Problem Set #4 Solutions
14.41 Public Economics

DUE: November 12, 2010

Question 1

Suppose that doctors must choose a level of care, x, for each of their patients. The cost of such care is $c(x) = 5x^2 + 5$. The benefit of care (translated into dollars) is $f(x) = 90x - 10x^2$. Suppose doctors have utility functions given by

$$U(x) = (1 - \lambda)P(x) + \lambda f(x) - c(x)$$

where $P(x)$ is the monetary payment the doctor receives from treating a patient with x units of care. Doctors care about a weighted average of their own monetary revenue from care $P(x)$ and the patient's benefit $f(x)$, with the weight given by the parameter $\lambda \in [0, 1]$.

1. What is the optimal level of care, x^*?

   Optimal care x^* occurs where SMB=SMC, i.e. $f'(x) = c'(x)$. Solve to get $x^* = 3$. Must also check that total benefit exceeds cost, i.e. $f(3) = 180 > 50 = c(3)$, which holds here.

2. Suppose that the Medicare system begins with retrospective payments. Under this scheme, doctors choose whichever level of x they feel is appropriate, and then the Medicare program gives the doctors $40 for every unit of x that they prescribe.

   (a) Under these incentives, what amount of care will each doctor prescribe? How does your answer depend on λ? To what does $\lambda = 0$ correspond? To what does $\lambda = 1$ correspond?

   $\lambda = 0$ is the case where the physician is a pure profit maximizer, and disregards any benefit or harm to the patient. $\lambda = 1$ is the case where the physician ignores his own revenue and cares only about the social benefits and costs. For a general $\lambda \in [0, 1]$, the physician chooses x^* to solve

   $$(1 - \lambda)P'(x) + \lambda f'(x) = c'(x)$$

   where $P(x) = 40x$. Solve to get x^* as a function of λ:

   $$x^*(\lambda) = \frac{4 + 5\lambda}{1 + 2\lambda}$$

   It is straightforward to check that $\frac{dx^*(\lambda)}{d\lambda} < 0$, which means that the physician treats less intensively as λ increases. When $\lambda = 1$ (the case where the physician cares only about the social benefits and costs), $x^* = 3$, lining up with the optimal care.

   (b) In general, is the level of care too high or too low (the answer may depend on λ)? Why?

   As just shown, $x^*(\lambda)$ is decreasing in λ. When $\lambda = 1$ (the case where the physician cares only about the social benefits and costs), we calculate that $x^*(1) = 3$, lining

up with the optimal care found previously in part 1. Thus, for any value of $\lambda < 1$, the doctor will treat too intensively (over provision). This is because the physician's financial incentive is larger than the social marginal benefit at the optimal level of care, causing over provision (except when the physician completely ignores his own financial incentive, i.e. when $\lambda = 1$).

For the remainder of this problem, set $\lambda = 0$.

3. Now suppose that the Medicare system switches to a prospective payment system. For our purposes, let's say that the prospective payment system compensates doctors by a fixed payment π provided that $x \geq \hat{x}$, where $\hat{x}$ is some level set by the Medicare administrators. That is, the prospective payment system gives doctors a fixed dollar amount per patient, but requires that doctor's provide at least a certain amount of care.

   (a) If the Medicare prospective payment system wants doctors to provide precisely the optimal level of care, what will they set as $\hat{x}$? Let $\hat{x} = x^* = 3$. As shown below, doctors with the utility function as given (pure profit maximizers) will not provide care beyond $\hat{x}$.

   (b) Provided that Medicare wants doctors to care for all patients (and not send patients away), what should they set as π? If $\hat{x} = 3$, then in order for doctors to treat Medicare patients, it must have

$$P(3) - c(3) \geq P(0) - c(0)$$
$$\Leftrightarrow \quad \pi - 50 \geq 0 - 5$$
$$\Leftrightarrow \quad \pi \geq 45$$

   Note: if you assume that when a doctor refuses a patient, then cost $= 0$ (rather than $c(0) = 5$), then $\pi \geq 50$. But this is an alternative interpretation of the fixed cost.

   Thus, if $\pi \geq 45$ (or 50), doctors will optimally provide $\hat{x} = 3$ units of care.

   (c) Demonstrate mathematically how doctors have limited incentive to provide care beyond $\hat{x}$. We just showed that doctors prefer to provide $\hat{x} = 3$ units to providing zero units of care. Now we prove that doctors will provide no more than $\hat{x} = 3$ units of care.

$$\max_{x \geq \hat{x}} \pi - c(x)$$

   But since the FOC is $c'(x) < 0$, the optimum occurs at $x^* = \hat{x} = 3$.

(d) Show that the total health benefits under this system are actually slightly smaller than those for under retrospective payment. Health benefits under the retrospective system are given by $f(4)$, while the health benefits under the prospective system are given by $f(3)$. Check that $f(4) = 200 > 180 = f(3)$.

Note that while health benefits are lower under prospective care, by design the care provided is optimal as additional care incurs SMC>SMB. That is, it is *not* optimal just to maximize $f(x)$—costs must also be factored in.

4. In reality, health economists found that PPS lowered costs and had little effect on actual health outcomes. Explain why this happened, citing the results above. PPS remove doctor incentive to over-provide care. Of course, health outcomes fall, but the extent is minor on the "flat-of-the-curve" (reference the RAND Health Insurance Experiment).

5. Now suppose that that there are two types of patients divided into two diagnosis related groups (DRGs). Some patients are "serious" cases (S), and the other patients are "not so serious" (N). The cost of care is as above. Suppose further that the Medicare system compensates doctors with $\pi_N = 10$ for $x_N \geq 1$; and $\pi_S = 60$ for $x_S \geq 3$.

(a) Calculate a doctor's profits for each type of patient.

$$\text{Serious: } \Pi = \pi_S - c(3) = 10$$
$$\text{Not Serious: } \Pi = \pi_N - c(1) = 0$$

(b) If doctors can re-label patients describe what will happen. As profits for serious patient are larger than for not-serious patients, doctors will have an incentive to "re-label" actual not-serious (N) cases as serious cases (S).

(c) How did "DRG Creep" undo some of the gains of PPS, both in this model and in reality? By providing an incentive to re-label patients, "DRG creep" sesults in over provision of care, undoing the gains of a PPS. Effectively, payments are no longer fully prospective, as the doctor has control over the DRG assignment.

Question 2

You have been hired by the Commonwealth of Massachusetts to evaluate a welfare reform put in place by the state, which made it very unpleasant to be on welfare by imposing harsh training requirements on those in the program. Specifically, Massachusetts wonders if the harsher requirements induced women to supply additional labor supply, and hence earn more in labor income. Welfare is only available to single mothers in the state. Welfare was reformed for residents of Boston in 2005, but not for residents of Springfield (a town in western Massachusetts) until 2007. For your evaluation, you are provided the following data on the average monthly earnings of different groups of women in the two cities for two years, 2004 and 2006.

City	Year	Marital Status	Labor Income
Boston	2004	Single	175
Boston	2004	Married	300
Boston	2006	Single	210
Boston	2006	Married	290
Springfield	2004	Single	120
Springfield	2004	Married	200
Springfield	2006	Single	125
Springfield	2006	Married	210

1. Propose two difference-in-difference estimators of the impact of the 1995 welfare reform in Boston. For each, give:

   (a) The assumptions required for the DD estimator to be valid.

   (b) A scenario under which the assumptions would be violated

   There are two possible "diff-in-diff" experiments that you could consider. The first assumes that married mothers in Boston (who aren't subject to the welfare reform) are a valid control group for single mothers in Boston. The second assumes that single mothers in Springfield are a valid control from for single mothers in Boston.

   Following the first method, the diff-in-diff estimator is given by

   $$\hat{\beta}_1 = \left(\text{single after} - \text{single before}\right) - \left(\text{married after} - \text{married before}\right)$$
   $$= (210 - 175) - (290 - 300)$$
   $$= 45$$

   One way to think about this is, assuming married mothers are a valid control group, that in the absence of reform, single mothers' earnings would have fallen by 10; since single mothers' earnings actually increased by 35, their earnings increased by 45 over

what they would have increased in the absence of reform. For this estimate to be an actual causal estimate, our regular diff-in-diff assumptions must hold: in the absence of welfare reform, earnings would have changed by the same amount for single mothers and married mothers. Another acceptable way of saying this is that the time bias for married and single mothers was the same over the period. This could be violated in two ways: 1) the trend in earnings for single and married mothers is not parallel over the period (so that in the absence of reform, earnings would have increased by more for single mothers anyhow) or 2) something else occurred simultaneously with the welfare reform that induced earnings for single mothers to increase. There are many ways in which this may be violated. Here are two examples:

- Firms may gradually become more accommodating for single mothers, by providing subsidized child care or allowing flexible hours. If so, then earnings for single mothers may naturally have increased by more at an annual basis than earnings for married mothers.

- Welfare reform may be implemented as part of a larger legislative package that also works to induce additional labor supply from single mothers (i.e. free child care, tax credits contingent on labor supply) such that these are actually driving the increase in single mothers' labor supply, rather than the strict welfare requirements.

Following the second diff-in-diff method, the estimator is given by

$$
\begin{aligned}
\hat{\beta}_2 = & \left(\text{Boston single after} - \text{Boston single before}\right) \\
& - \left(\text{Springfield single after} - \text{Springfield single before}\right) \\
= & \ (210 - 175) - (125 - 120) \\
= & \ 30
\end{aligned}
$$

One way to think about what this estimate is implying is that in the absence of reform, the earnings of single mothers in Boston would have changed by the same amount as earnings did for single mothers in Springfield (5); hence, 5 of the 35 increase for Boston single mothers' is due to time trends in the earnings of all single mothers. The remainder (30) must be attributable to welfare reform. Again, the assumption here is that in the absence of reform, the earnings for single mothers in Boston would have increased by the same amount as single mothers in Springfield between 1994 and 1996. One way in which this could be violated is

- The towns experienced differences in economic growth between 1994 and 1996. For instance, if general economic growth is stronger in Boston than Springfield, then a portion of the earnings differential is due economic growth rather than welfare reform. If this differential in growth rates is gradual and on-going over the entirety of the early 2000s, then pre-trends are different and we would suspect that our diff-in-diff estimate is invalid. If the differential growth began in 2004,

then an examination of pre-trends wouldn't reveal this violation, but the estimate would still be invalid because economic growth, rather than welfare reform, caused the earnings differential.

2. Which of these two estimators do you prefer, and why? This is subjective, and depends on whether you think married mothers in Boston, or single mothers in Springfield, are a valid comparison group. As long as you provided some justification, either answer is acceptable. (Personally, I would prefer using married mothers within Boston, as I suspect that bias from differential growth across cities would be greater than any differences in earnings growth between single and married mothers). In practice, one would need to know more about the labor market environment in both cities than the information that we've provided, and use this to justify the choice of control. Or, one could examine pre-trends and other summary statistics between the controls and the treatment, and choose the control for which the DD assumptions most closely hold.

3. You are worried that the state will not believe the assumptions underlying your estimators above.

(a) Propose another estimator that holds under more general assumptions, and construct this estimator. Use a difference-in-difference-in-difference (DDD) estimator. Note that the DDD estimator is NOT calculated by taking the difference of your two DD estimators! You can, however, set up the estimator in many different (but equivalent) ways, such as

$$
\begin{aligned}
\hat{\beta}_{DDD} = &\Big[\big(\text{Boston single after} - \text{Boston single before}\big) \\
&\quad - \big(\text{Boston married after} - \text{Boston married before}\big)\Big] \\
&- \Big[\big(\text{Springfield single after} - \text{Springfield single before}\big) \\
&\quad - \big(\text{Springfield married after} - \text{Springfield married before}\big)\Big] \\
= &\Big[\big(\text{Boston single after} - \text{Boston single before}\big) \\
&\quad - \big(\text{Springfield single after} - \text{Springfield single before}\big)\Big] \\
&- \Big[\big(\text{Boston married after} - \text{Boston married before}\big) \\
&\quad - \big(\text{Springfield married after} - \text{Springfield married before}\big)\Big] \\
= &\ 50
\end{aligned}
$$

(b) Explain the assumptions required for your estimator in 3(a) to be valid. The reason that we would want to use DDD instead of DD is because even if bias exists in the DD estimates (that is, the change in earnings between treatment and control would have been different even in the absence of welfare reform), the DDD can potentially correct for this. Consider our first DD estimate. This estimate is invalid if the amount by which earnings grows for married Boston mothers differs from that for single Boston mothers due to some non-welfare related factors. Suppose, however, you think that in the absence of welfare reform, the difference between earnings growth for single and married mothers in Boston is the same as that for single and married mothers in Springfield. In other words, the DD assumption is violated between single and married mothers in Boston, but is violated in the exact same way for Springfield mothers—that is, the time bias between single and married mothers in Boston is the same as the time bias for single and married mothers in Springfield. If this is true, then you can use DDD to correct the bias from a DD estimate.

So, for the DDD estimate to be valid, the difference in earnings changes between single and married mothers must have been the same in Boston as in Springfield in absence of the reform. Or, alternatively, the difference in earnings changes between single women in Boston and Springfield must be the same as for married women in Boston and Springfield in the absence of welfare reform.

(c) Give a scenario under which the assumptions in 3(b) would be violated. This is violated if something occurs (other than welfare reform) which differentially affects the earnings of one of four of these groups: single Boston mothers, married Boston mothers, single Springfield mothers, married Springfield mothers. If this is true, then the time bias between married and single mothers in Boston would be different from than in Springfield, and so you couldn't use an estimate of the time bias in Springfield to correct for the time bias in Boston. Suppose, for example, that Boston—but not Springfield—begins providing free child care to single mothers in addition to welfare reform. In this case the change in earnings between single and married mothers in Springfield is not a valid control for the wage change between single and married mothers in Boston, because part of the difference in wage changes for Boston mothers is due to child care, rather than welfare reform, and this factor does not influence the difference between earnings changes for single and married mothers in Springfield.

(d) Based on your DD estimates and your estimate in 3(a), was the welfare reform successful in increasing the labor earnings of single Boston women? All of the estimates suggest that welfare reform has a positive affect on the labor earnings of Boston single mothers.

Question 3

In public economics, we are often interested in transfer programs that maximize some social welfare function. For the current exercise, we will be interested in maximizing a utilitarian social welfare function, which is equivalent to maximizing the utility of a randomly chosen individual.

Suppose a random process assigns individuals different characteristics that affect their ability to earn income. If these random characteristics were observable, the government could use these characteristics as a basis for lump sum transfers and achieve the first best outcome (see the discussion in the course textbook at the beginning of section 17.4). In practice, however, we can only observe rough indicators of these characteristics, such as income. The challenge is to design the best transfer program based only on these indicators, yielding what we call the "second best" solution.

In this problem, we will consider a world where people choose to spend some of their time in leisure l and the remainder of their time $(1-l)$ to earn an income Y (the maximum available leisure has been normalized to be 1). We will assume that all individuals in our society have a common utility function $U(C, l)$ with consumption and leisure as arguments. If a person receives a wage w, income and leisure are related by $Y = (1-l) \cdot w$. Consumption is equal to earned income Y plus any government transfers T, so that $C = Y + T$. Thus, the utility function can be written simply

$$U(C, l) = U\big(Y + T, 1 - Y/w\big)$$

The particular form of the utility function has intentionally been left unspecified, but in the following problems you should draw your plots for a well-behaved utility function that features a believable trade-off between consumption and leisure. It is sufficient to solve everything drawing graphs only—no need for a mathematical representation of the utility function.

1. Plotting the utility function for a single individual.

   (a) Suppose there are no government transfers $(T = 0)$. Plot utility vs. income for a given individual (i.e. U on the y-axis, and Y on the x-axis). Discuss how the shape of the utility curve relates to decreasing returns and to the resulting trade-off between consumption and leisure. Mark the individual's optimal choice of earned income.

   See Figure 1. Because of decreasing returns, it is very unpleasant either to work a ton (have very little leisure) or to have very little consumption. Consumers value the first bit of leisure highly, and are willing to forgo some labor income (and thus forgo some consumption) to obtain that leisure. Conversely, workers with very little income to spend on consumption are willing to scale back some leisure and work a few more hours. Thus, utility as a function of earned income will have a $\cap$ shape, as shown by the curve U in Figure 1. The individual's optimal choice of earned income occurs at the point Y^* where the utility curve peaks.
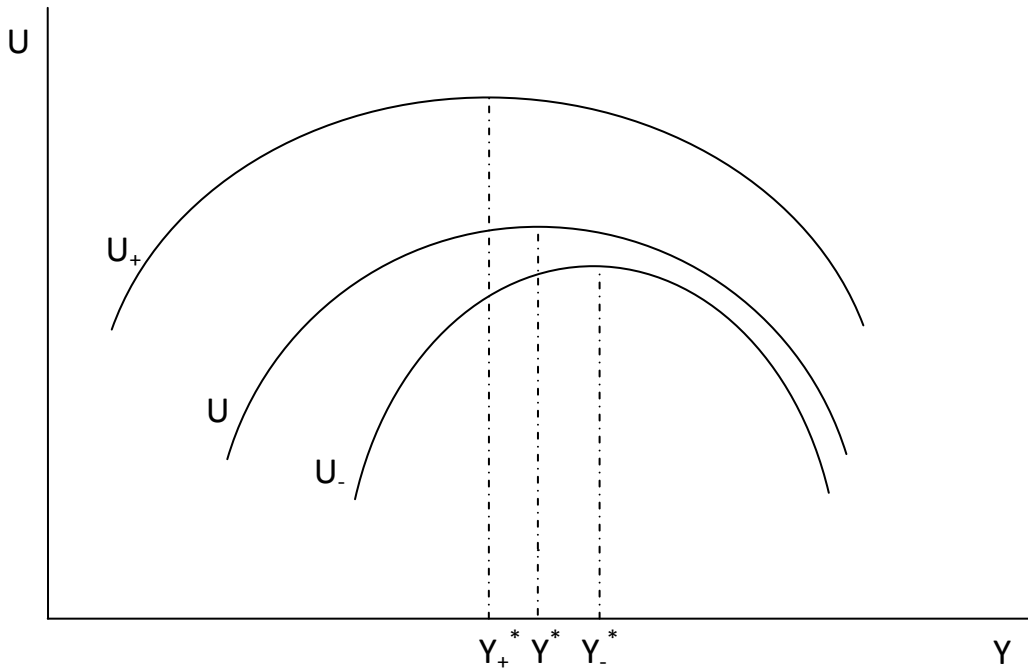
Figure 1: Utility as a function of earned income

(b) Now suppose the government gives the individual in part (a) a transfer of size T. On the same graph as above, draw the individual's new utility curve under the transfer. Label the individual's new optimal choice of earned income, and explain why this does or does not differ from the optimal choice of earned income in (a).

See Figure 1. A cash transfer means that at any level of earned income (and corresponding leisure), the individual is strictly better off. This results in an upward shift in the utility curve, as shown by the curve U_+ in Figure 1. Notice that for a given number of hours worked, a cash transfer increases the individual's total consumption, thereby decreasing the individual's marginal utility from consumption. In response, leisure becomes relatively more attractive than without the transfer. Thus, transfers cause an individual's optimal number of hours worked and labor income earned to decrease from Y^* to Y_+^*.

(c) Finally, suppose the government levies a tax T on the individual in part (a). On the same graph as above, draw the individual's new utility curve under the tax.

See Figure 1. A lump sum tax means that at any level of earned income (and corresponding leisure), the individual is strictly worse off than with no tax. This results in a downward shift in the utility curve, as shown by the curve U_- in Figure 1. For a given number of hours worked, a lump sum tax decreases the individual's total consumption, thereby increasing the individual's marginal utility from consumption. In response, leisure becomes relatively less attractive than without the tax. Thus, lump sum taxes cause an individual's optimal number of

2. Suppose we have two individuals A and B. Nature has given individuals A and B wages $w_A > w_B$, respectively. Plot the utility curves for A and B on the same graph (with taxes and transfers set to zero). Who chooses to earn more income? Why?

See Figure 2. For any specified amount of earned income Y, a high-wage earner (A) can earn that amount in fewer hours than can a low-wage earner (B). Thus absent any taxes or transfers, the utility curve for A lies above the utility curve for B. Moreover, for any specified amount of earned income Y, the marginal value of an addition unit of consumption is equal for both A and B (because consumption is simply equal to earned income, absent taxes and transfers). However, because A works fewer hours than B to earn the same Y, decreasing returns implies that the marginal value of leisure is *larger* for A than it is for B. Thus, for any amount of income B chooses to earn, A would have an incentive to earn even more, thus $Y^*_A > Y^*_B$ as in Figure 2.

NOTE: I have ignored the income effect of a higher wage, which works in the opposite direction of the income effect (see the reasoning above on the effect of lump sum transfers). Thus, the logic above holds as long as the income effect is small relative to the substitution effect (as is true for most utility functions we consider).
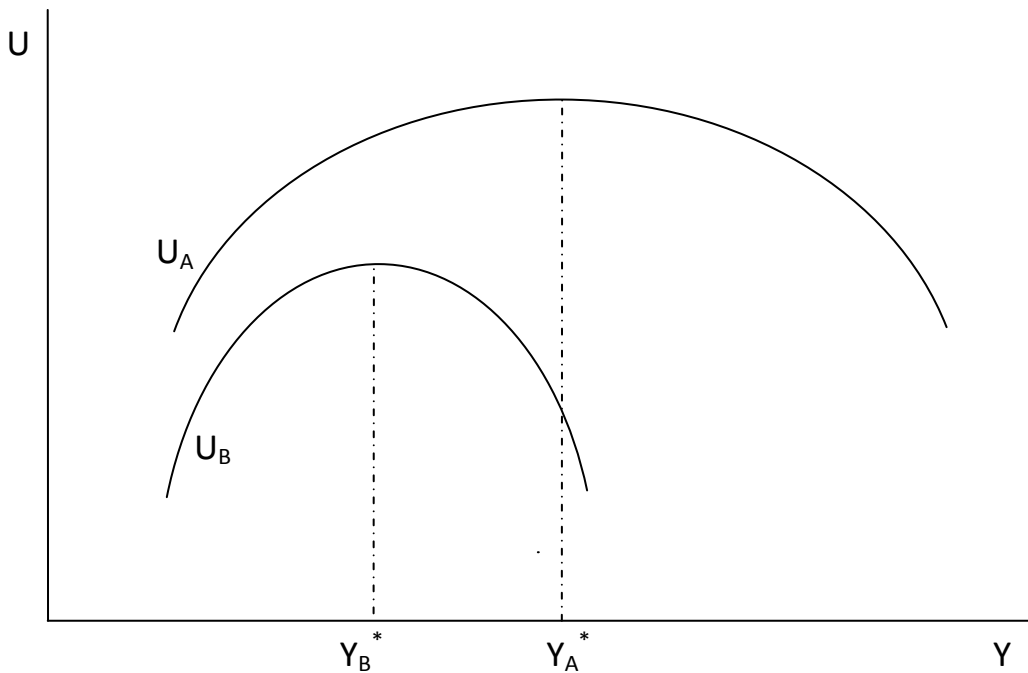

Figure 2: Utility curves for low (B) and high (A) earners

3. The government wants to transfer income from high earners to low earners. To do so,

it pays a transfer of T to individuals earning less than a specified limit $\overline{Y}$, and taxes individuals a lump sum amount T if they earn more than $\overline{Y}$.

Suppose the two individuals A and B from part 2 above comprise our society. The government uses the transfer scheme just outlined, in the hope that A pays the tax while B receives the transfer. Of course, there is the concern that A may masquerade as a low ability individual by intentionally reducing his pre-tax income to qualify for the transfer. The government realizes that for a given cutoff $\overline{Y}$, the transfer T must be limited so that A is not an impostor (i.e. does not choose to earn less than $\overline{Y}$).

(a) Classify this program as Categorical vs. Means-tested, and Cash vs. In-kind.
Means-tested, and Cash.

(b) For a given tax/transfer T and cutoff $\overline{Y}$, write out the condition that must be satisfied in order for A not to be an impostor.
Suppose that when A faces a lump sum tax T, the optimal choice of income to earn is Y_A^* (as in Figure 3; see discussion of this figure below). In this case, A's optimal utility is $U(Y_A^* - T, 1 - Y_A^*/w_A)$. But if A decides to masquerade and qualify for the transfer, he must earn income $\overline{Y}$, in which case his utility would be $U(\overline{Y} + T, 1 - \overline{Y}/w_A)$. Thus, the condition on T for A not to masquerade is

$$U(Y_A^* - T, 1 - Y_A^*/w_A) \geq U(\overline{Y} + T, 1 - \overline{Y}/w_A)$$

(c) Since the government's goal is to transfer income to B, their intuition is that B's earnings should not be restricted. That is, if Y_B^* is the level of earned income choosen by B if he were given a transfer T, the income cutoff is set at $\overline{Y} = Y_B^*$. Plot B's utility function when $\overline{Y} = Y_B^*$, and mark B's choice of earned income.
See Figure 3. B's utility curve when expecting to receive a cash transfer of T is given by U_B. B wants to earn income Y_B^* to maximize his utility, as long as he will actually qualify for the cash transfer with this income. And of course he will receive the transfer, since $\overline{Y}$ has been conveniently set exactly to equal Y_B^*. As shown in Figure 3, B's resulting utility is U_B^*.

(d) Continuing from 3(c), suppose the government has chosen the largest possible transfer T so that A is not willing to be an impostor, but that the constraint in part 3(b) binds. On the same graph from 3(c), plot two utility curves for A: the first utility curve in the case that A decides to earn more than $\overline{Y}$, and the second utility curve in the case that A decides to be an impostor. Make sure that the two utility curves for A correspond to the fact that the constraint in 3(b) binds.
Refer to Figure 3. If A must pay a lump sum tax of T, his utility curve as a function of Y will be U_A. However, if A instead acts as an impostor and receives a cash transfer of T, his utility curve is given instead by $\hat{U}_A$ (of course, A must earn no more than $\overline{Y}$ to actually receive the transfer). Note that $\hat{U}_A$ must everywhere
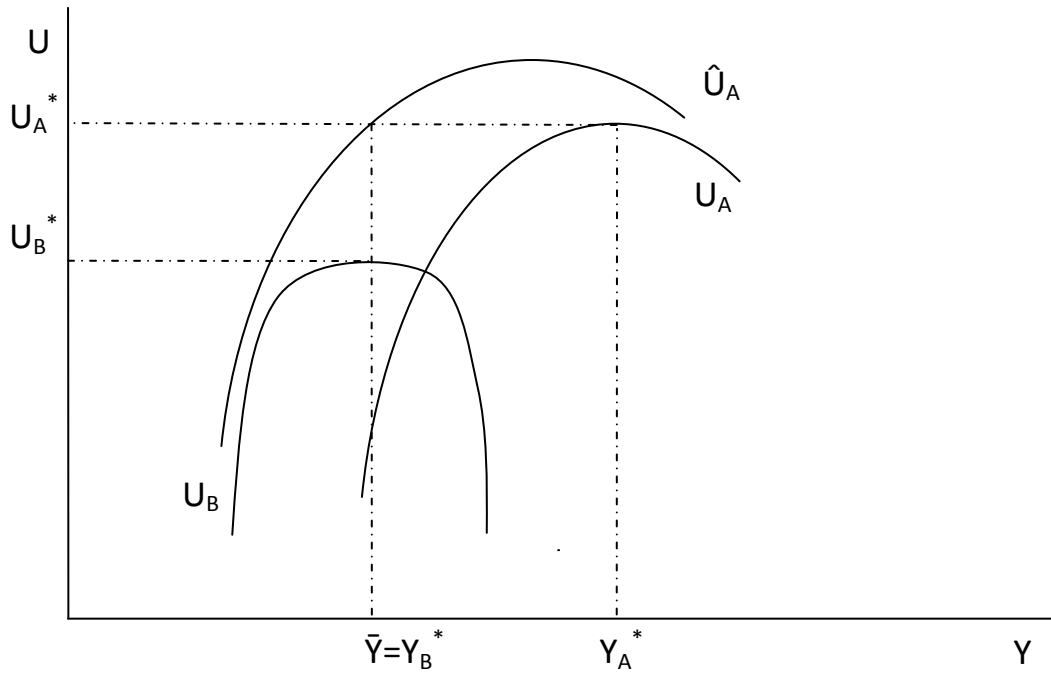
Figure 3: Utility curves for A and B under welfare

lie above the U_B curve, for reasons discussed above in parts 1 and 2.

The statement that the constraint in part 3(b) binds means that A is indifferent between being an impostor and acting genuinely, since in either case he receives utility of U_A^*. The curves U_A and $\hat{U}_A$ have been drawn to match this condition.

(e) Using the graph from 3(d), decide whether it would be welfare-improving to restrict B's income. That is, can social welfare be increased by lowering $\overline{Y}$ slightly to $\tilde{Y}$? Describe your reasoning carefully. Does your conclusion match the government's intuition expressed in 3(c)?

The key to this problem is that the government would like to transfer even more money from A to B, but under the situation in part 3(d) the government cannot raise T or else A will choose to be an impostor, and the welfare program will break down. However, there is actually a way to transfer more from A to B, but to do so we must place a restriction on B's earned income.

As shown in Figure 4, if the income cutoff is lowered slightly from $\overline{Y}$ to $\tilde{Y}$, B suffers a very small loss of welfare from reducing his income to meet the new cutoff (as seen by $U_B^* \approx \tilde{U}_B$). This is because B's utility function is flat in the region near $\overline{Y}$. However, A's imposter utility curve $\hat{U}_A$ is *not* flat near $\overline{Y}$, and thus, lowering the income cutoff hurts A very much (compare $U_A^* > \tilde{U}_A$) if he is trying to be an imposter.

So we have seen that slightly lowering the income cutoff hardly hurts B, but it hurts A very much *only if he is trying to be an imposter*. This means that A is not going to be an imposter, even if we raise T some. Because B is hardly hurt by the new cutoff but is meaningfully aided by the increased transfer payment, we have successfully transfered more money from A to B for a net social improvement.
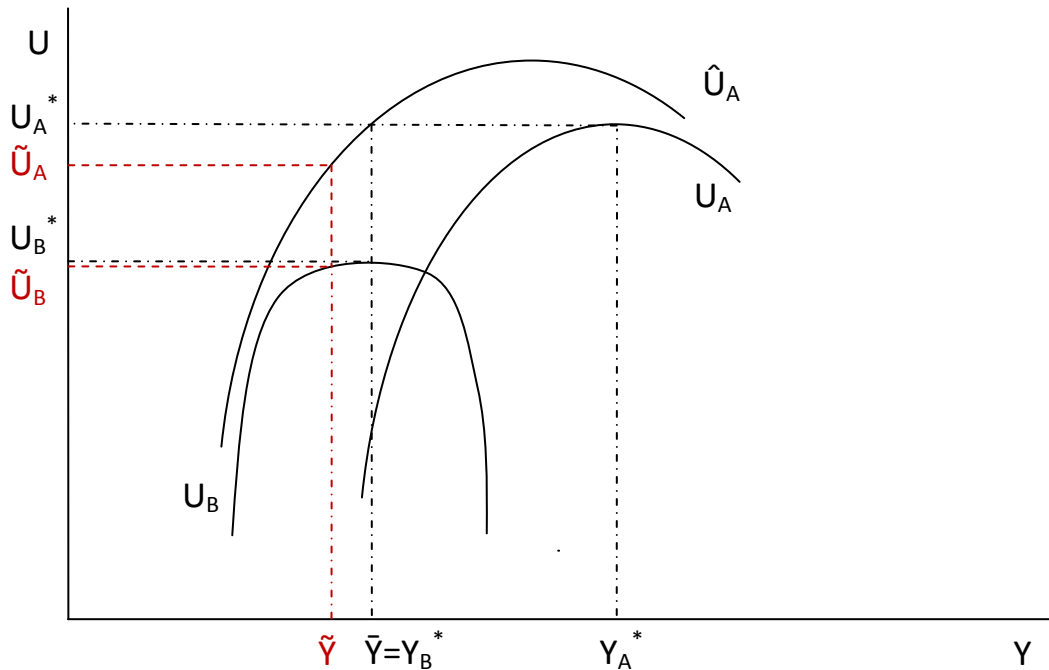

Figure 4: The welfare effects of

4. In one or two sentences, explain the policy lesson learned from this exercise.

We have learned that when income taxes are the only available tool for redistribution, it is desirable to restrict income eligibility for transfer payments to a level that is actually *lower* than the intended beneficiary would choose for himself.

Question 4 (20 points)

Suppose Montana establishes an income tax schedule that has a tax rate of 5% on the first $20,000 of income, 10% on the next $10,000, and then 20% on all taxable income above $30,000. Montana provides a $2,000 exemption (deduction) per family member. (Let's call this tax system A.)

1. The Abrams family has three members. Thomas is the sole earner, and he has two kids. The family's annual income is $35,000. Calculate their:

   (a) Statutory marginal tax rate, 20%. (apply $35,000 to tax schedule)

   (b) Effective marginal tax rate, 10%. (apply $35,000–{3 people}*$2,000/{person} = $29,000 to tax schedule)

   (c) Taxable income, $29,000, as calculated in 1(b)

   (d) Total taxes, and 0.5($20,000)+.10($9,000) = $1,900

   (e) Effective average tax rate. ATR = $\frac{1,900}{35,000}$=5.4%. An alternative way to calculate this is by using taxable income in the denominator, but this is discouraged.

2. The Brigham family has four members. Rachel is the sole earner, and she has three daughters. The family's annual income is $100,000. For the Brigham family, calculate the same 5 items as you did for the Abrams family in 1(a)-1(e).

   (a) Statutory marginal tax rate, 20%

   (b) Effective marginal tax rate, 20%

   (c) Taxable income, $100,000–{4 people}*$2,000/{person} = $92,000

   (d) Total taxes, and 0.5($20,000)+.10($10,000)+.20($62,000) = $14,400

   (e) Effective average tax rate. ATR = $\frac{14,400}{100,000}$=14.4%. An alternative way to calculate this is by using taxable income in the denominator, but this is discouraged.

3. Suppose that under Montana's tax system, taxes are levied at the household level (i.e. the marginal tax rates apply to combined spousal income). Does this tax system provide Thomas and Rachel a financial incentive to marry each other, or does it provide a disincentive? Separately, Thomas pays $1,900 in taxes, while Rachel pays $14,400 in taxes. This results in $16,300 total taxes paid.

   If married, then total household income would be $135,000. Simple calculations like those above give us that taxable income would be $121,000, resulting in total taxes of $20,000. Thus, the tax system provides a financial *disincentive* to marry.

4. Suppose that Montana decides to move to a flat tax rate of 15%, keeping the $2,000 per family member exemption. (Let's call this tax system B.)

(a) Specify whether each family benefits or suffers from the new tax system. Under the flat tax, Abrams family pays total taxes of 0.15($29,000)=$4,350, while the Brigham family pays total taxes of 0.14($92,000)=$13,800. Thus, relative to the tax system A above, the Abrams family is worse off, while the Brigham family is better off.

(b) How has the marriage incentive or disincentive changed from that in system A? Tax system B is now marriage neutral (constant MTR).

5. Rather than implementing the flat tax system, Montana keeps the income tax schedule described first (A), but instead of providing a $2,000 exemption per family member, introduces a $2,000 tax credit per family member. (Let's call this tax system C.)

(a) Which tax regime will each family prefer? Why? The Abrams family will have taxable income of $35,000 (no exemptions), and thus total taxes of .05($20,000)+.10($10,000)-{3 people}*$2,000/{person} = $3,000.

The Brigham family will have taxable income of $100,000 (no exemptions), and thus total taxes of .05($20,000)+.10($10,000)+.20($70,000)-{4 people}*$2,000/{person} = $8,000.

So each family prefers tax system C.

(b) Why does the distinction between a credit versus a deduction matter so much in terms of total tax revenue? A $1 deduction reduces tax revenue by the MTR, which is typically < 1. A $1 tax credit reduces tax revenue by $1. From a tax revenue perspective, a credit is more costly than a deduction.

6. Compare and contrast the vertical and horizontal equity implications of each of the three tax regimes A-C.

(a) Which tax system is the most vertically equitable, and which is the least? A vertically equitable system is progressive. Tax system B is the least vertically equitable, since there is no progressivity. Tax system C provides credits that are more valuable to the poor than the rich, so C is more vertically equitable than A. "Value" here is in terms of utility rather than in $s, since $ value is the same. However, if tax credits are non-refundable, then tax system C provides credits that are worth more (in $ terms) to the rich relative to the poor, so it is difficult to state whether system A or C is more vertically equitable.

(b) Which regime is the most horizontally equitable, and which is the least? A horizontally equitable system taxes people with similar earning capability equally, and does not tax lifestyle choices such as children/marriage. All three tax schemes violate horizontal equity since deductions/credits are independent of earnings (not the value of such deductions/credits, though). Further, tax system A and C provide marriage disincentives, while system B does not. While unclear, I would rank C≺A≺B in terms of preference for horizontal equity.

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Fall 2010