markets." *Annual Review of Economics*, 2: 311–336.

Einav, Liran, Amy Finkelstein, and Mark R. Cullen. 2010. "Estimating Welfare in Insurance Markets Using Variation in Prices." *Quarterly Journal of Economics*, 125(3): 877–921.

Einav, Liran, Amy Finkelstein, Iuliana Pascu, and Mark R. Cullen. 2012. "How General Are Risk Preferences? Choices under Uncertainty in Different Domains." *American Economic Review*, 102: 2606–2638.

Einav, Liran, and Amy Finkelstein. 2011. "Selection in Insurance Markets: Theory and Empirics in Pictures." *Journal of Economic Perspectives*, 25(1): 115–38.

Finkelstein, Amy, Nathaniel Hendren, and Erzo F.P. Luttmer. 2015. "The Value of Medicaid: Interpreting Results from the Oregon Health Insurance Experiment." National Bureau of Economic Research Working Paper 21308.

Gruber, Jonathan. 1997. “The Consumption Smoothing Benefits of Unemployment Insurance.” *The American Economic Review*, 192–205.

Gruber, Jonathan. 2000. “Disability Insurance Benefits and Labor Supply.” *Journal of Political Economy*, 108(6): 1162–1183.

Hackmann, Martin, Jonathan T. Kolstad, and Amanda E. Kowalski. 2015. “Adverse Selection and an Individual Mandate: When Theory Meets Practice.” *American Economic Review*, 105: 1030–66.

Handel, Benjamin, Igal Hendel, and Michael Whinston. 2015. “Equilibria in Health Exchanges: Adverse Selection vs. Reclassification Risk.” *Econometrica*, 83(4): 1261–1313.

Handel, Benjamin R. 2013. “Adverse Selection and Inertia in Health Insurance Markets: When Nudging Hurts.” *American Economic Review*, 103(7): 2643–82.

Hendren, Nathaniel. 2013. “Private Information and Insurance Rejections.” *Econometrica*, 81(5): 1713–1762.

Hendren, Nathaniel. 2017. “Measuring Ex-Ante Welfare in Insurance Markets.” *working paper*.

Kostol, Andreas Ravndal, and Magne Mogstad. 2015. “Earnings, Disposable Income, and Consumption of Allowed and Rejected Disability Insurance Applicants.” *The American Economic Review*, 105(5): 137–141.

Liebman, Jeffrey B. 2015. “Understanding the Increase in Disability Insurance Benefit Receipt in the United States.” *Journal of Economic Perspectives*, 29(2): 123–50.

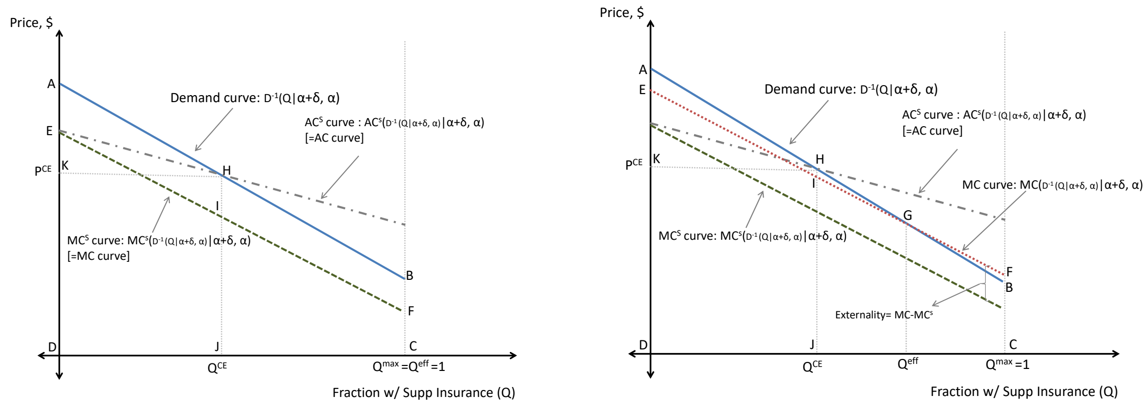
Low, Hamish, and Luigi Pistaferri. 2015. “Disability Insurance and the Dynamics of the Incentive Insurance Trade-Off.” *American Economic Review*, 105(10): 2986–3029.

Menezes, C. F., and D. L. Hanson. 1970. “On the Theory of Risk Aversion.” *International Economic Review*, 11(3): 481–487.

Meyer, Bruce D., and Wallace K.C. Mok. 2013. “Disability, Earnings, Income and Consumption.” *National Bureau of Economic Research Working Paper 18869*.

Thomson, Sarah, Robin Osborn, David Squires, and Miraya Jun. 2013. “International Profiles of Health Care Systems, 2013: Australia, Canada, Denmark, England, France, Germany, Italy, Japan, the Netherlands, New Zealand, Norway, Sweden, Switzerland, and the United States.” The Commonwealth Fund.

Figure 1: Graphical Illustration: Marginal Coverage Counterfactuals

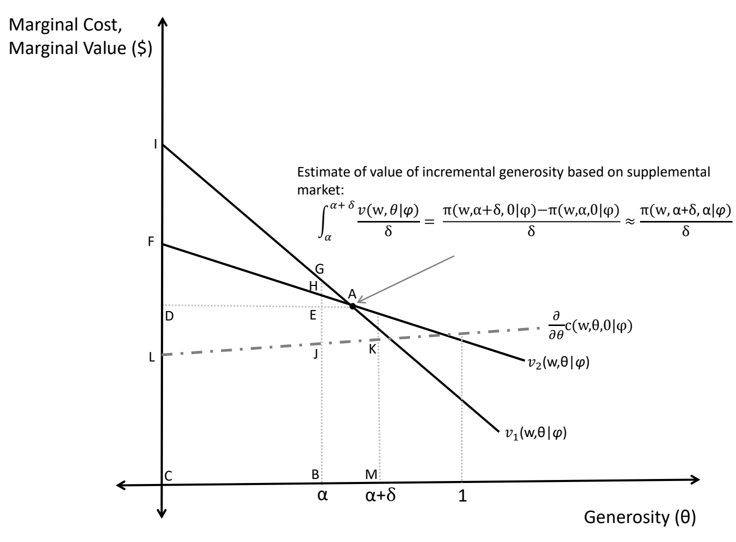


(A) No Externality

(B) Externality

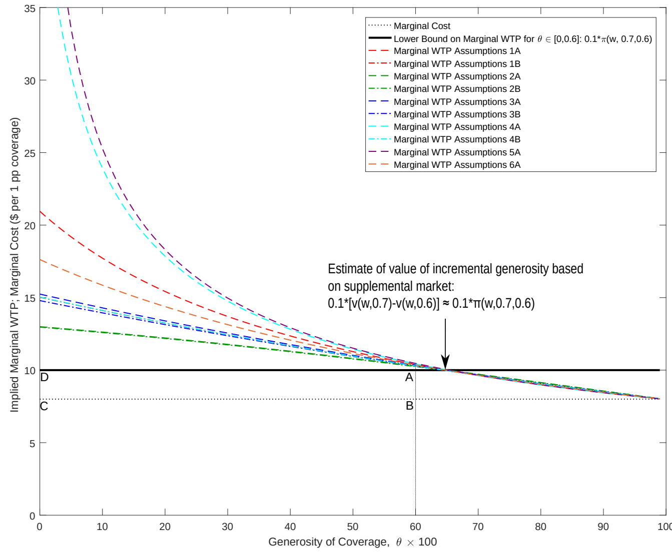
Notes: The above figure illustrates the welfare counterfactuals related to the incremental coverage sold in the existing market for supplemental insurance. Panel (A) displays the case where there is no moral hazard and considers a competitive equilibrium as the relevant benchmark against which to measure the welfare associated with a public insurance extension. Panel (B) displays the case where there is moral hazard such that the incremental coverage exerts a negative externality on the primary insurer which is not internalized by the supplemental insurer when setting prices in the benchmark perfectly competitive private supplemental insurance market.

Figure 2: Graphical Illustration: Bounding Surplus from Inframarginal Coverage for a Given Individual



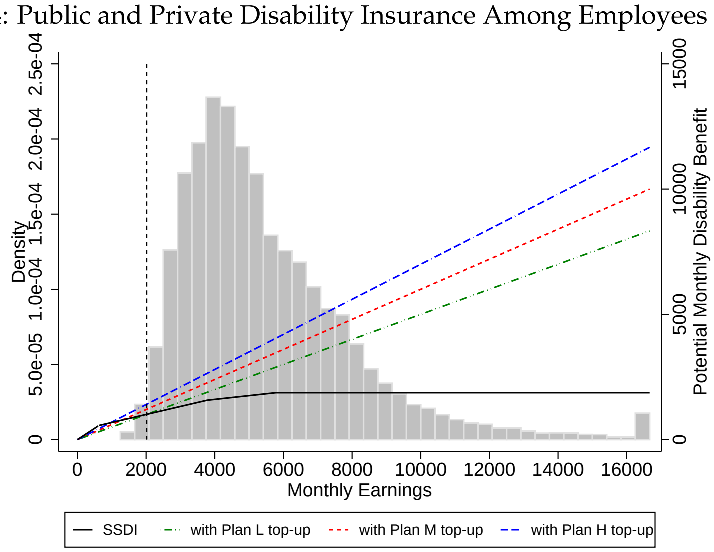
Notes: For an individual indexed by ϕ, this figure displays the individual's demand for insurance on the intensive margin (e.g., the marginal valuation $v(w,\theta|\varphi) = \frac{\partial}{\partial\theta}\pi(w,\theta,0|\varphi)$), where the horizontal axis represents the generosity of insurance (θ) and the vertical axis is measured in dollars. As in Proposition 1, suppose that (i) $v(w,\theta|\varphi)$ is weakly decreasing in θ, and (ii) $v(w,\theta|\varphi)$ is weakly decreasing in w. Under assumptions (i) and (ii), the willingness-to-pay for supplemental coverage scaled by the amount of supplemental coverage, $\frac{\pi(w,\alpha+\delta,\alpha|\varphi)}{\delta}$, provides a (under)estimate of the mean value of $v(w,\theta|\varphi)$ for $\theta \in [\alpha, \alpha+\delta]$, represented by point A. By Proposition 1 we have: $\pi(w,\alpha,0|\varphi) \geq \frac{\alpha}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi) =$ Area DEBC. This figure represents a context with moral hazard, where the marginal cost of coverage $\frac{\partial}{\partial\theta}c(w,\theta,0|\varphi)$ is upward sloping. The net welfare associated with the baseline coverage for this individual would be bounded below by $\big($Area DEJL$\big)$ if the individual has no supplemental coverage or $\big($Area DEBC-$\frac{\alpha}{\alpha+\delta}$ (Area LKMC)$\big)$ if the individual does have supplemental insurance.

Figure 3: Numerical Example



Notes: Fixing the willingness-to-pay for supplemental insurance at $100, this figure displays the numerical analogue of Figure 2 under the range of assumptions considered in Table 1. Specifically, this figure considers an individual indexed by φ and displays the individual's marginal cost and marginal valuation of insurance generosity on the intensive margin, where units are scaled to represents dollars per 1 percentage point of insurance coverage. Given the willingness-to-pay for supplemental insurance is $100, an (under)estimate of the individual's mean marginal valuation of insurance for a 1 percentage point increase in coverage is $10 over the range $\theta \in$[0.6, 0.7]. Based on Proposition 1, the lower bound on the individual's valuation of the coverage is $600 ($\pi(w, 0.6, 0|\varphi) \geq 6 \times \pi(w, 0.7, 0.6|\varphi)$) and the lower bound on the net surplus from the inframarginal coverage is $120 (Area ABCD in this figure). Under each of the considered sets of assumptions in Table 1, this figure displays the implied marginal willingness-to-pay for insurance on the intensive margin based on the parameters calibrated to match the willingness-to-pay for supplemental insurance.

Figure 4: Public and Private Disability Insurance Among Employees



Notes: This figure displays both: (i) the potential monthly disability benefit for public and private insurance for each level of monthly earnings (on the right vertical axis), and (ii) a histogram of the monthly earnings among salaried employees at the firm (on the left vertical axis). Referencing the right vertical axis, the solid line displays the SSDI public disability benefit formula for the year 2003 (the first year of our sample). The remaining three lines display the benefit formula for those who have one of the firm's three available top-up private LTD plans in addition to SSDI public disability insurance. As described in the main text, the estimation sample focuses on individuals with SSDI replacement rate less than the replacement rate of Plan L of 50%. In terms of this figure, these are the individuals whose monthly income lies to the right of the intersection of the "with Plan L top-up" line and the "SSDI" line. This level of monthly earnings based on the 2003 benefit formula is roughly $2,020 and this is indicated in the figure by the vertical reference line. In addition to displaying the public and private potential disability benefits, this figure also displays a histogram of the monthly earnings for all salaried employees (censored at $200,000/12). As can be seen in this figure, the vast majority of salaried employees at the firm have high enough earnings that their implied SSDI replacement rate lies below the 50% threshold used to define the estimation sample.

Table 1: Numerical Example

	(1) Lower bound on π(w,0.6, 0|φ)	(2) Assumptions 1A			(3) Assumptions 1B			(4) Assumptions 2A			(5) Assumptions 2B			(6) Assumptions 3A		
Supplemental Insurance WTP: π(w, 0.7, 0.6|φ)		calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio
$85	$510	0.21	$561.02	2.70	4.42E-06	$542.06	2.07	12.22	$540.27	2.01	2.24E-04	$539.71	1.99	1.29	$544.15	2.14
$90	$540	0.41	$651.61	2.86	8.59E-06	$608.25	2.14	24.54	$598.85	1.98	4.49E-04	$597.74	1.96	2.52	$612.37	2.21
$95	$570	0.60	$752.47	3.03	1.25E-05	$678.60	2.21	37.06	$654.21	1.94	6.78E-04	$652.60	1.92	3.69	$684.50	2.27
$100	$600	0.77	$864.29	3.20	1.63E-05	$753.14	2.28	49.89	$705.19	1.88	9.13E-04	$703.19	1.86	4.80	$760.32	2.34
$105	$630	0.94	$987.77	3.39	1.99E-05	$831.87	2.35	63.17	$751.06	1.81	1.16E-03	$748.79	1.79	5.87	$839.55	2.40
Assumptions																
utility	no restrictions beyond sufficient conditions in either Propositions 1 or 2	CRRA			CARA			CRRA			CARA			CRRA		
risk, [loss (probability)]		loss=$0 (0.98), -$40K (0.02)			loss=$0 (0.98), -$40K (0.02)			loss=$0 (0.50), -$1.6K (0.50)			loss=$0 (0.50), -$1.6K (0.50)			loss=$0 (0.90), -$8K (0.10)		
wage		wage=$55K			wage=$55K			wage=$55K			wage=$55K			wage=$55K		

	(7) Assumptions 3B			(8) Assumptions 4A			(9) Assumptions 4B			(10) Assumptions 5A			(11) Assumptions 6A		
WTP for supplemental insurance, π(w, 0.7, 0.6|φ)	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio	calibrated parameter	implied π(w,0.6, 0|φ)	surplus ratio
$85	2.41E-05	$541.84	2.06	0.15	$587.03	3.57	3.30E-06	$542.07	2.07	0.15	$593.12	3.77	0.32	$551.93	2.40
$90	4.70E-05	$607.24	2.12	0.29	$717.43	3.96	6.41E-06	$608.30	2.14	0.28	$734.76	4.25	0.62	$630.48	2.51
$95	6.89E-05	$676.03	2.18	0.42	$876.40	4.40	0.00E+00	$0.00	-5.33	0.41	$913.07	4.81	0.91	$715.93	2.62
$100	8.97E-05	$747.97	2.23	0.55	$1,070.18	4.92	1.21E-05	$753.44	2.28	0.54	$1,138.45	5.49	1.18	$808.50	2.74
$105	1.10E-04	$822.83	2.29	0.66	$1,306.17	5.51	1.48E-05	$832.40	2.35	0.65	$1,424.00	6.29	1.44	$908.42	2.86
Assumptions															
utility	CARA			CRRA			CARA			CRRA			CRRA		
risk, [loss (probability)]	loss=$0 (0.90), -$8K (0.10)			loss=$0 (0.985), -$53,333.33 (0.015)			loss=$0 (0.985), -$53,333.33 (0.015)			loss=$0 (0.98), -$40K (0.02)			loss=$0 (0.98), -$40K (0.02)		
wage	wage=$55K			wage=$55K			wage=$55K			wage=$40.5K			wage=$80K		

Notes: The above table describes a numerical example which compares the bounding approach described in the text to a more structural analysis that defines a particular utility function and distribution of risk. Consider an individual indexed by φ who faces some potential loss and has compulsory public insurance that covers 60% of this risk. Further, suppose the individual has the option to purchase private supplemental insurance to cover an additional 10% of the risk on top of the public insurance. Following the definitions in the text, let $\pi(w, 0.6, 0|\varphi)$ represent the individual's willingness-to-pay for compulsory public insurance relative to no insurance, and let $\pi(w, 0.7, 0.6|\varphi)$ represent the individual's willingness-to-pay for supplemental insurance to top-up the compulsory public insurance. Suppose the individual's demand/preferences satisfy the sufficient condition in either Proposition 1 or 2, we get a lower bound on $\pi(w, 0.6, 0|\varphi)$ for any given observed $\pi(w, 0.7, 0.6|\varphi)$. This bound is applicable regardless of the distribution of uncertainty the individual faces and regardless of what form the utility takes. To contrast this bound with an approach that specifies more of the underlying primitives, the table displays the implied value of $\pi(w, 0.6, 0|\varphi)$ given a value of $\pi(w, 0.7, 0.6|\varphi)$ under various assumptions. Specifically, for each set of assumptions and each value of the willingness-to-pay for supplemental coverage ($\pi(w, 0.7, 0.6|\varphi)$), Table 1 reports the calibrated utility parameters to match this willingness-to-pay for supplemental insurance and the implied willingness-to-pay for the inframarginal coverage, $\pi(w, 0.6, 0|\varphi)$, based on these calibrated parameters. For each scenario considered, the table also displays the *surplus ratio*, which we define as the ratio of the surplus from the inframarginal coverage under the stated assumptions to the lower bound on surplus from the inframarginal coverage derived under Proposition 1 (*surplus ratio*= $\frac{\pi(w,0.6,0|\varphi)-c(w,0.6,0|\varphi)}{\text{Bound}\left(\pi(w,0.6,0|\varphi)-c(w,0.6,0|\varphi)\right)}$). The surplus ratio describes how tight the lower bound is under a given set of assumptions, with a smaller ratio indicating a tighter bound. Taking the case of $\pi(w, 0.7, 0.6|\varphi) = \$100$, Figure 3 plots numerical analogue of Figure 2 under the sets of assumptions described in this table.

Table 2: Long-Term Disability Plan Details

	Coverage				
	Plan L	Plan M	Plan H		
Replacement Rate, All years	50%	60%	70%		
	Annual Premium (fraction of annual earnings)			**Relative Premium (fraction of annual earnings)**	
	Plan L	Plan M	Plan H	Plan M-Plan L	Plan H- Plan M
Year					
2003	0	0.00152	0.00315	0.00152	0.00163
2004	0	0.00152	0.00261	0.00152	0.00109
2005	0	0.00151	0.00259	0.00151	0.00108
2006	0	0.00162	0.00273	0.00162	0.00111
	Annual Premium (scaled by reference earnings of $60K)			**Relative Premium (scaled by reference earnings of $60K)**	
	Plan L	Plan M	Plan H	Plan M-Plan L	Plan H- Plan M
Year					
2003	0	91	189	91	98
2004	0	91	157	91	65
2005	0	91	156	91	65
2006	0	97	164	97	67
	Plan Enrollment in Estimation Sample				
	Plan L	Plan M	Plan H		
Year					
2003	18.7%	20.9%	60.3%		
2004	19.5%	16.3%	64.2%		
2005	20.4%	15.0%	64.6%		
2006	22.2%	13.5%	64.3%		

Notes: This table describes the three long-term disability plans available on the menu of plans offered to employees in the estimation sample. In the context of disability, both benefits and costs are stated in relative terms, relative to the annual earnings. The replacement rate for each plan describes the fraction of annual earnings paid out in the case of disability. In this table, premiums are stated as a fraction of annual earnings, and scaled by $60K, roughly the median annual earnings in the estimation sample.

Table 3: Summary Statistics

	Firm Data			March CPS 2004-2007 (corresponding to 2003-2006)			
	All Employees	Salary Employees	Employees in Estimation Sample	All Employees	Manufacturing Employees	Manufacturing White Collar Employees	Manufacturing White Collar Employees with DI RR <0.5 and wage<200k
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employee-years	203,457	62,539	47,884	307,018	40,685	11,478	10,650
(unique employees)	(69,297)	(20,709)	(15,754)	(228,952)	(38,954)	(11,331)	(10,265)
Fraction Male	0.76	0.72	0.72	0.58	0.71	0.74	0.75
Fraction Salary	0.31	1.00	1.00	0.37	0.29	1.00	1.00
Mean Job Tenure	13.0	13.2	13.5	-	-	-	-
Fraction White	0.78	0.86	0.87	0.69	0.70	0.81	0.81
Age							
Mean	44.1	44.4	44.3	40.8	41.9	43.1	43.2
Median	45	45	45	41	42	43	43
Std Dev	10.3	9.5	9.2	11.1	10.6	9.5	9.4
Wage							
Mean	$44,401	$65,160	$66,668	$44,118	$47,578	$76,145	$73,293
Median	$36,516	$58,794	$59,986	$33,906	$36,813	$63,685	$65,134
Std Dev	$66,696	$28,521	$28,477	$49,209	$45,177	$62,994	$34,366
SSDI Replacement Rate							
Mean	42.2%	34.5%	34.0%	45.2%	43.6%	33.0%	32.0%
Median	44.1%	35.4%	35.4%	44.4%	43.8%	33.6%	33.1%
Std Dev	7.8%	8.8%	8.6%	15.7%	14.5%	12.6%	9.8%

Notes: This table displays summary statistics for employees in the data. All dollar quantities are inflation adjusted to 2005 dollars using the CPI-U. Column (1) displays summary statistics for all employees from the firm, column (2) displays summary statistics for all salary employees at the firm, and column (3) displays summary statistics for employees in the estimation sample. The estimation sample is restricted to salary employees who have the relevant menu of LTD plans offered to them, who have annual earnings less than $200,000, and who have an SSDI replacement rate less than 50%. Columns (4) through (7) display summary statistics for employees from the March Current Population Survey (CPS) for the corresponding years, 2004-2007 (which describe labor market outcomes from 2003-2006). Column (4) displays the summary statistics for all employees in the CPS, while column (5) displays summary statistics for all manufacturing employees in the CPS. Column (6) displays summary statistics for manufacturing employees in white collar occupations, where occupations are classified as white collar if they are managerial or professional occupations. Column (7) displays summary statistics for manufacturing employees with white collar occupations who have implied SSDI replacement rates less than 50% (using their reported monthly earnings as a proxy for their AIME) and annual earnings less than $200,000. As described in the text, the table reports the mean pre-tax SSDI replacement rate for workers in the sample using the SSA formula replacing the average indexed monthly earnings (AIME) with an individual's monthly earnings according to the firm's human resources records (or mean reported monthly earnings in the CPS in columns (4) through (7)). We note this is an imperfect calculation because we don't have data on each worker's full work history which would be needed to precisely calculate the AIME following the SSA formula.

Table 4: Identifying Variation

	Highest Relative Price	Lower Relative Price			Coefficient	p-value
	2003	2004	2005	2006		
	(1)	(2)	(3)	(4)	(5)	(6)
Fraction Male	0.72	0.72	0.73	0.73	6.23E-07	0.39
Mean Age	43.8	44.1	44.4	44.8	4.52E-08	0.38
Mean Job Tenure	13.4	13.5	13.5	13.6	-1.62E-08	0.79
Mean ln(Annual Earnings)	10.97	11.00	11.02	11.05	-1.99E-06	0.12
Fraction White	0.87	0.87	0.87	0.86	-8.14E-08	0.95
Predicted probability of LTD claim	0.0032	0.0032	0.0031	0.0031	1.41E-04	0.38
N	12,687	11,969	11,840	11,388		

Notes: This table displays summary statistics by the variation in premiums used for identification. The row labeled "Predicted probability of LTD claim" reports the mean fitted value from a regression of an indicator of LTD receipt on the demographic characteristics in the table, where we control flexibly for age and wage using indicators for deciles of these distributions. Columns (1) through (4) display summary statistics for employee demographics by year. The remaining columns display how the identifying variation in the relative price of Plan H ($p_{it}^H - p_{it}^M$) is related to the demographics in the table. Column (5) and Column (6) displays the coefficient and p-value associated with a regression of the continuous relative premium for Plan H on the demographic characteristic and a time trend.

Table 5: Demand and Cost Estimates

Panel A: Demand Estimates		
	Plan H (1)	Plan H (2)
Relative premium Plan H	-71.26	-64.93
	(11.77)	(12.21)
Constant	0.72	0.70
	(0.03)	(0.02)
Controls		
Time Trend	x	x
Individual Fixed Effects		x
N	47,884	47,884
Implied Mean WTP for Incremental Coverage, $/annual earnings		
Estimate	0.00310	0.00328
Std Error	(0.00032)	(0.00034)

Panel B: Mean Costs	Plan H	
	Mean	Std Error
Per capita cost, $/annual earnings		
All	0.00111	(.00014)
Do Purchase incremental coverage (dep var=1)	0.00155	(.00021)
Do not purchase incremental coverage (dep var=0)	0.00036	(.00013)
Relative premium, $/annual earnings	0.00124	(1.09E-06)

Notes: The above table displays the demand and cost estimates. Panel A columns (1) and (2) display the results of estimating a linear demand specification for Plan H coverage, without individual fixed-effects (column 1) and with individual fixed-effects (column 2). The bootstrapped standard error on the mean implied willingness-to-pay for the incremental coverage (relative to annual earnings) is calculated using 10,000 bootstrap samples. Panel B displays the mean cost estimates for everyone and separately for those who do and do not purchase Plan H. As discussed in Section 4, the mean cost reported here is the mean present discounted value of disability claim costs relative to annual earnings scaled to represent a 10% replacement rate. For reference, the relative premium for Plan H is listed below the mean cost estimates.

Table 6: Implied Welfare Analysis

Panel A: Marginal and Inframarginal Coverage Observed in the Status Quo	(Lower Bound on) Mean WTP				(Lower Bound on) Per-Capita Welfare				Mean Cost Per-Capita	
	relative to annual earnings		% of cost	scaled by 65K	relative to annual earnings		% of cost	scaled by 65K	relative to annual earnings	
(1) Marginal Coverage: Observed Allocation of Supplemental Insurance	0.00359	(0.00049)	366%	$233	0.00261	(0.00054)	266%	$170	0.00098	(0.00016)
(2) Inframarginal Coverage: Compulsory public coverage with 34% replacement rate	0.01053	(0.00110)	279%	$684	0.00677	(0.00119)	179%	$440	0.00377	(0.00058)

Panel B: Counterfactual: Extension of compulsory baseline 60% rep rate coverage to include incremental 10% rep rate coverage (relative to no incremental insurance)	Moral hazard semi-elasticity: 10 pp increase in the replacement rate leads to a X% increase in the PDV of lost earnings due to disability									
	0% (Baseline)	2.5%	5.0%	7.5%	10.0%	15.0%	20.0%	30.0%	40.0%	50.0%
Per-capita welfare										
per dollar of annual earnings	0.00199	0.00182	0.00166	0.00151	0.00136	0.00107	0.00081	0.00032	-0.00012	-0.00052
	(0.00036)	(0.00037)	(0.00038)	(0.00040)	(0.00041)	(0.00044)	(0.00047)	(0.00052)	(0.00058)	(0.00063)
scaled by 65K	$129	$118	$108	$98	$88	$70	$53	$21	-$8	-$34
	(23)	(24)	(25)	(31)	(31)	(33)	(35)	(34)	(38)	(45)
% of compulsory insurer costs	179%	142%	115%	95%	78%	53%	35%	12%	-4%	-14%
Mean compuslory insurer costs										
per dollar of annual earnings	0.00111	0.00128	0.00144	0.00159	0.00174	0.00203	0.00229	0.00278	0.00322	0.00362
	(0.00017)	(0.00020)	(0.00022)	(0.00025)	(0.00027)	(0.00031)	(0.00035)	(0.00043)	(0.00049)	(0.00056)

Notes: This table displays the implied welfare measures using demand estimates from Table 5 column (1). Panel A presents our baseline welfare analysis analyzing the welfare associated with the marginal and inframarginal coverage under the observed allocation of insurance in the status quo. Row (1) displays welfare associated with the incremental coverage evaluated the mean observed allocation of supplemental coverage. As discussed in the text, the mean observed allocation of the incremental coverage is very close to the allocation under a competitive equilibrium for this coverage, so we think about these welfare measures as approximating the welfare associated with a competitive market for the incremental coverage. Row (2) presents the a lower bound on the welfare associated with the inframarginal disability insurance providing a 34% replacement rate, the mean public disability replacement rate among individuals in the sample. Panel B presents estimates of welfare under a hypothetical compulsory insurance extension from a baseline 60% replacement rate to a 70% replacement rate, relative to a scenario in which no one has this incremental coverage. Each column displays these estimates under the stated assumed moral hazard semi-elasticity: the percentage change in the PDV of lost earnings due to disability with respect to a change in the replacement rate. The bootstrapped standard errors on the mean willingness-to-pay and welfare estimates are calculated using 10,000 bootstrap samples.

Table 7: Robustness: Alternative Specifications

Panel A: Lower Bound on Value of Public Coverage Based on Alternative Specifications

	Lower Bound on Mean WTP				Lower Bound on Per-Capita Welfare			
	relative to annual earnings (1)		% of mean cost (2)	scaled by 65K (3)	relative to annual earnings (4)		% of mean cost (5)	scaled by 65K (6)
	Est	Std Err			Est	Std Err		
1. Baseline	0.01053	(.0011)	279%	684	0.00677	(.00119)	179%	440
Robustness to Alternative Demand								
2. Probit demand	0.01014	(.00104)	269%	659	0.00637	(.00115)	169%	414
3. Logit demand	0.01009	(.00103)	267%	656	0.00633	(.00115)	167%	411
4. Linear demand, wtp=max(linear fitted value,0)	0.01239	(.00159)	328%	805	0.00862	(.00177)	228%	560
5. Linear-log demand, constrained to go through (q=0, p=0.01)	0.00981	(.00034)	260%	638	0.00605	(.00046)	160%	393
6. Log-log demand, constrained to go through (q=0, p=0.01)	0.00827	(.00031)	219%	538	0.00450	(.00046)	119%	293
Robustness to Identifying Variation								
7. No Controls	0.01019	(.00112)	270%	662	0.00643	(.00132)	170%	418
8. Demographics included	0.01055	(.00101)	280%	686	0.00678	(.00114)	180%	441
9. Individual fixed-effects	0.01115	(.00118)	295%	725	0.00738	(.00125)	196%	480
10. Propensity Score Reweighted	0.01094	(.00129)	290%	711	0.00717	(.00138)	190%	466
Robustness to Accounting for Tax Treatment								
11. Baseline specification but incorporating tax treatment of premiums and benefits	0.01053	(.0011)	279%	684	0.00677	(.00119)	179%	440
Robustness to Alternative Sample								
12. Exclude individuals who appear to be passive choosers in any year	0.01018	(.00117)	263%	662	0.00632	(.00129)	163%	411

Panel B: Parameter Estimates from Alternative Specifications

	Demand				Mean Cost	
	Relative Premium		Constant			
	Coeff (1)	Std Err (2)	Coeff (3)	Std Err (4)	Mean (5)	Std Err (6)
1. Baseline	-71.26	(11.77)	0.72	(0.026)	0.00111	(.00014)
Robustness to Alternative Demand						
2. Probit demand	-187.70	(37.67)	0.57	(0.026)	0.00111	(.00014)
3. Logit demand	-303.70	(61.07)	0.91	(0.091)	0.00111	(.00014)
4. Linear demand, wtp=max(fitted linear value,0)	-71.26	(11.77)	0.72		0.00111	(.00014)
5. Linear-log demand, constrained to go through (q=0, p=0.01)	-0.30	(0.001)	-1.35	(0.005)	0.00111	(.00014)
6. Log-log demand, constrained to go through (q=0, p=0.01)	-0.21	(0.001)	-0.93	(0.004)	0.00111	(.00014)
Robustness to Identifying Variation						
7. No Controls	-75.30	(14.68)	0.73	(0.029)	0.00111	(.00014)
8. Demographics included	-72.63	(14.00)	0.34	(0.024)	0.00111	(.00014)
9. Individual fixed-effects	-64.93	(12.21)	0.70	(0.015)	0.00111	(.00014)
10. Propensity Score Reweighted	-65.22	(14.28)	0.71	(0.021)	0.00111	(.00014)
Robustness to Accounting for Tax Treatment						
11. Baseline specification but incorporating tax treatment of premiums and benefits	-109.60	(21.82)	0.72	(0.021)	0.00072	(.0001)
Robustness to Alternative Sample						
12. Exclude individuals who appear to be passive choosers in any year	-66.61	(13.11)	0.70	(0.029)	0.00114	(.00019)

Notes: This table illustrates that the main results are similar when using alternative functional forms for demand, using alternative controls isolating slightly different variation, accounting for the tax treatment of premiums and benefits, and focusing on employees who appear to be "active choosers". Panel A displays the implied lower bound on the value of public coverage based on the alternative specifications (analogous to that reported in Table 6 Panel A row 2); Panel B displays the underlying demand and mean cost estimates. As discussed in Section 4, the mean cost reported here is the mean present discounted value of disability claim costs relative to annual earnings scaled to represent a 10% replacement rate. Panel A reports bootstrapped standard errors using 10,000 bootstrap samples. Each row represents the results of a distinct specification. For reference, row (1) displays the baseline estimates (from Table 5 column 1) and implied welfare bounds (from Table 6 Panel A row 2). Rows (2) through (6) display the estimates and implied welfare bounds using alternative specifications of the demand curve. Row (5) reports the results for a linear-log specification where the dependent variable is $PlanH_{it}$ and the main independent variable is $ln(p_{it}^H - p_{it}^M)$; the log-log specification in Row (6) reports results for a specification with the dependent variable $ln(PlanH_{it}+1)$ and the main independent variable $ln(p_{it}^H - p_{it}^M)$. Rows (7) through (10) display the estimates and implied welfare bounds concentrating on slightly different aspects of the identifying variation by including alternative sets of controls. Row (11) displays the estimates and implied welfare bounds accounting for the tax treatment of LTD premiums, LTD benefits, and SSDI benefits. In this specification, we make these adjustments assuming a constant marginal tax rate in this population of 35% (roughly the average marginal tax rate based on the observables we have in the data). Row (12) displays the results for an alternative sample excluding the roughly 13% of employees who appear to be "passive" choosers at some point during the sample period. We designate an employee as a "passive" chooser if his/her insurance selections in any year during our sample period are completely consistent with all the various default options across the range of employee benefits offered by the firm including health insurance, prescription drug insurance, dental insurance, and disability insurance.

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APPENDIX

A Proof of Proposition 2

Proposition 2. Suppose an individual's utility can be represented by the increasing, thrice differentiable function $u(c)$. Define $\pi(w,\theta,\gamma|\varphi)$ as: $E[u(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))] = E[u(w+(1-\gamma)x)]$, where $\theta > \gamma$ and the expectation is taken over $x \leq 0$, representing the uncertain losses the individual faces. Additionally, suppose the individual is risk averse and his/her utility exhibits weakly decreasing absolute risk aversion. Then,

$$\pi(w,\alpha,0|\varphi) \geq \frac{\alpha}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi). \tag{18}$$

and thus we obtain the bound in Corollary 1.

Proof. Based on Lemma 1 below, we complete the proof by demonstrating: (i) $\frac{\partial}{\partial\theta}\big(\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma}\big) \leq 0$, and (ii) $\frac{\partial}{\partial\gamma}\big(\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma}\big) \leq 0$.

proof of (i):

Let $z \equiv w+(1-\gamma)x$ and $y \equiv -\pi(w,\theta,\gamma|\varphi)-(\theta-\gamma)x$. Define a function $F(\beta) = Eu(z+\beta y) - Eu(z)$.[68] Obviously, $F(0) = 0$. By definition of $\pi(w,\theta,\gamma|\varphi)$, we know that $F(1) = 0$.
We want to show that

$$\frac{\partial}{\partial\theta}\big(\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma}\big) \leq 0. \tag{19}$$

Note that this is equivalent to,

$$\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma} \geq \frac{\partial}{\partial\theta}\pi(w,\theta,\gamma|\varphi) = \frac{-Exu'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))}{Eu'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))}. \tag{20}$$

Re-writing this condition we get:

$$E\Big[\big(\pi(w,\theta,\gamma|\varphi)+(\theta-\gamma)x\big)u'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))\Big] \geq 0. \tag{21}$$

Substituting in the definitions above we get:

$$E[-yu'(z+y)] = -F'(1) \geq 0. \tag{22}$$

Under risk aversion, F is concave. Because $F(0) = F(1) = 0$, we know that $F'(1) \leq 0$, and thus the above condition holds.

proof of (ii):

Let $z \equiv w+(1-\gamma)x-(\theta-\gamma)x-\pi(w,\theta,\gamma|\varphi)$ and $y \equiv \pi(w,\theta,\gamma|\varphi)+(\theta-\gamma)x$. Define a function $F(\beta) = Eu(z+\beta y) - Eu(z)$. Obviously, $F(0) = 0$. By definition of $\pi(w,\theta,\gamma|\varphi)$, we know that $F(1) = 0$.
We want to show that:

$$\frac{\partial}{\partial\gamma}\left(\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma}\right) \leq 0. \tag{23}$$

Note that this is equivalent to,

$$\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma} \leq -\frac{\partial}{\partial\gamma}\pi(w,\theta,\gamma|\varphi) = \frac{-Exu'(w+(1-\gamma)x)}{Eu'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))}. \tag{24}$$

[68] The technique used for this part of the proof draws upon a similar technique used in Eeckhoudt and Gollier (2001).

Let us re-write this as follows:

$$\pi(w,\theta,\gamma|\varphi)Eu'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))+(\theta-\gamma)Exu'(w+(1-\gamma)x)\leq 0. \tag{25}$$

Because the individual's utility exhibits weakly decreasing absolute risk aversion, we know by Lemma 2 below that: $Eu'(w+(1-\gamma)x)\geq Eu'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))$. So, the LHS of the above is bounded above

$$\pi(w,\theta,\gamma|\varphi)Eu'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))+(\theta-\gamma)Exu'(w+(1-\gamma)x)\leq E\Bigg[\Big(\pi(w,\theta,\gamma|\varphi)+(\theta-\gamma)x\Big)u'(w+(1-\gamma)x)\Bigg]. \tag{26}$$

Re-writing the RHS term using the above definitions,

$$E\Bigg[\Big(\pi(w,\theta,\gamma|\varphi)+(\theta-\gamma)x\Big)u'(w+(1-\gamma)x)\Bigg]=E[yu'(z+y)]=F'(1).$$

Under risk aversion, F is concave. Because $F(0)=F(1)=0$, we know that $F'(1)\leq 0$. □

Lemma 1. Suppose (i) $\frac{\partial}{\partial\theta}\big(\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma}\big)\leq 0$, and (ii) $\frac{\partial}{\partial\gamma}\big(\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma}\big)\leq 0$.
Then,

$$\text{[a]}\quad \pi(w,\alpha,0|\varphi)\geq\frac{\alpha}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi),\quad\text{and}\quad\text{[b]}\quad\pi(w,\alpha+\delta,0|\varphi)\geq\frac{\alpha+\delta}{\delta}\pi(w,\alpha+\delta,\alpha|\varphi) \tag{27}$$

Proof. Under the assumptions, we get the following:

$$\frac{\pi(w,\theta,\gamma|\varphi)}{\theta-\gamma}\geq\frac{\pi(w,\theta+\epsilon,\gamma|\varphi)}{\theta+\epsilon-\gamma}\geq\frac{\pi(w,\theta+\epsilon,\gamma+\mu|\varphi)}{\theta+\epsilon-(\gamma+\mu)} \tag{28}$$

where the first inequality follows from assumption (i) and the second from assumption (ii). This holds for all $\mu,\epsilon\geq 0$. Evaluating this at $\mu=\theta-\gamma$, $\theta=\alpha$, $\gamma=0$, and $\epsilon=\delta$ gives result [a] and result [b]. □

Lemma 2. If $u(c)$ exhibits weakly decreasing absolute risk aversion, then $Eu'(w+(1-\gamma)x)\geq Eu'(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))$

Proof. Weakly decreasing absolute risk aversion means,

$$\frac{\partial}{\partial c}\Big(\frac{-u''(c)}{u'(c)}\Big)\leq 0. \tag{29}$$

This is equivalent to,

$$\frac{-u'u'''+(u'')^2}{(u')^2}\leq 0. \tag{30}$$

Multiplying both sides by $\frac{u'}{u''}$ (≤ 0) and rearranging terms we get:

$$\frac{-u'''}{u''}\geq\frac{-u''}{u'}. \tag{31}$$

Notice that $v=-u'$ is a valid utility function as it is increasing in c. Since we know this holds for all c, $-u'$ is more risk averse than u, and thus we can represent $-u'$ as an increasing concave transformation of u: $-u'=\phi(u)$.

The result then follows from showing that the distribution of $u(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))$ second order stochastically dominates the distribution of $u(w+(1-\gamma)x)$ (and thus every concave utility function, including ϕ, prefers it). Consider two distributions, $F_A(z)$ and $F_B(z)$ with the same mean. Suppose these distributions are defined over a finite domain $[\underline{z},\overline{z}]$, where $F_A(\underline{z})=F_B(\underline{z})=0$ and $F_A(\overline{z})=F_B(\overline{z})=1$. Showing $F_A(z)$ second order stochastically dominates $F_B(z)$ is equivalent to showing:

$$\int_{\underline{z}}^{y}[F_A(z)-F_B(z)]dz\leq 0,\qquad\forall y\in\{\underline{z},\overline{z}\}. \tag{32}$$

Applying this to our context, we want to show:

$$\int_{\underline{z}}^{y}[F_x(\frac{u^{-1}(z)-w+\pi(w,\theta,\gamma|\varphi)}{1-\theta})-F_x(\frac{u^{-1}(z)-w}{1-\gamma})]dz \leq 0, \qquad \forall y \in \{\underline{z},\overline{z}\}. \tag{33}$$

It is easy to show that the cumulative density functions cross exactly once at the point $z^* = u(w + \frac{1-\gamma}{\gamma-\theta}\pi(w,\theta,\gamma|\varphi))$:

$$F_x(\frac{u^{-1}(z)-w+\pi(w,\theta,\gamma|\varphi)}{1-\theta})-F_x(\frac{u^{-1}(z)-w}{1-\gamma}) \leq 0 \qquad \forall z \in \{\underline{z},z^*\},$$
$$F_x(\frac{u^{-1}(z)-w+\pi(w,\theta,\gamma|\varphi)}{1-\theta})-F_x(\frac{u^{-1}(z)-w}{1-\gamma}) \geq 0 \qquad \forall z \in \{z^*,\overline{z}\}. \tag{34}$$

Thus, we know that $\int_{\underline{z}}^{y}[F_x(\frac{u^{-1}(z)-w+\pi(w,\theta,\gamma|\varphi)}{1-\theta})-F_x(\frac{u^{-1}(z)-w}{1-\gamma})]dz \leq 0, \quad \forall y \in \{\underline{z},z^*\}$. In addition, it is straightforward to show that the fact that the distributions have the same means ($Eu(w+(1-\gamma)x) = Eu(w+(1-\theta)x-\pi(w,\theta,\gamma|\varphi))$) implies that $\int_{\underline{z}}^{\overline{z}}[F_x(\frac{u^{-1}(z)-w+\pi(w,\theta,\gamma|\varphi)}{1-\theta})-F_x(\frac{u^{-1}(z)-w}{1-\gamma})]dz = 0$. Thus, it must be the case that $\int_{\underline{z}}^{y}[F_x(\frac{u^{-1}(z)-w+\pi(w,\theta,\gamma|\varphi)}{1-\theta})-F_x(\frac{u^{-1}(z)-w}{1-\gamma})]dz \leq 0, \quad \forall y \in \{\underline{z},\overline{z}\}$.

□

B Moral Hazard and Selection: Estimates and Robustness

As discussed in Section 3, the data and environment has both strengths and weaknesses in terms of capturing the costs associated with disability. A strength of the empirical environment is that there is individual-level administrative cost data. While in principle one could use the very same price variation used to estimate the demand curves to estimate moral hazard and selection, a practical limitation is that it is difficult to obtain precise estimates of selection and moral hazard within the context of disability insurance because realized costs are noisy proxies for expected costs given the low incidence of disability. In the face of these strengths and weaknesses, we take the following approach. First, our baseline welfare analysis focuses on estimating welfare in the status quo allocation of insurance. Since this estimation draws on observed realized costs, this analysis fully incorporates moral hazard and selection within the status quo insurance allocation. Second, we analyze welfare within counterfactuals that depart from the status quo allocation of insurance under a wide range of assumptions on the moral hazard elasticity. As will become clear, the counterfactuals we focus on do not require estimating the degree of selection. Overall, we find that the key lessons of the counterfactual welfare analysis are not very sensitive to the amount of incremental moral hazard within a plausible range of elasticities.

While our baseline welfare analysis does not depend on estimating moral hazard or selection, here we present estimates of moral hazard and selection leveraging the available price variation. As noted in the text, there is limited statistical power for these analyses, so they should be interpreted with this caveat in mind.

Moral Hazard Let c_{it} represent the present discounted value of the realized costs relative to annual earnings associated with providing individual i in year t an incremental 10% replacement rate paid in the event of disability.[69] We investigate the possibility of moral hazard by estimating the following reduced form equation:

$$c_{it} = \beta_0 + \beta_1(p_{it}^H - p_{it}^M) + \beta_2 p_{it}^M + \lambda X_{it} + \epsilon_{it}, \tag{35}$$

where $(p_{it}^H - p_{it}^M)$ and p_{it}^M are the relative prices of Plan H and Plan M, respectively. The demand results reveal that the demand for Plan H coverage and Plan M coverage are both responsive to the respective relative prices. Thus, the test for moral hazard is then a test on whether lower relative prices (and thus more people on more generous coverage) lead to higher claims. In addition to estimating the reduced form specification described above, we also estimate the analogous instrumental variables (IV) specification where we estimate the relationship between costs and the share of people with Plan H and Plan M coverage, instrumenting these shares with the variation in relative prices.

Table A1 Panel A displays these estimates. Across all the specifications, the estimates are statistically indistinguishable from zero, consistent with the incremental disability coverage inducing no moral hazard in

[69] Recall that we use an interest rate of 4% in the baseline estimation.

this setting. Note that while the estimates are consistent with no moral hazard associated with the incremental coverage, the estimates are not very precise. This lack of precision is not surprising, given the low incidence of disability claims and the range of variation exploited in this IV strategy.

Selection As discussed in Section 4, our baseline analysis investigates welfare under the status quo allocation of insurance and thus does not require estimating the degree of selection. Additionally, the counterfactual analysis considers an extension of the compulsory insurance to include the supplemental coverage relative to a setting in which no one has the supplemental coverage, which again does not require estimating the degree of selection. Nevertheless, below we investigate selection in this setting for completeness.

Table 5 Panel B in the text displays the mean cost scaled to represent a 10% replacement rate (the mean value of c_{it}) for everyone in the estimation sample and separately for those who do and do not purchase the incremental coverage. Note that the mean relative price for Plan H is very close to the average cost of those individuals willing to pay for the incremental coverage. In other words, the predicted competitive equilibrium in the market for the incremental coverage would be close to the observed pair of average prices and quantities regardless of the shape of the average and marginal cost curves far outside of the variation in the data. Thus, we can think of the observed mean (relative) costs of the insured and quantity of individuals insured as an approximation of the competitive equilibrium for the incremental coverage, which allows us to interpret the welfare measures describing the status quo allocation of supplemental insurance as approximating that of a competitive equilibrium for supplemental insurance.

While mean costs in the status quo are an approximation of the costs in a competitive equilibrium, we can use alternative methods to predict counterfactual mean costs in a competitive market and demonstrate that these yield similar estimates. For instance, one way to measure selection in this setting is to use the price variation used to estimate demand to trace out the marginal and average cost curves of the insurer, using the Einav and Finkelstein (2011) approach. Alternatively, another way one could measure selection in this setting would be to assume there is no moral hazard and thus bring in another moment on the cost curve, the average costs of insuring everyone under Plan H (the mean value of c_{it} for the population if there is no moral hazard). Comparing these approaches, the former approach leverages variation in costs among those marginal to the price variation in the data, while the latter approach provides a measure of global selection in this population. Figure A2 plots the average and marginal costs curves obtained from each of these approaches. (Table A1 Panel B column (1) reports the underlying point estimates for the approach leveraging the marginal price variation.) There are at least two things to note in this figure. First, we obtain very similar cost curves representing selection regardless of which method we use to measure selection in this setting. Second, regardless of the shape of the average and marginal cost curves far outside of the variation in the data, the observed average price and quantity across the sample period are close to the predicted competitive equilibrium using either set of cost curves.

C Additional Demand Estimates

As discussed in Section 2, the main estimation focuses on the demand for Plan H over Plan M because most of the premium variation in this context is in the relative premium for Plan H over Plan M. However, in addition to our main estimates on the demand for Plan H relative to Plan M, we also investigate the demand for Plan M relative to Plan L coverage to provide suggestive evidence on the validity of Assumption 1. To do this, we use the limited variation in the (relative) premium for Plan M compared to Plan L to estimate the demand for Plan M coverage. Specifically, we estimate the relative demand for Plan M by estimating the following equation:

$$PlanMorH_{it} = I(r_\pi(0.6, 0.5|\varphi) \geq p^M_{it}) = \theta_0 + \theta_1 p^M_{it} + \phi X_{it} + e_{it}, \tag{36}$$

where $PlanMorH_i$ indicates that the individual chose Plan H or Plan M coverage and p^M_{it} is the price of Plan M relative to Plan L (as $p^L_{it} = 0$).

Table A2 displays the Plan M demand estimates as well as the baseline Plan H demand estimates for reference. There are two important things to note about the Plan M demand estimates as compared to analogous estimates for Plan H coverage. First, while the negative premium coefficient estimates in Panel A columns (3) and (4) suggest that the demand for the incremental coverage provided by Plan M is price-sensitive, the coefficient estimates and the corresponding mean implied willingness-to-pay for coverage are much less precisely estimated than the analogous estimates for Plan H coverage. The difference in precision across these estimates is not surprising given the limited variation in Plan M premiums during the sample period relative to the variation in the Plan H premium (see Table 2). Second, though the Plan M demand estimates are statistically imprecise, the general pattern of the mean implied willingness-to-pay estimates is consistent with the assumption we use to derive a lower bound on the total welfare (Assumption 1). Assumption 1 implies that an individual's willingness-to-pay for incremental coverage is decreasing in the replacement rate of the baseline coverage, and thus an individual's willingness-to-pay for Plan M is weakly greater than his/her willingness-to-pay for Plan H.[70] Consistent with this assumption, the estimate for the mean willingness-to-pay for Plan M coverage is higher than the estimated mean willingness-to-pay for Plan H coverage, though the Plan M estimates are imprecise enough that these estimates are not statistically distinct. While the baseline welfare analysis in the text uses the more precise (and more conservative) Plan H demand estimates, Appendix D reports the analogous welfare measures based on the Plan M demand estimates for comparison.

D Additional Robustness Analysis

In addition to the robustness analysis presented in the text, we examine the robustness of the results to additional alternative specifications. Table A3 displays the results of this additional analysis. Panel A displays the implied lower bound on the value of public coverage based on the alternative specifications, and Panel B displays the underlying regression estimates for the alternative specifications. Each row represents the results of a distinct specification. For reference, row (1) displays the baseline estimates and implied welfare bounds (based on Table 5 Panel A column (1)). Rows (2) through (4) display the estimates and implied welfare bounds using alternative specifications of the cost measures. The baseline analysis uses the present discounted value of costs using an interest rate of 4%, where we use the maximum potential duration for spells censored at five years (as described in the text, Section 2). Row (2) displays an alternative specification where costs are measured only through the first five years following the year of disability onset (the years for which we have complete claims data). This specification yields a less conservative bound than the baseline analysis. Rows (3) and (4) display specifications where costs are defined as the present discounted value of the maximum potential duration for truncated spells, using alternative interest rates to calculate the present discounted value. Comparing these specifications to the baseline estimates, we see that the analysis is not very sensitive to the chosen discount rate within a range of reasonable interest rates.

The baseline welfare analysis utilizes the demand for Plan H, estimated based on the variation described in Table 2. Leveraging the modest amount of variation in Plan M premiums, we can repeat the welfare analysis using the implied Plan M demand curve. Table A3 row (5) displays an alternative specification that relies on the Plan M demand estimates. As discussed above, the implied mean valuation of Plan M exceeds that of Plan H, so this alternative specification provides a less conservative lower bound on the value of disability coverage. However, as discussed above, the relatively small amount of variation in Plan M premiums limits the statistical precision of welfare analysis based on the Plan M estimates as compared to the baseline welfare analysis which leverages the Plan H estimates.

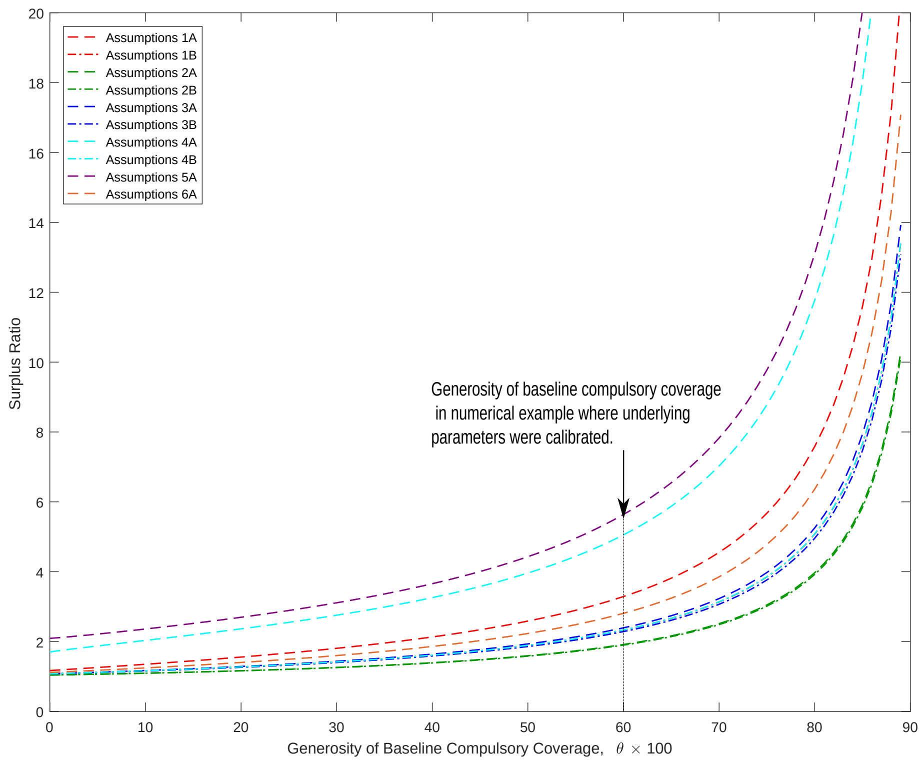
E Tax Treatment of Premiums and Benefits

For the LTD plans offered at this employer, premiums are paid by employees with pre-tax dollars, and the benefits individuals receive from their LTD policy in the event of a disability are taxable. In contrast, SSDI benefits are largely exempt from tax. Because it is not clear that employees know the differential tax treatment of each of these, premiums and the benefits are treated symmetrically in the baseline specification. Robustness analysis reported in the text explores an alternative specification that reflects the tax treatment of premiums and benefits, where we assume LTD premiums are paid with pre-tax dollars, LTD benefits individuals receive are taxable, and public SSDI benefits are not taxable (effectively raising the mean SSDI replacement rate from 34% to 52%). For simplicity, we assume that the same marginal tax rate is applicable to premiums and benefits, and we use a marginal tax rate of 35%, roughly the average marginal tax rate among individuals in this sample accounting for state and federal income taxes. While accounting for the tax treatment of LTD premiums and benefits leads to a lower implied surplus for a fixed extension of LTD coverage, accounting for the tax treatment of public SSDI benefits (and the effectively higher after-tax replacement rate) exactly offsets this giving us the same lower bound on the welfare of public disability insurance as in the baseline specification. To see this, suppose that individuals face a constant marginal tax rate τ. In addition, suppose that compulsory public insurance benefits are not taxable and LTD benefits are taxable. Let $WelfareExtn_\tau(10 \times (1-\tau))$ denote the estimated welfare associated with a $(10 \times (1-\tau))$ percentage point increase in the disability replacement rate of compulsory government insurance (relative to no incremental

[70] Under Assumption 1 used to calculate the welfare bound (from Proposition 1), $\pi(w, \alpha + \delta, \alpha|\varphi)$ is decreasing in α.

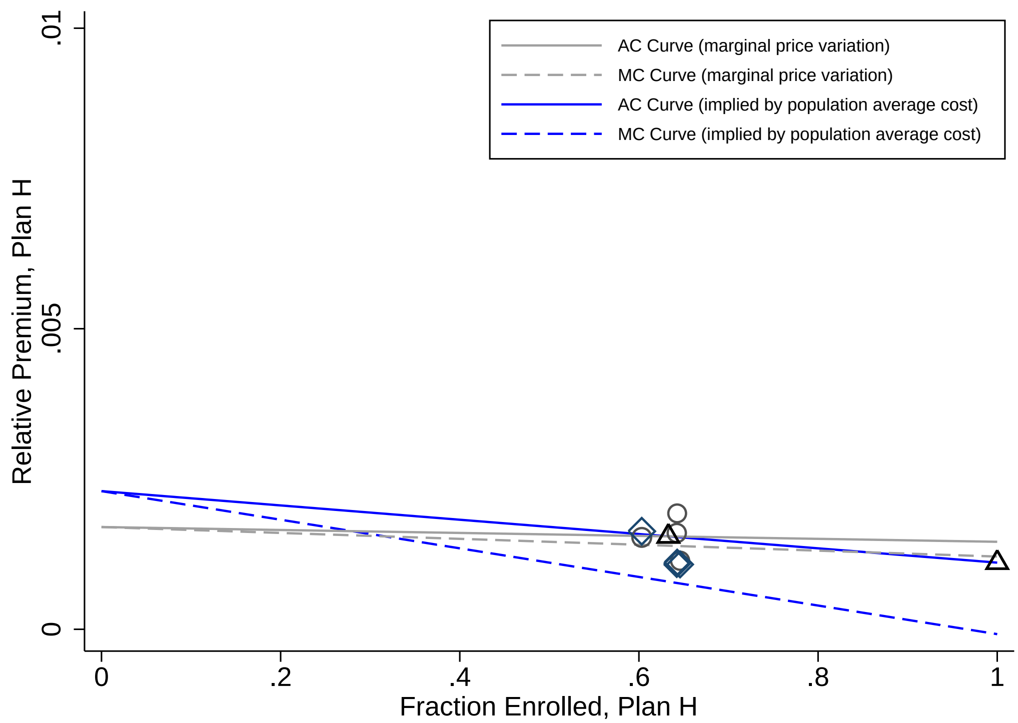
coverage) given that LTD premiums are paid with pre-tax dollars and the marginal tax rate is τ. To account for the tax treatment of premiums, the mean willingness-to-pay should be scaled down by $(1-\tau)$ relative to the baseline estimates if the tax treatment is salient to consumers, and the baseline estimates for the government's costs should be symmetrically scaled down by $(1-\tau)$ to reflect costs associated with the incremental coverage net of tax revenue. Thus, it is easy to see that accounting for taxation leads the welfare associated with a $(10 \times (1-\tau))$ percentage point extension of the replacement rate of government provided disability coverage to be a scaled version of the baseline estimates of an extension not accounting for the tax treatment: $WelfareExtn_{\tau}(10 \times (1-\tau)) = (1-\tau)WelfareExtn_{0}(10)$. The lower bound on the value of government provided coverage is unchanged. To see this, let $WelfarePublic(\alpha,\tau)$ represent the welfare associated with the inframarginal public coverage accounting for the tax rate τ and the public insurance is of generosity α. Assuming public benefits are tax-exempt, it is easy to show that the lower bound on welfare is invariant to accounting for the tax treatment: $\{\text{Lower bound on } WelfarePublic(\alpha,\tau)\} = \alpha\frac{WelfareExtn_{\tau}(10\times(1-\tau))}{10\times(1-\tau)} = \alpha\frac{(1-\tau)WelfareExtn_{0}(10)}{10\times(1-\tau)} = \alpha\frac{WelfareExtn_{0}(10)}{10} = \{\text{Lower bound on } WelfarePublic(\alpha,0)\}$.

Figure A1: Numerical Example: Surplus Ratio and Baseline Coverage Generosity



Notes: This figure displays the surplus ratio (defined in the text) as the baseline coverage generosity varies, holding the underlying parameters fixed based on the calibration depicted in Figure 3 and Table 1.

Figure A2: Selection: Alternative Estimation Approaches



Notes: This table displays linear cost curves associated with Plan H coverage, where the curves are inferred using two different methods. The first method for estimating the average and marginal cost curves follows Einav and Finkelstein (2011) and uses variation in prices and the induced variation in the fraction of the population with Plan H coverage to trace out how the average expected cost of those on Plan H varies. The second method for inferring the average and marginal cost curves is to assume there is no moral hazard and interpolate between the average cost if the whole population were insured and the average cost of the actual insured population. These approaches are represented in the figure by the gray and blue lines, respectively. The gray circles represent the mean costs by year for those with Plan H coverage; the black triangles represent the mean costs of those with Plan H and everyone in the population, pooling data across the entire sample period. The blue diamonds represent the observed pairs of Plan H premium and enrollment by year (the variation used to estimate demand).

Table A1: Moral Hazard and Selection

Panel A: Moral Hazard								
	Realized Costs of All Employees (2SLS)				Realized Costs of All Employees (Reduced Form)			
	Costs	Costs	I(LTD Claim)	I(LTD Claim)	Costs	Costs	I(LTD Claim)	I(LTD Claim)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Plan H	-0.0071	0.0024	-0.0339	-0.0358				
	(0.0105)	(0.0236)	(0.0201)	(0.0375)				
PlanMorH	-0.0155	-0.0530	-0.0599	-0.0524				
	(0.0190)	(0.0844)	(0.0414)	(0.1590)				
Relative Premium Plan H					0.16	0.03	1.10	2.57
					(0.58)	(1.22)	(0.97)	(1.94)
Premium Plan M					3.41	4.08	13.11	5.44
					(3.57)	(5.15)	(6.78)	(10.15)
Constant	0.0180	0.0427	0.0724	0.0675	-0.0044	-0.0052	-0.0184	-0.0092
	(0.0197)	(0.0582)	(0.0397)	(0.1120)	(0.0057)	(0.0068)	(0.0106)	(0.0137)
Time Trend Included		x		x		x		x
Dep Var								
Mean	0.0011	0.0011	0.0032	0.0032	0.0011	0.0011	0.0032	0.0032
SD	0.0302	0.0302	0.0561	0.0561	0.0302	0.0302	0.0561	0.0561
N	47,884	47,884	47,884	47,884	47,884	47,884	47,884	47,884

Panel B: Selection								
	Realized Cost of Employees on Plan H				Realized Cost of Employees on Plan M or Plan H			
	Costs	Costs	I(LTD Claim)	I(LTD Claim)	Costs	Costs	I(LTD Claim)	I(LTD Claim)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Relative Premium Plan H	0.018	0.609	1.110	3.738				
	(0.839)	(1.486)	(1.580)	(2.374)				
Premium Plan M					4.529	4.154	13.490	15.020
					(4.327)	(5.397)	(8.075)	(9.981)
Constant	0.002	0.001	0.003	-0.002	-0.006	-0.005	-0.017	-0.019
	(0.001)	(0.002)	(0.002)	(0.003)	(0.007)	(0.008)	(0.012)	(0.015)
Time Trend Included		x		x		x		x
Dep Var								
Mean	0.0015	0.0015	0.0041	0.0041	0.0013	0.0013	0.0037	0.0037
SD	0.0358	0.0358	0.0636	0.0636	0.0329	0.0329	0.0606	0.0606
N	30,306	30,306	30,306	30,306	38,227	38,227	38,227	38,227

Notes: This table displays the moral hazard and selection estimates which leverage the premium variation for LTD plans. Panel A displays the results related to moral hazard, where columns (1) through (4) display the IV results and columns (5) through (8) display the reduced form results. Panel B displays the selection estimates, where columns (1) through (4) focus on selection into Plan H. In addition, columns (5) through (8) focus on selection into at least Plan M coverage (relative to Plan L) leveraging the modest amount of variation Plan M premiums. The outcome variables considered in these regressions are two different cost measures: the present discounted value of costs (relative to annual earnings) incurred using the maximum potential duration for truncated spells as described in the text ("Costs", the baseline cost measure used in the text), and an indicator for having any LTD claim ("I(LTD Claim)").

Table A2: Demand and Cost Estimates: Comparing Plan H and Plan M

Panel A: Demand Estimates

	Plan H	Plan H	PlanMorH	PlanMorH
	(1)	(2)	(3)	(4)
Relative premium Plan H	-71.26	-64.93		
	(11.77)	(12.21)		
Ln (relative premium Plan H)				
(Relative) premium Plan M			-91.19	-38.15
			(38.30)	(35.34)
Constant	0.72	0.70	0.95	0.87
	(0.03)	(0.02)	(0.06)	(0.05)
Controls				
Time Trend	x	x	x	x
Individual Fixed Effects		x		x
Dep Var				
Mean	0.63	0.63	0.80	0.80
Std dev	0.48	0.48	0.40	0.40
N	47,884	47,884	47,884	47,884
Implied Mean WTP for Incremental Coverage, $/annual earnings				
Estimate	0.00310	0.00328	0.00481	0.00936
Std Error	(0.00032)	(0.00034)	(0.02792)	(3.75262)

Panel B: Mean Costs

	Plan H		PlanMorH	
	Mean	Std Error	Mean	Std Error
Per capita cost, $/annual earnings				
All	0.00111	(.00014)	0.00111	(.00014)
Do Purchase incremental coverage (dep var=1)	0.00155	(.00021)	0.00133	(.00017)
Do not purchase incremental coverage (dep var=0)	0.00036	(.00013)	0.00023	(.00016)
Relative premium, $/annual earnings	0.00124	(1.09E-06)	0.00154	(1.95E-07)

Notes: The above table displays the demand and cost estimates. Panel A columns (1) and (2) display the results of estimating a linear demand specification for Plan H coverage, without individual fixed-effects (column 1) and with individual fixed-effects (column 2). For comparison, Panel A columns (3) and (4) display estimates of the demand for Plan M coverage (relative to Plan L coverage). The bootstrapped standard error on the mean implied willingness-to-pay for the incremental coverage (relative to annual earnings) is calculated using 10,000 bootstrap samples. Panel B displays the mean cost estimates for everyone and separately for those who do and do not purchase the plan corresponding to each column. As discussed in Section 4, the mean cost reported here is the mean present discounted value of disability claim costs relative to annual earnings scaled to represent a 10% replacement rate. For reference, the relative premium for the plan corresponding to each column is listed below the mean cost estimates.

Table A3: Additional Robustness Analysis

Panel A: Lower Bound on Value of Public Coverage Based on Alternative Specifications

	Lower Bound on Mean WTP				Lower Bound on Per-Capita Welfare			
	relative to annual earnings		% of mean cost	scaled by 65K	relative to annual earnings		% of mean cost	scaled by 65K
	(1)		(2)	(3)	(4)		(5)	(6)
	Est	Std Err			Est	Std Err		
1. Baseline	0.01053	0.00110	279%	684	0.00677	0.00119	179%	440
Robustness to Alternative Cost Measures								
2. Alternative Cost Measure, truncated at five years	0.01053	0.00110	430%	684	0.00817	0.00112	334%	531
3. Alternative Cost Measure, discounted at 2%	0.01053	0.00110	222%	684	0.00600	0.00126	126%	390
4. Alternative Cost Measure, discounted at 6%	0.01053	0.00110	265%	684	0.00673	0.00119	170%	437
Robustness to Using Plan M Demand (instead of Plan H)								
5. Plan M Demand (time trend included)	0.01636	0.09402	416%	1,063	0.01259	0.09403	320%	818

Panel B: Parameter Estimates from Alternative Specifications

	Demand				Mean Cost	
	Relative Premium		Constant			
	Coeff	Std Err	Coeff	Std Err	Mean	Std Err
	(1)	(2)	(3)	(4)	(5)	(6)
1. Baseline	-71.26	(11.77)	0.72	(0.026)	0.00111	(.00014)
Robustness to Alternative Cost Measures						
2. Alternative Cost Measure, truncated at five years	-71.26	(11.77)	0.72	(0.026)	0.00069	(.0001)
3. Alternative Cost Measure, discounted at 2%	-71.26	(11.77)	0.72	(0.026)	0.00134	(.00021)
4. Alternative Cost Measure, discounted at 6%	-71.26	(11.77)	0.72	(0.026)	0.00112	(.00017)
Robustness to Using Plan M Demand (instead of Plan H)						
5. Plan M Demand (time trend included)	-91.19	(38.3)	0.95	(0.060)	0.00111	(.00014)

Notes: This table displays additional robustness analysis (beyond that displayed in Table 7). Panel A displays the implied lower bound on the value of public coverage based on the alternative specifications (analogous to that reported in Table 6 Panel A row 2); Panel B displays the underlying demand and mean cost estimates. As discussed in Section 4, the mean cost reported here is the mean present discounted value of disability claim costs relative to annual earnings scaled to represent a 10% replacement rate. Panel A reports bootstrapped standard errors using 10,000 bootstrap samples. Each row represents the results of a distinct specification. For reference, row (1) displays the baseline estimates (from Table 5 column 1) and implied welfare bounds (from Table 6 Panel A row 2). Rows (2) through (4) display the estimates and implied welfare bounds using alternative specifications of the cost measure. The baseline analysis uses the present discounted value of costs using a 4% interest rate in this discounting, where we use the maximum potential duration for spells censored at five years (as described in the text, Section 2). Row (2) displays an alternative specification where costs are measured only through the first five years (the years for which we have claims data); rows (3) and (4) display specifications where costs are defined as the present discounted value of the maximum potential duration for truncated spells, using alternative discount rates. Row (5) displays an alternative specification that relies on the less precise Plan M demand estimates (rather than the baseline Plan H demand estimates) to value disability insurance.