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PUBLIC LIABILITIES AND HEALTH CARE POLICY

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ABSTRACT

Many countries have large future public liabilities attributable to health care programs. However, little explicit analysis exists about how health care policies affect these program liabilities. We analyze how reimbursement and approval policies affect public liabilities through their impact on the returns to medical innovation, a central factor driving spending growth. We consider how policies impact innovative returns through expected earnings, their risk-adjustment, and their timing and defaults through the approval process. Our analysis implies that cutbacks in government programs may raise government liabilities and expansions may lower them. We quantitatively calibrate these non-standard effects for the US Medicare program.

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1 Introduction

Many developed nations are increasingly concerned about the growth of future government liabilities in health care and how to assess the effects of changes in health policy on these liabilities. In the US, many private and public efforts have attempted to limit the growth in overall health care spending and public liabilities, including prospective payment Medicare reforms in the 1980s, the dramatic rise in managed care firms in the 1980s and 1990s, and the current expansions of consumer-oriented health care. The most recent incarnations include Accountable Care Organizations, bundled payments, and other measures of the Affordable Care Act (ACA). Despite these repeated efforts, the health care economy has grown and is predicted to continue to grow faster than the rest of the economy.

These private and public efforts to slow down spending growth run into difficulty partly because they are motivated by their impact on incentives at a given point in time rather than the impact on the growth in spending across time. For example, many argue that prospective payment or bundling reforms reduce the incentive to spend at a given time without any explicit understanding of why growth may be altered. Indeed, little explicit economic analysis exists of how various policies will affect the growth of future health care spending over time. As a result, there is little explicit analysis on how various reforms affect the present value of future public liabilities. This paper addresses this gap in the literature by offering a framework in which they can be analyzed explicitly and quantitatively.

We analyze how health care policies affect future spending growth through their impact on the returns from medical innovation. Following the work of Newhouse (1992), research suggests that medical innovation is central to the growth in health care spending. Moreover, public programs are central to driving global innovative returns, as a large share of the world's care is publicly financed in rich countries. Therefore, public reforms have large impacts on the uncertain future profits associated with medical innovation, which drive future spending growth in both the public and the private sector.

We consider cases in which the impact of government policies on medical research and development (R&D) returns comes from three different sources: expected earnings, their risk-adjustment, and their timing and "defaults" through the approval process. For the impact on expected earnings, we stress the non-monotonic effects of government expansions on innovative returns. In particular, we stress that government expansions often lower both demand prices (premiums plus copays) to raise access but also supply prices (reimbursements) through government monopsony power. This result may imply that R&D returns rise when government expansions include poorer parts of the population by raising quantity more than lowering markups. For example, Medicaid may slightly raise innovative returns in this manner. However, innovative returns fall when expansions include richer parts of the population when markups may fall more than quantity rises. For example, the single-payer European payment systems may lower innovative returns in this manner. The non-monotonic impact of government expansions across the income distribution implies that innovation incentives may rise with program cut backs and fall with program expansions.

The second way in which reforms may affect innovative returns is through risk-adjustments of expected earnings due to both private-sector risk such as the business cycle as well as public-sector risk such as future policy uncertainty. For private sector risk, if pro-cyclical earnings are undesirable (e.g., a CAPM world), a means-tested program such as Medicaid lowers risk because means-testing buffers the demand of the poor in recessions. For public sector risk, policy uncertainty surrounding new reforms may counteract expected earnings effects. An example would be the uncertainty of the ACA Medicaid expansions, which may lower R&D even though under certainty such expansions should raise R&D.

We analyze the impact common policy changes have on the present value of public program liabilities through affecting innovative returns. More precisely, we consider when the innovation incentives discussed drive the future growth rate of a public program. The present value of liabilities of any program, such as say Medicare, is determined by the discounted value of all future annual spending levels of the program. Given the non-monotonic effects of program expansions on innovation incentives, they may impact future program liabilities in non-standard ways. In particular, government cutbacks may raise future public liabilities and government expansions may lower them. This occurs when innovation incentives are negatively related to program expansion. If this is the case, then a smaller program grows faster, potentially offsetting that it started at a lower level in determining the present value of liabilities.

We calibrate these program effects using existing utilization and reimbursement data in the US. First, we show that our calibration methods performed well on the historical program expansion for the Medicare Part D program for drugs. In particular, using pre-implementation data, we calibrate the price and quantity effects and show they were close to those observed post-implementation of about a 20% fall in supply prices and about a 5-10% rise in utilization. Consequently, as prices fell more than quantity rose, innovation incentives declined with this program expansion, making differences in short- and long-run effects relevant. We then use the same type of calibration methods to assess the impact of cut-backs in the Medicare part A&B program covering hospital and physician services, and indirectly the devices and products used in supplying those services. In particular, we consider means-testing the program to a larger extent than is done presently. We calibrate the non-monotonic nature of innovative returns due to such mean-testing using existing utilization and reimbursement data. As implied by our analysis, we calibrate that cutting the program by means-testing Medicare Part A&B would raise innovative returns by about 22%. We calibrate the upward pressure this program cut would have on Medicare program liabilities.

Our analysis naturally relates to several strands of previous work. Chernew and Newhouse (2011) summarize models of health care spending growth in the literature. Baumgardner (1991) presents the role of managed care in controlling spending. Weisbrod (1991) discussed forms of third-party pricing affecting the profits and type of medical R&D undertaken, and Finkelstein (2004) and Clemens (2012) documented evidence on the link between third party coverage and innovation. More closely related to this paper, Koijen, Philipson, and Uhlig (2012) documented a large "medical innovation premium" that historically is paid to medical R&D investors and the growth of the health care sector this premium implied. Malani and Philipson (2012) considered the nonstandard impacts of reforms on clinical trials, by far the largest component of medical R&D costs. Our work extends this work by providing an explicit and quantifiable framework for analyzing the policy impacts on program liabilities. The purpose of this work is mainly positive in nature; we do not argue that more or less spending, whether privately or publicly financed, is desirable or not. Rather, we are primarily concerned with predicting how program changes affect program liabilities.

2 Health Policy and Public Liabilities: A General Formulation

Let a government program be defined by a set of policy variables represented by a vector g, such as the supply price (reimbursement), demand price (premium or copay), eligibility criteria (e.g., means-testing), and payment structures (such as fee-for-service or capitation), all of which ultimately drive quantity and markups in both the private and public sector. Let $F(g)$ denote the share of the population eligible for the public program, potentially 100% if it is a universal single-payer program. For a firm engaged in medical innovation, let $\pi_G(g)$ and $\pi(g)$ denote the per capita variable profits in the public and private sector. The overall profits from both sectors are then given by:

$$\Pi(g) \equiv F(g)\pi_G(g) + (1 - F(g))\pi(g) \tag{1}$$

This specification is general in the sense that both quantity and markups in both sectors may be affected by the government policies. This formulation considers only variable profits after marketing the innovation and not the total profits netting out the fixed costs of R&D. The argument here is that larger variable profits lead to larger R&D investments to receive those larger profits. At this level of generality, changing an element of the policy vector g affects profits as in:

$$\frac{d\Pi}{dg} = F_g[\pi_G - \pi] + F\frac{d\pi_G}{dg} + (1 - F)\frac{d\pi}{dg}$$

The first effect is if the policy affects eligibility, in which case public profits replace private ones for the newly eligible part of the population. The second is the effect on per capita profits in the two different sectors, weighted by their size. For example, consider when the policy change concerns expanded eligibility by some dimension such as age, income, or disease status. Such an eligibility change may not only affect the newly eligible through the first effect but also the per capita profits if, for example, the larger public program lowers future reimbursement. We will consider special cases of these within- and between-sector effects by specifying more precisely what policy levers are under consideration and what they imply for profitability.

2.1 Innovation Incentives and Public Liabilities

The impact of reforms on the present value of future liabilities comes from how they affect the level of spending today and from how they affect future growth rates of spending through medical innovation. Innovative returns of medical products are affected not only by yearly earnings but also by the approval process affecting the timing and nonpayment of those earnings. Approval reforms affect the "duration" (or value-weighted timing) of returns and the implicit "default" rates of R&D investments.For a given innovation with a patent life of l years, the present value is denoted $P(g)$ at the start of the patent life. If development is regulated to last for τ years, this present value discounts the annual profits in the patent window of $l - \tau$ years:

$$P(g) \equiv \sum_{t=0}^{l-\tau} \frac{\Pi}{(1+r)^{\tau+t}} = A(\tau, l)\Pi$$

where now and $A(\tau, l) \equiv \sum_{t=0}^{l-\tau} \frac{1}{(1+r)^{\tau+t}}$ is defined as the value of a dollar paid each year of the effective patent life. Profits clearly rise with the length of the patent and a rise development time has two reinforcing negative effects; it delays a shortened effective patent life[1].

[1]There are some noteworthy aspects of uncertainty in the approval process not considered here. First, given that discounting is decreasing but convex in development times, $A_\tau < 0$ and $A_{\tau\tau} > 0$,an increase in development risk may *raise* expected profits. Increased variance in development time raises the value of early profits more than it lowers the loss in later profits. Second, non-approval probablities are the analog of "defaults" on the "R&D loan" made by investors. DiMasi (2001) estimated the cumulative such default probability in 1990s of about 83% Naturally, as default probabilities raise discounting further, this lowers overall returns. The earlier in development the more sensitive the overall profits are to changes defaults vis a vis variable profits post marketing. Venture capital investors are more concerned with approval risk than investors in later rounds of funding, such as private- or public-equity, who are concerned with reimbursement

The full innovative value P is a function of policies g that includes the approval process, as well as reimbursement prices affecting variable profits once the innovation is marketed. These innovative returns drive future spending growth on the public program, and as a result the present value of future liabilities of the program. Consider when program spending in a given year is denoted $S(g)$ and assume that the growth factor in spending is a function $\gamma(P(g))$ of the returns to innovation. There are many different models that would generate a relationship between the degree to which the sector expands/contracts and incentives for innovation[2]. This reduced form relationship between innovative returns and spending growth represents that a larger incentive to innovate may either imply a larger or smaller growth in spending in the future. The present value of public liabilities, V, is given by the discounted value of current spending and its future growth:

$$V = \sum_{t=0}^{\infty} \frac{S(g)[1 + \gamma(P(g))]^t}{[1 + r]^t}$$

Direct algebra yields that a policy change affects the relative value of public liabilities according to[3]:

$$\frac{V_g}{V} = \frac{S_g}{S} + \frac{1}{r - \gamma} A\gamma_P \Pi_g$$

This says that the effect on liabilities is affected by current spending effects corrected by how the policy change affects future growth through the incentives for innovation. Approval policies affects program liabilities of the program through their effect on the degree of "effective" intellectual property protection provided (A). For example, FDA approval policies that prolong development lowers future Medicare liabilities, and policies that strengthens intellectual property raises those liabilities. If profits are not affected by the policy change $\Pi_g = 0$ or future spending growth is not affected by the incentives to innovate $\gamma_P = 0$ then naturally the effect on liabilities coincides with the effect on spending, $\frac{V_g}{V} = \frac{S_g}{S}$, because future spending growth is not affected. If there are effects on future spending growth then discounting makes it matter less to the value of liabilities, that is, $\frac{V_g}{V}$ is decreasing in r. Moreover, the closer spending growth is to the discount rate before the policy change the larger is the innovation effect on liabilities. This occurs because present values are convex in the net discount rate $r - \gamma$ because a rise in discounting lowers the present value less the larger the discount rate is. Lastly, intellectual property protection amplifies the growth effects of reforms, that is, $\frac{V_g}{V}$ is increasing in a

When spending and profits move in the same direction due to a policy change, $\frac{S_g}{S}\Pi_g > 0$,then spending reductions or expansions are associated with reductions or expansions in the value of future liabilities. When spending cuts reduce innovation incentives, then the negative spending effect is reinforced by the lower growth, $\frac{V_g}{V} < \frac{S_g}{S} < 0$ and when expansion fuels innovation liability effects are magnified, $\frac{V_g}{V} > \frac{S_g}{S} > 0$. However, when profits and public spending move in different directions due to a policy change, $\frac{S_g}{S}\Pi_g < 0$, then spending and liability effects may differ in sign so that cut-backs in spending may lead to larger liabilities and vice versa. If the cut raises profits the two effects are offsetting;

risk. Scientific or regulatory approval risk is likely to be diversifiable, but reimbsuremnt risk may be less so.

[2]For example, consider when the chance of discovery is denoted by the increasing and concave function $K(R)$ as a function of fixed RD costs R. Expected profits would be $K(R)P(g) - R$ resulting in a positive realtionship between RD and innovative return $R(P(g))$, that could be subsequently related to growth or contraction in the sector dependent on the type of RD was undertaken.

[3]This follows from $V = S(g)(1 + r)/(r - \gamma(P(g)))$ and $P(g) = A\Pi(g)$, which implies $V_g = S_g + \frac{1+r}{(r-\gamma)^2}\gamma_P A\Pi_g = \frac{S_g}{S}V + \frac{1}{(r-\gamma)}\gamma_P A\Pi_g V$

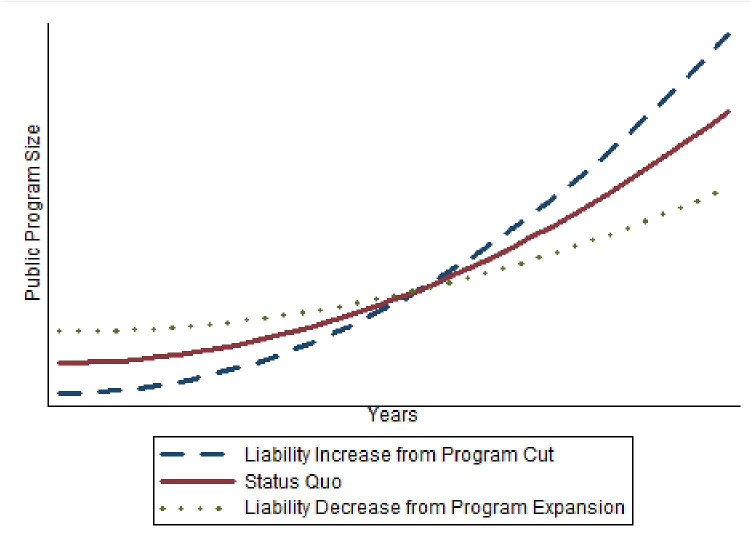

Figure 1: Level versus Growth Effect of Spending

the initially smaller program may grow faster, which may be more than fully offsetting $\frac{V_g}{V} > 0 > \frac{S_g}{S}$. In general, the innovation effects on growth may reinforce or counteract the level effects. If the level and growth effects counteract each other, liabilities may fall with a program expansion or rise with a program cutback. Because the change in the level of spending is front-loaded and growth effects are back-loaded, more discounting means the growth effects are less likely to offset spending effects .

Figure 1 shows two qualitative cases when reforms affect the present value of liabilities differently than they affect the levels of initial spending. The solid line in the middle is program spending over time in the case of no reform. The area beneath it is the present value of liabilities under the status quo. The dashed line is the scenario of a spending cut that raises R&D incentives and hence future spending growth. In this case, with a program cut, spending initially decreases. However, if the cut raises profits this raises future spending and may thus cause liabilities to rise. The other case in the figure concerns when a program expansion causes spending to rise but growth falls as may be the case when going to a universal single-payer program. In this case, liabilities may fall with the program expansion even though current spending may rise.

In the figure, when discounting becomes smaller the divergence in paths induced by changes in growth is more likely to dominate the initial spending effects. More precisely, the liability effect is determined by the change in the *relative* growth rate, which may be large for small changes in the *absolute* growth rate. For example, if the current spending of a program is cut 20%, then if growth rates go from 3% to 4%, this entails a relative growth rate difference of 33%, which may offset the spending cut under common discount rates.

This discussion concerned the case when future profits raised spending through innovation. However, the discussion does not preclude that there may be a negative relationship between profits and spending growth. An example of when future profits may be associated with lower spending growth is when innovation leads to lower real prices of health care and demand is inelastic, say when drug spending replaces hospital services. In most of our discussions, however, we will consider positive effects of profits on spending growth motivated by historical evidence relating medical innovation and spending growth.

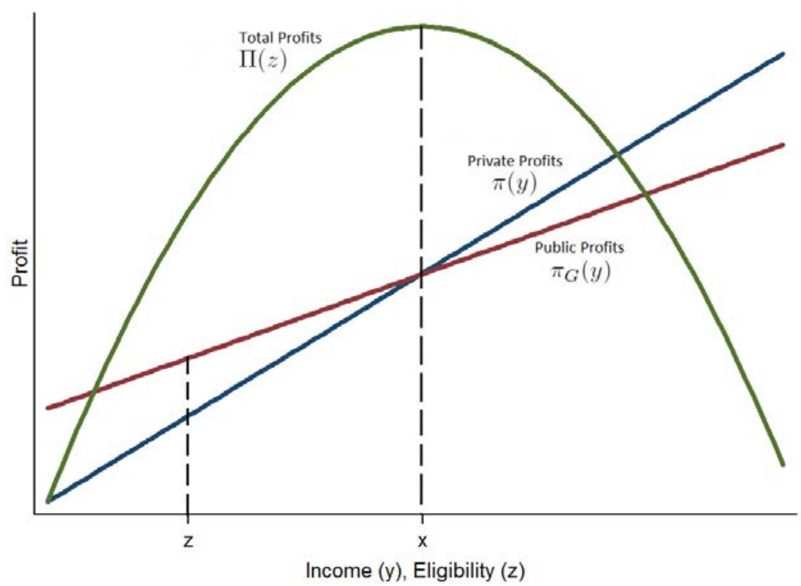

Figure 2: Profit by Sector

3 Program Changes and Public Liability Effects

The general formulation above needs to be specified in more detail to study specific program changes. We consider the impact of expanding public coverage across the income distribution as well as changes in reimbursement and copays altering the supply and demand prices the program induces.

3.1 Changes in Eligibility

We argue that income-based eligibility expansion has important non-monotonic effects on innovative returns. Let $\pi_G(y)$ and $\pi(y)$ denote per capita profits in the two sectors for a given level of income y. Figure 2 shows the case we will assume throughout that profits rise in both sectors but are higher in the public sector for the relatively poor, who buy more care with lower demand prices, and higher in the private sector for the relatively rich, who may buy care at higher supply prices outside the program. In this case, we have that $\pi_G(y) > \pi(y)$ for $y < x$ and $\pi_G(y) < \pi(y)$ for $y > x$ for some level of income x at which the two coincide.

For a given income distribution $F(y)$ with density $f(y)$, a means-tested program may be defined by a cutoff level of income z below which eligibility occurs, making a share $F(z)$ eligible and $1 - F(z)$ ineligible. For example, in the US multiples of the federal poverty line are often used as a Medicaid eligibility cutoff. The total profits across the public and private sector for a given level of eligibility are then:

$$\Pi(z) = \int_{y=0}^{z} \pi_G(y) f(y) dy + \int_{y=z}^{\infty} \pi(y) f(y) dy$$

As depicted in Figure 2, the total profits peak where per capita profits cross at x. Profits increase below x by bringing in the poor at larger profits, and decrease above x by bringing in the rich at lower profits.

More precisely, the marginal impact on profits from raising eligibility is:

$$\frac{d\Pi}{dz} = f(z)[\pi_G(z) - \pi(z)]$$

and is thus positive below x and negative above x. As a result, there is a bell-shaped non-monotonic relationship between profits and eligibility whereby profits first rise and then fall with eligibility.

A special case of these overlapping profits occurs when expanded eligibility for public coverage may replace either private insurance with profits $\pi_I(y)$ or uninsurance with profits π_U. If we denote by $I(y)$ the increasing private insurance rate as a function of income the profits in the private sector are:

$$\pi = I\pi_I + (1 - I)\pi_U$$

Consider when profits among privately insured and uninsured rise with income but vanish without income; $\pi_I(0) = \pi_U(0)$. Then if insured per capita profits rise above public per capita profits at some point as income rises, the overall private profits will rise above public profits as well if the insurance rate I rises to full uninsurance for large enough income. As a special case of above, the profits are non-monotonic as a function of eligibility.

3.1.1 Markup and Quantity Effects from Eligibility Changes

In the most general case, policies g may affect quantities, prices, and costs. Consider when overall profits are driven by the medical care quantities or utilization (m), with reimbursement (supply prices) p_S and p'_S in the public and private sector, premiums and co-pays (demand prices) p_D and p'_D, and production costs c:

$$\Pi(g) = F[(p_S - c)m_G(p_D)] + (1 - F)[(p'_S - c)m(p'_D)] \tag{2}$$

The intermediary relationships between payers and providers are therefore subsumed in this particular specification through the direct relationship between government policies and profits that result from the quantity and markups implied by any such intermediary relationships. A medical product may be used more if government reimbursement of doctors and hospitals is higher. For example, in the US Medicare program, the producer may sell to hospitals that participate in part A, doctors in part B, private payers in part C, or drug plans in part D. In this case, the quantities and prices of the formulation above may then be interpreted as those induced by the policies and regulations g governing the four programs. This formulation therefore merges the effects of provider adoption of innovations developed. The effect of supply prices on innovation may be direct when the government sets administrative price for drugs and biologics directly. Alternatively, it may set prices for procedures by providers that then determine the willingness of those providers to demand technologies under such reimbursement rates, e.g. a more generous DRG rate to hospitals may raise demand for technologies within that DRG. Indeed, device manufacturers in the US are often more concerned with marketing to providers than payers for this reason. In addition, non-patented procedural innovation is very often accompanied with device innovation in the sense that the new procedure involves a new device. This implies that innovative returns of non-patentable procedural innovation are often protected in a similar way to that of patentable medical product innovation, whether drugs or devices. In sum, the formulation above assumes that the end payer, not intermediary payers, matters for for innovation incentives.

To consider eligibility effects in this formulation assume demand is a function of price and income

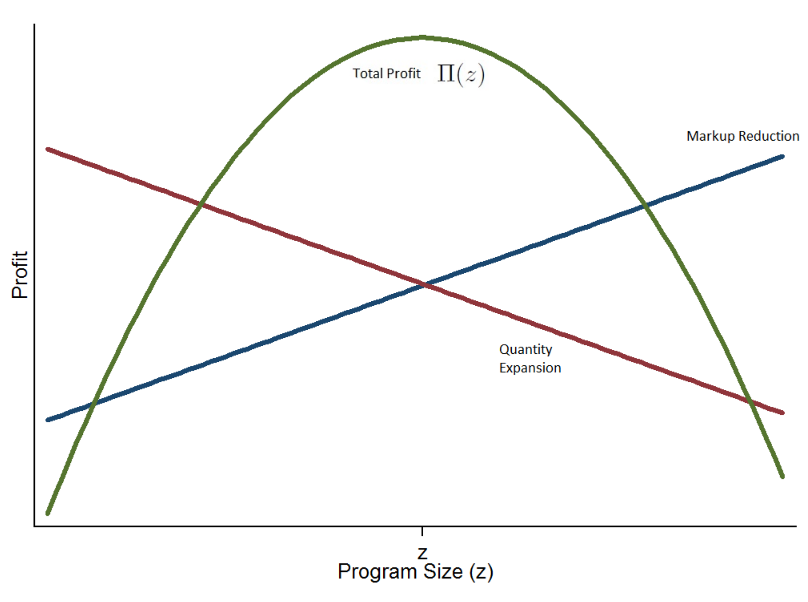

Figure 3: Profits Broken into Quantity Expansion and Markup Reduction

so that profits are $\pi_G(y) = (p_S - c)m(p_D, y)$ and $\pi(y) = (p'_S - c)m(p'_D, y)$. The effect of an expansion of eligibility on overall profits is then:

$$\frac{d\Pi}{dz} = f(z)[(p_S - c)m(p_D, z) - (p'_S - c)m(p'_D, z)]$$

Changes in the levels of eligibility have two offsetting effects on overall profit. First, the program raises utilization by lowering demand prices which has a positive effect on profits. Second,the public program may lower supply prices which has a negative effect on profits. Thus profits rise or fall depending on whether the positive utilization effect dominates the negative markup effect:

$$\frac{d\Pi}{dz} > 0 \Leftrightarrow \frac{m(p_D, z)}{m(p'_D, z)} \geq \frac{(p'_S - c)}{(p_S - c)}$$

Now if subsidy has the greatest impact on the utilization of the poor, $m_{py} > 0$, then the quantity effect likely dominates for the poor and the markup effect likely dominate for the rich.

These effects are illustrated in Figure 3, which depicts the quantity gains and markup reductions associated with a public program.

At the extreme left when the poorest people are being added, the quantity effect will likely dominate the markup effect. At the other extreme is when very rich individuals are added, in which case their demand will not be affected much by the lower copay in the public program but their markup will be lowered if they are subsumed under a government buyer. The positive impact may be exemplified by US Medicaid expansions and the negative impact by universal European single payer programs. The end result is a bell-shaped profits curve as a special case of the crossing per capita profits in the two sectors.[4]

[4]Although overall eligibility expansions may have large and non-monotonic innovation effects, the most recent eligibility reforms in the US may not have altered such incentives much. The recent ACA reforms eligibility criteria for health insurance subsidies were widened to expand both the Medicaid population as well as well as the private coverage population through exchange subsidies. CBO estimates that an increase in insurance coverage from ACA by about 8 percent, about

These effects can be expanded to include eligibility effects on the demand and supply price of the program, such as for example falling reimbursements with larger program size. Denote by $\pi_G(z) \equiv (p_S(z) - c)m(p_D(z), z)$ the profits on program participants as a function of eligibility when eligibility affects pricing. Then the total effect of eligibility on profits becomes

$$\frac{d\Pi}{dz} = f(z)[\pi_G(z) - \pi(z)] + F\frac{d\pi_G}{dz}$$

A program expansion now has two effects; the first is the marginal impact of those newly added to the program as before and the second is through the price effects of the ones already in the program. For example, if one were to means-test a previously universal program, then this would first entail a rise in profits for the richer part of the population no longer in the program. In addition, if program size drives down reimbursements there would be a second reinforcing effect due to the increased profits of those remaining in the program.

3.1.2 Liabilities and Changes in Eligibility

For any public program, total spending is the size of the eligible program population times the per capita spending of its beneficiaries. In our framework, program size and per capita spending are given by the fraction eligible and the reimbursement and utilization of the eligible populations care:

$$S(g) = Fp_S m_G \tag{3}$$

Consider the effect of changes in eligibility, z, when those changes may simultaneously affect future per capita spending levels through innovation.As discussed previously, changing eligibility impacts the growth of public liabilities V through the current level of public spending and the effect on profits that determine future spending growth:

$$\frac{d\Pi}{dz} = f(z)(\pi_G - \pi) \qquad \frac{dS}{dz} = f(z)m_G p_S + F(z)m_G\frac{dp_s}{dz}$$

Both profits and the level of spending may increase or decrease depending on the marginal income level where eligibility expansions occur. For profits, if eligibility is expanded marginally for the poor, then the profit effect may be positive but if eligibility is expanded for the rich, then profit may fall. For spending, increased eligibility can raise or reduce spending levels depending on whether the rise in beneficiaries is offset by the fall in the reimbursement from greater monopsony power. Public liabilities will rise (fall) with eligibility if both the spending and innovation effects increase (decrease) $\frac{dS}{dz}, \frac{d\Pi}{dz} > 0$ (< 0). However, public liabilities will fall with increased eligibility or rise with decreased eligibility if the two effects have different signs. When $\frac{dS}{dz}, \frac{d\Pi}{dz} < 0$, then cut backs may raise liabilities and expansions may reduce them.[5]

half coming from Medicaid and the other half from increased private coverage. Many studies exist on the impact of Medicaid on health care spending centered at about a 25% increase in spending from such coverage. Under the same maintained effect of private coverage, this would thus simply result in a 2 percent increase in overall spending, a modest growth especially taking into account that the US market is only roughly half of the world market driving innovation, which we discuss further below.

[5] The issue arises whether a full public program leads to lower profitability than no program at all. As long as the profits fall with larger coverage, this is not central to whether marginal changes in means-testing raises or lowers liabilities. The important point is that when profitability falls with program eligibility in the relevant range, marginally larger programs may mean reduced innovation incentives and potentially a reduction in the present value of liabilities.

3.2 Changes in Demand and Supply Prices

Now consider when the policies are $g \equiv (p_S, p_D)$ representing reimbursement to providers or innovators (supply price) and the premiums or copays to patients (demand price). For any subsidy program, the supply is larger than the demand price because the government pays for the wedge between them. Therefore, unlike in the private sector where supply and demand prices coincide, increasing the supply price raises price without lowering quantity, and thus has the monotonic positive profit effect. Increasing the demand price discourages utilization without affecting markups and thus has the monotonic negative profit effect.[6]

$$\frac{d\Pi}{dp_S} = F\frac{d\pi_G}{dp_S} = Fm_G > 0 \qquad \frac{d\Pi}{dp_D} = F\frac{d\pi_G}{dp_D} = F(p_S - c)\frac{dm_G}{dp_D} < 0$$

When supply and demand prices vary freely, textbook arguments imply that demand subsidy programs raise the equilibrium supply price and lower the equilibrium demand price, thereby raising profits (see, e.g., Varian (2010)). What is less recognized, but relevant to health care, is that many times expansions in demand subsidy programs will simultaneously lower both demand and supply prices. The total effect on profits of the expansion of a demand subsidy program then depends on whether greater quantity through lower demand prices dominates lower markups through reductions in supply prices.

$$\frac{d\Pi}{dp_D}(dp_D) + \frac{d\Pi}{dp_S}(dp_S)$$

For example, Medicare in the US raises utilization by expanding the pool of customers, but they do so at discounted prices, making the profit effects ambiguous. An example of the dual price effects of government expansions is the recent Medicare Part D program for outpatient drugs in the US. This program lowered total demand prices (premium plus copay) dramatically, while at the same time instituting pricing transparency regulations that implied lower supply prices to manufacturers. [7] There exist an ongoing current debate about the desirability of lowering supply prices further through direct price negotiations between the US government and manufacturers. This is suggestive of the European experience in which government expansions reduce incentives for innovation.

These arguments maybe extended to consider interactions between public pricing and the private market. For example, fee schedules in the public sector may be adopted in the private sector, or if there are cross-subsidies, private prices may rise when public prices fall. The total effect of public pricing when there are also private market effects is given by:

$$\frac{d\Pi}{dp_S} = F\frac{d\pi_G}{dp_S} + (1-F)\frac{d\pi}{dp_S} \qquad \frac{d\Pi}{dp_D} = F\frac{d\pi_G}{dp_D} + (1-F)\frac{d\pi}{dp_D}$$

If utilization or markups respond in different ways in the two sectors, the effects of changes in public pricing may differ. A rise in public profits from increased public reimbursement may potentially be offset by reductions in private profits, for example if cross-subsidies fall more. Likewise, the fall in public profits from higher copays may potentially be offset by higher private profits if, say, program

[6]Total demand prices (premium plus co-pays) are reduced by a public program even though co-pays alone may be higher or lower than in the private sector. For example, Medicare part D sometimes have higher co-pays than private coverage, but it subsidizes the premium by about 75%.

[7]This is consistent with the overall findings of several papers that found a rise in utilization and fall in prices upon Part D implementation (Yin *et al.* (2008), Lichtenberg and Sun (2007), Neuman *et al.* (2007), Duggan and Scott-Morton (2008), Ketcham and Simon (2008), Yin *et al.* (2008)).

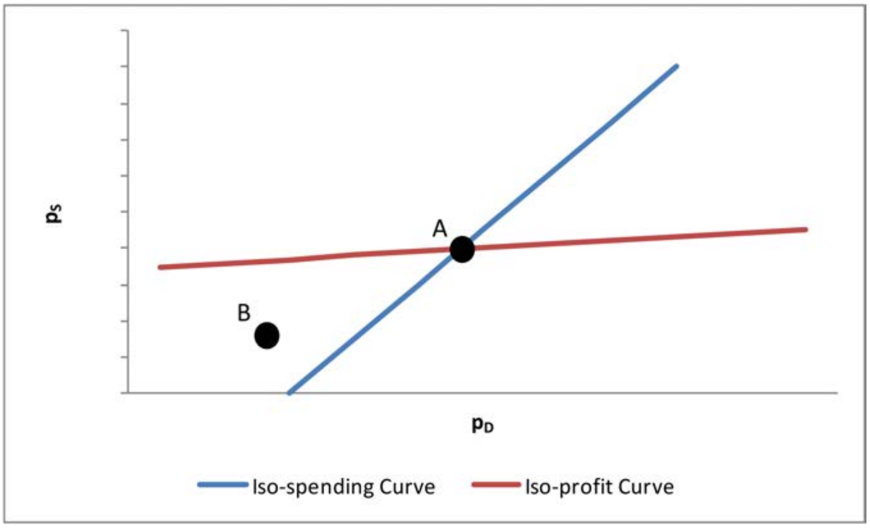

Figure 4: Levels vs Growth Effects for Price Reforms

participants go outside the public program as a result.

3.2.1 Liabilities and Changes in Demand and Supply Prices

Consider the effect of changes in public prices on program liabilities. Figure 4 depicts iso-profit curves as a function of the two prices, $\{(p_D, p_S) : \Pi(p_D, p_S) = \pi\}$. The curves involve higher profit levels to the northwest in the figure as supply prices raise profits and demand prices lower them. The implementation of a program that lowers both demand and supply prices from point A to point B concerns a southwest shift in the figure and thus depends on whether the slope of the iso-profit curves will raise or lower profits. Determining if profits increase depends on whether the utilization gains dominate the markup reductions.

The figure also depicts the iso-spending curves $\{(p_D, p_S) : S(p_D, p_S) = s\}$ of the public program. Changes in the levels of public program may be reinforced or offset by changes in growth in spending due to higher innovative returns depending on whether they have the same or different signs. Overall profits and public spending are related by the fact that the public profits come from public spending as in:

$$\Pi = F\pi_G + (1 - F)\pi = S[\frac{p_S - c}{p_S}] + (1 - F)\pi$$

Without any interactions between the private and public sector, the overall profit effects of price changes are likely to be the same sign as the public program effects. In other words, lower reimbursements lower both public spending and profits, and lower copays raises both public spending and profits. However, when a public program expansion lowers both demand and supply prices, it is possible that the total effect on growth versus levels may differ as indicated in Figure 1. This occurs when slopes of the iso-profit line and the iso-spending line differ substantially. When they do differ, there is always a reform with reductions in two prices that affects spending in the opposite direction of profits. When this is the case, level effects are counteracted by growth effects.

An important case when iso-profit and iso-spending slopes may differ is when there are interactions between private and public pricing. In this case, the level and growth effects on public pricing reforms may differ. Consider when the private price is $p(p_D, p_S, g)$ as a function of the public pricing. For example, fee schedules in the public sector may be adopted in the private sector or a direct government intervention with price controls in the private sector may take place in conjunction with public price changes. Now the total effect of prices on profits are given by:

$$\frac{d\Pi}{dp_S} = F\frac{d\pi_G}{dp_S} + (1-F)\frac{d\pi}{dp_S} = \frac{dS}{dp_S} + (1-F)[\frac{dp}{dp_S}][\frac{d\pi}{dp}]$$

$$\frac{d\Pi}{dp_D} = F\frac{d\pi_G}{dp_D} + (1-F)\frac{d\pi}{dp_D} = \frac{dS}{dp_D} + (1-F)[\frac{dp}{dp_D}][\frac{d\pi}{dp}]$$

Thus, the difference in the profit and spending effects $\frac{d\Pi}{dp} - \frac{dS}{dp}$ are attributable to spillovers in the private market. Because price effects on spending are ambiguous when demand slopes downward, when there are interactions between the private and public sector growth effects may offset level effects. Offsetting occurs when reimbursement increases in the public sector lowers profits in the private sector or when copay increases in the public sector raise profitability in the private sector. One set of interactions between the two sectors that may occur is through cross-subsidies where lower public prices raise private prices. Another interaction is through competitive effects on providers when a higher public price raises private prices in order to compete for patients. Regardless of the sign and the magnitude of the interactions, they drive a wedge between spending and profit effects and thus between levels and growth effects.

4 Risk-Adjustment of Innovative Returns

The previous discussion focused on how reforms affected the expected earnings from innovation. This section discusses the implications of non-diversifiable systematic risk on the risk-adjustment of those earnings. We consider a standard stochastic discount factor (SDF) framework for valuing innovative returns under uncertainty (see, e.g., Cochrane (2002)). In this framework, there is a discount factor that varies across future states of nature to discount the payoffs in each of those states. We consider when future uncertainty comes from both the private sector, in terms of the business cycle, or the public sector, in terms of political risk concerning the government policy that will prevail. For example, such policy uncertainty may be argued to be present currently both in the US, due to the implementation of the ACA, and in Europe, due to the fiscal pressures of many countries.

Consider first the general valuation problem when a given random vector X affects profits according to $\Pi(x)$ as well as the SDF $M(x)$ by which future claims in a given state x are valued. The value of the firm in the first period equals future profits in each state discounted by the SDF:

$$E[M\Pi] = \frac{E[\Pi]}{1+r} + Cov(M, \Pi)$$

Here we have used that a certain payment of one dollar in each state has value $E[M] = 1/(1+r)$ with r denoting the risk-free interest rate. The value of the firm is made up of expected earnings or earnings (the first term) that are risk-adjusted by how much the flows covary with future discounting (the second term). Downward risk-adjustment of expected earnings occurs when the profits of medical innovation pays off more in "good" times , which are discounted more than "bad" times: $Cov(M, \Pi) < 0$. This standard formulation does not assume that firms are risk-averse but rather that owners of firms are risk averse and thus take into account how the risk of the firm affects their overall portfolio risk. A larger return required from investors to hold the firm raises the cost of capital of the firm and hence lowers its R&D investments into new medical innovations. Generally, a health care policy thus affects the present value of profits from medical innovation through both expected profits and the risk-adjustment of those profits:

$$\frac{dE[M\Pi]}{dg} = \frac{dE[\Pi/(1+r)]}{dg} + \frac{dCov(M,\Pi)}{dg}$$

The first is due to the expected earnings effects of reforms, such as those discussed in the previous section. The second term is due to the effects reforms have on the risk-adjustment of earnings which we address in more in detail here.

4.1 Risk-Adjustment under Private Sector Risk

Consider first when the uncertainty stems from private sector risk. Generally, risk-adjustment associated with the cycle will depend on income effects of the subsector in question. Cyclical sectors of health care, such as preventive and elective care, are predicted to lower returns and raise investments compared to less cyclical sectors, such as curative or emergency medicine. To analyze how health policy affects risk-adjustment consider when the aggregate private sector risk is the state of the economy or business cycle. We represent this as the mean income e in the income distribution $F(y;e)$ which is thereby increasing in y but assumed decreasing in e as a larger mean income means a lower share of the population has income below a certain level.

Under a given level of eligibility z the size of the eligible population is then $F(z;e)$ and the profits for a given state of the economy are:

$$\Pi(e) = F(z;e)\pi_G(e) + (1 - F(z;e))\pi(e)$$

where $\pi_G(e) \equiv E[\pi_G(y)|y \leq z; e]$ and $\pi(e) \equiv E[\pi(y)|y > z; e]$ are the average per capita profits in the two sectors given a state of the economy. We assume that countercyclical earnings are desirable so that the SDF $M(e)$ is decreasing in the state of the economy. This implies that when profits $\Pi(e)$ increase (decrease) with the state of the economy, downward (upward) risk-adjustment of earnings occurs.

Figure 5 below depicts how recessions and booms affect such risk-adjustment. It depicts the per capita profits in the two sectors as a function of income as discussed in previous sections. Without a public program the profits vary according to the average along the private profit line, $\pi(y)$. The slope of the private profit line is higher than the slope of the public one so that overall profits covary to the maximum degree with the cycle, which implies the largest amount of risk-adjustment.

Now consider how a means-tested public program affects the risk-adjustment of earnings. For a means-tested program, the size of the eligible population covaries negatively with the economy, as recessions raise the eligible population; $F(z;e)$ falls in e.[8] For example, the Medicaid program has counter-cyclical participation, as opposed to say the Medicare program where eligibility is by age, and thus does not depend on the cycle. In Figure 5, the overall profits are now made up from both sectors. Moreover, for some disease classes, such as say HIV, the share of demand coming from Medicaid dominates and is highly cyclical. The darker part of the public profit line are for those eligible for the

[8] For recent empirical work that implicitly relates to this risk, see Cawley *et al.* (2011) who found a limited effect of the recent "great recession" on overall insurance. Private coverage dropped at the same time Medicaid coverage expanded in this recession.

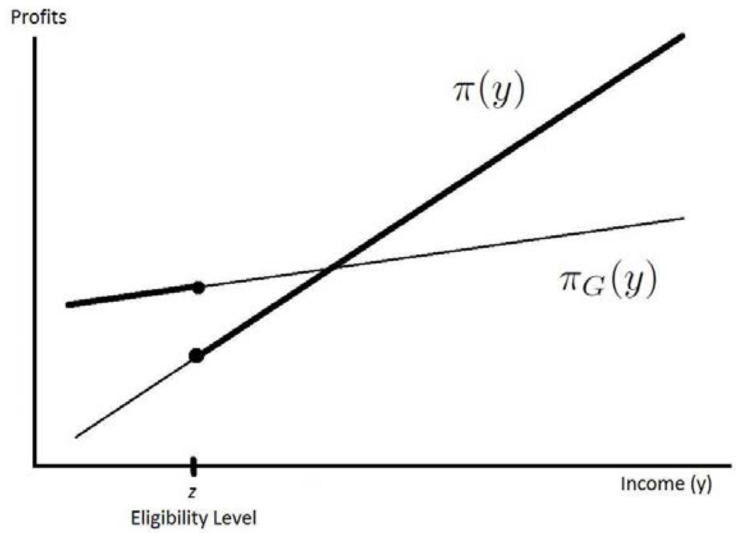

Figure 5: Means-Testing and the Business Cycle

program ($y < z$) and the darker parts of the private profits are for those not eligible ($y > z$). Thus, the overall profits are a mix of the two darker lines dependent on the income distribution. When a recession hits there are two effects. People who were on the private profit line jump up to the public profit line providing a counter-cyclical boost to profits because some poor become eligible in recessions. This effect is counteracted by the fact that profits fall for those not changing eligibility with the cycle.

More precisely, business cycle risk can be broken down into two components: one due to eligibility risk and one due to risk in per capita profits as in:

$$\frac{d\Pi}{de} = \frac{dF}{de}[\pi_G - \pi] + F\frac{d\pi_G}{de} + (1 - F)\frac{d\pi}{de}$$

The first term shows that booms contract eligibility and the two remaining terms show that booms affect per capita profits. The cyclicality of per capita profits is weighted by their relative sizes so naturally if an innovation's demand is financed more by Medicaid, public sector per capita risk matters more.

There are several factors which determine this overall profit effect of the cycle. First, the location of the innovation's demand in the income distribution matters; means-testing buffers the demand for products with patients near eligibility, e.g. HIV patients financed by Medicaid, more than it does for product with relatively richer patients. Second, the income elasticity in both sectors is central, whether conditional on coverage or due to changes in employment-based coverage when the cycle covaries with employment. Some forms of care are more sensitive to the cycle such as preventive and elective care compared with curative or emergency care. Third, recessions may induce governments to restrict reimbursement and copays, which may dampen the counter-cyclicality due to eligibility expansions. For many European countries with single payer systems this is taking place currently and the cyclicality of markups is more important than no changes in universal eligibility. Lastly, under the maintained assumption that per capita profits in the public sector are less sensitive to income than those in the private sector, reflected in the lower slope in the figure above, a larger public market share of the product means less of a downward risk-adjustment.

Pricing reforms, in terms of changes in supply or demand prices (p_S, p_D), also affect the impact of the business cycle. Because profits are monotonic in the two prices, changes in either of them shift the public sector line up or down. This may increase or decrease the sensitivity of profits to the cycle dependent on the price change considered. For example, more generous reimbursement lifts the public sector profit line upwards, thereby providing less sensitivity to the cycle and lower risk-adjustment partly because the boost of eligibility in recessions raises profits more.

4.2 Risk-Adjustment under Public Sector Risk

When the policy itself is uncertain it may be represented by a random variable X with distribution $K(x; g)$ where the previous vector of policies g we now interpret as a set of parameters of this distribution. Reforms under policy uncertainty affect the distribution of policy outcomes, with the special case of the previous analysis of certain policies concerning the degenerate case with no variability; $K = 1_{\{g\}}$.

Consider when there is uncertainty about future public per capita profits $\pi_G(x)$ and reforms affect the distribution of these profits. For example, this may be the case when there is uncertainty about future reimbursement rates, copays, or any other regulations that affect per capita profits in the public program. Under public sector risk, the value of profits is:

$$E[M\Pi] = \frac{E[\Pi]}{1+r} + Cov(M, \Pi) = \frac{FE[\pi_G] + (1-F)\pi}{1+r} + FCov(\pi_G, M)$$

This equation has the direct implication that risk-adjustment of returns is proportional to the public program's share of demand for the innovation. A larger public share means a larger exposure to systematic government risk. For example, firms whose products have larger market shares in Medicare and Medicaid would be risk-adjusted more as they are more exposed to, say, reimbursement shocks.

Generally, new policy activity will introduce both changes in the expected mean level of the policy, but also potentially raise the variance or covariance of the policy due to the new more uncertain nature of what policy will eventually prevail. Consider when uncertainty is represented by a normal distribution, $N(x; g)$ and the policy variable represented by the vector $g = (\mu, \sigma, v)$ of its mean, standard deviation, and covariance with the SDF M. Now reform initiatives may impact expected per capita profits $E[\pi_G]$ through the mean, μ, and variance, σ, in a reinforcing or counter-acting manner. The effect of a change in the mean will depend on the first-derivative of $\pi_G(x)$ and the impact of the increase in risk will depend on the second derivative of $\pi_G(x)$.

Consider the impact of uncertain eligibility reforms as captured by the normal distribution $N(z; g)$ over future eligibility levels. Assume as discussed before that profits as a function of eligibility, $\Pi(z)$, are a bell-shaped function which is concave; the first derivative decreases by first being positive and then negative; $\Pi'' < 0$. If we ignore any covariance with stochastic discounting, the expected eligibility first raises and then lowers expected profits; $E[\Pi]$ first rises then falls with μ. However, the future eligibility risk always lowers expected profits; $E[\Pi]$ falls with σ. An example would be the recent Medicaid expansions under ACA; the mean effect likely raised expected profits but the uncertainty of ACA lowered expected profits and R&D investments. Generally, the risk-adjustment due to the uncertainty surrounding new eligibility reforms is likely to be negative.

Consider now the impact of uncertain future reimbursement reforms when the uncertain policy is the supply price $x = p_S$ with a distribution $N(p_S; g)$. Changes in its distribution through $g = (\mu, \sigma, v)$ represents changes in expected future reimbursement rates, the degrees of uncertainty over future reimbursement, and the covariance of reimbursement with stochastic discounting. In this case it follows that:

$$E[M\Pi] = \frac{F(\mu - c)m_G + (1-F)\pi}{1+r} + Fm_G v$$

As a result, reforms have the following effects on profits:

$$\frac{dE[M\Pi]}{d\mu} = \frac{Fm_G}{(1+r)} \qquad \frac{dE[M\Pi]}{d\sigma} = 0 \qquad \frac{dE[M\Pi]}{dv} = Fm_G$$

The mean effect is as discussed in previous sections. Since reimbursements mark up each unit of utilization, an increase in the expected future reimbursement matters more for public programs with higher total utilization. Because of the linearity in the supply price, reimbursement risk *per se* does not affect expected profits in this formulation. However, a change in the covariance with discounting does raise risk-adjustment and does so again proportional to the total utilization in the public sector.

Related to the last effect, Koijen *et al.* (2012) documented a very large "medical innovation premium" of about 4-6% annually for publicly traded medical R&D firms in the US the last 3 decades.[9] If investors require a premium for holding the additional risk of the medical R&D sector, this reduces medical R&D investments, whose returns must at least cover this premium paid to investors. In the formulation above, such a medical innovation premium comes from the covariance term $Cov(M, \Pi) < 0$. Koijen *et al.* (2012) analyzed the implications of such a premium for the growth of the health care sector when the premium reflected markup uncertainty in the sense that supply prices were negatively correlated with discounting $v = Cov(p_S, M) < 0$.

5 Domestic Health Care Policy and World Innovative Returns

Innovation incentives are determined by world returns. The larger the share of world returns a reformed domestic program affects the larger the change in innovation incentives that reform produces. Put differently, reforms in a small or poor country will not affect innovative returns much compared to changing the US Medicare program. By the same reasoning, the US states serving as "laboratories" for US federal reforms will not be highly informative about one of the central impacts of those federal reforms: how they affect spending growth induced by innovation.[10]

Consider when N_1 denotes the potential size of the population under the reformed program and N_0 and Π_0 denote the size and per capita profits of the world population outside the program. The population outside the program may be inside the country of the program being reformed. For example, for Medicare reforms the nonprogram population would include both the nonelderly within the US and all populations outside the US. The aggregate world profits Π_w are given by:

$$\Pi_w \equiv N_0\Pi_0 + N_1\Pi = N_0\Pi_0 + N_1[F\pi_G + (1-F)\pi]$$

Naturally, the effect of any reform on the absolute and relative world profits falls the less significant the

[9] The risk-adjustment of returns $R \equiv \Pi/E[M\Pi]$ rather than prices comes from using $E[MR] = 1$. Applying this to the riskless asset, one obtains $E[MR - R_f] = 0$ where R_f is the risk-free interest factor. This in turn implies the risk-premium formulation $E[R] - R_f = -R_f Cov(M, R)$ which says when profits are high when the SDF is low (profits pay off in good times) larger excess returns are required.

[10] Consistent with this argument; Kolstad and Kowalski (2012) find no growth effects of the reforms in the state of Massachusetts, while the similar reforms embedded in the national ACA will clearly have large effects on innovation incentives.

program demand is relative to world demand:

$$\frac{d\Pi_w}{dg}/\Pi_w \equiv \frac{N_1 \frac{d\Pi}{dg}}{N_0\Pi_0 + N_1\Pi}$$

This has the direct implication that the future R&D effects of reforms must be evaluated in how they interact with any simultaneous other changes in world innovative returns. For example, innovative returns may rise over time through the growth of emerging markets, even if Medicare is reformed to reduce its per capita profits. Put differently, world markups may be declining in developed markets at a slower pace than world quantity is rising in emerging markets. Just as policies of a small single European country today do not affect world profits and innovation much, the US may affect innovation less over time even though it dominates world profits today. In addition, if the flow of new innovations occurs irrespective of US reforms because of the market size expansion of emerging economies, this alters optimal US policy.

In addition, domestic versus world returns to innovation have a bearing on attributing domestic liabilities to domestic reforms or other factors. One such factor is aging, which existing growth accounting has argued does not substantially contribute to total spending growth (see Newhouse (1992) and Zweifel *et al.* (1999)). Indeed, as an anecdotal confirmation the US population is younger than other rich countries but spends more on health care. This analysis has been an accounting exercise tracing out how domestic aging patterns and age profiles contribute to overall domestic spending growth. However, innovation and growth in domestic per capita spending is driven by *world* aging as opposed to a given country's domestic aging. More precisely, consider when the two groups above represent two countries with growth factors A_0 and A_1 induced by aging, then the sizes of the populations are $N_0A_0^t$ and $N_1A_1^t$ after t years. Now consider a growth rate $\gamma(\Pi(A_0, A_1))$ of domestic spending as a function of world aging that drives world innovative returns. The value of public liabilities for the first country is then:

$$V_1 = \sum SN_1A_1^t \frac{[1+\gamma(\Pi(A_0, A_1))]^t}{[1+r]^t} = SN_1 \left[\frac{1+r}{1+r-\beta A_1[1+\gamma(\Pi(A_0, A_1))]}\right]$$

This implies that domestic aging has a dual effect on domestic liabilities; domestic aging (A_1) affects the people on the domestic program but world aging (A_0 and A_1) affects its per capita growth rate in spending through innovation. This makes domestic aging assessments misleading; a country may have no aging ($A_1 = 1$) but be greatly affected by world aging through medical innovation ($A_0 > 1$) as would be the case for some European countries. To illustrate this point, consider the US Medicare program, which according to the Centers for Medicare & Medicaid Services has doubled in its beneficiaries since 1980 but risen about 12 times in aggregate spending. According to domestic growth accounting, this suggests that per capita spending growth rather than aging is far more important to aggregate Medicare spending growth. However, according to the World Health Organization, the world's elderly population doubled during the same period, raising innovative returns in absolute terms dramatically. It therefore seems an open question whether market size expansions through world aging may play a larger role in explaining Medicare spending growth than currently estimated. Indeed, existing evidence by Acemoglu and Linn (2004) suggests that a doubling in Medicare aging alone would be associated with a 400-600% growth in medical innovation, which could explain part or all of the growth in per capita spending of the program.

6 Calibration of Effects of Medicare Program Changes

In this section we calibrate the effects of future program changes to Medicare Part A&B. For validation purposes, we first show that our calibration methods using pre-implementation data performed well at predicting the effect of the Medicare Part D program for drugs; Calibrated revenue effects were close to the revenue effects estimated for the program change. We then use the same type of calibration to assess the impact of substantially means-testing Medicare Part A&B covering hospital and physician services, and indirectly the devices and products used in supplying those services. We analyze how means-testing Medicare Part A&B would affect innovative returns and find that it would raise them by about 22%. We calibrate the upward pressure this means-testing has on Medicare program liabilities despite cutting the program.

6.1 Expansion of Medicare Part D as Validation of Calibration Methods

We first calibrate the revenue effects of Part D of Medicare using observed parameters prior to when the program was implemented, and compare those to estimated program effects in the literature. A simple back of the envelope calculation is illustrative of why our calibration matches the observed program effects on revenues. For the price effects, consider when supply prices fall with eligibility linearly. In 2003, the Medicaid prescription drug rebate was about 31 percent with Medicaid enrollment at 18 percent of the population according to CBO (2005). We predict Part D enrollment to be 8 percent of the population, so, with linearity, the prescription drug rebate is 44 percent of 31 percent, or 14 percent.[11]

For the utilization effects, consider when insurance coverage produces a 50 percent increase in prescription drug utilization as estimated by Manning *et al.* (1988). Since 34 percent of the elderly do not have prescription insurance before Part D was implemented and the literature estimates that in general 63 percent of uninsured individuals take up public coverage when eligible, 21 percent of the elderly population is predicted to switch to insurance coverage.[12] A 50 percent increase in utilization for 21 percent of the elderly population implies an overall utilization effect of about 11 percent for the elderly. These price and utilization effects are in line with the estimates in the literature using post-implementation data. This literature finds that supply prices declined as a result of Part D by about 20 percent and utilization increased by about 5-10 percent.[13] Moreover, as price declined more than quantity rose, this government expansion lowered profits and is on the downward sloping part of the inverted U-shaped profit function discussed.

[11] Using the Sommers *et al.* (2012) estimate that 63 percent of uninsured individuals take up public coverage when eligible, we estimate that 63 percent of the elderly will enroll in Part D (or 63 percent of the 13 percent of the population which is elderly). Since the projected Part D enrollment of 8 percent of the population is 44 percent of Medicaid enrollment of 18 percent of the population, the Part D rebate is 44 percent of the Medicare rebate.

[12] Prescription coverage estimate is from the MEPS and literature estimate is from Sommers *et al.* (2012).

[13] Duggan and Scott Morton (2010) find that Part D plans lowered supply prices for top-selling branded pharmaceutical treatments by approximately 20 percent and estimate that the the number of prescriptions increased 10 percent due to Part D. See also Carroll (2008). Note that other studies look at the effect on demand price not supply price, such as Lichtenberg and Sun (2007). They estimate that the prices faced by patients declined by over 15 percent and prescriptions increase 7% for Part D eligibility individuals. Ketcham and Simon (2008) find that Part D reduced out of pocket costs for the elderly medication by 21.7% and increased utilization by 4.7%.

6.1.1 Background

Medicare is a program in the US since 1965 that guarantees health insurance to individuals 65 and over as well as to younger individuals with certain disabilities or diseases. Medicare Part D is a prescription drug coverage program for Medicare eligible individuals in the US that was part of the Medicare Modernization Act of 2003 (MMA), and it was implemented in January 2006. Under Part D, eligible individuals can obtain prescription-only plans, full Medicare plans that include prescription drug benefits, or can maintain their current prescription drug coverage. The premium subsidy for such plans are around 75%. Copays vary with the level of spending and plan choice.[14] Before Part D, according to MEPS data, 66% of the elderly had prescription drug insurance; 15% had only public coverage, 41% had only private coverage, and 11% had both public and private coverage. The majority of the public coverage came from Medicaid for low income individuals. After the introduction of Part D, 49% of the elderly population enrolled in Part D and 82% had some form of prescription drug coverage.[15]

6.1.2 Calibration of Post-Implementation Effects using Pre-Implemenation Data

Our theoretical discussion stressed the quantity and markup effects by income that generated non-standard innovation incentives from program expansions. We calibrate quantity expansion and markup reductions at each income decile to calibrate the implied overall profit effects. Since Medicare Part D is for the elderly, we use income deciles for individuals 65 and older in the US. Using such pre-implemenation data, we calibrate that Part D decreased prices 21% and raised utilization by 16%. We calibrate that it reduced profits by about 8%.

We first calibrate the positive effects of program expansion on utilization. We make three assumptions to simplify the calibration. First, utilization does not change for individuals who do not change insurance coverage. Second, the implementation of Part D only induces people to change to public coverage. Third, private and public insurance have the same utilization because they have similar demand prices. Therefore, the effect of Part D on utilization is equal to the fraction of individuals who switched from no coverage to public coverage times the effect of insurance on utilization. We calibrate the fraction of individuals who switched to public coverage from no coverage using an estimate that 63% of uninsured individuals take up public coverage when eligible (Sommers *et al.* 2012). We assume drug utilization to be 50% higher for those that switched using estimates from the RAND Health Insurance Experiment (Manning *et al.*, 1988).[16]

We estimate the negative effect of program expansions on supply prices by using data on Medicaid enrollment and rebates for the period 1995-2003. Specifically we run a regression of the total Medicaid prescription drug rebate, as defined by the CBO, on the log of the fraction of the US population enrolled in Medicaid. We assume that the effect of expansion on the rebate follows a log relationship, which increases the markup reduction at a high rate initially and then declines with expansion.

The results are reported in the Appendix. The regression coefficient of 12.78 means that if 10 percent

[14] After the first $250 of spending, Part D had a co-insurance rates that decrease with spending except for drug expenditures between $2,500 and $5,100 which have no coverage and is know as the “donut hole”. For spending less than the donut hole the co-insurance rate is 25% and for spending exceeding the donut hole level co-insurance is 5%. In 2007, approximately 30% of prescription drug costs for individuals over 65 and covered by Part D were paid out of pocket (MEPS).

[15] The before estimates are for 2005 wave and the after estimates are for 2007 wave of the Medical Expenditure Panel Survey (MEPS). See also Engelhardt and Gruber’s (2011).

[16] According to the RAND Health Insurance Experiment (HIE), going from a 95 percent coinsurance rate to a 25 percent coinsurance rate increases prescriptions by 50 percent (Manning *et al.*, 1988).

Table 1: Estimation results : Total Medicaid Prescription Drug Rebate

Variable	Coefficient	(Std. Err.)
Ln(Enrollment Fraction)	12.78	(2.54)
Intercept	-5.96	(7.02)

Notes: Estimate for 1995-2003. Total Medicaid Prescription Drug rebate, source: Congressional Budget Office. Enrollment as a fraction of US population, source: Bruen and Ghosh (2004)

of the population is added to the program, then the drug rebate is 23% and increases to 53% with full enrollment. For Medicare Part D, which has an enrollment rate around 6 percent of the US population, the results would imply a supply price rebate of 17 percent.[17] This price effect is similar to the effects cited in the literature of observed supply price declines post-implementation around 20 percent.

Using these calibrated quantity and price effects, we calibrate and graph the markup reduction, quantity expansion, and profits for the introduction of Part D in the figure below. The relative profits are given by

$$\frac{\Pi(z)}{\Pi(0)} = \frac{(p_S(z) - c)}{(p_S(0) - c)} \sum_{i=0}^{z} \left(\frac{m(i)}{m(0)} \right)$$

where $p_S(z)$ and $m(z)$ are the supply price and utilization at income decile z. Due to costs being unobserved, we approximate relative markups by relative prices, $\frac{(p_S(z)-c)}{(p_S(0)-c)} \propto \frac{p_S(z)}{p_S(0)}$, which is more accurate for larger innovative markups. For example, many drugs markups are almost equal to prices if pills cost pennies to produce. We plot the calibrated program implementation effects under two conditions. The first condition is a counterfactual with no Medicaid coverage and the second condition includes Medicaid.[18] Under both conditions, graphed in Figure 6, markup reduction and quantity expansion follow the crossing pattern and profits follow a bell shaped curve discussed.

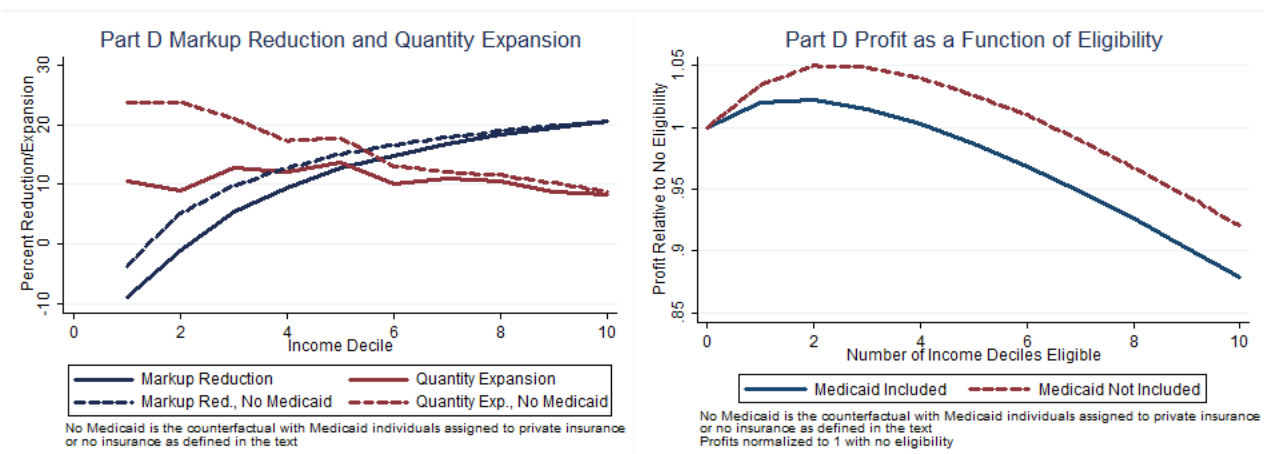

Figure 6: Quantity Expansion, Price Markup, and Profits

Without Medicaid, profits initially increase reaching a peak at a 5% gain at a 20% eligibility level. Profits with full eligibility decline 8% below profits with no program. Profits are higher without Medicaid

[17]The elderly are 13% of the US population according to the Census and 49% of the elderly have Part D coverage which gives us the enrollment rate of 6%.

[18]We use the Cutler and Gruber (1996) estimate that 72% of publicly insured individuals would be uninsured if public coverage is not available, to calibrate that 72% of individuals with Medicaid coverage are uninsured and the other 28% are privately insured.

because prior public coverage crowds out the effect of public expansion on quantity.

6.2 The Impact of Means-Testing Medicare Part A&B on Innovation Incentives

Medicare covers hospital care under Part A and outpatient medical services under Part B. For simplicity, we refer to Medicare Part A&B as Medicare in this section. The previous section used our framework to predict post-implementation effects from pre-implemenation data on part D. Here we use existing data on part A&B to calibrate the counterfactual effects of means-testing those parts of the program. Using a similar method to the one we used in the validation exercise for Part D, we calibrate the counterfactual effects of substantively means-testing Medicare on prices, utilization, and profits. We consider making Medicare similar to Medicaid by excluding richer individuals, as opposed to means-testing their premiums. Calibrating the effect of a 30 percent decrease in eligibility due to such means-testing, we find that we predict prices would increase by 22, utilization decrease by 28%, and profits increase by 16% with such a program cut.

6.2.1 Calibration of Revenue Effects

There is an abundant literature on the effects of Medicare. We are specifically interested in the effect of Medicare on prices and utilization to examine the non-monotonic profit effects discussed. Consider first the previously discussed effect of eligibility on profits:

$$\frac{d\Pi}{dz} = f(z)[\pi_G(z) - \pi(z)] + F\frac{d\pi_G}{dz}$$

From this, we concluded that there are two effects of means-testing a previously universal program. The first was the positive profits from the richer part of the population no longer in the program. The second was that there are increased profits of those remaining in the program.

To get a feel for the magnitudes, consider the following back-of-the-envelope calculation of the profit effects from means-testing, which considers price changes alone, holding utilization constant. Figure 7 shows this price effect. The figure depicts the case when a universal Medicare program has a 1/3 markup reduction and no markup reduction with no eligibility, and prices are linearly interpolated in between. With full eligibility, revenue is the area C+D with area 2/3. With a 1/3 cut in Medicare eligibility, the revenue of rich individuals no longer eligible rises from D to B+D, since they face higher private supply prices. For the remaining 2/3 of eligible individuals the supply price increases, so that revenue from them rises from C to A+C. Under this scenario, revenue increases roughly 19% from going from 2/3 (the area C+D) to 23/27 (the area A+B+C+D). Added to these price effects would be the offsets due to any drop in utilization of the rich made ineligible.

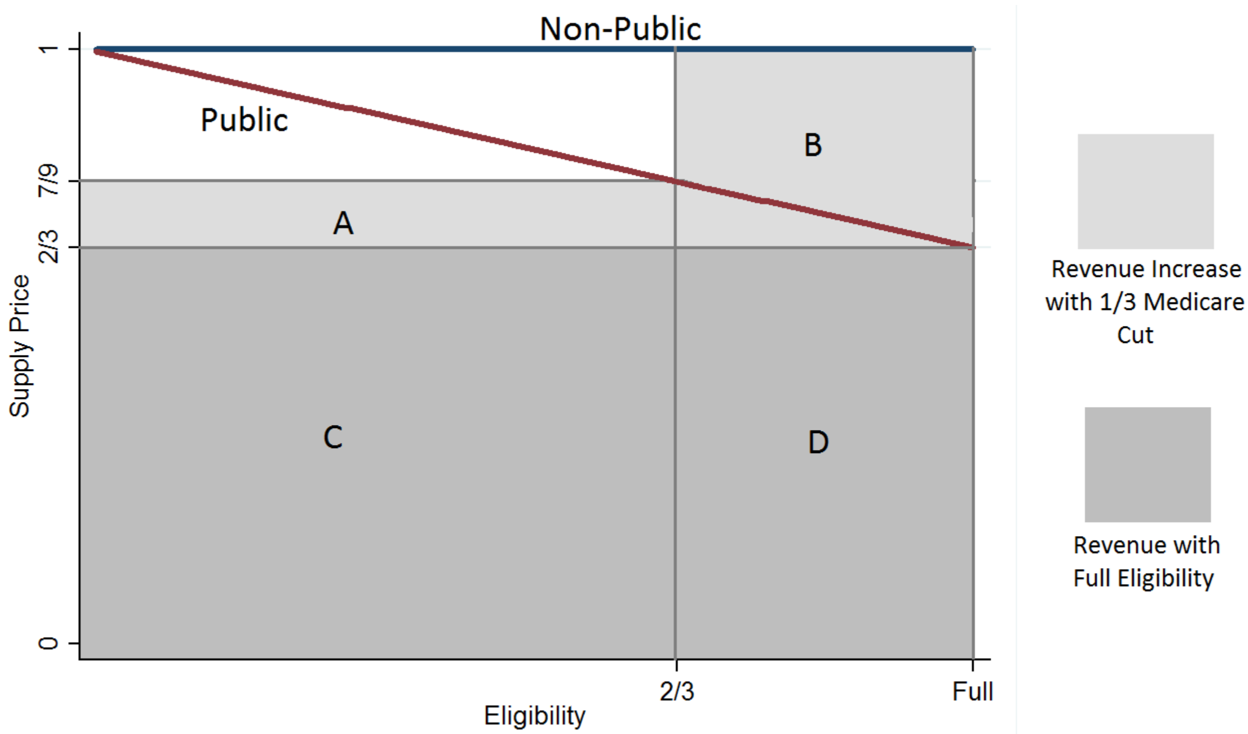

Figure 7: Price Change with 1/3 Medicare Cut, Holding Utilization Constant

Because Medicare Part A&B covers a large variety of medical services and the medical products used within them, including hospital stays and outpatient costs, it is more difficult to define the units used for price and utilization. Using estimates from Part A&B, the literature finds that utilization increases between 7-46 percent with Medicare coverage.[19]

Effects by Income Decile To fully calibrate the effects of means-testing of Medicare, we calibrate quantity expansion and markup reductions for each income decile similar to the way we calibrated it in the validation of the methods for Part D. We make two significant changes. First, since universal Medicare coverage for the elderly has existed for nearly 50 years, we use individuals just below the age cut off (60 to 64 year olds) to estimate coverage levels without eligibility and we assume full Medicare enrollment when eligible. Second, since we are not making an out of sample prediction, we use Medicare estimates to calibrate quantity expansion and markup reductions from Medicare. We find that means-testing raises prices, lowers utilization, and increases profits.

For quantity effects, based on the existing literature, we assume that individuals who switch from no insurance to Medicare increase utilization by 35 percent and individuals who switch from private insurance to Medicare increase utilization by 10 percent.

[19]For Part A, which covers hospital care, Card *et al.* (2008) uses regression-discontinuity at age 65 to estimate the effect of Medicare. They find that hospital admissions increase by 10 percent between 64 and 65 year olds relative to private insurance. Finkelstein *et al.* (2012) estimates that Medicare increased hospital admissions 46 percent between 1965 and 1970. For Part B, which covers outpatient services, Newhouse and Phelps (1974) estimate a coinsurance rate elasticity on outpatient visits of -0.1 which for an approximately 66% coinsurance decrease with Medicare relative to no insurance leads to a 7% increase in utilization. Wallen *et al.* (1986) find that similar coinsurance elasticity for mental health services, which a subsection of outpatient care. Their elasticity of -0.32 with a 66% coinsurance decrease with Medicare leads to a 21% increase in utilization.

For price effects, we use estimates from the literature of the effect of Medicare on hospital and physician reimbursements ranging from roughly 20 to 50 percent.[20] We assume that a universal Medicare program has a 35 percent markup reduction and no markup reduction with no eligibility, and prices are linearly interpolated in between.

Relative profits given the quantity and price effects are as before:

$$\frac{\Pi(z)}{\Pi(0)} = \frac{(p_S(z) - c)}{(p_S(0) - c)} \sum_{i=0}^{z} \left(\frac{m(i)}{m(0)} \right)$$

As with Part D, we estimate and graph the markup reduction, quantity expansion, and profits for the introduction of Part D under two conditions. The first condition is a counterfactual with no Medicaid and the second condition includes Medicaid coverage. As shown in Figure 8, markup reduction and quantity expansion cross and profits follow a bell shaped curve which are predicted in the theory. Without Medicaid, profits increase up to 22% with a 30% eligibility decline from full eligibility. With Medicaid, this profits increase amounts to 22%.

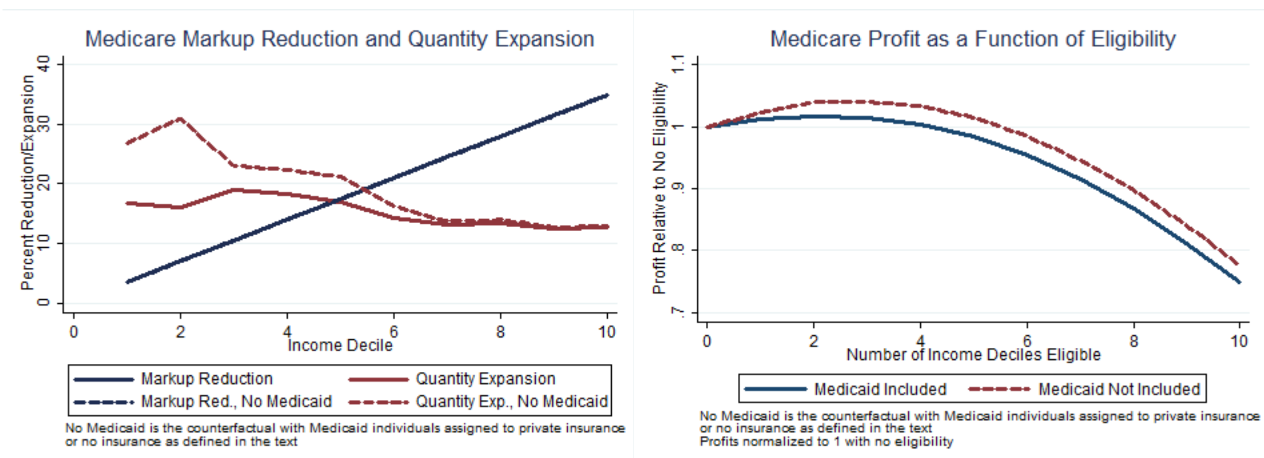

Figure 8: Profits Broken into Quantity Expansion and Markup Reduction

6.3 The Impact of Means Testing Medicare Part A&B on Medical R&D and Public Liabilities

With our calibrated profit effects, we can calibrate the impact of means-testing Medicare part A&B on their program liabilities.

6.3.1 Impact on Innovative Returns

The associated effect on public spending is shown in the figure below. When eligibility increases, spending initially increases but falls when expansions lower reimbursements more than they raise utilization.

[20] Historical Medicare rebate estimates for physician fees range from roughly 20% to 40% with recent estimates around 17% (Direct Research, 2003). Medicare rebate estimates for hospitals vary geographically, and range from 32% to 52% relative to private insurance (Ginsburg, 2010).

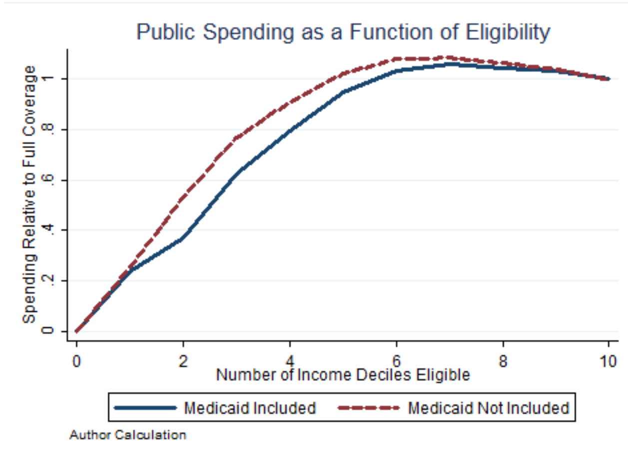

Figure 9: Public Spending as a function of eligibility

6.3.2 The Impact of Program Size on Future Liabilities

To calibrate the effect that means-testing Medicare has on Medicare liabilities, we first need the calibrated effect on profitability, $d\Pi/dz$, and then the effect of profitability on future spending growth, $d\gamma/d\Pi$. We are interested in what we refer to as the "profit-to-growth effect" (PGE). More precisely, the PGE is the effect on the absolute percent of growth for a given percentage change in profits. For example, if profits increase by 10% and the PGE is 0.05, then the absolute percentage of spending growth increases by 0.5 percentage points, say from 6% percent to 6.5%.

Cutting the program through means-testing decreases current program spending but raises the growth rate of the program. The key relationship concerns the one between the world profit increase and future spending growth. Figure 10 maps out different liability effects as a function of PGE. For example, for an PGE of 0.2, the program liabilities increase 226% for a 30% cut.

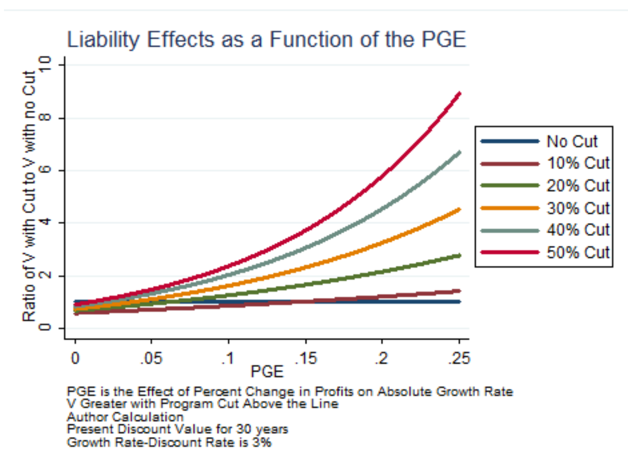

Figure 10: Liability Effects as a function of the PGE

To illustrate these magnitudes, consider the following hypothetical calculation. Suppose we cut Medicare for the top 20% of the income distribution. If they have 30% higher prices in the private sector, that means overall profits increase 6% with constant utilization. A 6% increase in profits raises the spending growth rate by about 1 percentage point if the PGE is 0.16. A 1 percentage point increase in growth rate affects the present value of future growth by 15% over 25 years when the discount rate is 3% and initial growth is 6%. Thus, the 20% spending reduction is offset by a 15% rise in the present value of increased growth.

These calibrations highlight that although a cut in Medicare eligibility may have small negative effects on spending initially, it has a large effect on the innovative returns that drive future spending growth. A cut in a government program, even with conservative estimates for the PGE, may raise government liabilities substantially. We are not aware of any reliable estimates of the impact of profitability on spending growth. Therefore, we report the smallest PGE for which means-testing actually raises liabilities- in other words, the smallest effect $d\gamma/d\Pi$ for which means-testing does not affect liabilities, $V' = V$.[21]

Figure 11 depicts the lowest PGE level consistent with no change in liabilities as a function of common values of the discount rate used for medical spending for a finite horizon of 30 years. For example, if the growth rate without reforms is 6% ($\gamma = 0.06$) and the discount rate is 3.5% ($r = 0.035$) then the figure tells us that for an PGE of .02 the present value of public liabilities, V, is the same for a 30% cut in the program and no cut in the program. For PGE greater than .02, V is greater with a 30% cut than with no cut; for PGE less than .02, V is greater with no cut than with a 30% cut. The larger the cut in the program, the larger the PGE required to equate V.

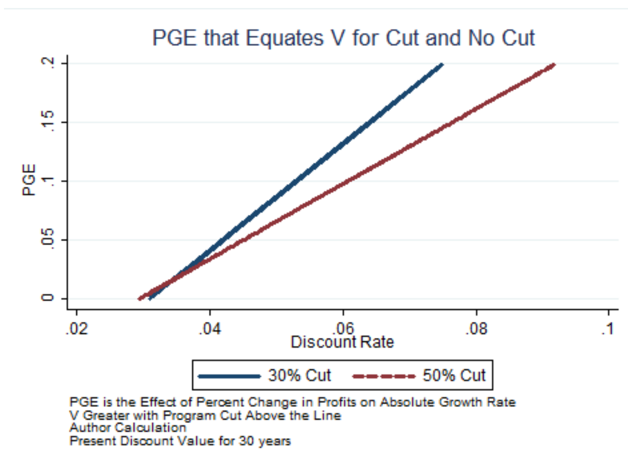

Figure 11: PGE that Equates V for Cut and No Cut

There exists some evidence on the degree to which innovative returns drive the future spending growth that underlies the PGE calculations. Acemoglu and Linn (2004) estimated an elasticity of about 4 for the effects of revenue on new product innovations; a 10% increase in revenues was associated with a 40% increase in new molecular entities introduced.[22] These effects are magnitudes larger than the PGEs we discuss.

[21] To exemplify the threshold effect, consider when growth is proportional to profits $\gamma = \theta P$. In this case $\theta (= d\gamma/d\Pi)$ satisfies:

$$\frac{V'}{V} = \left(\frac{S'}{S}\right)\left[\frac{r - \theta P}{r - \theta P'}\right] = 1 \Rightarrow \theta = \frac{r(\frac{S'}{S} - 1)}{P\frac{S'}{S} - P'}$$

because when the future growth is discounted more, more of it is required to offset current spending effects.

[22] These elasticities translate directly into profit elasticities when profits are proportional to revenues. For example, under constant marginal costs and constant elasticity of demand, prices are marked up over costs according to $p = ac$ so that profits are proportional to revenues $\pi = m(p - c) = (1 - \frac{1}{a})mp$

As we discussed, the relative size of the Medicare program in world returns is important for assessing how means-testing Medicare affects innovation. The program only covers about 12% of the US population, and hence about half a percent of the world's population. However, as is well known, the US dominates world health care consumption and the US elderly represent a large share of overall US health care consumption for many products and diseases. Furthermore, the share of the world prevalence of a given disease in the Medicare program may differ, as for example between low levels for HIV or pediatric diseases and high levels for Alzheimer's. Figure 12 modifies the calibration for different assumed rates of the share of world profits coming from Medicare. For example, this share would be zero for a non-elderly non-US disease and close to 100 percent for an exclusively US elderly disease. The x-axis measures the fraction of world returns coming from Medicare. The y-axis measures the impact on world profits. The separate lines concern different levels of means-testing.

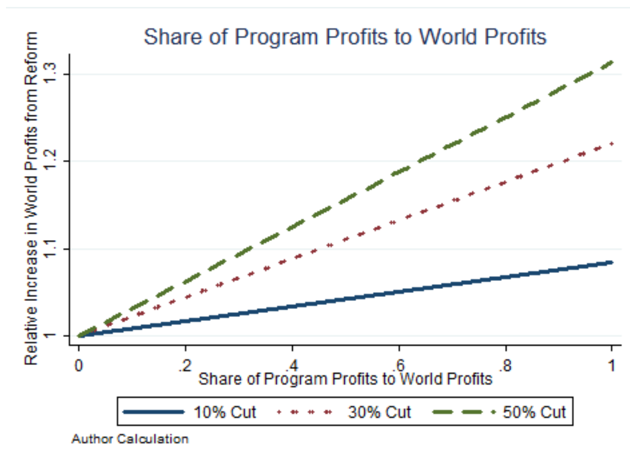

Figure 12: Share of Program Profits to World Profits

Naturally, the more important the program is to world innovative returns, the larger is the overall profit effect and hence the growth effect on innovation. In the extreme case of a US elderly disease, all profits come from Medicare and the right tail effects apply. In the other extreme case when the disease is for the non-elderly or outside the US, the left tail effects apply. For example, a 30% cut in the Medicare program for a technology for which a 25% share of the world profits initially came from Medicare would increase world profits by over 5%. These profit effects can be fairly substantial even for modest means-testing.

7 Concluding Remarks and Future Research

Focusing on the return to medical innovation as the major determinant of spending growth, we analyzed the effects of health care policies on public liabilities. We derived how reforms affected medical R&D returns in terms of earnings, the risk-adjustment of those returns, their duration as well as the default through the approval process. We argued that government expansions and price regulations have non-monotonic effects on R&D, that means-testing greatly affected risk-adjustment of returns, and that approval risk may raise innovative returns. The analysis implied that cutbacks in government programs may raise the value of government liabilities and that expansions may lower them. We assessed the implications of these arguments for means-testing Medicare and found that modest effects of profits on future spending growth may induce such cuts to raise Medicare liabilities.

It is important to stress that our analysis does not take a normative position on whether higher or lower spending and public liabilities are desirable, but rather only assesses the positive impacts of common reforms on them. It is also noteworthy that most of our analysis, although not our general formulation, assumed that higher overall profits would result in larger spending growth. This may not be the case if cost pressures pushed larger profits to be obtainable only for cost- and spending-reducing innovations. For example, under certain forms of government programs, such as defined contributions plans, larger profits may be obtained only by lowering spending. More generally, positive growth effects may be applicable under existing payment structures but not if those payment structures change.

Our analysis suggests many future avenues of research. First, valuation of government health care liabilities should use discount rates observed in asset markets rather than Treasury rates as is often done by agencies such as the CBO in the US. This is particularly relevant for valuing spending under the Part D program whose spending should be discounted by the discount rates observed for the firms generating the product sales of the program. Given the findings reported in Koijen *et al.* (2011) of a large "medical innovation premium," it is likely that the present value of Medicare Part D spending is far lower than commonly estimated using Treasury rates. Future empirical work may usefully investigate whether firms that are exposed differentially to government risk, for example from different shares of demand coming from Medicare or Medicaid, have different risk-returns patterns as implied by our discussion.

Second, our discussion of aging effects raises a more general issue about growth accounting of health care spending. Our discussion suggests that a major issue with previous work in this area is that decompositions based on independent factors are invalid. For example, changes in domestic income, aging, and insurance coverage all affect world innovative returns. However, when any of these factors raise R&D incentives, then it is partly the reason why per capita spending levels grow over time. A more satisfactory decomposition of overall growth in health care spending must analyze innovation being jointly determined by the various independent factors discussed in previous work. A quantitative structural model of how factors contribute to spending growth, rather than just statistical decompositions, seems needed for this.

Third, our analysis concerned a single public program but has alternative implications for when individuals choose between multiple public programs. For example, in the US, older individuals have the choice between traditional Medicare or Medicare Advantage. As is true for most subsidy programs, the relative demand for the two programs seems to have been driven by the relative subsidy rates, as implied by various federal budget reforms in the past. A better understanding of innovation effects under multiple public programs is needed, when participation is endogenous and public prices change participation.

Fourth, our analysis does not distinguish between centralized *health care* pricing (as in Medicare Part A and B) and centralized *health insurance* pricing (as in Part C). Public pricing of health care versus health insurance may have different impacts on innovation incentives and is a useful avenue for future work. This would potentially involve making the supply prices of our analysis a function of various insurance reforms, presumably positively related to insurance generosity.

Fifth, our analysis has important implications for the many reforms worldwide aimed at lowering government spending but preserving medical innovation incentives. Many European nations face this issue with great fiscal imbalances and cost pressure. Our analysis implies that if fiscal pressures lead to further means-testing, it may raise innovation incentives. Thus, innovation incentives are preserved under fiscally induced government cutbacks by reducing government spending on the wealthier in favor of the poor. This will induce short-run effects that may differ from the long run liability effects we discussed.

Sixth, more analysis needs to be done on how the composition of innovation changes with public health care policy. Given that medical product innovation is commonly argued to be the source of observed spending growth, our analysis was focused on how such innovation incentives are altered by health policy. Of equal importance for future research should be how organizational innovation is affected by health policy, such as providers responding to changes in reimbursement incentives such as e.g. ACOs of the ACA. The focus on product innovation here is due to that few people argue that organizational innovations is what has made health care sector expanded, indeed the argument is often that the lack of such organizational innovation has contributed to the growth of the sector.

Lastly, the negative impact of government risk on health care investment deserves more general attention. If direct R&D stimuli are partially or fully offset by the government risk that accompanies them, this may mitigate their intended effects. In other words, push or pull measures that are associated with great legislative risk may not stimulate R&D much. For example, the uncertainty surrounding the current health care policies in the US seems to have reduced investment incentives even though some reforms are clearly pro-innovation.

Generally, the overall argument we hope to have made, that we think deserves more general consideration, is that explicit and quantitative analysis of the impacts of reforms on innovative returns and the implied future spending growth must be developed. These analyses seem fundamental to health economics and very important for both positive and normative analysis of health care policies.

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Appendix: For Online Publication

Data Description

Prescription Insurance Coverage

We estimate both aggregate prescription insurance coverage and prescription insurance coverage fractions by income decile using the 2005 wave of the Medical Expenditure Panel Survey (MEPS). We define public prescription insurance in 2005 to be individuals with Medicaid coverage in 2005 or individuals who had at least 30 percent of their prescription drug expenditures covered by a public program. We define private insurance coverage as individuals listing that they are enrolled in private prescription insurance or individuals who had at least 30 percent of their prescription drug expenditures covered by a private program. We do not include under 65 disability Medicare recipients in the dataset.

Our definition of the prescription insurance coverage categories differs slightly from Engelhardt and Gruber (2011) who use the same dataset. They use 2002-2005 for pre-Part D. They define public coverage to be anyone who was enrolled in Medicaid at any year between 2002 and 2007, enrolled in Part D in 2007, or had any amount of their prescription drug coverage paid for by a public program. They defined private coverage to be anyone who was listed as enrolled in a private prescription drug plan or had any amount of their prescription drug coverage paid for by a private program

Health Insurance Coverage

We use the same 2007 wave of the MEPS to estimate health insurance coverage for 60-64 years old. We use this estimate as the counterfactual health insurance coverage rates for the elderly population if they were not eligible for Medicare. Since Medicare has full eligibility for the elderly has has been implemented for almost 50 years, we do not have an elderly counterfactual estimate. We define public coverage to be individuals who were described in the MEPS as publicly insured in December or individuals who were enrolled in Medicare or Medicaid in December of 2007. We define private coverage as individuals who were listed as having insurance but did not meet our criterion for public coverage, or individuals who had ESI/Union insurance, group insurance coverage, or non-group insurance coverage of December 2007. We assume full enrollment when eligible for Medicare. We assign individuals to private insurance coverage if they are listed as having both private and public coverage.

Calibration Table

Below we list the prescription and health insurance coverage, quantity expansion, markup reduction and profit calibrations by income decile.

Income Decile	No Insurance: Pre-Part D	Markup Reduction	Quantity Expansion	Profit
1	.34	-8.89	10.64	102.05
2	.29	-1.01	9.07	102.19
3	.4	5.36	12.74	101.46
4	.39	9.44	12.21	100.27
5	.43	12.85	13.66	98.66
6	.32	14.91	10.22	96.89
7	.35	16.8	10.93	94.85
8	.34	18.41	10.62	92.63
9	.28	19.59	8.76	90.32
10	.26	20.62	8.30	87.88

Table 2: Prescription Insurance Coverage, Part D

Income Decile	No Insurance: 60-64	Private Insurance: 60-64	Markup Reduction	Quantity Expansion	Profit
1	.45	.28	3.5	16.81	101.27
2	.28	.17	7	15.98	101.65
3	.55	.22	10.5	18.98	101.48
4	.41	.46	14	18.43	100.44
5	.41	.51	17.5	17.06	98.45
6	.29	.64	21	14.28	95.42
7	.17	.81	24.5	13.2	91.51
8	.09	.89	28	13.31	86.82
9	.11	.89	31.5	12.51	81.28
10	.05	.95	35	12.67	74.96

Table 3: Health Insurance Coverage, Part A&B