Public and Private Insurance

Theory and cross-country facts

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Preliminary draft, December 8, 2009

Abstract

Insurance provision differs across developed countries both in terms of total amounts expended, and of whether it is supplied via public schemes or private contractual arrangements. To understand this cross-country variation, we propose a model in which public insurance schemes are constrained by unobservable effort choices and private insurance transactions. We show that public transfers imperfectly crowd out private insurance transactions, and thus are able to change consumption allocations, if insurance transactions are costly. We characterize how public and private insurance depend on transaction costs and explore how much of their observed cross-country variation is explained by available cost indicators.

Keywords: public transfers, private insurance, moral hazard, transaction costs.

JEL: E21, D82, H21, G22.

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1 Introduction

Public and private insurance provision differs widely across countries (see Section 2). This paper links insights from the classic analyses of insurance provision to the recent literature on dynamic public finance to investigate the feasibility and nature of public insurance schemes in the presence of hidden private insurance transactions. We find that transaction costs are important both for the existence of public insurance schemes and the observed differences of public and private insurance provision across countries.

A recent literature explores the relationship between hidden actions and efficient consumption allocations. In that literature, the social efficiency of consumption allocation under uncertainty is constrained by individual agents' private interactions. The hidden-information problems studied by Mirrlees (1971), Cole and Kocherlakota (2001), and many other contributions to "New Dynamic Public Finance" let income be observable and determined by effort choices based on privately observed ability realizations. In that setting, insurance contracts may be signed and public policies designed before ability levels are realized, but only non-contingent self-insurance is possible when assets are traded by agents who have private information about their own ability when their private effort choice determines income.

In the real world, however, governments do implement insurance-oriented policies, at the same time as private financial and insurance contracts also provide contingent payoffs, under a variety of technological and institutional constraints which need not uniformly bind across different economies. Depending on information collection and processing technology, as well as such institutional features as the stringency of privacy protection, it may be costly or impossible for private firms or government agencies to monitor insurance purchases in the way modeled by Ales and Maziero (2009) for the US.

This paper is motivated by the variability across countries of private and public insurance expenditures, documented in Section 2. Aiming to interpret these data, we propose in Section 3 a theoretical model linking insights from recent research to classic analyses of insurance provision, based on the hidden-action moral hazard workhorse of both classic insurance theory, such as Pauly (1974) and Shavell (1979), and of recent contributions to dynamic public finance such as

Ábrahám and Pavoni (2005). Hidden actions do not imply that self-insurance is optimal, because privately chosen effort only determines the probability distribution, rather than the realization, of observable income. This makes it possible for nontrivial securities to offer payoffs contingent on idiosyncratic realizations, and makes the resulting modeling environment suitable for our purpose of characterizing real-life public and private provision of insurance.

We show that the economy's equilibrium is generally inefficient, because the market price of income-contingent securities does not account for the impact of insurance on effort incentives. When insurance is costless, competitive trade of such securities fully offsets not only random shocks but also any contingent transfers, and public policy is completely unable to address incentive issues. If production of private insurance contracts depends nonlinearly on the amount of such transactions, however, then public transfers cannot be fully undone costlessly by private markets.[1] A tractable specification of preferences and insurance production costs delivers intuitive implications for the amount and composition of insurance. More generally, when private insurance transactions are costly then public contingent transfers do affect equilibrium allocations, and can potentially improve the trade off between consumption smoothing and effort incentives, to an extent that depends on the size and shape of private transaction costs.

The importance of transaction costs for hidden insurance trades has been emphasized previously by Bisin and Gottardi (1999) who show that non-linear prices for private insurance transactions (introduced by transaction costs) are important to ensure equilibrium existence. Furthermore, Gottardi and Pavoni (2009) show, in research complementary to ours, that a linear tax on hidden insurance trades is optimal. One major difference compared with our paper is that Gottardi and Pavoni (2009) have to deal with corner solutions for hidden assets due to non-convexities introduced by bid-ask price spreads for the hidden assets. Our model set-up instead guarantees an interior solution which simplifies the analysis.

Section 4 returns to the data, discussing empirical indicators of the transaction and administration costs that, in the theoretical model, play a crucial role in determining the extent and

[1] Different sets of assumption may have similar observable implications, of course. For example, the theoretical setting of Krueger and Perri (1999) also implies that the intensity of public redistribution is negatively related to the scope of private insurance contracts. In their analysis, however, limited enforcement rather than hidden actions is the reason why private financial markets are incomplete and, under the assumption that the penalty for default is permanent financial autarchy, redistribution policies are viewed as the exogenous determinant of limited insurance.

character of private and public insurance. Section 5 concludes.

2 Cross-country facts

We measure differences in public and private insurance provision across countries using data on private insurance claims from the OECD Insurance Statistics Yearbook and data on public social expenditures from the OECD Social Expenditure Database. To focus on interactions between public and private insurance against labor market and health shocks, we use the amount of non-life private insurance claims for private insurance and exclude pensions in the public-insurance data. Comparable data are available for the 1996-2005 decade. Since the time-series variation in the private-insurance data is rather noisy, we summarize its cross-country variation with the median over that period. Further details about the data set are in the data appendix.

Figure 1 shows that no obvious pattern emerges when we plot public against private insurance. Vast differences are observed in both the total amount and composition of insurance amounts. Public social insurance transfers are about 20% of GDP in Scandinavian countries, and less than 15% of GDP in the US or Canada. Across these groups of countries private insurance expenditures appear to substitute public schemes: in the US and Canada, non-life private insurance at about 3% of GDP is much more important than in Scandinavian countries. But other countries (such as Italy, Greece, Turkey, Japan and South Korea) have a small volume in both public and private insurance. Across the OECD sample, the correlation coefficient between public and private insurance shares of GDP is positive at 0.32, and insignificant at the 10% level. We show in the next section how a stylized model of public and private insurance can help interpret these data.

3 Insurance and efficiency

Insurance is feasible, but partial, when it is possible to verify the realization of relevant events but information on their probability is incomplete and asymmetric. We now study the determinants of such partial insurance, adapting a standard hidden-action moral hazard problem (Ábrahám and Pavoni, 2005) which focuses on insurance of ex-ante identical individuals.

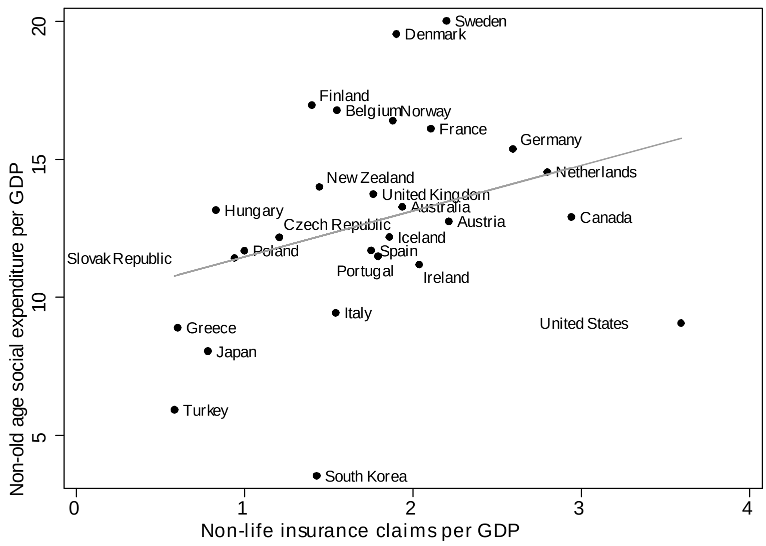

Figure 1: Public and private insurance across OECD countries. Notes: 1996-2003 and 1996-2005 averages in % of GDP, respectively. Public insurance is measured as social expenditure per GDP other than pension and survivorship payments (source: OECD, Social Expenditure Database); private insurance is measured as claims per GDP, excluding life insurance (source: OECD, Insurance Statistics Yearbook). Solid graph: predicted values of linear regression.

In the first period, agents derive utility $u(c_1)$ from consumption and an additively separable disutility $-v(e_1)$ from effort. Effort, which is privately observed, influences the probability $f(z|e_1)$ that in the second and last period of the model their income y_2 equals z, for each z in the support Y_2 of income realizations. We suppose that $f(z|e_1) > 0$ for all $z \in Y_2$ and all e_1, and that $f_e(z|e_1) \equiv \partial f(z|e_1)/\partial e_1$ is increasing in z. The first "full support" assumption ensures that effort can never be inferred from the realization of income, and remains private information in equilibrium. The latter assumption, since

$$\sum_{\{z \in Y_2\}} f(z|e_1) = 1 \Rightarrow \sum_{\{z \in Y_2\}} f_e(z|e_1) = 0, \tag{1}$$

suffices to imply $\sum_{\{z \in Y_2\}} z f_e(z|e_1) > 0$ so that higher effort increases the mean of the income distribution. Since $f_e(z|e_1)$ is increasing in z and sums to zero over the support of the distribution, it is negative (positive) in the lower (higher) portion of the income distribution's support. In principal-agent models with hidden effort, the stronger assumption that the likelihood ratio $f_e(z|e_1)/f(z|e_1)$

montonically increases in z delivers the sensible and realistic implication that constrained-efficient consumption levels also are an increasing function of income realizations.

In the second and last period of the model economy, individual consumption is in general a function $c(z)$ of income realizations. If the resulting utility $u(c(z))$ is discounted by a factor β, individual maximization with respect to effort e_1 of

$$\mathcal{U} = u(c_1) - v(e_1) + \beta \sum_{\{z \in Y_2\}} u(c(z)) f(z|e_1) \tag{2}$$

implies the first order condition

$$\beta \sum_{\{z \in Y_2\}} u(c(z)) f_e(z|e_1) = v'(e_1). \tag{3}$$

3.1 Hidden effort and savings

The constrained efficient consumption allocations in a principal-agent problem with hidden effort can be characterized using the first-order approach, if the likelihood ratio $f_e(z|e_1)/f(z|e_1)$ is monotonically increasing in z and the cumulative distribution function of z is convex in effort (Rogerson, 1985b). These sufficient conditions are satisfied in many economic applications and allow to characterize the constrained-efficient allocation by c_1, e_1, and $\{c(z)\}$ which maximize the typical individual's welfare (2), subject to the incentive compatibility condition (3) and resource constraints. If resources can be reallocated costlessly across individuals and transferred over time according to a given social rate of transformation $R = 1 + r$, and there are so many individuals as to let $f(z|e_1)$ represent the population fraction as well as the probability of income realizations, the relevant Lagrangian is

$$
\begin{aligned}
\mathcal{L}_p &= u(c_1) - v(e_1) + \beta \sum_{\{z \in Y_2\}} u(c(z)) f(z|e_1) \\
&\quad + \lambda \left(y_1 - c_1 + \frac{1}{1+r} \sum_{\{z \in Y_2\}} (z - c(z)) f(z|e_1) \right) \\
&\quad + \mu \left(\beta \sum_{\{z \in Y_2\}} u(c(z)) f_e(z|e_1) - v'(e_1) \right),
\end{aligned} \tag{4}
$$

where λ is the shadow price of aggregate resources as of period 1, and μ the shadow price of the unobserved effort constraint.

The first-order conditions for $c(z)$ and c_1 together imply

$$
\left[f(y_2|e_1) + \mu f_e(y_2|e_1) \right] \frac{1}{u'(c_1)} = \frac{1}{\beta(1+r)} \frac{f(y_2|e_1)}{u'(c(y_2))}, \text{ for all } y_2. \tag{5}
$$

The constrained efficiency condition (5) would imply constant consumption and full insurance if it were the case that $\mu = 0$, which is implied by $f_e(z|e_1) \equiv 0$. When instead effort affects the probability distribution of income realizations, the shadow price of the incentive constraint is positive, and (the marginal utility of) consumption in the second period generally depends on the y_2 income realization.[2]

Summing (5) over the support of second period income realizations, and recalling (1), yields a reciprocal Euler equation (Rogerson, 1985a):

$$
\frac{1}{u'(c_1)} = \frac{1}{\beta(1+r)} \sum_{\{z \in Y_2\}} \frac{1}{u'(c(z))} f(z|e_1). \tag{6}
$$

[2] More specifically, rewriting (5) as

$$
\frac{1}{u'(c(y_2))} = \left[1 + \mu \frac{f_e(y_2|e_1)}{f(y_2|e_1)} \right] \frac{\beta(1+r)}{u'(c_1)},
$$

we see that (the marginal utility of) consumption is related to the likelihood ratio, capturing the effect of effort on the income distribution. If $f_e(y_2|e_1)/f(y_2|e_1)$ increases in y_2, so does consumption.

Since $1/x$ is a convex function, Jensen's inequality and (6) imply

$$u'(c_1) < \beta(1+r) \sum_{\{z \in Y_2\}} u'(c(z)) f(z|e_1).$$

If it is possible to access a financial market where assets yield the social rate of intertemporal transformation $1+r$, however, it is individually optimal to satisfy the standard Euler equation

$$u'(c_1) = \beta(1+r) \sum_{\{z \in Y_2\}} u'(c(z)) f(z|e_1), \tag{7}$$

which is inconsistent with (6) when consumption is random. Since individuals benefit from shifting some of the first-period consumption to the future and exerting less effort, efficiency is thus further constrained when savings are *not* observable.

The social optimum need not in general be characterized by maximization subject to the individual first-order condition (3) and (7), because the relevant concavity conditions may be violated when both effort and savings are hiddenly chosen. Ábrahám, Koehne and Pavoni (2009) show that the first-order approach remains valid if one imposes the sufficient conditions of a monotone likelihood ratio, a utility function with non-increasing absolute risk aversion and a *log*-convex probability distribution function. The constrained-efficient consumption allocation can then be characterized by adding (7) to the Lagrangian, with shadow price ω. The first order condition with respect to $c(z)$ is then

$$\beta u'(c(z)) f(z|e_1) - \frac{\lambda}{1+r} f(z|e_1) + \mu \beta u'(c(z)) f_e(z|e_1) - \omega \beta (1+r) u''(c(z)) f(z|e_1) = 0. \tag{8}$$

Thus, the constrained-efficient shape of $c(z)$ now depends not only on that of the likelihood ratio $f_e(\cdot)/f(\cdot)$, but also on that of the risk-aversion coefficient $-u''(\cdot)/u'(\cdot)$. Since $\lambda = u'(c_1) + \omega u''(c_1)$, using the first-order condition with respect to c_1, we have

$$\left[f(z|e_1) + \mu f_e(z|e_1) - \omega(1+r) f(z|e_1) \frac{u''(c(z))}{u'(c(z))} \right] \frac{1}{u'(c_1) + \omega u''(c_1)} = \frac{1}{\beta(1+r)} \frac{f(z|e_1)}{u'(c(z))}. \tag{9}$$

Summing and using (1), the constrained efficient allocation obeys

$$\left[1-\omega(1+r)\sum_{\{z\in Y_2\}} f(z|e_1)\frac{u''(c(z))}{u'(c(z))}\right]\frac{1}{u'(c_1)+\omega u''(c_1)}=\frac{1}{\beta(1+r)}\sum_{\{z\in Y_2\}}\frac{1}{u'(c(z))}f(z|e_1). \quad (10)$$

Hidden savings reduce the economy's ability to decouple consumption and income realizations further beyond what is implied by incentives to provide effort. When agents can trade non-contingent assets in privately known amounts, the standard Euler equation is satisfied, and the expectation of reciprocal future marginal utility is not equal to the reciprocal of current marginal utility.[3]

A more explicit characterization of the relevant distortions is possible if absolute risk aversion is constant across consumption levels, a feature that will also prove useful in our discussion of costly insurance below. With $u'(x)=\exp(-\eta x)$, and $u''(x)=-\eta u'(x)$, (10) simplifies to

$$\left[\frac{1+\omega(1+r)\eta}{1-\omega\eta}\right]\frac{1}{\exp(-\eta c_1)}=\frac{1}{\beta(1+r)}\sum_{\{z\in Y_2\}}\frac{1}{\exp(-\eta c(z))}f(z|e_1):$$

the only source of deviation from the reciprocal Euler equation in this special case is the multiplicative term in square brackets on the left-hand side, which would be unity if $\omega=0$ and hidden savings do not constrain efficiency. Using this expression in (9) yields

$$\exp(\eta c(z))-\sum_{\{z\in Y_2\}}\exp(\eta c(z))f(z|e_1)=\frac{\mu}{1-\omega\eta}\frac{f_e(z|e_1)}{f(z|e_1)}\beta(1+r)\exp(\eta c_1),$$

indicating that when savings are hidden and $\omega>0$ then inverse marginal utility responds more strongly to income realizations than would be appropriate in light of the shape of likelihood ratios $f_e(\cdot)/f(\cdot)$, and possible if efficiency were only constrained by hidden effort.

[3]Even as individual saving volumes remain hidden, savings may be observable at the aggregate level. Then, anonymous trades may be taxed linearly so as to distort the private rate of intertemporal transformation, discourage savings, and, in certain model environments, improve welfare (Golosov and Tsyvinsky, 2007).

3.2 Hidden private insurance

So far, we have illustrated existing results in the context of a simple model. Next, we introduce securities that pay off upon realization of the verifiable contingencies corresponding to observable realizations of y_2, and we proceed to characterize their equilibrium role from the same constrained-efficiency perspective applied above and in the literature on hidden savings. In our model economy, contingent securities fulfill a sensible role alongside hidden savings, because income is random for each effort level. The realization of y_2 and any public transfers contingent on it are assumed to be observable and verifiable, but consumption remains unobservable because individual portfolios of contingent assets are private information.

Competitive trade of such stylized securities may occur through clearing houses (or insurance firms) that collect portfolios of assets contingent on a large number of different individuals' income realizations. Since all individuals are *ex ante* identical, prices of securities only depend on the income realization they refer to. As in any insurance market, however, the payoff of each security does depend on the identity of the individual who, after issuing or purchasing the security, experiences the relevant realization. It will be convenient to express the prices of such securities in terms of second-period aggregate resources, because this convention maintains a useful distinction between the inter- and intratemporal dimensions of individual budget constraints.

Let $p(z_j)$ be the price of a security that entitles its purchaser to a unit of income when the purchaser's idiosyncratic realization is $y_2 = z_j$, and binds its issuer to pay a unit of income when the issuer's realization is $y_2 = z_j$. As all uncertainty is idiosyncratic, private or public entities' portfolios can be riskless when their holdings are diversified across sufficiently many individuals. In competitive equilibrium, individuals choose first-period effort e_1 and consumption c_1 as well as a portfolio of long and short positions $q(z)$ in contingent securities, taking their prices $p(z)$ as given. Optimal choices can be characterized in terms of the Lagrangian

$$\mathcal{L}_i = u(c_1) - v(e_1) + \beta \sum_{\{z \in Y_2\}} u(c(z)) f(z|e_1)$$
$$+\iota \left[\sum_{\{z \in Y_2\}} \zeta(z) \left[z + q(z) - c(z) \right] - \sum_{\{x \in Y_2\}} q(x)p(x) + (y_1 - c_1)(1+r) \right] : \qquad (11)$$

ι denotes the second-period shadow price of lifetime resources, $\zeta(z)$ are the shadow prices of resources available when the second period income realization is z where $\sum_{\{z\in Y_2\}}\zeta(z) = 1$, and the first-order conditions are

$$\begin{aligned} c_1 &: \; u'(c_1) = \iota(1+r), \\ c_2(z) &: \; u'(c(z))\beta f(z|e_1) = \iota\zeta(z), \; \forall z, \\ q(z) &: \; \zeta(z) = p(z). \end{aligned} \tag{12}$$

Risk-averse individuals will generally take short positions in securities that pay off upon high income realizations, long positions in those that pay off in less fortunate contingencies.

3.2.1 Full inefficient insurance

When it is costless to transfer resources across individuals (and, from the point of view of each individual, across idiosyncratic income realizations), then the insurance market delivers full insurance, if an equilibrium exists, and perfectly smooth consumption at $\bar{c}_2 = \Sigma z f(z|e_1) + (y_1 - c_1)(1+r)$. Since idiosyncratic random deviations of income realizations from their mean are zero on average, long and short transactions of realization-specific claims in amounts $q(z) = \bar{c}_2 - z - (y_1 - c_1)(1+r)$ imply zero profits for insurance firms if they occur at the actuarially fair prices $p(z) = f(z|e_1)$,

$$\Sigma_z \left[\bar{c}_2 - z - (y_1 - c_1)(1+r)\right] p(z|e_1) = \Sigma_z \left[\bar{c}_2 - z - (y_1 - c_1)(1+r)\right] f(z|e_1) = 0, \tag{13}$$

and those prices rule out all riskless arbitrage opportunities. In this case, the individual first order conditions (12) imply

$$u'(c(z))\beta = u'(\bar{c}_2)\beta = \iota, \forall z;$$

and the long and short sets of securities which individuals are interested in buying and selling are separated by $z = \bar{c}_2 = \Sigma z f(z|e_1) + (y_1 - c_1)(1+r)$, and both the usual and the reciprocal Euler equations hold at

$$u'(\Sigma z f(z|e_1) + (y_1 - c_1)(1+r)) = \frac{u'(c_1)}{\beta(1+r)}. \tag{14}$$

Since consumption does not depend on income realizations, however, effort is endogenously set at too low a level. The reason is that insurance prices are formed in a market where payoffs can be contingent on observable income realizations, but not on the total amount of individual security holdings because insurance contracts are non-exclusive. The income-contingent consumption allocation determined by (14) would be consistent with the constrained optimality condition under hidden savings and effort, in (9), only if $f_e(\cdot) = 0$ and $\omega = 0$, i.e., only if unobservable effort and saving choices were inconsequential.

The resulting competitive equilibrium allocation inefficiently stabilizes consumption across idiosyncratic realizations because effort incentives depend on *total* insurance purchased and are not taken into account by price-taking anonymous trades (Pauly, 1974). Purchases and sales of state-contingent assets cannot internalize their effects on effort when insurance is priced according to the probability distribution implied by equilibrium effort and savings. Through effort incentives, an additional unit of state-contingent consumption $q(z)$ affects the probability of that state's realization. Differentiating the first order condition for individual effort (3),

$$\frac{\partial e_1(\cdot)}{\partial q(z)} = \frac{\beta u'(c(z)) f_e(z|e_1)(1 - p(z))}{v''(e_1) - \beta \sum_{\{z \in Y_2\}} u(c(z)) f_{ee}(z|e_1)}, \text{ for } c(z) = z + q(z) - \sum_{\{x \in Y_2\}} q(x)p(x) + (y_1 - c_1)(1+r).$$

The denominator is positive by the effort choice's second order condition. The numerator is positive when the probability of z being realized is increased by effort (i.e., for relatively high z realizations), negative when the opposite is the case.

To account for the effect of insurance on the system's costs and revenues, the marginal price of q units of z-contingent assets should equal $f(z|e_1) - q(z) f_e(z|e_1) \left[\partial e_1(\cdot)/\partial q(z)\right]$ rather than the actuarially fair probability, $f(z|e_1)$. The wedge between the social and competitively determined insurance costs,

$$-q(z) f_e(z|e_1) \frac{\partial e_1(\cdot)}{\partial q(z)} = -q(z) \left(f_e(z|e_1)\right)^2 \frac{\beta u'(c(z))(1 - p(z))}{v''(e_1) - \beta \sum_{\{z \in Y_2\}} u(c(z)) f_{ee}(z|e_1)},$$

is positive for $q(z) < 0$, negative for $q(z) > 0$, and vanishes only at the $z = \Sigma z f(z|e_1) + (y_1 - c_1)(1+r)$ where the insurance market is not active. Thus, the market price is too high for state-contingent payments that individuals make, too low for payments that individuals receive: insurance is too inexpensive when competitively traded marginal insurance contracts disregard effort incentives. Just like hidden intertemporal trade, hidden insurance trade reduces effort and average consumption to an extent that more than compensates the social welfare impact of smoother consumption patterns. In the economy's equilibrium, individuals self-insure too much, and also purchase too much insurance through formal contracts.

Insurance contracts can address this externality, originally identified by Pauly (1974), by specifying prices in terms of the total (rather than marginal) quantity purchased (see also Bizer and DeMarzo, 1992). This may be possible for specific risks: nonlinear pricing schedules are commonly observed for coverage of accidents, and information is routinely obtained about total coverage when claims are processed (Shavell, 1979). To internalize equilibrium effort implications for risks that bear on marginal utility of consumption, however, it would be necessary to observe the full portfolio of insurance contracts or, equivalently, each agent's consumption.

When insurance transactions are actuarially fair and hidden, public contingent transfers cannot influence the allocation of consumption, because they are fully offset by private contractual arrangements. If upon realization of $y_2 = z$ an individual receives a net, possibly negative transfer $s(z)$ from a public redistribution scheme, along with the amount $q(z)$ paid off by private insurance contracts held, the public scheme's coexistence with private insurance is completely inconsequential: upon realization of $y_2 = z$, consumption is

$$c(z) = z + q(z) + s(z) + (y_1 - c_1)(1 + r) - \sum_x q(x)p(x|e_1) - \sum_x s(x)t(x|e_1), \tag{15}$$

where the summations account for the ex-ante cost of private asset portfolios, and for that of the public scheme as $t(x|e_1, s(x))$ denotes the cost of transferring a unit of consumption contingent on realization x. Regardless of whether the cost for the public scheme is actuarially fair, by adjusting the amount of private insurance $q(z)$ individuals can perfectly offset public transfers so as to ensure that (15) holds and (14) is satisfied at the same $c(z)$ for any $s(z)$. The equilibrium allocation, determined by individual choices, still stabilizes consumption fully and fails to deliver constrained-optimal effort incentives. Just like hidden savings imply that only suboptimal self insurance can be achieved in hidden-information settings, only suboptimal full insurance against random events influenced by hidden actions is possible when trade in contingent securities is frictionless.

3.2.2 Insurance transaction costs

Since neither full insurance nor the irrelevance of public policy are realistic, we proceed to illustrate how plausible insurance-provision costs can change these results. If for a private (or public) insurance scheme delivering a unit of consumption to an individual costs more than a unit, or collecting resources from individuals makes less than a unit available for redistribution, insurance reduces mean income and average consumption more strongly than would be implied by its impact on effort incentives.

To pin down the equilibrium amount of insurance, we suppose that insurance transactions encounter decreasing returns: the marginal cost of delivering one unit in state i is increasing in the total amount delivered to consumers who are long in such securities and, symmetrically, the marginal cost of collecting one unit from individuals who short i-contingent securities is also increasing. Such costs may reflect increasing scarcity of factors employed in supplying insurance and the resulting non-linearity of prices for insurance ensures equilibrium existence (Bisin and Gottardi, 1999).

For analytical tractability we assume that transaction costs vanish smoothly as transactions go to zero so that we can continue to focus on interior solutions in the maximization problem. See Gottardi and Pavoni (2009) for a model with discrete bid-ask spreads and corner solutions at $q(z) = 0$.

To obtain analytic results, we adopt exponential functional forms for both marginal utility (which therefore displays constant absolute risk aversion) and marginal costs: a contract that specifies delivery of one unit of consumption upon realization of $y_2 = z$ costs

$$p(z|e_1, \bar{q}(z)) = f(z|e_1) \exp\left(\bar{q}(z)\nu\right), \tag{16}$$

where ν indexes the sensitivity of unit costs to the total amount of such contracts being traded, $\bar{q}(z_j)$. In competitive equilibrium the amount $\bar{q}(z_j)$, while endogenous at the aggregate level, is taken as given by each seller and purchaser of contingent assets who solves the problem

$$\begin{aligned}
\max_{c_1,e_1,\{q(z)\}} \quad & u(c_1) - v(e_1) + \beta \sum_z \left[u\left(c(z)\right) f(z|e_1) \right] \\
\text{s.t} \quad & c(z) = z + q(z) - \sum_x q(x) p(x|e_1, \bar{q}(x)) + (y_1 - c_1)(1+r),\ \forall z.
\end{aligned} \tag{17}$$

The optimality condition with respect to $q(z)$,

$$u'(c(z))\beta(1+r)f(z|e_1) = u'(c_1)p(z|e_1, \bar{q}(z)), \forall z, \tag{18}$$

has linear form $-\eta c(z) - \nu \bar{q}(z) + \ln(\beta(1+r)) = -\eta c_1$ if utility has constant absolute risk aversion so that $u'(x) = \exp(-\eta x)$, and prices are given by (16). In an *ex ante* symmetric equilibrium where $\bar{q}(z) = q(z)$, combining the linear optimality condition with the realization-specific resource constraint (17) implies

$$c(z) = \frac{\nu}{\eta+\nu}\left[z - \Sigma_x q(x)p(x|e_1, q(x)) + (y_1 - c_1)(1+r)\right] + \frac{\eta}{\eta+\nu}\left[c_1 + \frac{1}{\eta}\ln(\beta(1+r))\right] \tag{19}$$

Consumption is a linear function of the income realization z, with slope ranging from zero when $\nu = 0$ and insurance is complete, to unity as $\nu \to \infty$ and transactions become prohibitively costly for non-infinitesimal amounts.

The intercept of the linear relationship is an expression involving the first-period endowment and other exogenous parameters, and also total insurance purchases and first period consumption. To characterize these endogenous choices, note that insurance payments are linear in z: as insurance absorbs the fraction of z realizations that is not (linearly) reflected in consumption levels,

$$\begin{aligned}
q(z) \quad &= \quad c(z) - \left[z - \sum_x q(x)p(z|e_1, q(z)) + (y_1 - c_1)(1+r) \right] \qquad (20) \\
&= \quad -\frac{\eta}{\eta+\nu}\left[z - \Sigma_x q(x)p(x|e_1, q(x)) + (y_1 - c_1)(1+r)\right] + \frac{\eta}{\eta+\nu}\left[c_1 + \frac{1}{\eta}\ln(\beta(1+r))\right].
\end{aligned}$$

Considering the expression $q(z) - \Sigma_x q(x) f(x|e_1)$ yields

$$q(z) = \frac{\eta}{\nu + \eta} \left(\Sigma_x x f(x|e_1) - z \right) + \Sigma_x q(x) f(x|e_1) \ . \tag{21}$$

If non-contingent bonds do not exist, $c_1 = y_1$ and summation over the resource constraints in (17) implies that overall insurance payments net out to zero, $\Sigma_x q(x) f(x|e_1) = 0$. Equation (21) then simplifies to

$$q(z) = \frac{\eta}{\nu + \eta} \left(\Sigma_x x f(x|e_1) - z \right)$$

which can be inserted in (19) to express the second-period consumption profile in terms of the model's parameters.

If consumers have access to a non-contingent bond, there is no closed-form solution and the solution becomes cumbersome as the budget constraint contains linear and log-linear terms of $q(z)$. In this case the intercepts of the consumption and insurance profile are determined by solving a system of non-linear equations.

The solution simplifies in the extreme cases where insurance is costless ($\nu = 0$) or impossible ($\nu \to \infty$), so that the intertemporal consumption choice satisfies the familiar Euler equations that apply in the absence of uncertainty or in the standard precautionary-savings setting where only self-insurance is possible. In the interesting intermediate cases where insurance is possible but partial, the probability-weighted sum of conditions (18) reads

$$u'(c_1) = \beta(1+r) \sum_z u'(c(z)) \frac{f(z|e_1)}{p(z|e_1, \bar{q}(z))} f(z|e_1). \tag{22}$$

In general, state contingent prices that deviate from actuarial fairness imply that, in what would otherwise be a standard Euler equation over the intertemporal dimension of consumer choices, realization-specific rates of transformation are applied to random marginal utility realizations in the second period.

Note both equation (22) and (7) may hold with equality since actuarially unfair prices for state-contingent securities prevent arbitrage. The implicit assumption that a non-contingent intertemporal transfer of resources is "cheaper" than a transfer using a set of securities with the same payoff may be motivated with costly verification of the state z. Our specification of transaction costs above implies that consumers in general will borrow or save as well as hold a full portfolio of state-contingent securities.

As regards the implications of most immediate interest in this paper, the volume of transactions in z-specific individual contingent securities in (21) obviously decreases in the cost parameter ν, and increases in the risk aversion parameter η. More importantly, the non-linear transaction costs that reduce the extent of private insurance, and its implications for inefficient effort supply, also prevent private insurance arrangements from crowding out public transfers fully. Hence, non-linear costs for private insurance make it possible to characterize the intensity of public insurance activities: when private contracts offset only a portion of income shocks z and of the public transfers $s(z)$ that are contingent on them, taxes and transfers can and should affect the corresponding consumption levels and individual incentives to exert effort. We turn next to characterizing such effects.

3.2.3 Public policy under incomplete private insurance

In order to maintain symmetry with what we assumed for the private sector, we allow for smoothly increasing marginal transaction costs for a public transfer scheme: transferring a positive net amount $s(z)$ to each individual who experiences realization z costs an amount $t(s(z)|e_1)$ which is larger than, and increasing in, $s(z)$; symmetrically, obtaining $-s(z)$ from individuals yields an increasingly small amount of resources when $s(z)$ is negative. For clarity we abstract from the effect of private or public insurance on aggregate resources in this subsection and assume that the transaction costs of private insurance and public insurance are rebated with a lump-sum transfer T where

$$T \equiv \sum_x q(x)\left[p(x|e_1, q(x)) - f(x|e_1)\right] + \sum_x s(x)\left[t(x|e_1, s(x)) - f(x|e_1)\right].$$

With

$$\begin{aligned} c(z) &= z + q(z) + s(z) + (y_1 - c_1)(1+r) - \sum_x q(x)p(x|e_1, q(x)) - \sum_x s(x)t(x|e_1, s(x)) + T \\ &= z + q(z) + s(z) + (y_1 - c_1)(1+r) - \sum_x q(x)f(x|e_1) - \sum_x s(x)f(x|e_1), \end{aligned}$$

the efficient allocation, which is constrained by aggregate resources as well as by hidden effort, savings, and private insurance choices, is characterized by the solution of the Lagrangian[4]

$$\begin{aligned}
\mathcal{L}_p &= u(c_1) - v(e_1) + \beta \sum_{\{z \in Y_2\}} u(c(z)) f(z|e_1) \\
&\quad + \lambda \left(y_1 - c_1 + \frac{1}{1+r} \sum_{\{z \in Y_2\}} (z - c(z)) f(z|e_1) \right) \\
&\quad + \mu \left(\beta \sum_{\{z \in Y_2\}} u(c(z)) f_e(z|e_1) - v'(e_1) \right) \\
&\quad + \omega \left(u'(c_1) - \beta(1+r) \sum_{\{z \in Y_2\}} u'(c(z)) f(z|e_1) \right) \\
&\quad + \sum_{\{z \in Y_2\}} \varphi(z) \left(u'(c_1) - \beta(1+r) \frac{f(z|e_1)}{p(z|e_1, q(z))} u'(c(z)) \right).
\end{aligned} \tag{23}$$

Since the contingent-transfers schedule $s(z)$ is known to individuals in equilibrium, private insurance transactions $q(z)$ are performed in order to smooth out shocks to disposable income, $z + s(z)$. Their shadow price $\varphi(z)$ is positive for $z-$contingent securities that individuals find optimal to hold in their portfolios, while $\varphi(z) < 0$ if it is optimal for individuals to short the relevant security (and pay, rather than receive, units of consumption when their income realization is z).

The first-order condition for the state-contingent transfer $s(z)$ is

$$\begin{aligned}
&\left[\beta u'(c(z)) f(z|e_1) - \frac{\lambda}{1+r} f(z|e_1) + \mu \beta u'(c(z)) f_e(z|e_1) \right] c'(s(z)|z, ...) \\
&- \left[\omega \beta (1+r) u''(c(z)) f(z|e_1) + \varphi(z) \beta (1+r) \frac{f(z|e_1)}{p(z|e_1, q(z))} u''(c(z)) \right] c'(s(z)|z, ...) \\
&+ \varphi(z) \beta (1+r) u'(c(z) \frac{f(z|e_1)}{p(z|e_1, q(z))^2} \frac{\partial p(z|e_1, q(z))}{\partial q(z)} q'(z) = 0,
\end{aligned} \tag{24}$$

where $\lambda = u'(c_1) + \omega u''(c_1) + u''(c_1) \sum_{\{z \in Y_2\}} \varphi(z)$ by the first-order condition with respect to c_1,

[4] We assume that the Hessian of the objective function is negative semi-definite so that the solution to this problem characterizes the optimum. The sufficient conditions in Ábrahám, Koehne and Pavoni (2009) validate this assumption in our model for the limit case where securities become prohibitively costly to trade (so that the only hidden choices are effort and non-contingent savings). In general, however, stronger sufficient conditions are required. We do not elaborate on these conditions since we have not been able to characterize them in an insightful way. Unfortunately, as in simpler settings with hidden effort and hidden savings, little can be said about public insurance if we do not assume the validity of the first-order approach.

and $c'(s(z)|z,...)$ denotes the partial derivative of consumption with respect to the transfer. The first-order condition (24) is consistent with $c'(s(z)|z,...) \neq 0$ if $\partial p(z|e_1, q(z))/\partial q(z) \neq 0$. In fact, if the price of private insurance did not depend on quantities transacted, efficiency would be heavily constrained by full crowding out (as in the actuarially fair case discussed at the end of Section 3.2.1) of any public transfers meant to shape consumption. If $\partial p(z|e_1, q(z))/\partial q(z)$ differs from zero, $-1 < q'(s(z)|z,..) < 0$ and

$$c'(s(z)|z,...) = (1 - f(z|e_1))(1 + q'(s(z)|z,..)) > 0, \tag{25}$$

where we again slightly abuse notation indicating with $q'(s(z)|z,...)$ the partial derivative, with respect to contingent transfers, of individually optimal holdings of realization-specific securities.

To characterize how hidden partial insurance constrains efficient consumption patterns, we can rearrange (24) to read

$$\begin{aligned} \frac{\lambda}{\beta(1+r)u'(c(z))} \quad &= \quad 1 + \mu\frac{f_e(z|e_1)}{f(z|e_1)} - \omega(1+r)\frac{u''(c(z))}{u'(c(z))} \\ &\quad -\varphi(z)\frac{1+r}{p(z|e_1, q(z))}\left[\frac{u''(c(z))}{u'(c(z))} - \zeta\frac{q'(s(z)|z,..)/q(z)}{c'(s(z)|z,...)}\right], \end{aligned} \tag{26}$$

where

$$\zeta \equiv \frac{p'(q(z)|z,..)}{p(z|e_1, q(z))}q(z)$$

is the elasticity of the $z-$specific security's price schedule and $p'(q(z)|z,..)$ denotes the partial derivative of the price of the security if income equals z with respect to contingent transfer $q(z)$.

The first two terms with multipliers on the right-hand side in (26) are familiar, and reflect the constraints imposed on insurance by hidden effort and savings. The last term on the right-hand side in (26) highlights the implications of hidden private insurance. If $\zeta = 0$, that term has the sign of $\varphi(z)$, and implies that marginal utility is too smooth across income realizations: consumption $c(z)$ is larger than it should be from the social point of view for realizations for which $\varphi(z) > 0$ and private contracts increase individual resources. As remarked above, private insurance is excessive when securities are traded at marginal cost in competitive markets, neglecting their impact on effort incentives.

When instead decreasing returns in costly transactions imply that $\zeta > 0$, then public transfers can and should affect the price and amount of private insurance. Inasmuch as the expression in square brackets in (26) differs from zero, the resulting cross-realization pattern of marginal utility differs from the one which would be constrained efficient in the complete absence of private insurance. When $\zeta > 0$, transfers partially crowd out insurance, so $-1 < q'(s(z)|z,..) < 0$ and $c'(s(z)|z,...) > 0$: thus, the term in square brackets is less negative than absolute risk aversion. As the shadow prices $\varphi(z)$ of hidden private insurance choices are intuitively also smaller in absolute value when those choices are restrained by transaction costs, $\zeta > 0$ implies that, when private insurance is possible and (partially) crowded out by transfers, the cross-realization pattern of marginal utilities is less smooth than in the $\zeta = 0$ case of perfect and inefficient insurance.

In order to bring consumption/income profiles closer to the efficient configuration, public transfers generally aim at reducing the amount of insurance supplied by competitive interactions in our model. This implication, while intuitively explained by the tendency towards over-insurance of private competitive contracts, appears to unrealistically imply that public insurance contracts should amplify the random fluctuations of individual incomes. In the model, however, the fluctuations amplified by efficient public schemes are those of incomes *plus* insurance receipts. Since public transfers substitute private insurance, their relationship to income realization depends on the character of that crowding-out effect, which in turn depends on the shape of both private and public transaction costs.

An example Some aspects of the relevant channels of interaction may be illustrated in the case where marginal utility of consumption and costs of transactions both have an exponential functional form, with parameters $-\eta$ and ν respectively. As shown above, these parametric assumptions conveniently imply that private insurance absorbs a constant fraction $\eta/(\eta+\nu)$ of income shocks, which include contingent public transfers when they are part of individuals' disposable income. Equation (21) implies that

$$q'(s(z)|z,...) = -\frac{\eta}{\eta+\nu}.$$

If the cost of the public insurance scheme is also exponential $t(z|e_1, s(z)) = f(z|e_1)\exp(s(z)\rho)$, so that (25) reads

$$c'(s(z)|z,...) = (1 - f(z|e_1))\frac{\nu}{\eta + \nu}, \tag{27}$$

and $\zeta = \nu q(z)$, the crucial term in equation (26) simplifies to,

$$\zeta \frac{q'(s(z)|z,..)/q(z)}{c'(s(z)|z,...)} = -\frac{\eta\nu/(\eta+\nu)}{c'(s(z)|z,...)} = \frac{\eta}{1 - f(z|e_1)}.$$

In our example this term does not depend on the size and slope of private transaction costs as indexed by ν. One can show that if transaction costs affected aggregate resources, this term would decrease (in absolute terms) in the size and slope of private transaction costs as indexed by ν.

More generally, there are two effects at work. On the one hand steeper private transaction costs reduce the crowding out of private insurance and make public transfers more effective tools for the purpose of shaping consumption's responsiveness to shocks. On the other hand a large ν also reduces the extent to which public policy should increase consumption volatility and restore the effort incentives diminished by private insurance opportunities: for a given cost parameter ρ of public transfers, in fact, a larger ν will imply a more important insurance role for the public scheme. Thus, the model implies that private and public schemes will each be smaller when their own costs are higher. Since higher private transaction costs influence both the feasibility and the desirability of public insurance, however, they may or may not imply that more costly (hence smaller) private insurance makes it optimal to expand the size of public insurance schemes.

We now elaborate on this point by deriving the transfers $s(z)$ which implement the constrained-efficient solution. Using the parametric assumptions introduced in the previous subsection, equations (26) and (27) imply that constrained-efficient consumption equals

$$c(z) = \mathbf{c} + \frac{1}{\eta}\ln\left(1 + \mu\frac{f_e(z|e_1)}{f(z|e_1)} + \omega(1+r)\eta - (1+r)\frac{\varphi(z)}{p(z|e_1, q(z))}\eta\frac{f(z|e_1)}{1 - f(z|e_1)}\right), \tag{28}$$

where the constant is given by

$$\mathbf{c} \equiv \frac{1}{\eta}\ln(\beta(1+r)) - \frac{1}{\eta}\ln\underbrace{\left(u'(c_1)(1-\eta(\omega+\sum_{\{z\in Y_2\}}\varphi(z)))\right)}_{\lambda}.$$

Equation (19) implies that agents' optimally chosen consumption is

$$c(z) = \mathbf{c}_p + \frac{\nu}{\eta+\nu}(z+s(z))$$

where

$$\mathbf{c}_p \equiv \frac{\nu}{\eta+\nu}\left[(y_1-c_1)(1+r) - \Sigma_x q(x)p(x|e_1,q(x)) - \Sigma_x s(x)t(x|e_1,s(x))\right] + \frac{\eta}{\eta+\nu}\left[c_1+\frac{1}{\eta}\ln(\beta(1+r))\right].$$

Hence, state-contingent transfers

$$\begin{aligned} s(z) \;&=\; \frac{\eta+\nu}{\nu\eta}\ln\left(1+\mu\frac{f_e(z|e_1)}{f(z|e_1)}+\omega(1+r)\eta-(1+r)\frac{\varphi(z)}{p(z|e_1,q(z))}\eta\frac{f(z|e_1)}{1-f(z|e_1)}\right) \\ &\quad -z+\frac{\eta+\nu}{\nu}(\mathbf{c}-\mathbf{c}_p), \end{aligned}$$

implement the constrained-efficient allocation under hidden insurance.

If we use the approximation $\ln(1+x)\approx x$,

$$\begin{aligned} s(z) \;&\approx\; -z+\frac{\eta+\nu}{\nu\eta}\frac{f_e(z|e_1)}{f(z|e_1)}\mu \\ &\quad -(1+r)\frac{\varphi(z)}{p(z|e_1,q(z))}\frac{\eta+\nu}{\nu}\frac{f(z|e_1)}{1-f(z|e_1)} \\ &\quad +\frac{\eta+\nu}{\nu}(\omega(1+r)+\mathbf{c}-\mathbf{c}_p). \end{aligned}$$

For $z' > z$,

$$
\begin{aligned}
s(z') - s(z) &= -(z'-z) \\
&\quad + \frac{\eta+\nu}{\nu\eta}\mu\left(\frac{f_e(z'|e_1)}{f(z'|e_1)} - \frac{f_e(z|e_1)}{f(z|e_1)}\right) \\
&\quad + (1+r)\frac{\eta+\nu}{\nu}\left(\frac{\varphi(z)}{p(z|e_1,q(z))}\frac{f(z|e_1)}{1-f(z|e_1)} - \frac{\varphi(z')}{p(z'|e_1,q(z'))}\frac{f(z'|e_1)}{1-f(z'|e_1)}\right)
\end{aligned}
$$

Thus, without incentive problems, $\mu = 0 = \varphi(z) = \varphi(z')$, and public transfers exactly offset differences in income realizations.[5] Hidden effort with $\mu > 0$ makes public transfers less redistributive in order to elicit more effort if the likelihood ratio is monotone. Hidden insurance sales and purchases with $\varphi(z) > \varphi(z')$ may increase or reduce redistribution depending on how the odds $f(z|e_1)/(1-f(z|e_1))$ and the actuarial unfairness of prices change in z. If we consider two states, one state in which $\varphi(z) > 0$ and the security $q(z)$ is purchased and one state in which $\varphi(z') < 0$ and the security $q(z')$ is sold, hidden insurance sales and purchases unambiguously increase the difference in consumption between these two states.

4 Another look at the facts

The model quite intuitively predicts that private insurance contracts should be less developed when they encounter more strongly increasing transaction costs, and that public insurance should be more intense not only when effort incentive constraints are less binding and risk aversion is stronger, but also when public programs are relatively less costly than private insurance. While all these and other features may explain the variation across countries of private and public insurance, we focus on transaction and administration costs as an essential element of realistically imperfect insurance systems, and explore the extent to which they can *ceteris paribus* explain cross-country evidence.

We use OECD data on administration costs per net revenue collection as our measure for transaction costs of public insurance and operating expenses per claim as our measure of transaction

[5] Note that hidden savings with $\omega > 0$ do not affect the slope of the profile of public transfers with CARA utility in this.first-order approximation. The effect of hidden savings would show in higher-order terms of the approximation which we neglect in the example presented in the text.

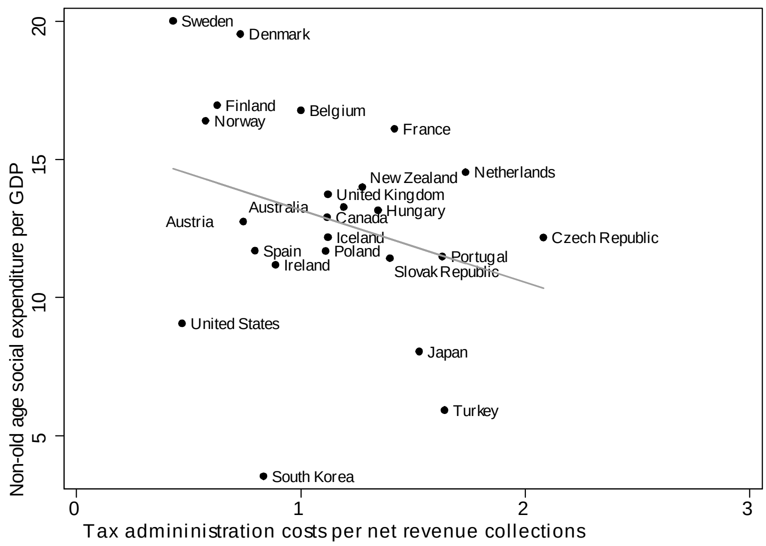

Figure 2: Public insurance and its cost in %. Notes: Social expenditure is the average for the period 1996-2003 in the Social Expenditure Database, OECD. The tax administration cost is the average for the period 2000-2002 in OECD (2004), Table 17. Solid graph: predicted values of linear regression.

costs for private insurance.[6] These data are far from perfect, as operating expenses also include acquisition costs for example, but they capture at least some of the variation we are interested in and are the best data available for our purposes.

Figures 2 and 3 show that the transaction costs differ considerably across countries and are negatively related to public and private insurance transactions, consistent with our model. For example, the low public and private insurance in a Mediterranean country like Portugal is associated with relatively high administration costs of tax collection (about 2% of the revenues) and high operating expenses per claim (about 40% of claims) in the private insurance market. Scandinavian and Anglo-Saxon countries both have lower operating expenses per claim than most countries (about 20-30%) but Scandinavian countries also have rather low public administration costs (at less than 1% of collected revenues, even lower than in Anglo-Saxon countries like Australia, Canada

[6]Since there are no data on claims and operating expenses for the US, we use 18% as a proxy for the private transaction cost per claim in the US, suggested by the estimates of the loading factor in Brown and Finkelstein's (2007) analysis of the US long-term care market. As a proxy for US claims, we use the data on gross-written non-life insurance premiums for the US and compute claims by multiplying US premiums by the claim/premium ratio averaged across all countries for which we have data.

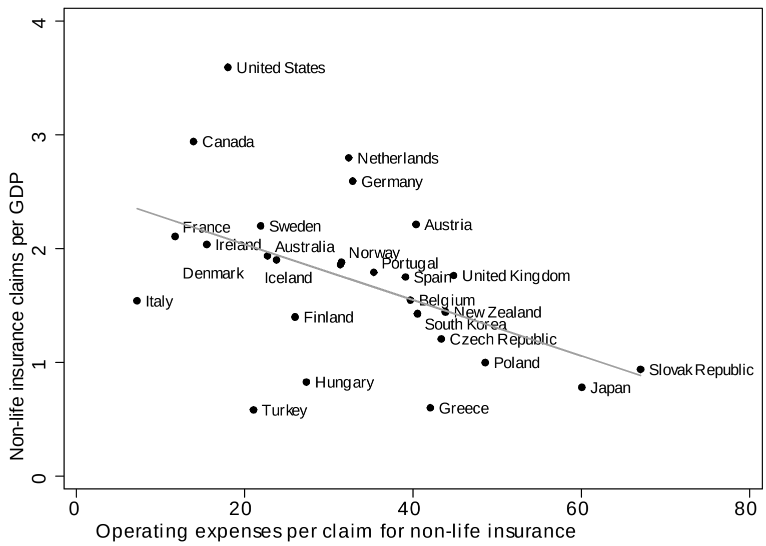

Figure 3: Private insurance and its costs in %. Notes: Medians for the period 1996-2005. Data are from the OECD, Insurance Statistics Yearbook. Solid graph: predicted values of linear regression.

or the UK).

The bivariate correlation between social expenditures and administration costs in Figure 2 is -0.29. The value becomes -0.43 and significant at the 5% level if we exclude South Korea which is an outlier in Figure 2. The bivariate correlation between non-life insurance claims and operating expenses per claim in Figure 3 is -0.48, strongly significant at little more than 1%. The association between transaction costs and insurance is also quantitatively important. Regressing public social expenditure on a constant and public transaction costs (excluding South Korea) reveals that an increase of public transaction costs by one standard deviation (0.43 percentage points) is associated with 1.4 percentage points less public insurance. Analogously, an increase of private transaction costs by one standard deviation (14.32 percentage points) is associated with 0.35 percentage points less private insurance.

These results remain very similar if we add private transaction costs as a control in the regression for public insurance and public transaction costs as control in the regression for private insurance. Neither of the additional controls is significant in such specifications. This is consistent with our model since we have seen that higher transaction costs for private insurance make public transfer more effective in altering consumption levels but also change the constrained-efficient consumption levels.

5 Concluding comments

The modeling framework developed in this paper offers distinctive and qualitatively general insights into the implications of private insurance for public insurance policies. In theory, transaction costs in private insurance markets play a crucial role in making it possible for public transfers to affect the consumption allocation, and in shaping the amount and character of constrained-optimal public insurance policies. Insurance activities are indeed costly in reality, and we find that available cross-country information on the cost of public and private insurance systems are sensibly and significantly related to their size.

Our simple empirical investigation also indicates that much of private and public insurance variation remains unexplained by transaction costs. Other aspects of private insurance organization may be relevant, such as the extent to which market concentration or information pooling may reduce inefficiently generous insurance. While the small number of cross-country data heavily constrains further investigation, it may also be interesting in future work to explore the relationship between the transaction or administration cost indicators analyzed in this paper, and differences in countries' historical experiences and socioeconomic configuration.

6 Data appendix

We use all available OECD data for the time period 1996-2005 in our empirical analysis where not all sample years are available for all variables and some countries such as Mexico and Switzerland are excluded because of missing data. The variables are defined as follows.

Non-old age social expenditure per GDP: Total public social expenditure minus the expenditures in the categories "old age" and "survivors", divided by GDP. Average for the years 1996-2003 in the OECD Social Expenditure Database. Our measure for public social expenditure includes (i) incapacity-related benefits (care services, disability benefits, benefits accruing from occupational injury and accident legislation, employee sickness payments); (ii) health (in- and out-patient care, medical goods, prevention); (iii) family (child allowances and credits, child care support, income support during leave, sole parent payments); (iv) active labor market policies (employment services, training youth measures subsidized employment, employment measures for the disabled); (v) unemployment (unemployment compensation, severance pay, early retirement for labor market reasons); housing (housing allowances and rent subsidies); and (vi) other social policy areas (non-categorical cash benefits to low-income households, other social services; i.e. support programs such as food subsidies).

Tax administration costs per net revenue collection: Annual costs of administration incurred by a revenue authority divided by the revenue collected over the course of a fiscal year. Average for the years 2000-2002 in OECD (2004), Table 17.

Non-life insurance claims per GDP: Gross claims payments, covering all gross payments on claims made during the financial year, divided by GDP. Median, by country, for the years 1996-2005 in the OECD Insurance Statistics Yearbook. Non-life insurance includes, among others, insurance in the categories motor vehicle, maritime and aviation, freight, fire and property damages, pecuniary losses, general liability accident and health. Data on claims for the US are not available and imputed using the median of gross non-life insurance premiums multiplied by the average claim-premium ratio for those OECD countries for which data on both premiums and claims are available.

Operating expenses per claim for non-life insurance: Gross operating expenses are the sum of acquisition costs, change in deferred acquisition costs and administrative expenses. These are divided by claims. Median, by country, for the years 1996-2005 in the OECD Insurance Statistics Yearbook. Data for the US are not available and are imputed using the estimate for the loading factor of 1.18 for the long-term care market in Brown and Finkelstein (2007).

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