Indirect Tax Reforms and Poverty in Tanzania

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Abstract

This paper analyzes the impacts of indirect marginal tax reforms on poverty and welfare in Tanzania by using the normalized consumption dominance curves which is first prompted by Makdissi and Wodon (2002). It shows how to use $\overline{CD}$ curves and estimators of critical poverty lines to design an effective indirect tax reform and to determine the range of poverty lines over which the tax reform is able to reduce poverty and improve welfare. The empirical analysis is based on the data sets from 2008-2009 National Panel Survey of Tanzania.

Keywords: Tax reform; Poverty; Social welfare; Normalized consumption dominance curve

1. Introduction

Global imbalance in economic development appears to be more serious than ever as the world's economy boosts faster, with some less developed countries lagging far behind, such as Malawi, Tajikistan and Tanzania, where prevailing poverty is invariantly accompanied by deeply flawed financial system and stupendously high income inequality. Improving income distribution to reduce poverty level in these countries by implementing efficiently designed policies will tremendously enhance the harmony of world economic development, thus is becoming the cynosure of researchers and analysts. Most extant literature, however, treated poverty and inequality separately instead of simultaneously. Truth is income inequality can be most effectively improved by distributional policies, i.e. indirect taxes such as VAT, excise tax, and sales tax which will greatly affect final prices of consumption goods, consequently increasing the real income of the poorest people whose income is mostly used in consuming goods of basic needs and saved little. Therefore, chances are that governments of these less developed countries can devise an appropriate indirect tax system to redistribute income and reduce poverty.

Noted, though, an optimal tax is not a one-time achievement for any government. Existing tax systems more often than not are far from optimal and any reform of the system takes a long and arduous journey, thus focusing on a smooth, less painful tax system reform is more realistic, practical and remunerative than pursuing an optimum. Ahmad and Stern (1984) investigated marginal commodity tax reform, which is a popular idea among economists and policy makers by its nature of practicality and applicability. To access the redistribution effect of such marginal tax reform, we do not need prerequisite knowledge or estimation of individual demand and utility functions, which are usually difficult to either observe or aggregate once observed. Thus an obvious advantage of marginal indirect tax reform is its less reliance on the information set and data set compared to implementing optimal tax rate.

There are three main development paths for marginal commodity tax reforms. First, Ahmad and Stern (1984) defined a marginal tax reform as increasing tax on commodity j and using the funds raised from j to subsidize commodity l, which, under certain circumstances such as the marginal social cost of taxing on good l is higher than marginal social cost of taxing on good j, can be social welfare improving. More generally, marginally subsidizing commodity l by taxing j while keeping the total tax revenue unchanged will have a positive impact on welfare. Feldstein (1975) pointed out that not only dependent on the marginal efficiency cost of funds, such tax reform also relies on the distributional characteristics of the two commodities to succeed. Affecting a commodity's price either directly or indirectly by own- or cross-substitution effect, any change in indirect tax rate changes consumer demand for different commodities differently, ultimately affecting total tax revenue which is one of the determinant factors for the social cost of taxation.

To include various reforms in a single welfare judgment, Ahmad and Stern (1984) went on to generate welfare weights for their welfare function, which had been adopted in many later literature. Following Ahmad and Stern, Daltonian school scholars, Mayshar and Yizhaki (1995) first assumed to rank households by some

observable characteristics, making an established social welfare structure is unnecessary in household comparison.[1] Unlike Ahmad and Stern (1984), who compared total consumption values of two commodities, however, Daltonian school compared shares of consumption on two goods and ranked them in reference to concentration curves, whereas the bottom represents the lowest ranking of income and the top represents the highest ranking of income, since the concentration curves give the specific value of the share of consumption on a commodity. This rank thus allows us to calculate the percentage of population under a certain consumption level and the quantity of commodity they consumed. Therefore, Daltonian tax reform only needs concentration curves for the two commodities involved to function.

Recently, more thoughts are given to marginal commodity tax reforms in poverty-reducing research. This method was first prompted by Besley and Kanbur (1988), followed by Makdissi and Wodon (2002), Liberati (2003) and Duclos *et al.* (2005). Makdissi and Wodon (2002) extended Besley and Kanbur (1988) definition of poverty indices FGT (Foster et al., 1984) by employing additive poverty measures, they exploited the normalized consumption dominance curves to judge the impact of marginal tax reform on poverty and social welfare. Basing on this methodology, Makdissi, Duclos and Wodon(2008) conceived a comprehensive interpretation of implementing poverty-reducing marginal tax reforms. The normalized consumption dominance curves ($\overline{CD}$ curves) indicate the cumulative consumption shares weighted by powers of poverty gaps, represent the consumption pattern of those who are under the poverty line and help us to determine the social efficiency of marginal tax reform.[2] Given a maximum poverty line and a dominance order, the reform that increases tax on commodity j and subsidizes commodity l is reducing poverty if $\overline{CD}$ curve of commodity l is higher than $\overline{CD}$ curve of commodity j. Thus if the maximum poverty line is extended to infinite, theoretically a tax reform can be social welfare improving.

[1] This idea is consistent with Daltonian criterion, hence the name Daltonian school

[2] See Duclos, Makdissi, and Wodon (2008)

Duclos and Makdissi (2004) measured the poverty by setting poverty line in this manner. Besides, they also built the ethical content of the classes of poverty indices, which could help to increase the range of poverty line over which the tax reform can be deemed good for poverty reduction. Yitzhaki and Lewis (1996) had an analysis of poverty reducing, but they inspected population at percentiles $p = F(z)$, which would induce sampling variability.

The remainder of this paper is organized as follows. Section 2 illustrates the methodology of analyzing the impact of indirect tax reform on Tanzania's poverty. Section 3 introduces background of Tanzania. Section 4 will go on to discuss the specific impacts of indirect tax reforms with data from the 2008-2009 National Panel Survey of Tanzania. Finally, section 5 gives a brief conclusion.

2. Methodology

This paper mainly uses the methodology proposed by Duclos, Makdissi, and Wodon (2008) to check whether the indirect tax reforms in Tanzania are able to reduce poverty and improve social welfare. The tax reform that increases tax on good j and decreases tax on good l could change prices of those two commodities. What matters however is the impact of such price-changing policies on poverty and social welfare, thus we need to set appropriate poverty index and social welfare function.

First, let's introduce utilitarian social welfare function

$$U=\int_0^a u(y)dF(y) \tag{1}$$

The social welfare indices $u(y)$ is defined has the following property

$$(-1)^{i+1}u^{(i)}(y) \geq 0 \quad \text{for } i = 0, 1, 2,.....s \tag{2}$$

Here pre-reform nominal and real income are the same since we take reference prices

as the pre-reform prices. $F(y)$ is the income distribution function. We define $\Omega^s = \{U \mid u(y) \in \hat{C}^s$ and $(-1)^{i+1} u^{(i)}(y) \geq 0 \ \forall_i = 0,1,2,....,s \}$ where $\hat{C}^s$ indicates welfare functions are continuous and s-th differentiable. If the utility function is homothetic, then the social welfare function can easily be used to measure relative inequality. First, define the equally distributed equivalent income ε as the level of income that, if obtained by every individual in the income distribution, would enable the society to reach the same level of welfare as actual income.[3]

$$U(\varepsilon) = \int_0^a u(y)dF(y) \tag{3}$$

$$\varepsilon = U(\varepsilon)^{(-1)}(\int_0^a u(y)dF(y)) \tag{4}$$

Then the relative inequality I can be expressed as

$$I = \frac{\mu - \varepsilon}{\mu} = 1 - \frac{\varepsilon}{\mu} \tag{5}$$

where $\mu = \int_0^a ydF(y)$ is mean income, the index of inequality I is measured by the distance between the equally distributed income and the mean incomes expressed as a proportion of mean income. Since $\varepsilon = \mu(1 - I)$ and $u'(y) \geq 0$ according to $(-1)^{i+1} u^{(i)}(y) \geq 0$, higher ε indicates higher social welfare. Therefore, we can either increase μ or increase equality of income distribution $1 - I$ by reducing inequality I to increase social welfare. As long as inequality exists, to reach the same level of social welfare, mean income μ must be higher than ε. I also shows the per capita proportion of income that is "wasted" in social welfare terms because of inequality.[4] So indirect tax reform that reduces inequality would lead to social welfare improvement.

Duclos, Makdissi and Wodon (2008) proposed additive poverty indices by choosing a poverty line z, the consumers whose income are less than this amount z are deemed to

[3] This note is first introduced by Atkinson(1970)
[4] See Duclos and Araar (2006)

be poor. Here we also use $p(y,z)$ indicates levels of poverty for an individual with income y. Note if $y > z$, then the consumer would not be defined as poor, then $p(y,z)=0$. So the additive poverty indices can be expressed as

$$P(z) = \int_0^a p(y,z)dF(y) \tag{6}$$

Besides, for the discussion of restricted stochastic dominance orders, we need $p(y, z)$ be a continuous function that is s-time differentiable or piecewise differentiable over $[0, a]$ and with the property

$$(-1)^i p^{(i)}(y, z) \geq 0 \quad \text{for } i = 0, 1, 2,.....s \tag{7}$$

Where $p^{(i)}$ is i-th derivative of the poverty measure function in respect to its first argument. This property does make sense over s orders. For instance, when i =1, it shows $(-1)\, p'(y, z) \geq 0$, so $p'(y, z) \leq 0$, which means consumers' level of poverty is reduced as the income increases, which consistent with reality. For $i = 2$, $(-1)^2 p^{(2)}(y, z) \geq 0$ and $p^{(2)}(y, z) \geq 0$, which states that the poorer a consumer, the easier to decrease his level of poverty by increasing income. We define the classes of above poverty indices $P(z) \in \Pi^s$.[5]

We use restricted dominance for welfare and poverty orderings. Many stochastic dominance orders exist, and each order has an ethical explanation in term of welfare and poverty analysis.

When $s = 1$, the social welfare indices $u(y)$ must be weakly increases in y and that poverty measure $p(y, z)$ must be weakly decreases in y based on property (2) and (7) which states $u'(y) \geq 0$ and $p'(y, z) \leq 0$. First order indices tell us that increase one individual income could raise his welfare and decrease poverty level. However, it is not Pareto improvement since we impose symmetry and anonymity assumption on it.

[5] See Duclos and Makdissi (2004)

Pareto improvement refers to any change in economic management that improves the situation of one or more members of the community without worsening the lot of anyone. But because of symmetry assumption, any interchange of income between two individual could keep social welfare and poverty unchanged, so though the final result is better we cannot ensure such reform makes on one worse. Pen (1971) sates that ordering two distributions of living standards over the first-order classes of indices is equivalent to making the living standards "parade" simultaneously alongside each other, and verifying if one parade weakly dominates the other,[6] so we usually named first-order welfare improving as "Pen improving tax reform".

For s = 2, second-order social welfare and poverty indices obey the Pigou-Dalton principle of transfers. Pigou-Dalton transfers is a mean-preserving equalizing transfers of income from a rich person to poor person.[7] Such transfer contributes to welfare improvement and poverty reduction. On the other hand, this means that the same amount of money brings more utility to poor person than to rich person. So $u''(y) \leq 0$ which also demonstrates social welfare indices is concave. The same naturally implied $p''(y) \geq 0$, those two properties display inequality aversion. We define such second-order welfare improving as "Dalton-improving tax reform".

For s=3, Kolm (1976) proposes composite transfers, a favorable Pigou-Dalton transfer that takes money from the poor to the rich within the lower range of income distribution accompanied by an unfavorable transfer that takes money from the poor to the rich within the higher part of income distribution. In order to get social welfare improvement and poverty reduction, the third-order indices have to be sensitive to favorable transfer happened in the lower part of distribution such that the beneficial effect of the favorable transfer exceeds the negative effect of the adverse transfer, implying $u''' \geq 0$ and $p''' \leq 0$. This is "Kolm-improving tax reform".

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[6] See Pen (1971)

[7] See Pigou (1912) and Dalton (1920)

As s increases, the generalized transfer principles of Fishburn and Willig (1984) can be used to interpret higher-order indices. Increasing the order of dominance also facilitates the search for socially improving tax reform. Additionally, it is said that all indices associated to a given order of dominance represent the same rank over the two distributions whenever these two dominance curves of this order do not intersect.

Duclos and Makdissi (2004) defined stochastic dominance curves

$$D^S(z) = \frac{1}{(s-1)!}\int_0^z (z-y)^{s-1} dF(y) \quad \text{for orders of dominance, s=1,2,....s} \tag{8}$$

Then we focus on how to compare two income distribution functions $F(\cdot)$ and $G(\cdot)$ using stochastic dominance curves. From equation (8), we know that when s=1, $D^1(z) = F(z)$; furthermore, for all integers $s \geq 2$, $D^s(z) = \int_o^z D^{s-1}(y)dy$. First, comparing poverty level of distribution functions $F(\cdot)$ and $G(\cdot)$, when distribution $F(\cdot)$ has higher level of poverty, we have that

$$\Delta P_{FG}(z) = \int_0^a p(y,z)dG(y) - \int_0^a p(y,z)dF(y) < 0 \tag{9}$$

This indicates that the tax reform which adjusts the income distribution move from distribution $F(\cdot)$ to distribution $G(\cdot)$ is socially favorable since it reduced poverty. Duclos and Makdissi (2004) made the following two propositions upon which such income distribution movement is neither poverty increasing nor welfare decreasing.

PROPOSITION 1: *A necessary and sufficient condition for* $\Delta P_{FG}(z) \leq 0$, *for any poverty line* $z \in [0, z^+]$ *and any absolute poverty index* $P(z) \in \Pi^s$, *is*

$$D_F^s(y) - D_G^s(y) \geq 0 \quad \forall y \leq z^+$$

To compare absolute poverty, we just refer to the dominance curves, over the range

$y \leq z^+$, the higher position of the dominance curve, the higher poverty level this distribution is.

For social welfare comparisons, we can say that the welfare does not decrease in a movement from distribution $F(\cdot)$ to distribution G $(\cdot)$ if

$$\Delta U_{FG} = \int_0^a u(y)dG(y) - \int_0^a u(y)dF(y) \geq 0$$

Thus proposition 2 define criteria for social welfare comparisons,

PROPOSITON 2: *A sufficient condition for* $\Delta U_{FG} \geq 0$, *for all* $U \in \Omega^s$, *is*

$$D_F^s(y) - D_G^s(y) \geq 0 \quad \forall y \in [0,a]$$

And if $s \geq 3$,

$$D_F^i(a) - D_G^i(a) \geq 0 \quad \forall i \in \{2,....,s\text{-}1\}$$

The conditions for comparisons of poverty and for welfare are almost the same when $s \geq 3$ despite different value area of income. The income range for social welfare comparisons is more extensively.

Let t be vector of tax rates, for simplicity, we set producer prices to be a constant 1 and invariant to changes of tax rate t so that consumer prices $q=1+t$ and $dq_k = dt_k$ where k represents commodity k, if $x_k(y,\theta,q)$ is the consumption of good k of a consumer with income y, preference θ, then using Roy's identity and setting reference prices to pre-reform prices, we find that

$$\frac{\partial v(y,q,\theta)}{\partial q_k} = \frac{\partial v(y^R,q^R,\theta)}{\partial q_k^R} = \frac{\partial v(y,q,\theta)}{\partial y} \cdot \frac{\partial y}{\partial q_k} = -x_k \cdot \frac{\partial v(y,q,\theta)}{\partial y} \quad \text{if } q=q^R,\ y=y^R$$

$$\frac{\partial y^R}{\partial q_k}\Big|_{q=q^R} = \frac{\partial v(y,q,\theta)}{\partial q_k} \Big/ \frac{\partial v(y^R,q^R,\theta)}{\partial y^R} = -x_k \cdot \frac{\partial v(y,q,\theta)}{\partial y} \Big/ \frac{\partial v(y^R,q^R,\theta)}{\partial y^R} = -x_k \qquad (10)$$

$$\frac{\partial y^R}{\partial t_k}\Big|_{q=q^R} = -x_k \qquad (11)$$

Equation (11) demonstrates that we can censor the impact of marginal tax changes on consumer welfare by observing pre-reform consumption of good k.

Define per capita consumption $X_k(q) = \int_0^a x_k(y,q)dF(y)$, since $x_k(y,q)$ is loss of consumer welfare because of marginal tax increase on good k, $X_k(q)$ demonstrates average social well-being cost of an increase in the price of good k.

Government total revenue of per capita commodity taxes is $R(q) = \sum_{k=1}^{K} t_k X_k(q)$, government always intends to keep revenue neutrality, this requires $dR(q) = 0$. Now suppose it increases tax on commodity j and decreases tax on commodity l, this leads to the following revenue changes.

Since $q=l+t$ and $dq_k = dt_k$, we have

$$\frac{\partial R}{\partial q_j} = \frac{\partial R}{\partial t_j} = X_j(q) + \sum_{k=1}^{K} t_k \frac{\partial X_k}{\partial t_j} \quad \text{and} \quad \frac{\partial R}{\partial q_l} = \frac{\partial R}{\partial t_l} = X_l(q) + \sum_{k=1}^{K} t_k \frac{\partial X_k}{\partial t_l}$$

$$\Rightarrow dR(q) = [X_j(q) + \sum_{k=1}^{K} t_k \frac{\partial X_k}{\partial t_j}]dq_j + [\sum_{k=1}^{K} X_l(q) + t_k \frac{\partial X_k}{\partial t_l}]dq_l = 0 \qquad (12)$$

Define γ as

$$\gamma = 1 + \frac{1}{X_l}\sum_{k=1}^{K} t_k \frac{\partial X_k}{\partial t_l} \Big/ 1 + \frac{1}{X_j}\sum_{k=1}^{K} t_k \frac{\partial X_k}{\partial t_j} \tag{13}$$

Wildasm（1984）interprets γ as the differential efficient cost of raising one dollar of public funds by taxing commodity j and using the proceeds to subsidize commodity l, the numerator and denominator of equation (13) are the inverse of the marginal economic efficiency cost of taxing j and l($\frac{1}{MECF_j} and \frac{1}{MECF_l}$), thus $\gamma = \frac{MECF_j}{MECF_l}$, then higher value of γ means higher marginal economic cost of gaining funds from taxing j relative to taxing l , so it is less economically efficient by taxing j and subsidize good l. γ=1 means no economic efficiency cost advantage exists in such reform.

Combining equation (12) and (13), it is easily to get

$$dq_j = -\gamma(\frac{X_l}{X_j})dq_l \tag{14}$$

Thus the requirement for revenue neutrality can be defined as dq_j to be a proportion of dq_l.

What interests us is the specific impact of changes in goods' prices on dominance curves, thus learn about the social efficiency of such pricing-change policy. Duclos, Makdissi and Wodon (2008) use consumption dominance curve (CD) to show the effects of tax reform. We have that

$$CD_k^s(z) = \frac{\partial D^s(z)}{\partial t_k}, \quad s=1,\ 2..... \tag{15}$$

According to equation (8), when s=1, $D(z)=F(z)$, thus, $CD_k^1(z) = \frac{\partial D(z)}{\partial t_k} = \frac{\partial F(z)}{\partial z}\frac{\partial z}{\partial t_k} = \mathrm{x}_k(\mathrm{z},\mathrm{q}^R)\mathrm{f}(\mathrm{z})$ where $f(z)$ is the income density. This is

the consumption pattern of persons whose income is at z.

For $s \geq 2$,

$$\frac{\partial D^s(z)}{\partial t_k} = \frac{1}{(s-1)!}\int_0^z (s-1)(z-y)^{(s-2)}(-\frac{\partial y}{\partial t_k})dF(y) = \frac{1}{(s-2)!}\int_0^z (z-y)^{(s-2)} x_k(y,q^R)dF(y)$$

$$CD_k^s(z) = \frac{\partial D^s(z)}{\partial t_k}|_{q=q^R} = \begin{cases} x_k(z,q^R)f(z) & \text{if s = 1} \\ \frac{1}{(s-2)!}\int_0^z x_k(y,q^R)(z-y)^{s-2}dF(y) & \text{if s = 2,3, ...} \end{cases} \quad (16)$$

Therefore, we can say that $CD_k^s(z)$ captures changes in ethically weighted sums of deprivation; it can also be interpreted as the ethically weighted cost of taxing good k.

Normalizing $CD_k^s(z)$ by average consumption of good k, we get

$$\overline{CD_k^s}(z) = \frac{CD_k^s(z)}{X_k(q)} \quad (17)$$

Thus ethically weighted cost of taxing good k is demonstrated as a proportion of average consumption.

First-order $\overline{CD_k^1}(z)$ curve shows the portion in the total consumption of good k of those whose income is at the poverty line z. As s increases, more weight imposed on the bottom of income distribution, so higher-order of $\overline{CD_k^s}(z)$ curves weight consumption shares by increasing power of poverty gaps. When there is no economic efficiency cost advantage (γ=1), increasing the tax on good j while subsidizing good l is poverty improving at any order of ethical dominance if $\overline{CD_l^s}(z)$ curve is higher than $\overline{CD_j^s}(z)$ for all $z \in [0, z^+]$, if extends z^+ to be infinity, this kind of tax reform can be welfare improving. Duclos, Makdissi and Wodon (2008) exploited two theorems to check whether an indirect marginal tax reform is poverty- and welfare-improving.

THEOREM 1: *A necessary and sufficient condition for a marginal tax reform* $dq_j = -\gamma(\frac{X_l}{X_j})dq_l > 0$ *(it means* $dq_j > 0$ *and* $dq_l < 0$*), to be s-order poverty improving, that is, to decrease poverty weakly for all* $P(z) \in \Pi^s$*, for all* $z \in [0, z^+]$ *and for a given* $s \in \{1, 2, 3, ...\}$*, is that*

$$\overline{CD_l^s}(y) - \gamma\overline{CD_j^s}(y) \geq 0 \qquad \forall \ y \in [0, z^+] \tag{18}$$

Thus we can say the tax reform is poverty reducing if $\overline{CD_l^s}(y)$ curve is always above $\gamma\overline{CD_j^s}(y)$ curve when income is below z^+.

Based on (16) and (17), this condition can be written as

$$\int_o^z [x_l(y, q^R) - \gamma x_j(y, q^R)](z - y)^{s-2} dF(y) \geq 0 \quad \forall \ y \in [0, z^+] \tag{19}$$

So change in consumption pattern weighted by poverty gaps also shows the effect of tax reform. In other word, for a tax reform to be poverty release we need the two normalized CD curves associated with this class of measures do not intersect before the maximum poverty line.

THEOREM 2: *A sufficient condition for a marginal tax reform,* $dq_j = -\gamma(\frac{X_l}{X_j})dq_l > 0$ *to be s-order welfare improving, that is, to increase social welfare for all* $U \in \Omega^s$ *and for a given* $s \in \{1, 2, 3....\}$*, is that*

$$\overline{CD_l^s}(y) - \gamma\overline{CD_j^s}(y) \geq 0 \qquad \forall \ y \in [0, \infty] \tag{20}$$

It indicates such tax reform can be welfare improving if Theorem1 still valid when maximum poverty line z^+ is extended to infinite.

Now we analyze how to measure the distributive benefit of such indirect tax reform that increase tax on good j while reduce tax or subsidize on good l, equation (16) and (17) illustrates $\overline{CD_l^s}(z)$ is the socially weighted gain by reducing the tax of good l. the same meaning applied to $\overline{CD_j^s}(z)$, so the ratio $\frac{\overline{CD_l^s}(z)}{\overline{CD_j^s}(z)}$ can be deemed as the distributive benefit of taxing good j and subsidize good l, this ratio is $\delta^s(z)$:

$$\delta^s(z)=\begin{cases}\dfrac{\overline{CD_l^s}(z)}{\overline{CD_j^s}(z)} & \text{if } \overline{CD_j^s}(z) \neq 0 \\ \gamma^{++} & \text{if } \overline{CD_j^s}(z) = 0\end{cases} \tag{21}$$

When s=1, $\delta^1(z)=\frac{\overline{CD_l^1}(z)}{\overline{CD_j^1}(z)}=\frac{x_l(z)/X_l(q)}{x_j(z)/X_j(q)}$, we know that Engel curves describe how real expenditure varies with household income, $\delta^1(z)$ is just the normalized ratio of Engel curves at income z, greater $\delta^1(z)$ indicates those who are at given income z spend more on the consumption of good l than the consumption of good j, so subsidizing commodity l could decrease poverty and having good redistributive effect. Normally, the higher value of $\delta^s(z)$ means the more effective or efficiency the tax reform is, since it demonstrates the society gains more by taxing good j than by taxing good l. However, we cannot decide the tax reform is socially improvement just according to the larger value of $\delta^s(z)$ for that such tax reform also has economic cost because of the deadweight loss of taxation. Recall that γ is the economic efficiency cost of taxing j relative to that of taxing l, only when $\delta^s(z) \geq \gamma$ for all $z \in [0, z^+]$ can we say the tax reform is poverty reducing. Thus despite Theorem 1 and 2, we can also determine whether or not an indirect marginal tax reform could succeed to alleviate poverty and improve welfare by checking whether $\delta^s(z) \geq \gamma$ for all $z \in [0, z^+]$ and for all $z \in [0, \infty)$.

Let's define a critical efficiency threshold as γ^+. Then according to Theorem 1, given maximum poverty line z, for any value of $\gamma < \gamma^+$ such as γ_2 in Figure 1 (where $\gamma_2 < \gamma^+ < \gamma_1$), condition (18) can be satisfied, which ensures the tax reform is poverty reducing. Also, if the critical upper poverty line is denoted by z^+, then given γ, for any values of $z < z^+$, condition (18) will still be valid for poverty relief. Otherwise, for $\gamma \geq \gamma^+$ and $z \geq z^+$, the tax reform would not be poverty improving. But there is an exception for $\overline{CD_j^s}(z)=0$ upon which we can set values of γ and z whatever we want, even to infinity. The key is to get critical economic efficiency threshold and critical upper poverty line. We know that the tax reform can be socially improving if $\delta^s(z) \geq \gamma$; therefore, we can denote economic efficiency threshold as

$$\gamma_s(z^+) = \inf \{\delta^s(z) \mid z \in [0, z^+]\} \tag{22}$$

Similarly, define $z_s(\gamma^+)$

$$z_s(\gamma^+) = \sup\{ z \mid \delta^s(y) \geq \gamma^+, y \in [0, z], z \leq z^{++} \} \tag{23}$$

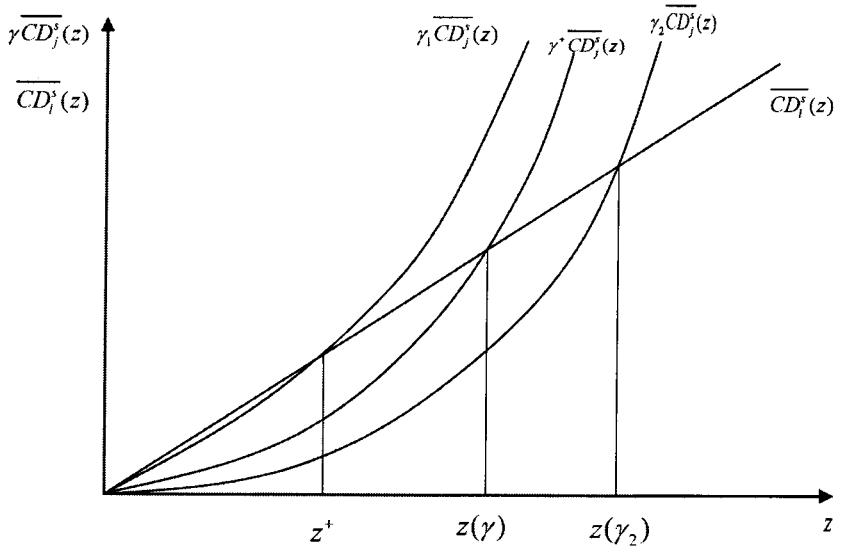


Figure 1 $\overline{CD}(z)$ **Curves and Critical Efficiency Parameters**

In Figure 1, $\gamma_s(z^+) = \gamma_1$ and $z_s(\gamma^+) = z(\gamma)$, so there are two ways to achieve social improving tax reform for $z=z^+$. First, increase the order of dominance for two $\overline{CD}$ curves since it facilitates the search for socially improving tax reform; second, extend the restricted value of z^+ to equate with $z_s(\gamma^+)$.

3. Country Background

The United Republic of Tanzania, a country in East Africa, is a 26-region state, with the second largest population of 40.4 million in east Africa. Its two official languages are Swahili and English. Since 1996, Dodoma, also the principal commercial city, had been the official capital of Tanzania. The currency used in Tanzania is Tanzanian Shilling (TZS or TSH).

Classified as a low income country by World Bank and also considered as the least developed country by the United Nations, Tanzania is suffering extreme poverty among the poorest countries in the world. As measured by international standards, 88.5 percent of its population lives below the $1.25 per day poverty line, and 96.6 percent population lives on less than $2 per day.[8] Measured by national poverty line, poverty rate decreased during the past years as shown in Table 1, though the absolute number of people living in poverty increased by 1.5 million in the time between 2000 and 2007 surveys. Moreover, its GINI index remains 34.6 for many years.

Table 1 Poverty ratio (% of population below national poverty line)

Year	1990	2000	2007
Poverty Ratio	38.6	35.6	33.4

Source: World Bank http://data.worldbank.org/country/tanzania

[8] 2009 UN Human Development Report

Economic Performance

Tanzania's economy is highly dependent on agriculture, which contributes one quarter of GDP and employs 80 percent of population, mostly producing subsistence produce such as corn, rice and wheat. Its manufacturing sector contributes the least to GDP. Table 2 gives the change of Tanzania's per capita GDP during the recent years. Though Tanzania's per capita GDP is among the lowest in the world, its economy has seen a positively upward trend, represented by the expanding share of exports and significant financial deepening. After employing a series of reforms, Tanzania has absorbed more of both foreign direct investment and foreign aid, and seen a higher GDP growth rate than Sub-Sahara.[9]

Table 2 GDP per capita (current US$)

Year	2006	2007	2008	2009
GDP per capita	398	446	548	535

Source: World Bank http://data.worldbank.org/country/tanzania

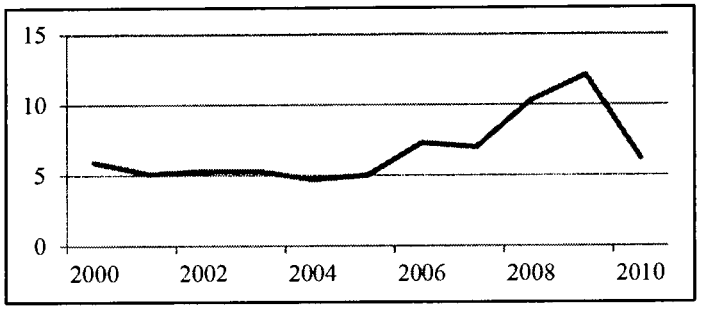
From Figure 2 we can see during 2000 and 2005 the country kept a stable annual inflation rate of about 5 percent. However, inflation rate increased much since 2006 to 12.8 percent in 2009. Such an increase could have been caused by globally higher oil price and the subsequently heightened cost in transportation, and other exogenous shocks such as weather abnormality which tremendously reduced food crop harvest and increased global food prices which accounts for future inflation tendency.[10] Inflation rate taken into account, the poverty line used for the empirical analysis in Section 4 of this paper is approximately adjusted to TSH 450 per person per day in 2008-09, from the national poverty line estimated by the Tanzania Household Budget Survey (NBS) in 2001 using the January 2000 Household Budget Survey data of TSH

[9] World Bank: Tanzania Country Brief

[10] Mkukuta Annual Implementation Report 2009/10

7253 per person per 28 days, i.e. TSH 259 per person per day[11] and the 72 percent increase in price level between January 2000 and 2007, as shown in Figure 2, to fit Tanzania's 2008-09 National Panel Survey conducted in 2009.

Figure 2 Annual inflation rate of Tanzania (consumer prices) (%)

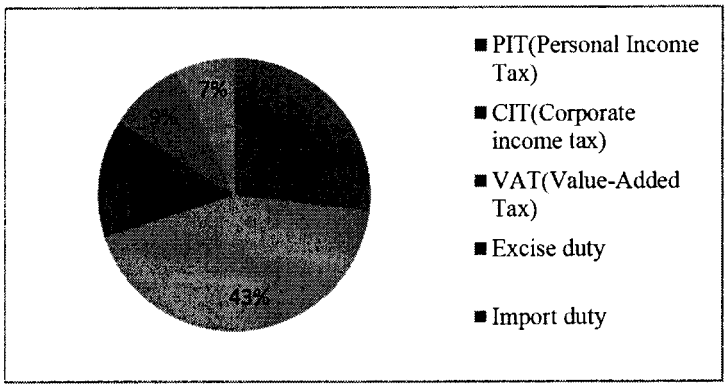


Source: World Bank http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

Tax Revenue Composition

The primary components of general tax revenue in Tanzania are value added tax (VAT), excise duty, import duty, personal income tax and corporate income tax. The first three component taxes (VAT, excise duty and import duty) are also composition of consumption taxes. Apparently, consumption taxes represent the largest share of total tax revenue in Figure 3.

Figure 3 Tanzania tax revenue by source



Source: Tanzania Revenue Authority, http://www.tra.go.tz/info statistics.htm

[11] National Bureau of Statistics Tanzania: Household Budget Survey 2000/01 Final Report

Seeking modern reforms, Tanzanian government continues to expand the tax base and increase domestic revenue. Revenue from VAT and excise tax on domestic goods is most contributing to total revenue increase whereas taxes on imports and income contribute relatively less.

Education

Education in Tanzania is generally in very poor condition. Many schools are short of high quality teachers and basic educational equipment. But the government has realized the great impact of education on national development and people's future earnings; higher education usually leads to optimistic income, whereas smaller literate adult population would result in a shortage of skilled manpower which in turn would impede economic development. Starting education sector reform since 1995, Tanzania government has developed a Basic Education Master Plan (BEMP) in early 1997 to guide development in basic education provision, and in 2002 it designed the Education Sector-development Program (ESDP) to implement various programs, strategies and policies to reduce education cost and to expand relevant facilities. The overall objectives of the education reforms are to increase equitable access to high quality education and to increase adult literacy. Those efforts have improved Tanzanian school enrolment. Primary school enrolment has greatly increased in the past years. 57 percent of 5-14 years age children attended school in 2007. As of 2006, primary school completion rate (percent of children who reach grade 5 among all children enrolled in primary school) improved significantly by 87.2 percent. However, this improvement in children school enrolment is not represented in rural area. The 2007 Household Budget Survey shows that primary and secondary education enrolment rates in rural areas are still extremely low.[12] The rural children, so it seems unfortunately, have been left far behind their urban contemporaries in the education system.

[12] World Bank: Tanzania Country Brief

Health

Tanzania has long suffered malnutrition, with large percentage of its population chronically undernourished, and a life expectancy of 57 in 2009. Mortality rate of children who are under five-year old is almost 60 percent.[13] Most children are underweight. Adult mortality rate in 2009 was 46 percent for men and 31 percent for women.[14] Almost 44 percent of Tanzanians are energy deficient and unable to simultaneously sustain their body and carry out even a slight physical activity. A lot of farmers cannot do farm work effectively due to the low daily calories intake. This translates into low agriculture productivity. The leading cause of high children mortality during neonatal period is malaria; pneumococcal disease and rotavirus account for high under-five mortality rate. The prevalence of HIV/AIDS also imposed a persistent grave threat to Tanzanians health. HIV infection rate in Tanzania is estimated to have reached 8.1 percent, five times higher than the worldwide rate. Injecting drug use is the leading cause of increasing transmission of HIV. Its prevalence among women is more severe, both because women play an important role in Tanzanian economy, and babies could contract HIV after birth through breast milk. Not only is a threat to health, HIV/AIDS also a serious handicap to economy development, since the government has to relocate large amount of public resource for medical care and HIV/AIDS prevention, and most of the costs are borne by family and communities, thus further weakening the already lagging domestic productivity.

Transportation

Transportation system in Tanzania is futile. It only has 9 percent paved roads as of 2004, a poorly-looking percentage compared to 12 percent in low-income countries.[15] It seriously impedes the development of some transportation-reliant industries such as mining, tourism and international trade. Poor roads and rail systems lead to high producer prices due to longer supply chains and higher transportation cost.

[13] World Health Statistics 2011
[14] Mortality Country Fact Sheet-United Republic of Tanzania
[15] United Republic of Tanzania-Transport Sector Snapshot

For the indigent Tanzanians, the transportation fee is so high relative to their low income that most of them cannot afford it. Thus their travelling relies heavily on walking and bicycles. Motorized vehicles transportation is still costly for most of them, except for the few wealthy people who can afford motorized vehicles. So overall, the demand for non-motorized transportation is likely to be large.

However, most of current researchers and policy makers focus on subsidization to motorized public transportation and pay very little attention to financing non-motorized transportation services. For this reason, accidents rate in Tanzanian public transportation is higher among low-income countries. In Tanzania, the proportion of accidents caused by public transportation is beyond their warrant numbers.[16] We have to clear the fact that a large section of the population are using bicycles or just walking; non-motored transportation comprise most part of transportation systems, so we can never design an efficient and safe road network without taking into account of the large amount of walking and bicycle riding men on road.

Aware of this phenomenon, I will analyze in Section 4 the individual specific expenditure on different transportation models in Tanzania and discuss some transportation system policies which are efficient in reducing poverty and improving welfare.

The $\overline{CD}$ curves and relevant methodology established in Section 2 are mainly forward alleviating social conditions of the poor in terms of food, health, education and transportation in Tanzania.

4. Empirical Analysis

In this section, I will analyze the practical implications of the indirect marginal tax reform on Tanzania's poverty and welfare using the tools established above and data

[16] United Republic of Tanzania-Transport Sector Snapshot

sets of Tanzania National Panel Survey (TZNPS) 2008-2009. TZNPS, implemented by the Tanzania National Bureau of Statistics, is the first series of nationally representative household panel surveys that assembles information on a wide range of topics including agricultural production, non-farm income generating activities, consumption expenditures, and a wealth of other socio-economic characteristics.[17] The survey was conducted over twelve months from October 2008 to October 2009. Besides, TZNPS is also part of Living Standards Measurement Survey of World Bank. It has observations of 3280 households and consists of Household Questionnaire, Agriculture Questionnaire, and Community Questionnaire. Here I use the data files pertaining to the sections of Household Questionnaire. The Household Questionnaire is composed of thematic sections, from which we are able to construct a full consumption-based welfare measure, permitting distributional and incidence analysis. Expenditures on health and education are not included in the nonfood expenditures in the Household Questionnaire of TZNPS (2008-2009), so I will discuss the impacts of indirect tax reforms when it is applied to nonfood with respectively to education, health and food. Then the analysis of tax reform in transportation system will follow. All of the expenditures have been normalized by the TSH 450 poverty line after taking inflation rate into account. So the final per capita expenditure is the normalized value. For example, a value of 4 on the horizontal axis of all the following figures means that a household expenditure is equal to TSH1800 (450*4); we can discuss the impact of marginal indirect tax reform on poverty and welfare according to the characteristics of $\overline{CD}$ curves for the two catalogues of commodities at a given order.

Health vs Nonfood

First, let us apply marginal indirect tax reform to health expenditures and nonfood expenditures. To determine which one should be taxed and which should be subsidized. we need have a look of the figures of $\overline{CD}$ curves for education expenditures and nonfood expenditures at different orders. At the first order of

[17] Tanzanian National Bureau of Statistics (2009)

dominance with γ=1, Figure 1.1 shows $\overline{CD}^1_{Health}$ and $\overline{CD}^1_{Nonfood}$ first intersect at $\hat{z}_1(1) = 8.312$ which is the value of critical first-order poverty line listed in Table 1.1. The standard error of the estimator $\hat{z}_1(1)$ is 0.389 which indicates 95 percent confidence interval for the true value of $z_1(1)$ is [7.56, 9.08]. Note that $\overline{CD}^1_{Health}$ is above $\overline{CD}^1_{Nonfood}$ before the first intersection, so we can 95 percent ensure that it is first-order poverty improving up to the poverty line 7.56 by marginally increasing taxes on nonfood expenditures and reducing taxes on or subsidizing for health expenditures. *It indicates the balanced-budget indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 7.56 at 95 percent confidence interval.* It cannot be Pen improving since the two $\overline{CD}$ curves still have intersection during the given range of per capita expenditure. However, it does not assure that all the people who live below the critical poverty line could gain from the tax reform. Tax neutrality requires that the tax reform meets equation (14), given the average per capita expenditure for health X_{Health}=0.141, average per capita consumption of nonfood $X_{Nonfood}$=3.471, by reducing one percentage tax on health expenditures, 0.041 percent of tax must be added to nonfood expenditures. The poor household who is below critical poverty line $\hat{z}_1(1) = 8.312$ could gain from this reform only if his expenditure ratio between health and nonfood is larger than 0.04. So there is still 5 percent of poor population lose from this tax reform. It turns out that the first-order poverty improving cannot be Pareto improving even if we observe its impact at poverty line.

For s=2 and 3 with γ=1, Taxing commodities for nonfood and reducing taxes for health expenditures is Dalton-improving and Kolm-improving tax reform, this can be certified by the critical poverty lines in Table1.1 and $\overline{CD}$ curves in Figures 1.2 and 1.4. First, Table 1.1 shows that there is no critical poverty line both at second- and third-order of dominance when γ=1, $\overline{CD}^2_{Health}$ curve lies above $\overline{CD}^2_{Nonfood}$ without

intersection in Figure1.2. Additionally, the distributive benefit $\delta^2(z)$ in Figure 1.2 is always bigger than 1 which means distributive benefit of this marginal indirect tax reform surpasses its economic efficiency cost ($\delta^2(z) \geq \gamma$). Recall that $\overline{CD}^2_{Health}$ displays the share in total expenditures of health of the poor people who live below poverty line z, so Figure 1.2 also tells us that this share for health is larger than it for nonfood for all poverty lines, then reducing taxes on health expenditures and increasing taxes on nonfood expenditures transfers money from rich people to poor which is consistent with Pigou-Dalton principle of transfers. *It indicates the tax reform is second-order poverty reducing for all poverty indices in* Π^2 *and for all poverty lines during the range* $[0, \infty]$*, thus is also second-order welfare improving according to Theorem 2.* Note that Figure 1.4 implies $\overline{CD}^3_{Health}$ curve also lies above $\overline{CD}^3_{Nonfood}$ curve everywhere. it states that this marginal indirect tax reform is sensitive to the favorable transfers happened in lower part of income distribution, *so it is third-order poverty reducing for all poverty indices in* Π^3 *and for all poverty lines during the range* $[0, \infty]$.

Since the tax reform is both second-and third-order welfare improving for $\gamma=1$, obviously, it would be also welfare improving and poverty reducing for $\gamma=0.5$. We know that $\gamma=1$ indicates $MECF_{Nonfood}$ equals to $MECF_{Health}$, so $\gamma=0.5$ means that marginally taxing nonfood expenditures and subsidizing health expenditures has economic efficiency cost advantage. With unchanged distributive benefit curve $\delta^s(z)$, it demonstrates the indirect tax reform is also welfare improving at second- and third-order of dominance when $\gamma=0.5$, this can be verified by the absence of critical values for $\hat{z}_2(0.5)$ and $\hat{z}_3(0.5)$ in Table 1.1. *Thus we can say the indirect tax reform is poverty reducing for all poverty indices in* Π^2, Π^3 *and for all poverty lines belong to* $[0, \infty]$ *at second- and third-order.* Respectively, when $\gamma=1.5$, $MECF_{Nonfood}$ is bigger than $MECF_{Health}$, the estimators of critical poverty lines $\hat{z}_2(1.5) = 26.917$,

$\hat{z}_3(1.5) = 58.914$ in Table 1.1, which means $\overline{CD}^3_{\text{Health}}$ and $1.5*\overline{CD}^3_{Nonfood}$ curves is estimated to be intersected at 58.914, *it indicates the indirect tax reform is third-order poverty improving for all poverty indices in* Π^3 *and for all poverty lines below 58.914. Similarly, it implies the indirect tax reform is second-order poverty reducing for all poverty indices in* Π^2 *and for all poverty lines below 26.917 when* γ=1.5. But it is not welfare improving at second- and third-order because of the estimated intersection between two curves.

In Tanzania, government has used various sources of funds targeting for achieving universal health coverage, public financing through taxation and donor funding are the main resources, approximately 10 percent of total government revenue is allocated to health care financing.[18] According to our analysis, for keeping a balanced government revenue, this amount of funds can be obtained by taxing more on other nonfood commodities, such as cars, TV, radio cassettes etc. Besides, the imports of health supplies were exempted from payment of VAT by Tanzania Revenue Authority, the supply to a registered medical practitioner, optician, dentist, hospital or patient of equipment designed solely for medical/prosthetic use is also on the special VAT reliefs list of Tanzania Revenue Authority.[19] Based on health condition described in section 3, it is wise for the government to reduce taxes on women's health expenditures and finance infrastructures which used to prevent widespread infection of HIV/AIDS by rising funds through taxing nonfood commodities.

Education vs Nonfood

Now we focus on the effect analysis of indirect marginally tax reform when it is employed in education expenditures and non food expenditures. First, let us consider its impact at different orders of dominance when γ=1, $\overline{CD}^1_{Education}$ and $\overline{CD}^1_{Nonfood}$

[18] See MOSHW (2008)

[19] See The Tanzania Revenue Authority Act (1995).

cross at 13.569 in Figure 2.1, it is the estimated value of $z_1(1)$ in Table 2.1. $\overline{CD}^1_{Education}$ is anywhere above $\overline{CD}^1_{Nonfood}$ before the first intersection, thus marginally increasing taxes for nonfood commodities and subsidizing for education expenditures while keeping government tax revenue unchanged could reduce the poverty gap if Tanzania's poverty line is below 13.150(13.569-0.214*1.96). *It indicates the tax reform reduces poverty weakly for all poverty* indices *in* Π^1 *and for all poverty lines below 13.569 at the first order.* It is not welfare improving since we still find a critical poverty line at which the two curves intersect. Figure 2.2 illustrates that $\overline{CD}^2_{Education}$ and $\overline{CD}^2_{Nonfood}$ never crossed during the expenditure range. Therefore, reducing taxes for education and increasing taxes for nonfood is welfare improving, we call it Dalton-improving tax reform. The same result in Figure 2.3 demonstrates that this kind of indirect tax reform is also Kolm-improving at the third-order of dominance. *Therefore, the indirect tax reform is poverty reducing for all poverty indices in* Π^2, Π^3 *and for all poverty lines belong to* $[0,\infty]$ *both at second- and third-order of dominance.*

Table2.1 gives the critical poverty lines under which the marginally indirect tax reform could reduce poverty with various ratios of economic efficiency costs γ, note that the critical poverty lines $\hat{z}_1(\gamma)$ is diminishing in γ at the first order, it decreases from 21.068 to 3.069 as the MECF ratios increasing from 0.5 to 1.5. The reason for thus tend is that the social cost of this tax reform is increasing as MECF ratios rise, with unchanged distributive benefit ratios $\delta^1(z)$, it imposes more constraint on critical poverty lines. Specifically, Table 2.1 lists $\hat{z}_1(0.5)=21.068$, *it indicates the tax reform is first-order poverty reducing for all poverty* indices *in* Π^1 *and for all poverty lines below 21.068 when* $\gamma=0.5$. $\hat{z}_1(1.5)=5.076$ *indicates it is first-order poverty reducing for all poverty indices in* Π^1 *and for all poverty lines below 5.076 when* $\gamma=1.5$, so it is not Pen-improving tax reform at the first-order. At

the second- and third-order, no critical poverty lines exists whatever the value of γ is, this is also proved by $\delta^2(z)$ in Figure 2.2, the minimum value of distributive benefit ratio $\delta^2(z)$ is bigger than 1.5 during the expenditure range, so decreasing taxes on education expenditures and increasing taxes on nonfood expenditures is not only poverty reducing but also Dalton-improving and Kolm-improving for γ values from 0.5 to 1.5, *then we can say the indirect tax reform is poverty reducing for all poverty indices in* Π^2, Π^3 *and for all poverty lines in* $[0,\infty]$ *at second- and third-order of dominance.*

Education plays an important role in Tanzania's economy; the economy is vulnerable to market shocks and global crisis for the shortage of skilled labor force impeded manufacturing development. Though the government has greatly increased school enrollment through Education Sector-development Program (ESDP), education quality is still need to be improved, so some training programs of teachers have been implemented recently years. In order to recruit qualified teachers at all levels, the government intends to subsidize teacher's residential housing. Moreover, realizing that rural children have been left far behind their urban contemporaries in the education system, government should provide more subsidies to rural teaching system.

Food vs Nonfood

It is important to study the impact of indirect tax reform that reducing taxes on food expenditures and rising taxes on nonfood expenditures since consumption on food occupied large share of the total expenditures in poor country. Any policy that influencing food prices would have profound impact on the country's poverty level and social welfare.

Considering impact of such marginal indirect tax reform at the first-order, we take a look of the results in Table 3.1, it shows that the estimator of first-order critical

poverty line $\hat{z}_1(0.5)$ is 18.826 with standard error 0.203, so the 95 percent confidence interval for the true value of first-order critical poverty line at γ=0.5 would be [18.428, 19.223], *it indicates the balanced-budget indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 18.428 at 95 percent confidence interval.* Thus, it is not Pen-improving. For γ=1, given the average food expenditure X_{Food}= 1.435 and per capita nonfood expenditures $X_{Nonfood}$= 3.471, one percentage of tax reduction on food must be compensated by 0.413 percentage tax increase on nonfood expenditures in order to keep budget neutrality. The two $\overline{CD}^1$ curves intersect at $\hat{z}_1(1)$ = 12.230 in Figure 3.1 which is also the value of critical first-order poverty line in Table 3.1. Because of the intersection of the two $\overline{CD}^1$ curves, the tax reform is just first-order poverty improving up to the poverty line 12.230 and cannot be welfare improving, *it indicates such balanced-budget indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 12.230.* When γ= 1.5, with the increase in economic efficiency cost of the tax reform, the critical poverty line $\hat{z}_1(1.5)$ shrinks to 6.625, *it indicates the balanced-budget indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 6.625*, since we do find a critical poverty line at which two $\overline{CD}^1$ curves intersect, we cannot define the tax reform as Kolm-improving. Overall, at the first-order, subsidizing food expenditures and taxing nonfood expenditures can reduce poverty of Tanzania up to some critical poverty lines; but unable to be welfare improving.

In what follows, we analyze the impact of the tax reform at second- and third-order of dominance. For γ=0.5 and γ=1, the absence of critical second- and third-order poverty lines in Table 3.1 demonstrates that the tax reform is Dalton-improving and Kolm-improving, *it indicates the indirect tax reform is poverty reducing for all poverty indices in* Π^2, Π^3 *and for all poverty lines belong to* $[0, \infty]$ *both at second- and third-order of dominance.* This is consistent with the facts in Figure 3.2 and 3.3

where there is no intersection either between $\overline{CD}^2$ curves or between $\overline{CD}^3$ curves. So the tax reform respects the Pigou-Dalton principle of transfers at second-order and is sensitive to favorable transfers within the low income range at the third-order. However, Table 2.1 lists $\hat{z}_2(1.5) = 27.226$ and $\hat{z}_3(1.5) = 63.988$, so for γ=1.5, the tax reform is just poverty reducing up to the critical poverty lines and is not welfare improving at second- and third-order of dominance. *It demonstrates the indirect tax reform is second-order poverty reducing for all poverty indices in* Π^2 *and for all poverty lines below 27.226; also it is third-order poverty improving for all poverty indices in* Π^3 *and for all poverty lines below 63.988.*

Over the past years, because of bad weather in Tanzania, domestic food production failed to meet its demand, Tanzania has to import food from foreign countries. It leads to higher food prices which magnified poverty in the country. In Tanzania, domestically produced agricultural commodities have been exempted from VAT since 2006, VAT was mainly applied both to domestically manufactured and imported goods. There is a higher level of consumption among the rich of imported items such as cars, TV, videos. So the government is supposed to raise funds from increasing VAT on those imported items while decreasing taxes for imported foods or use the funds to subsidize domestic farmers. Consumers would be charged less on food consumption through such pricing-change policy; it is good for low-income population since food expenditure account for a large part of their total expenditures and this kind of indirect tax reform is able to increase their real incomes.

Transportation

In what follows, we focus on investigating the normalized consumption dominance curves of different transportation modes in Tanzania and some policy advices about transportation system would be given upon the analysis results.

Public transportation vs Non-public transportation

The government has paid much attention to the development of public transportation in Tanzania. Government investment in the transport sector started to increase in the 1990s; various projects continued to be implemented in the public transportation sector. To determine whether such policy orientation is suitable to real transportation circumstances in Tanzania, we refer to the normalized CD curves of public transportation and non-public transportation. Figures 4.1 shows $\overline{CD}^1_{\text{Nonpublic transp}}$ lies above $\overline{CD}^1_{\text{Public transp}}$ before the first intersection 3.025 which is the critical first -order poverty line in Table 4.1. In Figure 4.2 and 4.3, normalized CD curves of non-public transportation is always above that of public transportation whatever it is at second- or third-order of dominance. These results suggest that government should subsidize non-public transportation and taxing public transportation based on theorem 1 when $\gamma \leq 1$ or larger.

Then we consider the specific impacts if government subsidizes non-public transportation and taxes public transportation. With the assumption γ=0.5, Table 4.1 shows $\hat{z}_1(0.5)$=8.535 which states the tax reform is first-order poverty reducing if the poverty line is below 7.424($\hat{z}_1(0.5)$-1.96*0.567). *It indicates the balanced-budget indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 7.424 at 95 percent confidence interval.* When s=2 and 3, the absence of critical poverty lines $\hat{z}_2(0.5)$ and $\hat{z}_3(0.5)$ indicates that the tax reform is Dalton-improving and Kolm-improving, *which means the indirect tax reform is poverty reducing for all poverty indices in* Π^2, Π^3 *and for all poverty lines in* $[0,\infty]$ *at the second- and third-order as* $\gamma = 0.5$. When γ=1, Figures 4.1 states the tax reform is first-order poverty reducing up to poverty line approximately $\hat{z}_1(1) = 3.025$, so *the indirect tax reform is first-order poverty improving for all*

poverty indices in Π^1 *and for all poverty lines below 3.025.* The value of $\hat{z}_2(1)$ in Table 4.1 illustrates that $\overline{CD}^2_{\text{Nonpublic transp}}$ and $\overline{CD}^2_{\text{Public transp}}$ curves cross at 12.126, $\overline{CD}^2_{\text{Nonpublic transp}}$ lies above $\overline{CD}^2_{\text{Public transp}}$ before the first intersection, it indicates that for those individuals whose normalized expenditures are less than 12.126, their consumptions share in the total expenditure of non-public transportation is larger than their consumption share in the total expenditure of public transportation. More generally, it means that poor people spend more on non-public transportation rather than on public transportation. *Thus the indirect tax reform is second-order poverty improving for all poverty indices in* Π^2 *and for all poverty lines below 12.126*, but it cannot be welfare improving until to the third-order of dominance since there is no critical third-order poverty line in Table 4.1, *it indicates the indirect tax reform is poverty reducing for all poverty indices in* Π^3 *and for all poverty lines in* $[0,\infty]$ *at third-order of dominance.* When γ=1.5, *the results in Table 4.1 indicates the tax reform is first-order poverty improving for all poverty indices in* Π^1 *and all poverty lines below 2.487.* Figure 4.4 illustrates that $\overline{CD}^2_{\text{Nonpublic transp}}$ and 1.5* $\overline{CD}^2_{\text{Public transp}}$ curves cross at $\hat{z}_2(1.5)$=5.790, so *tax reform is still poverty improving for all poverty indices in* Π^2 *and all poverty lines below 5.790 at the second-order.* Similarly, $\hat{z}_3(1.5)$ *=10.045 in Table 4.1 explains it is third-order poverty improving for all poverty indices in* Π^3 *and all poverty lines below 9.02(*$\hat{z}_3(1.5)$*-1.96*0.520) at 95 percent confidence interval.*

The above analysis suggests that it is illogical for government to subsidize public transportation expenditures by taxing non-public transportation expenditures. However, the non-public transportation is composed by bicycles and own-occupied motorized vehicles; it is worth studying which one was attributed to higher normalized CD^2 curve of non-public transportation. So as to consider an appropriate indirect tax reform for the transportation system, I am going to take separate comparisons of public transportation with bicycles and public transportation with

own-occupied motorized vehicles.

Public transportation vs Bicycles

Just as what we did above, let us first compare the normalized CD curves of public transportation and bicycles when $\gamma=1$, the two $\overline{CD}^1$ curves have an intersection at $\hat{z}_1(1) = 6.750$ in Figure 5.1. The estimated standard error for this critical first-order poverty line is 0.260; $\overline{CD}^1_{Bicycle}$ is above $\overline{CD}^1_{\text{Public transp}}$ before this intersection, so we can be 95 percent certain that it is first-order poverty improving by marginally increasing taxes on public transportation expenditures while reducing taxes on bicycles expenditures for any poverty line below 6.240. *It indicates this kind of balanced-budget indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 6.240 at 95 percent confidence interval.* There is no intersection in Figure 5.2 and no value for $\hat{z}_2(1)$ in Table 5.1, thus the tax reform is Dalton-improving and obeys the Pigou-Dalton principle of transfers at the second-order of dominance. *It indicates the indirect tax reform is poverty reducing for all poverty indices in* Π^2 *and for all poverty lines belong to* $[0,\infty]$ *at the second-order of dominance.* The same result happened in the third-order of dominance, $\overline{CD}^3_{Bicycles}$ is anywhere above $\overline{CD}^3_{\text{Public transp}}$ in Figure 5.3, so it still welfare improving and poverty reducing *which indicates the indirect tax reform is third-order poverty reducing for all poverty indices in* Π^3 *and for all poverty lines belong to* $[0,\infty]$. Respectively, the tax reform can be defined as Dalton-improving and Kolm-improving tax reform when $\gamma=0.5$, since $\gamma=0.5$ indicates ($\text{MECF}_{\text{Public transp}} < \text{MECF}_{\text{Bicycles}}$) the existence of economic efficiency cost advantage by increasing taxes for public transportation expenditures and reducing taxes for bicycles expenditures. The decrease in cost would definitely increase the range of poverty lines over which the reform is able to reduce poverty and improve welfare.

Table 5.1 gives the critical first-order poverty line $\hat{z}_1(0.5)$=8.401 which is obviously larger than $\hat{z}_1(1) = 6.750$. Thus for γ=0.5, the tax reform could reduce poverty as long as the poverty line is set below 8.201($\hat{z}_1(0.5)$-1.96*0.102), *it indicates this kind of indirect tax reform is first-order poverty reducing for all poverty indices in* Π^1 *and for all poverty lines below 8.201 at 95 percent confidence interval.* For γ=1.5, Table 5.1 lists critical poverty lines $\hat{z}_s(1.5)$ for the three orders(s=1,2,3), the three critical poverty lines all have its numerical values which demonstrates the tax reform is poverty reducing up to critical poverty lines and is unable to socially improve well-being.

The above result reflects the dominant travel mode in Tanzania is bicycles. Even government provides household with a subsidized public transportation system, the prices of public transportation are still expensive for the poor people because of their extremely low incomes, only the middle and higher income classes could afford it. For the poor people in Tanzania, cycling and walking are the only logical choices. However, bicycles are deemed to be backward, old-fashioned way of moving by many governments, for pursing modernization construction, Tanzania's government discriminate fiscally against non-motorized vehicles. Bicycles were treated as luxury items; tariffs on imported bicycles have been pretty high in Tanzania. Moreover, the revenue gained from the tariffs was never reinvested in non-motorized vehicles services. The poor quality of bicycling condition leads to increased number of accidents involving in cyclists. For the poor people's travelling relies heavily on bicycling, it does not make sense for government to tax more on bicycles expenditures and invest little on the bicycles services.

Public transportation vs Motorized vehicles

Having comparing bicycles and public transportation, we pay attention to another part of non-public transportation: the motorized vehicles. Considering its impact under γ=1, we first have a look of Figure 6.1 and Table 6.1. Figure 6.1 represents

$\overline{CD}^1_{\text{Public transp}}$ almost always lies above $\overline{CD}^1_{\text{Motor}}$ at the given expenditure range [0, 8], Table 6.1 shows the critical first-order poverty line $\hat{z}_1(1)=14.433$ with standard error 0.210, so we can 95 percent ensure for any poverty line below 14.021 it is first-order poverty improving by increasing taxes on motorized vehicles expenditures and decreasing taxes or subsidizing for public transportation expenditures. *It indicates this kind of balanced-budget indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 14.021 at 95 percent confidence interval.* At the second-order of dominance, Table 6.1 states the two $\overline{CD}^2$ curves is estimated to intersect at $\hat{z}_2(1)=31.708$, so the tax reform is just poverty reducing for given critical poverty line and not supposed to be welfare improving. *It demonstrates such indirect tax reform is second-order poverty reducing for all poverty indices in* Π^2 *and for all poverty lines below 31.708.* Though they do not cross in Figure 6.2, it only states the tax reform is welfare improving during the range [0, 8]. $\hat{z}_3(1)$ is not given in Table 6.1 which means the critical third-order poverty line can be extended to infinite, it is coincide with Figure 6.3 where this no intersection between two $\overline{CD}^3$ curves, *so the indirect tax reform is third-order poverty reducing for all poverty indices in* Π^3 *and for all poverty lines belong to* $[0, \infty]$.

For γ=0.5, according to the results in Table 6.1, we can say that for any poverty line less than $\hat{z}_1(0.5)=14.574$, it is first-order poverty improving to implement the tax reform, *which indicates the indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 14.574.* Additionally, implementing a balanced-budget indirect tax reform by marginally increasing taxes on motorized vehicles and decreasing taxes on public transportation is welfare improving both at second- and third-order since $\hat{z}_2(0.5)$ and $\hat{z}_3(0.5)$ do not exist, so we call it Dalton-improving and Kolm-improving. When γ=1.5, the critical poverty lines become less than that under γ=0.5 for that the social efficiency cost of tax reform

increases as γ rises. Apparently, the tax reform is still able to reduce poverty but cannot be social welfare improving when γ increases.

Therefore, in terms of motorized vehicles, it is a right policy to subsidize public transportation while taxing non-public transportation. However, we have to clear that a huge amount of bicycles included in non-public transportation and they are owned and used by a large section of population, so bicycles play a significant role in improving transportation system. Subsidized public transportation is in vain or negatively on increasing mobility of poor for the reason that it is not predominant travel mode in Tanzania. On the contrary, such a program is in most cases an indiscriminate policy; it helps the middle and higher income classes more than the poor, who still cannot afford the price of a ticket.[20] Marginal utility of money in reducing poverty would be improved by investing it to bicycling sector instead of subsidizing public transportation. Furthermore, government usually ignores the external cost of car use, such as air pollution, congestion and administrative costs of accidents. These can be seen as implicit subsidy which helps richer more rich and aggravates inequality.

Facing with the fact that low income dominates in a large proportion of the population in Tanzania and their main transport mode is cycling, making bicycles more affordable would greatly improve accessibility of many poor families and be conductive to the reduction of poverty. Considering the external cost of car use and the inefficient subsidized public transportation, it is favorable for government to transfer investment in public transportation to cycling services such as bicycle paths, bicycle parking, maintenance station, etc. With respect to indirect tax reform, it is a good option to raise funds by increasing taxes on motorized vehicles to subsidize cycling.

Overall, the efficient tax policy in transportation system should be a balanced-budget indirect tax reform by marginally reducing taxes on bicycles and increasing taxes on

[20] Earthtec Consultancy(PTY) LTD (2007)

motorized vehicles. I am going to have a detailed analysis of such tax reform using normalized CD curves of bicycles and motorized vehicles.

Bicycles vs Motorized vehicles

Figure 7.1 gives $\overline{CD}^{1}_{\text{Bicycle}}$ and $\overline{CD}^{1}_{\text{Motor}}$ curves during the normalized per capita expenditure range [0, 8] , when γ=1, according to Table 7.1, the two curves should intersect at the maximum poverty line $\hat{z}_1(1)$=7.161 up to which it is first-order poverty reducing by increasing at the margin taxes for motorized vehicles expenditures and decreasing or subsidizing bicycles expenditures since $\overline{CD}^{1}_{\text{Bicycle}}$ is above $\overline{CD}^{1}_{\text{Motor}}$ before the first intersection. *It indicates this kind of indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 7.161.* However, it is not Pen improving for γ^+=1 since a critical poverty line at which the two curves intersect still exists.

Figure7.2 shows the normalized CD curves for bicycle and motorized vehicles at the second-order, as expected, $\overline{CD}^{2}_{\text{Motor}}$ is always above $\overline{CD}^{2}_{\text{Bicycle}}$ during the given expenditure range [0,8], since $\overline{CD}^{2}$ demonstrates the share in total expenditure of the commodity of the poor people who live below poverty line z, Figure 7.2 indicates that expenditures on bicycles is relative higher than expenditures on motorized vehicles for the poor people whose normalized per capita expenditures are below maximum poverty line, it explains that poor people rely on non-motorized vehicles which are less in cost, note that the expenditures on motorized vehicles of the people whose total expenditures are below approximately 2 is almost 0, it means the extremely poor people are unable to buy any motorized vehicles in Tanzania. According to equation (14), given the average bicycles expenditure X_{Bicycles}= 0.197 and average motorized vehicles expenditure X_{Motor} = 0.30, with γ= 1, by subsidizing one percentage on bicycles expenditures, 0.567 percentage must be added to taxes on motorized expenditures for balanced-budget. However, this tax reform is not Dalton improving,

since Table7.1 provides critical second-order poverty line $\hat{z}_2(1) = 44.793$, *It demonstrates that such indirect tax reform is second-order poverty reducing for all poverty indices in* Π^2 *and for all poverty lines below 44.793.* Figures 7.3 illustrates that the tax reform is Kolm-improving at the third-order of dominance for that $\overline{CD}^3_{Motor}$ curve is anywhere below $\overline{CD}^3_{Bicycle}$. Furthermore, Table 7.1 presents no value for $\hat{z}_3(1)$, so the tax reform is poverty reducing for infinite poverty line and sensitive to favorable transfers, *It indicates that such indirect tax reform is third-order poverty reducing for all poverty indices in* Π^3 *and for all poverty lines belong to* $[0, \infty]$.

Then focusing on impact of the tax reform at different order of dominance with assumption γ=0.5 and γ=1.5, the critical poverty lines in Table 7.1 could help us explain it. Observing results in Table 7.1 we find that the critical poverty lines $\hat{z}_s(\gamma^+)$ increases with order s for a given efficiency cost ratio γ^+, for example, $47.432(\hat{z}_3(1.5)) > 22.478(\hat{z}_2(1.5)) > 6.876(\hat{z}_1(1.5))$, thus increasing the ethical content of the classes of poverty indices extends range of poverty lines over which the tax reform can viewed as a good tool for reducing poverty. Alternatively, at a given order of s, as the efficiency ratio γ increases, the critical poverty lines is of more constraint, for instance , $6.879(\hat{z}_1(1.5)) < 7.161(\hat{z}_1(1)) < 14.487(\hat{z}_1(0.5))$, this is owe to increased economic efficiency cost γ and unchanged distributive benefit $\delta^1(z)$. when γ=0.5, given $X_{Bicycles}$= 0.197 and X_{Motor} = 0.30, one percentage decrease of tax on bicycles expenditure have to be accompanied by 0.328 percentage increase of tax on motorized vehicles for budget neutrality. Table 7.1 shows the critical first-order poverty line $\hat{z}_1(0.5)$= 14.487, *It indicates this kind of indirect tax reform is first-order poverty improving for all poverty indices in* Π^1 *and for all poverty lines below 14.487.* Absence of values for $\hat{z}_2(0.5)$ and $\hat{z}_3(0.5)$ indicates the tax reform is second-order Dalton improving and third-order Kolm improving, so at the second-order with γ=0.5, increasing at margin taxes on motorized vehicles and decreasing taxes on bicycles

obeys Pigou-Dalton principle of transfers. *It indicates that such indirect tax reform is poverty reducing for all poverty indices in* Π^2 *and for all poverty lines belong to* $[0,\infty]$ *at the second-order of dominance.* Additionally, the poverty and utility indices prefer to a favorable Pigou-Dalton transfer that take money from poor to rich within the lower range of income distribution rather than an unfavorable transfer that take money from poor to rich within the higher part of income distribution at the third-order of dominance, *it indicates that such indirect tax reform is third-order poverty reducing for all poverty indices in* Π^3 *and for all poverty lines belong to* $[0,\infty]$. For γ= 1.5, according to equation (14), one percentage decrease of taxes on bicycles must be compensated by 0.985 percent increase of taxes on motorized vehicles. Table 7.1 shows the three critical poverty lines all exist for the three orders of dominances. Specifically, $\hat{z}_1(1.5) = 6.879$ with standard error 0.274, $\hat{z}_2(1.5)$ =22.478 with standard error 0.749 and $\hat{z}_3(1.5)$=47.432 with standard error 1.393. Then we conclude that for γ=1.5, the tax reform can reduce poverty for any poverty line that below the critical poverty lines but is unable to improve social welfare for the entire range of normalized per capita expenditure.

According to the above analysis we can be certain that a budget-balanced indirect tax reform that marginal increasing taxes for motorized vehicles expenditures and decreasing taxes for bicycles expenditure is an efficient tool for improving transportation system of Tanzania since it could effectively improve accessibility of poor families and thus reduce national poverty. In practice, government should tax the motorized vehicles more on the usage of gasoline and road fees, meanwhile removing bicycles from luxury items, decreasing tariff on imported bicycles or subsidizing domestic bicycling industry so as to provide households bicycles of good quality with lower prices.

5. Conclusion

In this paper I use the methodology proposed by Duclos, Makdissi, and Wodon (2008)

to analyze whether the indirect tax reforms can alleviate social conditions of the poor in terms of food, health, education and transportation in Tanzania.

It shows the normalized consumption dominance curves can be used to design an efficient indirect tax reform such as which commodity should be taxed and which one should be subsidized and to assess the expenditure range over which the tax reform can be deemed as a good tool for poverty reduction since the graphs of $\overline{CD}$ curves reflect the distribution characteristics of expenditures on commodities across the entire expenditure distribution. Furthermore, unlike the concentration curve which is limited to second-order, $\overline{CD}$ curves help us to inspect the impact of indirect tax reform on welfare and poverty at any order of ethical dominance we are interested in.

Overall, the analysis results in Section 4 demonstrate the indirect tax reform that decreasing at the margin taxes on expenditures of health, education and food while increasing taxes on nonfood expenditures can effectively reduce poverty in Tanzania. As for transportation system, it is an improper policy to provide subsidized public transportation and impose high tariff on imported bicycles. In terms of using tax reform in reducing poverty, Tanzanian government should raise funds by increasing taxes on motorized vehicles expenditures to subsidize bicycles expenditures.

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APPENDIX

Figure 1.1 Normalized Consumption Dominance Curves for Health and Nonfood, s=1

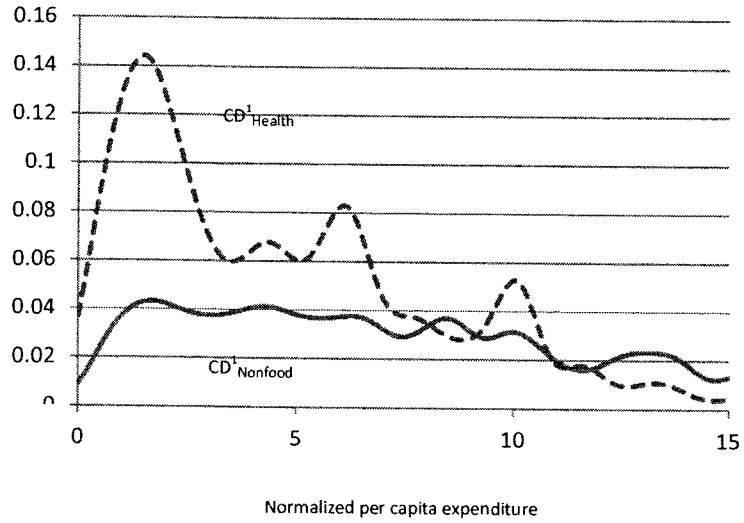

Figure 1.2 Normalized Consumption Dominance Curves for Health and Nonfood, s=2

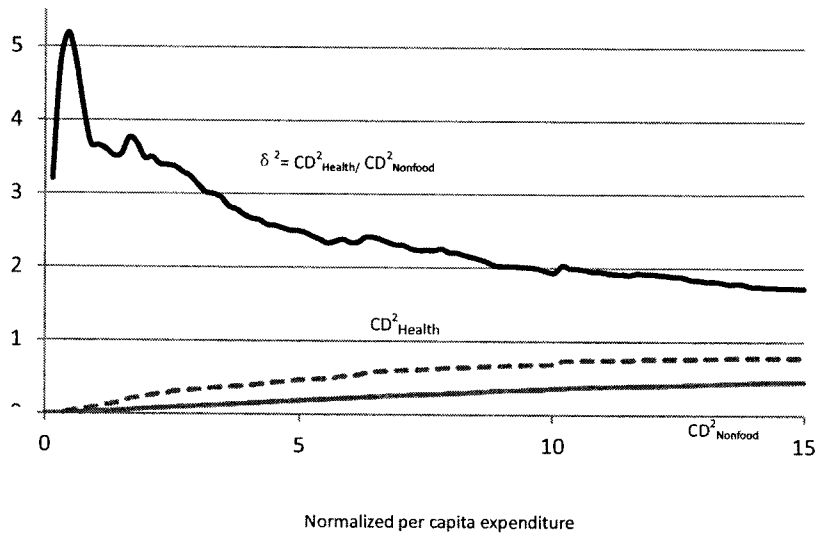

Figure 1.3 Normalized Consumption Dominance Curves for Health and Nonfood, s=2

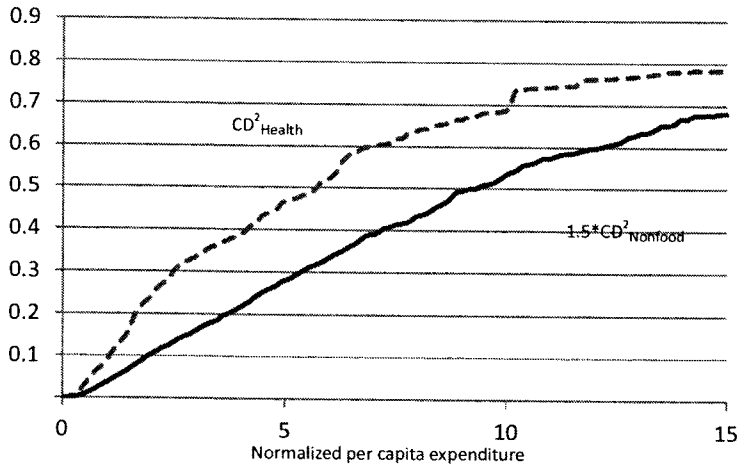

Figure 1.4 Normalized Consumption Dominance Curves for Health and Nonfood, s=3

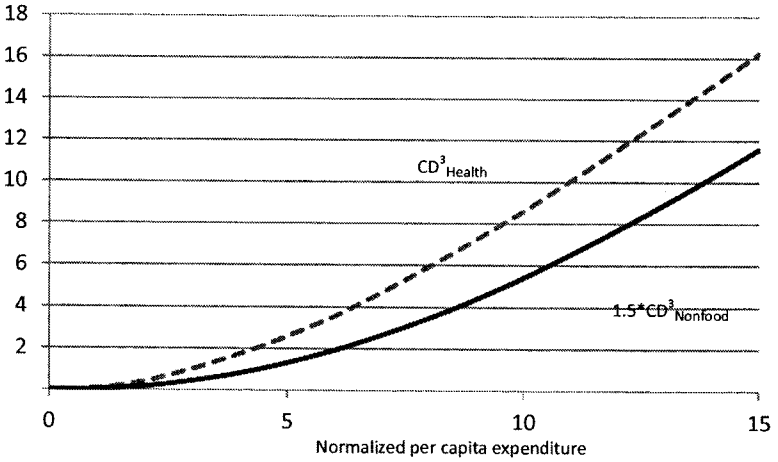

Figure 2.1 Normalized Consumption Dominance Curves for Education and Nonfood, s=1

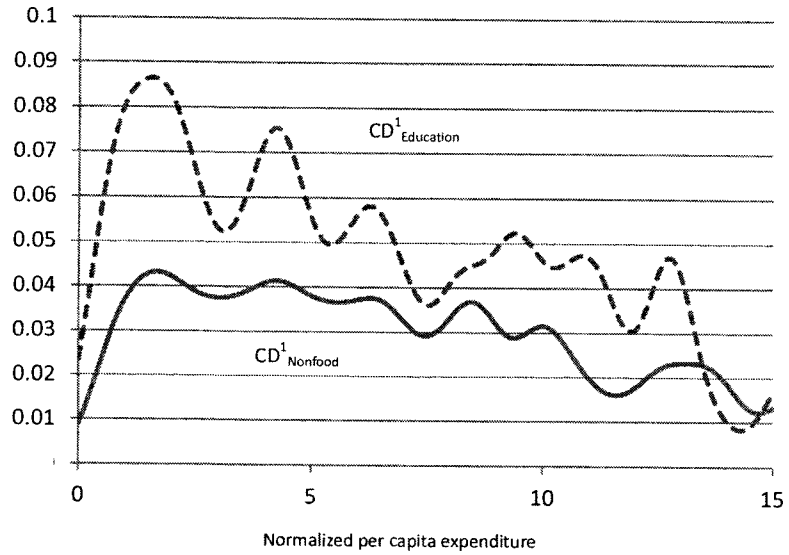

Figure 2.2 Normalized Consumption Dominance Curves for Education and Nonfood, s=2

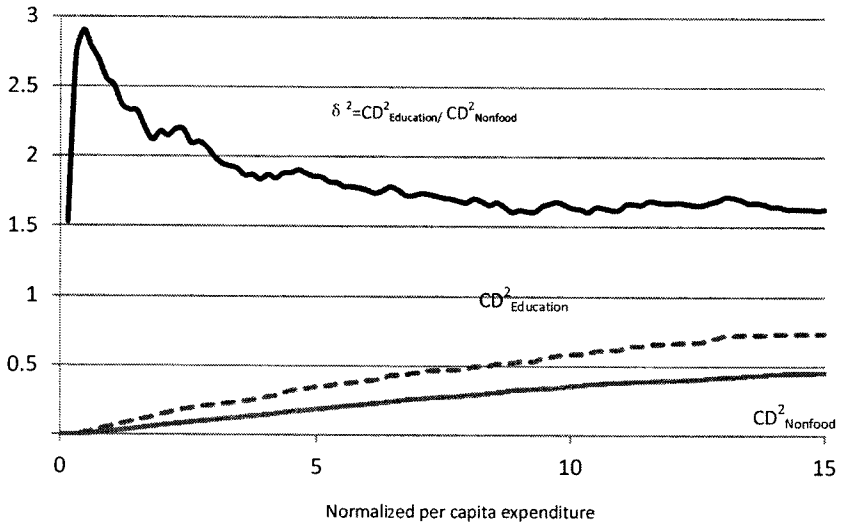

Figure 2.3 Normalized Consumption Dominance Curves for Education and Nonfood, s=3

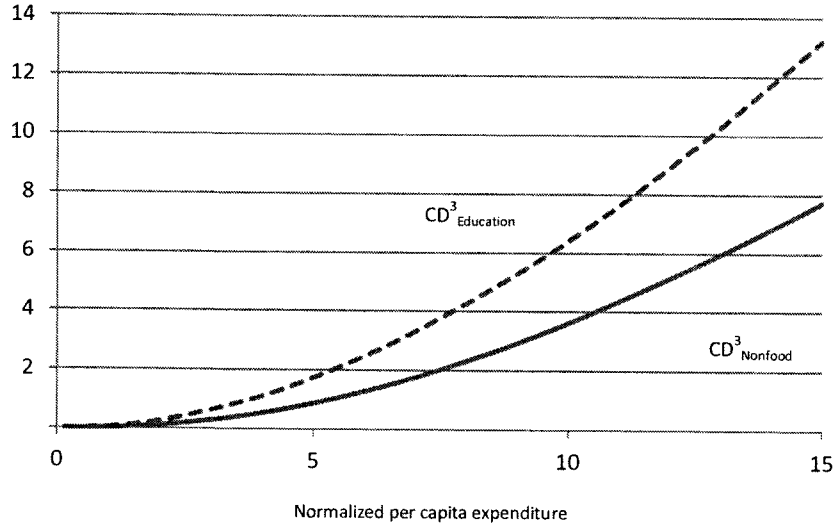

Figure 3.1 Normalized Consumption Dominance Curves for Food and Nonfood, s=1

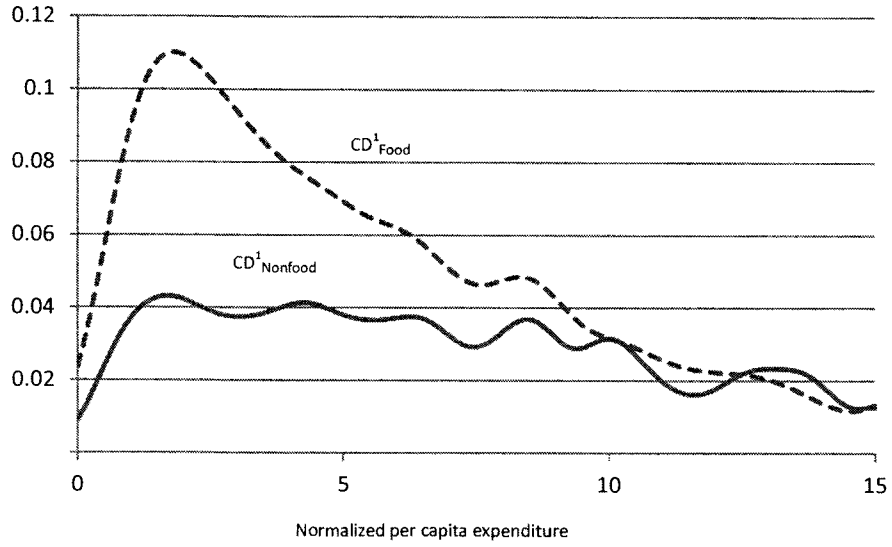

Figure 3.2 Normalized Consumption Dominance Curves for Food and Nonfood, s=2

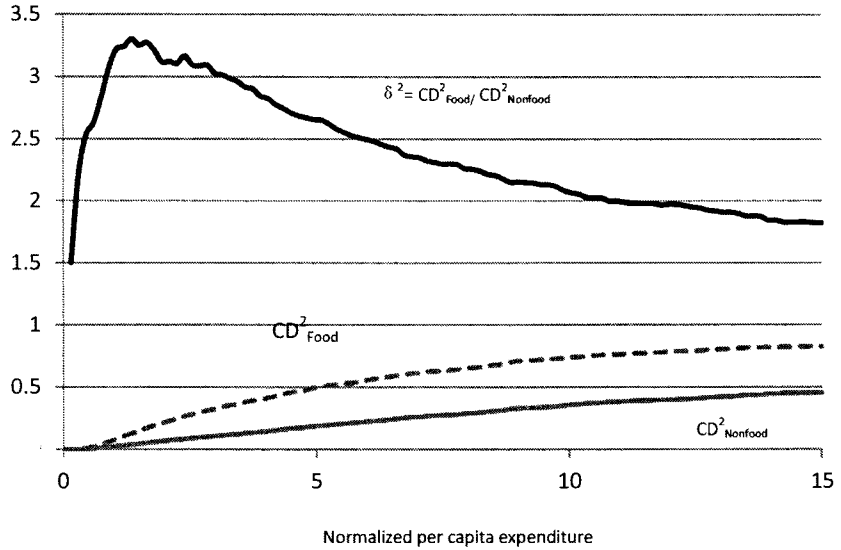

Figure 3.3 Normalized Consumption Dominance Curves for Food and Nonfood, s=3

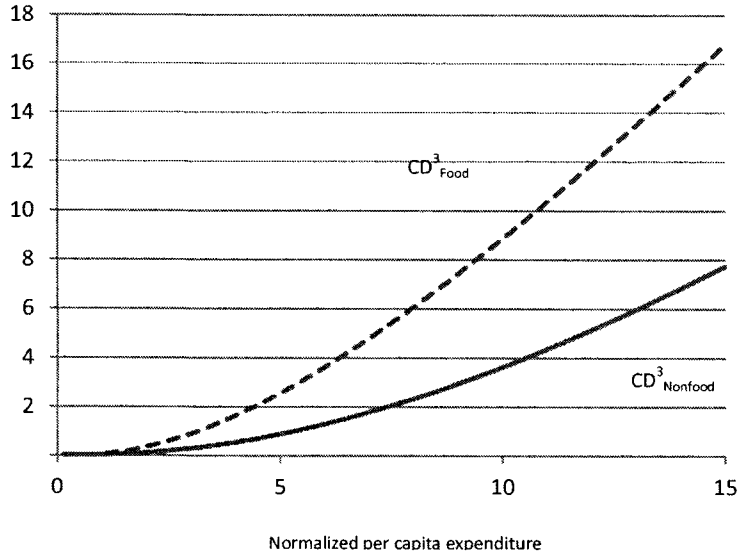

Figure 4.1 Normalized CD curves for Public transportation and Non-public transportation, s=1

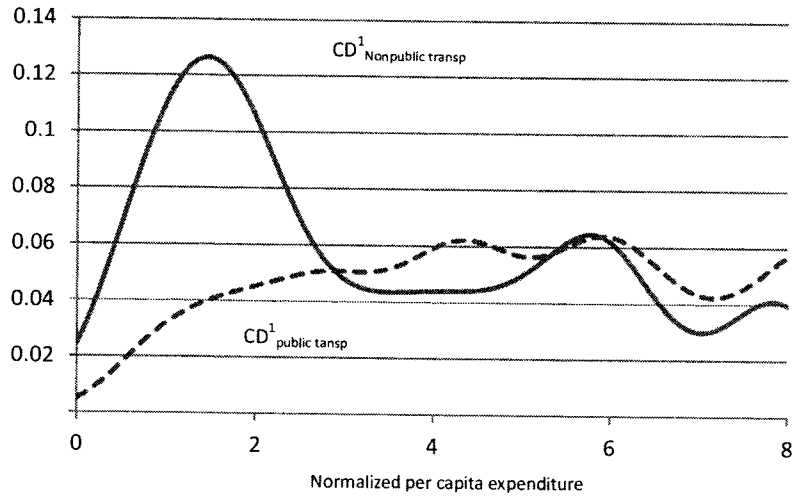

Figure 4.2 Normalized CD curves for Public transportation and Non-public transportation, s=2

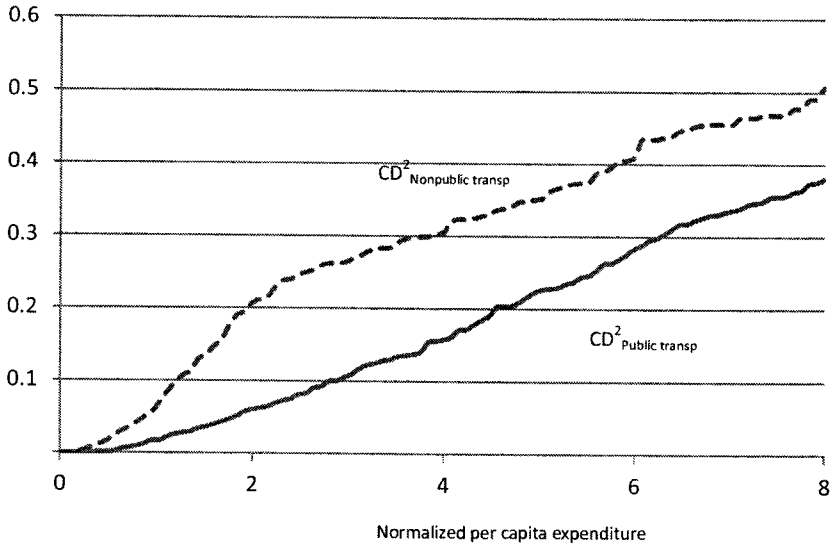

Figure 4.3 Normalized CD curves for Public transportation and Non-public transportation, s=3

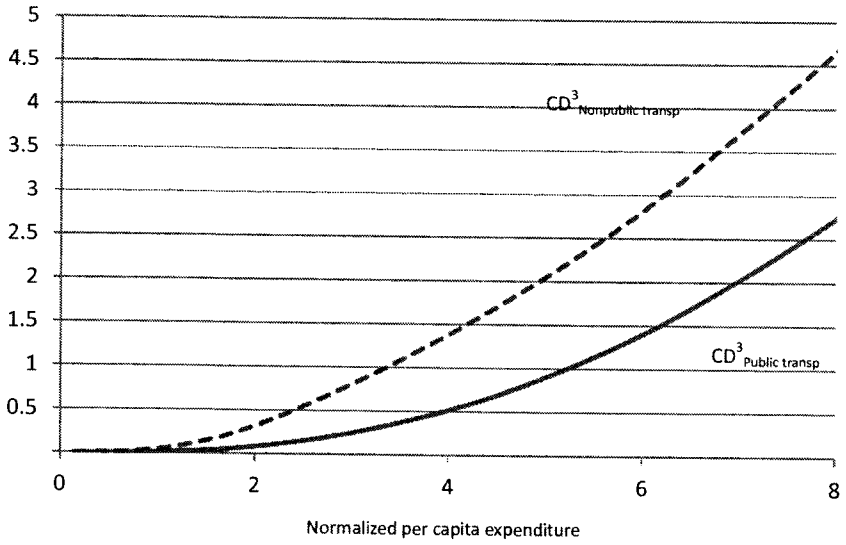

Figure 4.4 Normalized CD curves for Public transportation and Non-public transportation, s=2

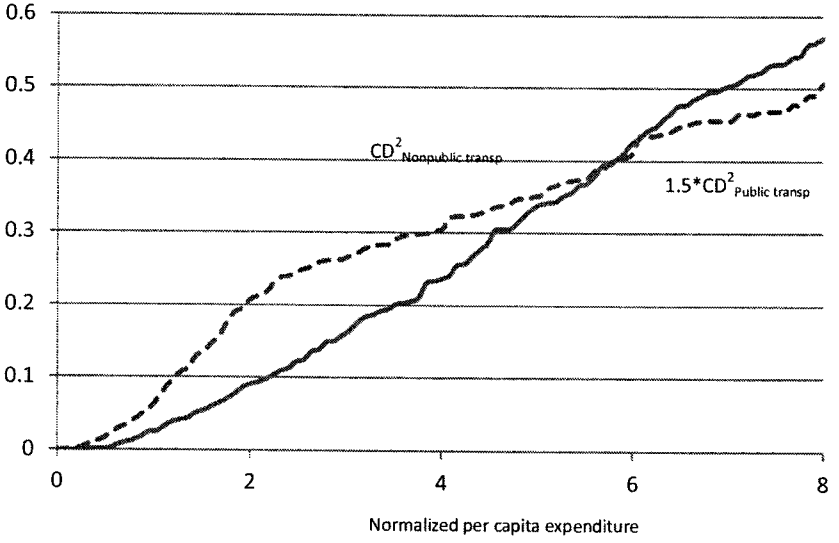

Figure 5.1 Normalized CD curves for Public transportation and Bicycle, s=1

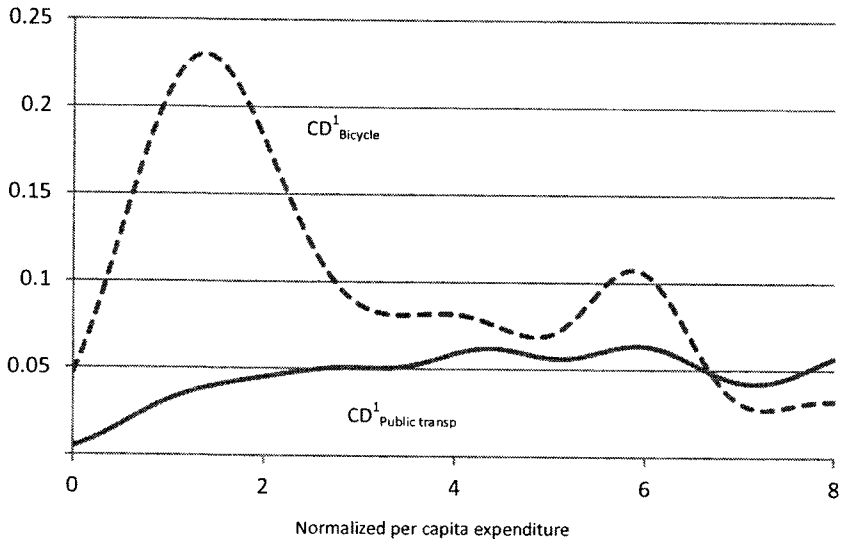

Figure 5.2 Normalized CD curves for Public transportation and Bicycle, s=2

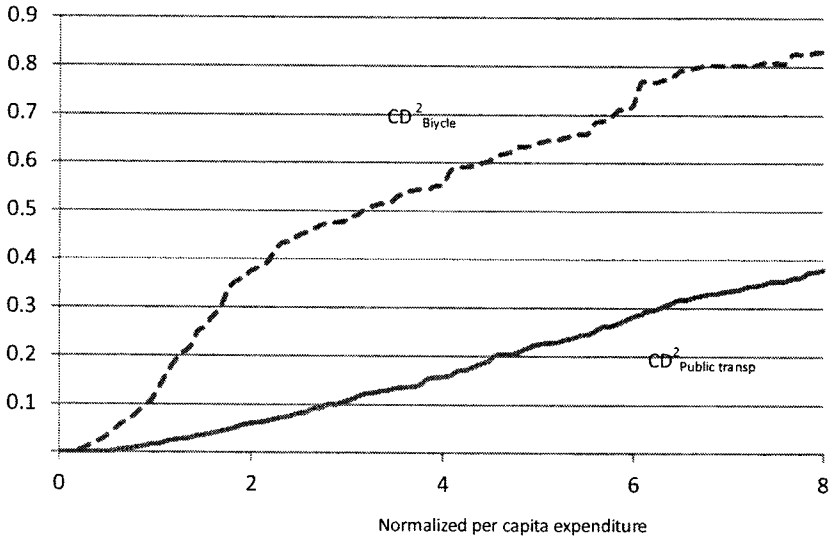

Figure 5.3 Normalized CD curves for Public transportation and Bicycle, s=3

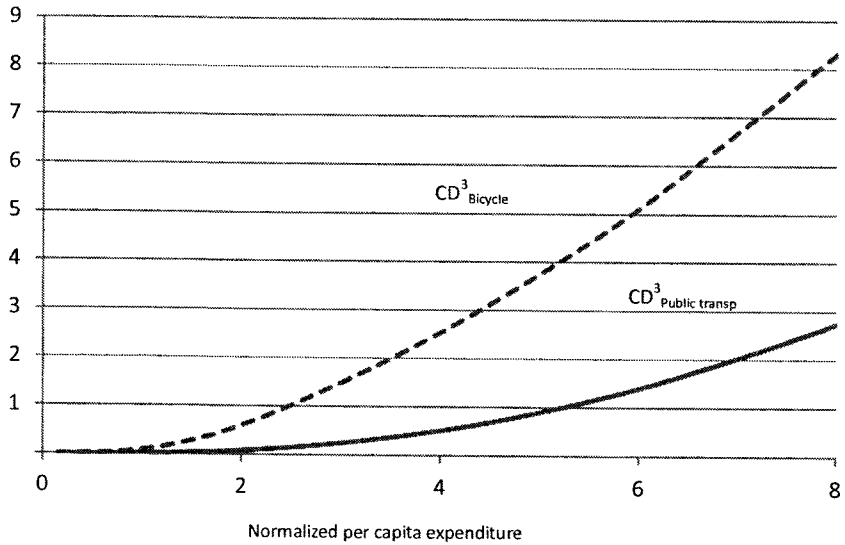

Figure 6.1 Normalized CD curves for Public transportation and Motorized vehicles, s=1

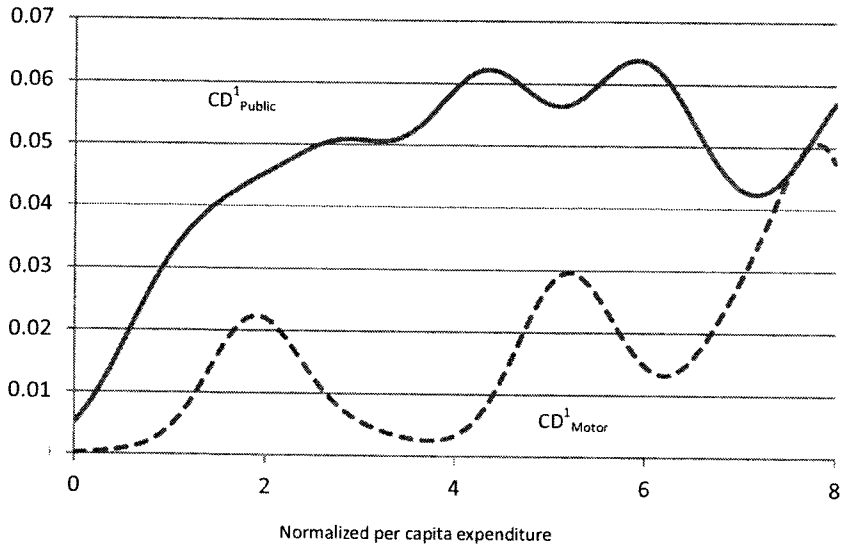

Figure 6.2 Normalized CD curves for Public transportation and Motorized vehicles, s=2

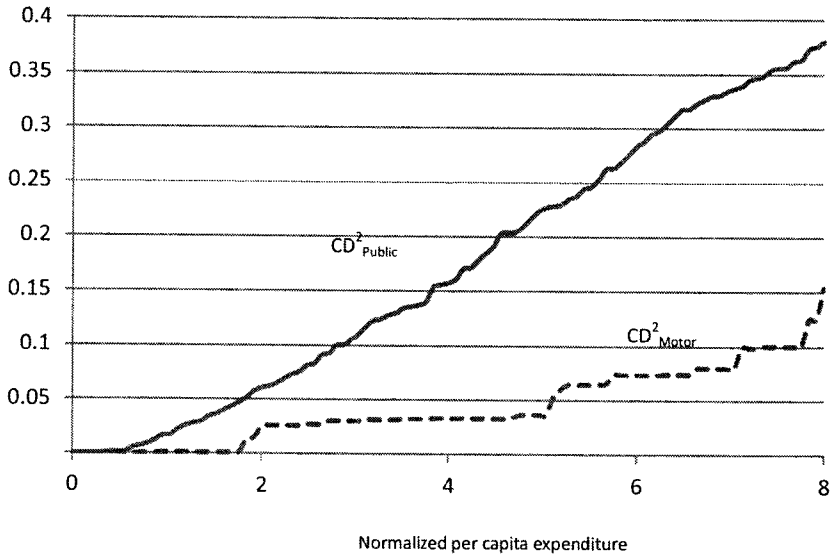

Figure 6.3 Normalized CD curves for Public transportation and Motorized vehicles, s=3

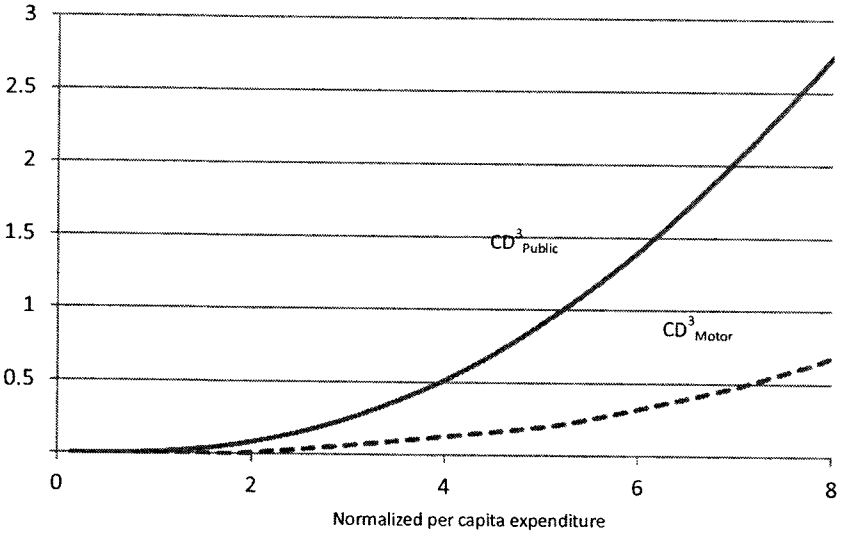

Figure 7.1 Normalized CD curves for Bicycle and Motorized vehicles, s=1

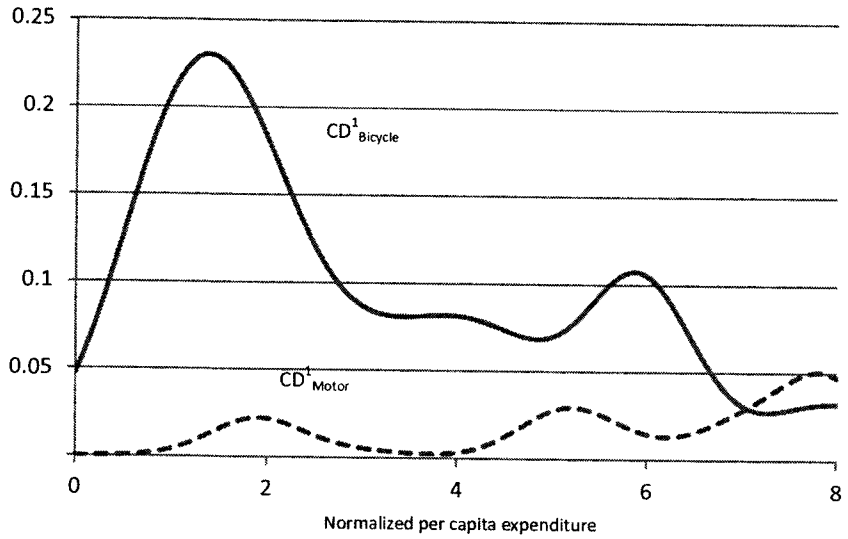

Figure7.2 Normalized CD curves for Bicycle and Motorized vehicles, s=2

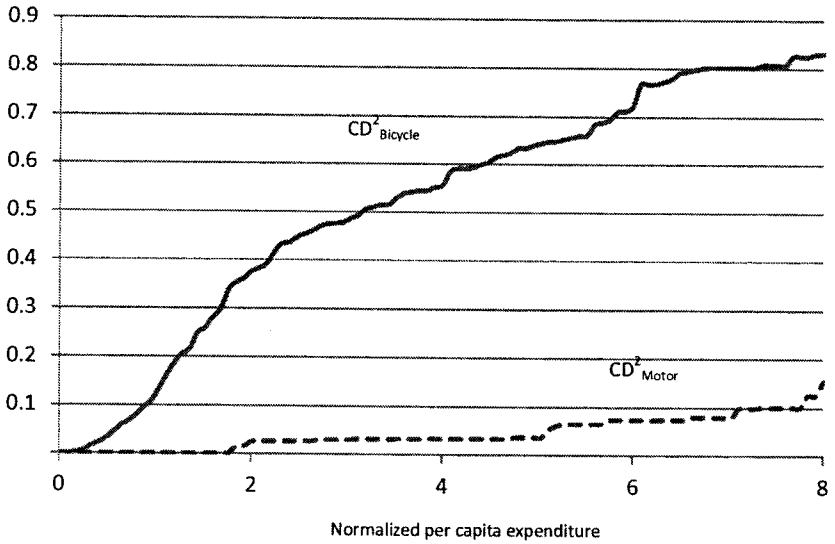

Figure 7.3 Normalized CD curves for Bicycle and Motorized vehicles, s=3

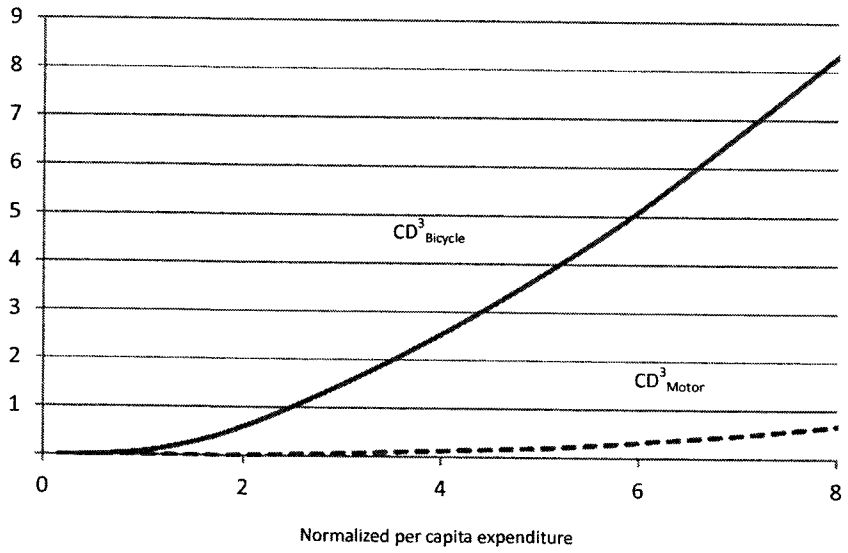

Table 1.1 Critical Poverty Lines $z_s(\gamma)$ for Different Efficiency Ratios γ and for Different Orders of Dominance *s(*)*

(Health vs Nonfood)

	γ=0.5	γ=1.0	γ=1.5
$z_1(\gamma)$	12.378 (0.324)	8.312 (0.389)	6.874 (0.308)
$z_2(\gamma)$	-	-	26.917 (0.303)
$z_3(\gamma)$	-	-	58.914 (0.505)

Table 2.1 Critical Poverty Lines $z_s(\gamma)$ for Different Efficiency Ratios γ and for Different Orders of Dominance *s(*)*

(Education vs Nonfood)

	γ=0.5	γ=1.0	γ=1.5
$z_1(\gamma)$	21.068 (0.733)	13.569 (0.214)	5.076 (0.477)
$z_2(\gamma)$	-	-	-
$z_3(\gamma)$	-	-	-

Table 3.1 Critical Poverty Lines $z_s(\gamma)$ for Different Efficiency Ratios γ and for Different Orders of Dominance *s(*)*

(Food vs Nonfood)

	γ=0.5	γ=1.0	γ=1.5
$z_1(\gamma)$	18.826 (0.203)	12.230 (0.460)	6.625 (0.714)
$z_2(\gamma)$	-	-	27.226 (0.883)
$z_3(\gamma)$	-	-	63.988 (0.719)

Table 4.1 Critical Poverty Lines $z_s(\gamma)$ for Different Efficiency Ratios γ and for Different Orders of Dominance *s(*)*

(Non-public vs Public Transportation)

	γ =0.5	γ =1.0	γ =1.5
$z_1(\gamma)$	8.535 (0.567)	3.025 (0.576)	2.487 (0.196)
$z_2(\gamma)$	-	12.126 (0.335)	5.790 (0.330)
$z_3(\gamma)$	-	-	10.045 (0.520)

Table 5.1 Critical Poverty Lines $z_s(\gamma)$ for Different Efficiency Ratios γ and for Different Orders of Dominance *s(*)*

(Bicycles vs Public Transportation)

	γ =0.5	γ =1.0	γ =1.5
$z_1(\gamma)$	8.401 (0.102)	6.750 (0.260)	3.629 (0.311)
$z_2(\gamma)$	-	-	12.901 (1.161)
$z_3(\gamma)$	-	-	27.980 (3.092)

Table 6.1 Critical Poverty Lines $z_s(\gamma)$ for Different Efficiency Ratios γ and for Different Orders of Dominance *s(*)*

(Motor vs Public Transportation)

	γ =0.5	γ =1.0	γ =1.5
$z_1(\gamma)$	14.574 (0.329)	14.433 (0.210)	7.048 (0.530)
$z_2(\gamma)$	-	31.708 (1.317)	16.977 (0.920)
$z_3(\gamma)$	-	-	30.353 (0.548)

Table 7.1 Critical Poverty Lines $z_s(\gamma)$ for Different Efficiency Ratios γ and for Different Orders of Dominance *s(*)*

(Bicycle vs Motor)

	γ =0.5	γ =1.0	γ =1.5
$z_1(\gamma)$	14.487 (0.167)	7.161 (0.497)	6.879 (0.274)
$z_2(\gamma)$	-	44.793 (1.765)	22.478 (0.749)
$z_3(\gamma)$	-	-	47.432 (1.393)