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Fuel Tax Incidence in Developing Countries

The Case of Costa Rica

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Abstract

Although fuel taxes are a practical means of curbing vehicular air pollution, congestion, and accidents in developing countries—all of which are typically major problems—they are often opposed on distributional grounds. Yet few studies have investigated fuel tax incidence in a developing country context. We use household survey data and income-outcome coefficients to analyze fuel tax incidence in Costa Rica. We find that the effect of a 10 percent fuel price hike through direct spending on gasoline would be progressive, its effect through spending on diesel—both directly and via bus transportation—would be regressive (mainly because poorer households rely heavily on buses), and its effect through spending on goods other than fuel and bus transportation would be relatively small, albeit regressive. Finally, we find that although the overall effect of a 10 percent fuel price hike through all types of direct and indirect spending would be slightly regressive, the magnitude of this combined effect would be modest. We conclude that distributional concerns need not rule out using fuel taxes to address pressing public health and safety problems, particularly if gasoline and diesel taxes can be differentiated.

Key Words: fuel tax incidence, transportation, Costa Rica

JEL Classification Numbers: Q52, Q56, Q48, R48, H23

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Allen Blackman, Rebecca Osakwe, and Francisco Alpizar *

1. Introduction

Over the past four decades, vehicle fleets in developing countries have grown at 6 percent per year, double the rate for developed countries (Dargay et al. 2007). As cars, trucks and buses have proliferated, so too have attendant negative externalities, including air pollution, traffic congestion, and accidents. Today, vehicles are a leading source of local air pollution in developing countries, contributing more than 90 percent of emissions in some cases (Timilsina and Dulal 2009). In addition, they generate 13 percent of global emissions of greenhouse gases (Pachauri and Reisinger 2007). And annual deaths from accidents in developing countries average almost 1 per 100 vehicles, a rate three times higher than that for industrialized countries (Sterner 2003).

Unfortunately, a number of factors limit policymakers' ability to curb these problems using conventional command-and-control measures, such as maintenance and inspection programs, fuel economy standards, driving restrictions, and technology mandates. Mobile sources are exceptionally plentiful while regulatory institutions are typically undermanned and underfunded. Just as important, political will for such regulation is often inadequate (Sterner 2003; Russell and Vaughn 2003).

An often-discussed means of sidestepping these institutional constraints is to impose a tax on vehicular fuel: higher taxes can spur cuts in driving, substitution out of fuel-inefficient vehicles, and consequently a reduction in polluting emissions, congestion, and traffic accidents (Sterner 2007; Timilsina and Dulal 2008). Although fuel taxes have the potential to generate deadweight welfare losses, welfare analyses for both industrialized and developing countries have found that given the large negative externalities associated with driving (and the potential for offsetting distorting labor taxes with fuel tax revenue) the net effect of fuel taxes on welfare

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is generally positive and substantial (Parry and Small 2005; West and Williams 2007; Parry and Timilsina 2008).

Notwithstanding that evidence, a common argument against raising fuel taxes is that it would be regressive—poor households would bear an unfair burden. Studies of fuel tax incidence in industrialized countries, where vehicle ownership is widespread in all socioeconomic classes, have generated mixed results (Parry et al. 2007; Poterba 1991; Santos and Catchesides 2005; West and Williams 2004). Intuitively, one might expect fuel taxes to be less regressive in developing countries where vehicle ownership is concentrated in higher socioeconomic brackets (Sterner 2007). Some emerging research provides support for this hypothesis (Datta 2008; Ziramba et al. 2009). To our knowledge, this question has yet to be addressed in the case of Central or South America.

To help fill this gap, we use data from a 2005 household income and expenditure survey and a 2002 input-output matrix to analyze the incidence of fuel taxes in Costa Rica. Costa Rica is a particularly interesting case study because it is classified as an “upper middle income country” (World Bank 2009)—if fuel taxes are not regressive in Costa Rica, they are unlikely to be regressive in poorer countries where vehicle ownership is even more concentrated in higher socioeconomic brackets.

We find that effect of a 10 percent price hike through direct spending on gasoline would be progressive, its effect through spending on diesel—both directly and via bus transportation—would be regressive (mainly because poorer households rely heavily on buses), and its effect through spending on goods other than fuel and bus transportation would be relatively small, albeit regressive. Finally, we find that although the overall effect of a 10 percent fuel price hike through all types of direct and indirect spending would be slightly regressive, the magnitude of this combined effect would be modest. We conclude that distributional concerns need not rule out using fuel taxes to address pressing public health and safety problems, particularly if gasoline and diesel taxes can be differentiated.

The remainder of the paper proceeds as follows. The second section presents background information on Costa Rica—specifically, its vehicle fleet, vehicular air pollution, congestion, and traffic accident problems and its public discourse about distributional effects of fuel taxes. The third section presents our incidence analysis, with discussions of our methods, data, and results. The last section presents a summary and conclusion.

2. Background

2.1. Vehicle Fleet

Between 1999 and 2007, Costa Rica's vehicle fleet grew at 3 percent per year, spurred by robust economic and population growth (Table 1). By 2007, roughly 800,000 cars, trucks and buses were registered in Costa Rica, one for every six citizens (Table 1). Seventy percent of these vehicles were in the greater metropolitan area (GMA) of San José, which is home to 60 percent of the country's population (Herrera and Rodríguez 2008).

Table 1. Economic, transport, and fuel statistics for Costa Rica, 1999–2007

Year	Population ^a (millions)	GDP per capita ^a (‘91 col.)	Vehicles ^b (no.)	Price, diesel (‘91 col./liter)	Price, regular gasoline (‘91 col./liter)	Sales, regular gasoline ^d (barrels)	Sales, diesel ^d (barrels)	Traffic accidents ^e (no.)
1999	3.838	1,398	612,300	29	42	179,722	415,052	48,983
2000	3.810	1,423	641,302	39	56	229,768	394,918	50,358
2001	3.907	1,439	664,563	37	53	251,806	423,255	53,208
2002	3.998	1,480	689,763	34	49	259,584	430,905	58,380
2003	4.089	1,575	728,421	39	55	257,762	443,723	53,668
2004	4.179	1,642	705,975	43	60	265,521	460,323	52,362
2005	4.266	1,739	705,546	53	72	282,415	503,681	57,127
2006	4.354	1,892	729,487	57	82	299,301	587,228	68,627
2007	4.443	2,039	797,902	64	84	311,997	650,535	69,761
Avg. annual percentage change	1.85	4.86	2.94	14.25	9.58	7.43	5.95	4.82

Sources: ^aInternational Monetary Fund (IMF), World Economic Outlook Database; ^bMinisterio de Obras Públicas (MOPT), Dirección de Planificación Sectorial; ^cRefinadora Costarricense de Petróleo (RECOPE); ^dRefinadora Costarricense de Petróleo (RECOPE); ^eMinisterio de Obras Públicas (MOPT), Dirección de Planificación Sectorial, using data from Consejo de Seguridad Vial.

2.2. Negative Externalities

Costa Rica's vehicle fleet contributes to severe air pollution, congestion, and traffic accidents. It generates approximately three-quarters of polluting emissions in the GMA (Herrera and Rodríguez 2005), where average annual levels of total suspended particulates, nitrogen oxides, and especially sulfur dioxide, all exceed national or international norms (Table 2).¹ A contingent valuation survey conducted in the mid-1990s found that GMA residents viewed mobile source air pollution as their single most important environmental problem (Celis et al. 1996 cited in Johnstone et al. 2001).

Table 2. Mean annual concentrations of air pollutants in San José, Costa Rica, and World Health Organization and European Union guidelines

City	Pop. (000)	TSP ^a (ug/m ³)	PM10 ^b (ug/m ³)	SO ₂ ^c (ug/m ³)	NO ₂ ^d (ug/m ³)	Years
San José, CR	1,186	101	18	160	31	2000
WHO ^e guideline		60		50	40	
EU ^f limit		--	40	20	30	

^aTotal suspended particulate matter; ^bparticulate matter smaller than 10 microns; ^csulfur dioxide; ^dnitrogen dioxide; ^eWorld Health Organization; ^fEuropean Union.

Source: Baldasano et al. 2003.

Cars, trucks, and buses also contribute to untenable congestion on the GMA's poorly planned and maintained road network, particularly in the morning and evening rush hours, when traffic is often completely gridlocked. Travel speeds in the GMA average less than five miles per hour, and a survey of car commuters found they would be willing to pay half of the national average hourly wage for travel time reductions (Vega et al. 2004; Alpizar and Carlsson 2003).

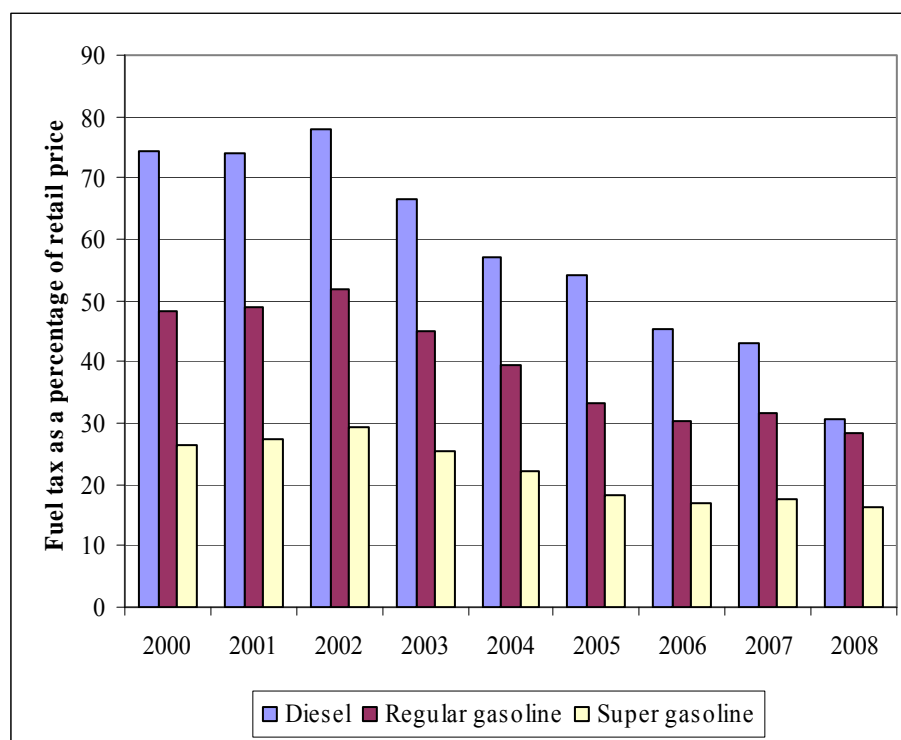
Finally, traffic accidents are a major problem throughout Costa Rica. Despite safety campaigns, the number of accidents has grown by 5 percent per year in recent years (Table 1). In 2007, a fifth of disability pensions administered by the Costa Rican Social Security agency were for victims of traffic accidents (Ávalos 2007).

¹ Carbon monoxide levels also regularly exceed national limits (Alfaro and Ferrer 2001).

2.3. Fuel Taxes

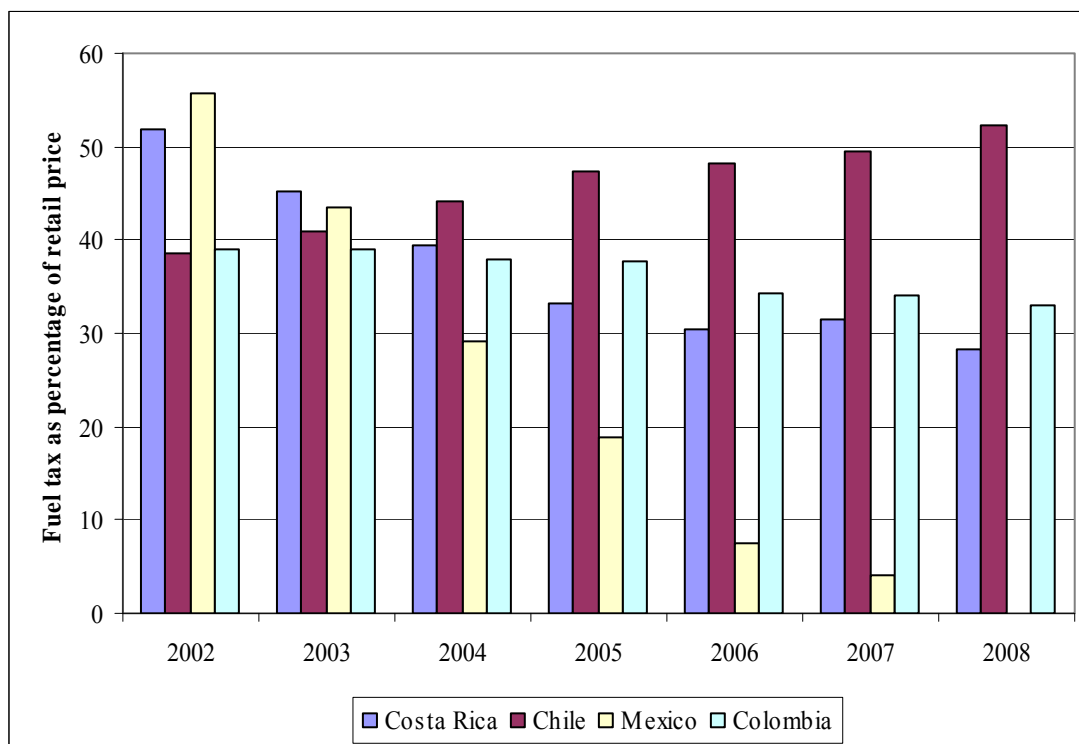
The 2001 Law of Tax Simplification and Efficiency (No. 8114) replaced a complicated system of fuel taxes and fees administered by several regulatory agencies with a single tax administered by the Ministry of Finance. The tax is a fixed sum per liter for each type of fuel (regular gasoline, premium gasoline, and diesel) adjusted four times a year for inflation. In May 2009, the tax was 181 colones per liter for regular gasoline, 189 colones per liter for premium gasoline, and 107 colones per liter for diesel (*La Gaceta* 2009). Because the fuel tax is a fixed sum, its percentage contribution to the total retail price of fuel depends on that pretax price of fuel. In recent years, this contribution has ranged from 28 percent to 52 percent for regular gasoline and has been within the range of the percentage contribution of fuel taxes in other Latin American countries (Figures 1 and 2). The 2001 law that established Costa Rica's fuel tax mandated that revenues be allocated as follows: 66.4 percent to the Ministry of Finance (*Ministerio de Hacienda*), 29.0 percent to the National Road Council (*Consejo Nacional de Vialidad*, CONAVI), 3.5 percent to National Forestry Finance Fund (*Fondo Nacional de Financiamiento Forestal*, FONAFIFO), 1.0 percent to the University of Costa Rica (*Universidad de Costa Rica*, UCR), and 0.1 percent to the Ministry of Agriculture (*Ministerio de Agricultura y Ganadería*, MAG).

Figure 1. Tax as share of average annual retail price of fuel in Costa Rica, 2000–2008



Source: RECOPE.

Figure 2. Tax as share of retail price of regular gasoline for Costa Rica, Chile, Colombia, and Mexico, 2000–2008



Sources: CEPAL and Costa Rica Finance Ministry.

2.4. Distributional concerns

The notion that rising fuel prices unfairly burden the poor is a staple of Costa Rican political discourse and has been used to argue for reductions in fuel taxes. Concern has often focused on diesel, which is used to fuel thermoelectric generating plants, trucks, and buses.² In the past several years, faced with rising diesel prices, the Costa Rican Electricity Institute (*Instituto Costarricense de Electricidad*, ICE), along with associations of bus drivers and truck drivers, has lobbied for a reduction in the tax on diesel on the grounds that it would make electricity, bus transport, and food shipped by truck more affordable to low-income households. For example, in 2008 national legislation was introduced to exempt electric power plants from

² In addition, diesel is increasingly used in private vehicles because the relatively high price of gasoline has created incentives for households to switch to diesel cars (Herrera and Rodriguez 2005).

paying the diesel tax (January 2008, file 16759), exempt buses and taxies from the tax (October 2008, file 17132), and reduce all fuel taxes by 30 percent and disallow increases for a year (January 2008, file 16924). In addition, in July 2008, bus drivers threatened a national strike on the grounds that fuel prices had become untenably high (Cantero 2008).

3. Incidence Analysis

This section presents an analysis of the incidence of fuel taxes in Costa Rica. The first subsection discusses methods and presents our analytical framework. The second subsection discusses our data. The next subsection focuses on first-order impacts—that is, those that are most significant—and the last section focuses on second-order impacts.

3.1. *Methods*

The incidence of fuel taxes is typically assessed by characterizing the variation across economic strata of some measure of the change in households' welfare attributable to the tax (e.g., the dollar amount of fuel taxes they paid or the change in their consumer surplus) normalized by a measure of their pretax welfare (for example, total income or expenditure). The literature on fuel tax incidence highlights three methodological issues. The first concerns the measure of the pretax welfare used both to sort households into economic strata and to normalize changes in welfare. Studies that use annual income to proxy for pretax welfare generally find that gasoline taxes are regressive (KPMG Peat Marwick 1990). However, these studies have been criticized on the grounds that “permanent income” (Friedman 1957), not annual income, drives households' consumption choices and that socioeconomic strata defined by annual income include households whose income is much higher or lower than their permanent income (because they are headed by people who are particularly young and old or in the midst of a transient financial shock) and whose consumption choices, therefore, differ markedly from other members of these strata. Most recent analyses of fuel tax incidence use measures of permanent income, such as annual household expenditure, to proxy for pretax welfare (Poterba 1991; Walls and Hanson 1999; Metcalf 1999; Hassett et al. 2009). These studies tend to find that fuel taxes are less regressive than studies that rely on annual income to measure welfare. Here, we use annual expenditure as a proxy for lifetime income.

The second methodological issue concerns indirect impacts of fuel taxes on households' welfare. An ideal analysis of fuel tax incidence would measure general equilibrium changes in consumer and producer prices of all goods and services in the economy due to a fuel tax increase, and then measure the effects of those price changes on household welfare in different

economic strata. However, the informational requirements of such an analysis, which include demand and supply elasticities for all goods and services and the distribution of ownership of firms across economic strata, are extensive (West and Williams 2004). Many studies of fuel tax incidence omit altogether consideration of indirect impacts of fuel taxes (Poterba 1991; Walls and Hanson 1999; Bureau 2009). Those that do not often make simplifying assumptions to facilitate modeling these effects—specifically, that supply is perfectly elastic, so impacts of fuel taxes on producer prices can be ignored, and in many cases, that demand for various goods and services is perfectly inelastic (Metcalf 1999; Hassett et al. 2009; Datta 2009). Despite the assumption that consumers do not respond to price changes, these studies often find that indirect impacts of fuel taxes are relatively small (Metcalf 1999). Here, following Hassett et al. (2009) and others, we use coefficients from an input-output matrix to simulate the indirect impact of fuel taxes and we assume that supply is perfectly elastic and demand is perfectly inelastic so that economic agents do not adjust their purchases of goods and services because of the tax (i.e., they do not substitute out of newly expensive goods and services).³ Given this assumption, our analysis generates an upper bound on the effect of a fuel tax on household expenditures.

A final methodological issue is the recycling of fuel tax revenue: the incidence of fuel taxes depends on whether and how tax revenue is used (Metcalf 1999; Wiese et al. 1995). Here, we abstract from this issue and focus on tax impacts absent recycling.

We use the following simple analytical framework to assess the incidence of a fuel price hike due to a tax increase. Average household expenditure on fuel type j in expenditure decile s , E_{fjs} , is defined as the price of that fuel type, P_{fj} , times the average quantity consumed, Q_{fjs}

$$E_{fjs} = P_{fj} Q_{fjs} . \quad (1)$$

We consider four types of fuel expenditures: direct expenditure on gasoline (g), direct expenditure on diesel (d), indirect expenditure on diesel via spending on bus transportation (b), and indirect expenditure on fuel (both gasoline and diesel) via spending on six other categories of goods and services, which are indexed by i . Hence, average total expenditure on all categories of fuel in decile s , E_{Ts} , is

³ This assumption is less unrealistic than it normally would be, given that it applies to broad categories of goods (e.g., food, housing) and substituting out of these categories is generally difficult.

$$E_{Ts} = E_{fgs} + E_{fids} + E_{fbs} + \sum_{i=1}^6 E_{fis} . \quad (2)$$

Given our assumption that consumers do not respond to price changes—that is, that quantity in equation (1) is fixed—it is easy to show that the change in expenditure on fuel type j in decile s , ΔE_{fjs} , due to a change in the price of fuel type j , ΔP_{fj} , is simply the percentage change in price times the original expenditure:

$$\Delta E_{fjs} = (\Delta P_{fj} / P_{fj}) E_{fjs} . \quad (3)$$

We assume a uniform increase in the price of fuel across all of our four categories of fuel, so (3) may be written

$$\Delta E_{fjs} = (\Delta P_f / P_f) E_{fjs} . \quad (4)$$

Combining equations (2) and (4), the change in expenditure on fuel in decile s due to a fuel price hike is

$$\Delta E_{Ts} = (\Delta P_f / P_f) \left(E_{fgs} + E_{fids} + E_{fbs} + \sum_{i=1}^n E_{fis} \right) . \quad (5)$$

Direct expenditures on gasoline and diesel, E_{fgs} and E_{fids} , are derived from survey data (discussed below). Indirect expenditure on diesel via spending on bus diesel in decile s , E_{fbs} , is the expenditure on bus travel, also derived from survey data, times the percentage of this spending devoted to fuel, α_{fb} , derived from the public bus regulatory authority's pricing model, that is

$$E_{fbs} = E_{bs} \alpha_{fb} . \quad (6)$$

Finally, indirect expenditure on fuel (both gasoline and diesel) in decile s via spending on the other six categories of goods and services is the expenditure in each category, derived from survey data, times the percentage of this spending devoted to fuel, γ_{fi} , derived from a social

accounting matrix (discussed below), that is

$$E_{fis} = E_{is} \gamma_{fi}. \quad (7)$$

To assess the incidence of spending on each of our four categories of fuel, we multiply (5) through by the percentage change in the price of fuel, divide each category by total expenditure, and use (6) and (8) to arrive at

$$\begin{aligned} \Delta E_{Ts} / E_{Ts} = & (\Delta P_f / P_f)(E_{fgs} / E_{Ts}) + (\Delta P_f / P_f)(E_{fds} / E_{Ts}) \\ & + (\Delta P_f / P_f)(E_{bs} \alpha_{fb} / E_{Ts}) + \sum_{i=1}^6 (\Delta P_f / P_f)(E_{is} \gamma_{fi} / E_{Ts}) \end{aligned} \quad (8)$$

Intuitively, each term on the right-hand side is the increase in the share of total spending devoted to fuel type j in decile s . We compare these increases across deciles to assess the incidence of the fuel price hike. For any given category of fuel, the effect of the price hike is regressive if the relevant increases are higher in “poorer” deciles than they are in “richer” ones, and it is progressive if the opposite is true. For example, if the increase in the share of total spending devoted to gasoline is higher in poorer deciles than in richer ones, the effect of the price hike through spending on gasoline is regressive. For each category of fuel expenditure, we also calculate the Suits index, a widely used measure of tax incidence—the tax analog of the Gini coefficient used to measure income inequality (Suits 1977). The Suits index is bounded by -1 and 1 . For a proportional tax, it is equal to zero, for a progressive tax it is positive, and for a regressive tax it is negative.

3.2. Data

Our data on average household expenditures in each decile (on all goods and services, E_{Ts} , gasoline E_{fgs} , diesel, E_{fds} , bus transportation, E_{bs} , and other goods and services, E_{is}) are derived from the National Statistics and Census Institute (*Instituto Nacional de Estadística y Censos*, INEC) 2004–2005 Household Income and Expenditure Survey, a random survey of 4,231 Costa Rican households. We use monthly expenditure to calculate the upper and lower bounds of expenditure deciles in the INEC data. Table 3 presents the results: the upper bounds of the deciles range from \$178 to \$52,796.

Table 3. Costa Rica 2004–2005 monthly expenditure decile brackets and vehicle ownership, by decile

Decile	Min. total expenditure (2004 US \$)	Max. total expenditure (2004 US \$)	Vehicle ownership (%)
1	0	178	6
2	178	268	10
3	268	353	15
4	353	455	21
5	455	571	30
6	572	730	33
7	731	953	44
8	953	1,297	60
9	1,301	2,117	69
10	2,131	52,796	91

Source: INEC.

Our data on the percentage of spending on bus transportation devoted to fuel, α_{fb} , is drawn from the cost-based pricing model of the Public Service Regulatory Authority (*Autoridad Reguladora de Servicios Públicos*, ARESEP), the institution that sets bus fares in Costa Rica (ARESEP 2008). This model mandates that the cost of diesel accounts for 21 percent of busfares. Accordingly, we assume that 21 percent of households' expenditures on bus transportation is devoted to diesel.

Our data on the percentage of spending on six other categories of goods and services devoted to fuel, γ_{fi} , is drawn from a 2002 input-output matrix for Costa Rica extracted from Sánchez (2006). Input-output matrices catalogue estimates of the intersectoral economic dependencies (Leontief 1986; ten Raa 2005). More specifically, each column of an input-output matrix corresponds to an output, and each row corresponds to an input used to produce it. Each cell indicates the average dollar value of the corresponding input needed to produce one dollar of the corresponding output. Sánchez's (2006) social accounting matrix, which embeds an input-output matrix, contains dozens of inputs and outputs. To make it compatible with our INEC survey data, we aggregated these inputs and outputs to nine broad categories represented in these data (using expenditures on each input or output to calculate a weighted average for each category). Table 4 presents the results for fuel. These coefficients can be interpreted as the percentage of spending on each category of goods and services devoted to fuel.

Table 4. Costa Rica input-output coefficients for fuel: Dollar value of fuel used in producing \$1 of six categories of goods and services

Sector	Input-output coefficient
Housing	0.0612
Recreation	0.0109
Food	0.0060
Clothing	0.0039
Health	0.0032
Education	0.0009

^aA catch-all “other” category with a coefficient of \$0.0256 is omitted for clarity.

Source: Sánchez 2006 and authors’ calculations.

Finally, we assume a 10 percent across-the-board increase in the price of fuel. To our knowledge, the amount by which the price of fuel would need to be increased to maximize social welfare in Costa Rica, taking into account negative externalities associated with local and global air pollution, traffic congestion, and traffic accidents, has yet to be estimated. However, it is probably safe to assume that a 10 percent price hike would still fall short of welfare-maximizing level: Parry and Timilsina (2008) found that fuel prices in Mexico City would need to be raised by 1600 percent to maximize welfare.

3.3. First-Order Effects

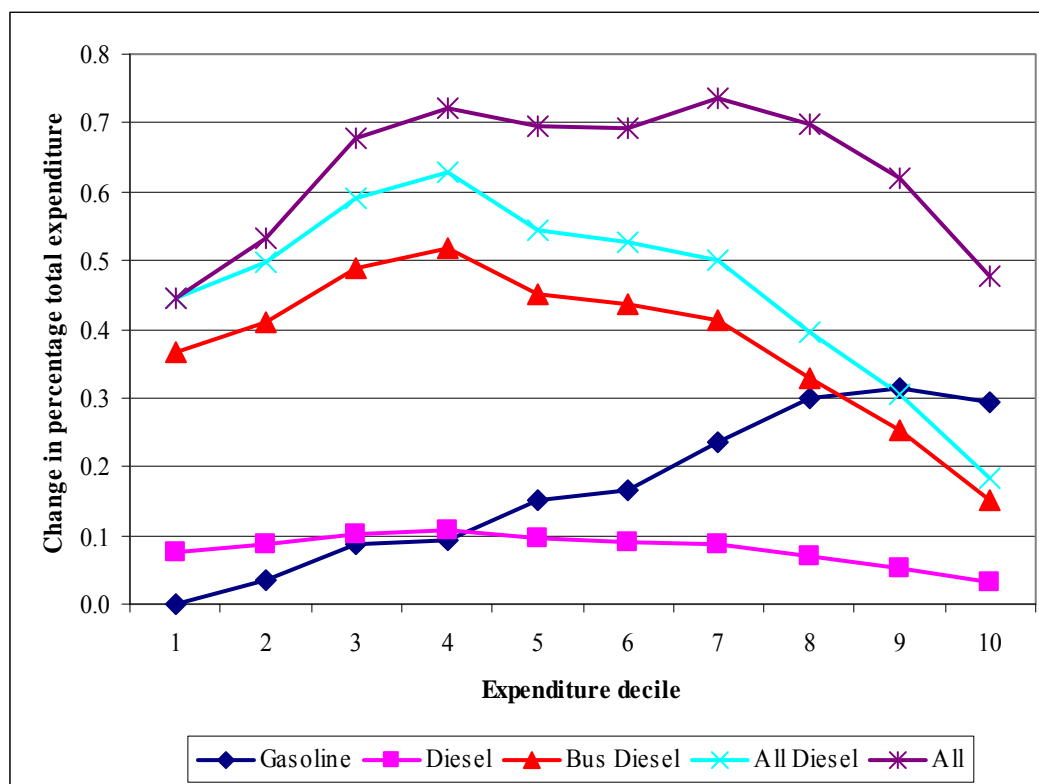
Table 5 and Figure 3 present the results of our incidence analysis for the first three categories of fuel expenditures—direct spending on gasoline, direct spending on diesel, and indirect spending on diesel via bus transportation. We refer to these as first-order effects because they are considerably larger than effects for the last category, the indirect spending on fuel via other goods and services.

Table 5 and Figure 3 indicate that the effect of a 10 percent fuel price hike through direct spending on gasoline is progressive: the increase in the share of total spending devoted to gasoline is higher in richer deciles than in poorer ones, and the Suits index for this increase is positive (0.091). The largest impact is in the ninth decile, where a 10 percent increase in gasoline prices spurs slightly less than a one-third of 1 percent increase in total spending (\$5.61 per month).

**Table 5. First- and second-order effects of 10% fuel price hike in Costa Rica:
Resultant change in percentage of total household expenditure on nine commodities, by decile**

Decile	First-order effects					Second-order effects							All effects
	Gasoline	Diesel	Bus diesel	All diesel	All	Food	Housing	Clothing	Health	Education	Recreation	All	All
1	0.0000	0.0770	0.3670	0.4440	0.4440	0.0186	0.1256	0.0013	0.0004	0.0000	0.0066	0.1525	0.5965
2	0.0350	0.0860	0.4110	0.4970	0.5320	0.0181	0.1213	0.0019	0.0005	0.0000	0.0106	0.1525	0.6845
3	0.0860	0.1030	0.4890	0.5920	0.6780	0.0182	0.1117	0.0018	0.0007	0.0001	0.0102	0.1426	0.8206
4	0.0930	0.1090	0.5190	0.6280	0.7210	0.0174	0.1067	0.0018	0.0005	0.0001	0.0117	0.1382	0.8592
5	0.1500	0.0950	0.4500	0.5450	0.6950	0.0163	0.0929	0.0021	0.0006	0.0001	0.0115	0.1235	0.8185
6	0.1650	0.0910	0.4350	0.5260	0.6910	0.0158	0.0878	0.0021	0.0007	0.0001	0.0126	0.1189	0.8099
7	0.2360	0.0870	0.4140	0.5010	0.7370	0.0144	0.0818	0.0021	0.0008	0.0001	0.0126	0.1118	0.8488
8	0.3000	0.0690	0.3280	0.3970	0.6970	0.0123	0.0655	0.0017	0.0009	0.0002	0.0126	0.0931	0.7901
9	0.3130	0.0530	0.2530	0.3060	0.6190	0.0093	0.0623	0.0016	0.0011	0.0002	0.0117	0.0862	0.7052
10	0.2940	0.0320	0.1520	0.1840	0.4780	0.0049	0.0493	0.0010	0.0010	0.0002	0.0089	0.0653	0.5433
Suits index	0.091	0.103	-0.272	-0.188	-0.010	-0.277	-0.163	-0.150	0.084	0.179	-0.063	-0.160	-0.011

Figure 3. First-order effects: Increase in share of total household spending on fuel due to 10% price hike, by fuel type and decile



The same qualitative result holds for direct spending on diesel, although the distribution of the increased spending across deciles is less skewed toward the highest expenditure deciles. The largest impact is in the fourth decile, where a 10 percent increase in diesel prices spurs a slightly more than one-tenth of 1 percent increase in total spending (\$0.48 per month). The Suits index for the average increase in the share of total spending devoted directly to diesel is positive (0.103). Presumably, our results for direct spending on gasoline and diesel are at least partly, if not mainly, due to the concentration of vehicle ownership in Costa Rica in richer deciles (Table 3).

Our qualitative results for the last first-order effect—indirect spending on diesel via bus transportation—are opposite those for direct spending on gasoline and diesel: the effect of a fuel price hike through bus diesel would be regressive. The increase in the share of total spending devoted to bus diesel is higher in poorer deciles than in richer ones, and the Suits index for this increase is negative (−0.272). Moreover, in most deciles, the magnitude of this effect is larger than for direct spending on either gasoline or diesel. The largest impact is in the fourth decile,

where a 10 percent increase in diesel prices spurs more than a half of 1 percent increase in total spending (\$2.27 per month). Presumably, this result reflects poorer Costa Rican households' heavy reliance on the country's extensive, quasi-public system of bus transportation.

Hence, the distributional impact of a diesel tax is different for direct spending on this fuel and indirect spending via bus transportation. Given that the latter swamps the former, it is not surprising that when these two categories of spending are aggregated, the effect of a fuel price hike through both types of diesel is regressive. The increase in the share of total spending devoted to diesel due to a price hike is higher in poorer deciles than in richer ones, and the Suits index is negative (-0.188).

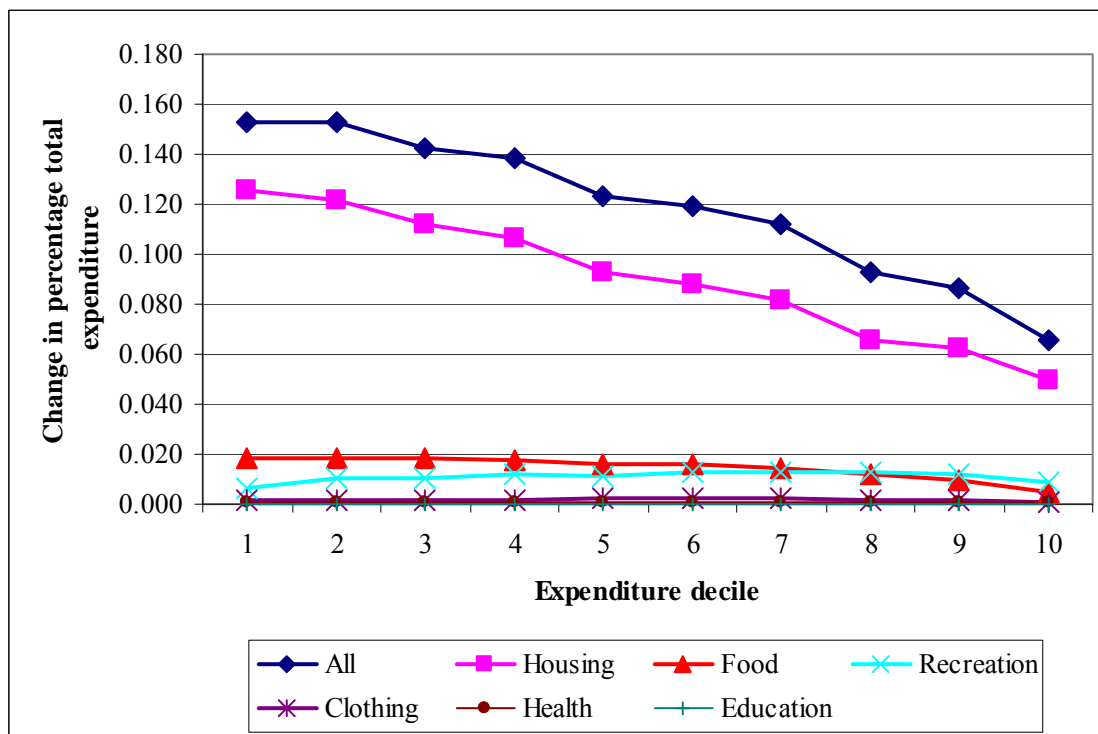
Finally, the sixth column in Table 3 aggregates all three first-order effects: increased direct spending on gasoline, increased direct spending on diesel, and increased indirect spending on diesel via bus transportation. Here too, the bus diesel effect dominates. As a result, the increase in the share of total spending due to all three first-order effects is slightly higher in the poorer deciles than in the richer ones, and the Suits index is negative (-0.010). The largest effect is in the seventh decile, where a 10 percent increase in fuel prices spurs slightly less than a three-quarters of 1 percent increase in total spending (\$6.73 per month).

3.3. Second-Order Effects

Table 5 and Figure 4 present the results of our incidence analysis for the indirect spending on fuel via six categories of nontransportation goods and services, which we refer to as second-order effects. Our calculations suggest that the effect of a price hike through four of the six second-order effects—food, housing, clothing, and recreation—would be regressive. Only in the case of health and education would they be progressive. Of the six effects, the largest are for spending on housing and food. The remaining four effects are an order of magnitude smaller than the first-order effects discussed above. Given that the two largest second-order effects are regressive, it is not surprising that when all six second-order effects are aggregated, they are also regressive, with a Suits index equal to -0.160 .

By definition, the second-order effects are much smaller than the first-order effects. The largest second-order effect is in the first decile, where a 10 percent increase in fuel prices spurs slightly less than a one-sixth of 1 percent increase in total spending (\$0.19 per month). On average, for all deciles, first-order effects are six times larger than second-order effects.

Figure 4. Second-order effects: Increase in share of total household spending on fuel due to 10% price hike, by final good or service and decile

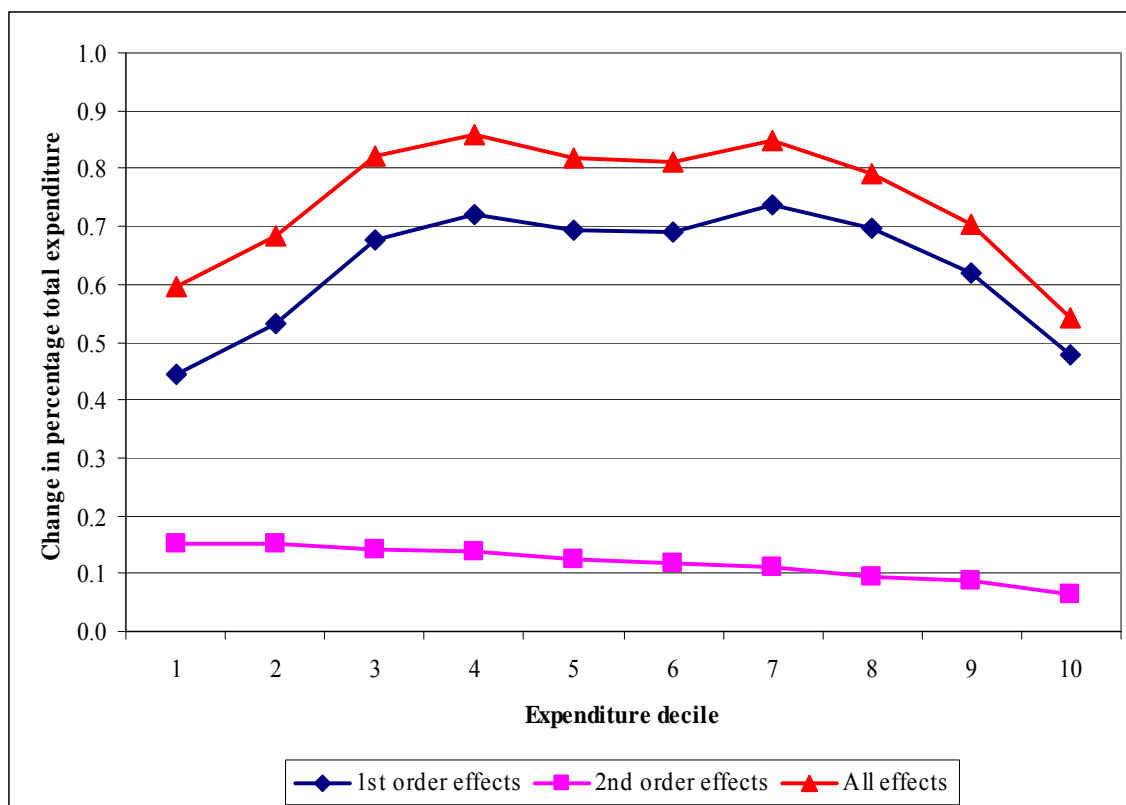


3.4. Total Effects

Table 5 and Figure 5 present the results of our incidence analysis for combined first- and second-order effects. They suggest that the overall effect of a fuel price hike in Costa Rica would be only slightly regressive: the middle deciles devote the greatest proportion of their spending to fuel. The Suits index for this increase is negative (-0.011). On average, for all deciles, fully half of this total effect is due to spending on bus diesel.

The total effect of a 10 percent fuel price hike is modest, even in the socioeconomic strata that would be most affected. The largest total effect is in the fourth decile, where a 10 percent fuel price increase spurs a 0.86 percent increase in total spending (\$1.07 per month). On average, for all deciles, a 10 percent tax hike raises spending by three-quarters of 1 percent.

Figure 5. Combined first- and second-order effects: Increase in share of total household spending on fuel due to 10% price hike, by type of effect and decile



4. Conclusion

We have used 2005 household survey data together with 2002 input-output coefficients to analyze the distributional impacts of a 10 percent fuel price hike in Costa Rica. We found that the first-order impacts are different for gasoline and diesel. The effect of the price hike through direct spending on gasoline would be progressive: households in the highest socioeconomic strata would be most affected. By contrast, the effect of the price hike through spending on diesel—both direct spending and spending via bus transportation—would be regressive: households in lower and middle socioeconomic strata would be most affected because they rely heavily on bus transportation. We found that the second-order distributional impacts of a 10 percent fuel price hike through spending on goods other than fuel and bus transportation would be relatively small: on average, one-sixth the size of first-order effects. Finally, we found that combined effect of a 10 percent fuel price hike through all types of direct and indirect spending on all types of goods and services would be slightly regressive: the middle deciles devote the

greatest proportion of their spending to fuel through all types of spending. However, the magnitude of this combined effect would be modest: the largest impact is in the fourth decile, where a 10 percent fuel price hike spurs less than a 1 percent increase in spending.

What are the policy implications of these results? In general, they suggest that in Costa Rica—and possibly in similarly upper-income developing countries—increases in gasoline taxes, whether imposed to help mitigate vehicles’ negative externalities or for other reasons, would not exacerbate income inequality, since wealthier strata would bear most of the burden of the increase. However, the same is not true of increases in diesel taxes, which have the greatest effect on lower- and middle-income strata, mostly because they would increase the cost of bus travel.

One possible specific policy implication is that in Costa Rica and similar countries, policymakers can avoid adverse distributional consequences of fuel tax hikes by differentiating taxes on diesel and gasoline and reserving steep increases for the latter. This reasoning has not been lost on Costa Rican policymakers. The 2001 Law of Tax Simplification and Efficiency set taxes on gasoline 70 percent higher than taxes on diesel.

But while differentiating tax increases by type of fuel could mitigate distributional concerns, this policy may be problematic on other grounds. First, if consumers buy far more diesel than gasoline as in Costa Rica (Table 1), increasing gasoline taxes will generate less revenue than increasing diesel taxes. Second, if diesel vehicles are more plentiful than gasoline vehicles, increasing taxes on gasoline would probably do a worse job of mitigating vehicles’ negative externalities because, compared with gasoline vehicles, diesel vehicles typically generate more of the fine particles that are especially damaging to human health (Sternier 2003). Finally, taxing gasoline at a higher rate than diesel can create incentives for businesses and households to buy diesel vehicles. In Europe, for example, the share of such cars in the automobile fleet is growing quickly and is strongly correlated with increases in the price of gasoline relative to diesel (Sternier 2007).

An alternative policy prescription, also supported by our findings, is to use revenue from fuel tax hikes to subsidize bus travel. In Costa Rica, and presumably countries like it, diesel taxes are regressive in large part because they raise spending on bus travel.

In the final analysis, in deciding whether to raise fuel taxes, policymakers in developing countries need to balance an array of distributional, political, fiscal, and environmental goals. Our analysis demonstrates that distributional concerns need not trump competing goals.

References

- Alfaro, M. del R., and G. Ferrer. 2001. Concentración de monóxido de carbono en San José. Informe Técnico. Universidad Nacional.
- Alpizar, F., and F. Carlsson. 2003. Policy implications and analysis of the determinants of travel mode choice: An application of choice experiments to metropolitan Costa Rica. *Environment and Development Economics* 8: 603–19.
- Autoridad Reguladora de Servicios Públicos (ARESEP), Dirección de servicios de transportes. 2008. “Informe preliminar de estudio de oficio, modalidad autobuses.” Anexo No. 1: Cuadro de ajustes tarifarios según resoluciones y fechas de corte, durante el período de inclusión.
- Ávalos, A. 2007. “Accidentes son causa de 20% de las pensiones por invalidez” *La Nación*, November 15.
- Baldasano, J.M., E. Valera, and P. Jiménez. 2003. Air quality data from large cities. *The Science of the Total Environment* 307: 141–65.
- Bureau, B. 2009. Distributional effects of a carbon tax on car fuels in France. Working Paper, Paris School of Mines (CERNA).
- Cantero, M. 2008. “Autobuseros amenazan con paralizar servicio a usuarios”. *La Nación*. July 5.
- Celis, R., J. Echeverría, and A. Conejo. 1996. Informe final economía ambiental: Sistema de ordenamiento de la Gran Área Metropolitana (San José, SOAGAM).
- Dargay, J., D. Gately, and M. Sommer. 2007. Vehicle ownership and income growth worldwide: 1960-2030. *The Energy Journal* 28(4): 143–70.
- Datta, A. 2008. The Incidence of fuel taxation in India. Working Paper, Indian Statistical Institute, New Delhi.
- Friedman, M. 1957. *A Theory of the Consumption Function*. Princeton: Princeton, N.J.
- Hassett, K., A. Mathur, and G. Metcalf. 2009. The incidence of a U.S. carbon tax: A lifetime and regional analysis. *The Energy Journal* 30(2): 155–78.
- Herrera, J., and S. Rodríguez. 2005. Segundo informe de calidad del aire de la ciudad de San José año 2004-2005. Escuela de Ciencias Ambientales, Universidad Nacional, Costa Rica.
- . 2008. Informe de calidad del aire de la ciudad de San José, Año 2007. Escuela de Ciencias Ambientales, Universidad Nacional, Costa Rica.

- Johnstone, N., J. Echeverría, I. Porras, and R. Mejías. 2001. The environmental consequences of tax differentiation by vehicle age in Costa Rica. *Journal of Environmental Planning and Management* 44(6): 803–14.
- KPMG Peat Marwick. 1990. Changes in the progressivity of the federal tax system, 1980–1990. Prepared for the Coalition Against Regressive Taxation. Washington, DC.
- La Gaceta*. 2009. No. 91, May 13.
- Leontief, W. 1986. *Input-Output Economics*, 2nd ed. New York: Oxford University Press.
- Metcalf, G. 1999. A distributional analysis of green tax reforms. *National Tax Journal* 52(4): 655-681.
- Pachauri, R.K., and Reisinger, A. (eds.). 2007. Climate Change 2007: Synthesis Report. Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). IPCC: Geneva, Switzerland.
- Parry, I., and K. Small. 2005. Does Britain or the United States have the right gasoline tax? *American Economic Review* 95(4): 1276–89.
- Parry, I., and G. Timilsina. 2008. How should passenger travel in Mexico City be priced? Discussion Paper 08-17. Washington, DC: Resources for the Future.
- Parry, I., M. Walls, and W. Harrington. 2007. Automobile externalities and policies. *Journal of Economic Literature* XLV: 373–99.
- Poterba, J. 1991. Is the gasoline tax regressive? In D. Bradford (ed.), *Tax Policy and the Economy*, vol. 5. Boston: MIT Press, 145–64.
- Russell, C., and W. Vaughan. 2003. The Choice of Pollution Control Policy Instruments in Developing Countries: Arguments, Evidence and Suggestions. *International Yearbook of Environmental and Resource Economics*, vol. VII. Cheltenham, UK: Edward Elgar.
- Sánchez, M. 2006. Matriz de contabilidad social (MCS) 2002 de Costa Rica, y los fundamentos metodológicos de su construcción. Comisión Económica para América Latina (CEPAL), Mexico. Estudios y Perspectivas, Serie 47.
- Santos, G., and T. Catchesides. 2005. Distributional Consequences of Gasoline Taxation in the United Kingdom. *Transportation Research Record* 1924: 103–11.
- Stern, T. 2003. *Policy Instruments for Environmental and Natural Resource Management*. Washington, DC: Resources for the Future Press.

- . 2007. Fuel taxes: An important instrument for climate policy. *Energy Policy* 35: 3194–202.
- Suits, D. 1977. Measurement of tax progressivity. *American Economic Review* 67(4): 747–52.
- ten Raa, T. 2005. *The Economics of Input-Output Analysis*. Cambridge: Cambridge University Press.
- Timilsina, G., and H. Dulal. 2008. Fiscal policy instruments for reducing congestion and atmospheric emissions in the transport sector: A review. Policy Research Paper 4652. Washington, DC: World Bank.
- . 2009. A review of regulatory instruments to control environmental externalities from the transport sector. Policy Research Paper 4867. Washington, DC: World Bank.
- Vega, E., Mejías, C. Camacho, and G. Barrantes. 2004. Informe: Cuatificación de las externalidades en el transporte con tecnologías limpias. Instituto de Políticas para la Sostenibilidad (IPS). Heredia, Costa Rica.
- Walls, M., and J. Hanson. 1999. Distributional aspects of an environmental tax shift: The case of motor vehicle emissions taxes. *National Tax Journal* 52(1): 53–65.
- West, S., and R. Williams. 2004. Estimates from a consumer demand system: Implications for the incidence of environmental taxes. *Journal of Environmental Economics and Management* 47:535–558.
- . 2007. Optimal taxation and cross-price effects on labor supply: Estimates of the optimal gas tax. *Journal of Public Economics* 91(3-4): 593–617.
- Wiese, A., A. Rose, and G. Schluter. 1995. Motor-fuel taxes and household welfare: An applied general equilibrium analysis. *Land Economics* 71: 229–34.
- World Bank. 2009. Country Classifications. Available at <http://siteresources.worldbank.org/DATASTATISTICS/Resources/CLASS.XLS>.
- Ziramba, E., W. Kumo, and O. Akinboade. 2009. Economic Instruments for Environmental Regulation in Africa: An Analysis of the Efficiency of Fuel Taxation for Pollution Control in South Africa. Unpublished manuscript. Department of Economics, University of South Africa.