Maputo
Mozambique

CI5313 Transporte Sustentable y Tecnologías Disruptivas

Clases 10 y 11
23-30 de septiembre de 2021

Tema

- Políticas de transporte sustentable I

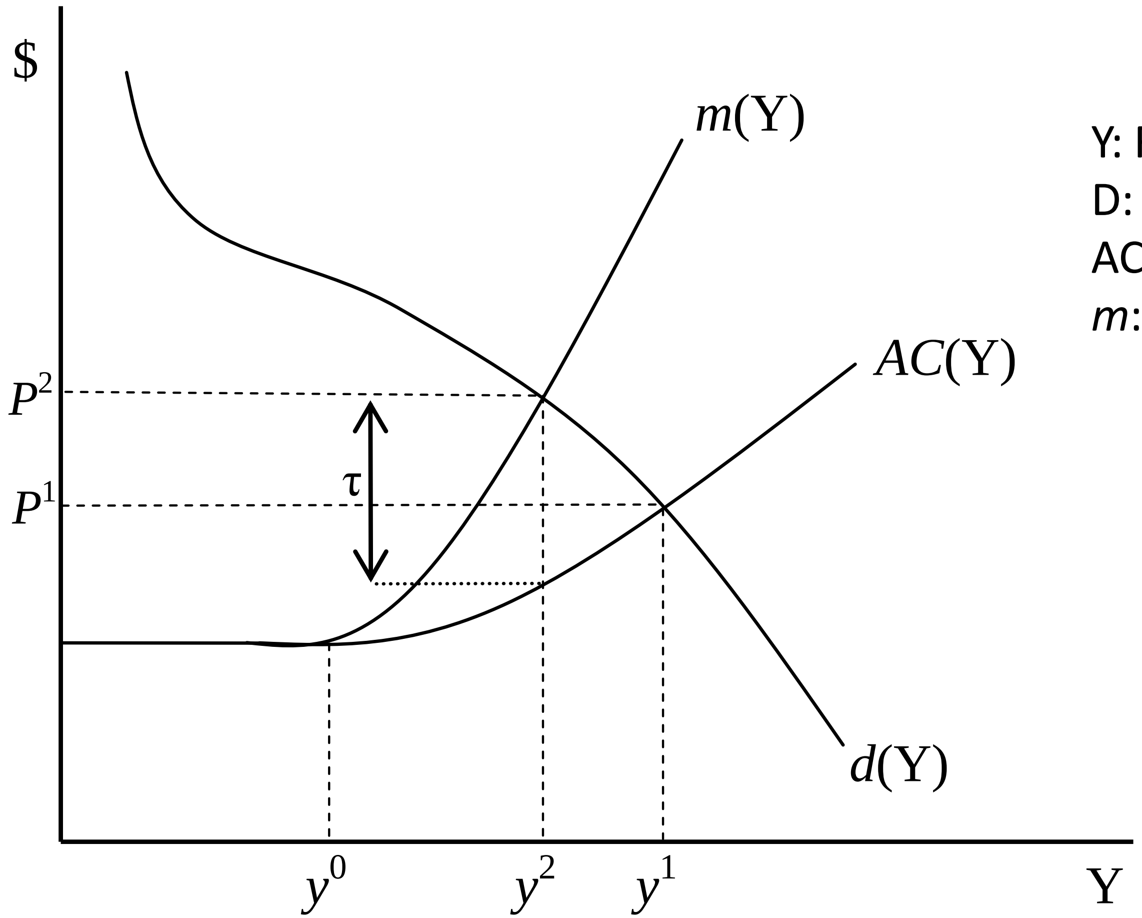
Hacia sistemas de transporte sustentable

1. Incentivos económicos
   - Impuestos y tarificación
   - Subsidios
2. Ingeniería de tránsito y diseño de vialidad
   - Infraestructura modal
3. Uso de suelos y planificación urbana

Hacia sistemas de transporte sustentable

- Incentivos económicos:
  - Tarificación por externalidades.
    - Nombres que se han dado: congestión, emisiones.
  - Subsidios al transporte público
  - Impuesto al combustible.
  - Tarificación de estacionamientos.
  - Subsidios al uso de la bicicleta.

Tarificación por congestión



Y: Flujo
D: Función demanda inversa
AC: Costo medio
m: Costo marginal

Ver Capítulo 2 en Steer Davis Gleave (2009) [Tarificación Vial por Congestión para la Ciudad de Santiago]. Informe Final

Costo medio (average cost): $AC\ (Y) = VT \cdot T_v(Y)$

VT: Valor del tiempo [$/h]

$T_v(Y)$: Tiempo de viaje [h]

Costo total (total cost): $TC(Y)$= $AC\ (Y) \cdot Y$

Costo marginal: $m(Y) = \frac{\partial}{\partial Y}[AC\ (Y) \cdot Y] = AC\ (Y) + \underbrace{Y \cdot \frac{\partial}{\partial Y} AC\ (Y)}_{costo\ externo}$

Tarifa óptima por congestión: $\tau = VT \cdot\ y^2 \cdot \frac{\partial}{\partial Y} AC\ (y^2)$

y^2: nivel óptimo de flujo, que se alcanza cuando se aplica tarifa τ. Se obtiene de la intersección de curva de demanda inversa con curva de costo marginal.

(es y con superíndice 2, no es y cuadrado)

y^1: nivel de flujo de equilibrio, que se alcanza cuando no hay tarifa por congestion. Se obtiene de la intersección de la curva de demanda inversa con la curva de costo medio.

¿De donde sale curva costos medios creciente?

Table 4.1: Overview of flow-travel time functions

Name	Functions *)
Irwin *et al.* (1961)	$t_a(v_a) = \begin{cases} t_a^f + \alpha_a v_a, & v_a < C_a \\ t_a^f + \beta_a v_a + (\alpha_a - \beta_a) C_a, & v_a \geq C_a \end{cases}$
Davidson (1966)	$t_a(v_a) = t_a^f \left(1 + \alpha_a \frac{v_a/C_a}{1 - v_a/C_a}\right)$
Akcelik (1991)	$t_a(v_a) = \begin{cases} t_a^f \left(1 + \alpha_a \frac{v_a/C_a}{1 - v_a/C_a}\right), & v_a < \rho C_a \\ t_a^f \left(1 + \alpha_a \frac{\rho}{1-\rho}\right) + \frac{\alpha_a}{(1-\rho)^2} \left(\frac{v_a}{C_a} - \rho\right), & v_a \geq \rho C_a \end{cases}$
BPR (1964)	$t_a(v_a) = t_a^f \left(1 + \alpha_a \left(\frac{v_a}{C_a}\right)^{\beta_a}\right)$
Smock (1962)	$t_a(v_a) = t_a^f \exp\left(\frac{v_a}{C_a}\right)$
Soltman (1965)	$t_a(v_a) = t_a^f 2^{v_a/C_a}$
Overgaard (1967)	$t_a(v_a) = t_a^f \alpha_a^{\left(\frac{v_a}{C_a}\right)^{\beta_a}}$
Mosher(1) (1963)	$t_a(v_a) = t_a^f + \ln(C_a) - \ln(C_a - v_a)$
Mosher(2) (1963)	$t_a(v_a) = \alpha_a - \frac{C_a\left(t_a^f - \alpha_a\right)}{v_a - C_a}$

*) t_a = travel time on link a, t_a^f = free-flow travel time on link a, v_a = flow on link a, C_a = capacity of link a. All other unknowns are nonnegative parameters of the functions, mostly link type-specific.

Tu, H. 2008. Monitoring travel time reliability on freeways. Ph.D. thesis, Delft University of Technology, The Netherlands

Tarificación vial

Londres

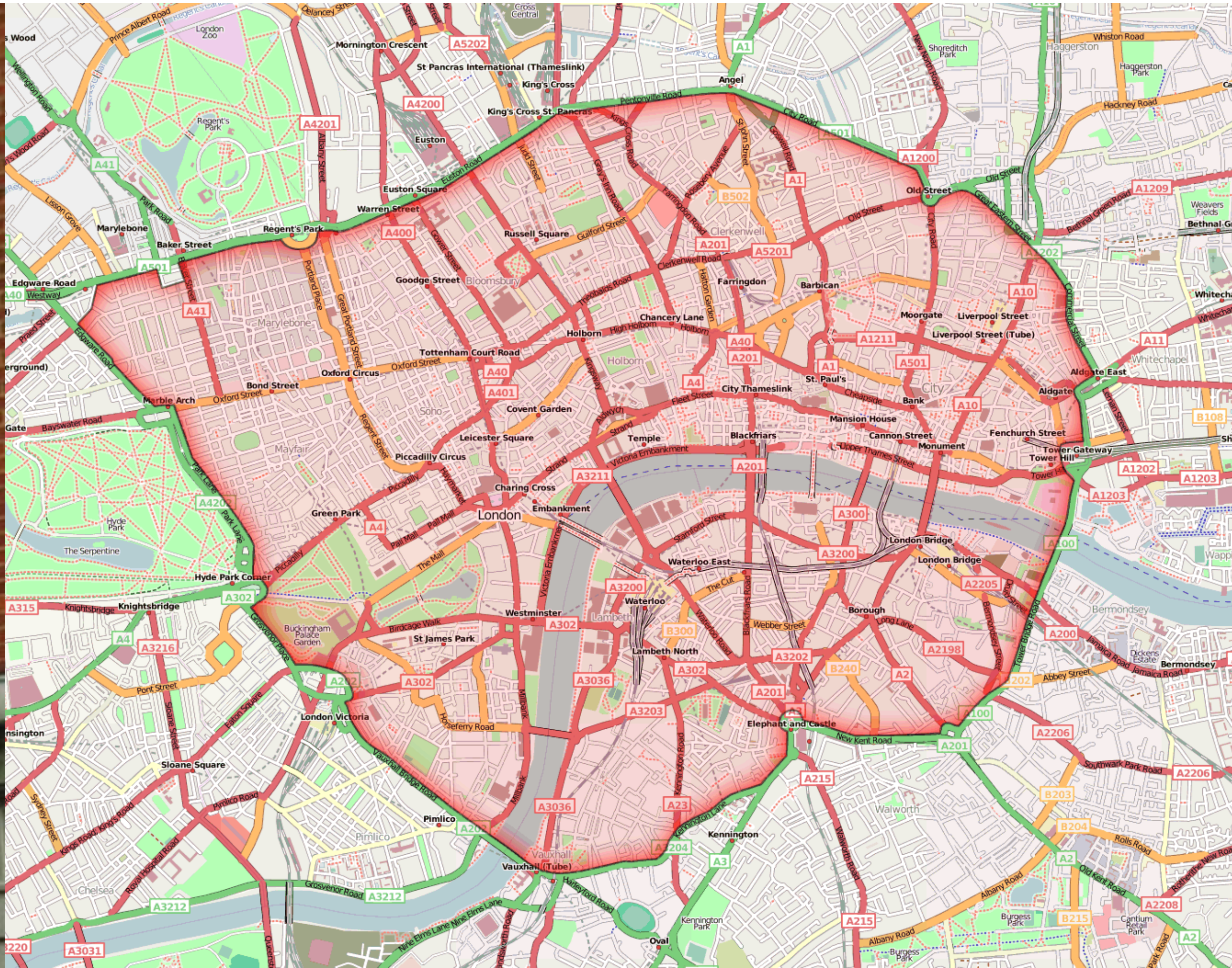
https://www.visitlondon.com/traveller-information/getting-around-london/congestion-charge

Tarifa

2003: 5 libras

2018: 11.5 libras

2021: 15 libras




Congestion charging
Central ZONE
Mon - Fri
7 am - 6 pm
Congestion charging
Central ZONE
Mon - Fri
7 am - 6 pm

Figure 3.1 Congestion in the central London congestion charging zone during charging hours (07.00-18.30). Moving car observer surveys.

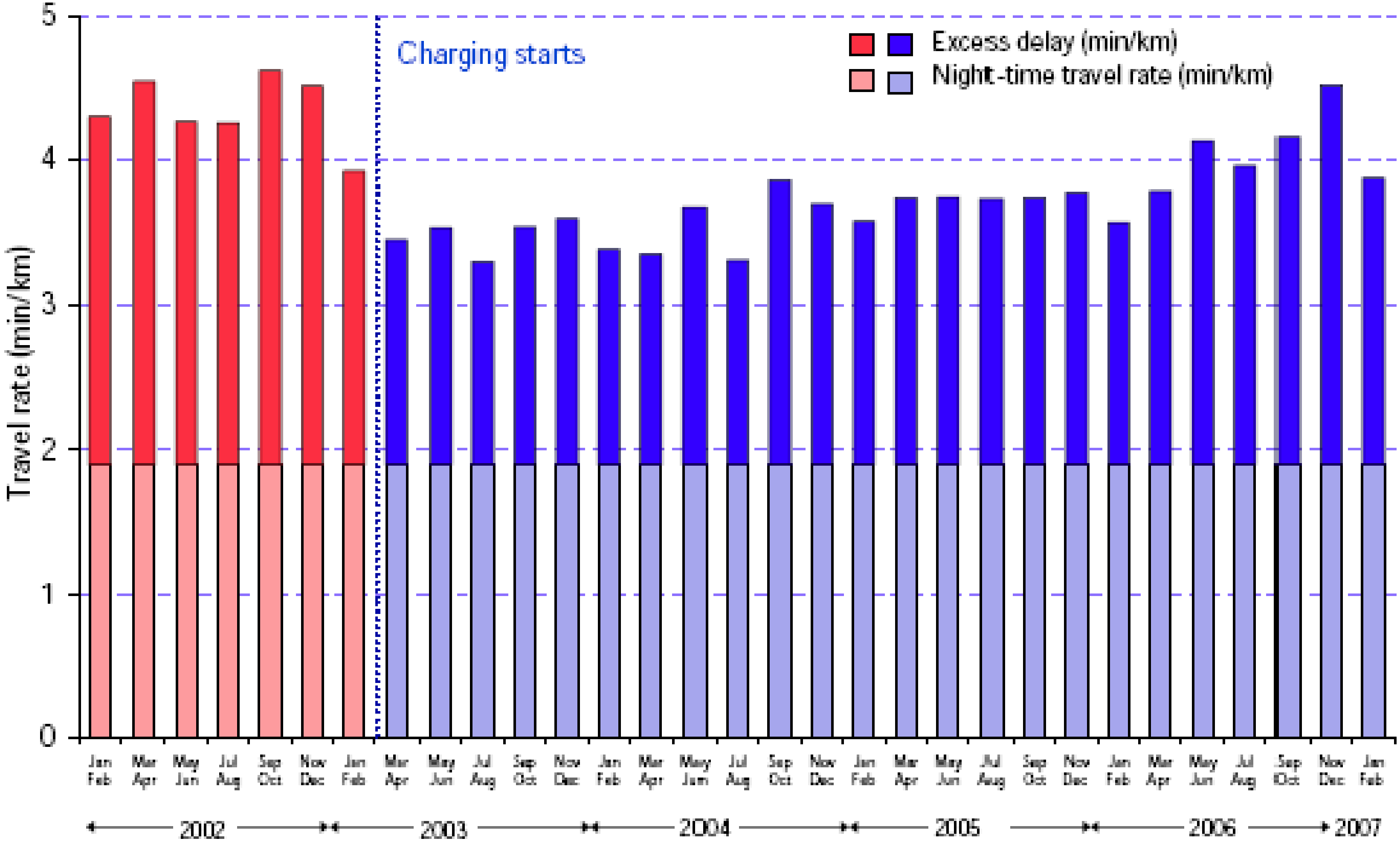
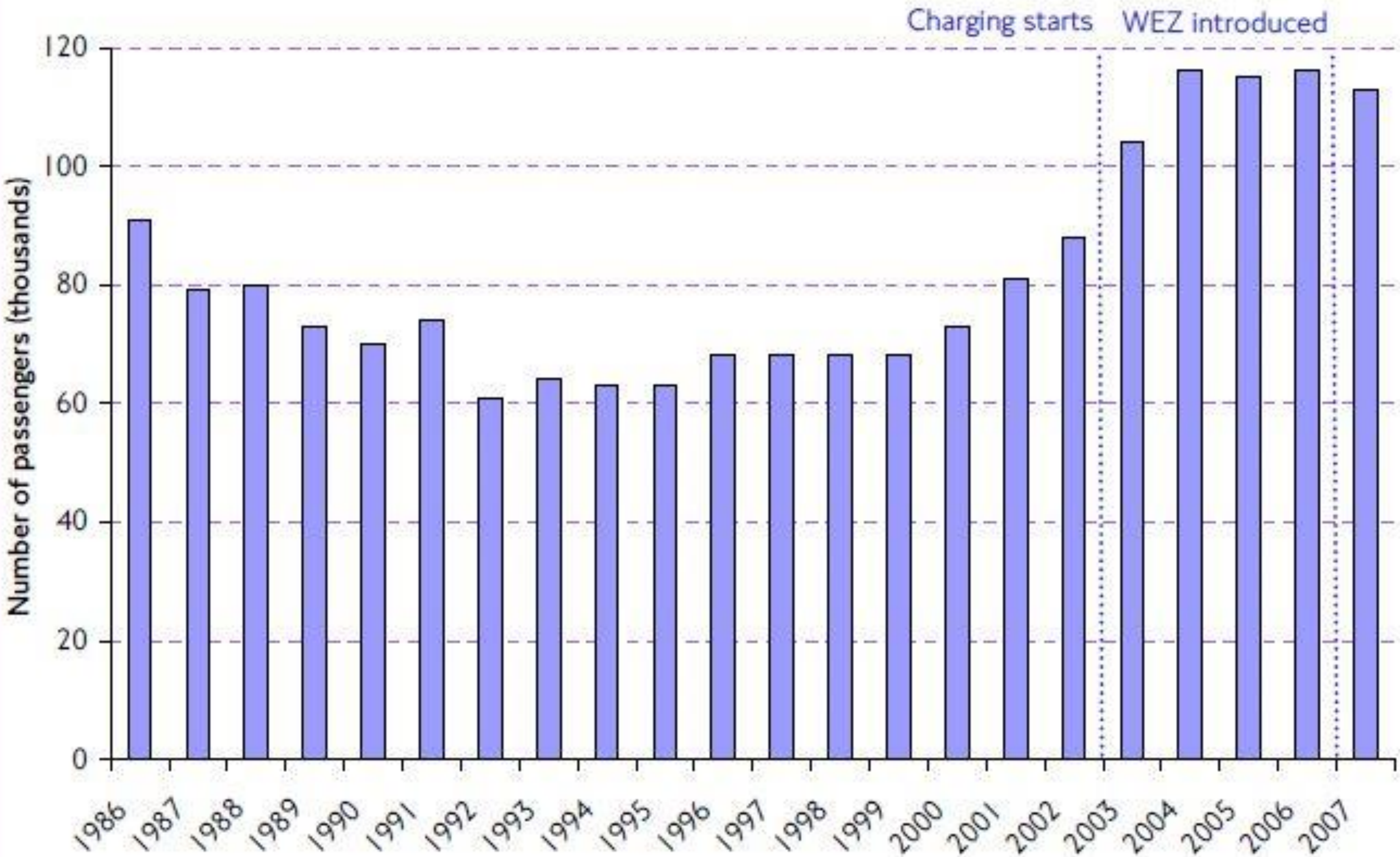


Figure 5.3 Bus passengers entering central London, 07:00-10:00. Autumn counts, 1986 to 2007. TfL Central Area Peak Count.



Cars sit in a traffic jam while cyclists ride by in Central London. // Hannah McKay/Reuters

London's Congestion Charge Is Showing Its Age

NICOLE BADSTUBER APR 11, 2018

After 15 years of existence, London's method of congestion charging is dated. It needs to be bigger, longer, and greedier.

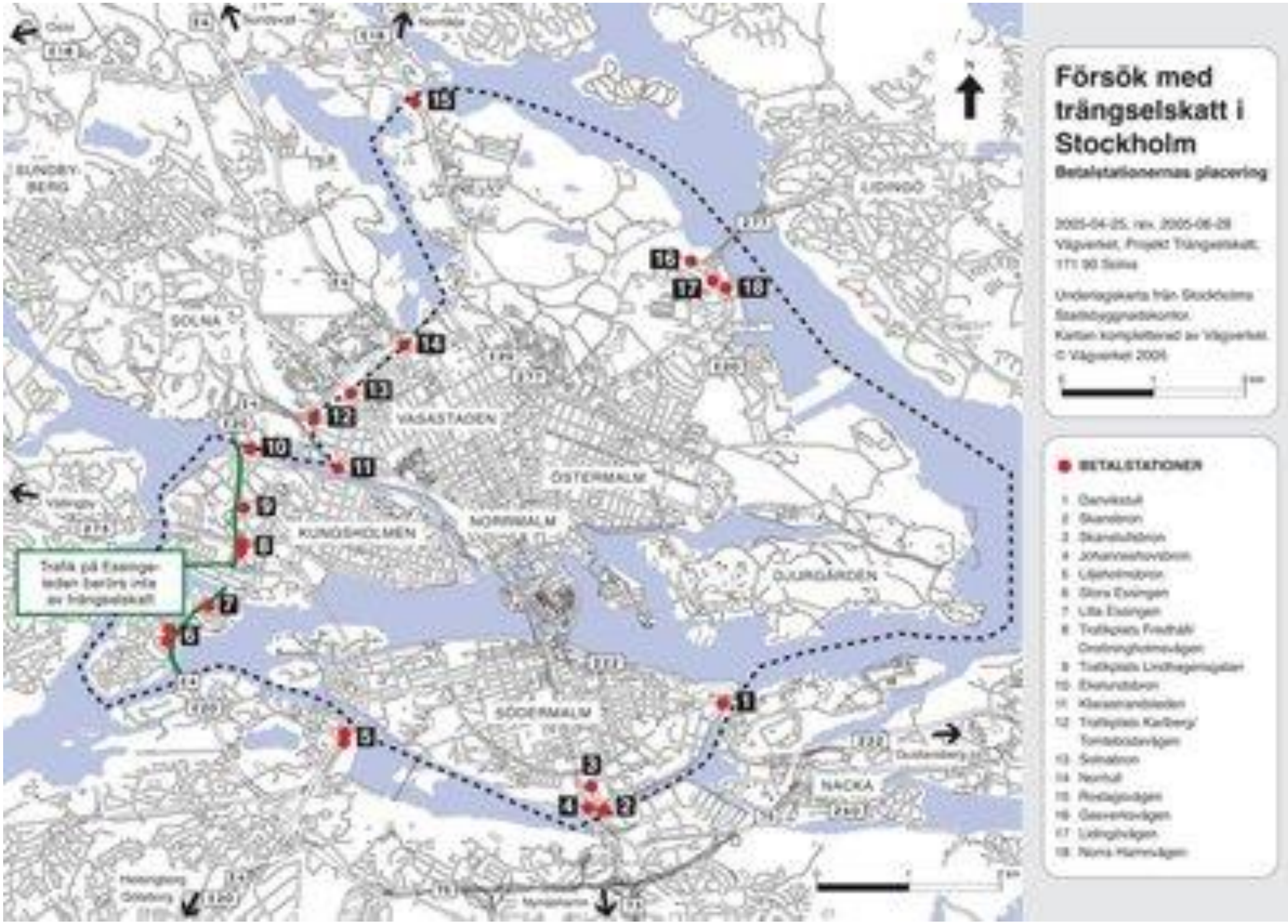
SHARE TWEET ...

London's congestion charge turned 15 in February and it is showing its age. When the charge was introduced, no one foresaw the rapid proliferation of private hire vehicles like Uber. From 2013 to 2017, private hire vehicle registrations soared by over 75 percent: These cars are exempt from paying the congestion charge. A new approach to road pricing is needed to address the changes in the way people and vehicles move around the city and to generate much-needed funds for London's transport system.

https://www.bloomberg.com/news/articles/2018-04-11/london-s-congestion-charge-is-showing-its-age

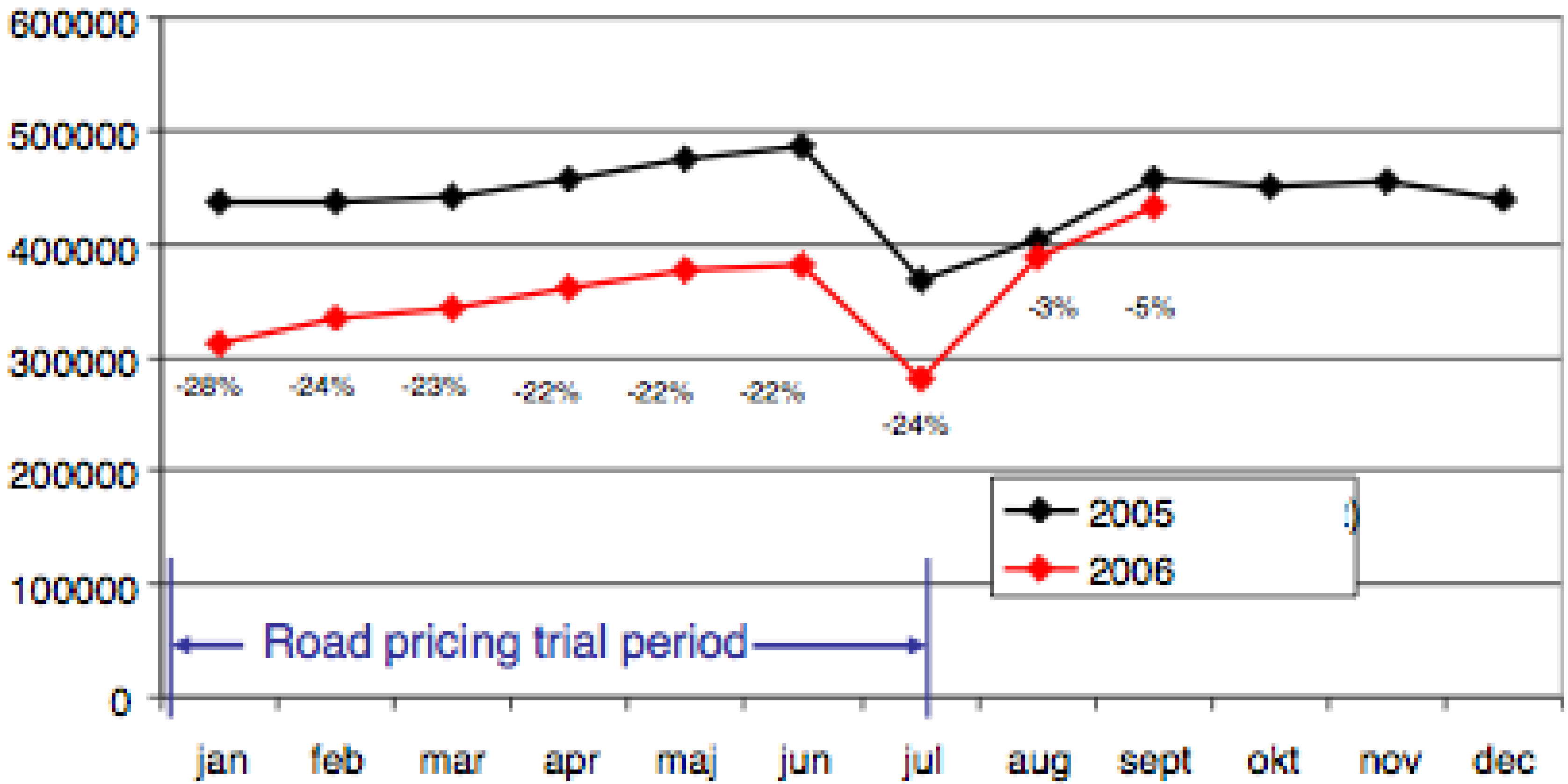
Temas

- Vehículos Uber y taxis no pagan.
- Aumento vehículos reparto.
- Cobro fijo independiente de hora de ingreso (anacrónico).
- Residentes pagan 10%.
- Vehículos eléctricos no pagan.



Tarificación por cordón en Estocolmo

Did the Stockholm Charge Work?
Vehicles crossing cordon on weekdays:
22% drop in traffic



Tarificación vial en Santiago: estudio SDG (2009)

5.3 Descripción de las alternativas definitivas

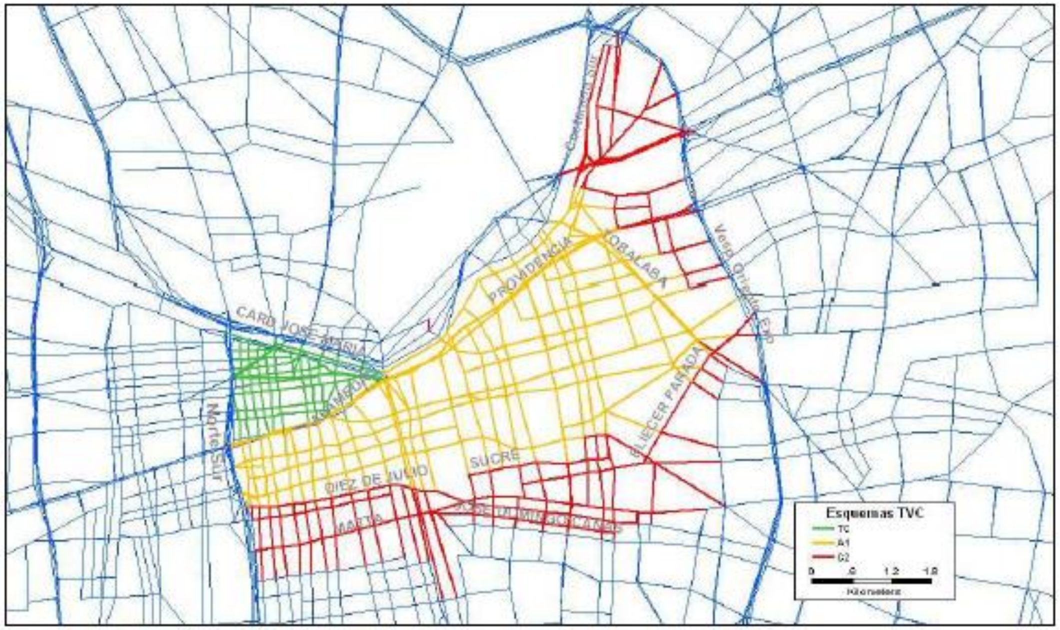
Las alternativas definitivas de tarificación vial para Santiago corresponden entonces a las tres siguientes cuya ubicación espacial se aprecia en la figura siguiente.

- TVC2 o Cordón 2
- TVA1 o Área 1
- TVTC o Triángulo Central

Horarios de cobro:

- Punta Mañana : 7:30 a 10:00
- Punta Tarde : 18:00 a 20:00

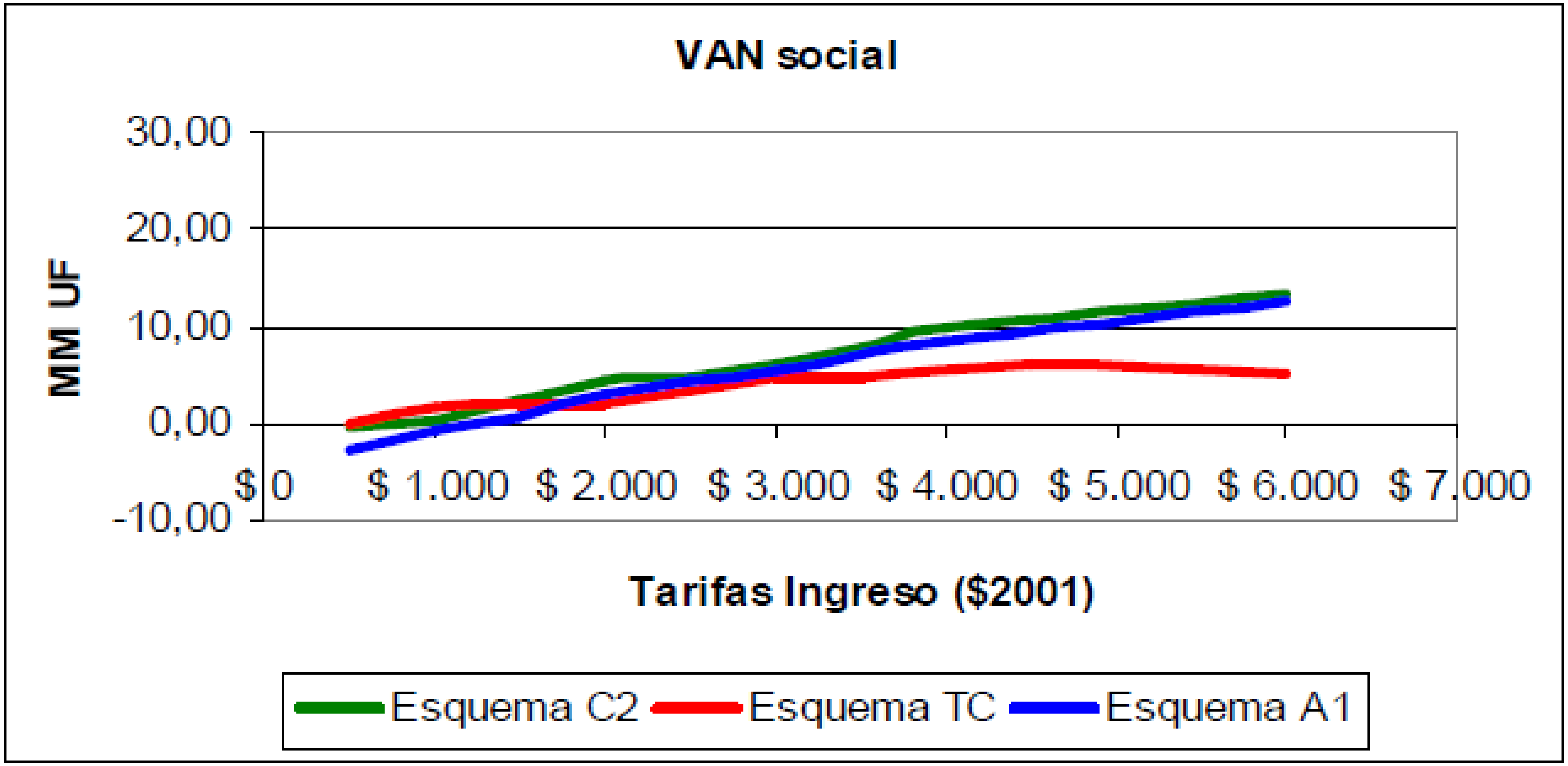
FIGURA 5-1 ALTERNATIVAS DEFINITIVAS DE TARIFICACIÓN VIAL PARA SANTIAGO



Steer Davis Gleave (2009) [Tarificación Vial por Congestión para la Ciudad de Santiago]. Informe Final

Tarificación vial en Santiago: estudio SDG (2009)

FIGURA 5-34 VAN SOCIAL



Steer Davis Gleave (2009) Tarificación Vial por Congestión para la Ciudad de Santiago. Informe Final

Tarificación vial en Santiago: estudio SDG (2009)

Lecciones de la experiencia internacional ¿Cómo aumentar grado de aceptación ciudadana a tarificación vial en Chile?

1. Que la congestión (y/o la contaminación en el caso de Santiago) sea considerada como un problema importante por los usuarios de las vías, y que la tarificación vial sea percibida como un instrumento eficaz para resolverlo.
2. Que la tarificación vial sea presentada como parte de una estrategia más amplia de medidas para mejorar las condiciones de tráfico en una determinada zona.
3. Que los ingresos que se obtengan sean invertidos en la zona en que se recauden y que las inversiones que se realicen sean adicionales a las ya programadas.

Steer Davis Gleave (2009) Tarificación Vial por Congestión para la Ciudad de Santiago. Informe Final

Tarificación vial en Santiago: estudio SDG (2009)

Lecciones de la experiencia internacional ¿Cómo aumentar grado de aceptación ciudadana a tarificación vial en Chile?

4. Que los precios que se cobren por el uso de las vías sean aceptados como correctos y con una base sólida en sean adicionales a las ya programadas.
5. Que el sistema que se implemente sea técnicamente confiable y que garantice el respeto a la privacidad de los usuarios de las vías.
6. Que tanto en la etapa previa como una vez implementado el sistema de tarificación vial se diseñe una estrategia comunicacional que explique los beneficios esperados y efectivos.
7. Que la implementación considere o no un plebiscito y si es el caso que procure generar una experiencia previa de uso.

Steer Davis Gleave (2009) Tarificación Vial por Congestión para la Ciudad de Santiago. Informe Final

Impuesto al combustible

- ¿Progresivo o regresivo?
- ¿Cómo se calcula en Chile?
- ¿Relación con externalidades de transporte?

(Clase 3)

Maisa Rojas Daniela Benavente

Rebaja del impuesto a los combustibles: ¿Cómo creamos un consenso social en torno al desarrollo sostenible?

OPINIÓN Voces **2 JUL 2021** 08:25 AM

OPINIÓN Voces

Rebaja al impuesto al combustible: el lobo vestido de oveja

Alejandro Tirachini
30 JUN 2021 08:30 AM

Consecuencias de la eliminación del impuesto específico al combustible

Por Edith Durán Junio 30, 2021 No hay comentarios

Leonardo Ramírez Baeza, estudiante Ingeniería Civil Industrial, Pontificia Universidad Católica de Chile.Bastián Henríquez Jara, estudiante Doctorado en Sistemas de Ingeniería, Universidad de Chile

https://www.latercera.com/opinion/noticia/rebaja-al-impuesto-al-combustible-el-lobo-vestido-de-oveja/3C6VMPPJRRFBHDNPGP25YMCAV4/

https://www.latercera.com/opinion/noticia/rebaja-del-impuesto-a-los-combustibles-como-creamos-un-consenso-social-en-torno-al-desarrollo-sostenible/NJXQHRTBBJDOHPPUZMHYM434U4/

https://sochitran.cl/2021/06/30/consecuencias-de-la-eliminacion-del-impuesto-especifico-al-combustible/

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Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The distributional incidence of the gasoline tax in Chile

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[b] ILADES Georgetown University, Chile

HIGHLIGHTS

- Gasoline tax is an optimal tax and is a significant instrument of climate policy.
- Despite its benefits, it faces political economy challenges in its implementation.
- In the public discussion in developing countries the tax is considered regressive.
- The estimation of the distributional incidence shows that it is slightly progressive.
- Increases in gasoline taxes can reduce both negative externalities and inequality.

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Suits Index

ABSTRACT

This paper analyzes the distributional incidence of the excise tax on gasoline in Chile using Household Budget Surveys. The incidence is calculated with respect to both income and expenditure distributions in order to consider the potential differences between transitory and permanent income. The Suits Index is estimated as a measure of the degree of progressivity of the tax, and confidence intervals are calculated using a bootstrap methodology to statistically compare changes in the incidence given changes in the tax. The results show that the tax, contrary to the evidence for several developed countries, is slightly or moderately progressive, with a lower degree of progressivity observed in the calculations based on income than those based on expenditure. The simulation of the 25% reduction in the tax rate implemented in 2008 shows that, in terms of incidence, its effect is to reduce the progressivity of the gasoline tax, which is the opposite of what was sought by the government with this policy.

Table 3
Fraction of households that spend on gasoline by income decile.

Income Decile	V EPF (%)	VI EPF Greater Santiago (%)	National (%)
1	4.5	6.3	5.8
2	5.7	9.1	10.3
3	11.8	16.9	17.8
4	14.9	21.3	22.6
5	16.2	22.1	24.2
6	22.5	29.6	31.1
7	30.7	38.5	41.9
8	47.1	49.9	49.9
9	64.5	63.6	67.8
10	84.3	83.0	86.0

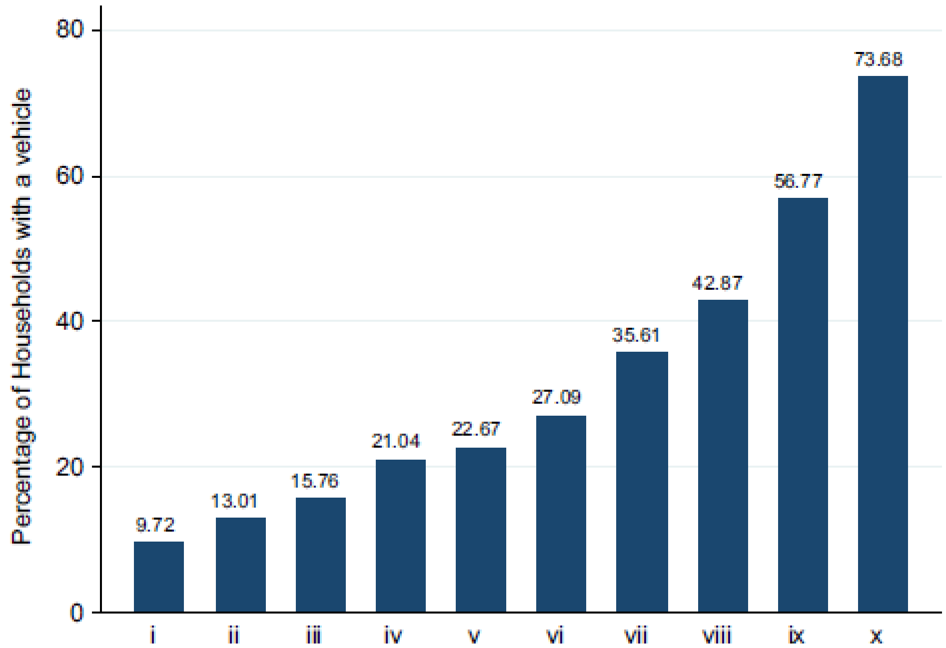
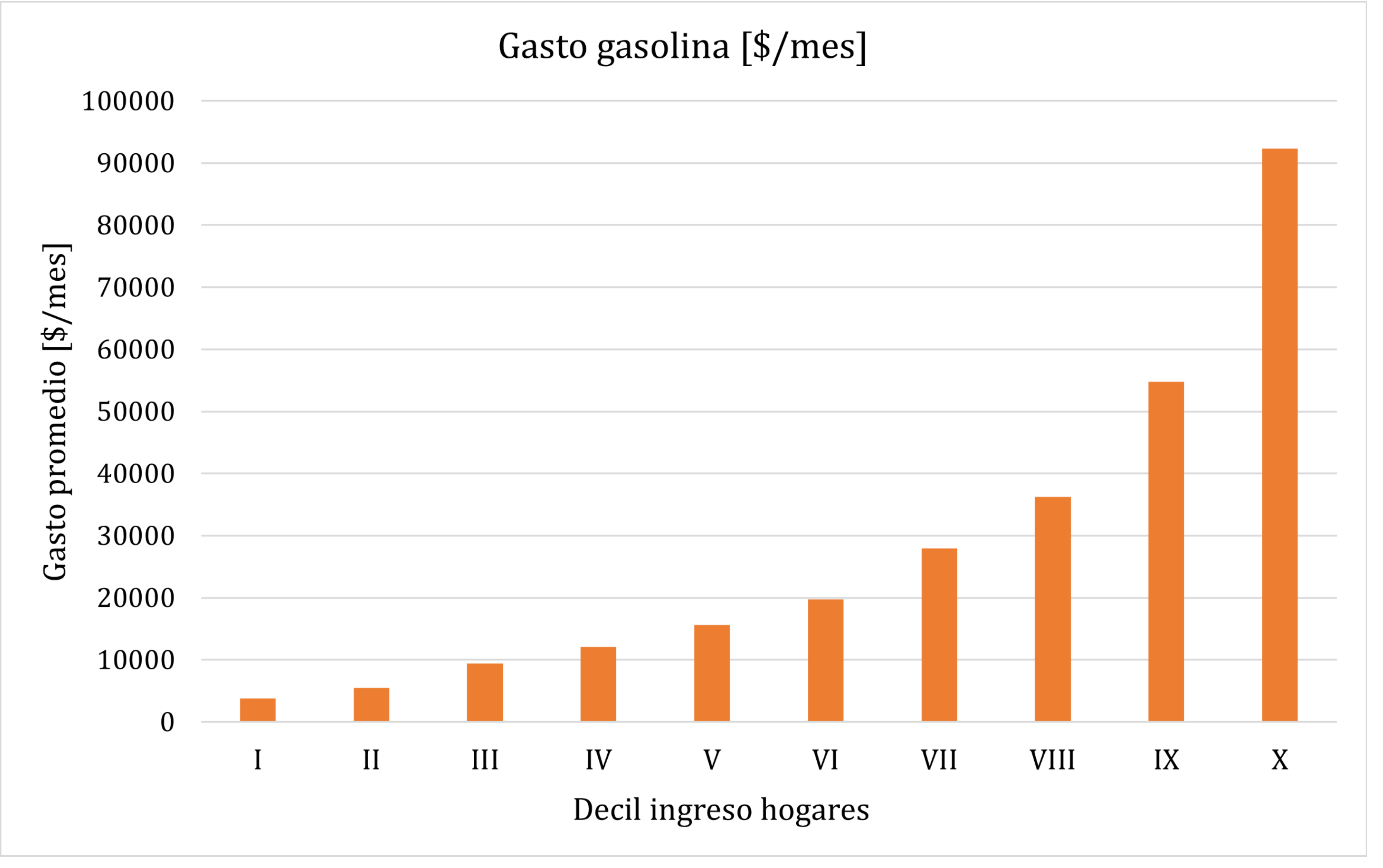


Fig. 2. Percentage of households owning a vehicle by income decile in 2006.

(Agostini y Jiménez, 2015)

Gasto en gasolina por decil de ingreso hogar



Elaboración propia basado en Encuesta de Presupuestos Familiares (INE, 2018)

Pregunta	**ID: 001.030.0739.010**	**Fecha de Creación: 07/11/2003**

¿Cuáles son los impuestos vigentes que se aplican a los combustibles?

Respuesta	**Fecha de Actualización: 09/06/2015**

1.- Impuesto al Valor Agregado (IVA): 19%.

2.- Impuestos Específicos a los Combustibles establecidos en la ley N° 18.502. La tasa que se aplicará será igual al "componente base" sumando o restando, según corresponda, el "componente variable" calculado y determinado de conformidad con la Ley N° 20.493, publicada en el D.O. del 14.02.2011, con vigencia desde el 24.02.2011.

COMPONENTE BASE: El componente base de los Impuestos Específicos a los Combustibles, según lo dispuesto en los artículos 1° y 6° de la Ley N° 18.502, es el que se indica a continuación:

Gasolina automotriz : 6,0 UTM por m3

Petróleo diesel : 1,5 UTM por m3

Gas natural comprimido : 1,93 UTM por 1.000 m3

Gas licuado de petróleo : 1,40 UTM por m3

COMPONENTE VARIABLE: Al componente base antes señalado, se sumará o restará un componente variable, consistente en un mecanismo integrado por impuestos o créditos fiscales específicos de tasa variable que incrementarán o rebajarán el componente base, y por ende el Impuesto Específico a los Combustibles a aplicar, según se establece en el artículo 3° de la Ley N° 20.493.

Puede obtener mayor información relativa a este tema en el sitio Web del SII, sección Ayuda, menú Aprenda sobre los impuestos, opción Descripción de los impuestos, Impuestos a los combustibles. Además en la sección Normativa y Legislación, opción Resoluciones, Resolución N° 42, de 2011.

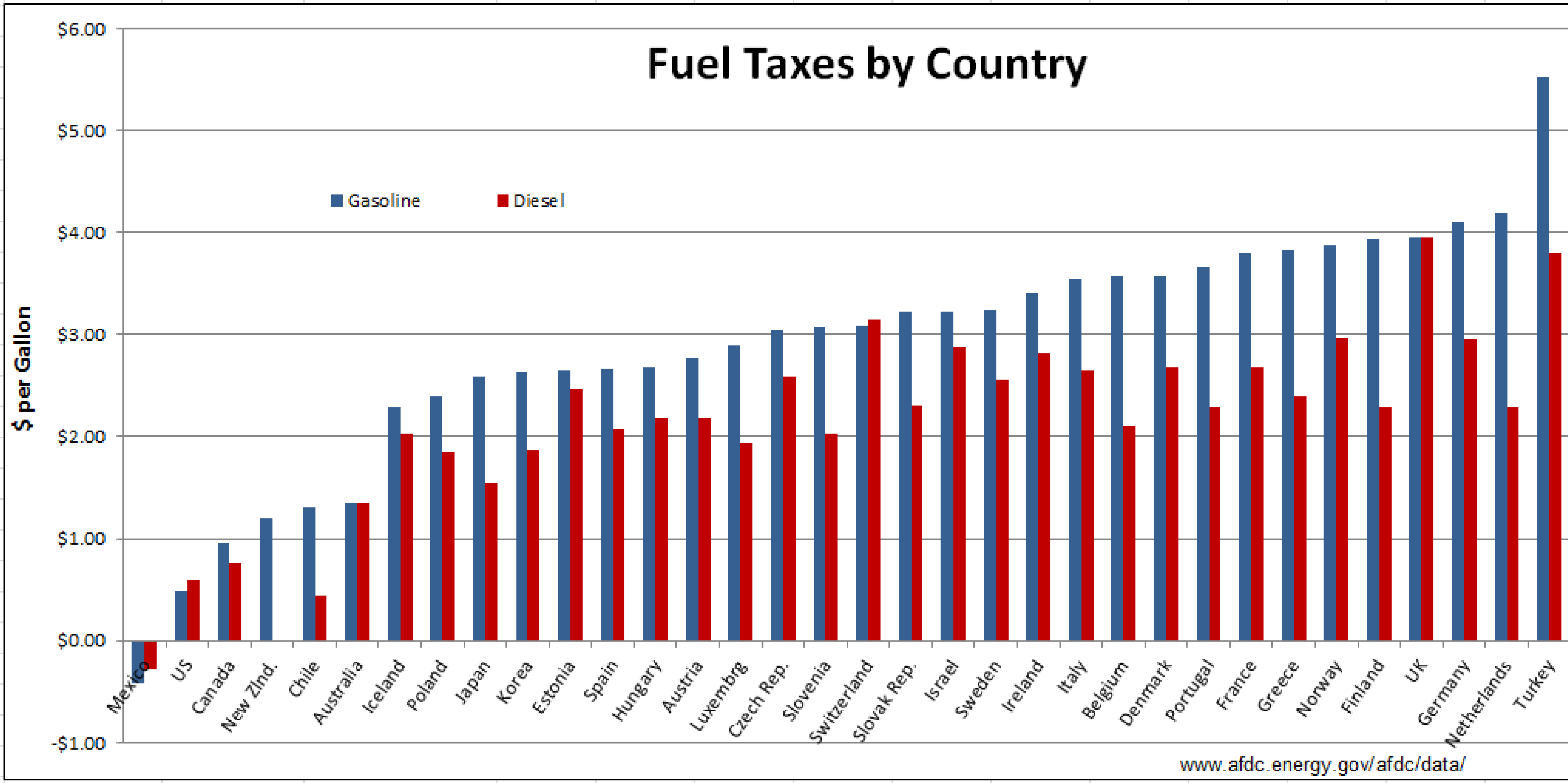
http://www.sii.cl/preguntas_frecuentes/iva/001_030_0739.htm

Data Source: OECD/EEA database on instruments for environmental policy, http://www2.oecd.org/ecoinst/queries/index.htm

Notes: Rates as of 01/01/2010. Data for the United States and Canada include average excise taxes at the state/provincial level. VAT is not included.

Last updated 04-18-2011

Worksheet available at www.afdc.energy.gov/afdc/data/



1 galón=3.79 litros

En Chile tasa impuesto gasolina aprox: 35% (IVA más impuesto específico)

Análisis de optimalidad del impuesto al combustible en Chile

Environment and Development Economics 17: 127–144
doi:10.1017/S1355770X11000404

International fuel tax assessment: an application to Chile

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ABSTRACT. Gasoline and diesel fuel are heavily taxed in many developed and some emerging and developing countries. Outside the United States and Europe, however, there has been little attempt to quantify the external costs of vehicle use, so policy makers lack guidance on whether prevailing tax rates are economically efficient. This paper develops a general approach for estimating motor vehicle externalities, and hence corrective taxes on gasoline and diesel, based on pooling local data with extrapolations from US evidence. The analysis is illustrated for the case of Chile, although it could be applied to other countries.

- Parry y Strand (2012): Impuesto óptimo al combustible en Chile
- Small y Parry (2005), paper original impuesto óptimo al combustible EEUU y Gran Bretaña

Parry and Strand (2012)

The model boils down to the following household optimization problem:

$$\underbrace{Max}_{m,v,g,X} \quad u(m, v, X, E_G(G), E_M(M))$$

$$+\lambda\{I + GOV - (p_G + t_G)G - c(g)v - p_X X\} \qquad (1a)$$

$$G = gM, \quad M = mv. \qquad (1b)$$

M denotes vehicle miles traveled by households, equal to the number of autos (v) times miles driven per auto (m). G is aggregate gasoline consumption, equal to gasoline combustion per mile g, or the inverse of fuel economy, times vehicle miles. $E_G(.)$ is externalities that vary in proportion to gasoline use, while $E_M(.)$ is externalities that vary in proportion to vehicle miles (see below). I is private household income (which is fixed) and GOV is a government transfer, which captures the recycling of gasoline tax revenues. $c(g)$ represents the fixed costs of vehicle ownership which are increasing with respect to reductions in g, because more fuel-efficient vehicles require the incorporation of (costly) fuel-saving technologies. X is an aggregate of all other goods in the economy. p_G and p_X are the producer prices for gasoline and the general good, which are given (Chile is a price taker in the world oil market). t_G is the excise tax on gasoline. The Lagrange multiplier λ is the marginal utility of income.

u: utilidad, i.e., satisfacción que se obtiene por consumir un producto o servicio.

Discusión concepto utilidad en economía: https://www.investopedia.com/terms/u/utility.asp

Table 1. *Benchmark data and parameter assumptions (for year 2006 or thereabouts)*

Data and parameter values	*Automobiles*	*Trucks*
Initial fuel consumption, million gallons	819	898
Initial fuel economy, miles/gallon	30.0	8.0
Vehicle miles, billion	24.6	7.2
Initial retail fuel price, $/gallon	4.27	3.17
Initial fuel tax, $/gallon	1.46	0.37
Fuel tax revenue, $billion	1.19	0.33
Externalities from fuel combustion, $/gallon		
Local tailpipe emissions (varying with fuel use)	0.29	0.18
Carbon	0.18	0.21
Externalities from driving, $/vehicle mile		
Local tailpipe emissions (varying with mileage)	0.02	0.07
Congestion	0.04	0.10
Accidents	0.06	0.07
Noise	0	0.01
Road damage	0	0.08
Fuel demand elasticity	–0.50	–0.50
Mileage to fuel price elasticity	0.50	0.60
Fuel economy elasticity	0.25	0.20

Source: See text and online appendix B for documentation.

Resultado Parry y Strand (2012)

4. Corrective fuel tax calculations

4.1. Benchmark results

The top half of table 2 presents the corrective tax calculations under our benchmark parameter assumptions.

4.1.1. Gasoline tax

The corrective gasoline tax is $2.35 per gallon, which is 60 per cent larger than the rate prevailing in 2006. Traffic accidents account for 40 per cent of the tax, congestion 27 per cent, local tailpipe emissions 26 per cent, and global warming 8 per cent.

This corrective tax estimate is higher than comparable estimates for the United States (e.g., Parry and Small, 2005). At first glance, this seems surprising given the lower valuation of health risks and travel time in Chile. However, one offsetting factor is that accident externalities are much larger in Chile, due to the much higher incidence of pedestrian/cyclist fatalities. In addition, despite the lower VOT in Chile, our nationwide figure for marginal congestion costs is comparable to that in US studies, because a larger share of nationwide driving occurs under highly congested conditions (in Santiago). Similarly, although the assumed VSL for Chile is lower, the (nationwide) pollution-mortality rate is greater, given the large share of the population residing in Santiago and therefore being exposed to elevated risks. Yet another factor is that the assumed miles per gallon is larger in Chile than the United States. This implies a greater reduction in mileage

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The external costs of private versus public road transport in the Metropolitan Area of Santiago, Chile

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Marginal external cost of motoring
Value of time
Value of life and limb

ABSTRACT

We estimate marginal external costs per kilometer for car and bus in the Metropolitan Area of Santiago, Chile, in terms of congestion, road damage, accidents, air pollution and noise. Estimates are provided for both peak and off-peak periods. To carry out our analysis, we collected and integrated the output of several local studies. These estimates should contribute to a better debate on how to manage efficiently motor vehicles externalities by means of both (pigouvian) tax instruments, public transport subsidies and regulation. We also offer a comparison of our results with those reported in the literature.

At peak times, marginal external costs per kilometer for petrol cars, diesel cars and buses are estimated at USD 0.51, USD 0.53 and USD 1.80 respectively. When these values are converted to passenger-kilometer, petrol cars, diesel cars and buses impose a marginal external cost of USD 0.41, USD 0.42 and USD 0.04 respectively. At off-peak times, all these values are reduced as congestion decreases significantly. The marginal external cost for petrol cars, diesel cars and buses are USD 0.15, USD 0.16 and USD 0.78 respectively. Differences in marginal external costs per passenger-kilometer between cars and buses shrink as these costs fall to USD 0.12, USD 0.13 and USD 0.05 for petrol car, diesel car and bus respectively.

Table 6
Marginal external costs per kilometer in Metropolitan Santiago (USD cents).

Study	Period	Vehicle type	Congestion	Road damage	Accidents	$PM_{2.5}$	O_3	CO2	Noise	Total marginal external costs		
										Median	10th percentile	90th percentile
Our study	Peak	Passenger Car (PC) - Petrol (<2.5 t)	44.9	0.0	2.0	2.6	0.4	0.1	0.4	50.9	33.0	72.8
		Passenger Car (PC) - Diesel (<2.5 t)	44.9	0.0	2.0	3.5	0.9	0.1	0.4	52.6	34.3	74.4
		Urban Bus – Rigid	123.8	3.8	5.5	23.3	15.3	0.7	4.2	179.6	123.2	244.6
	Off-peak	Passenger Car (PC) - Petrol (<2.5 t)	9.4	0.0	2.0	2.6	0.4	0.1	0.4	15.3	10.3	20.8
		Passenger Car (PC) - Diesel (<2.5 t)	9.4	0.0	2.0	3.3	0.8	0.1	0.4	16.4	10.9	22.5
		Urban Bus – Rigid	26.9	3.8	5.5	21.1	13.8	0.7	4.2	78.3	48.8	109.2
Parry and Strand (2012)	Peak	Passenger Car (PC) - Petrol (<2.5 t)	7.8	0.0	7.3	3.9	0.7	0.5	–	20.5	14.6	26.8
		Passenger Car (PC) - Diesel (<2.5 t)	7.8	0.0	7.3	5.3	1.4	0.4	–	22.5	15.7	30.0
		Urban Bus – Rigid	21.5	3.8	15.1	35.4	23.1	2.6	–	104.0	68.3	145.4
	Off-peak	Passenger Car (PC) - Petrol (<2.5 t)	3.7	0.0	7.3	3.9	0.6	0.4	–	16.3	10.6	22.2
		Passenger Car (PC) - Diesel (<2.5 t)	3.7	0.0	7.3	5.0	1.2	0.4	–	18.0	11.6	24.9
		Urban Bus – Rigid	10.6	3.8	15.1	32.2	20.8	2.5	–	87.1	54.7	124.7

'<2.5 t' stands for vehicles of weight less than 2.5 tons; '$PM_{2.5}$' stands for particulate matter of diameter less than 2.5 μm; 'O_3' stands for ozone.
All USD cent values are from 2015.
The upper panel of this table presents the values reported in this study. The lower panel reports the Parry and Strand (2012) results under the assumption explained in Section 9.

Rizzi y de la Maza (2017)

Estimación costos externos tráfico Unión Europea

Update of the Handbook on External Costs of Transport

Final Report

Report for the European Commission:

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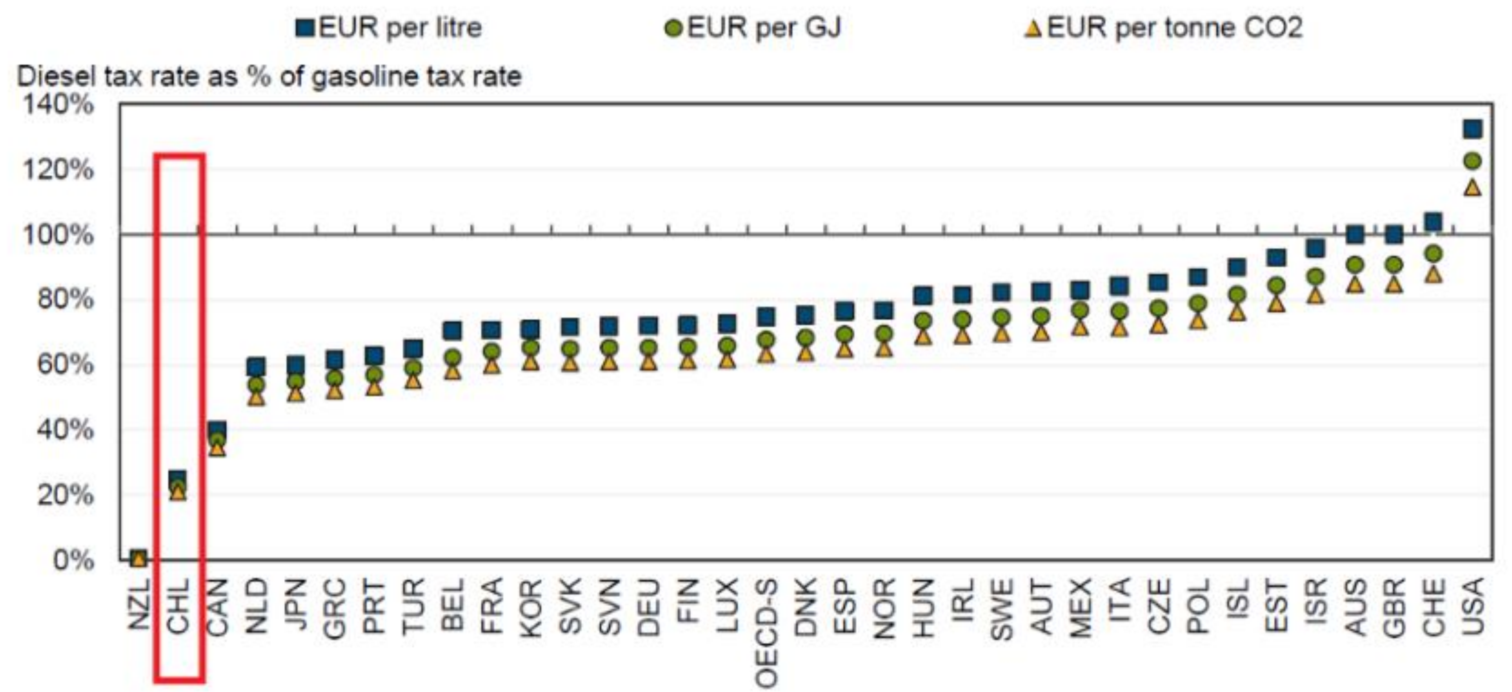
¿Se justifica que el impuesto al diésel sea menor que el impuesto a la gasolina?



Source: OECD calculations, based on data taken from *Taxing Energy Use* (OECD, 2013). Tax rates are as of 1 April 2012 (except 1 July 2012 for Australia). Figures for Canada and the United States include only federal taxes. OECD-S is the simple OECD average; OECD-W is the weighted OECD average.

Tasa de impuesto al diésel como porcentaje de la tasa del impuesto a la gasolina (En Chile: 25%). Fuente: Harding (2014)

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