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Insurance Contracts as Commodities: A Note

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This paper extends recent developments in general equilibrium theory and applies them to the problem of measuring the real output of an economy's insurance sector. These developments permit a priced commodity to be a complex incentive-compatible contract. These contracts are not bundles of more basic commodities. These contracts are elementary in the same sense that event-contingent goods deliveries are elementary in the Arrow-Debreu framework.

1. INTRODUCTION

National income and product accounting has proven useful in evaluating the performance of national economies. It has been particularly useful in measuring changes in an economy's productivity, or its ability to produce goods and services from the available capital, labour, and other inputs. The standard method in this accounting system is to represent the quantities of a set of goods by a scalar index. This quantity index is the value of these goods in terms of a set of fixed prices. Usually the prices used to aggregate the goods are those for some base period. With this method all the goods produced by a sector are represented by one number, the real output, or constant dollar value, of the sector. Changes in the inputs are then used to account for changes in this output measure. The all-important residual (the changes in the output measure not accounted for by the changes in the inputs) represents changes in the ability of the sector to produce its composite good.

This accounting method does not work well for the insurance sector. This is because the quantities of the commodities produced by this sector are not measured directly. The sector's commodities, in fact, are not even defined. Thus, the method adopted in the national income and product accounting system to measure the real output of the insurance sector has necessarily been somewhat ad hoc. And the resulting productivity change findings for this sector are suspect.

Let us look, for example, at the method currently used to measure the output of the U.S. fire and casualty insurance sector.[1] The value of the services provided by this sector

1. The Bureau of Economic Analysis (BEA) stopped publishing series on industry value-added in 1989. After we had written this paper we became aware of the BEA revisions of industry value-added series, De Leeuw *et al.* (1991). For the property and casualty insurance industry which we analyse, the definition of nominal output has remained unchanged; real output, however, is now defined as net premiums deflated by the Consumer Price Index for insurance contracts. We do believe that our critique applies in the same way to the revised definitions, especially since the definition of nominal output has not changed.

is now measured by the net premiums earned in the sector, that is, gross premiums earned minus benefits paid. Whether this measure appropriately reflects the current price value of the production of the insurance sector is questionable. Ruggles (1983, p. 67) suggests that gross rather than net premiums may be the appropriate measure of nominal output. Even if the use of net premiums is accepted, though, a problem remains: how to determine the constant dollar value of the commodity or commodities produced. The method currently used is to extrapolate the base-period net premiums using deflated gross premiums to obtain a measure of real output for the sector. The gross premiums are deflated by a price index of the cost of repairing the insured item. (See Marimont (1969, p. 31).) For example, car insurance gross premiums are deflated using the auto repair index.

This general approach implicitly assumes that the real output of the insurance services is proportional to deflated gross premiums. Note that this real output concept includes a component which has previously been excluded from the definition of the nominal value of these services. Furthermore, the nominal value is deflated by the price index of a component which has been excluded from the nominal value.

In this paper, we develop an approach that permits a component of the commodity vector to be a particular type of insurance contract. With our approach, an insurance contract of a given type is a commodity and has a price (a gross premium). Given the numbers of the various insurance contracts traded and their prices, this approach treats the insurance sector in precisely the same way as the national income and product accounting system now treats the manufacturing sector, for example.

Our paper is organized straightforwardly. In Section 2, we briefly review and extend the recent general equilibrium developments that we need for this analysis. In Section 3, we describe a simple economy which provides insurance. In Section 4, we describe two ways to measure the real output of this economy's insurance sector: the method currently used in the United States and our proposed alternative. In Section 5 we use two examples of this economy to examine the implications of the two methods for measuring technological change in the insurance sector and in the economy as a whole. Our examples indicate that the current method does not identify technological change in the insurance sector as well as our proposed alternative method. Finally, we make some concluding comments.

2. THE COMMODITY SPACE

The notion of using a commodity space with a large number of differentiated goods in the study of industrial production is not new. Both Hotelling (1929) and Lancaster (1971) model economic environments with a continuum of products. In both the locational example of Hotelling and the characteristic structure of Lancaster, products that are close in their respective spaces are close substitutes. Griliches (1971), in a notable paper, develops and applies an econometric methodology to correct for quality changes in the construction of price and quantity indexes for automobiles. Rosen (1974), in an important paper on hedonic pricing, analyses a competitive industry equilibrium for an environment with a continuum of differentiated goods. Mas-Colell (1975) provides a formal general equilibrium theory for a class of such environments. His key innovation is the use of the space of signed measures as the commodity space. Notable subsequent work on this problem includes that by Hart (1979), Novshek (1980), and Jones (1984).

Prescott and Townsend (1984) use the space of signed measures to extend general equilibrium theory to the study of economies with private information and, in particular, to environments with moral hazard in providing insurance. With this approach, the important connection between national income and product accounting and general equilibrium analysis is lost. In Prescott and Townsend's world, commodities, that is, components of the commodity vector, cannot be characterized as inputs and outputs to the business sector, so the concepts of income and product are lost.

We now show that this approach can be extended, or reinterpreted, so that components of the commodity vector are insurance contracts of a particular type. Insurance contracts are products that are outputs of the business sector and inputs to the household sector. With this approach, the insurance sector can be treated like any other sector in national income and product accounting.

In standard general equilibrium analysis the commodity space L is a linear space and the commodity point x is an element of L. For example, if L is finite dimensional we may use $L=\Re^l$ with l commodities. A commodity is then a component of the x vector. The production possibility set Y_j of an industry j is a subset of the commodity space, $Y_j \subset L$. A feasible production plan y_j of the industry is an element of its production possibility set, $y_j \in Y_j$. For an industry, components of a production plan (commodities) are grouped as inputs and outputs. Let this partitioning of the production plan be $y_j=(y_j^i, y_j^o)$, where y_j^i is the vector of inputs for industry j and y_j^o is the vector of outputs. Let $p=(p^i, p^o)$ be the price vector conformable with the production plan. Application of the standard national income and product accounting method to industry j in this general equilibrium framework yields nominal output at time t as $p_t^o y_{jt}^o$. Real output, that is, output in constant prices, is $p_b^o y_{jt}^o$, where p_b is the base-period price vector.

Prescott and Townsend (1984) introduce private information and insurance into classical competitive analysis. With their approach there is a set S, points of which specify a consumption realization, including actions of individuals. These actions may involve the delivery or receipt of commodities by an agent. An agent of type j belonging to the finite set of types J has preferences over a closed subset of lotteries on $\mathscr{B}(S)$, the Borel σ-algebra of S. The linear space in which this set resides is the space of signed measures $\mathscr{M}(S)$. If x belongs to the consumption possibility set $X_j \subset \mathscr{M}(S)$, its utility to a type j agent is

$$u(x)=\int_S U(s)x(ds)$$

where the underlying utility function U is continuous. The function $u: X_j \to \Re$ is weak* continuous given that S is compact.

While there is no formal difference between Prescott and Townsend's definition and the standard definition of the commodity space, there is, a substantial difference in the interpretation of the commodity space. Effectively, an element of the set of events S is to be interpreted as an element of the commodity space L in the standard analysis. In Prescott and Townsend's environment an agent no longer chooses one particular consumption plan, but a probability distribution over all possible plans. The trouble with this approach is that components of x do not have the interpretation of commodities, since they represent probabilities for particular events.

We finesse this problem as follows. Let $L(S)$ be the space of lotteries, or insurance contracts, on $\mathscr{B}(S)$. This space, like S, is compact and metric since $L(S)$ is compact in the weak* topology and therefore metrizable. The space of signed measures on the Borel σ-algebra of $L(S)$ is $\mathscr{M}(L(S))$. For our environment elements in $\mathscr{M}(L(S))$ with the same first moments are equivalent. Relative to the agents they are equivalent because agents maximize expected utility and lotteries on lotteries are lotteries. Relative to the insurance technology they are equivalent since only first moments matter for determining technological feasibility. Consequently, $\mathcal{M}(S)$ is a suitable commodity point and is the one used with our approach. Therefore, having insurance contracts as commodities does not require a more complicated commodity space than the one used in Prescott and Townsend (1984).

With our approach components of the commodity vector can be incentive-compatible contracts and, in particular, an insurance contract. In the subsequent insurance applications we consider the case in which the commodity space is $\mathcal{M}(S)\times\mathfrak{R}^m$, where components of $\mathcal{M}(S)$ are the insurance contracts and components of $\mathfrak{R}^m$ are the other commodities besides the insurance contracts.

3. AN ECONOMY WITH INSURANCE

We now describe an economy that provides insurance. In this economy, agents own a durable good that may be damaged due to some accident. An agent can obtain insurance against the possible accident. The provision of insurance contracts, however, requires resources.

In this economy, each agent is endowed with one unit of labour and k units of a durable good. The stock of the durable good is specific to an agent; that is, the durable good cannot be transferred to another agent. At the beginning of the period, an agent can increase the stock of the durable good by investment $i\geqq 0$. The agent derives utility from the consumption of a good c and from the flow of services from the durable good. These services are proportional to the stock of the durable good, $k+i$, held by the agent during the period.

Again, the durable good may be damaged. The probability that a fraction $\theta\in\Theta$ of the durable good is destroyed is π_θ. The set Θ is finite, and Π is the set of probability distributions on Θ. An agent is characterized by the intrinsic accident probabilities $\bar{\pi}$, which are independent of actions taken by the agent. These probabilities are public information. Actual accident probabilities, π, can differ from the agent's intrinsic probabilities if the agent and an insurance firm undertake some joint action. This will be taken up below as part of the description of the insurance contract.

An insurance contract specifies payments of the durable good conditional on the damage θ. These payments, or claims, are denoted by d_θ. If an agent consumes an insurance contract and an accident θ occurs, then the agent's stock of the durable good in the next period is

$$k'=(1-\theta)(k+i)+d_\theta.$$

The agent's (partially indirect) utility function is the expected value of

$$U(c,k+i)+V(k').$$

The functions U and V are strictly increasing, strictly concave, and continuously differentiable.

The insurance industry can affect the accident probabilities of its customers, for example, through advice or monitoring. For this reason we want to include the possibility that an agent's actual accident probabilities deviate from the agent's intrinsic probabilities. What the actual probabilities should be becomes part of the insurance contract. To complete the description of an insurance contract, we must specify claims in case of an accident. Insurance claims are in the form of the durable goods and therefore must be non-negative, $d_\theta\geqq 0$. If no goods are damaged, $\theta=0$, then the claim is constrained to be zero. Thus, $d_0=0$. Let D be the set of claim vectors d with the properties that $d_0=0$ and $d_\theta\geqq 0$ for all θ.

An insurance contract of type z is characterized by its claim vector and by the intrinsic and actual probabilities, $\bar{\pi}_\theta$ and π_θ of the claims d_θ. An insurance contract of type $z=(\bar{\pi}, \pi, d)$ can only be consumed by an agent with intrinsic accident probabilities $\bar{\pi}$. This is possible because an agent's $\bar{\pi}$ is public information. The set of contracts is $Z=\Pi\times\Pi\times D$.

This completes the description of the commodities traded in the economy. The commodity point of the economy is now defined as $x=(c, i, \mu, -n)$, where n denotes units of labour and μ a signed measure on the set of possible contracts Z, and $\mu\in\mathcal{M}(Z)$. The commodity space is, then, defined as $L=\Re\times\Re\times\mathcal{M}(Z)\times\Re$.

The economy has a finite set of agent types J with $\bar{\pi}_{j\theta}$ the intrinsic probability of loss θ for a type j agent. There is a continuum of each agent type with the measure of type j being λ_j. The total measure of agents is 1, so λ_j is the fraction of type j. We use π_j to denote the vector of accident probabilities for an agent of type j.

Preferences satisfy the expected utility hypothesis with respect to random consumption streams. The utility of a type j agent from a commodity bundle x is

$$u_j(x)=U(c, k+i)+\textstyle\sum_\theta \pi_{j\theta}V\left[(1-\theta)(k+i)+\displaystyle\int_Z d_\theta\mu(dz)\right].$$

Given the non-negativity restriction on consumption, investment in the durable good, and the time endowment for labour, the consumption possibility set of a type j agent is

$$X_j=\{x=(c, i, \mu, -n)\in L\colon c, i\geqq 0;\ n\in[0, 1];\ \mu(Z)\in\{0, 1\};\ \text{if } \mu(Z)=1,$$
$$\text{for some } z=(\bar{\pi}, \pi, d)\in Z, \mu(\{z\})=1, \text{ and that } z \text{ satisfies } \bar{\pi}=\bar{\pi}_j\}.$$

The consumption possibility set restricts an agent to consume at most one insurance contract. It also restricts the insurance contract consumed to be one for which the intrinsic accident probabilities assumed in the contract are equal to the actual intrinsic accident probabilities of the agent.

The economy has three constant returns-to-scale production sectors. We adopt the convention that inputs appear with a negative sign in the commodity vector.

Sector 1. The first sector is the consumption good-producing sector. Its production possibility set is

$$Y_1=\{y=(c, i, \mu, -n)\in L\colon i, \mu=0;\ c, n\geqq 0;\ \alpha_1 c\leqq n\}.$$

In this sector, n units of labour are used to produce c units of the consumption good and labour productivity is constant at $1/\alpha_1$. Sector 1 sells the produced consumption good directly to the agents.

Sector 2. The second sector produces the durable good. Its production possibility set is

$$Y_2=\{y=(c, i, \mu, -n)\in L\colon c, \mu=0;\ i, n\geqq 0;\ \alpha_2 i\leqq n\}.$$

In this sector, n units of labour are used to produce i units of the durable good and labour productivity is constant at $1/\alpha_2$. Sector 2 sells the produced durable good to the agents and to the insurance sector.

Sector 3. The interesting sector is the third, which produces the insurance services. To define its production possibility set, we first describe the problem of an insurance firm. There is a continuum of each agent type, and the losses θ are independent across agents. Since an insurance firm issues many contracts of each type, the average claim per contract of a given type is equal to the expected claims.[2] Labour resources are required to monitor the contract with $\alpha_3(\bar{\pi}, \pi)$ units of labour needed per type z contract produced. These requirements are for record-keeping purposes, to identify accident probabilities of the agent purchasing the contract and the damages if an accident occurs, or to change the accident probabilities of an agent.[3] The production possibility set for an insurance firm is

$$Y_3 = \left\{ y = (c, i, \mu, -n) \in L \colon c = 0;\ i, n \geqq 0;\ \int_Z \alpha_3(\bar{\pi}, \pi)\mu(dz) \leqq n; \int_Z [\textstyle\sum_\theta d_\theta \pi_\theta]\mu(dz) \leqq i \right\}.$$

Sector 3, the insurance sector, has two inputs. This sector uses n units of labour to monitor μ contracts. The productivity of labour in monitoring a type z contract is $1/\alpha_3(\bar{\pi}, \pi)$. This sector also acquires durable goods from the second sector as an intermediate input. If an accident occurs, the durable goods are distributed among agents according to the terms of the contract.

We can also define an aggregate production possibility set $Y = Y_1 + Y_2 + Y_3$. Note that the aggregate production possibility set is a convex cone.

An allocation $[(x_j), y_1, y_2, y_3]$ is feasible if $\sum_j \lambda_j x_j = \sum_i y_i$, where $x_j \in X_j$ for all j and $y_i \in Y_i$ for all i. A competitive equilibrium is a feasible allocation $[(x_j^*), y_1^*, y_2^*, y_3^*]$ and a linear price functional $p = (p_1, p_2, p_3, p_4)$, where $p_3 \colon Z \to \Re$ is continuous, with $p_3(z)$ being the price of a contract z, for which the following conditions are satisfied:

- For all $x \in X_j$: if $u(x) > u(x_j^*)$, then $px > px_j^*$ for all j.
- For all $y \in Y_i$: $py_i^* \geqq py$ for $i = 1, 2, 3$.

This is the usual definition of competitive equilibrium.

4. MEASURING OUTPUT IN THE INSURANCE ECONOMY: TWO METHODS...

We now describe two ways to measure nominal and real output for the insurance sector of our economy. One is based on the method currently used in U.S. national income and product accounting. This method defines nominal output as the net premiums earned by the sector. Real output is then obtained by extrapolating the base-period nominal output using deflated gross premiums. The other method is based on the definition of the commodity point for the insurance economy. This definition implies that the relevant goods produced by the insurance sector are contracts and their prices are the premiums paid.

Let $(x_t, y_{1t}, y_{2t}, y_{3t})$ and p_t be a competitive equilibrium of the insurance economy in period t. Let b denote the base period. The gross premiums earned in period t by the insurance sector are

$$R_t = \int_Z p_{3t}(z)\mu_t(dz).$$

2. We use the Uhlig (1988) law of large numbers for a continuum of identically and independently distributed random variables.

3. By dealing with monitoring rather than costly state verification, the example is simplified. With the Townsend (1988) extension of the revelation principle to environments with costly state verification, introducing this feature is straightforward but notationally cumbersome.

Claims paid by the insurance sector in period t are

$$C_t = \int_Z p_{2t}[\textstyle\sum_\theta \pi_\theta d_\theta]\mu_t(dz).$$

According to the method currently used in U.S. national income and product accounting, the nominal output of the insurance sector is net premiums, $R_t - C_t$, and the real output of the sector is, then,

$$\frac{R_t/p_{2t}}{R_b/p_{2b}}(R_t - C_t).$$

The gross premiums used to extrapolate base-period nominal output are deflated by the price of the durable good p_{2t}. The real output measure is normalized to make base-period real output coincide with base-period nominal output.

We now propose an alternative way to measure real output for the insurance sector. This method treats the insurance sector in the same way that U.S. national income and product accounting treats sectors in which the number of units of output are measured directly: current-period output is evaluated using base-period prices. Our proposal is based on the definition of the commodity point in the insurance economy and takes an insurance contract as the relevant commodity.

Recall that the insurance sector can produce a continuum of differentiated commodities: contracts differentiated by type, accident probability distribution, and claims distribution. The value of the insurance sector's output in current-period prices, that is, nominal output, is, then, simply gross premiums earned, instead of net premiums as with the current method. The real output of the sector is obtained by evaluating the contracts traded in the current period at their base-period prices (premiums),

$$\int_Z p_{3b}(z)\mu_t(dz).$$

Notice that the equilibrium in our insurance economy will typically be such that, of the continuum of insurance contracts, only a finite number of types are produced in any period. To calculate real output by weighting the quantities of different products by the base-period price vector, prices for insurance contracts not traded in the base period are needed; knowledge of prices for traded contracts is not sufficient. We propose to use the base-period supply reservation prices to value all contracts traded in the current period.

Our proposal will not affect the measure of nominal output for the whole economy. The proposal does affect the measures of nominal and real gross output for the insurance sector and real outputs for the whole economy. The proposal will also affect the household sector's composition of expenditures on final goods. To see this, note that in our economy with insurance the currently used method treats repairs as a final good purchased by households whereas the proposal treats repairs as an intermediate good purchased by the insurance sector.[4]

The insurance sector does not use any intermediate inputs with the currently used method. Real value-added and real output are, therefore, the same for this sector. For the alternative method, however, real value-added and real output are different since claims are treated as intermediate inputs to the insurance sector. For the following

4. In our economy with insurance we assume that claim payments are actually used to repair or replace the damaged goods. In cases where claim payments are used to purchase some other consumption goods, we might still consider these transactions to be "repairs" and treat these consumption purchases as intermediate good purchases by the insurance sector.

examples, the term *labour productivity* will mean value-added productivity. The economy has only one factor of production. Thus, labour productivity and total factor productivity coincide.

5. ... AND TWO EXAMPLES

As we emphasized in the introduction, one very important use of national income and product accounting data is to identify changes in the production capacity of the economy and of sectors of the economy. Here we explore, via two examples, the implications for productivity accounting of adopting our proposed alternative measure of the output in the insurance sector. There are well known index number problems associated with output indexes, and we cannot expect to obtain an "ideal" output index. It then appears to be appropriate to compare the relative performance of the two methods for some well defined problems which capture essential characteristics of technological change in the insurance sector.

In the first example we find that the measured increase in real output associated with a decrease in the labour required to monitor a contract is larger for our method than for the current method. This means, of course, that productivity increases in the insurance sector are undermeasured by the current method.

In the second example, the insurance company can reduce the accident probabilities by taking actions which require the use of labour. Insurance companies can—and in some cases do—help their customers reduce accident probabilities by providing information about how to change practices in order to reduce accident probabilities and the size of damages. The nature of the technology change in this second example is that the insurance sector becomes better able to reduce accident probabilities. This might occur, for instance, because of the publication of a study that identifies the accident risks of alternative practices.

Prices as well as quantities are needed for national income and product accounting. Both example economies have fixed-proportion technologies. Consequently, they have a unique supply reservation price system, which is a function of the parameters of the technology only.

We normalize the price of labour p_4 to 1. With this normalization, the equilibrium price of the consumption good is $p_1 = \alpha_1$ and the equilibrium price of the durable good is $p_2 = \alpha_2$. The supply reservation price of an insurance contract of type z is the expected cost of providing such a contract. This cost is the labour cost of monitoring plus the value of expected claims. Thus, the price of an insurance contract of type z is

$$p_3(z) = \alpha_3(\bar{\pi}, \pi) + p_2 \textstyle\sum_\theta d_\theta \pi_\theta.$$

Any contract traded in equilibrium must be traded at these supply reservation prices. This is the price system used in the following examples.

Example 1

This economy has only one agent type, so the index j is dropped. An agent of this type has these current-period utility functions:

$$U(c, k+i) = \gamma \ln c + (1-\gamma) \ln (k+i), \quad \text{where } 0 < \gamma < 1.$$

The indirect utility of having stock k' at the beginning of the next period is

$$V(k') = \beta \ln k', \quad \text{where } \beta > 0.$$

Here θ has two possible values. If $\theta = 0$, then there is no accident. If $\theta = \theta_1 \in (0, 1)$, then a fraction θ_1 of the durable good is lost. Since claims are zero when there is no accident, the claim payment d_1 in the event of an accident specifies the contract. Since we do not consider changes in the accident probabilities, $\bar{\pi} = \pi$, we use $\alpha_3 = \alpha_3(\bar{\pi}, \bar{\pi})$ to reduce notation.

Conditional on obtaining an insurance contract, the optimal consumption, investment, and coverage decisions (with an interior solution) are

$$c = \frac{\gamma(1-\alpha_3+\alpha_2 k)}{\alpha_1(1+\beta)}$$

$$i = \frac{(1-\gamma+\beta\pi_0)(1-\alpha_3+\alpha_2 k)}{[1-\pi_1(1-\theta_1)]\alpha_2(1+\beta)} - k$$

$$d_1 = \frac{[\beta\theta_1-(1-\gamma)(1-\theta_1)](1-\alpha_3+\alpha_2 k)}{[1-\pi_1(1-\theta_1)]\alpha_2(1+\beta)}.$$

Conditional on not obtaining insurance, the optimal choices of the agent (with an interior solution) are

$$c = \frac{\gamma(1+\alpha_2 k)}{\alpha_1(1+\beta)} \qquad i = \frac{(1-\gamma+\beta)(1+\alpha_2 k)}{\alpha_2(1+\beta)} - k.$$

For the parameter values of the economies considered here, the solutions for both problems are interior.

The only change in the economy between the base and the current period is that the value of α_3 is 0·05 in the former and 0·04 in the latter. This corresponds to labour in the insurance sector being 25% more productive in the current period than in the base period. The other values of the parameters are $\beta = 1$, $\gamma = 0{\cdot}5$, $\pi_1 = 0{\cdot}1$, $\theta_1 = 0{\cdot}99$, and $k = 2$. Equilibrium is characterized by agents purchasing insurance in both periods. The value added by the insurance sector as a percentage of total output is 5% in the base period, which roughly conforms with the national income and product accounting data for the U.S. economy.

We find that, with the current method, the real output of the insurance sector falls 5% while labour productivity rises 19%.[5] Measured output of insurance falls even though every agent is receiving a better insurance policy. This, we think, is a deficiency of the current method. It is not a problem for our alternative method. With our method, output of the insurance sector rises 0·2% while labour productivity in the sector rises 25%.

Example 2

In this second example the economy is identical to that in the first in every respect except one. The difference is that here an agent's actual accident probabilities deviate from the intrinsic accident probabilities if the contract specifies that the insurance firm shall allocate resources to help the policyholder reduce the probability of an accident. If the insurance firm takes no action the actual accident probability is equal to the agent's intrinsic probability $\pi_1(0) = \bar{\pi}_1 = 0{\cdot}10$, which is the accident probability for Example 1. If action is taken the actual accident probability is reduced to $\pi_1(1) = 0{\cdot}08$. If no action is taken, then the labour requirement is $\alpha_3(\bar{\pi}, \pi(0)) = 0{\cdot}05$ in the base period. This is the

5. Table I in the Appendix reports the equilibrium allocations. Table II there compares the output and productivity accounting for the insurance sector for the current method and our proposed alternative.

Example 1 base year labour requirement. If action is taken to reduce the accident probability, then the labour requirement in the base year is $\alpha_3(\bar{\pi}, \pi(1)) = 0{\cdot}10$.

In the base period, equilibrium is characterized by the insurance firms taking no action; that is, contracts have $\bar{\pi} = \pi$. Consequently, the equilibrium allocation in the base-period equilibrium is essentially the same as in the first example.

The nature of the technology change is that the labour services associated with the accident-reducing actions decline from $\alpha_3(\bar{\pi}, \pi(1)) = 0{\cdot}10$ in the base period to $\alpha_3(\bar{\pi}, \pi(1)) = 0{\cdot}07$ in the current period. This is the only change in the economy. The consequence of this change is that the current-period traded insurance contract has $\pi = \pi(1)$ and so has lower accident probabilities in the current period than the contract traded in the base period.

Here, with the current accounting method, the measured output of the insurance sector declines 5% while productivity in the sector declines 32%. Clearly, in this example, the current accounting method fails to identify productivity change and output change in the insurance sector. That is not true for our proposed method. It provides reasonable changes for the insurance sector: a real output increase of 10%, a real value-added increase of 100%, and a factor productivity increase of 40%.

6. CONCLUDING COMMENTS

We have shown that the output of the U.S. insurance sector can be measured in a way consistent with the standard method used for other sectors. This can be done, at least in theory, by treating an insurance contract of a given type as one of a continuum of commodities. Base-year prices can then be used to obtain the constant dollar value, or real output, of the insurance sector. We have also shown, by example, that the current method of measuring the output of the insurance sector is not producing estimates reasonably close to those obtainable with our proposed standard method. Compared to our method, the current method underestimates increases in real insurance sector output and so in the sector's productivity growth.

But a natural question arises: Is using our proposed method to measure real insurance output practical? For economies like that in our first example, we think it is. The claim experience of a given type of insurance contract could be used to estimate the accident probabilities. The claim payment could be determined by reading the insurance policy. To compute the base-period supply reservation prices of the contracts traded in the current but not the base period, an estimate of the base-period labour requirement per contract produced is also needed. Econometric methods could be used to estimate this labour requirement.

Implementing our proposed method when actions of the insurance sector can affect accident probabilities, as in the second example economy, is not as straightforward. Again, the problem is to estimate the supply reservation prices of contracts not traded in the base period. The fact that contracts now serve two purposes—providing insurance against loss and modifying accident probabilities—makes this problem harder to solve. We must identify agents who are characterized by the same prior accident probabilities, but who choose different insurance contracts. This may not be impossible, since one of the factors which determine the insurance decision of an agent is the value of the insured object. Thus, agents with the same prior accident probabilities but different levels of wealth may choose different types of insurance contracts.

In conclusion the construction of our proposed standard method of measuring insurance output does require a considerable amount of new information. But we think devoting resources to obtaining that information is warranted. Young (1985) indicates that the impact of technological change on the structure of the insurance sector is substantial, while the discussion of Baumol (1990) and our two examples show that this technological change will not be adequately reflected by the currently used national income and product accounting method. The main reason for this undermeasurement is that the currently used method does not capture changes in the quality of the insurance sector's output. Once these quality changes are accounted for, the observation that the insurance sector, along with most service sector industries, shows below average productivity growth may be overturned. Hirshhorn and Geehan (1977), in a study of the Canadian life insurance sector, construct a real output index which is in the spirit of the method we have proposed. For the time period 1953–73, their index shows an average labour productivity growth of 2·8% in the life insurance sector. The average productivity growth of the Canadian economy for this period was 2·5%. These numbers suggest that productivity growth in the service sectors may actually be above rather than below average.

APPENDIX

TABLE I

Equilibrium quantities in the two examples

		Consumption	Investment	Insurance claims
Base period	Both examples	0·7375	0·0671	1·4543
Current period	Example 1	0·7400	0·0741	1·4593
	Example 2	0·7325	0·0820	1·4442

TABLE II

Insurance output and productivity accounting with the two methods

		Real output	Real value added	Labour productivity
Current method				
Base period	Both examples	0·0500	0·0500	1·0000
Current period	Example 1	0·0476	0·0476	1·1900
	Example 2	0·0475	0·0475	0·6780
Proposed method				
Base period	Both examples	0·1954	0·0500	1·0000
Current period	Example 1	0·1959	0·0500	1·2500
	Example 2	0·2155	0·1000	1·4286

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