Measures of the Insurance Sector Output

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1. Introduction

National income and product accounting has proven invaluable in evaluating the performance of national economies and also of the performance of sectors of national economies. It provides a measure of the capability of an economy or sector to produce goods and services given the capital, labor and other inputs. How this capability changes over time, that is changes in the quantity of output produced not accounted for by changes in the quantities of inputs used, is a key measure used in judging performances of national economies and sectors of national economies. To carry out these productivity change exercises, measures of both inputs and outputs are needed.

In the case of the insurance sector, measuring inputs is not without problems but these problems are not that different from those for other sectors. Measuring the outputs of the insurance sector is another matter. Only recently (Hornstein and Prescott, 1989) has there even a conceptual definition of the products of this sector. There, of course, is a procedure that has and is being used to compute a quantity which is labelled constant price output of insurance services in the national income and product accounts. This quantity, we shall argue, is likely to be a poor proxy for appropriately measured real product of the insurance sector. Having no reasonable measure of output of the insurance sector, current measures of productivity change in that sector are suspect. In this paper we propose an operational hedonic procedure to directly measure the output of the casualty insurance sector.

There is general agreement that at the level of individual profit centers an important part of the change in output is not accounted for by changes in the purchased inputs, that is there are exogenous productivity changes. There are obvious factors, for example new knowledge, which can change the production function. One such example is the practice of field rotation introduced in the early middle ages in Europe. If the set of available goods is not fixed, however, the distinction between changes in inputs and changes in productivity

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is to some extent arbitrary. Some technological improvements are associated with the introduction of new goods, for example using artificial fertilizers as a replacement for the crop rotation system. It is unclear whether we should treat this as a quantity change for a new input or a change in the technology. Another example is the standard neoclassical growth model, where each unit of labor becomes more efficient over time. If we measure labor input by raw units of labor, we will observe an increase in productivity, that is a change in technology. If labor input is measured by efficiency units we will observe no change in productivity (technology), but an increase in the labor input. This has repercussions for economic policy. If we subscribe to the first view, increased output has been brought about by technological improvements and a more efficient use of available labor. Economic policy should therefore try to further this technological knowledge. If we follow the second view, output increases because labor itself is more productive. Further increases in output may best be achieved by an expansion of the education system.

At an empirical level this clearly becomes a measurement problem. As the efficiency labor example shows, progress can be made if we obtain quality measures of inputs. We suspect that over time improvements will be made in this direction, and what has previously been deemed a change in the technology will no longer be seen as such. It is our view, however, that there will remain significant changes to the technologies of profit centers. In general these changes include anything which imposes exogenous limits on the feasible production plans of profit centers, like changes in the stock of knowledge, changes in the legally allowed or required actions, changes in public highways, etc. For this reason the residual will remain an important and useful concept.

Our work is aimed at providing an empirical measure of the output of the insurance sector. We focus on property insurance and here, in particular, on automobile insurance. This is a growing sector, but admittedly, compared to total gross national product, this sector is not large accounting for only a per cent or two of value added. We concentrate on this sector for the following reason. Casualty insurance contracts appear to be the easiest set of financial contracts to deal with using recent developments in general equilibrium theory which permit a financial contract to be a commodity. Given the set of financial contracts, our proposed method permits an extension of the hedonic approach to the measurement of financial contracts. If it proves impractical here, then there is not much hope for the quantitatively more important parts of the very important financial intermediation sector, which currently accounts for more than a sixth of value added.

We emphasize that this is an exploratory analysis. At the current stage we have not been able to find publicly available data that is sufficient to carry out the measurement exercise that we are proposing. We do think that given the regulatory structure of the insurance industry much of the data needed for our proposal does exist and it is a more a matter of collecting them. Before this data is collected, we think that there should be extensive discussion of the approach in the hope and expectation that it would result in the collection of data better suited for the measurement exercise.

2. Output, employment, and productivity in the U.S. economy using current measures

The development of the U.S. economy in the postwar period has been characterized by a shift of economic activity from the goods producing sector to the service sector in general. This has serious implications for the reliability of our output and productivity measures,

both at the aggregate and the sectoral level. In particular the slowdown in measured real gross national product (GNP) and productivity growth may be attributed to a systematic underestimation of output growth in the service sector. While we are relatively confident that the output measures from the goods producing sector are not that bad, output measures for the service sector in general are in many cases highly suspect. To the extent that the service sector produces intermediate goods, unreliable output measures in the service sector can result in misallocation of value added between the goods producing sector and the service sector. As far as the service sector's production for final consumption is concerned mismeasurement also affects measured total GNP of the economy. The shift in economic activity towards the service sector in general then implies that our existing measures of output and productivity become less and less reliable. Therefore we have to develop new measures of output for the growing service sector. We now briefly review the evidence for this shift in economic activity and its implications for productivity measures in the economy.

We let the manufacturing industry represent the goods producing sector of the economy. This sector is still one of the most important sectors of the U. S. economy and it has been the traditional source of growth in the economy. Furthermore output measures of this industry are considered to be among the most reliable. The service sector in general is represented by the service industry and the finance, insurance, and real estate (FIRE) industry. Since we are interested in evaluating the production of financial contracts we also look at banking and credit institutions, and the insurance carriers. Together these three industries account for about 25 percent of value added in FIRE, real estate accounts for 65 percent.

Our selection of measures to represent the relative importance of these sectors is partly determined by what data are available at our chosen level of industry disaggregation. We use the measures for value added in current dollars and full-time equivalent employees to represent the resource use in a sector. We take the share of sectoral value added (employment) in total value added (employment) as an indicator of the relative amount of resource use in a sector. Value added in constant prices per full-time equivalent employee is used as an indicator on how efficient the economy and the sectors are. All data are taken from the Current Survey of Business.

The increasing importance of the service sector for the U. S. economy is reflected in its changing contribution to both gross domestic product (GDP) and employment. The same data show a corresponding decline of the goods producing sector's importance. As Graph 1 shows the shares of total value added originating in the service and FIRE industries increased substantially from a combined total of 20 percent in 1947 to 32 percent in 1986. During the same time the share of total value added originating in the manufacturing sector declined from 28 percent in 1947 to 20 percent in 1986. In Graph 3 the same pattern can be observed for employment. While the shares of full-time equivalent employees increased for both the service and the FIRE sector, it decreased for the manufacturing sector. The combined share of the service sector increased from 15 percent in 1948 to about 30 percent in 1987, while the share of manufacturing declined during the same time from 32 percent to 20 percent. The financial industries essentially follow the pattern of the service and FIRE sectors with respect to value added shares, (Graph 2) and employment shares (Graph 4). Insurance carriers are somewhat of an exception since value added shares show substantial fluctuations and no pronounced trend, and the employment share has remained relatively constant since the late fifties.

Graph 1
Valued Added in Manufacturing, FIRE, and Services as Percent of GDP

Percent

Note: Yearly data on value added in current dollars.
 Source: U. S. Department of Commerce, Survey of Current Business.

Graph 2
Valued Added for Banking and Credit Institutions, and Insurance Carriers as Percent of GDP

Percent

Note: Yearly data on value added in current dollars.
 Source: U. S. Department of Commerce, Survey of Current Business.

Graph 3
*Employment in Manufacturing, FIRE,
 and Services as Percent Total Employment*

Percent

Note: Yearly data on full-time equivalent employees.
 Source: U.S. Department of Commerce, Survey of Current Business.

Graph 4
*Employment for Banking and Credit Institutions,
 and Insurance Carriers as Percent of Total Employment*

Percent

Note: Yearly data on full-time equivalent employees.
 Source: U.S. Department of Commerce, Survey of Current Business.

Graph 5
*Real Value Added per Employee in Manufacturing,
 FIRE, and Services*

Index, 100 at 1948

Note: Yearly data on value added in 1982 dollars per full-time equivalent employees.
 Source: U. S. Department of Commerce, Survey of Current Business.

Graph 6
*Real Value Added per Employee for Banking and Credit Institutions,
 and Insurance Carriers*

Index, 100 at 1948

Note: Yearly data on value added in 1982 dollars per full-time equivalent employees.
 Source: U. S. Department of Commerce, Survey of Current Business.

We have mentioned that the slow down in aggregate productivity growth has been attributed to the increasing importance of the service sector in general. The reason is that this sector shows a relatively low productivity growth when existing measures of real output are used. As can be seen from Graph 5, where we measure productivity by real value added per full-time equivalent employee, the manufacturing industry is the main source of productivity growth during the postwar period. The service and FIRE industries not only show below average productivity growth, but productivity is actually declining for FIRE and stagnating for services. Graph 6 shows productivity measures for the financial industry. Only insurance carriers show an increase in productivity, which is, however, still below average. The essentially flat productivity profile for banking institutions is the result of obtaining real value added by extrapolation, using employee numbers as the related series.

3. How output is currently measured and what's wrong with it

For many service sector industries, there currently are no reliable output measures. In the case of the insurance sector there is not even a conceptual definition of the output to guide the construction of a reasonable measure of its product. Without a conceptual measure it is not clear what data should be collected and how they should be used to compute an output measure. National income and product accounting, at least in the United States, deals with this problem of no direct output measure for a sector by extrapolating some value considered to be base period output, using a variable which is thought to be related to the actual real product of the industry. In many cases this related variable is an input used in the industry. Of course this makes the output measure virtually useless for any productivity accounting exercise.

In this section we describe the extrapolation procedure which is used in U.S. national income and product accounting to obtain a measure of real output for property insurance. Unlike some sectors, no input variable is used to extrapolate real product. We, none the less, argue that this measure is not a reliable one.¹ The nominal output produced by the nonlife insurance sector is currently 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 in 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, a major issue remains: What is 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.² (See Marimont 1969,

¹ We note that there also appears to be no conceptual definition of the output of an insurance company in insurance economics. While there is some discussion on the presence of scale economies for insurance companies, there seems to be no agreement on what constitutes output of such a company. For example, Doherty (1981) discusses the use of premiums, claims or net-premiums as measures of output.

² The Bureau of Economic Analysis (BEA) stopped publishing series on industry value-added in 1989. After we wrote 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 essentially the same way to the revised definitions, especially since the definition of nominal output has not changed.

p. 31.) The gross premiums are deflated by a consumer price index (CPI) based price deflator. For example, car insurance gross premiums are deflated using the auto repair price index.

More formally, we restate this procedure. Let R be the nominal value of premiums, C the nominal value of benefits paid, and N the nominal value of the inputs used to provide the insurance services (administrative expenses). Then for period t

$$R_t = N_t + C_t,$$

where we assume zero profits, and we neglect interest earned by the insurance company on premiums paid. Let w_t be the price index for inputs, and p_t the price index for the benefits paid. Also let n_t be nominal input deflated by the input price index in period t , and c_t be benefits paid deflated by p_t .

With currently employed national income and product accounting, the nominal value X_t of the insurance sector in the period t is

$$X_t = R_t - C_t.$$

The real or constant dollar value of the insurance sector is obtained by extrapolating the base period nominal value using deflated gross premiums. Thus, the constant price output x_t in period t is defined to be

$$x_t = \frac{R_t / p_t}{R_b / p_b} X_b,$$

where the base period is denoted by subscript b .

This general approach implicitly assumes that the real output of insurance services is proportional to deflated gross premiums. Note that the major component of gross premiums, benefits paid, has previously been excluded from the definition of the nominal value of these services, yet, the nominal value is deflated by the price index of this excluded component.

It is unreasonable to expect a perfect measure of real output. For the currently used method, however, we can construct examples for which measured output changes are not equal to what common sense dictates. In the first example the currently used measure indicates a change in real output, although the number and the nature of the insurance contracts purchased do not change. In the second example the currently used measure indicates no change in real output, although the number of contracts purchased does increase.

Example 1. For this example there is a change in the relative price of benefits paid and inputs used in the production. The number and nature of traded insurance contracts, however, does not change. Since traded insurance contracts do not change, we think any sensible procedure should find no change in real product. This property does not hold for the currently employed definition. To see this note that measured real output as currently defined is proportional to deflated gross premiums-deflated by p_t , a price index for benefits paid. Deflated gross premiums are the sum of benefits paid and expenses for administrative inputs used, deflated by the price index for benefits paid, that is

$$R_t / p_t = (w_t / p_t) \cdot n_t + c_t.$$

For this example the only change is in w_t / p_t , which is the price of administrative inputs relative to the price of benefits. For this example there is no change in the quantities of inputs

or in the number and nature of insurance contracts produced. Yet, with the current measurement procedure, constant price output changes because of the change in w_i / p_i , which is a relative price.

There are reasons to think that there could have been such a change in the prices of inputs to the insurance sector relative to the price of repair services. A costly activity associated with providing insurance is keeping records and computers are used extensively in this activity. Over the last twenty years the price of computer services has declined by more than a factor of a hundred. (See Baily and Gordon, 1988.) This suggests that this relative price has probably fallen in this period and therefore that the current method may have significantly under measured the change in the product of the casualty insurance sector.

Example 2. The key feature of this example is an increase in productivity that results in a lowering of the premium for a given type of insurance contract and a corresponding increase in the number of these contracts traded. For the example these numbers are such that total premiums is not changed. Thus, the only change for this example is an equal percentage decrease in the insurance contract premium and an equal increase in the number of contracts traded. The prices of the inputs to the insurance sector do not change. With the current method, even though there is an increase in the number of insurance contracts traded, that is the quantity of output, the measured constant price output of the insurance sector does not change. This we think is a serious deficiency of the current measure. Whenever there is a technological change that decreases (increases) the prices, that is the premiums, of insurance contracts, holding other things constant, there is a decrease (increase) in measured output. If there are increases in productivity and resulting decreases in contract prices, output increase is under measured.

There are reasons to think that there may have been technological advance in the insurance sector associated with learning how to more effectively use computers, whose quality was rising and price falling. These examples demonstrate that with the current procedure, greater administrative productivity that results in lower contract prices will reduce gross premiums and therefore measured constant price output of the insurance sector. The only possible conclusion is that the current measure of real product of the casualty insurance sector is worthless for estimating productivity change in that sector.

Some alternative procedure is needed to measure the real or constant price output of the insurance sector. The examples suggest that the appropriate procedure is to estimate the number of insurance contracts produced and use this as a measure of real output. There are problems in doing this. Industry studies show that noticeable changes in the number of insurance contracts, claim frequency, and the value of the average claim occurred in the recent past.³ For the number of insurance contracts purchased and the real value of an average claim we have to rely on indirect measures. To obtain an estimate of the number of insurance contracts purchased we look at the number of registered vehicles. The increase in this number from 1980 to 1988 is estimated at 20 percent. Assuming no significant decrease in the form of car insurance this will result in a comparable increase in cars covered by insurance contracts.

³ The following data on car registrations, average value of claims, price indexes, and claim frequency are taken from ISO 1989.

Changes in the nature of insurance contracts are diverse, but substantial. For the real average value of a claim the change depends on the type of insurance coverage considered and the price deflator used. During the time period from 1980 to 1988 the nominal value of the average claim for property damage increased by 60 to 90 percent, depending on the coverage type of the claim.⁴ At the same time applicable price indexes vary widely, such that the change in the real value of an average claim ranges from a negative 30 percent to a positive 54 percent, depending on the price index and claim type considered.⁵ For the claim frequency, that is the number of claims per insured vehicle, the observed change also depends on the coverage type of the insurance contract. In the period from 1980 to 1988 this frequency ranged from minus 10 to plus 10 percent depending on the claim type.⁶ Any reasonable procedure must be such that changes in the nature of the insurance contracts traded are taken into account.

We think that the method currently used is a deficient measure of real output for the preceding examples. These examples do not involve exceptional changes in the economic environment, rather they represent events we expect to occur regularly. Why then does national income and product accounting rely on this extrapolation method to obtain the real output of the insurance sector? It is for the same reason that there is a proliferation of output measures in the literature on scale economies in the insurance sector. There is simply no agreement on what the commodity is that an insurance company produces. In the following sections we argue that the relevant commodity is an insurance contract, and the gross premium is its price. In addition we argue that insurance companies produce a large number of differentiated commodities: for example if insurance companies can discriminate among agent types with different average claim, they will set premiums accordingly.

4. Financial contracts as commodities

Both Hotelling (1929) and Lancaster (1979) 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 change in the construction of price and quantity indexes for automobiles. Rosen (1974), in an important paper on hedonic pricing, analyzes a competitive industry equilibrium for an environment with a continuum of differentiated goods. Subsequently Mas-Colell (1975) provides the 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 include that by Hart (1980), Novshek (1980), and Jones (1984).

⁴ The nominal value of the average claim increased by 91 percent for property damage liability, 76 percent for collision and 60 percent for comprehensive coverage. Source: ISO 1989.

⁵ For the years from 1980 to 1988 the CPI index for used cars increased by 89.4 percent, the CPI index for auto body repair increased by 46.3 percent and the CPI index for auto repair increased by 46.3 percent. Using these CPI indices the change of the average real claim for property damage liability is between 0 and 54 percent, for collision it is between minus 14 and plus 30 percent and for comprehensive coverage it is between minus 30 and plus 14 percent. Source: ISO 1980.

⁶ For the years 1980 to 1988 claim frequency for property damage liability coverage decreased by 9.6 percent, for collision coverage it decreased by 3.5 percent, and for comprehensive coverage it increased by 10.5 percent. Source: ISO 1989.

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 their approach, the important connection between national income and product accounting and general equilibrium analysis is lost. In this world, commodities, that is, components of the commodity vector, cannot be characterized as inputs and outputs to the business sector and consequently the concepts of income and product are lost.

We now show that their 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.

The Prescott and Townsend (1984) approach uses a closed and bounded, finite-dimensional set S . An agent of type j belonging to the finite set J has preferences over a closed subset of lotteries on $\mathcal{B}(S)$, the Borel σ -algebra of S . The linear space in which this set resides is the space of signed measures $M(S)$. If x belongs to the consumption possibility set $X_j \subset M(S)$, 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 $u: X_j \rightarrow \mathbb{R}$ is weak* continuous given that S is compact. The trouble with this approach is that components of x do not have the interpretation of commodities.

We finesse this problem as follows. Let $L(S)$ be the space of lotteries on $\mathcal{B}(S)$. It like S is a compact metric space 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 $M(S)$. Having lotteries, which is how we represent insurance contracts, as points in the commodity space does not require a more complicated commodity space. Here, as in Prescott and Townsend (1984) our commodity space is $M(S)$.

In the subsequent analyses, a finite number of additional commodities are added to the insurance contract commodities. The resulting commodity space is then $M(S) \times \mathbb{R}^n$, where n is the finite number of commodities in addition to insurance contracts. In equilibrium, we find that an agent chooses either the null measure of insurance contracts (consumes no insurance) or the measure which places mass one on a single point in $L(S)$ (consumes one insurance contract of that particular type). Jones (1988) uses essentially the same commodity space in his discussion of hedonic price functions.

5. An economy with insurance

We now study 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 this possible accident. The provision of insurance contracts, however, requires resources.

Each agent is endowed with one unit of labor 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 $i \geq 0$. The agent derives utility from the consumption of a good c and from the flow of services from the durable good. The services from the durable good are proportional to the stock $k + i$ held by this 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 . The accident probabilities π are fixed and independent of actions taken by the individual. These probabilities are characteristics of agents and are public information.

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 next period stock of durable good k' 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.

Insurance claims are in the form of the durable goods and therefore are required to be nonnegative, $d_\theta \geq 0$. If there is no damage, $\theta = 0$, the claim is constrained to be zero. Thus, $d_0 = 0$. Let D be the set of claims vectors d with the properties that $d_0 = 0$ and $d_\theta \geq 0$ for all θ . An insurance contract is characterized by its claim vector and by the probabilities π_θ of the claims d_θ . An insurance contract of type $z = (\pi, d)$ can only be consumed by an agent with accident probabilities π . This is possible because an agent's π is public information. The set of contracts is $Z = \Pi \times D$.

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 labor and μ a signed measure on the set of possible contracts Z , $\mu \in M(Z)$. The commodity space is, then, defined as $L = \mathbb{R} \times \mathbb{R} \times M(Z) \times \mathbb{R}$.

There is a finite set of agent types J with $\pi_{j\theta}$ being the 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

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

Given the nonnegativity restriction on consumption, investment in the durable good, and the time endowment for labor, the consumption possibility set of a type j agent is

$$X_j = \left\{ x = (c, i, \mu, -n) \in L : c, i \geq 0, n \in [0, 1], \mu(Z) \in \{0, 1\}; \text{ if } \mu(Z) = 1, \right. \\ \left. \text{for some } z = (\pi, d) \in Z, \mu(\{z\}) = 1, \text{ and that } z \text{ satisfies } \pi = \pi_j \right\}.$$

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 accident probabilities assumed in the contract are equal to the actual accident probabilities of the agent.

There are 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

$$Y_1 = \left\{ y = (c, i, \mu, -n) \in L : i, \mu = 0, \text{ and } c, n \geq 0, \text{ and } \alpha_1 c \leq n \right\}.$$

This sector uses n units of labor to produce c units of the consumption good. The constant labor productivity in this sector is given by α_1^{-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

$$Y_2 = \left\{ y = (c, i, \mu, -n) \in L : c, \mu = 0, \text{ and } i, n \geq 0, \text{ and } \alpha_2 i \leq n \right\}.$$

This sector uses n units of labor to produce i units of the durable good. The constant labor productivity in sector two is α_2^{-1} . Sector 2 sells the produced durable good to the agents and to the insurance sector.

Sector 3. The interesting sector is the one producing 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 a large number of contracts of any type, the average claim per contract of a given type is equal to the expected claims.⁷ In addition to constant returns-to-scale we assume that there is no joint production of contracts. For a contract of type z , $\alpha_3(z)$ units of labor are needed per contract produced. These requirements are for record keeping purposes, identifying accident probabilities of the individual purchasing the contract, and identifying damages if an accident occurs.⁸ The production possibility set for an insurance firm is

$$Y_3 = \left\{ y = (c, i, \mu, -n) \in L : c = 0; \quad i, n \geq 0; \quad \alpha_3 \mu(\Pi \times D) \leq n; \right. \\ \left. \int_z \left[\Sigma_\theta d_\theta \pi_\theta \right] \mu(dz) \leq i \right\}.$$

Sector three, the insurance sector has two inputs. This sector uses a total of n units of labor to monitor $\mu(\Pi \times D)$ contracts. The productivity of labor in monitoring is $\alpha_3(z)^{-1}$ for a type z contract. This sector also acquires durable goods from sector two 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 $\Sigma_j \lambda_j x_j = \Sigma_i y_i$, $x_j \in X_j$ 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 $p_3: Z \rightarrow \mathbb{R}$ is continuous with $p_3(z)$ being the price of a contract z , for which the following conditions are satisfied:

⁷ We use the Uhlig (1989) law of large numbers for a continuum of identically and independently distributed random variables.

⁸ 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 verifications, introducing this feature is straightforward but notationally cumbersome.

- for all $\forall x \in X_j$: if $u(x) > u(x_j^*)$ then $p \cdot x > p \cdot x_j^*$, for all j
- For all $\forall y \in Y_i$: $p \cdot y_i \geq p \cdot y$, for $i = 1, 2, 3$.

This is the usual definition of competitive equilibrium.

We have limited heterogeneity to differences in the agents' characteristics, while assuming that each commodity is produced using one common technology. Like in other hedonic pricing economies this implies that the equilibrium (hedonic) price function for insurance contracts is determined by the technology. From our discussion of the insurance sector, the price of an insurance contract then is

$$p_3(z) = p_4 \alpha_3(z) + p_2 \sum_{\theta} \pi_{\theta} d_{\theta}$$

where p_4 is the wage rate and p_2 the durable goods price. We have defined the hedonic price function for insurance contracts by the supply reservation prices of contracts.

6. A proposed alternative to measure output in the insurance sector

We have shown that for an economy with insurance an insurance contract in theory can be viewed as a differentiated commodity. Given the quantities of the differentiated commodities and a set of constant prices for these commodities, the constant price product of the insurance sector can be computed in the standard way – that is the sum of the products of price and quantity over all insurance contract commodities produced. To do this a definition of the insurance contract type is needed. The nature of the automobile insurance market is that the premium depends upon a number of factors including the amount of coverage, the deductibility level, the nature of the use of the car and the car model being insured. The price of an insurance contract also depends upon the insured's characteristic such as age and sex. All factors affecting the price of the insurance contract must be included in the definition of the insurance contract commodities. All these features can be determined by an examination of the contract.

For the economy considered in the previous section, the insurance contract is indexed by the claim distribution. This suggests that the hedonic pricing function should depend on the claim distribution of an agent which purchases a contract with observable characteristics z . We take the expected value of claims, and the expected number of claims per contract as a first approximation for this claim distribution. Let (c, n) denote the vector of these two variables. There are industry organizations which collect information on claims for contracts with different observable characteristics z . The assumption is that all agents who purchase a contract with characteristic z are homogeneous with respect to their claim distribution. The insurance companies use this actuarial information in order to estimate the cost of providing a given insurance contract.

We now specify our proposed operational procedure to estimate the price and quantity data for insurance contracts with characteristics z . In the base period a representative sample of contracts is drawn. This sample is denoted I_b and i is an element of the sample. Insurance companies have computer files with information concerning the characteristics z , as these are the factors that determine the premium for an insurance contract. In addition the premium p_i and the value of claims c_i and the number of claims, in most cases zero, n_i . To summarize the first stage is to select a sample of contracts $\{z_i, p_i, c_i, n_i\}$ for i belonging to I_b .

The second step is to partition the set I_b into subsets based upon z , a vector variable which takes on a finite number of values. Thus

$$I_b(z) \equiv \{i \in I_b: z_i = z\}$$

is the partition y of the sample I_b . For each vector of characteristics z , the average values of claim values, premiums, and number of claims are computed for subsample $I_b(z)$. These averages are denoted c_z , p_z , and n_z respectively.

The third step is to use the c_z , p_z , and n_z for the base period to estimate a base year hedonic pricing function. The function estimated is

$$p_z = h_b(c_z, n_z).$$

The rationale for including these variables is that the cost of providing a contract depends upon the value of claims paid and on the number of claims.

This hedonic pricing formula will be used to value insurance contracts in other periods. To do this, the number of contracts of type z are needed for each year t such that the output of the casualty insurance sector can be computed. Thus a sample of contracts I_t is needed for each year t . We let x_{zt} be the number of contracts with $z_i = z$ in the sample I_t divided by the fraction of the contracts sampled. The c_{zt} and n_{zt} are just the average values for c_i and n_i for the sample I_t . With these variables along with the x_{zt} the output valued in base year prices x_t can be computed as follows

$$x_t = \sum_z h_b(c_{zt}, n_{zt}) x_{zt}.$$

This is our proposed measure of the real output of the insurance sector.

7. Concluding comments

Recent extensions in general equilibrium theory permit some financial contracts to be treated as differentiated commodities. In this study we explore the implications of this development for the measurement of the output of the casualty insurance sector. Our proposed scheme, we think, is operational and could be carried out at modest cost given that the data used is already in the computer data files of insurance contracts. The proposed scheme is far from perfect as any scheme necessarily is except in the highly abstract model economies of economic theory. But, an imperfect scheme that measures output directly is surely better than the current scheme which simply extrapolates base year value added using gross premiums deflated by a price index of repair costs.

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