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Consumption Dominance Curves:

Testing for the Impact of Tax Reforms

on Poverty

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Abstract

A new tool is presented to test for the robustness of the impact on poverty of marginal tax reforms for pairs of commodities. Consumption Dominance Curves exist for every order of stochastic dominance while the more standard concentration curves are only linked to the second order of dominance. An illustration is provided with Bolivian data.

Résumé

Dans cette note, nous présentons une nouvelle méthode permettant de tester la robustesse de l'impact sur la pauvreté de réformes fiscales marginales pour une paire de biens de consommation. Les courbes de dominance de consommation existent pour chaque ordre de dominance stochastique alors que les courbes de concentration usuelles ne sont liées qu'au deuxième ordre de dominance. Nous illustrons la méthode à l'aide de données boliviennes.

Mots-clé: Emploi, Bien public, Appariement

Codes JEL: H41, J23, J68

1. Introduction

When analyzing the distributive effects of a tax reform, economists usually check for non intersection of concentration curves (Peter Lambert, 1993a and b). For example, to propose a welfare improving indirect tax reform for all social welfare functions respecting the Dalton transfer principle, Shlomo Yitzhaki and Wayne Thirsk (1990) and Yitzhaki and Joel Slemrod (1991) identify pairs of commodities with non intersecting concentration curves, taking into account the differential in the efficiency cost of raising public funds through the two commodities. As noted in Yitzhaki and Jeffrey Lewis (1996), this method can be adapted to test for the impact of a tax reform on poverty, but with one limitation: the use of standard concentration curves limits the tests to second order dominance. In this note, we present a new graphical tool, the Consumption Dominance Curve (CD-Curve), which can be used to test for the impact of an indirect tax on poverty for any order of restricted stochastic dominance. In the context of poverty alleviation, Timothy Besley and Ravi Kanbur (1987) have shown the conditions under which changes in prices affect FGT (James Foster, Joel Greer and Erik Thorbecke, 1984) poverty measures. This note also extends Besley and Kanbur's results by considering a larger class of additive poverty measures. Our methodology is presented in section 2. Section 3 gives an empirical illustration. A brief conclusion follows.

2. Methodology

The government wants to reduce an additive index of poverty

$$P(F,z) = \int_0^a p\left(y^E(q,y),z\right) dF(y) \tag{A1}$$

where F is the distribution of income defined over $[0, a]$, $z < a$ is the poverty line defined in the equivalent income space[1] , y^E is the equivalent income[2] , q is a vector of unitary market prices e subject to taxes t, such that $q = e + t$, and y is income. The poverty measure p is non negative for all individuals and zero for those with income above z. In order to discuss restricted stochastic dominance of order s, we require that the poverty measure be a continuous function s-time differentiable or piecewise differentiable[3] over $[0, a]$ with

$$(-1)^s p_1^s \left(y^E (q, y), z\right) \geq 0. \tag{A2}$$

where $p_1^s(\cdot)$ is the $s-$th derivative of the function $p(\cdot)$ in respect to its first argument. At this point, it is worth to mention that the assumption made on continuity together with the assumption that the poverty measures is zero for all income higher than the poverty line plays a crucial role in the proof of our dominance conditions. Specifically, it enable us to derive restricted dominance condition for order higher than 2. If one is not ready to accept this assumption on the continuity of the successive derivatives, restricted dominance condition of order higher than 2 may collapse into the second degree restricted dominance condition if there is a large uncertainty about the value of the poverty line (see Buhong Zheng, 1999).

The class of poverty measures respecting assumptions A1, A2 and the continuity assumption is denoted by Π^s. The continuity assumption implies inter alia that an infinitesimal

[1] It is also possible to define the poverty line in the income space. However, it is more convenient to define it in the equivalent income space because the tax reform will not change the poverty line in this space.
[2] The equivalent income is defined implicitly as

$$v\left(q^R, y^E\right) = v(q, y),$$

where q^R is a reference price vector an $v(\cdot)$ is the indirect utility function. In this context, the equivalent income function represent a monetary measure of well-being.
[3] Note that if the $(s-1)$th derivative is a piecewise differentiable function this implies that the function and its $(s-2)$ first derivatives are differentiable everywhere. It is important to include piecewise differentiability because the $(s-1)$th derivative of a $FGT(s)$ measure is only piecewise differentiable (it is not differentiable at the poverty line) and we want those indices to be included in our analysis since they are the most commonly used indices in the poverty measurement literature.

increase in the equivalent income y^E does not induce a significant variation in the function $p\left(y^E(q,y),z\right)$. Assumption A2 implies that for $s=1$, an increase in equivalent income y^E reduces poverty; for $s=2$, a transfer from a richer to a poorer individual reduces poverty (Pigou-Dalton principle); and for $s=3$, poverty is reduced with a progressive transfer at a low income level and a regressive transfer at a higher income level if those transfers do not increase the variance of the distribution (transfer sensitivity). An interpretation of A2 for a higher order of dominance can be made using Peter Fishburn and Robert Willig's (1984) general transfer principles giving higher weights to transfers at the bottom of the distribution as s increases.

With a marginal tax reform for two goods i and j, the change in poverty for an individual with an income y is

$$dp\left(y^E(q,y),z\right)=p_1^1\left(y^E(q,y),z\right)\frac{\partial y^E(q,y)}{\partial t_i}dt_i+p_1^1\left(y^E(q,y),z\right)\frac{\partial y^E(q,y)}{\partial t_j}dt_j. \qquad (1)$$

As shown by Besley and Kanbur (1988), if the vector of reference prices used for computing equivalent income is the vector of prices before the reform, the change in equivalent income induced by a marginal change in the tax rate of good i is

$$\frac{\partial y^E}{\partial t_i}=-x_i(q,y), \qquad (2)$$

where $x_i(q,y)$ is the Marshallian demand for good i.

Revenue neutrality requires $R=\sum_{k=1}^K t_k X_k$ where X_k is the aggregate total consumption of the kth good $X_k=\int_0^a x_k(y)\,dF(y)$. As in Yitzhaki and Slemrod (1991), holding producer prices constant, this implies:

$$dt_j=-\gamma\left(\frac{X_i}{X_j}\right)dt_i \text{ where } \gamma=\frac{1+\frac{1}{X_i}\sum_{k=1}^K t_k\frac{\partial X_k}{\partial q_i}}{1+\frac{1}{X_j}\sum_{k=1}^K t_k\frac{\partial X_k}{\partial q_j}}. \qquad (3)$$

David Wildasin (1984) interprets γ as the differential efficiency cost of raising one dollar of public funds by taxing the jth commodity and using the proceeds to subsidize the ith commodity. Yitzhaki and Thirsk (1990) and Yitzhaki and Slemrod (1991) argue that if γ is larger than one, implying a greater deadweight loss in the economy after the fiscal reform, welfare dominance is precluded for the second order of dominance. Here however, we consider poverty reduction which is more restrictive than welfare dominance[4] , so that a tax reform with $\gamma > 1$ may be dominant at the second order if the efficiency cost is paid by the non-poor. Using (3) in (1)

$$dp\left(y^E(q,y),z\right) = -p_1^1\left(y^E(q,y),z\right)\left[\frac{x_i(y)}{X_i} - \gamma\frac{x_j(y)}{X_j}\right]X_i dt_i. \tag{4}$$

This equation is similar to the result in Besley and Kanbur (1988) except that they rule out the efficiency parameter γ by assuming no taxes, and they use the FGT indexes instead of the more general form $p\left(y^E(q,y),z\right)$.

We now introduce the concept of the Consumption Dominance Curve or CD-curve of order s. We start with $s = 1$ and define $C_k^1(y) = x_k(y)/X_k$, which is the ratio of consumption of good k for an individual with income y divided by the aggregate consumption of the good. Next, we define $C_k^2(y) = \int_0^y C_k^1(u)\,dF(u)$ and $C_k^s(y) = \int_0^y C_k^{s-1}(u)\,du$ for all integer $s \geq 3$. For $s = 2$, the curve represents the share of total consumption of good k consumed by the individuals whose income is less than y. Note that for $C_k^2(y)$, we integrate over income y while for a standard concentration curve, we would integrate over population percentiles. The advantage of CD-curves over concentration curves is that CD-curves can be used to test for dominance of any order, while concentration curves can only be used for $s = 2$. Using our notation, (4) can be rewritten as:

$$dp\left(y^E(q,y),z\right) = -p_1^1\left(y^E(q,y),z\right)\left[C_i^1(y) - \gamma C_j^1(y)\right]X_i dt_i. \tag{5}$$

[4] On this subject, we refer to Anthony Atkinson (1987), Foster and Anthony Shorrocks (1988a, b and c) and Jean-Yves Duclos and Paul Makdissi (2000).

The total change in poverty induced by the reform is then obtained by integrating (5)

$$\frac{dP(F,z)}{dt_i} = -X_i dt_i \int_0^a p_1^1 \left(y^E(q,y), z\right) \left[C_i^1(y) - \gamma C_j^1(y)\right] dF(y), \tag{6}$$

If the poverty line cannot exceed a certain value z^+, we can prove a standard restricted dominance results within our framework for marginal tax reform.

Proposition 1 *A necessary and sufficient condition for* $\frac{dP(F,z)}{dt_i} \leq 0$ *for all* $P(F,z) \in \Pi^s$, $s \in \{1,2,3,...\}$ *and for all* $z < z^+$ *is*

$$C_i^s(y) - \gamma C_j^s(y) \geq 0, \; \forall y \leq z^+. \tag{DS}$$

For example, with $\gamma = 1$, proposition 1 stipulates that the marginal tax reform will reduce poverty at a given order of dominance if the CD-Curve of good i is higher than the CD-Curve of good j for every income level under the maximum poverty line. If $\gamma \neq 1$, we can still compare the CD-Curve for good i with the CD-Curve of good j provided the later is multiplied by γ. In other words, a tax reform will decrease poverty for the class of poverty measures if the two CD-Curves associated with this class of measures are not intersecting before the maximum poverty line.

If there is no agreement on the maximum poverty line, we must test for dominance for all $z \in [0, \infty)$. In this situation, we can use the results of Foster and Shorrocks (1988b and c) and Duclos and Makdissi (2000) and interpret the poverty dominance test as a welfare or inequality dominance test for the appropriate order of dominance. Furthermore, for the second order of dominance, the condition will be similar to the test proposed by Yitzhaki and Slemrod (1991) and Yitzhaki and Thirsk (1990) except that we test for dominance over the income space whilst they test for dominance over the population quantile space[5] .

[5] It is worth to mention here that since the poverty measure is a strictly decreasing convex function instead of a strictly increasing convex function, we do not face the problem highlighted by Yitzhaki (1999) and we will have the same necessary condition for welfare dominance (concave function) than for poverty dominance, i.e. in both case the reform must not decrease marginally the mean of the distribution.

3. Empirical Illustration

We use a 1999 Bolivian survey (Encuesta Continua de Hogares 1999) representative of Bolivia's main cities. Per capita consumption (which is better measured than per capita income) is the variable used for y. For illustrative purpose, we will assume that $\gamma = 1$. While we will test for restricted dominance over a range of poverty lines, it is useful to note that a reasonable poverty line would turn out to be between 325 and 353 Bolivianos per person per month depending on the city (with six Bolivianos being equal to one US dollar), yielding half of the urban population below the poverty line (Wilson Jimenez and Quentin Wodon, 2000). We could illustrate the use of CD-curves with many pairs of commodities at various orders of dominance, but we restrict ourselves to one comparison in order to be brief.

The illustration consists in changing at the margin the tariffs of public interprovincial transportation and medicine costs. Figure 1 provides the CD-Curves of order two. The horizontal axis represents total per capita consumption normalized by the poverty line in Jimenez and Wodon, so that a value of one indicates that a household is exactly at the level of that particular poverty line. Recalling that $C_k^2(y) = \int_0^y x_k(y)/X_k dF(y)$, the CD-Curves measure the cumulative shares of each good consumed by the households with normalized per capita consumption below y/z. Up to slightly more than twice the poverty line used in Jimenez and Wodon, the CD-Curve for interprovincial transport lies above that for medicine costs. If we agree that the poverty line can not exceed 2 times the poverty line suggested by Jimenez and Wodon, this indicates that raising the tariff of medicines and reducing that of interprovincial transport would reduce any poverty measure of the second order respecting assumptions A1 and A2, including the FGT poverty gap. For higher poverty lines, there is no dominance at the second order. Figure 2 shows what happens at the third order of dominance for the same two goods. As before, the CD-Curve for interprovincial public transport lies above that for medicine costs, but this time, dominance is obtained throughout the interval considered for the poverty lines in the figures.

4. Conclusion

In this note, we have presented a new tool – the Consumption Dominance Curve – to test whether the reduction in poverty induced by a marginal tax reform for two commodities is robust over a large set of poverty measures and poverty lines. Building on work by Yitzhaki and Thrisk (1990) and Yitzhaki and Slemrod (1991), the method is similar in spirit to checking for non intersecting concentration curves, but it enables the analyst to chose the order of restricted stochastic dominance of interest, rather than being limited to the second order of dominance. Moreover, the method extend results provided in Besley and Kanbur (1988) for poverty measures of the FGT class to a larger class of poverty measures, and to the case when there is a differential in the efficiency cost of rasing public funds through various commodities.

A Proof of Proposition

If we refer to equation (6), we easily realize that the sufficiency condition for $s = 1$ is proved by simply noting that $p_1^1\left(y^E(q,y),z\right)$ is negative and that $dF(y)$ is necessary positive. To prove sufficiency for $s > 1$, we first need to integrate by parts $\int_0^a p_1^1\left(y^E(q,y),z\right)C_k^1(y)\,dF(y)$:

$$\int_0^a p_1^1\left(y^E(q,y),z\right)C_k^1(y)\,dF(y) = p_1^1\left(y^E(q,y),z\right)C_k^2(y)\Big|_0^a - \int_0^a p_1^2\left(y^E(q,y),z\right)C_k^2(y)\,dy. \tag{A.7}$$

We know that $C_k^2(0) = 0$ and that $p_1^1\left(y^E(q,a),z\right) = 0$. The first term of on the r.h.s. of the equation is thus nil. Consequently, equation (7) may be rewritten as

$$\int_0^a p_1^1\left(y^E(q,y),z\right)C_k^1(y)\,dF(y) = -\int_0^a p_1^2\left(y^E(q,y),z\right)C_k^2(y)\,dy. \tag{A.8}$$

Now, assume that $s > 2$, and that for some $t \in \{3, 4, ..., s-1\}$, we have:

$$\int_0^a p_1^1 \left(y^E(q,y), z\right) C_k^1(y)\, dF(y) = (-1)^{t-2} \int_0^a p_1^{t-1} \left(y^E(q,y), z\right) C_k^{t-1}(y)\, dy. \tag{A.9}$$

Integrating by parts equation (9), we get

$$\begin{aligned} \int_0^a p_1^1 \left(y^E(q,y), z\right) C_k^1(y)\, dF(y) &= (-1)^{t-2} p_1^{t-1} \left(y^E(q,y), z\right) C_k^t(y)\Big|_0^a \\ &\quad - (-1)^{t-2} \int_0^a p_1^t \left(y^E(q,y), z\right) C_k^t(y)\, dy. \end{aligned} \tag{A.10}$$

$C_k^t(0) = 0$ and, $p_1^{t-1}\left(y^E(q,a), z\right) = 0$ is implied by definition of a and by the continuity assumption. We can rewrite this equation as

$$\int_0^a p_1^1 \left(y^E(q,y), z\right) C_k^1(y)\, dF(y) = (-1)^{t-1} \int_0^a p_1^t \left(y^E(q,y), z\right) C_k^t(y)\, dy. \tag{A.11}$$

Equation (8) respects the relation depicted in equation (9). We have shown that if (9) is true then equation (11) is also true. This implies that equation (11) is true for all integer $t \in \{2, 3, ..., s-1\}$. Assumption A4 implies that the function $p_1^{s-1}\left(y^E(q,y), z\right)$ is continuous and differentiable everywhere or piecewise differentiable. Let us now suppose that this function has n points where it is not differentiable (n may equal 0). Let us denote by y_l, $l = 1, 2, ..., n$ those n points. Integrating by parts equation (11) for $t = s-1$, we obtain

$$\begin{aligned} \int_0^a p_1^1 \left(y^E(q,y), z\right) C_k^1(y)\, dF(y) &= (-1)^{s-2} p_1^{s-1} \left(y^E(q,y), z\right) C_k^s(y)\Big|_0^a \\ &\quad - (-1)^{s-2} \sum_{l=0}^{n} \int_{y_l}^{y_{l+1}} p_1^s \left(y^E(q,y), z\right) C_k^s(y)\, dy \end{aligned} \tag{A.12}$$

where $y_0 = 0$ and $y_{n+1} = a$. Using the usual argument, we can eliminate the first term of the r.h.s. of the equation. We thus have

$$\int_0^a p_1^1 \left(y^E(q,y), z\right) C_k^1(y)\, dF(y) = (-1)^{s-1} \sum_{l=0}^{n} \int_{y_l}^{y_{l+1}} p_1^s \left(y^E(q,y), z\right) C_k^s(y)\, dy. \tag{A.13}$$

From equation (6) and (13), we get

$$\frac{dP(F,z)}{dt_i} = (-1)^s X_i dt_i \sum_{l=0}^{n} \int_{y_l}^{y_{l+1}} p_1^s \left(y^E(q,y), z\right) \left[C_i^s(y) - \gamma C_j^s(y)\right] dy. \tag{A.14}$$

This last equation, together with our assumptions on $p_1^s\left(y^E(q,y),z\right)$ proves the sufficiency of the condition. In order to establish necessity, consider the set of functions $p\left(y^E(q,y),z\right)$ for which the $(s-1)$th derivative (for $s=1$ we take the function let $p_1^{s-1}\left(y^E(q,y),z\right)=p_1\left(y^E(q,y),z\right)$) is of the following form

$$p_1^{s-1}\left(y^E(q,y),z\right)=\begin{cases}(-1)^{s-1}\epsilon & y\le\overline{y}\\ (-1)^{s-1}(\overline{y}+\epsilon-y) & \overline{y}<y\le\overline{y}+\epsilon\\ 0 & y>\overline{y}+\epsilon\end{cases}, \tag{A.15}$$

Poverty indices whose function $p\left(y^E(q,y),z\right)$ have the particular above form for $p_1^{s-1}\left(y^E(q,y),z\right)$ belong to Π^s. This yields:

$$p_1^{s}\left(y^E(q,y),z\right)=\begin{cases}0 & y<\overline{y}\\ (-1)^{s} & \overline{y}<y<\overline{y}+\epsilon\\ 0 & \overline{y}>\overline{y}+\epsilon\end{cases}. \tag{A.16}$$

Imagine now that $C_i^s(y)-\gamma C_j^s(y)<0$ on an interval $[\overline{y},\overline{y}+\epsilon]$ for $\overline{y}<z^+$ and for ϵ that can be arbitrarily close to 0. For $p\left(y^E(q,y),z\right)$ defined as in (15), expression (14) is then positive and the marginal tax reform induces a marginal increase of poverty. Hence, it cannot be that $C_i^s(y)-\gamma C_j^s(y)<0$ for $y\in[\overline{y},\overline{y}+\epsilon]$ when $\overline{y}<z^+$. This proves the necessity of the condition. ■

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Figure 1: Interprovincial public transport vs medicine

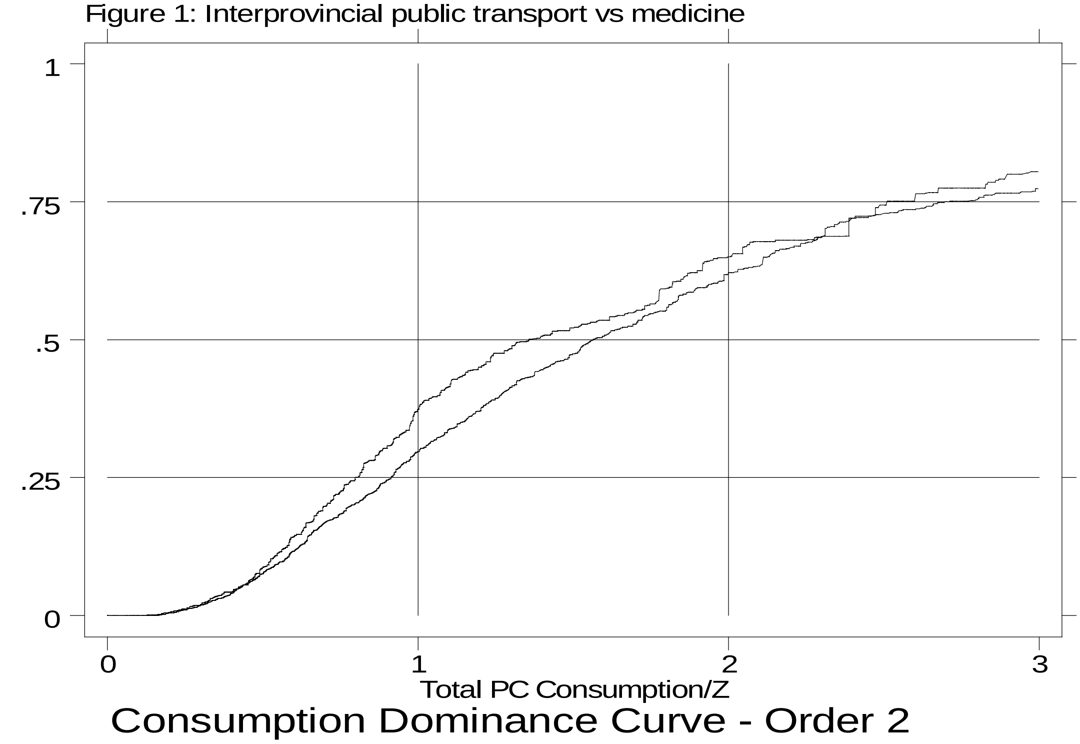
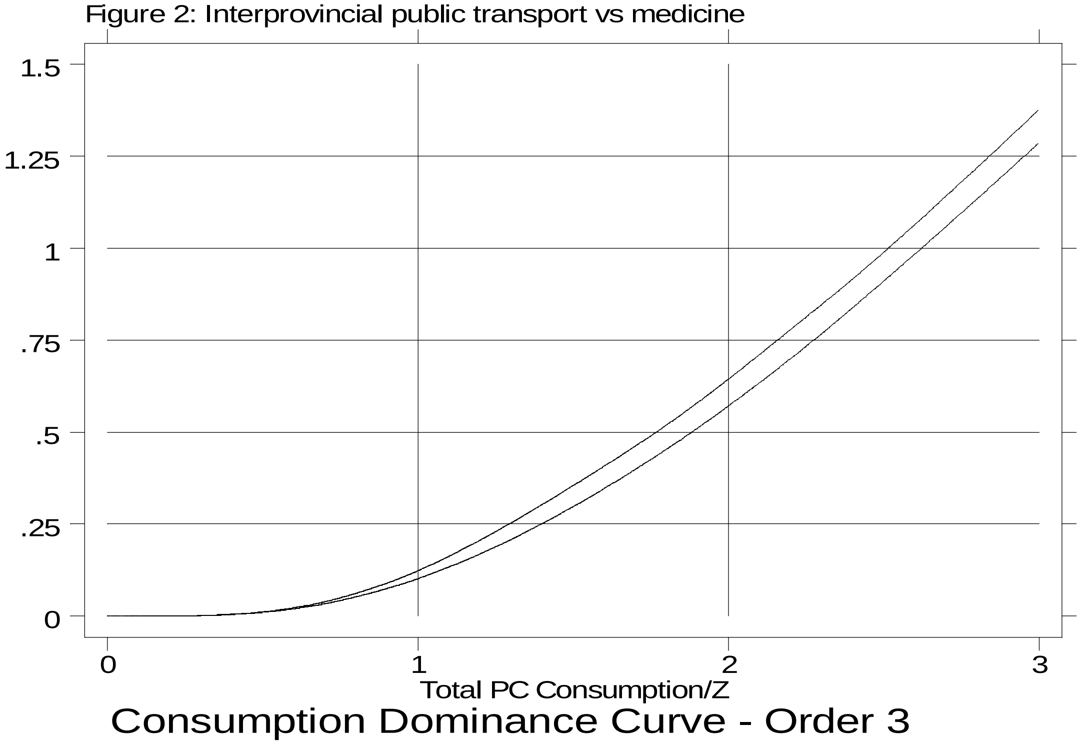


Figure 2: Interprovincial public transport vs medicine



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