The Insurance Value of Redistributive Taxes and Transfers*

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Abstract

Progressive tax and transfer schedules serve a redistributive role by transferring from high-income to low-income individuals, but they also serve an insurance role by transferring from the high-income years to the low-income years within each person's lifespan. This paper examines how the design of the tax and transfer system provides insurance against income risks by studying the two largest economic shocks faced by working-age households: layoffs and illness. Using 1.6 million layoffs and 1.2 million hospital stays linked to Canadian tax records, I first show that both events cause persistent declines in earnings lasting more than six years. The full tax and transfer system provides substantial insurance against these risks, shrinking the percentage of income lost post-layoff by 40% and post-hospitalization by 60%, which I estimate to be worth 7-10% of total post-event consumption. But less than half of this social insurance comes from the unemployment and disability insurance programs that formally insure these risks. The progressive shape of taxes and transfers provides the majority of social insurance, and is especially important for reducing the risk of catastrophic income losses and mitigating inequality in the income risks of layoffs and hospitalizations. Using a dynamic model, I find that the insurance value of redistributive taxes and transfers is considerable across the entire income distribution, and is more than twice as large at the bottom of the income distribution than at the top.

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1 Introduction

Think of the federal government as a gigantic insurance company with a sideline business in national defense.

— Peter Fisher, U.S. Treasury, 2003

Providing insurance against economic risk is one of the central roles of modern governments. Spending on formal social insurance programs such as health, retirement, unemployment and disability insurance consumes more than 50 percent of the U.S. federal budget, and an even larger share of government expenditures in other high-income countries (Chetty and Finkelstein 2013; Gruber 2016). But even these large-scale insurance programs represent only part of the insurance provided by the government. The entire system of taxes and transfers redistributes not just from high-income to low-income individuals—it also redistributes within each person's lifespan from high-income years to low-income years. In other words, redistributive taxes and transfers provide insurance against income risk.

This paper examines how much insurance value is generated by progressive taxes and transfers and how that insurance is distributed across the income distribution. Using a panel of 1.6 million layoffs and 1.2 million hospital stays linked to population income tax records in Canada, I study how these risks—the two largest sources of income risk for working-age households—are insured by the tax and transfer system. The qualitative fact that redistributive taxes and transfers are a source of social insurance has been well established in the theoretical literature on optimal taxation (Varian 1980; Eaton and Rosen 1980; Farhi and Werning 2013) and is an implicit input into formulas for optimal social insurance parameters such as the optimal level of unemployment insurance benefits (Baily 1978; Chetty 2006b). My empirical analysis uses newly linked administrative databases to contribute a new set of quantitative facts. First, redistributive taxes and transfers are the largest source of social insurance against the income risks of hospitalization and layoffs in Canada, exceeding the insurance value of the social insurance programs that formally insure these risks—unemployment and disability insurance. Second, the progressive shape of the tax and transfer schedule reduces the risk of catastrophic income losses and mitigates the inequality in income risks from layoffs and hospitalizations, which cause disproportionate losses to low-income individuals. These results imply that progressive tax and transfer schedules provide a higher degree of progressivity than their statutory rates would suggest. The results also imply that the optimal parameters of formal social insurance programs are highly sensitive to changes in redistributive policy.

I begin by developing a stylized model of the value of social insurance against income risk, which guides the parameters I subsequently estimate in my empirical analysis. The model details how the total insurance value provided by taxes and transfers can be defined as a person's willingness to pay to avoid replacing the entire tax and transfer system with the linear tax rate that holds their expected consumption constant. I decompose this total insurance value into the components provided by formal social insurance programs and by progressive taxes and transfers. I also show that if individuals' utility function is logarithmic in consumption, then the changes in log income following a shock are sufficient statistics which can be used to directly measure and decompose the insurance value of taxes and transfers.

My empirical analysis of social insurance uses an event study specification with a matched research design to identify the causal effects of layoff events and hospitalization events on subsequent income, measured before and after taxes and transfers.[1] I match 25- to 54-year-old workers who experience a layoff or a hospitalization event between 2003 and 2010 to a comparison group of workers with identical demographic characteristics and nearly identical individual and household income in the third year prior to the event.[2] Every year, 3% of the individuals in my sample are laid off and 2% are hospitalized. I compare the income trajectories of these workers to the matched comparison group using a non-parametric event study specification. The event study estimates reveal that the earnings trajectories of laid off and hospitalized workers were on parallel trends with their matched comparison group for more than a decade leading up to the adverse event. I observe that layoffs and hospitalizations cause substantial declines in earnings that persist at least 12 years (to the end of my panel), consistent with the longstanding literature documenting persistent earnings losses post-layoff (Jacobson, LaLonde, and Sullivan 1993; Davis and von Wachter 2011) and a more recent literature documenting persistent earnings losses post-hospitalization (García-Gómez et al. 2013; Fadlon and Nielsen 2017; Dobkin et al. 2018).

I estimate that the insurance provided by the full tax and transfer system is worth 8-10% of post-layoff consumption and 7-9% of post-hospitalization consumption during the six years that follow the adverse event. These estimates reflect the fact that post-layoff income declines by an average of 22% before taxes and transfers and by only 13% after taxes and transfers, while post-hospitalization income declines by 14% before and by only 6% after taxes and transfers. The insurance value of these

[1] I observe all layoffs (regardless of whether they occurred in a mass layoff) and all inpatient hospital stays, and I exclude childbirth-related hospitalizations from the analysis.

[2] All of the variables used for matching are measured in the same year, therefore placing no constraints on the pre-trends.

reductions in income risk is robust to any degree of consumption smoothing that individuals perform during the six post-event years, but the magnitudes I report reflect an assumed utility function that is logarithmic in consumption (i.e. constant relative risk aversion with a CRRA coefficient of 1). Prior evidence from the elasticity of individuals' labor supply to wages implies that individuals' risk aversion over long-run income changes can be reasonably approximated by a logarithmic utility function (Chetty 2006a). Assuming a higher level of risk aversion, however, would increase the insurance value of the tax and transfer system and raise the share of that social insurance provided by redistributive taxes and transfers relative to formal social insurance programs.

Only 45% of social insurance following a layoff and 26% of social insurance following a hospitalization comes from the unemployment and disability insurance benefits that formally insure those risks—more than half of social insurance comes from the progressive shape of the tax and transfer schedule.[3] Redistributive transfers provide social insurance in two ways: by replacing lost income with increased transfers, and by providing a stream of stable transfer income which buffers labor market risks by reducing the share of total income sensitive to earnings changes. Progressive taxes provide social insurance by reducing the effective tax burden of individuals who experience income losses, since marginal tax rates exceed average tax rates under a progressive tax schedule.

The insurance provided by redistributive taxes and transfers has an especially large effect on reducing the risk of catastrophic income losses. Layoffs increase the probability that an individual loses more than half their income by 5.0 percentage points after unemployment and disability benefits are received, but by only 2.6 percentage points after all taxes and transfers. Hospitalizations increase the probability of losing more than half one's income by 3.4 percentage points after unemployment and disability benefits are received, but by only 1.5 percentage points after taxes and transfers.

The insurance value of redistributive taxes and transfers is also highly progressive and therefore mitigates the inequality in the income risk from layoffs and hospitalizations. Progressive taxes and transfers completely flatten the gradient in income losses following a layoff which, before taxes and transfers, range from a 26% average income loss in the bottom income quintile to a 19% loss in the top quintile. Post-layoff income losses after taxes and transfers vary between only 12% and 14% at all income levels. The insurance value of taxes and transfers against hospitalization risk is even more progressive than against layoff risk, driven by higher replacement rates from redistributive

[3] Formal social insurance benefits following a layoff are almost entirely (98%) drawn from unemployment insurance and formal social insurance benefits following a hospitalization are almost entirely drawn from disability insurance (also 98%).

transfer income (which peak at 43% in the bottom income quintile). The progressivity of social insurance against hospitalization risk offsets but does not eliminate an even larger inequality in income losses, which range from an average of 29% in the bottom income quintile to 5% in the top quintile before taxes and transfers. Post-hospitalization income losses after taxes and transfers range from 9% in the bottom quintile to 4% in the top quintile, cutting the after-tax gradient by half.

Using a dynamic model, I show that the *ex ante* insurance value of the tax and transfer system against the income risks of layoffs and hospitalizations alone exceeds $400 annually at all income levels, and exceeds $1 000 per year in the bottom income quintile. Since the distinction between insurance and redistribution depends which income changes are anticipated by individuals, I can bound the total insurance value of the tax and transfer system using bounds on the information set that individuals use to anticipate their future income. Assuming layoffs and hospitalizations are unanticipated three years prior to the event, the total insurance value of taxes and transfers lies between the insurance value against layoff and hospitalization risk alone and the insurance value against all income variation conditional on the demographic and lagged income variables that I observe three years prior (which assumes that individuals have no private information about their income dynamics beyond the information observed by the econometrician).[4] Building on the framework developed by Hoynes and Luttmer (2011), I find that the maximum insurance value of the tax and transfer system is approximately four times larger than its insurance value against layoff and hospitalization risk at all income levels, ranging from over $4 000 per year at the bottom of the income distribution to under $2 000 per year at the top. The progressivity of the insurance value of taxes and transfers reflects the fact that incomes are more volatile at lower income levels, and implies that progressive tax and transfer schedules generate a greater degree of progressivity than their redistribution would suggest.

The large share of total social insurance provided by progressive taxes and transfers implies that the optimal parameters of unemployment and disability insurance are highly sensitive to changes in redistributive policy. Optimal social insurance formulas trade off the consumption smoothing value of social insurance benefits against the cost of the behavioral distortions that they generate. Under very general conditions, this trade-off can be expressed as a function of the behavioral elasticity to changes in benefits and the consumption drop following an adverse event, which is an implicit function of the tax and transfer schedule (Baily 1978; Chetty 2006b). However policymakers

[4]The assumption that layoff events are unanticipated three years prior to the layoff is consistent with the direct evidence in Hendren (2017).

frequently change redistributive tax and transfer policy for reasons unrelated to social insurance, and many formal social insurance programs (such as disability insurance) apply uniform program parameters across multiple jurisdictions (such as states or provinces) with substantial variation in tax and transfer progressivity. Variation in tax and transfer policy over time or space will alter the consumption drop following an adverse event, thus changing the optimal parameters of formal social insurance programs.

The remainder of the paper is organized as follows. Section 2 details the economic model that I use to measure and decompose the insurance value of taxes and transfers. Section 3 explains the data and the matched event study research design that I use to estimate the social insurance of layoff and hospitalization risk. Section 4 presents the results describing the size, sources and distribution of insurance value generated by taxes and transfers. Section 5 concludes.

2 Economic Model

I develop a simple economic model to examine the value of the insurance against income risk provided by tax and transfer programs. This model illustrates how the insurance value provided by the government can be decomposed into the portions provided by formal social insurance benefits and by redistributive taxes and transfers. The model also identifies the conditions under which the reduced form results I estimate in Section 4 are sufficient statistics which can be directly interpreted as measures of the welfare generated by social insurance.

2.1 Model Setup

This section lays out a stylized model of the social insurance of income risk. Individuals face the risk of an income shock at the beginning of the first period, after which their income path is known with certainty. I consider individuals' utility over a fixed time horizon and abstract from savings and labor supply decisions. By simplifying these aspects of economic behavior, the model provides transparent partial equilibrium formulas identifying the key economic parameters determining the insurance value of taxes and transfers.

Income Shock. At the start of period $t = 0$, an individual experiences an adverse income shock with probability p. Throughout this section, I use superscript NS to denote the state of the world where no shock occurred and use superscript S for the state of the world where the shock occurred. The realization of the shock determines the trajectory of the individual's gross income before taxes and transfers (y_{it}) over the $T + 1$ period discrete time horizon: $\{y_{it}^{NS}\}_{t=0}^{T}$ or $\{y_{it}^{S}\}_{t=0}^{T}$.

Taxes and Transfers. I assume for now that individuals consume hand-to-mouth, which implies that consumption c_{it} is equal to net income after taxes and transfers in each period. (Section 2.3 shows how the formulas change if individuals have access to frictionless credit markets and perfectly smooth their consumption, and I consider both possibilities in the empirical results.) I parametrize the shape of the tax and transfer system as

$$c_{it} = c(y_{it}, \omega_{it}|\theta, \lambda, \tau) = \lambda(y_{it} + \omega_{it} + \theta)^{1-\tau} \quad (1)$$

In this formula ω_{it} represents benefits received from formal social insurance programs such as unemployment or disability insurance, which can depend on the realization of the shock and the history of gross earnings $\{y_{is}\}_{s=0}^{t}$. The θ term is an unconditional transfer which, conditional on the other parameters, determines consumption when earnings and formal social insurance benefits are zero. The progressivity of the tax and transfer system is determined by $(1 - \tau)$. Formally, $(1 - \tau)$ is the elasticity of after-tax-and-transfer consumption to pre-tax income $(y_{it} + \omega_{it} + \theta)$. If $\tau = 0$ then taxes and transfers are linear with a slope of $(1 - \lambda)$. If $\tau > 0$ then taxes and transfers are progressive with marginal tax rates everywhere above average rates. Conditional on the other parameters, λ determines the overall level of taxation and pins down the total amount of government revenue.[5]

This functional form for the tax and transfer system is an adapted version of a two-parameter specification ($c_{it} = \lambda y_{it}^{1-\tau}$) with a long history in public finance (Musgrave 1959; Feldstein 1969; Kakwani 1977; Bénabou 2000; Bénabou 2002). Heathcote, Storesletten, and Violante (2017) show that this two-parameter system provides an excellent empirical fit to the U.S. statutory tax and transfer schedule in 2000-2006. The fit is weakest at the bottom of the income distribution, where after-tax consumption is higher than predicted. Adding an unconditional transfer parameter θ improves the empirical fit of the specification to both the U.S. and Canadian effective tax and transfer schedules (Appendix Figure 1).

Utility. Individuals' period utility is a function of consumption, $u(c_{it})$. Individuals discount the

[5]The parameters λ and τ capture the shape of the tax *and transfer* system (excluding formal social insurance benefits and the unconditional θ transfer). They do not isolate the shape of the statutory income tax schedule.

future with a discount rate β, so that present utility is $U\left(\{c_{it}\}_{t=0}^{T}\right)=\sum_{t=0}^{T}\beta^t u(c_{it})$. I assume that individuals' discount rate β is equal to 1 divided by the interest rate, so that utility and dollars are discounted at the same rate.

The individual's expected utility in period $t=0$ is:

$$\begin{aligned}\mathbb{E}U_i &= (1-p)U_i^{NS}+pU_i^{S}\\ &= (1-p)\sum_{t=0}^{T}\beta^t u\Big(c\left(y_{it}^{NS},\omega_{it}^{NS}|\theta,\lambda,\tau\right)\Big)+p\sum_{t=0}^{T}\beta^t u\Big(c\left(y_{it}^{S},\omega_{it}^{S}|\theta,\lambda,\tau\right)\Big)\end{aligned}$$

2.2 Decomposition of Insurance Value

I measure the insurance value of tax and transfer programs in terms of equivalent variation. To do so, I first consider the change in welfare from replacing the entire tax and transfer system with a counterfactual linear tax rate that holds government revenue and the individual's expected consumption constant. I then measure the change in consumption under the baseline tax and transfer system that would generate an equivalent change in welfare. After calculating this valuation of insurance from the full tax and transfer system, I decompose the insurance value into the component provided by formal social insurance benefits and the component provided by taxes and transfers that are not conditioned on the realization of the shock.

Insurance Value of the Full Tax and Transfer System. What is the value of the insurance against income risk provided by the full set of tax and transfer programs operated by the government, including formal social insurance benefits? I answer this question by measuring how social welfare would change if the entire tax and transfer system were replaced with a linear tax while holding government revenue constant.[6] The formula for the revenue-neutral linear tax rate $(1-\widehat{\lambda}^{tot})$ is derived in Appendix Section A.2.[7] I assume that there are no behavioral responses to changes in the tax and transfer system, which implies that a revenue-neutral change to the tax and transfer system also holds individuals' expected consumption constant.

[6]One could also consider the insurance value of the tax and transfer system relative to a system of lump sum taxation, as in Hoynes and Luttmer (2011). Appendix Section A.4 derives the insurance value provided by the tax and transfer system relative to lump sum taxation. Throughout the paper I measure the insurance value of the observed tax and transfer system relative to a counterfactual linear tax because, in practice, most policy variation exists in the progressivity of the tax and transfer system.

[7]Throughout this section, I use hats $\widehat{\cdot}$ to denote values under a counterfactual tax and transfer system.

Expected utility under the counterfactual linear tax system is

$$\begin{aligned}\mathbb{E}\widehat{U_i}^{tot} &= (1-p)\widehat{U_i^{NS}}^{tot} + p\widehat{U_i^{S}}^{tot} \\ &= (1-p)\sum_{t=0}^{T}\beta^t u\left(\widehat{\lambda}^{tot} y_{it}^{NS}\right) + p\sum_{t=0}^{T}\beta^t u\left(\widehat{\lambda}^{tot} y_{it}^{S}\right)\end{aligned}$$

The insurance value of the full tax and transfer system is defined as the equivalent variation Z_i^{tot}, which measures how much consumption would have to change under the baseline tax and transfer system in order to generate the same expected utility as the counterfactual linear tax:

$$\mathbb{E}U_i(Z_i^{tot}) \equiv (1-p)\sum_{t=0}^{T}\beta^t u\left(c_{it}^{NS}(1-Z_i^{tot})\right) + p\sum_{t=0}^{T}\beta^t u\left(c_{it}^{S}(1-Z_i^{tot})\right) = \mathbb{E}\widehat{U_i}^{tot} \tag{2}$$

A result of $Z_i^{tot} = 0.1$ would imply that individuals are willing to pay up 10% of their consumption in all periods to avoid replacing the tax and transfer system with a linear tax. Put another way, switching to a linear tax would cause a welfare change equivalent to destroying 10% of consumption in all periods.

I also define the insurance value of the tax and transfer system *ex post*, after the shock is realized, as the values $Z_i^{S,tot}$ and $Z_i^{NS,tot}$ which satisfy:

$$U_i^J(Z_i^{J,tot}) \equiv \sum_{t=0}^{T}\beta^t u\left(c_{it}^{J}(1-Z_i^{J,tot})\right) = \sum_{t=0}^{T}\beta^t u\left(\widehat{\lambda}^{tot} y_{it}^{J}\right) \equiv \widehat{U_i^J}^{tot} \text{ for } J \in \{S, NS\} \tag{3}$$

In other words, a person who experiences the shock values the insurance provided by the tax and transfer system *ex post* as being equivalent to $Z_i^{S,tot}$ percent of their consumption in all periods.

Component 1: Insurance Value of Progressive Taxes and Transfers. How much insurance is provided by the progressivity of taxes and transfers, over and above the insurance provided by formal social insurance programs? I isolate the insurance value coming from the portion of the tax and transfer system not conditioned on the realization of the shock by considering a second counterfactual. Suppose formal social insurance benefits were kept as-is while a revenue-neutral linear tax rate of $(1-\widehat{\lambda}^{\theta\tau})$ replaced the rest of the tax and transfer system.[8] In this new counterfactual, expected

[8] Appendix Section A.2 derives the value of $\widehat{\lambda}^{\theta\tau}$ that holds government revenue constant when progressive taxes and transfers are replaced with a linear tax ($\tau = 0, \theta = 0$) while formal social insurance benefits (ω_{it}) are unchanged.

utility is

$$\mathbb{E}\widehat{U_i}^{\theta\tau} = (1-p)\widehat{U_i^{NS}}^{\theta\tau} + p\widehat{U_i^{S}}^{\theta\tau}$$
$$= (1-p)\sum_{t=0}^{T}\beta^t u\left(\widehat{\lambda}^{\theta\tau}(y_{it}^{NS}+\omega_{it}^{NS})\right) + p\sum_{t=0}^{T}\beta^t u\left(\widehat{\lambda}^{\theta\tau}(y_{it}^{S}+\omega_{it}^{S})\right)$$

The insurance value of progressive taxes and transfers is defined by the equivalent variation that generates the same expected utility, analogously to equations (2) and (3) above. Before the shock is realized, the individual would be willing to give up $Z_i^{\theta\tau}$ percent of their consumption in all periods in all states to avoid replacing progressive taxes and transfers with a linear tax, where $\mathbb{E}U_i(Z_i^{\theta\tau}) = \mathbb{E}\widehat{U_i}^{\theta\tau}$. After the shock is realized, an individual who experiences the income shock values the insurance provided by progressive taxes and transfers as being equivalent to $Z_i^{S,\theta\tau}$ percent of their consumption in all periods, where $U_i^S(Z_i^{S,\theta\tau}) = \widehat{U_i^S}^{\theta\tau}$.

Component 2: Insurance Value of Formal Social Insurance. What is the value of the insurance provided by formal social insurance programs, such as unemployment and disability insurance? When utility is non-linear, the insurance value of the full tax and transfer system is not equal to the sum of its parts (Hoynes and Luttmer 2011).[9] For risk averse individuals, when each component of the tax and transfer system provides strictly positive insurance value then the sum of the insurance values of each component will be less than the insurance value of the whole tax and transfer system. It is therefore instructive to consider two types of insurance value decompositions: a *piecewise* decomposition and a *sequential* decomposition.

The piecewise decomposition measures the insurance value of formal social insurance benefits while holding the progressivity of the rest of the tax and transfer schedule fixed. Suppose that formal social insurance benefits ω_{it} were eliminated and rebated by adjusting the linear portion of the tax schedule to $\widehat{\lambda}^{\omega}$.[10] Then for each realization of the shock $J \in \{S, NS\}$, the individual's utility would be $\widehat{U_i^J}^{\omega} = \sum_{t=0}^{T}\beta^t u\left(\widehat{\lambda}^{\omega}(y_{it}^J+\theta)^{1-\tau}\right)$. Conditional on the realization of the shock, the insurance value of formal social insurance benefits is the equivalent variation $Z_i^{J,\omega}$ that satisfies $U_i^J(Z_i^{J,\omega}) = \widehat{U_i^J}^{\omega}$.

The sequential decomposition separates the insurance value of the full tax and transfer system into the share of insurance provided by the progressivity of taxes and transfers and the remaining share

[9] When utility is linear, individuals are risk neutral and place zero value on insurance from the whole tax and transfer system as well as each of its components.

[10] Appendix Section A.3 derives the value of $\widehat{\lambda}^{\omega}$ that holds government revenue constant when formal social insurance benefits are eliminated ($\omega_{it} = 0$) while leaving the progressivity of the tax and transfer schedule unchanged.

of the insurance provided by formal social insurance benefits. In this case, the order in which these two components are considered matters for the result. Suppose, as before, that we replace all taxes, transfers and social insurance benefits with a revenue-neutral linear tax rate of $(1-\widehat{\lambda}^{tot})$. Doing so has a welfare effect equivalent to scaling consumption in all periods by $(1-Z_i^{tot})$, as defined in equation (2). Eliminating the progressivity of the tax and transfer while maintaining the formal social insurance programs has a welfare effect equivalent to scaling consumption in all periods by $(1-Z_i^{\theta\tau})$. Therefore if we additionally eliminated formal social insurance benefits, the effect on welfare would be equivalent to further scaling consumption by $(1-Z_i^{\omega'}) \equiv (1-Z_i^{tot})/(1-Z_i^{\theta\tau})$. Expressed conditional on the realization of the shock, the sequential value of formal social insurance benefits after the progressivity of taxes and transfers has been eliminated is $(1-Z_i^{J,\omega'}) \equiv (1-Z_i^{J,tot})/(1-Z_i^{J,\theta\tau})$. This sequential decomposition of equivalent variation can be defined formally as

$$U_i^J(Z_i^{J,\omega'}|Z_i^{J,\theta\tau}) \equiv \sum_{t=0}^{T} \beta^t u\left(c_{it}^J(1-Z_i^{J,\theta\tau})(1-Z_i^{J,\omega'})\right) = \sum_{t=0}^{T} \beta^t u(\widehat{\lambda}^{tot} y_{it}^J) \equiv \widehat{U_i^S}^{tot} \text{ for } J \in \{S, NS\} \quad (4)$$

When the baseline tax and transfer system is progressive, the insurance value of formal social insurance under the sequential decomposition $Z_i^{J,\omega'}$ will be larger in magnitude than the insurance value under the piecewise decomposition $Z_i^{J,\omega}$. This relationship occurs because, for risk averse individuals, the insurance provided by formal social insurance benefits is more valuable under a linear tax and transfer system than under a progressive tax and transfer system.

2.3 Sufficient Statistics with Log Utility

This section shows that when individual utility is logarithmic in consumption, the insurance value of the tax and transfer system for someone who experiences the shock can be directly measured by comparing the drop in log income before taxes and transfers to the drop in log income after taxes and transfers. Sequentially decomposing each component of the insurance value of the tax and transfer system can also be performed directly, by comparing the drops in log income measures that sequentially include each component of the tax and transfer system. I show that using a discounted geometric mean to calculate average income over the $T+1$ periods measures the value of insurance when individuals consume hand-to-mouth, while a discounted arithmetic mean measures the value of insurance when individuals perfectly smooth consumption. These two means therefore provide straightforward bounds for the value of insurance under alternative degrees of credit market frictions or consumption smoothing behavior.

The derivations in this section motivate the reduced form parameters that I estimate in Section 4, which are chosen so that the reduced form results are directly interpretable as measures of the welfare created by social insurance under a logarithmic utility model.

Insurance Value of the Full Tax and Transfer System. Assume individual utility is equal to the logarithm of consumption, so $u(c_{it}) = \log(c_{it})$. For the moment, I continue to assume that individuals are hand-to-mouth consumers who consume their income after taxes and transfers in each period. Then average utility under the baseline tax and transfer system can be expressed as a function of the discounted geometric mean of consumption c_{it} in each period

$$\begin{aligned}
\frac{U_i^J(Z_i^{J,tot})}{\sum_{t=0}^T \beta^t} &= \frac{\log\left(c_{i0}^J(1-Z_i^{J,tot})\right) + \beta \log\left(c_{i1}^J(1-Z_i^{J,tot})\right) + \cdots + \beta^T \log\left(c_{iT}^J(1-Z_i^{J,tot})\right)}{\sum_{t=0}^T \beta^t} \\
&= \log\left(\left(c_{i0}^J\right)^{\frac{1}{1+\beta+\cdots+\beta^T}} \cdot \left(c_{i1}^J\right)^{\frac{\beta}{1+\beta+\cdots+\beta^T}} \cdots \left(c_{iT}^J\right)^{\frac{\beta^T}{1+\beta+\cdots+\beta^T}} \right) + \log\left(1 - Z_i^{J,tot}\right) \\
&\equiv \log\left(\overline{C_i}^J\right) + \log\left(1 - Z_i^{J,tot}\right) \qquad (5)
\end{aligned}$$

where $\overline{C_i}^J$ is defined as the discounted geometric mean of consumption from $t = 0$ to T for individuals who experience shock $J \in \{S, NS\}$.

Now suppose the entire tax and transfer system were replaced with a linear tax rate of $(1 - \widehat{\lambda}^{tot})$. Average utility under this linear tax and transfer system can be expressed as a function of the discounted geometric mean of income before taxes and transfers

$$\begin{aligned}
\frac{\widehat{U_i^J}^{tot}}{\sum_{t=0}^T \beta^t} &= \frac{\log\left(\widehat{\lambda}^{tot} y_{i0}^J)\right) + \beta \log\left(\widehat{\lambda}^{tot} y_{i1}^J)\right) + \cdots + \beta^T \log\left(\widehat{\lambda}^{tot} y_{iT}^J)\right)}{\sum_{t=0}^T \beta^t} \\
&\equiv \log\left(\overline{Y_i}^J\right) + \log\left(\widehat{\lambda}^{tot}\right)
\end{aligned}$$

Scaling consumption after the realization of the shock by the *ex post* equivalent variation $Z_i^{S,tot}$ and $Z_i^{NS,tot}$ holds utility constant under both tax and transfer systems. Therefore the equivalized difference in utility between those who experience the shock and those who experience no shock is the same under the baseline and the counterfactual linear tax and transfer system:

$$\frac{U_i^S(Z_i^{S,tot}) - U_i^{NS}(Z_i^{NS,tot})}{\sum_{t=0}^T \beta^t} = \frac{\widehat{U_i^S}^{tot} - \widehat{U_i^{NS}}^{tot}}{\sum_{t=0}^T \beta^t}$$

$$\log\left(1 - Z_i^{S,tot}\right) = \underbrace{\left[\log\left(\overline{Y_i}^S\right) - \log\left(\overline{Y_i}^{NS}\right)\right]}_{\approx \text{ percentage drop in } \overline{Y_i}} - \underbrace{\left[\log\left(\overline{C_i}^S\right) - \log\left(\overline{C_i}^{NS}\right)\right]}_{\approx \text{ percentage drop in } \overline{C_i}} + \underbrace{\left[\log\left(1 - Z_i^{NS,tot}\right)\right]}_{\approx 0} \quad (6)$$

Under logarithmic utility, equation (6) shows that the insurance value of the full tax and transfer system is approximately equal to the difference between the percentage drop in income before taxes and transfers and the percentage drop in consumption after taxes and transfers. The intuition for this equation is as follows. If the percentage drop in income were identical before and after taxes and transfers then the tax and transfer system provides no insurance, and $Z_i^{S,tot} \approx 0$. If the percentage drop in after-tax-and-transfer income $\overline{C_i}$ were zero then there is full social insurance under the baseline tax and transfer system, and $(1 - Z_i^{S,tot}) \approx \overline{Y_i}^S / \overline{Y_i}^{NS}$. In other words, switching from full insurance to a linear tax and transfer system is equivalent to scaling consumption down by the size of the income shock.

This approximation assumes that the tax and transfer system provides approximately no insurance value to individuals who do not experience the shock. That assumption is accurate when the probability of the shock is small and when the variance of income for those who experience no shock is small relative to the variance in income generated by the shock.

Insurance Value with Perfect Consumption Smoothing. The formulas describing the insurance value of the tax and transfer system change only slightly if, rather than consuming hand-to-mouth, individuals have access to frictionless credit markets. Assume that individuals can save and borrow at the interest rate $(1 + r) = 1/\beta$, and that there is no remaining uncertainty about the trajectory of income after taxes and transfers after the realization of the shock. Then individuals will maximize their utility by perfectly smoothing their consumption, setting consumption to be equal in all periods to the discounted arithmetic mean of their income after taxes and transfers:

$$\overline{C_i}'^J = \frac{1}{T+1} \sum_{t=0}^T \beta^t c(y_{it}, \omega_{it} | \theta, \lambda, \tau)$$

Therefore, with perfect consumption smoothing, the formula for the insurance value of the tax and transfer system derived in equation (6) holds so long as the discounted geometric means $\overline{Y_i}^S$, $\overline{Y_i}^{NS}$,

$\overline{C_i}^S$ and $\overline{C_i}^{NS}$ are replaced with discounted arithmetic means.

Component 1: Insurance Value of Progressive Taxes and Transfers. Suppose that formal social insurance benefits remain unchanged while the rest of the tax and transfer system is replaced with a revenue-neutral linear tax rate of $(1-\widehat{\lambda}^{\theta\tau})$. Then, with a logarithmic utility function, average utility under the counterfactual tax and transfer system is a function of the discounted mean of gross income y_{it} plus formal social insurance benefits ω_{it}:

$$\frac{\widehat{U_i^J}^{\theta\tau}}{\sum_{t=0}^T \beta^t} = \log\left(\overline{Y_i^J + \Omega_i^J}\right) + \log\left(\widehat{\lambda}^{\theta\tau}\right)$$

Analogously to equation (6), the insurance value of progressive taxes and transfers can therefore be approximated as the difference between the percentage drop in gross income plus social insurance benefits $(\overline{Y_i^J + \Omega_i^J})$ and the percentage drop in consumption $(\overline{C_i^J})$ caused by the shock

$$\frac{U_i^S(Z_i^{S,\theta\tau}) - U_i^{NS}(Z_i^{NS,\theta\tau})}{\sum_{t=0}^T \beta^t} = \frac{\widehat{U_i^S}^{\theta\tau} - \widehat{U_i^{NS}}^{\theta\tau}}{\sum_{t=0}^T \beta^t}$$

$$\log\left(1 - Z_i^{S,\theta\tau}\right) = \underbrace{\left[\log\left(\overline{Y_i^S + \Omega_i^S}\right) - \log\left(\overline{Y_i^{NS} + \Omega_i^{NS}}\right)\right]}_{\approx \text{ percentage drop in } \overline{Y_i + \Omega_i}} - \underbrace{\left[\log\left(\overline{C_i}^S\right) - \log\left(\overline{C_i}^{NS}\right)\right]}_{\approx \text{ percentage drop in } \overline{C_i}} + \underbrace{\left[\log\left(1 - Z_i^{NS,\theta\tau}\right)\right]}_{\approx 0} \tag{7}$$

Component 2: Insurance Value of Formal Social Insurance. Now consider the sequential decomposition of the full insurance value of the tax and transfer system into the components provided by the progressivity of taxes and transfers and by formal social insurance programs. As shown above, replacing the full tax and transfer system with a linear tax rate has a welfare effect equivalent to scaling consumption by $(1 - Z_i^{tot})$. Replacing only the progressivity of taxes and transfers with a linear tax rate, while leaving formal social insurance benefits unchanged, has a welfare effect equivalent to scaling consumption by $(1 - Z_i^{\theta\tau})$. Therefore additionally eliminating formal social insurance benefits is equivalent to additionally scaling consumption by $(1 - Z_i^{\omega'}) \equiv (1 - Z_i^{tot})/(1 - Z_i^{\theta\tau})$.

Under logarithmic utility, the sequential insurance value of formal social insurance for people who experience the shock has an intuitive expression:

$$\log(1 - Z_i^{S,\omega'}) = \log(1 - Z_i^{S,tot}) - \log(1 - Z_i^{S,\theta\tau})$$
$$\approx \underbrace{\left[\log\left(\overline{Y_i}^S\right) - \log\left(\overline{Y_i}^{NS}\right)\right]}_{\approx \text{ percentage drop in } \overline{Y_i}} - \underbrace{\left[\log\left(\overline{Y_i^S + \Omega_i^S}\right) - \log\left(\overline{Y_i^{NS} + \Omega_i^{NS}}\right)\right]}_{\approx \text{ percentage drop in } \overline{Y_i + \Omega_i}} \tag{8}$$

In sum, two intuitive reduced form parameters decompose the insurance value of the full tax and transfer system for individuals with logarithmic utility who experience a shock. First, the insurance value of formal social insurance programs is approximately equal to the difference in the percentage drop in gross income before and after social insurance benefits are received. Second, the insurance value of progressive taxes and transfers is approximately equal to the difference in the percentage drop in gross income after social insurance benefits are received and the percentage drop in income after taxes and transfers. Together, these sum to the total insurance value of the full tax and transfer system. I estimate and report these reduced form parameters following layoff and hospitalization shocks in Section 4, which are sufficient statistics for the welfare created by social insurance under this logarithmic utility model.

3 Empirical Methods

This paper studies how taxes and transfers insure the two largest income risks faced by working-age households—layoffs and illness—using linked Canadian administrative data. I link administrative records describing all layoffs and inpatient hospital stays in eight Canadian provinces to administrative tax data recording annual income, social insurance benefits, transfers and taxes. I analyze how these outcomes change following a layoff or a hospitalization by matching 25- to 54-year-old workers who experience a layoff or a hospitalization in a given year to a comparison group who were similar on a rich set of characteristics three years prior. I then compare these matched workers using a non-parametric event study specification. The event study reveals whether the two groups were following similar trends leading up to the event, and identifies how their outcomes diverged after the layoff or hospitalization.

3.1 Data Sources

I construct an annual panel of layoffs, inpatient hospitalizations and economic outcomes by linking administrative layoff records and hospital records with tax records.

The layoff records are drawn from ROE "Record of Employment" tax slips, which employers file with the Canadian government following each job separation. These slips indicate the reason for the separation—such as a layoff, a quit, an injury or illness, a parental leave, etc. The set of layoffs observed are not restricted to mass layoffs: all layoffs are included regardless of the fraction of workers laid off by the firm contemporaneously. These layoff records are linked to tax records using their shared tax identifier (Social Insurance Numbers, which are equivalent to U.S. Social Security Numbers).

The hospital records are drawn from the Discharge Abstract Database, which includes all inpatient admissions to Canadian acute care hospitals outside Quebec and Manitoba from 2000 to 2014.[11] Outpatient visits to the hospital and emergency room visits that did not result in an admission are not included in the database. Individuals' hospitalization records and tax records are linked using an exact deterministic match on date of birth, sex and postal code.[12] 88.4% of hospital records were successfully linked to a person in the tax records, and the linkage rate was consistently high across years, provinces, diagnoses and sex. 7.6% of hospital records did not match to anyone in the tax records and, to the extent that these belong to tax filers, these unlinked hospitalizations will attenuate my results. 4% of hospital records were matched to more than one person in the tax records, and the associated hospital records and tax records were excluded from the sample. Further details on the linkage procedure and quality assessments are described by Sanmartin et al. (2018).

The tax records are drawn from the T1 Family File, which includes 100% of Canadian tax filers from 1997 to 2015. Individuals are linked to their spouses and cohabiting children using information from their tax returns and child benefit claims. Wages earned by non-filers are observed using T4 "Statement of Remuneration Paid" slips filed by employers, which are equivalent to W-2 slips in the United States. All together, 96% of Canadians are observed in the T1 Family File (Statistics Canada 2016b). I topcode earnings and income at the 99.95th percentile in each year to mitigate the influence of outliers or erroneous data, but find that the results are not sensitive to topcoding.

[11] Quebec does not contribute its hopsital data to the Discharge Abstract Database, and Manitoba did not begin contributing data until April 2004.

[12] The average Canadian postal code contains fewer than 40 individuals, so it is very rare for two different people to share the same date of birth, sex and postal code.

Statistics Canada protects individuals' privacy during the linkage process and subsequent use of linked files. The data linkage was approved by Statistics Canada's Executive Management Board, and its use is governed by Statistics Canada's Directive on Record Linkage (2017). Only employees directly involved in the linkage process had access to the unique identifying information, and those employees did not have access to health-related or tax-related information. After the data linkage was completed, an analytical file was created with the identifying information removed (Statistics Canada 2016a). The de-identified files were used for this analysis, and all data processing was performed on a secure server onsite at Statistics Canada in Ottawa, Ontario.

3.2 Sample Construction

I study layoffs and hospitalization events that took place between 2003 and 2010 by partitioning the population into three groups in each of those index years for each type of event: a treated group who experienced the event in the index year, a comparison group who did not experience the event in the index year, and an excluded group. This section describes how those groups are constructed.

Analysis Sample. The analysis sample covers 25- to 54-year-olds with prior labor force attachment living in eight out of ten Canadian provinces who had no recent long-term disability claims.[13] I exclude residents of Quebec and Manitoba in the index year because hospital admissions from those two provinces are not available for the full sample period. I also exclude residents of the northern territories: the Yukon, the Northwest Territories and Nunavut. Health care in the territories is limited and many residents are flown south to hospitals in the provinces, including Quebec and Manitoba, for treatment. I apply these geographic restrictions when studying both layoff and hospitalization events so that the populations being analyzed are comparable. I require each person to have been employed at least once during the five years prior to (but not including) the index year. Because after-tax-and-transfer family income in the third year prior to the index year will be used as a matching variable, I restrict to individuals who filed their taxes in the third year before the event.[14] Finally, I focus on workers who have no recent disability claims: I exclude anyone who received long-term disability insurance benefits through the Canada Pension Plan or who claimed the disability tax credit during the three years prior to the index year.[15] The resulting analysis

[13] I select individuals who are no older than 54 in the index year so that the entire sample can be followed for 5 years without becoming eligible for public pension benefits. Canadians can claim early retirement benefits through the Canada Pension Plan starting at age 60.

[14] Tax filing rates are substantially higher in Canada than in the United States, and exceed 90% during the working ages studied here (Appendix Figure 4).

[15] Individuals receiving private long-term disability benefits are required by private insurers to apply for public

sample contains 11 million unique individuals and covers 79% of the 25- to 54-year-old residents in the eight provinces studied (Table 1).

Layoff Events. In each index year $k \in \{2003, \ldots, 2010\}$, I divide the analysis sample into a treatment group that was laid off in year k and a comparison group that was not laid off in year k. When defining layoff events I exclude temporary layoffs, where the laid off worker returns to work for the same employer in the following calendar year. Because layoffs generate subsequent job instability (Jarosch 2015), I restrict the analysis to individuals who experienced no layoffs in the prior three years. This three year "washout" period identifies the effect of an initial layoff inclusive of its indirect effect of increasing layoff probabilities in the subsequent years.[16] Pooling the eight index years, I observe 1.6 million layoff events that can be matched to 53 million comparison events (Table 1).

Hospitalization Events. My analysis of hospitalization events follows the same strategy as layoff events. In each index year $k \in \{2003, \ldots, 2010\}$, I divide the analysis sample into a treatment group that was hospitalized in year k and a comparison group that was not hospitalized in year k. When defining hospitalization events I exclude hospital stays due to childbirth. Adverse health events that require an inpatient stay frequently generate readmissions to the hospital related to the same illness. I therefore measure the effects of the initial observed health event inclusive of follow-on illness by restricting the analysis to individuals who experienced no inpatient hospital stays in the prior three years. Pooling the eight index years, I observe 1.2 million hospitalization events that can be matched to 56 million comparison events (Table 1).

3.3 Matched Research Design

The econometric challenge in this paper is to estimate the counterfactual outcomes of people who were laid off or hospitalized that would have occurred absent the event.[17] I estimate these counterfactuals by matching each person who experiences a layoff or a hospitalization event in index year k to a person from the comparison group with identical demographics and similar income during

benefits through the Canada Pension Plan, because private plans are the second-payer of benefits.

[16] Using a washout period is a middle ground between the common empirical practices of studying the only the first event observed for an individual in a panel (which becomes increasingly selective in later index years) or studying every event observed (which may be attenuated by the inclusion of follow-on events that have small incremental effects relative to the initial event). This empirical strategy is common in the medical literature, and has been applied in economic analyses as well (e.g. Autor, Donohue, and Schwab 2006; Dobkin et al. 2018). In medical analyses, this is commonly referred to as identifying the effects of an initial event inclusive of its sequelae.

[17] The "hospitalization event" considered in this research design encompasses the health decline that led to the hospital admission. The counterfactual therefore represents what would have happened absent the health decline that led to a hospitalization, not what would have happened to someone with the same health decline who did go to the hospital.

year $k-3$. This paired research design flexibly controls for selection on lagged observables into layoff and hospitalization events, and also reduces the computational cost of estimation by shrinking the size of the comparison group. Because I do not match on trends in the pre-period, the pre-trends remain flexible and can be used to evaluate potential bias due to selection on unobservables, as I discuss in the next section.

I apply the matching procedure in two stages: I first perform an exact match on demographic characteristics, then a caliper match on income characteristics. For each person who was laid off or hospitalized in index year k, I begin by finding the set of comparison individuals in index year k with the same sex, age, province of residence, marital status and family size in year $k-3$. I then select a single match within this set: the person who had the most similar income in year $k-3$ as measured by both individual employment income percentile and household income percentile after taxes and transfers.[18] I select the match that is closest in sum of squared deviation along both income percentiles, and choose randomly in the case of a tie. I set the caliper widths so that matched individuals differ by no more than 10 percentiles in either income variable. All matches are performed without replacement.

When constructing the matched comparison group for layoff events, I additionally include job tenure in year k as a caliper matching variable.[19] This is the only variable I condition on that is measured outside of year $k-3$. I include it in the conditioning set because the occurrence of layoff events is mechanically correlated with job tenure in the year of the layoffs for two reasons: one must have a job in order to be laid off, and firms conducting layoffs often explicitly condition on seniority when selecting which employees to dismiss.

More than 95% of layoff events and 98% of hospitalization events are successfully matched to a comparison event (Table 1). Unmatched events are excluded from the sample. The resulting matched sample contains 1.6 million matched layoffs and 1.2 million matched hospitalizations, with the observable characteristics in year $k-3$ well-balanced on observable characteristics by construction (Table 1).

[18] I construct percentiles of positive incomes separately by age, sex and year based on the national population of workers. Individuals may have zero employment income and may have zero or negative household income after taxes and transfers. I treat zero or negative incomes in each variable as separate outcomes and match exactly on these outcomes.

[19] I measure job tenure in calendar years and match based on exact tenure from 1 to 5 years, plus or minus one year of tenure at 6 to 10 years. I topcode at 11 or more years of tenure and match to anyone with 11 or more years of tenure.

3.4 Event Study Specification

I identify the economic consequences of layoff and hospitalization events by comparing the evolution of each outcome y (such as income) among individuals who experience the event in index year k with the evolution of that outcome among the matched comparison group.[20]

Regression Specification. For each index year $k \in \{2003, \ldots, 2010\}$, I estimate a separate non-parametric event study regression using ordinary least squares:

$$y_{ir}^{k} = \alpha_i^k + \sum_{r \neq -3} \beta_r^k + \sum_{r \neq -3} \delta_r^k \cdot \text{Treated}_i^k + \varepsilon_{ir}^k \tag{9}$$

Subscript i denotes individuals and subscript r denotes the number of years elapsed relative to the index year k when the event occurs. α_i^k are individual fixed effects, which allow each individual to have an arbitrarily different level of y. β_r^k estimates the evolution of the mean of y over time among the matched comparison group. δ_r^k are the coefficients of interest: they estimate the difference in the evolution of mean y over time between the individuals who experienced the event and the matched comparison group.

I estimate bootstrapped standard errors by randomly resampling the matched pairs with replacement, then re-estimating the event study regressions using 50 bootstrapped samples.

Identification Assumption. The estimates δ_r^k identify the average causal effect of treatment on the treated (ATT) if the outcomes of individuals who are laid off or hospitalized would have evolved in parallel to the matched comparison group absent the event. This identifying assumption can be evaluated by looking for parallel trends in the pre-period ($\delta_r^k = 0$ for $r \leq -1$). Even if the pre-trends are parallel, the identifying assumption could be violated if economic shocks are correlated at high frequencies with layoff or hospitalization events. For instance, if job separations cause a spike in hospitalizations and a long term decline in economic outcomes y_{it}, the event study regression would falsely attribute the direct effect of job separations on y_{it} to the associated hospitalizations.

Pooling Event Cohorts. In practice only one index year is required to identify the consequences of a layoff or a hospitalization event: a single event study provides a panel of treated and comparison individuals to compare over time. But the analyses below will pool the samples from eight index

[20] Matched research designs are widely used to construct appropriate comparison groups in event study specifications: recent examples include Jaëger (2016) and Sarsons (2017).

years spanning 2003 to 2010. I calculate the pooled event study estimator using an unweighted average over the estimates from each index year: $\bar{\delta}_r \equiv \mathbb{E}_k \, \delta_r^k$. The choice not to weight the index years is inconsequential in practice because the sample sizes and estimated effects are stable across index years (e.g. Figures 1A and 6A). But by explicitly specifying how the comparisons are weighted, this pooled estimator eliminates the potential biases of common multi-period event study specifications discussed in a growing econometric literature (Borusyak and Jaravel 2016; Abraham and Sun 2018; Goodman-Bacon 2018). Pooling the index years also increases the sample size, which helps to precisely identify the effects of layoff or hospitalization events on the full distribution of outcomes, not just the mean outcome, and also helps to examine heterogeneity in the effects of the events in subsamples spanning the income distribution.

4 Results

I study the insurance value of redistributive taxes and transfers by examining how the two largest income risks faced by working-age households—layoffs and illness—are insured by government programs. After showing that both layoff and hospitalization events cause large income losses that persist more than five years, I examine the size and the sources of social insurance against those losses.

I find that the insurance provided by the full Canadian tax and transfer system is worth 8 to 10% of post-layoff consumption and 7 to 9% of post-hospitalization consumption in a model with logarithmic utility. Across the entire income distribution, for both layoff and hospitalization events, the majority of social insurance comes from redistributive taxes and transfers: only 45% of the insurance value against layoff risk and 26% of the insurance value against hospitalization risk is derived from formal social insurance benefits provided by unemployment and disability insurance. Finally, I show that social insurance against both layoff and hospitalization risk is highly progressive. Income losses before taxes and transfers are disproportionately large for those who had low incomes prior to the event, but progressive social insurance completely flattens the gradient in income losses after taxes and transfers post-layoff and halves the gradient in income losses post-hospitalization. Redistributive transfers are a key source of this progressivity: partly by replacing lost income with increased transfers and partly by providing stable transfers to individuals with low income independent of the adverse event, which reduces the volatility of their income to labor market risk.

4.1 Layoff Events

I begin with an analysis of layoff events, which affect 3.0% of my analysis sample of 25- to 54-year old Canadians every year. All Canadian workers pay into a federal unemployment insurance program and are eligible for benefits when they are laid off, so long as their work hours in the previous 52 weeks exceeds a minimum threshold (which depends on the local unemployment rate at the time of the layoff). The duration of eligibility for unemployment benefits lasts 14 to 45 weeks, depending on the local unemployment rate and the number of hours worked during the preceding 52 weeks. However average income losses following a layoff last years, not weeks, persisting far beyond eligibility for unemployment benefits. I therefore examine how well the long-term income losses following a layoff are insured by the full tax and transfer system, what the underlying sources of that social insurance are, and how the social insurance against layoff risk is distributed across the income distribution.

4.1.1 Descriptive Income Losses

I lay the groundwork for my analysis of social insurance by replicating the well-known finding that layoffs cause substantial and sustained declines in earnings (Jacobson, LaLonde, and Sullivan 1993; Davis and von Wachter 2011; Morissette, Qiu, and Chan 2013). Mean individual earnings decline by \$11 000 in the year of a layoff and \$15 000 in the following year, then partially recover and stabilize at an annual loss of \$7 000 over the subsequent 12 years (Figure 1A). The pattern of earnings losses is nearly identical for workers laid off in each index year k from 2003 to 2010. Throughout the rest of the analysis I focus on estimates that pool all eight index years ($\bar{\delta}_r \equiv \mathbb{E}_k \, \delta_r^k$), and study the period from five years before to five years after the event where I observe data for all index years. Laid off workers lose 25% of their present value earnings during the year of the layoff and subsequent five years, which corresponds to an average annual loss of \$11 000 (Figure 1B).[21]

The laid off workers and the matched comparison group followed parallel earnings trajectories starting from the first year they were observed—up to 13 years prior—and lasting until the third year prior to the layoff (Figure 1A). Only outcomes in the third year prior to layoffs were used for matching, so the parallel evolution during the rest of the pre-period was not predetermined

[21] I calculate present value using a real discount rate of 3% and a discount-weighted geometric mean. This discounted geometric mean is the welfare-relevant metric in a model with logarithmic utility and hand-to-mouth consumption, as shown in Section 2.3. The results do not change substantially when using a discounted arithmetic mean, which is the welfare-relevant metric with perfect consumption smoothing. I discuss and contrast the two sets of results in Section 4.1.2.

mechanically. These parallel pre-trends support the identifying assumption that the laid off workers would have continued along the same trajectory as the comparison group absent the layoff event. Laid off workers begin to experience a dip in earnings two years prior to the layoff event, which matches the pattern first documented in mass layoffs by Jacobson, LaLonde, and Sullivan (1993). This earnings dip occurs along the intensive margin: laid off workers have stable employment rates prior to being laid off (Appendix Figure 2A), but their average earnings growth is slower in the two years leading up to being laid off (Figure 1B).

The full set of taxes and transfers that I will analyze when decomposing social insurance is only observable for taxfilers, but Figure 1A shows that the full sample (dashed line) and the sample restricted to taxfilers in each year (solid line) have virtually indistinguishable earnings trajectories. Employment earnings are observable for non-filers because employers file tax slips (T4s) directly with the tax authority. The similarity in outcomes between the full sample and the taxfiling sample suggests that the attrition of non-filers (shown in Appendix Figure 4) from the taxfiling sample does not generate substantial bias or lack of generalizability.[22]

Total income before taxes and transfers falls by 14% on average (\$12 000 per year) during the year of the layoff and five subsequent years, while following the same trajectory over time as individual earnings (Figure 1C). Income before taxes and transfers includes employment income, self-employment income, interest and dividends—the full set of income components is defined in Table 2. I measure income by taking total household income (including spouses and cohabiting children), then assuming that resources are shared within the family and adjusting for economies of scale within the household by dividing by the square root of household size.[23]

Total income after taxes and transfers falls by only 10% on average (\$8 000 per year), reflecting the cumulative social insurance provided by unemployment insurance, disability insurance, other transfer programs and reductions in taxes. In dollar terms, increases in transfers and reductions in taxes replace 33% of mean lost income. In relative terms, the full tax and transfer system reduces

[22] I address non-filing and mortality in my matched sample using pairwise deletion: I exclude both members of the matched pair in years where either member is missing.

[23] This square root adjustment is the most commonly used equivalence scale (e.g. Hoynes and Luttmer 2011). Equivalence scales estimate *equivalized* or *consumption-equivalent* income by accounting for the fact that resources are divided among members of the household but there are economies of scale in consumption: a two person family can spend less than twice as much (on housing, food, etc.) to achieve comparable consumption utility. The equivalence scale shifts the overall level of income through its assumption about the magnitude of scale economies, but has a negligible impact on the analysis of social insurance because insurance is measured using relative losses. Since layoffs have a negligible effect on household size (Appendix Figure 3), the change in log income before and after taxes and transfers is approximately equal to the change in log equivalized income before and after taxes and transfers.

the percentage drop in mean income by 29%. The small difference between insurance in absolute and relative terms stems from the fact that mean income after taxes is lower than mean income before taxes and transfers (because net tax revenue exceeds net transfers), so each dollar of after-tax income lost looms larger than a dollar of before-tax income lost.

All of the results reported above are estimated precisely and are statistically significant, with p-values less than <0.001. I display the 95% confidence intervals of the event study estimates graphically in Figures 1B, 1C and 1D as the width of the line for laid off individuals, since vertical confidence interval bars would lie entirely under the circles indicating each data point. To interpret the precision of the estimates, note that the parameters of interest (δ_r^k) in the event study regression described by equation (9) measure the difference in means between the treated and matched comparison group in each year r. Therefore the statistical significance of the event study estimates corresponds to a test of equality for two means, each calculated in a sample with more than one million observations.[24]

4.1.2 Insurance Value Decomposition

Having established that the tax and transfer system replaces lost income after a layoff, I now turn to analyzing the insurance value of the tax and transfer system and decomposing the sources of social insurance. I structure this analysis using the model from Section 2 by studying the effects of layoffs on four log income measures: income (*i*) before taxes and transfers, (*ii*) after UI and DI benefits, (*iii*) after all transfers, and (*iv*) after taxes and transfers. These estimates are interpretable reduced form statistics, but they are also sufficient statistics for the welfare effects of social insurance in a model with logarithmic utility, as shown in Section 2.3.[25]

Recall equation (6), which showed that the total insurance value of the tax and transfer system for

[24]The parameters δ_r^k would be exactly equivalent to a comparison of means if regression equation (9) omitted individual fixed effects or if the panel were perfectly balanced—in which case the individual fixed effects would be orthogonal to the remaining regressors. In practice, the panel is unbalanced by attrition due to mortality and non-filing (shown in Appendix Figure 4). However the attrition rate is low and the regression results are nearly unchanged when omitting individual fixed effects, which indicates that the individual fixed effects are *almost* orthogonal to the treatment-by-year event study regressors. Therefore the intuition about statistical significance based on a comparison of means remains relevant in this dataset, despite the inclusion of individual fixed effects.

[25]Chetty (2006a) and Chetty and Szeidl (2007) present evidence based on the elasticity of labor supply to wages that the coefficient of relative risk aversion over long-run income changes is approximately $\gamma = 1$, which corresponds to logarithmic utility. A logarithmic utility function is therefore a reasonable benchmark for interpreting the welfare effects of long-run income changes following a layoff or a hospitalization. The data I observe on the distribution of income declines could be used to identify the welfare generated by social insurance under alternative levels of risk aversion—Doing so simply breaks the sufficiency of log income declines as a measure of the welfare effects, and requires more involved modelling to obtain welfare measures.

an individual with logarithmic utility who experiences a layoff is

$$\log\left(1 - Z_i^{S,tot}\right) \approx \left[\log\left(\overline{Y_i}^S\right) - \log\left(\overline{Y_i}^{NS}\right)\right] - \left[\log\left(\overline{C_i}^S\right) - \log\left(\overline{C_i}^{NS}\right)\right]$$

where $Z_i^{S,tot}$ is the share of consumption that a laid off individual would be willing to pay in every period to avoid replacing all tax and transfer programs (including UI and DI) with a linear tax rate that holds the individual's consumption constant in expectation before the layoff shock is realized. $\overline{Y_i}$ and $\overline{C_i}$ are the discounted means of income before and after taxes and transfers respectively. I compute these discounted means over a six-year horizon starting from the year of the layoff k and ending in $k+5$, then estimate the average effect of layoffs on discounted log income.

Income following a layoff declines by 0.25 log points before taxes and transfers and by 0.14 log points after taxes and transfers, which implies that the insurance provided by the full tax and transfer system is worth 10.4% of post-layoff consumption under the log utility model (Figure 2; Table 3). I decompose the sources of social insurance by examining the sequential insurance offered by UI and DI benefits, other transfers, and taxes. Unemployment insurance is substantial in the first calendar year following the layoff, when pre-tax-and-transfer income losses peak at 0.32 log points but are only 0.23 log points after unemployment benefits (Figure 2). However, UI benefit spells last at most 45 weeks in Canada, while post-layoff earnings losses last more than six years. Therefore laid off workers receive few formal social insurance benefits after the first year post-layoff. Despite evidence that poor labor market conditions are associated with an increase in disability insurance take-up (Black, Daniel, and Sanders 2002; Charles, Li, and Stephens 2017; Maestas, Mullen, and Strand 2018), I find that layoffs cause a negligible increase in disability benefits: less than $20 per year on average (Appendix Figure 5). Unemployment insurance provides more than 98% of formal social insurance benefits following a layoff.

Only 45% of social insurance during the six years following a layoff comes from formal social insurance benefits—the majority of social insurance comes from other tax and transfer programs that are not conditioned on the realization of a layoff (Table 3). Unemployment insurance (and, to a negligible extent, disability insurance) reduces post-layoff income losses from 0.25 log points to 0.20 log points. Other government transfers further reduce those losses to 0.15 log points, and finally progressive taxation reduces the losses to 0.14 log points. If utility is logarithmic in consumption then the insurance provided by formal social insurance benefits (UI and DI) is worth 4.7% of consumption following a layoff, while insurance from other transfers are worth 4.4% of consumption and insurance from the progressivity of the tax schedule is worth 1.3% of consumption. These calculations reflect a sequential decomposition of the total value of social insurance, so the ordering affects the results. Measuring the value of formal social insurance value first provides an upper bound for its insurance value (as discussed in Section 2.2): formal social insurance benefits would provide less than 45% of total social insurance if the value of UI and DI were measured after the rest of the tax and transfer system had already partially insured the gross income losses.

I illuminate the mechanisms behind the social insurance provided by each broad component of the tax and transfer system by further decomposing the social insurance described by equation (6) into six interpretable factors:

$$
\begin{aligned}
\log\left(1 - Z_i^{S,tot}\right) &\approx \log\left(\frac{\overline{Y_i}^S}{\overline{Y_i}^{NS}}\right) - \log\left(\frac{\overline{C_i}^S}{\overline{C_i}^{NS}}\right) \\
&= \log\left(\frac{\overline{Y_i}^S}{\overline{Y_i}^{NS}}\right) - \log\left(\frac{\overline{Y_i}^S + \overline{\Omega_i}^S + \overline{\Theta_i}^S + \overline{\mathrm{T}_i}^S}{\overline{Y_i}^{NS} + \overline{\Omega_i}^{NS} + \overline{\Theta_i}^{NS} + \overline{\mathrm{T}_i}^{NS}}\right) \\
&= \log\left[1 + \frac{\Delta\overline{Y_i}}{\overline{Y_i}^{NS}}\right] - \\
&\quad \log\left[1 + \frac{\Delta\overline{Y_i}}{\overline{Y_i}^{NS}} \underbrace{\left(1 + \frac{\Delta\overline{\Omega_i}}{\Delta\overline{Y_i}}\right)}_{A.i} \underbrace{\frac{\overline{Y_i}^{NS}}{\overline{Y_i}^{NS} + \overline{\Omega_i}^{NS}}}_{A.ii} \underbrace{\left(1 + \frac{\Delta\overline{\Theta_i}}{\Delta\overline{Y_i} + \Delta\overline{\Omega_i}}\right)}_{B.i} \underbrace{\frac{\overline{Y_i}^{NS} + \overline{\Omega_i}^{NS}}{\overline{Y_i}^{NS} + \overline{\Omega_i}^{NS} + \overline{\Theta_i}^{NS}}}_{B.ii}\right. \\
&\qquad \left. \underbrace{\left(1 + \frac{\Delta\overline{\mathrm{T}_i}}{\Delta\overline{Y_i} + \Delta\overline{\Omega_i} + \Delta\overline{\Theta_i}}\right)}_{C.i} \underbrace{\frac{\overline{Y_i}^{NS} + \overline{\Omega_i}^{NS} + \overline{\Theta_i}^{NS}}{\overline{Y_i}^{NS} + \overline{\Omega_i}^{NS} + \overline{\Theta_i}^{NS} + \overline{\mathrm{T}_i}^{NS}}}_{C.ii}\right]
\end{aligned} \tag{10}
$$

Equation (10) shows that the percent change in income after taxes and transfers is equal to the percent change in income before taxes and transfers scaled by six social insurance factors. The first two factors measure the formal social insurance provided by UI and DI. Factor $A.i$ measures the replacement rate of lost income ΔY by formal social insurance benefits $\Delta\Omega$. Factor $A.ii$ reflects the share of formal social insurance benefits in the incomes of individuals who do not experience a layoff. This is a measure of income stabilization: individuals whose benefit income is large relative to earned income independent of an adverse event are less vulnerable to risks that affect their earned income. The second two factors analogously measure the social insurance from other transfer programs. Factor $B.i$ measures the replacement rate of lost income by government transfers $\Delta\Theta$ following a layoff. Factor $B.ii$ measures the income stabilization provided by transfer benefits independent of a layoff. The last two factors measure social insurance from the progressivity of the tax schedule, as represented by the gap between marginal tax rates and average tax rates. Factor $C.i$ measures the marginal tax rate on lost income following a layoff.[26] Factor $C.ii$ reflects the average tax rate on income for individuals who do not experience a layoff.[27] Progressive taxes provide social insurance by lowering an individual's tax burden ΔT when their income falls because marginal tax rates exceed average tax rates.

Applying equation (10) to the data, I find that the average loss in income is 22% before taxes and transfers and only 13% after taxes and transfers because unemployment insurance scales that loss by a factor of 0.82, other transfers scale the loss after unemployment benefits by a factor of 0.78, and progressive taxes scale the remaining loss by a factor of 0.92 (Table 3).[28] UI and DI replace 15% of lost gross income, while other transfer programs replace 11% of the remaining income lost after UI and DI benefits are received. UI and DI benefits are a negligible source of income stabilization, providing less than 3.5% of income after transfers for individuals who don't experience a layoff in the index year. The rest of the transfer system serves much larger stabilization role, providing 12.5% of average income after transfers. Finally, taxes owed decline with income losses post-layoff at a marginal rate of 20%, which lowers the tax rate paid on post-layoff income below the 13% average tax rate paid by individuals who do not experience a layoff event.

The results of the social insurance decomposition are not sensitive to assumptions about individuals' degree of consumption smoothing behaviour: the pattern of results reported in Table 3 assuming hand-to-mouth consumers is unchanged if I instead assume that individuals are perfect consumption smoothers, as I do in Appendix Table 1. Section 2.3 showed that the discounted *arithmetic* mean of income post-layoff measures the value of income for perfect consumption smoothers because they set their consumption to be equal in all periods to their discounted arithmetic mean lifetime income. In practice, perfect consumption smoothing is unrealistic: individuals would not only need access to frictionless credit markets, they would also need to have no residual uncertainty about their future income and lifespan. Therefore the contrast between hand-to-mouth consumers and perfect consumption smoothers constitutes a bounding exercise, illustrating the (lack of) sensitivity of the

[26] If taxable income declines by a marginal amount ε, factor $C.i$ is equal to 1 minus the marginal tax rate. For non-marginal income declines, it is equal to the 1 minus the integral of the marginal tax rate measured over the segment of the income distribution covered by the decline in pre-tax income.

[27] The marginal and average tax rates in $C.i$ and $C.ii$ are measured on income including transfers: virtually all Canadian transfers are taxable income, including UI benefits, DI benefits, cash welfare benefits and child benefits.

[28] The numbers reported here describe the average percent loss in income, which differs from the percent loss in average income reported in Figure 1 because of Jensen's inequality.

results to the two extremes of consumption smoothing behavior. A more consequential limitation is that I estimate consumption during the six years following a layoff using income during those six years. Discounted consumption and discounted income after taxes and transfers are constrained to be equal in the long-run by the lifetime budget constraint. However net income and consumption may not be equivalent during the six-year horizon being studied because of saving or dissaving that smooths income from outside that period, which I do not observe.

Consumption smoothing reduces the average declines in log income and thus lowers the magnitude of social insurance, but does not change the relative shares of social insurance generated by different portions of the tax and transfer system (Table 3; Appendix Table 1). Consumption smoothing reduces the average decline in income from 0.25 log points to 0.20 log points before taxes and transfers and from 0.14 to 0.12 log points after taxes and transfers, which shrinks the insurance value of the tax and transfer system from 10% of consumption under hand-to-mouth consumption to 8% of consumption under perfect smoothing. However, formal social insurance benefits from UI and DI constitute 45 to 46% of total social insurance regardless of the degree of consumption smoothing, with a 95 percent confidence interval of $\pm$ 0.4 percentage points. Formal social insurance, other transfers, and progressive taxes shrink the percentage loss in income by a factor of 0.82, 0.78 and 0.92 respectively for hand-to-mouth consumers; and by a nearly identical 0.83, 0.82 and 0.92 for perfect consumption smoothers. The insurance value decomposition is therefore robust to the assumed degree of consumption smoothing behavior.

4.1.3 Distributional Income Losses and Social Insurance

Thus far I have examined the value of social insurance through the lens of its effects on average losses in log income, which are sufficient statistics for welfare under logarithmic utility but do not give a full picture of how social insurance affects the distribution of income losses. This section explores how social insurance programs affect the entire distribution of post-layoff income losses, which is informative about the consequences of social insurance programs under any utility function that may be used to weight the welfare consequences of those income losses.

Figure 3 plots the effect of social insurance on the distribution of income losses generated by layoffs. The histograms in this figure describe the effect of layoffs on the distribution of percent changes in discounted income during the six years post-layoff, relative to average income during the five years pre-layoff.[29]

Although unemployment insurance provides a higher average replacement rate for lost earnings (Table 3), the rest of the tax and transfer system plays a more substantial role in averting catastrophic income losses (Figure 3). Layoffs increase the probability of losing more than half of one's income by 6.5 percentage points before taxes and transfers. Formal social insurance from UI and DI moderately compresses the distribution of income losses, shrinking the post-layoff increase in the risk of losing more than half of one's income from 6.5 to 5.0 percentage points. But the insurance value of the redistributive tax and transfer system is especially concentrated toward mitigating the largest income losses. After taxes and transfers, the post-layoff increase in probability of losing more than half of one's income shrinks from 5.0 to 2.6 percentage points, while the post-layoff increase in the probability of income losses under 30% grows from 3.2 percentage points to 4.9 percentage points. This reduction in the risk of catastrophic losses is a key source of the insurance value generated by redistributive taxes and transfers.

4.1.4 Heterogeneity in Social Insurance by Pre-Layoff Income

Having analyzed the mechanisms behind the social insurance of layoff risk in the preceding sections, I now explore who benefits from the social insurance provided by the tax and transfer system. This section examines how the value of social insurance against layoff risk is spread across the income distribution, and which sources of social insurance are relied upon by different income groups.

I measure heterogeneity in the social insurance of layoff risk by re-estimating the event study regression described by equation (9) on subsamples split by household income quintile or household income decile three years prior to the layoff event. I construct these income quantiles separately for each age, sex and year based on the national income distribution. Therefore each quantile has the same age and sex composition by construction.

The event studies of post-layoff income losses are qualitatively similar for individuals in the bottom and top pre-layoff income quintiles (Figure 4) to the event studies for the full sample (Figures 1D

[29] Appendix Figure 6 plots the underlying distributions of percent income changes among the individuals who experienced a layoff and among the matched control group. The histograms in Figure 3 measure the difference in these distributions of income losses between the laid off group and the comparison group, which captures the causal effect of the layoff event on the distribution. Appendix Figures 7 and 8 show that the entire distribution of income before and after taxes and transfers was similar among the treated group and the comparison group during the pre-period, then diverged dramatically at the time of the layoff event. These appendix figures reveal that there was no substantial pre-trend in the distribution of income before year $k-2$, which is a stronger condition than the parallel trends in mean income shown in Figure 1.

and 2). Discounted income after taxes and transfers declines post-layoff by 10% in the full sample, by 9% in the bottom income quintile and by 12% in the top income quintile. This parity in income losses after taxes and transfers belies large inequalities in income losses before taxes and transfers. The bottom income quintile experiences an average income decline of 0.30 log points before taxes and transfers, compared to 0.21 in the top income quintile and 0.25 in the full sample.

The risks of post-layoff income losses are disproportionately large for low-income workers before taxes and transfers, but flat across the income distribution after taxes and transfers (Figure 5A). Before taxes and transfers, the magnitude of average post-layoff income losses declines roughly monotonically from 0.30 log points in the bottom income decile to 0.18 log points in the top income decile of pre-layoff household income. After taxes and transfers, average post-layoff income losses have a flat gradient with a range between 0.16 and 0.13 log points across the entire income distribution.

The tax and transfer system flattens the gradient of income losses following a layoff because the social insurance it provides is progressively distributed (Figure 5B). If individuals have logarithmic utility functions and consume hand-to-mouth, the insurance value of the full tax and transfer system to someone who is laid off is worth 15% of consumption in the bottom income quintile, 9% of consumption in the middle quintile, and 6% of consumption in the top quintile (Table 3). This progressive distribution of social insurance value stems from progressivity in the insurance value of UI and other transfers. Formal social insurance benefits from UI (and to a negligible extent, DI) scale the percentage loss in income after taxes and transfers down by a factor of 0.79 in the bottom income quintile but by only 0.90 in the top income quintile, driven primarily by higher replacement rates at lower income levels. Other redistributive transfers scale the percentage loss in income after taxes and transfers down by a factor of 0.70 in the bottom income quintile but by only 0.90 in the top income quintile, this time driven primarily by the greater income stabilization provided by transfer income to individuals with low income pre-layoff. Independent of a layoff, transfers comprise 24% of total income for individuals in the bottom income quintile but only 4% of total income for those in the top quintile, so risks to earned income are dampened toward the bottom of the income distribution. The progressive shape of the tax schedule provides a similar amount of social insurance across the entire income distribution: tax progressivity scales percentage losses in income by a factor of 0.91 to 0.92 across all income quintiles, and the value of insurance from progressive taxation ranges from 1.2% of consumption to 1.5% of consumption.

Formal social insurance benefits from UI and DI provide less than half of total social insurance at all income levels, whether individuals consume hand-to-mouth or perfectly smooth their consumption during the six years following a layoff. For hand-to-mouth consumers, the share of social insurance from UI and DI ranges from 38% to 48% across the income distribution (Table 3). For perfect consumption smoothers, the share from UI and DI ranges from 36% to 49% (Appendix Table 1). For each of these estimates, I can reject the hypothesis that more than 50% of social insurance comes from UI and DI at the 95% confidence level.

4.2 Hospitalization Events

This section replicates the analyses performed in Section 4.1 examining the value, sources and distribution of social insurance from the tax and transfer system, this time following hospitalization events instead of layoff events. Each year, 2.1% of my analysis sample of 25- to 54-year old Canadians experience a hospitalization event. Recent studies have shown that post-hospitalization earnings losses rival medical costs (García-Gómez et al. 2013; Fadlon and Nielsen 2017; Dobkin et al. 2018). And these post-hospitalization earnings losses may disproportionately affect low-income households, who experience higher rates of illness and disability (Marmot et al. 1991; Canadian Institute for Health Information 2016; Baker, Currie, and Schwandt 2017). Yet despite extensive academic and policy interest in the universality and adequacy of health insurance, there is little evidence about how the income risks of illness are distributed or how they are insured.

4.2.1 Descriptive Income Losses

Average earnings decline immediately in the year of hospitalization by $4 000 and remain roughly $4 000 lower throughout the subsequent twelve years (Figure 6A). The trajectory of earnings losses is similar for individuals hospitalized in each index year from 2003 to 2010, as was also the case for layoffs. I will therefore continue to pool the estimates from all eight index years in subsequent figures, and focus on the period from five years before to five years after the event during which I observe data for all index years.

In the taxfiling sample there is an upward trend in the earnings of hospitalized individuals prior to the hospitalization, which is due entirely to attrition by non-filers (Figure 6A). The matched sample of taxfilers (shown in a solid line) excludes observations during years where either member of the matched pair did not file their taxes. Among these matched taxfilers, the earnings of hospitalized individuals start $500 below their matched controls 13 years pre-hospitalization and rise smoothly to parity over the next decade. Individual earnings are also observable for non-filers, and in the full sample (shown in a dashed line) there is no visible pre-trend: hospitalized individuals and matched control individuals followed parallel earnings trajectories. The attrition rate is low during the period close to the index year, never exceeding 7% within the five years pre- and post-hospitalization (Appendix Figure 4B). Additionally, the full sample and the sample of taxfilers follow nearly identical earnings trajectories from five years prior to the hospitalization event until twelve years post-hospitalization, which is the last year of data observed. Focusing on outcomes during the period from five years before to five years after the hospitalization, as I do when in the pooled estimates, therefore also mitigates potential bias due to attrition.

Similar to laid off individuals, there is a dip in the average earnings of hospitalized individuals during the two years immediately preceding hospitalization, which is small in magnitude relative to post-hospitalization income losses (Figure 6A). This dip underscores the fact that the event study does not isolate the causal effect of the events occurring during the hospital stay itself. Rather, the inpatient hospitalization event is an observable proxy for an underlying deterioration in health that begins for some individuals prior to the hospitalization, and starts to affect earnings during the preceding two years. The event study estimates should therefore be interpreted as the causal effect of the illness associated with the hospitalization event.

The decline in mean income following a hospitalization is smaller than the decline in mean income following a layoff, but the share of losses insured by the tax and transfer system is similar for both events. Average individual earnings fall by 8.2% ($4 000 per year) in present value over the six years starting in the year of the hopitalization event (Appendix Figure 9). During those years, average equivalized household income before taxes and transfers falls by 4.1% ($2 600 per year), while average income after taxes and transfers falls by 2.9% ($1 500 per year). The decline in mean income following a hospitalization masks substantial heterogeneity, since many hospital stays involve little or no missed work and have no long-term effect on a person's work capacity. By contrast, every layoff involves a job separation by definition, and the decline in mean income following a layoff is 14% before taxes and transfers and 10% after taxes and transfers (Figure 1). The inclusion of hospitalization events that are associated with small or short-term health declines does not bias the analysis of the magnitude or sources of social insurance. This paper uses both types of shocks as observable sources of income risk in order to identify the value of social insurance against the income losses that do occur, whether following a layoff event or a hospitalization event. I find that the social insurance provided by the full tax and transfer system reduces the percentage drop in mean income post-hospitalization by 29%, which is identical to the magnitude of social insurance for layoff risk described in Section 4.1.1. The sections that follow examine how, despite the overall similarity in size, social insurance against hospitalization risk and layoff risk differs in its sources, in its distributional effects, and in its progressivity.

4.2.2 Insurance Value Decomposition

This section examines the effects of hospitalization events on log income before and after each successive component of the tax and transfer system is received. I measure and decompose the welfare created by each component of social insurance by interpreting the reduced form results using the model described in Section 2.3 and equation (10).

Following a hospitalization event, income declines by 0.15 log points on average before taxes and transfers and by 0.06 log points after taxes and transfers, which implies that the insurance provided by the full tax and transfer system is worth 8.5% of consumption under the log utility model (Table 4; Figure 6B). Unlike unemployment insurance benefits, which are capped at 14 to 45 weeks, long-term disability insurance provides sustained benefits to individuals who demonstrate that they have a "severe and prolonged disability" that prevents them from performing any substantial gainful activity. The Canadian federal government also provides universal short-term disability insurance (called Employment Insurance Sickness benefits) for up to 15 weeks to workers who are "unable to work because of sickness, injury or quarantine." Therefore workers who are disabled by a hospitalization event receive sustained formal social insurance benefits, starting in the year of the hospitalization and continuing throughout the subsequent years post-hospitalization (Figure 6B). Despite evidence of benefit substitution between unemployment and disability insurance (Koning and Vuuren 2010; Staubli 2011; Borghans, Gielen, and Luttmer 2014), I find that hospitalizations cause a negligible increase in UI benefits: less than $10 per year on average. Short-term and long-term disability insurance provide more than 98% of formal social insurance benefits following a hospitalization (Appendix Figure 10).

Only one quarter of total social insurance following a hospitalization event is derived from formal social insurance benefits (Table 4). Disability insurance (and unemployment insurance, to a negligible extent) reduces post-hospitalization income losses from 0.15 log points to 0.125 log points. Other government transfers further reduce those income losses to 0.07 log points, and finally progressive taxation reduces income losses to 0.06 log points. If utility is logarithmic in consumption then individuals who are hospitalized value the insurance provided by DI and UI as being worth 2.2% of their consumption, whereas insurance provided by other transfers is worth 5.8% of consumption and insurance from the progressivity of the tax schedule is worth 0.5% of consumption. If I assume that individuals perfectly smooth their consumption rather than consuming hand-to-mouth, then the total value of social insurance declines (from 8.5% of consumption to 6.9% of consumption) but the share of social insurance derived from each component of the tax and transfer system remains unchanged (Appendix Table 2). Regardless of the degree of consumption smoothing, DI and UI benefits provide 25 to 26% of total social insurance.

The smaller role of formal social insurance programs in insuring hospitalization risk (25% of total insurance) than layoff risk (45% of total insurance) is caused by differences in the replacement rates provided by unemployment insurance, disability insurance and other transfers (Tables 3 and 4). Recall equation (10), which showed that the total value of social insurance can be decomposed into six components: the replacement rate and income stabilization provided by UI and DI, the replacement rate and income stabilization provided by other transfers, and the difference between marginal and average tax rates generated by the progressive shape of the tax schedule. I find that DI replaces a somewhat smaller share of income lost post-hospitalization than UI replaces post-layoff: 12% vs. 15%. Other transfers replace a much larger share of lost income post-hospitalization than post-layoff, however: 40% vs. 11%. The other four components of social insurance are almost identical in size for hospitalizations and for layoffs.

4.2.3 Distributional Income Losses and Social Insurance

The redistributive tax and transfer system provides substantial social insurance by reducing the risk of catastrophic income losses following a hospitalization, and does so to a much larger extent than disability insurance benefits (Figure 7).[30] Hospitalizations increase the probability of losing more than half one's income by 4.2 percentage points before taxes and transfers. Formal social insurance from DI and UI moderately compresses the distribution of income losses, shrinking the

[30]Appendix Figure 11 plots the underlying distributions of percent income changes among the individuals who experienced a hospitalization and among the matched control group. The histograms in Figure 7 plot the difference in these distributions of income losses between the hospitalized group and the comparison group, which measures the causal effect of the hospitalization event on the distribution. Appendix Figures 12 and 13 show that the entire distribution of income before and after taxes and transfers was similar among the treated group and the comparison group during the pre-period, then diverged dramatically at the time of the hospitalization event.

post-hospitalization increase in the risk of losing more than half one's income from 4.2 to 3.4 percentage points. But after taxes and transfers, the post-hospitalization increase in the risk of losing more than half one's income shrinks from 3.4 to 1.5 percentage points. This pattern is consistent with the social insurance of layoff risk discussed in Section 4.1.3 and shown in Figure 3. The redistributive tax and transfer system is thus essential for insuring the catastrophic income losses generated by both layoffs and hospitalizations.

4.2.4 Heterogeneity in Social Insurance by Pre-Hospitalization Income

I conclude the analysis of hospitalization events by examining how the value of social insurance following a hospitalization is spread across the income distribution. I show that the distribution of social insurance against hospitalization risk is more progressive than social insurance against layoff risk, but not enough so to fully offset the fact that post-hospitalization income losses are far more unequal than post-layoff income losses.

Individuals near the bottom of the income distribution prior to a hospitalization lose a larger share of their income post-hospitalization than those near the top of the income distribution, but social insurance cuts this gradient in half after taxes and transfers (Figure 8A; Table 4). Post-hospitalization losses in log income before taxes and transfers are six times larger in the bottom income quintile than the top quintile (0.34 log points vs. 0.06 log points). After taxes and transfers, income losses in the bottom income quintile are "only" three times larger than the top quintile (0.095 log points vs 0.035 log points).[31] The inequality in income losses following a hospitalization reflects the combined effect of multiple potential channels of heterogeneity: individuals with low incomes tend to experience more severe health events, work in more physically demanding occupations which may be difficult to return to following a health decline, and as shown here, are better insured against the risk of income losses and may therefore exhibit a larger degree of moral hazard.

Redistributive transfers are the primary source responsible for the highly progressive social insurance that reduces inequality in post-hospitalization income losses after taxes and transfers (Figure 8B; Table 4). For individuals with logarithmic utility who consume hand-to-mouth, the insurance value of the full tax and transfer system to someone who is hospitalized is worth 21% of consumption in the bottom income quintile, 6% of consumption in the middle quintile, and 2% of consumption in the top quintile. Unlike for layoff risk, the progressivity of social insurance against hospitalization

[31] Appendix Figure 14 shows the underlying event studies for the bottom and top income quintile.

risk is generated almost entirely by redistributive transfers. The insurance value of redistributive transfers following a hospitalization ranges from 17% of consumption in the bottom income quintile to 1% of consumption in the top income quintile. By contrast, the insurance value of DI and UI benefits post-hospitalization ranges from 4% to 1% and the insurance value of tax progressivity ranges from 0.8% to 0.2% from the bottom to the top income quintile. If I instead assume that individuals perfectly smooth their consumption rather than consuming hand-to-mouth then the value of social insurance falls by approximately 20% across the board, but the progressivity and sources of social insurance remain virtually unchanged (Appendix Table 2).

The greater progressivity of social insurance against hospitalization risk than layoff risk is driven by differences in the replacement rates provided by unemployment insurance, disability insurance and other transfers—the same factors that explained the smaller role of formal social insurance in insuring hospitalization risk than layoff risk in Section 4.2.2. The effective replacement rate of disability insurance is regressive, replacing 3.8% of post-hospitalization income losses in the bottom income quintile and 13% to 15% of income losses in the top four quintiles (Table 4). By contrast, the replacement rate of unemployment insurance is progressive, replacing 16% of post-layoff income losses in the bottom income quintile and 8% of income losses in the top quintile (Table 3). Because eligibility for disability insurance has more stringent work history requirements than unemployment insurance, effective replacement rates for disability insurance are regressive despite the fact that statutory replacement rates for disability insurance are even more progressive than for unemployment insurance.[32] Other transfers more than compensate for the regressivity of disability insurance following a hospitalization, replacing 43% of post-hospitalization income losses in the bottom income quintile and 20% of post-hospitalization income losses in the top quintile. These replacement rates are larger and more progressive than the replacement rate of redistributive transfers following a layoff, which peaks at 14% in the second income quintile and falls to 7% in the top income quintile. The other four components of social insurance—income stabilization from UI and DI, income stabilization from other transfers, and the difference between marginal and average tax rates—are almost identical in magnitude and progressivity when insuring layoff and hospitalization events.

[32] To be eligible for long-term disability insurance benefits from the Canada Pension Plan, a person must have earnings exceeding the substantial gainful activity threshold ($\approx$ \$5 000) in at least four of the last six years, or three of the last six years for individuals with at least 25 years of contributions. To be eligible for unemployment insurance benefits, a person must have worked a minimum of 420 to 700 hours (10.5 to 17.5 Full Time Equivalent weeks) during the previous 52 weeks, depending on the local unemployment rate.

5 Conclusion

This paper shows that progressive taxes and transfers generate considerable social insurance, providing more insurance value against layoff and hospitalization risk than the unemployment and disability insurance programs that formally insure those risks. Redistributive transfers have a particularly large effect on shrinking catastrophic income losses and insuring individuals with low incomes against income risk. By insuring income risk throughout the income distribution and especially at the bottom of the income distribution, social insurance increases the total value of the tax and transfer system for everyone while increasing the effective progressivity of taxes and transfers beyond what their redistributive schedule implies.

The lifecycle dimension of the insurance provided by the tax and transfer system is an important aspect that is not addressed by the current set of results. I have examined social insurance over a six year horizon following a layoff or a hospitalization and computed average values for individuals over ages 25 to 54. Quantifying the variation in the insurance value of redistributive taxes and transfers over the lifecycle would be a valuable extension to the work of this paper. Additionally, recent work in the "new dynamic public finance" literature considers the value of age-dependent taxation in the optimal design of the tax and transfer system, given lifecycle income profiles and the accumulation of idiosyncratic productivity shocks (e.g. Weinzierl 2011; Farhi and Werning 2013; Heathcote, Storesletten, and Violante 2019). But many major income shocks are not idiosyncratic: they are correlated with age and income over the lifecycle. For example, adverse health shocks occur more frequently to individuals with low incomes and grow in frequency with age. The results of this paper suggest that incorporating a richer profile of income risk over the lifecycle may affect the optimal level of age-dependent taxation.

The findings in this paper also highlight the diversity of tax and transfer policies that affect individuals' insurance against income risk, which raises considerable challenges for optimal social insurance policy and the choice of instruments to provide social insurance. Changes to safety net transfers such as cash welfare, "unconditional" transfers such as child benefits, or the shape of the income tax schedule will all affect the amount and the distribution of insurance provided against income risk. Deriving the optimal combination of policy parameters that provide a welfare-maximizing level of insurance conditional on (oft-changing) societal preferences for redistribution is a challenging but important topic for future research.

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Table 1: Summary Statistics Before and After Matching

	Before Matching		After Matching	
Panel A: Layoff Events	**Laid Off** in Index Year k	**Not Laid Off** in Index Year k	**Laid Off** in Index Year k	**Not Laid Off** in Index Year k
Female	47%	53%	47%	47%
Age in Index Year	38.4	40.2	38.4	38.4
25-29	21%	14%	21%	21%
30-34	17%	15%	17%	17%
35-39	16%	16%	16%	16%
40-44	17%	19%	17%	17%
45-49	16%	19%	16%	16%
50-54	13%	17%	13%	13%
Province in Index Year				
BC, AB, SK	36%	37%	36%	36%
ON	50%	54%	52%	52%
NS, NB, PEI, NL	14%	9%	12%	12%
Married, Year k–3	69%	76%	69%	69%
Individual Earnings, Year k–3	31,032	46,762	31,419	31,500
Household After-Tax Income, Year k–3	65,208	84,280	65,194	65,171
Events, Pooling Index Years 2003–2010	1,637,503	53,059,746	1,568,756	1,568,756
Unique Individuals	10,844,021		2,949,304	
Panel B: Hospitalization Events	**Hospitalized** in Index Year k	**Not Hospitalized** in Index Year k	**Hospitalized** in Index Year k	**Not Hospitalized** in Index Year k
Female	58%	50%	58%	58%
Age in Index Year	41.8	39.8	41.8	41.8
25-29	11%	16%	11%	11%
30-34	12%	15%	12%	12%
35-39	15%	16%	15%	15%
40-44	19%	18%	19%	19%
45-49	22%	18%	22%	22%
50-54	22%	16%	22%	22%
Province, Year k–3				
BC, AB, SK	39%	36%	39%	39%
ON	48%	53%	49%	49%
NS, NB, PEI, NL	12%	10%	12%	12%
Married, Year k–3	73%	75%	73%	73%
Individual Earnings, Year k–3	42,332	44,814	42,498	42,477
Household After-Tax Income, Year k–3	78,728	81,814	78,822	78,700
Events, Pooling Index Years 2003–2010	1,184,343	56,417,076	1,167,699	1,167,699
Unique Individuals	11,080,373		2,418,694	

Notes: This table presents frequencies, means and counts from the analysis sample described in Section 3.2, before and after the matching procedure described in Section 3.3.

Table 2: Definitions of Income Components

Income Components	Statistics Canada Variable Name	Definition
Labor Income		
Employment earnings	T4E	Total earnings from T4 'Statement of Remuneration Paid' slips
Self-employment income	SEI	Sum of net self-employment income from: business, professional, commission, farming, fishing, Indian exempt self-employment
Other employment income	OEI	Other employment income (ex: tips, director's fees. varies over time.)
Exempted income for Status Indians	EXIND	Employment income for a Status Indian exempted from income tax
Nonlabor Income		
Limited partnership income	LTPI	Net partnership income for limited or non-active partners of a partnership that did not include a rental or farming operation
Dividends	XDIV	Amount of dividends received by the taxfiler
Interest and other investment income	INVI	Income earned from interest such as government bonds, corporate bonds, trusts, bank deposits, mortgages, notes, foreign dividend income, etc.
Rental income, net	RNET	Net income from rental income after costs and expenses are deducted
Alimony or separation allownaces	ALMI / TALIR	Taxable income received from a former spouse for spousal support (alimony) and/or for child support (maintenance)
Other income	OI	Taxable income not listed elsewhere on the tax return (ex: artist's project grants, research grants, retiring allowances, etc.)
Pension and superannuation income	SOP4A	Pension income from private sources, including foreign pensions
RRSP income of individuals aged 65 or over	RRSPO	Income from Registered Retirement Savings Plans (RRSPs) at ages 65+
Transfers and Credits		
Old Age Security pension	OASP	The pension is part of the Old Age Security program, a federal porgram that provides financial security to Canadian Seniors. Excludes Guaranteed Income Suppment (GIS) and Spousal Allowance (SPA): see NFSL.
Canada/Quebec pension plan	CQPP	Income received from Canada or Quebec Pension Plan (CPP/QPP), such as retirement, disability, survivor's, children's and death benefits.
Net federal supplements	NFSL	Combination of Guaranteed Income Supplement (GIS), Allowance for the Survivor, and Spouse's Allowance which are parts of the Old Age Security (OAS) program for seniors with low or no income
Employment insurance	EINS	Employment insurance benefits including layoff, sickness, injury, pregnancy, birth or adoption of a child
Goods and services tax credit	GHSTC	Sales tax credit intended to offset the cost of the General Sales Tax (GST) for lower income individuals and families
Provincial refundable tax credits	PTXC	Provincial refundable tax credits (ex: Child's Fitness, healthy homes renovation tax credit, etc.)
Refundable medical expenses	MDREF	Refundable tax credit that can be claimed for medical expenses incurred by low income residents of Canada
Social assistance	SASPY	Social assistance provided to meet the cost of basic requirements for a single person or a family
Workers' compensation	WKCPY	Payments received for worker's compensation for eligible injuries
Child tax benefits	CTBI	Income supplement for individuals with at least 1 qualified dependent child
Family benefits	FABEN	Benefits received from Family Allowance and family benefits from both federal and provincial programs
Universal child care benefit	UCCB	An amount of $100 paid for each dependent child under age 6
Registered disability savings plan	RDSP	Income from a registered disability savings plan for persons with long-term disability who hold a valid disability certificate (Government provides deposits and matching into RDSP)
Working income tax benefit	WITB	Federal refundable tax credit with a basic amount and a disability supplement for low-income individuals who are in the workfroce
Taxes		
Federal taxes	NFTXC	Income tax required to be paid to the federal Government of Canada
Provincial taxes	NPTXC	Income tax required to be paid to a provincial government
Quebec abatement	ABQUE	Reduction of the federal income tax paid by Quebec residents

Notes: These income components are reported on Canadian tax returns or tax slips. The Statistics Canada variable names are used by the Income Statistics Division in their databases such as the T1 Family File (T1FF) and the Longitudinal Administrative Database (LAD). Further details about each variable can be found in the data dictionary for the LAD (Statistics Canada 2018).

Table 3: Decomposition of Social Insurance Post-Layoff

	Full Sample	Household Income Quintile 3 Years Pre-Layoff				
		Bottom	2nd	3rd	4th	Top
Average Change in Log Income (Discounted Geometric Mean in Years k to $k+5$)						
Before Taxes and Transfers	-0.248	-0.298	-0.266	-0.232	-0.211	-0.207
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
After UI and DI	-0.198	-0.226	-0.203	-0.187	-0.179	-0.185
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
After All Transfers	-0.151	-0.153	-0.146	-0.147	-0.150	-0.165
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
After Taxes and Transfers	-0.138	-0.139	-0.133	-0.133	-0.137	-0.149
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Insurance Value of All Taxes and Transfers (% of Consumption)	10.42	14.65	12.51	9.38	7.17	5.60
	(0.04)	(0.11)	(0.08)	(0.07)	(0.06)	(0.06)
Insurance Value of UI and DI	4.70	6.62	5.97	4.28	3.04	2.12
	(0.01)	(0.04)	(0.03)	(0.02)	(0.02)	(0.02)
Insurance Value of Other Transfers	4.43	6.79	5.32	3.82	2.85	1.97
	(0.03)	(0.10)	(0.06)	(0.05)	(0.04)	(0.04)
Insurance Value of Taxes	1.29	1.24	1.21	1.28	1.28	1.52
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Share of Social Insurance from UI and DI	45.2%	45.6%	47.8%	45.7%	42.4%	37.9%
	(0.2)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)
Percentage Loss in Income Before Taxes and Transfers	-21.9%	-25.8%	-23.4%	-20.7%	-19.0%	-18.7%
Percentage Loss in Income After Taxes and Transfers	-12.9%	-13.0%	-12.4%	-12.5%	-12.8%	-13.9%
UI and DI: Insurance Scaling Factor	0.82	0.79	0.78	0.82	0.86	0.90
Replacement Rate	15.1%	16.3%	18.0%	15.4%	12.0%	8.4%
Income Stabilization	3.5%	6.1%	4.4%	2.7%	1.8%	1.3%
Other Transfers: Insurance Scaling Factor	0.78	0.70	0.74	0.80	0.85	0.90
Replacement Rate	10.7%	8.6%	14.1%	12.0%	10.1%	6.5%
Income Stabilization	12.5%	23.5%	14.0%	9.0%	5.8%	3.8%
Taxes: Insurance Scaling Factor	0.92	0.92	0.92	0.91	0.92	0.91
Marginal Tax Rate	20.3%	16.1%	18.6%	20.8%	22.5%	25.5%
Average Tax Rate	13.0%	8.6%	11.2%	13.4%	15.6%	18.3%
Number of Layoff Events	1,560,277	364,629	359,950	314,180	283,255	237,909

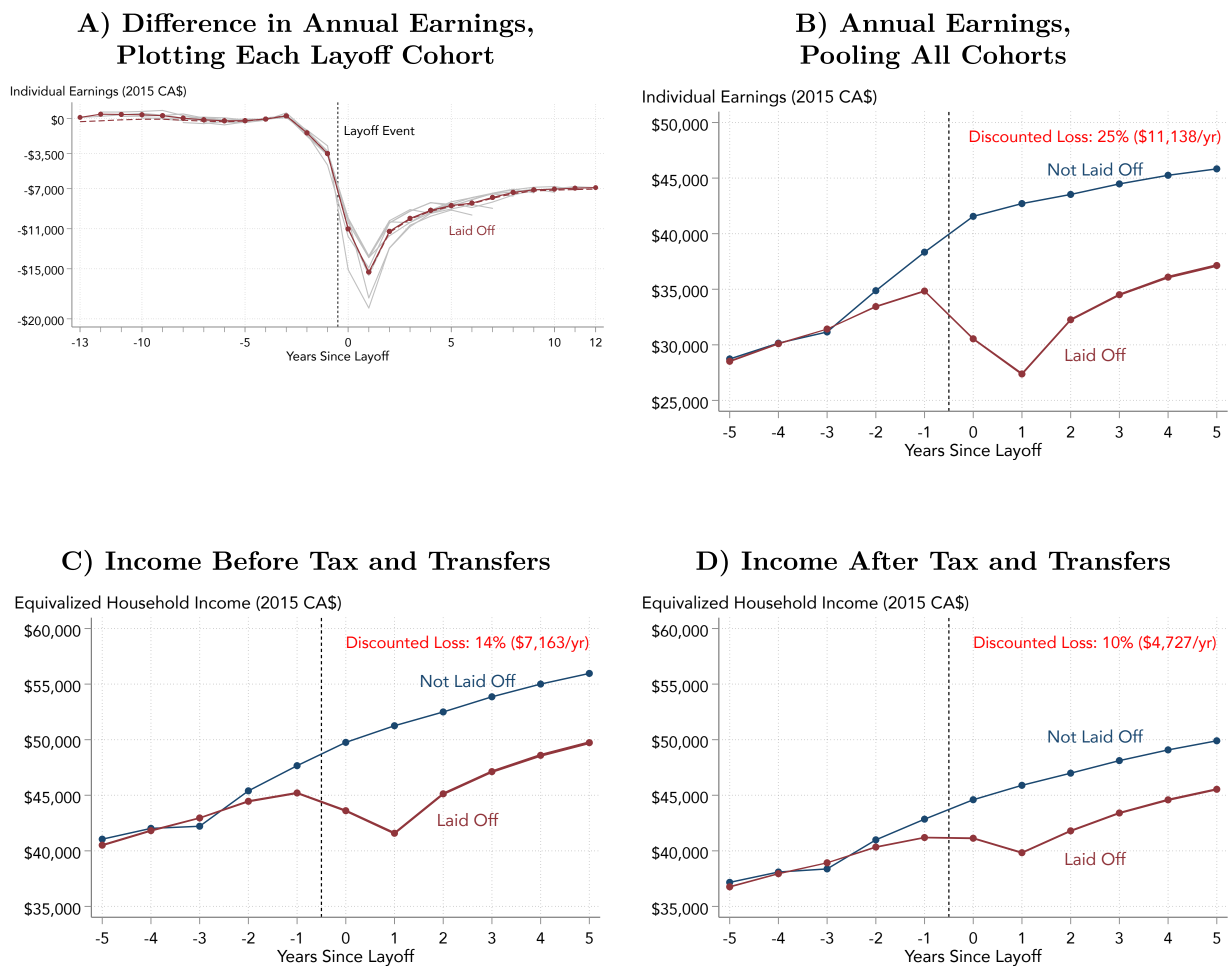
Notes: The upper panel reports the mean difference in discounted log income between each laid off person and their matched pair. The discounted log income is computed for each individual as the log of the discounted geometric mean of income over a six year horizon starting in the year of the layoff, using an annual discount rate of 0.97. The insurance value of all taxes and transfers and of each component of taxes and transfers is derived using equations (6), (7) and (8) as a function of the changes in log income. The lower panel reports the percentage losses in income before and after taxes and transfers, calculated using the discounted mean of log income in the treated and matched comparison group. The percentage loss in income after taxes and transfers is equal to the percentage loss in income before taxes and transfers multiplied by the three "insurance scaling factors", which are derived in equation (10). Equation (10) further decomposes each scaling factor into two components. This table reports each of these six components in the most interpretable units rather than directly presenting the multiplicative factors *A.i, A.ii, B.i, B.ii, C.i* and *C.ii*. The equivalent set of results calculated using discounted arithmetic means instead of discounted geometric means, which measures the value of insurance under perfect consumption smoothing rather than hand-to-mouth consumption, is reported in Appendix Table 1.

Table 4: Decomposition of Social Insurance Post-Hospitalization

	Full Sample	Household Income Quintile 3 Years Pre-Hospitalization				
		Bottom	2nd	3rd	4th	Top
Average Change in Log Income (Discounted Geometric Mean in Years k to k+5)						
Before Taxes and Transfers	-0.149	-0.335	-0.183	-0.121	-0.089	-0.056
	(0.001)	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)
After UI and DI	-0.125	-0.294	-0.146	-0.099	-0.075	-0.048
	(0.001)	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)
After All Transfers	-0.065	-0.104	-0.076	-0.061	-0.054	-0.037
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
After Taxes and Transfers	-0.060	-0.095	-0.070	-0.057	-0.050	-0.035
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Insurance Value of All Taxes and Transfers (% of Consumption)	8.52	21.36	10.64	6.19	3.88	2.05
	(0.06)	(0.18)	(0.10)	(0.09)	(0.04)	(0.05)
Insurance Value of UI and DI	2.23	3.61	3.51	2.13	1.37	0.77
	(0.01)	(0.07)	(0.04)	(0.03)	(0.02)	(0.02)
Insurance Value of Other Transfers	5.83	16.93	6.62	3.65	2.10	1.08
	(0.05)	(0.17)	(0.08)	(0.07)	(0.03)	(0.03)
Insurance Value of Taxes	0.46	0.82	0.52	0.41	0.40	0.19
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Share of Social Insurance from UI and DI	26.2%	16.9%	33.0%	34.3%	35.5%	37.6%
	(0.2)	(0.3)	(0.4)	(0.5)	(0.6)	(0.8)
Percentage Loss in Income Before Taxes and Transfers	-13.8%	-28.5%	-16.7%	-11.4%	-8.5%	-5.4%
Percentage Loss in Income After Taxes and Transfers	-5.8%	-9.0%	-6.8%	-5.6%	-4.8%	-3.5%
UI and DI: Insurance Scaling Factor	0.85	0.90	0.81	0.83	0.85	0.86
Replacement Rate	11.9%	3.8%	14.9%	15.0%	13.8%	12.7%
Income Stabilization	3.2%	6.9%	4.6%	2.6%	1.6%	0.9%
Other Transfers: Insurance Scaling Factor	0.53	0.39	0.54	0.63	0.72	0.78
Replacement Rate	39.2%	42.8%	36.4%	30.7%	23.7%	20.1%
Income Stabilization	12.8%	32.4%	15.4%	8.9%	5.3%	2.9%
Taxes: Insurance Scaling Factor	0.93	0.91	0.93	0.93	0.92	0.95
Marginal Tax Rate	20.2%	15.4%	17.3%	19.5%	22.2%	23.9%
Average Tax Rate	14.0%	7.5%	11.1%	13.7%	15.9%	19.7%
Number of Hospitalization Events	1,161,414	198,527	229,162	233,769	245,667	253,793

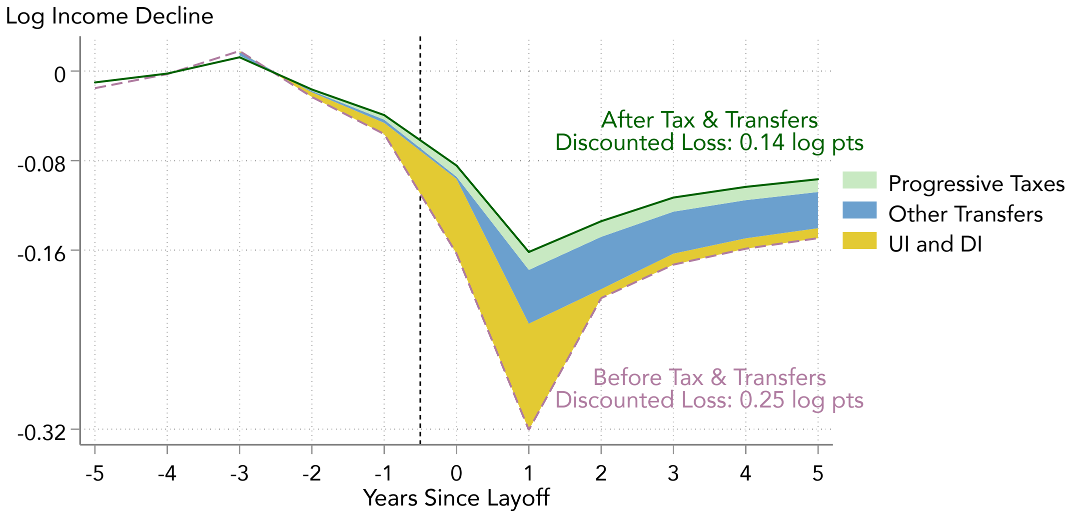
Notes: This table replicates Table 3 for hospitalization events. See the notes to Table 3 for details. The equivalent set of results calculated using discounted arithmetic means instead of discounted geometric means, which measures the value of insurance under perfect consumption smoothing rather than hand-to-mouth consumption, is reported in Appendix Table 2.

Figure 1: Layoffs Cause Persistent Declines in Average Income



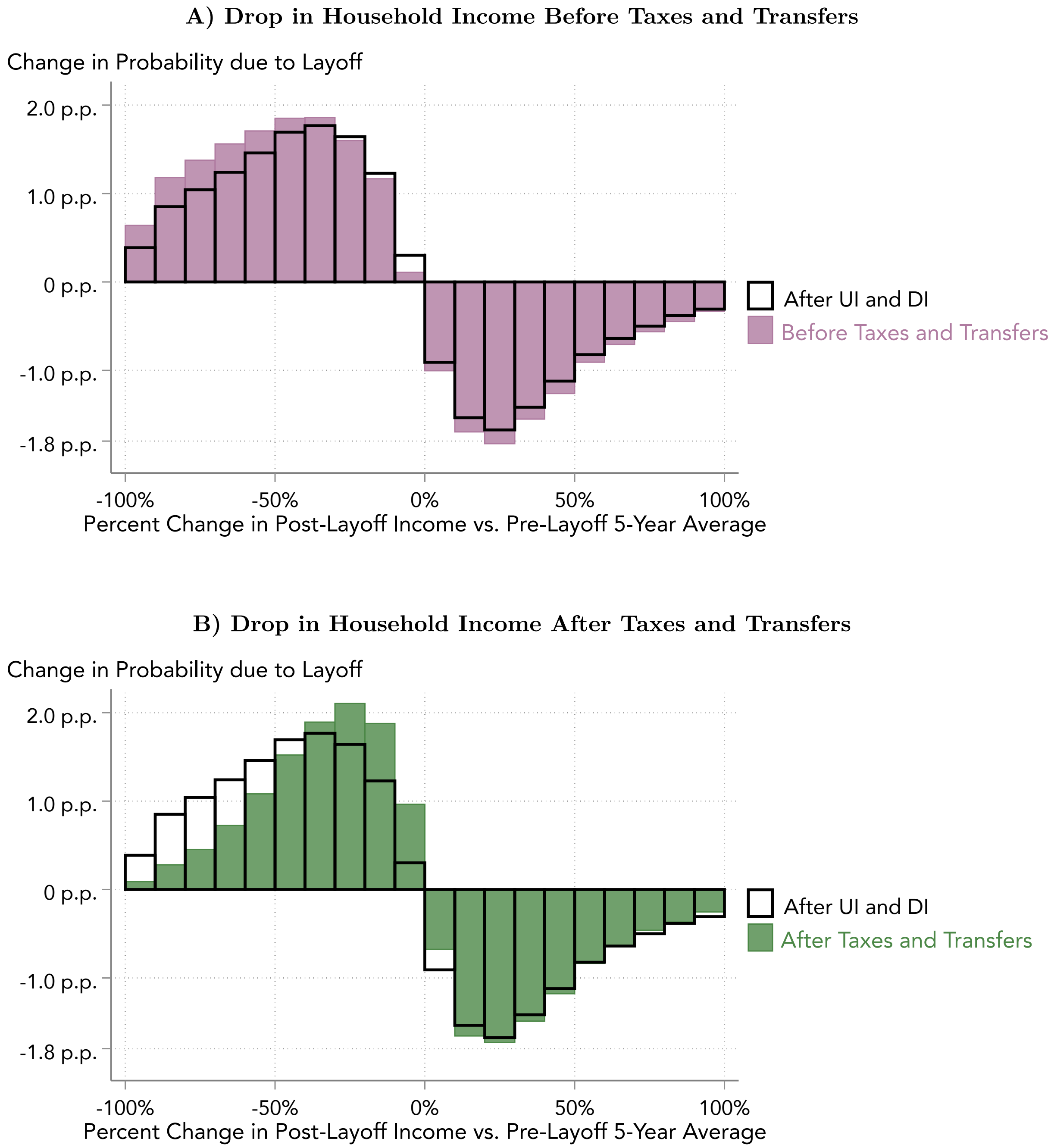
Notes: In Panel A, eight grey lines plot the coefficients from event studies estimated using equation (9) for each of the eight cohorts laid off in index years 2003 through 2010. The solid red line plots the pooled event study estimate, which is equal to the unweighted average of the estimates from the eight index years. These estimates are constructed using the taxfiling sample, which excludes both members of a matched pair in any year where either did not file their taxes. The pooled estimates using the full sample are plotted as the dashed red line. Panels B, C and D plot pooled event study estimates from the taxfiling sample for three different income measures. Each point for laid off individuals is plotted at the observed level of their mean outcome in that year. The line for "not laid off" individuals is normalized to have the same mean as the laid off individuals over years $k-5$ to $k-3$ to ease comparison of trends. The difference between these two lines is equal to the event study estimate. The discounted losses reported in each panel are computed using a discounted geometric mean over the six year period starting in the year of the layoff. Standard errors are computed using 50 bootstrap iterations resampling matched pairs, with the 95% confidence intervals plotted in Panels B, C and D as the width of the line for laid off individuals.

Figure 2: Social Insurance Against Layoff Risk is Primarily from Redistributive Taxes and Transfers



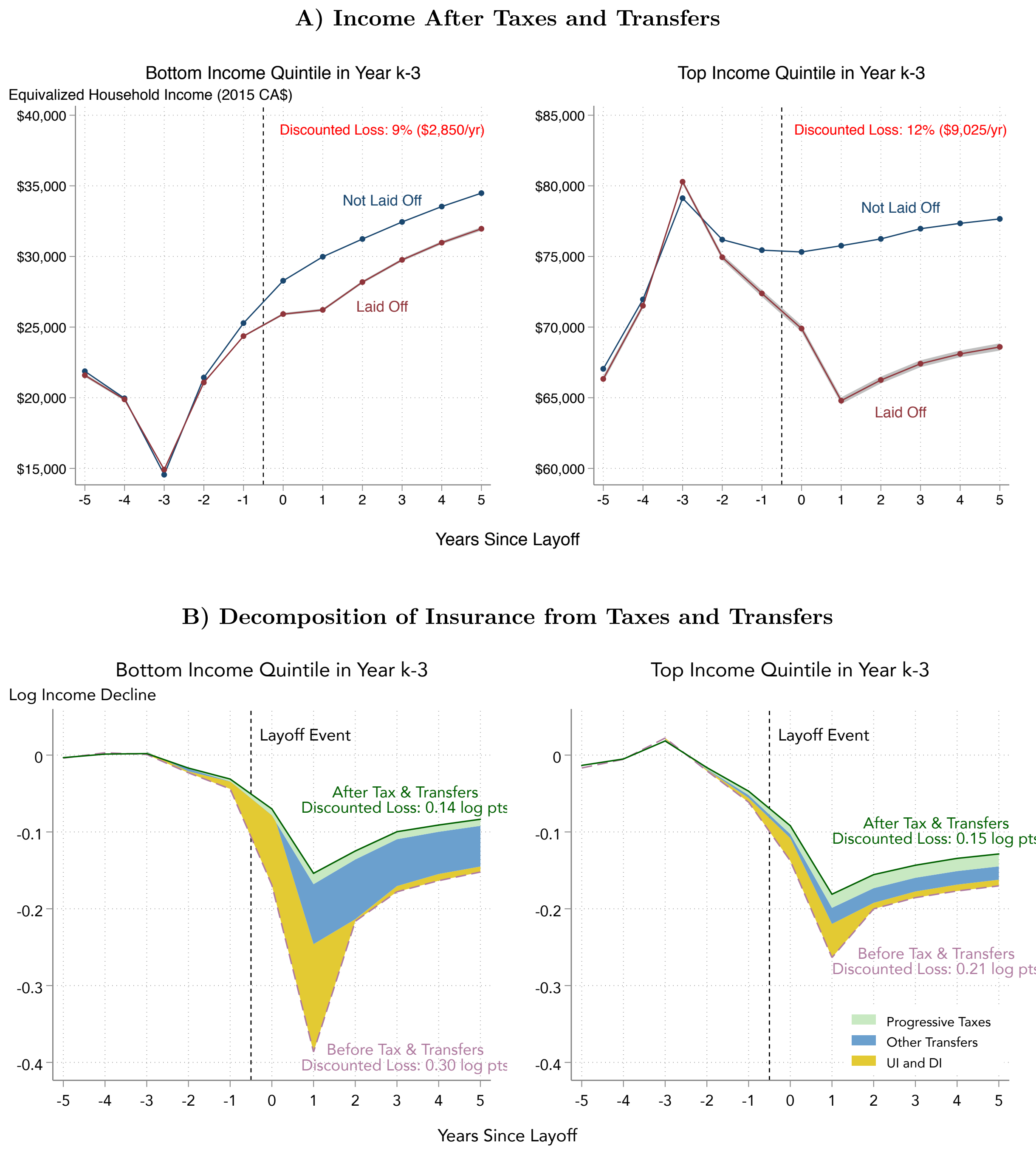
Notes: This panel plots the pooled event study estimates of the difference in log income between laid off individuals and the matched comparison group for four measures of log income: (i) before taxes and transfers, (ii) after UI and DI benefits, (iii) after all transfers, and (iv) after taxes and transfers. The differences between these lines, which are shaded as solid areas, measure the sequential decomposition of the insurance value of the tax and transfer system described by equations (6), (7) and (8). The associated numeric estimates are reported in Table 3.

Figure 3: Social Insurance Compresses the Distribution of Post-Layoff Income Losses



Notes: Each histogram presents estimates of the causal effect of layoff events on the distibution of income gains and income losses during the subsequent six years, measured relative to pre-layoff income. The height of each bar measures the difference in probability mass between the laid off group and the matched control group. The underlying distributions of relative income changes in the treated group and control group are plotted in Appendix Figure 6. The underlying distributions of income levels before and after taxes are plotted separately in each year in Appendix Figures 7 and 8. The rightmost bar measures the difference in probability of income gains of 100% or more. The histogram for changes in "income after UI and DI" is plotted in both Panel A and Panel B to facilitate comparisons with the changes in income before and after taxes and transfers.

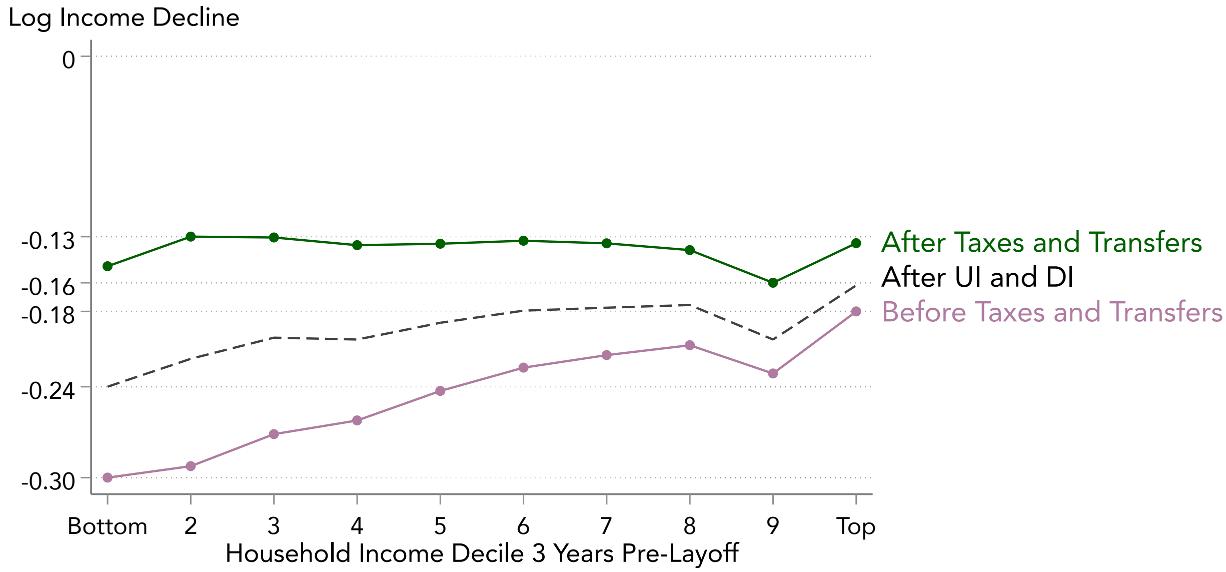
Figure 4: Low-Income Workers Experience Larger Post-Layoff Income Losses Before Taxes and Transfers but Similar Income Losses After Taxes and Transfers



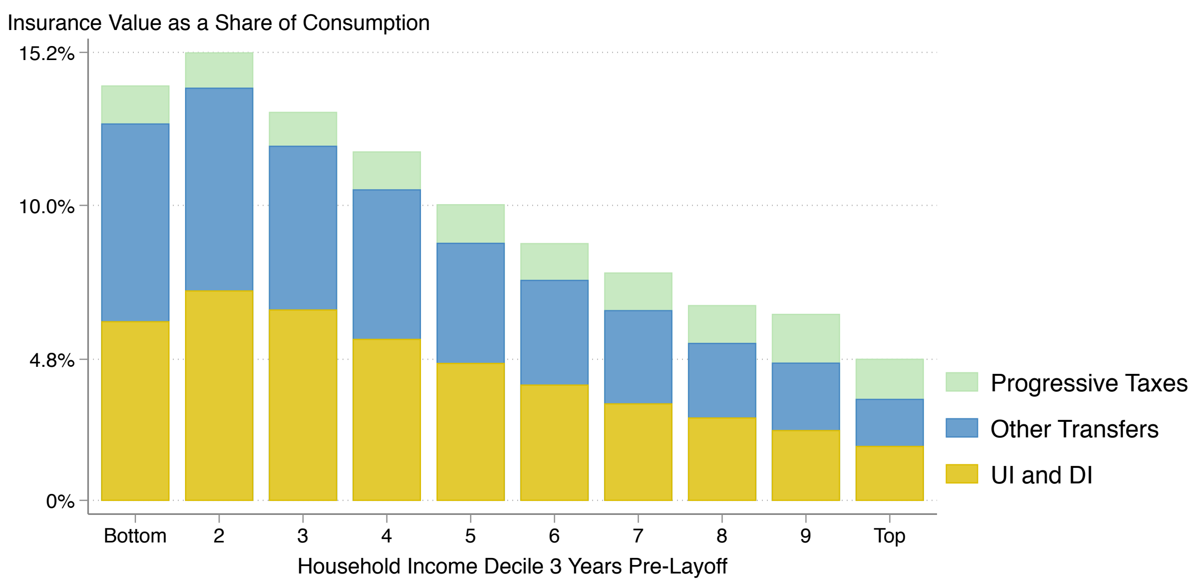
Notes: Panel A replicates Figure 1D in subsamples restricted to individuals in the bottom and top quintiles of household income in the third year prior to the layoff event. The 95% confidence intervals for each event study estimate are plotted as the shaded grey region. Panel B replicates Figure 2 in the same subsamples. See the notes to Figures 1 and 2 for details. The associated numeric estimates are reported in Table 3.

Figure 5: Redistributive Taxes and Transfers Provide the Majority of Social Insurance Against Layoff Risk Throughout the Income Distribution

A) Incomes Losses Post-Layoff, by Pre-Layoff Income Decile



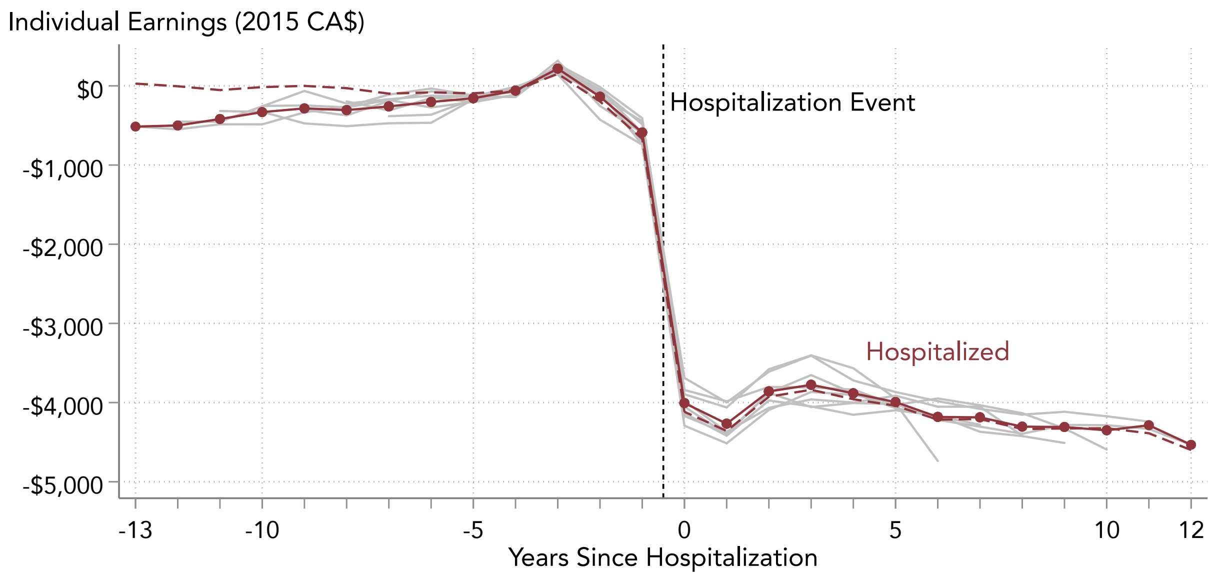
B) Decomposition of Insurance Value, by Pre-Layoff Income Decile



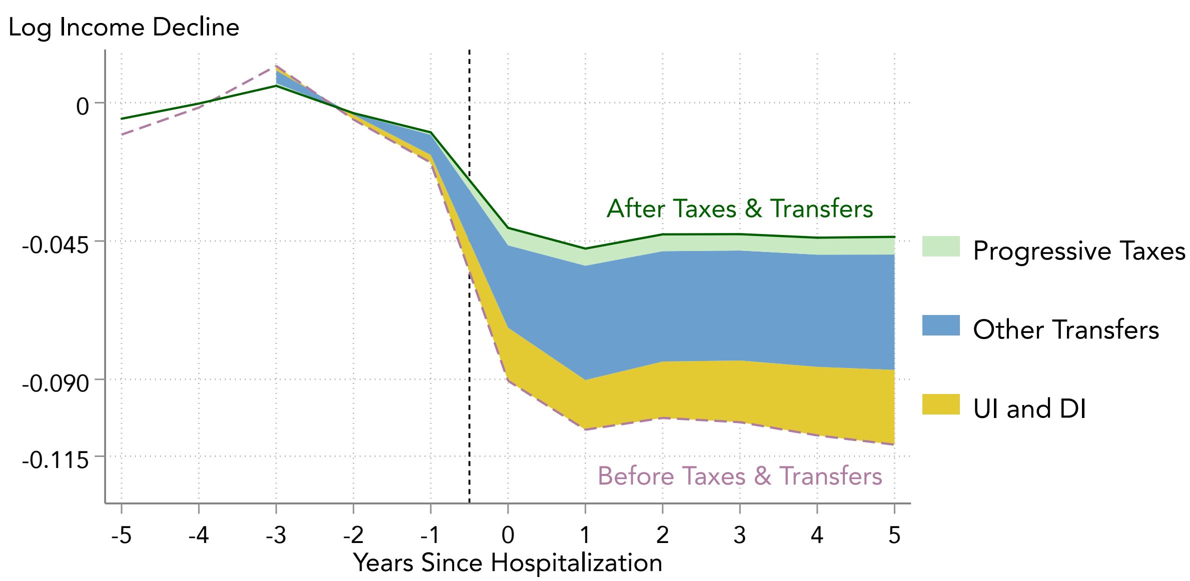
Notes: Panel A plots the mean difference in discounted log income between each laid off person and their matched pair, estimated separately by household income decile three years prior to hospitalization. The discounted log income is computed for each individual as the log of the discounted geometric mean of income over the six year period starting in the year of the layoff using an annual discount rate of 0.97. Panel B plots the insurance value of each component of taxes and transfers, derived using equations (6), (7) and (8) and the changes in log income plotted in Panel A. The values plotted by income decile in Panels A and B are reported by income quintile in the uppermost panel of Table 3.

Figure 6: Social Insurance Against Hospitalization Risk is Primarily from Redistributive Taxes and Transfers

A) Difference in Individual Earnings, Plotting Each Hospitalization Cohort



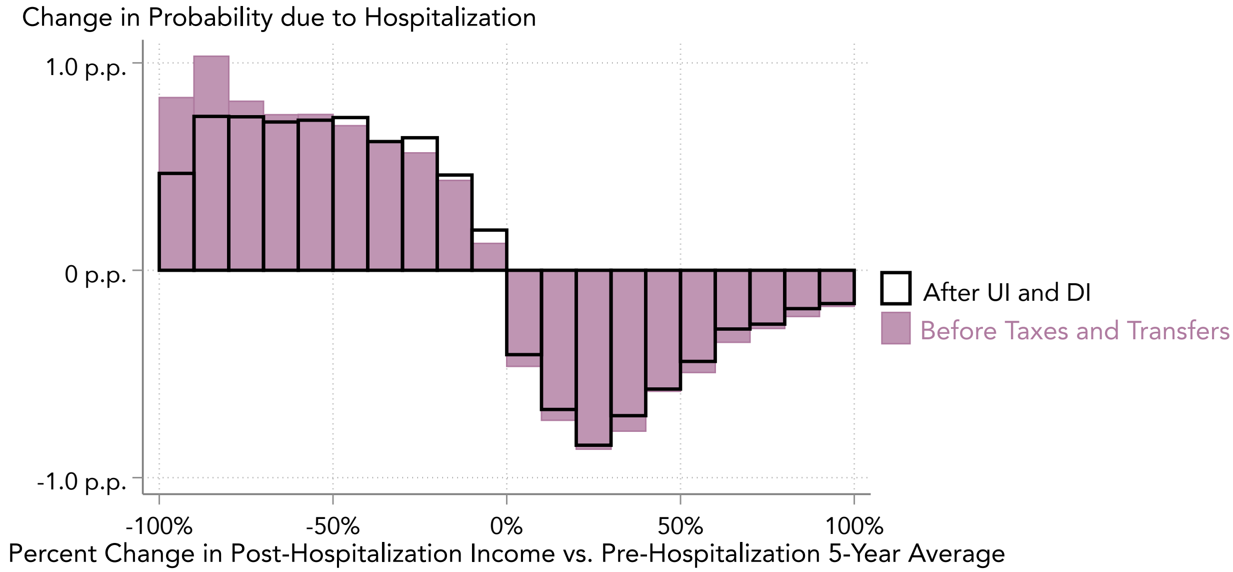
B) Decomposition of Social Insurance from Taxes and Transfers



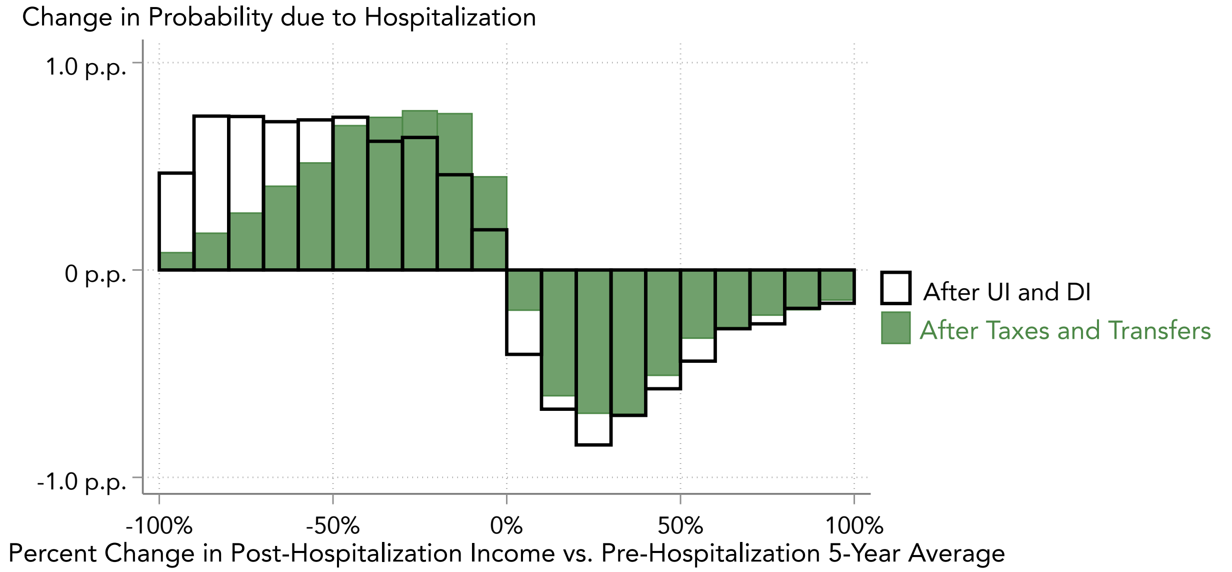
Notes: Panel A replicates Figure 1A using hospitalization events. Panel B replicates Figure 2 using hospitalization events. See the notes to Figures 1 and 2 for details. The associated numeric estimates for Panel B are reported in Table 4.

Figure 7: Social Insurance Compresses the Distribution of Post-Hospitalization Income Losses

A) Drop in Household Income Before Taxes and Transfers



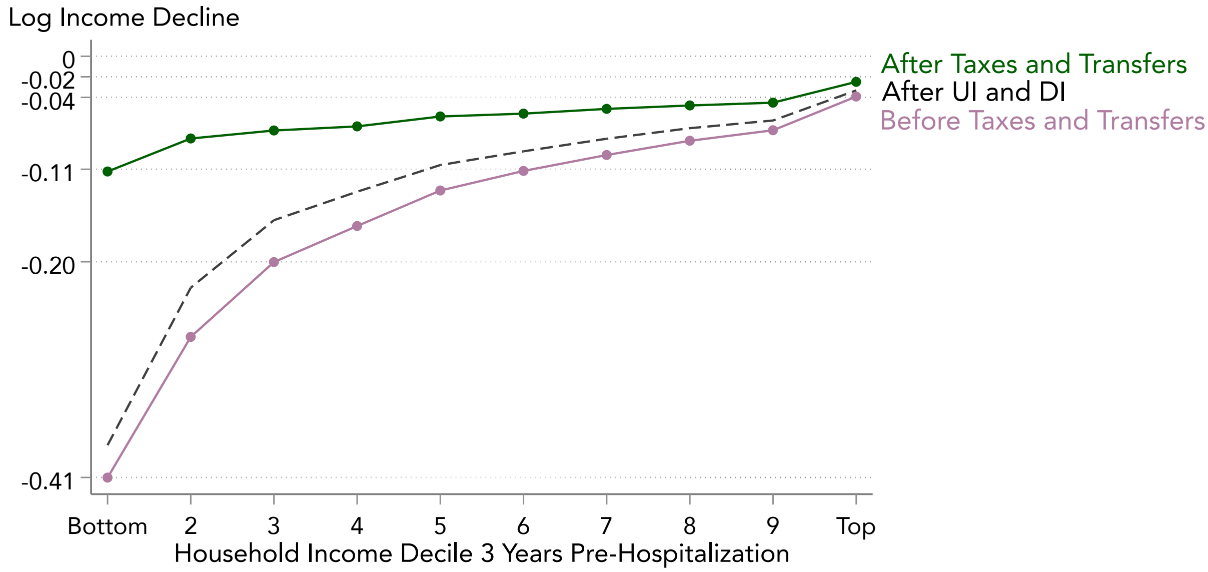
B) Drop in Household Income After Taxes and Transfers



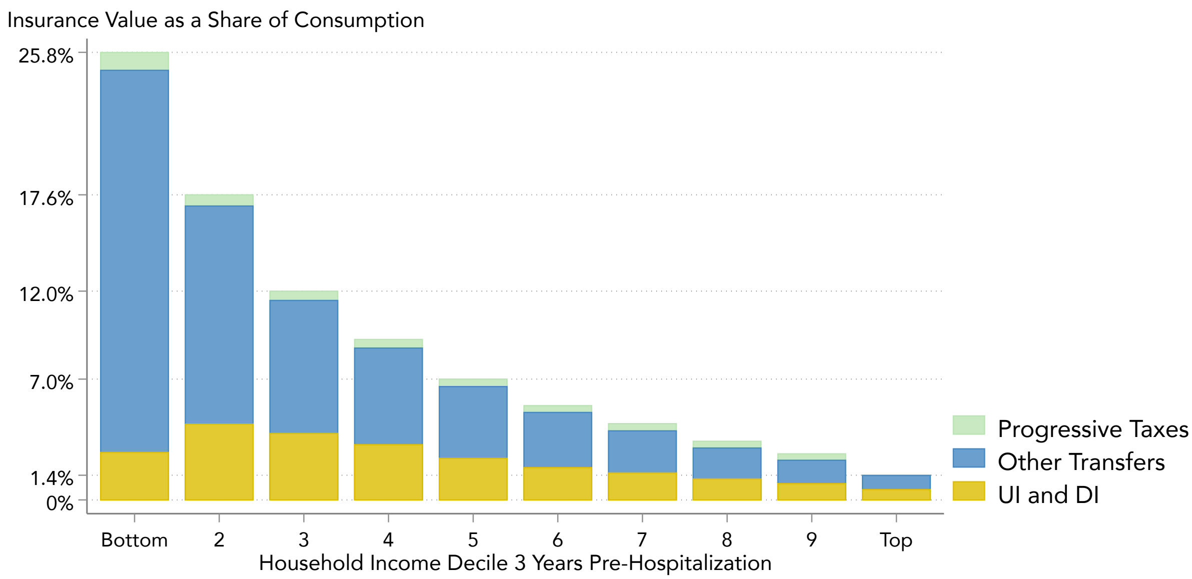
Notes: This figure replicates Figure 3 using hospitalization events. See the notes to Figure 3 for details.

Figure 8: Redistributive Taxes and Transfers Provide the Majority of Social Insurance Against Hospitalization Risk Throughout the Income Distribution

A) Incomes Losses Post-Hospitalization, by Pre-Hospitalization Income Decile



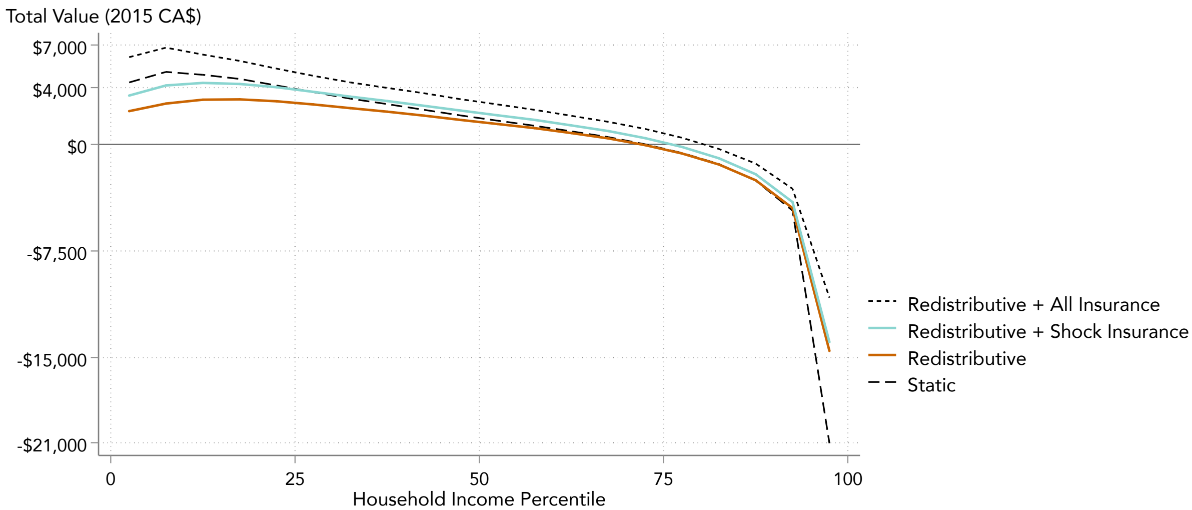
B) Decomposition of Insurance Value, by Pre-Hospitalization Income Decile



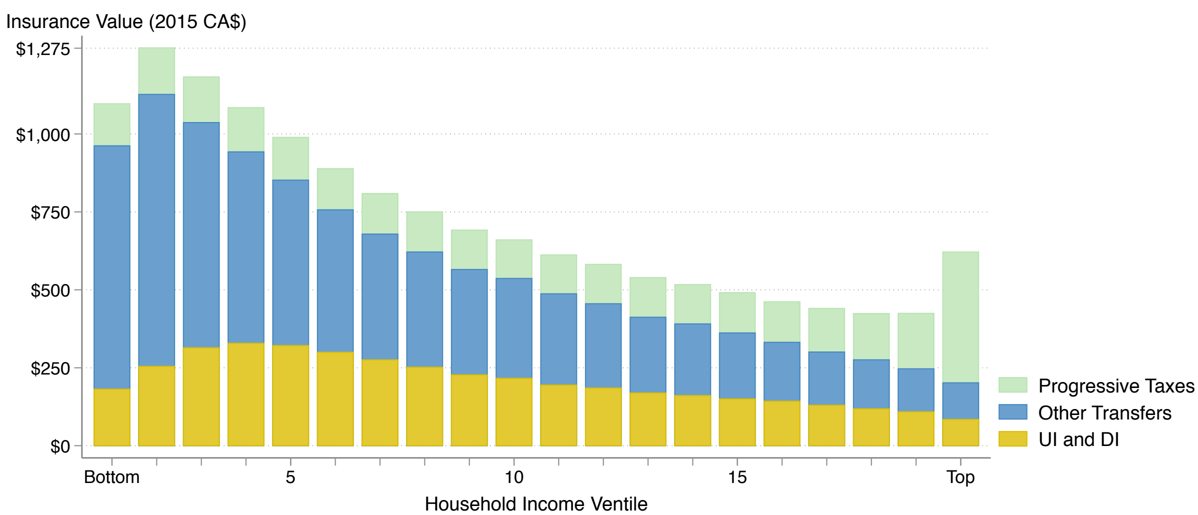
Notes: This figure replicates Figure 5 using hospitalization events. See the notes to Figure 5 for details. The values plotted by income decile in Panels A and B are reported by income quintile in the uppermost panel of Table 4.

Figure 9: Annual Value of Social Insurance Against Layoff and Hospitalization Risk from Taxes and Transfers

A) Total Annual Value of the Tax and Transfer System



B) Annual Value of Social Insurance Against Layoff and Hospitalization Risk



Notes: This figure plots the *ex ante* annual value of taxes and transfers estimated for each income ventile during 2005 to 2010. Individuals' information sets are measured in 2002 using the same set of matching variables described in Section 3.3, with the paired caliper match step replaced by an exact match to all individuals with the same ventile of individual and household income. In Panel A, the static value is estimated in 2005. The redistributive value is the expected amount of redistribution during 2005 to 2010. The "redistributive + shock insurance" value incorporates the value of insurance measured during 2005 to 2010 against the income risks experienced by individuals following a layoff or a hospitalization event between 2003 and 2010. The "redistributive + all insurance" value incorporates the value of insurance against all income fluctuations in 2005 to 2010 conditional on the information set measured in 2002. Panel B decomposes the *ex ante* insurance value of taxes and transfers against layoff and hospitalization risk into the same three components whose *ex post* value following layoff and hospitalization events is plotted in Figures 5B and 8B. The same figures are plotted in Appendix Figure 15 with values expressed as a share of consumption instead of in dollars.

Appendix Table 1: Decomposition of Social Insurance Post-Layoff Under Perfect Consumption Smoothing, Using Discounted Arithmetic Means

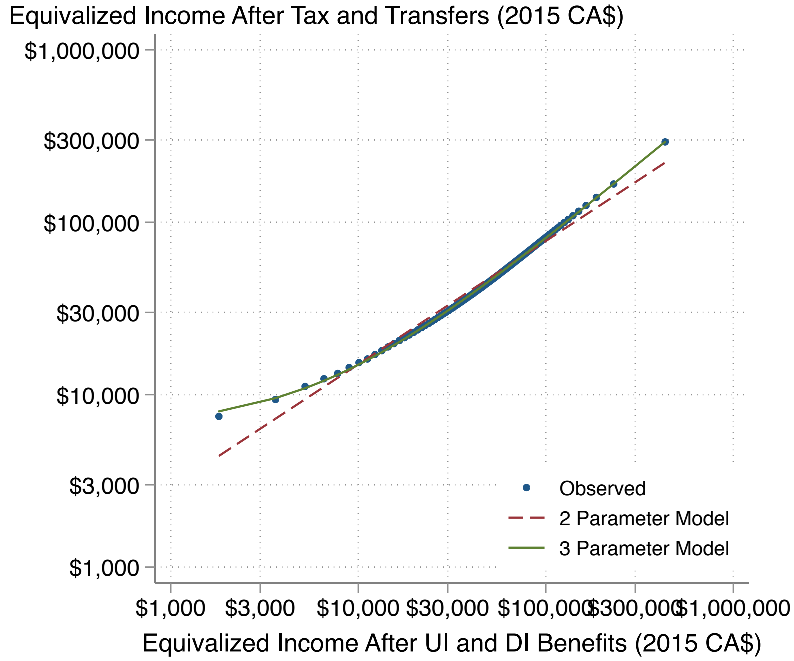
	Full Sample	Household Income Quintile 3 Years Pre-Layoff				
		Bottom	2nd	3rd	4th	Top
Average Change in Log Income (Discounted Arithmetic Mean in Years *k* to *k+5*)						
Before Taxes and Transfers	-0.202	-0.240	-0.213	-0.190	-0.176	-0.175
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
After UI and DI	-0.165	-0.184	-0.167	-0.157	-0.154	-0.160
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
After All Transfers	-0.134	-0.136	-0.128	-0.130	-0.134	-0.147
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
After Taxes and Transfers	-0.122	-0.124	-0.117	-0.118	-0.122	-0.133
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Insurance Value of All Taxes and Transfers (% of Consumption)	7.65	10.87	9.18	6.86	5.25	4.12
	(0.04)	(0.08)	(0.08)	(0.05)	(0.05)	(0.04)
Insurance Value of UI and DI	3.50	5.21	4.43	3.11	2.17	1.45
	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)
Insurance Value of Other Transfers	3.03	4.56	3.71	2.64	1.97	1.34
	(0.03)	(0.08)	(0.06)	(0.04)	(0.04)	(0.02)
Insurance Value of Taxes	1.12	1.09	1.04	1.10	1.12	1.33
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Share of Social Insurance from UI and DI	45.9%	48.6%	48.3%	45.5%	41.3%	35.5%
	(0.2)	(0.5)	(0.4)	(0.3)	(0.4)	(0.3)
Percentage Loss in Income Before Taxes and Transfers	-18.3%	-21.3%	-19.2%	-17.3%	-16.1%	-16.1%
Percentage Loss in Income After Taxes and Transfers	-11.5%	-11.7%	-11.0%	-11.2%	-11.5%	-12.5%
UI and DI: Insurance Scaling Factor	0.83	0.79	0.80	0.84	0.88	0.92
Replacement Rate	14.5%	17.4%	17.5%	14.1%	10.6%	7.0%
Income Stabilization	2.5%	4.4%	3.1%	1.9%	1.3%	0.9%
Other Transfers: Insurance Scaling Factor	0.82	0.76	0.78	0.84	0.88	0.92
Replacement Rate	8.5%	6.4%	11.8%	9.7%	7.9%	5.0%
Income Stabilization	10.2%	19.3%	11.4%	7.4%	4.7%	3.1%
Taxes: Insurance Scaling Factor	0.92	0.92	0.92	0.92	0.92	0.91
Marginal Tax Rate	20.5%	16.5%	18.8%	20.9%	22.6%	25.6%
Average Tax Rate	13.4%	9.2%	11.6%	13.8%	15.9%	18.6%
Number of Layoff Events	1,560,277	364,629	359,950	314,180	283,255	237,909

Appendix Table 2: Decomposition of Social Insurance Post-Hospitalization Under Perfect Consumption Smoothing, Using Discounted Arithmetic Means

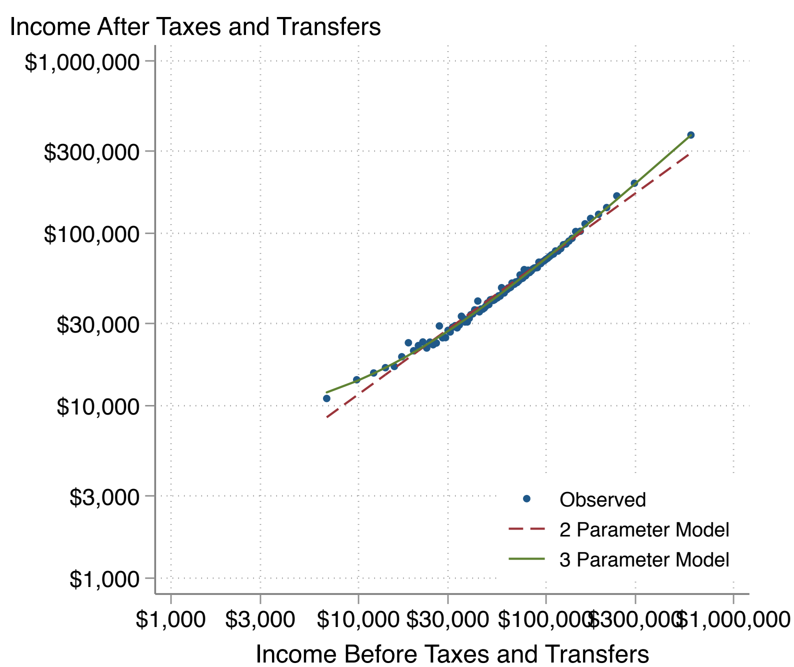
	Full Sample	Household Income Quintile 3 Years Pre-Hospitalization				
		Bottom	2nd	3rd	4th	Top
Average Change in Log Income (Discounted Arithmetic Mean in Years *k* to *k+5*)						
Before Taxes and Transfers	-0.124	-0.296	-0.148	-0.096	-0.071	-0.043
	(0.001)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)
After UI and DI	-0.106	-0.261	-0.120	-0.080	-0.062	-0.038
	(0.001)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)
After All Transfers	-0.057	-0.098	-0.066	-0.053	-0.046	-0.031
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
After Taxes and Transfers	-0.052	-0.088	-0.060	-0.049	-0.043	-0.029
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Insurance Value of All Taxes and Transfers (% of Consumption)	6.88	18.73	8.34	4.57	2.81	1.44
	(0.04)	(0.16)	(0.13)	(0.07)	(0.06)	(0.04)
Insurance Value of UI and DI	1.70	3.11	2.66	1.52	0.94	0.50
	(0.02)	(0.06)	(0.05)	(0.03)	(0.01)	(0.01)
Insurance Value of Other Transfers	4.75	14.80	5.19	2.68	1.52	0.75
	(0.04)	(0.14)	(0.09)	(0.06)	(0.04)	(0.02)
Insurance Value of Taxes	0.43	0.82	0.50	0.37	0.35	0.19
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Share of Social Insurance from UI and DI	24.7%	16.6%	31.9%	33.3%	33.5%	35.1%
	(0.2)	(0.3)	(0.4)	(0.6)	(0.6)	(1.0)
Percentage Loss in Income Before Taxes and Transfers	-11.6%	-25.6%	-13.7%	-9.2%	-6.9%	-4.2%
Percentage Loss in Income After Taxes and Transfers	-5.1%	-8.5%	-5.9%	-4.8%	-4.2%	-2.8%
UI and DI: Insurance Scaling Factor	0.86	0.90	0.82	0.84	0.87	0.88
Replacement Rate	11.5%	5.2%	14.9%	14.0%	11.9%	10.9%
Income Stabilization	2.3%	5.2%	3.3%	1.8%	1.2%	0.7%
Other Transfers: Insurance Scaling Factor	0.55	0.40	0.56	0.67	0.76	0.81
Replacement Rate	38.6%	44.1%	35.5%	28.0%	20.9%	17.5%
Income Stabilization	10.6%	27.7%	12.8%	7.3%	4.4%	2.4%
Taxes: Insurance Scaling Factor	0.92	0.91	0.92	0.93	0.93	0.94
Marginal Tax Rate	20.9%	16.3%	18.3%	19.9%	22.4%	24.8%
Average Tax Rate	14.3%	8.1%	11.5%	14.0%	16.2%	19.9%
Number of Hospitalization Events	1,161,414	198,527	229,162	233,769	245,667	253,793

Appendix Figure 1: Parametrization of Effective Tax and Transfer Rates

A) Canada: Tax Data

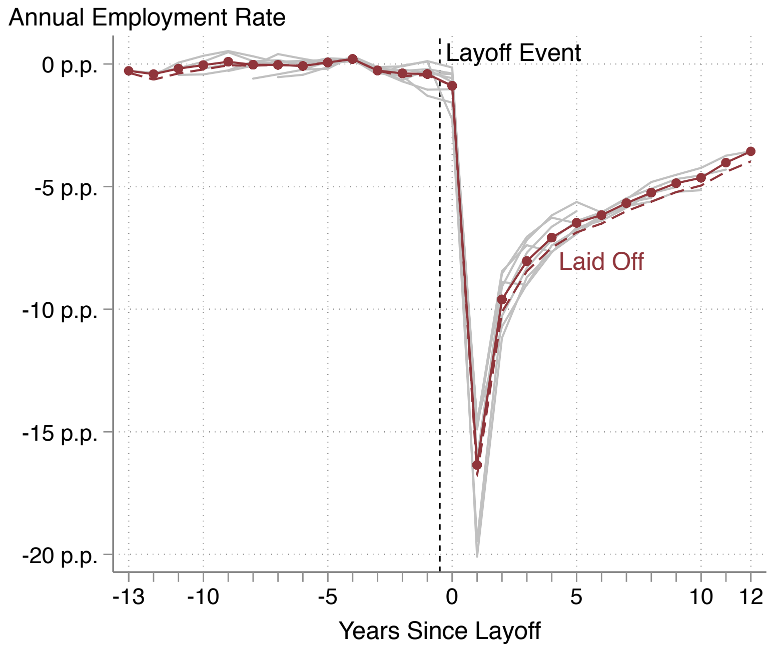


B) United States: PSID Data

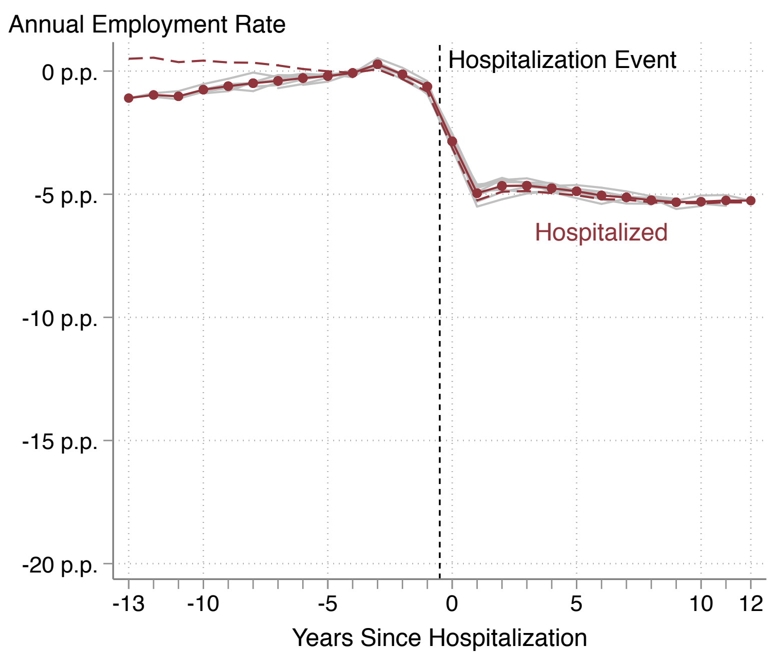


Appendix Figure 2: Changes in Annual Employment Rates around Layoffs and Hospitalizations

A) Layoffs

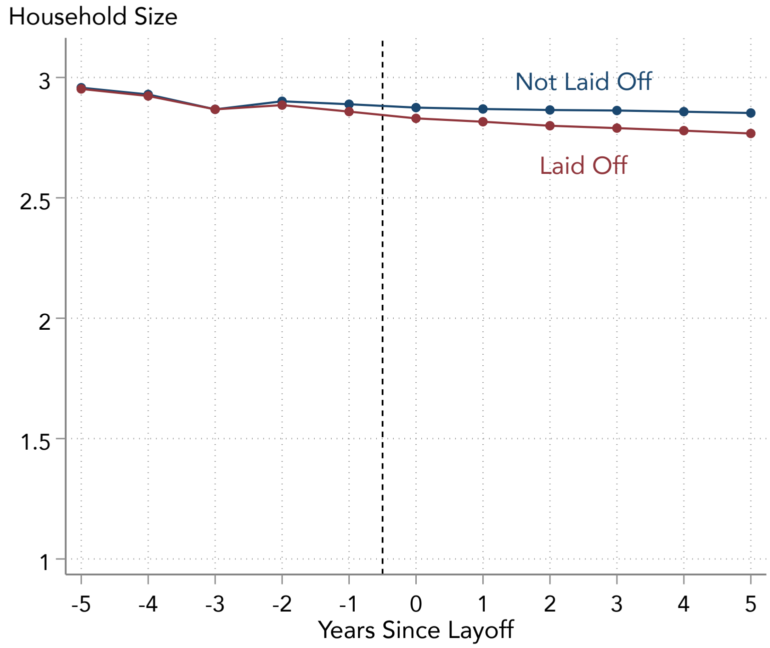


B) Hospitalization

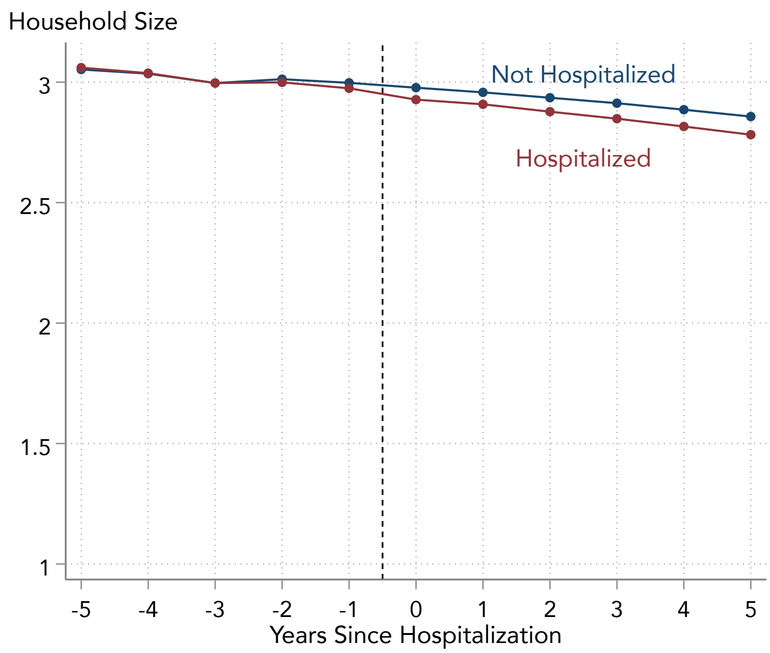


Appendix Figure 3: Changes in Household Size around Layoffs and Hospitalizations

A) Layoffs

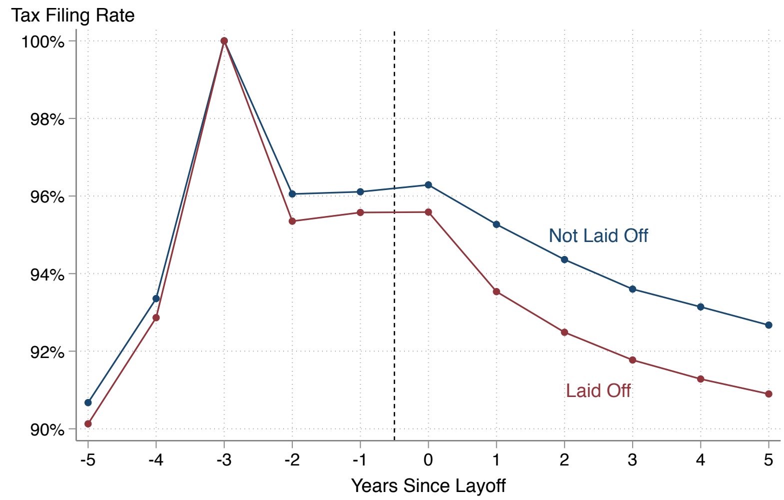


B) Hospitalizations

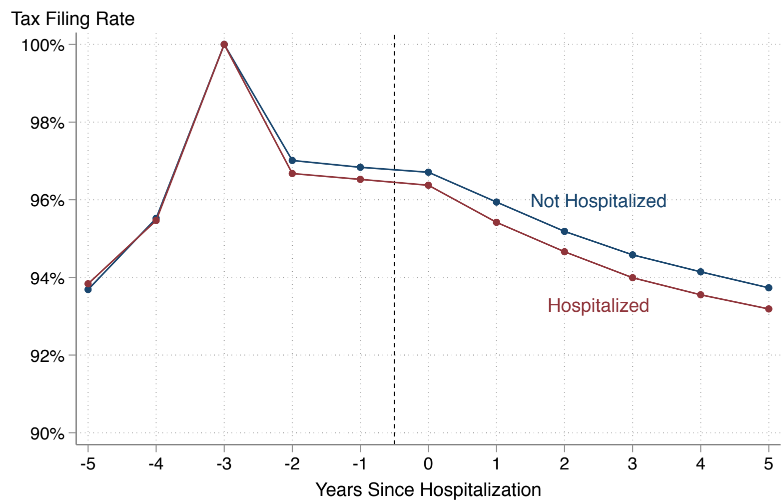


Appendix Figure 4: Tax Filing Rates around Layoffs and Hospitalizations

A) Layoffs

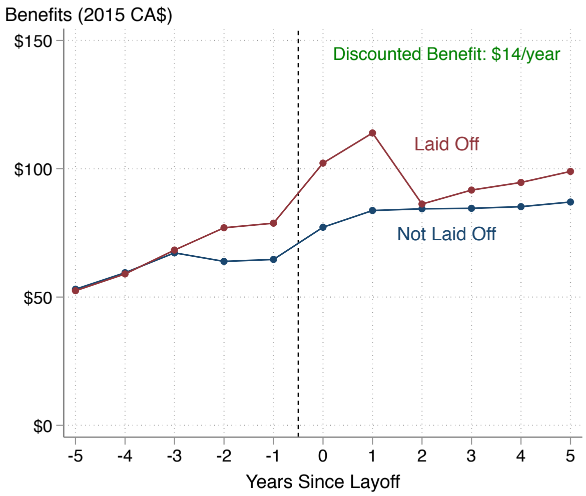


B) Hospitalizations

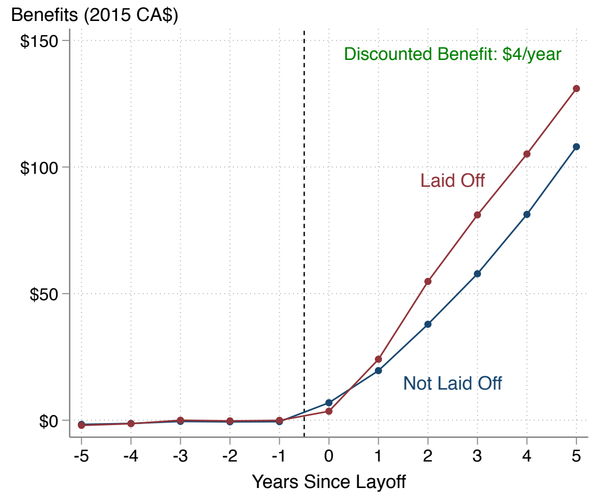


Appendix Figure 5: Formal Social Insurance Post-Layoff is 98% UI and 2% DI

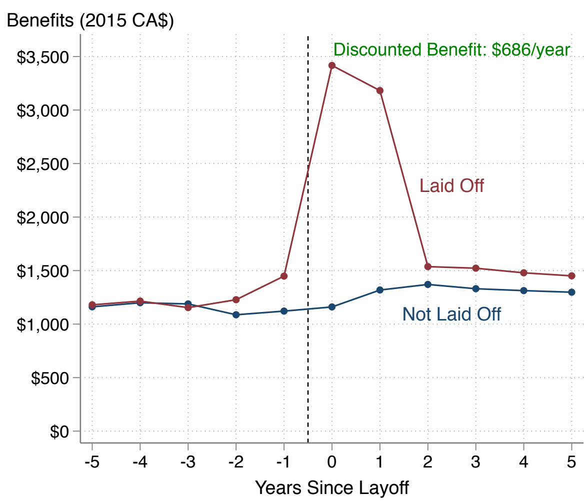
A) Short Term Disability Insurance



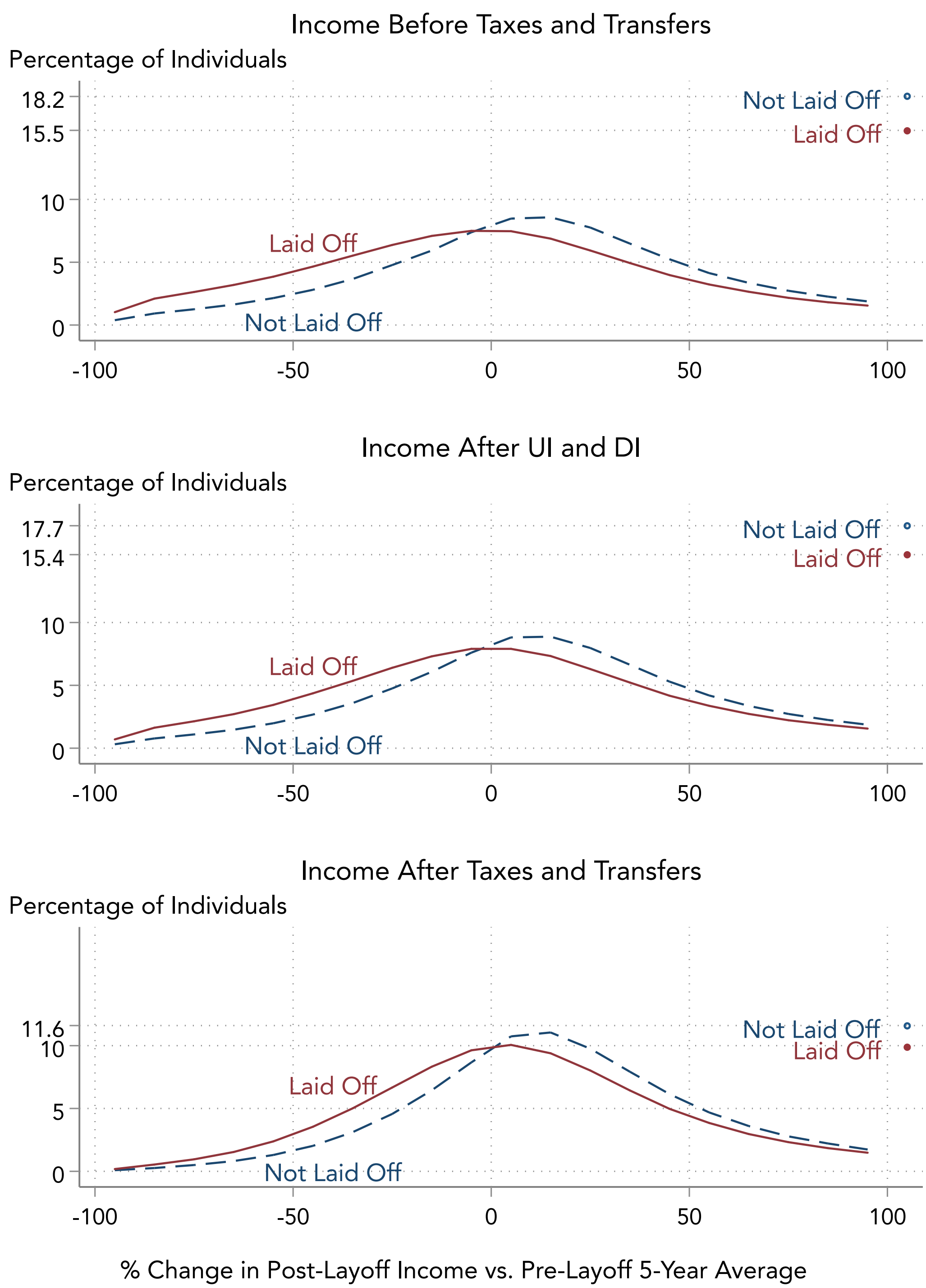
B) Long Term Disability Insurance



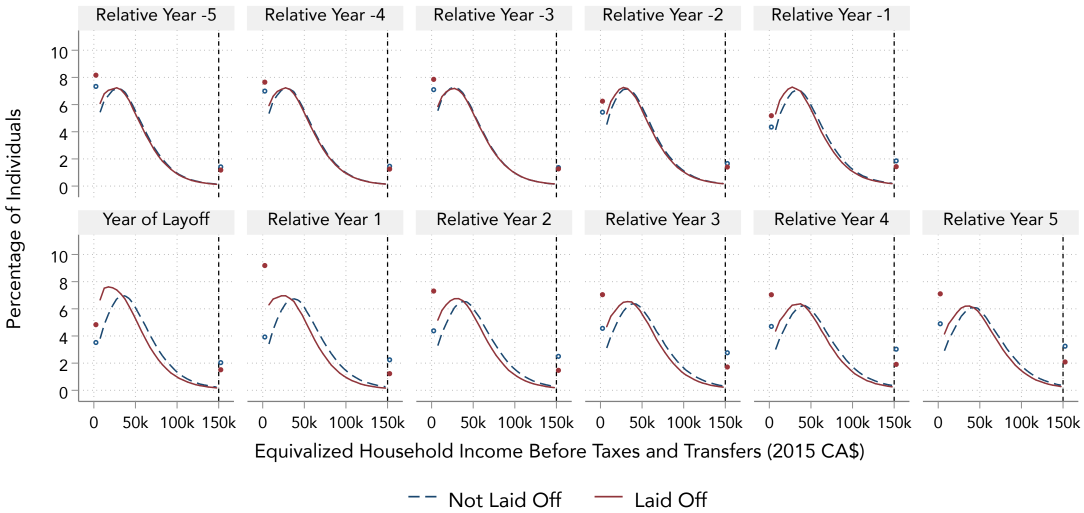
C) Unemployment Insurance



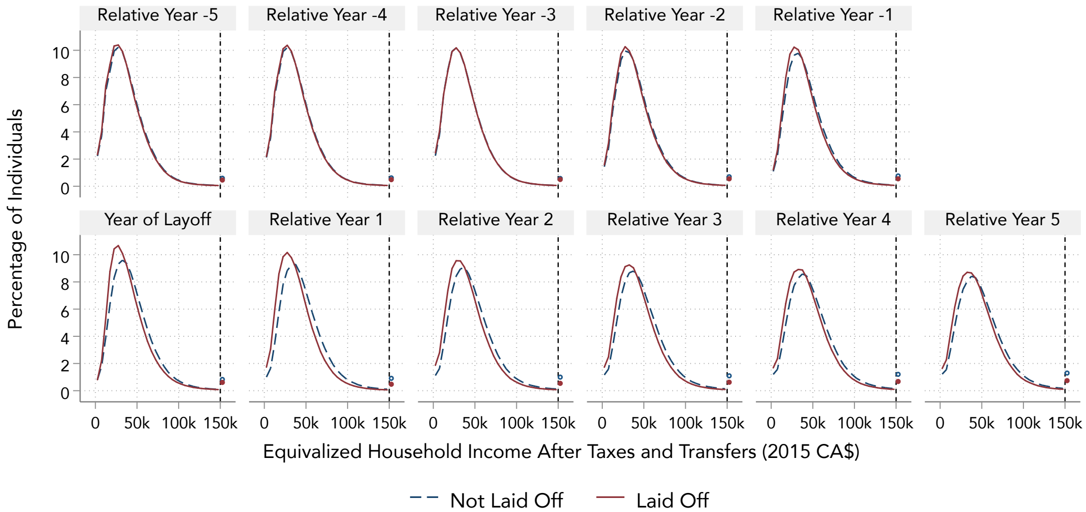
Appendix Figure 6: Distributions of Earnings Changes Post-Layoff Relative to Pre-Layoff Mean



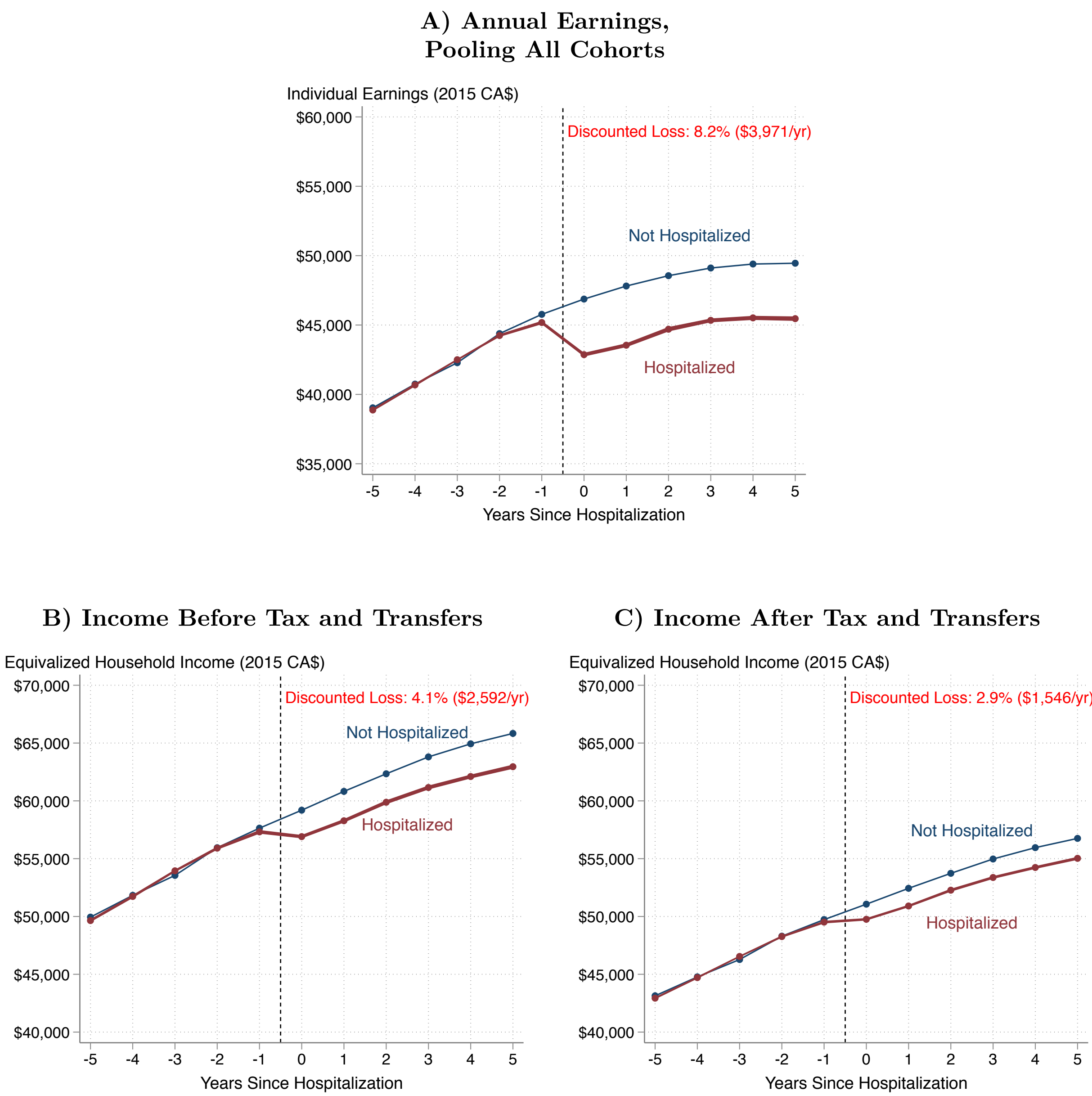
Appendix Figure 7: Distributions of Income Before Taxes and Transfers Each Year Pre- and Post-Layoff



Appendix Figure 8: Distributions of Income After Taxes and Transfers Each Year Pre- and Post-Layoff

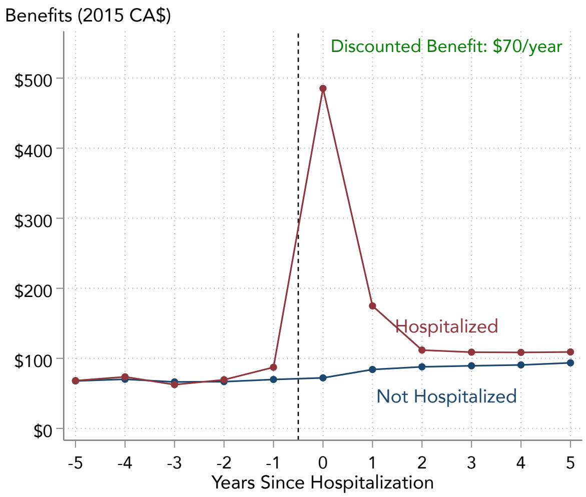


Appendix Figure 9: Changes in Earnings and Income around Hospitalizations

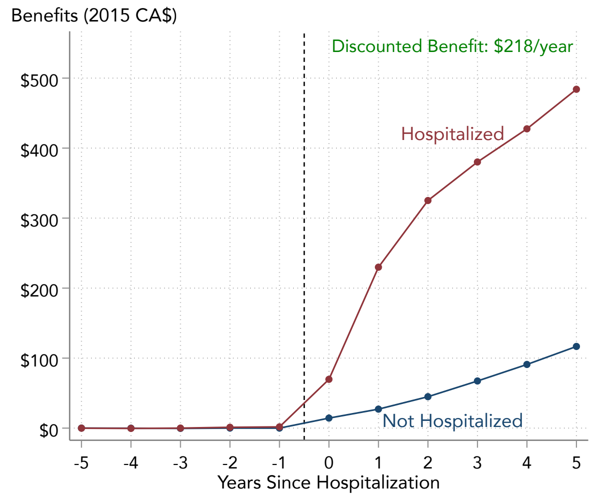


Appendix Figure 10: Formal Social Insurance Post-Hospitalization is 98% DI and 2% UI

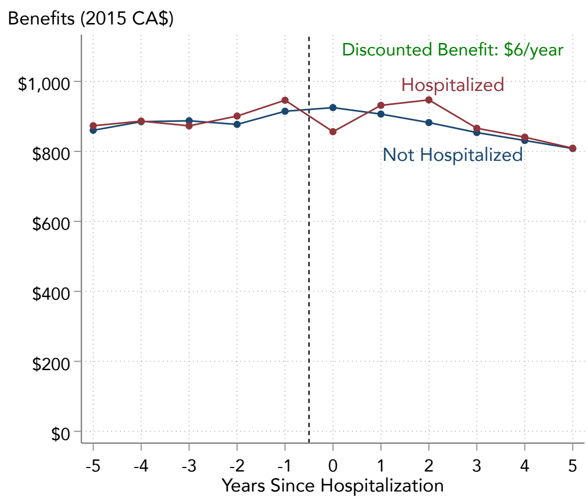
A) Short Term Disability Insurance



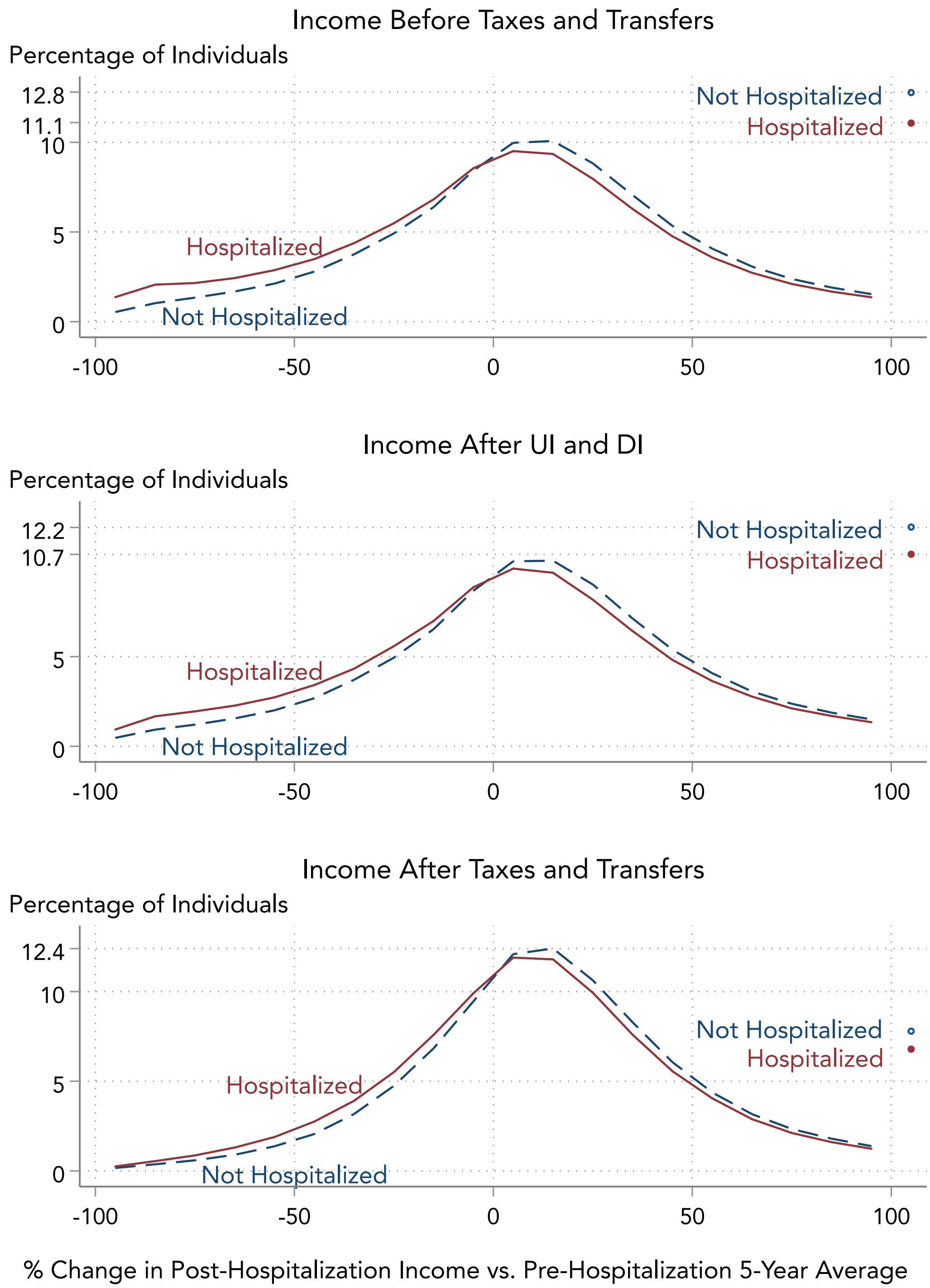
B) Long Term Disability Insurance



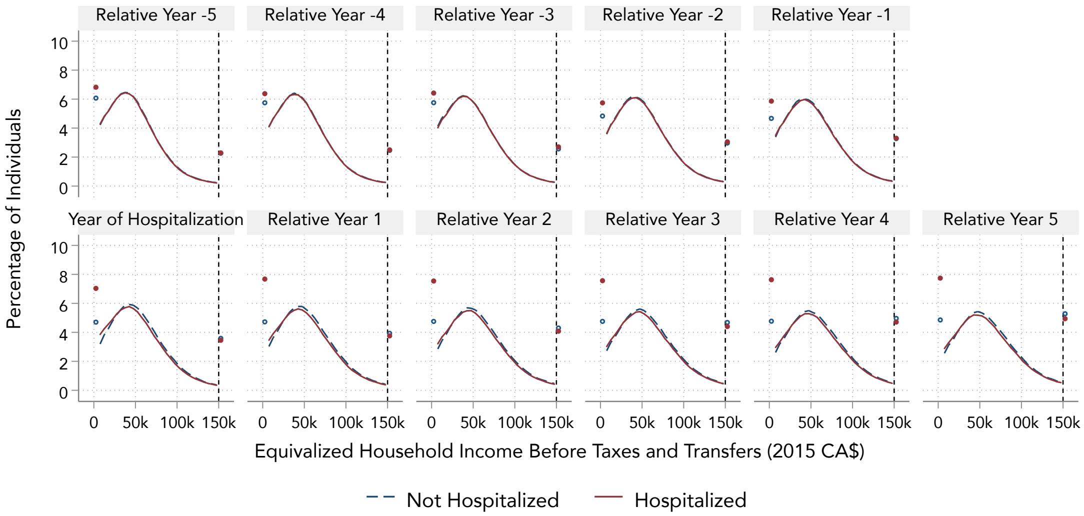
C) Unemployment Insurance



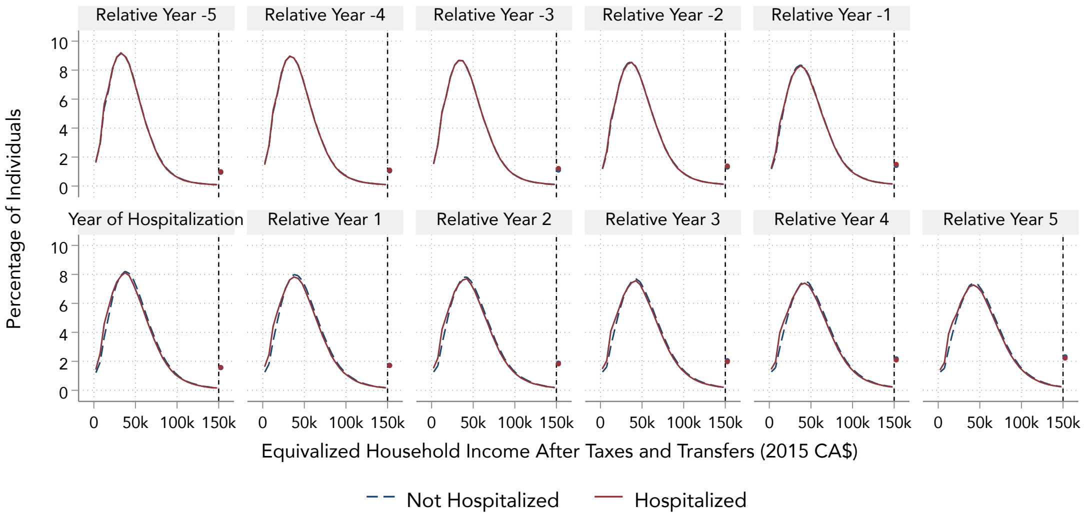
Appendix Figure 11: Distributions of Earnings Changes Post-Hospitalization Relative to Pre-Hospitalization Mean



Appendix Figure 12: Distributions of Income Before Taxes and Transfers Each Year Pre- and Post-Hospitalization

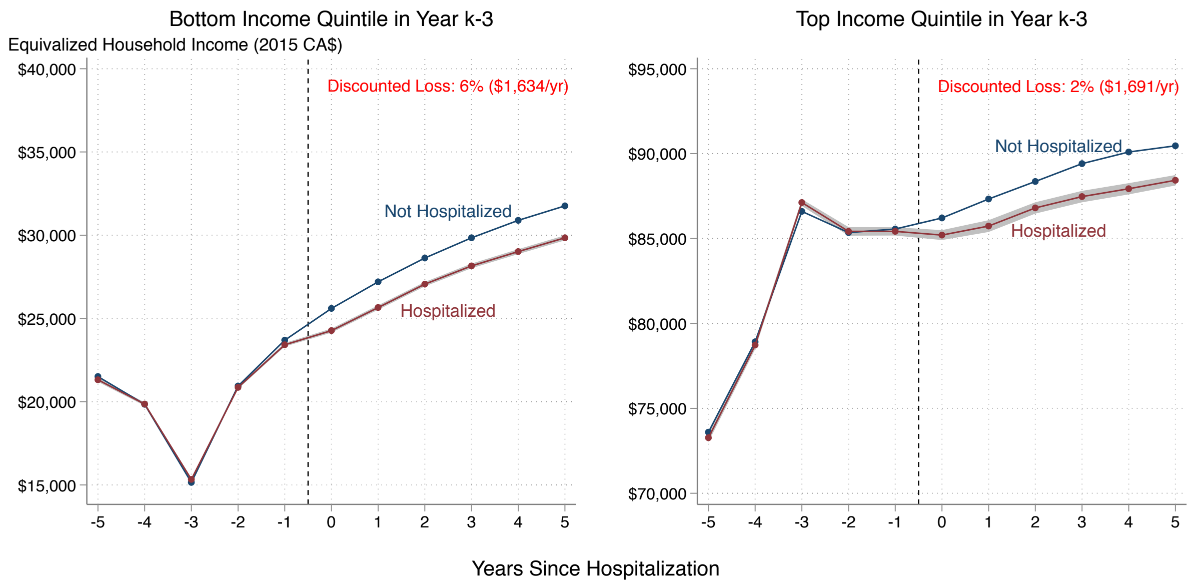


Appendix Figure 13: Distributions of Income After Taxes and Transfers Each Year Pre- and Post-Hospitalization

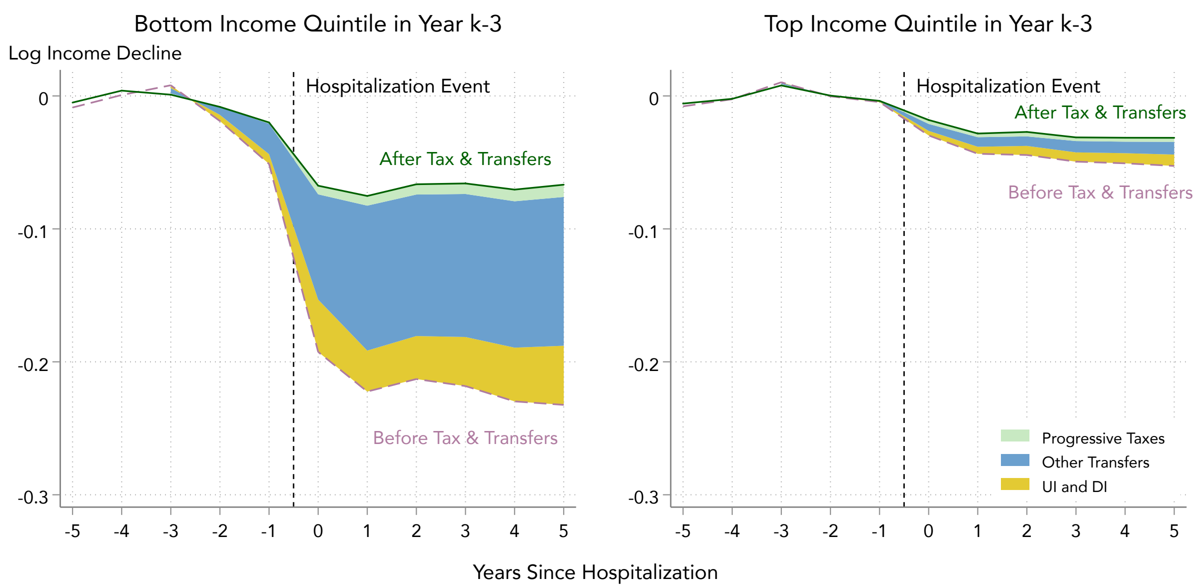


Appendix Figure 14: Low-Income Workers Experience Larger Post-Hospitalization Income Losses Before and After Taxes and Transfers

A) Income After Taxes and Transfers

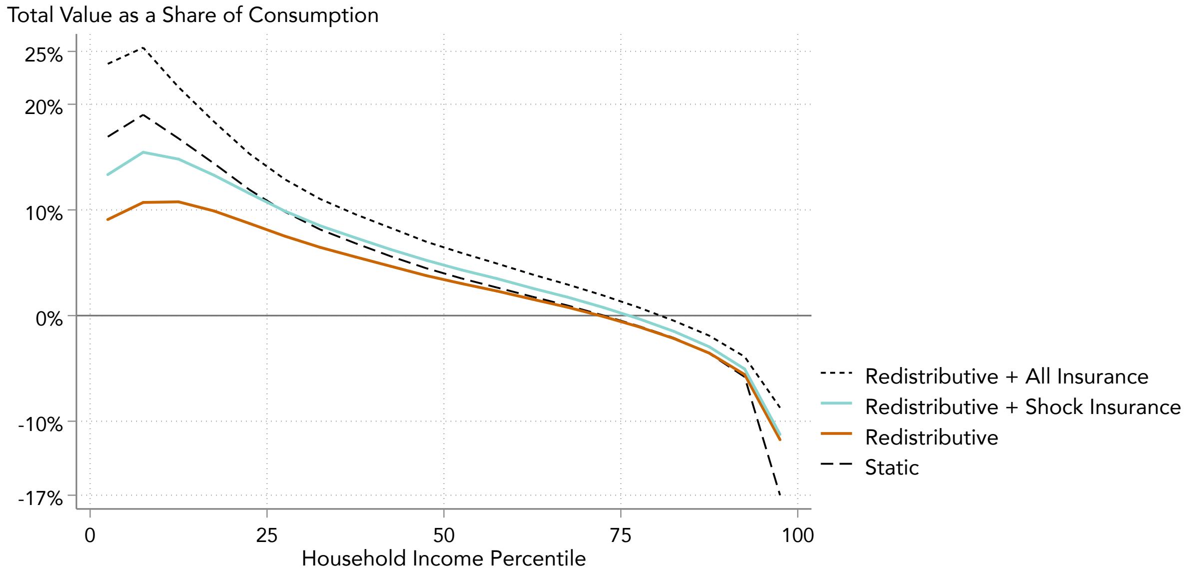


B) Decomposition of Insurance from Taxes and Transfers

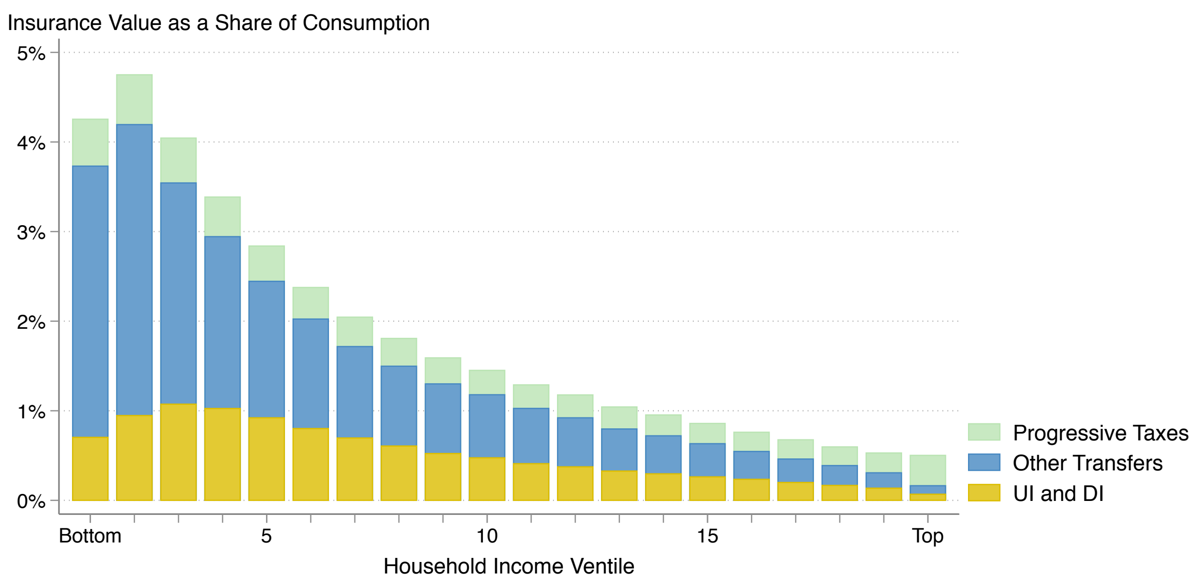


Appendix Figure 15: Annual Value of Social Insurance Against Layoff and Hospitalization Risk from Taxes and Transfers, as a Share of Consumption

A) Total Value of the Tax and Transfer System



B) Annual Value of Social Insurance Against Layoff and Hospitalization Risk



Appendix

A Additional Derivations for the Economic Model

A.1 Revenue Neutral Linear Tax Replacing Full Tax and Transfer System

A.2 Revenue Neutral Linear Tax Replacing Redistributive Taxes and Transfers

A.3 Revenue Neutral Linear Tax Replacing Formal Social Insurance

A.4 Insurance Relative to Lump Sum Taxation