Energy Policies in the Transportation Sector

by

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Abstract

Transport is the sector with the highest final energy consumption and, without any significant policy changes, is forecast to remain so (IEA, 2010). Energy use could increase as much as 70% by 2050 if no further policies are adopted in support of efficiency, alternative vehicles/fuels and modal shifting. (IEA, 2012). The objective of this paper is to review and classify energy efficiency policies mechanisms in selected countries for the transportation sector. It also suggests a new approach for these policies. Energy efficiency innitiatives is expected to improve from 5% to 34% worldwide. Those policies are normally isolated and non-coordinated actions. Energy policies for the transportation sector should be part of a broader agenda, which includes policies envisaging basic R&D and commercial implementation of transportation technologies and mode change. Transportation companies, policymakers and academia should make an effort work closely together to build a future agenda to achieve better results in the low carbon economy.

Keywords: energy policy, transportation, energy efficiency

Introduction

Although some authors question the veracity of anthropogenic influences on climate change, the first part of the Intergovernmental Panel on Climate Change (IPCC's) fifth assessment report says scientists are 95% certain that humans have been the "dominant cause" of global warming since the 1950s. Transport is the sector with the highest final energy consumption and, without any significant policy changes, is forecast to remain so (IEA, 2010). Energy use could increase as much as 70% by 2050 if no further policies are adopted in support of efficiency, alternative vehicles/fuels and modal shifting. (IEA, 2012). Different policy mechanisms were used by policymakers to promote energy technologies worldwide in recent years, considering both technology-neutral and technology-specific approaches. In the technology-neutral approach, policymakers set up the goal of a policy without picking a specific technology to promote. Although plenty of transportation energy policies were launched in the two last decade around the world, a more coordinated action is needed to improve energy efficiency in the transportation sector. The sector comprises both passenger and freight modes. The passenger modes include light-duty cars and trucks, buses, 2- and 3-wheel vehicles, airplanes, and passenger trains. The freight modes, which are used in the movement of raw, intermediate, and finished goods to consumers, include trucks (heavy-, medium-, and light-duty), marine vessels (international and domestic), rail, and pipelines (EIA, 2017).

The subject of this paper addresses the beginning of a three year project. The general objective of this project is to develop a macroeconomic model, based on econometric relations and highlighting the energy sector, to simulate the impacts in the state of Brazilian economic activity, employment, energy supply and consumption and CO_2 emissions of current and possible future public policies. The project intends to evaluate the importance, effectiveness, and efficiency of energy policies in the transportation sector in Brazil. The objectives of this paper are to review and classify energy efficiency policies mechanisms in selected countries for the transportation sector. It also suggests a new approach for these policies.

Methodology

Energy policy for transportation in selected countries are classified into different policy mechanisms. The four known criteria of technology-push, demand-pull, market incentives and command-and-control were aggregated into four quadrants (de Mello Santana, 2017). This classification was made to clarify these policy mechanisms to help policymakers better design and deploy energy policy mechanisms. The first category is called technology-control, where policies are technology-push and command-and-control type because they have the potential to reduce private costs and are mandatory. The second is called market-control policy, where policies are demand-pull and command-and-control type because they have the potential to increase private profits and are mandatory. The third is called open market policies, where policies are demand-pull and market-incentive type because they have the potential to increase private profits and are not mandatory. The last category is called techno-economic, and they are technology-push and market-incentive because they have the potential to reduce private costs and are not mandatory.

Energy policy mechanisms: a new approach for policymakers

Different policy mechanisms were used by policymakers to promote energy technologies worldwide in recent years, considering both technology-neutral and technology-specific approaches. In the technology-neutral approach, policymakers set up the goal of a policy without picking a specific technology to promote. Cap-and-trade policy is a good example, where governments set up emission limits rather than dictate technologies. Technology-specific approaches pick one or more technologies to promote though specific policy mechanisms. The Wind Production Tax Credit (PTC), a part of the Energy Policy Act of 1992 in the U.S., is an example of a technology specific approach.

A technology-push perspective indicates the key role that science and technology play in developing technological innovations and adapting to the changing characteristics of the industry structure. A demand-pull approach identifies a broader set of market features, including characteristics of the end market (particularly, the users) and the economy as a whole, that affects the performance of innovation (Stefanoa, Gambardellab, & Veronab, 2012).

The literature also classifies energy policy mechanisms in terms of command-and-control or market incentive policies. Command-and-control is direct regulation in which governments set a mandatory regulation that the market must follow. Although those policies typically have a high impact effect, they are usually costly because of regulatory enforcement and market opposition. Market incentives are policies designed to incentivize the market to develop or provide a good or service. Changes are not mandatory, which makes these policies more easily accepted by the market, but these policies are normally less effective than a command-and-control policy portfolio. Demand-pull policies target increases in private profits, while technology-push policies reduce private costs (Nemet G. F., 2009). Command-and-control policies contain mandates, while market incentives are voluntary. Unfortunately, the literature doesn't combine these mechanisms.

Based on these policy mechanisms classifications, de Mello Santana (2017) classified the mechanisms into four categories, using the four criteria of technology-push, demand-pull, market incentives and command-and-control. The first category is called technology-control, where policies are technology-push and command-and-control type because they have the potential to reduce private costs and are mandatory. The second is called market-control policy, where policies are demand-pull and command-and-control type because they have the potential to increase private profits and are mandatory. The third is called open market policies, where policies are demand-pull and market-incentive type because they have the potential to increase private profits and are not mandatory. The last category is called techno-economic, and they are technology-push and market-incentive because they have the potential to reduce private costs and are not mandatory. Figure 1 illustrate this classification of energy policy mechanisms.

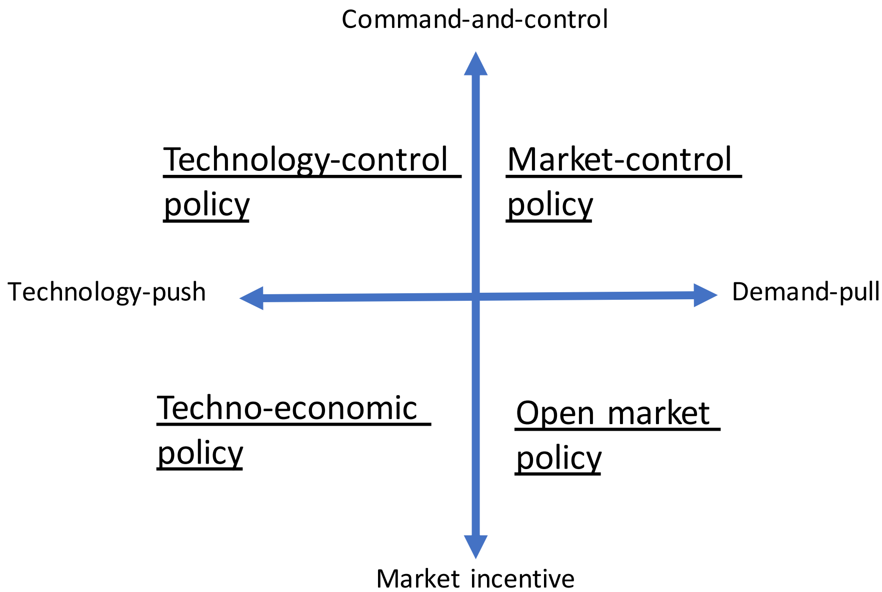

Figure 1: Classification of energy policy mechanisms

Energy Policies in the Transportantion Sector

To tackle the emissions problem and to address other issues as oil security and technology innovations, many countries have introduced mandatory or voluntary measures to reduce vehicle's fuel consumption and its related CO_2 emissions. Mandatory standards can be effective mechanisms for limiting or promoting specified energy technologies (Shi, 2014; Gabe, 2016). However, a higher level of regulatory enforcement is required to monitor direct government investments and mandatory standards when these policy mechanisms are set up. In the other hand, voluntary standards are used to incentivize the market to adopt best energy technologies and practices.

While voluntary measures have a non-binding nature, wherewith automakers can choose whether they will or will not to commit with fuel economy measures, in mandatory measures the automakers are to required participate in fuel economy programs and comply with a set of regulations to reach fuel economy targets. Examples of measures are (mandatory or) voluntary fuel economy standards, (mandatory or) voluntary emissions standards, and (mandatory or) voluntary labeling. Generally, these measures are implemented in association with other mechanism such as vehicle taxation and charges connected to emissions performance, fiscal incentives to automakers, incentives for fuel efficient and low emissions vehicles such as hybrid electric vehicles (HEVs). These measures also can include rewards and/or penalties if the agreements are not fulfilled (IEA, 2008; Onoda, 2008; Wagner and Wang, 2009; IEA; 2011; Cheah and Heywood, 2011; Atabani *et al*., 2011; IEA, 2012).

Voluntary measures are easier to implement and therefore have been adopted in most countries. However, voluntary agreements between governments and automakers have shown less effective results considering fuel economy targets (Feng An and Sauer, 2004; Onoda, 2008; Oliver, 2009; ICCT, 2015; GFEI, 2016). In fact, the European Union and countries as Japan, China, South Korea, Canada, USA and Mexico switched to mandatory systems, which have already produced larger results in terms of controlling fuel demand and reduction of carbon emissions (Wadud, 2014; ICCT, 2015; GFEI, 2016), even though the success of these mechanisms seems to be dependent on how the policies are designed (IEA, 2008; Atabani *et al*., 2011).

Nine world regions have adopted policies requiring vehicle manufacturers to improve the energy efficiency of new light-duty vehicles (LDV); in 2013, over 80% of global new passenger car sales were subject to such regulations (ICCT, 2014). Four regions—Japan, US, Canada, and China—have adopted GHG or efficiency standards for heavy-duty vehicles (HDVs), (ICCT, 2014). The International Maritime Organization (IMO) has adopted efficiency standards for new international marine vessels, moreover the International Civil Aviation Organization (ICAO) has not yet adopted energy efficiency standards for aircraft (ICCT, 2014).

Classification and Prospects of Energy Policies in the Transportation Sector

Tha main energy policies implemented in the world for light-duty, heavy-duty vehicles, marine, rail and aviation found in literature are: fuel efficiency standards, fuel efficiency tires, low carbon fuels, low sulfur fuels, technology transfer, direct investments in mode change, credit incentives, tax credit, fuel consumption labels, information campaign, eco-driving and fuel efficiency standards for LDV and HDV.

Figure 2 shows the main energy policies implemented in the transportation sector around the world, classified according de Mello Santana (2017) criteria. Technology tranfer is classified as technology-control policy. Direct investments, credit incentives and tax credit are techno-economic policy. Fuel-efficient tires, low carbon/sulfur fuels are market-control policy. Furthermore, fuel consumption labels, information campaign and eco-driving are usualy open-market policy. Fuel efficiency standards for HDV and HDV is usually voluntary at the beginning (open-market policy approach), but in some cases it evolves into a mandatory policy (market-control policy).

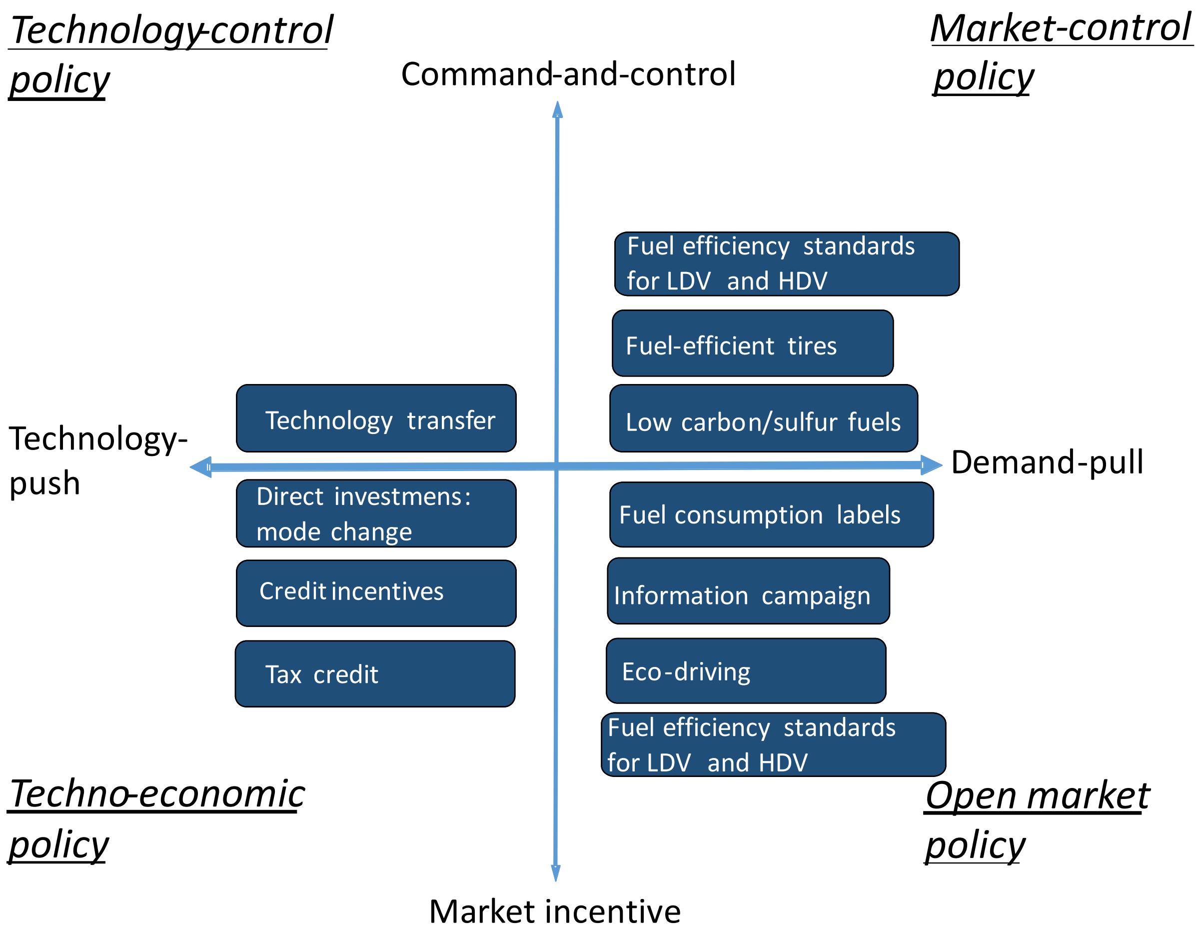

Figure 2: Classification of energy policies implemented in the transportation sector around the world

Table 1 shows some of these policy mechanisms, the countries and the estimated energy savings according to literature review. These energy policies should be designed and implemented together to achieve better results. However, they are normally isolated and non-coordinated actions. Those policies should be part of a broader agenda, which includes policies envisaging basic R&D and commercial implementation of transportation technologies and mode change. Transportation companies, policymakers and academia should make an effort work closely together to in most cases to build a future agenda to achieve better results in the low carbon economy.

Table 1: Energy policies in several countries and the estimated energy savings expected
Source: adapted from ICCT (2014), IEA, 2008; Onoda, 2008; Wagner and Wang, 2009; IEA; 2011; Cheah and Heywood, 2011; Atabani et al., 2011; IEA, 2012.

Policies	Countries	Estimated energy savings
Fuel-efficient tyres	European Union, Canada, United States and Japan	5%
Fuel efficiency standards for LDV	Canada, European Union, South Korea, China, Brazil, United States, India, Russia, Japan, Mexico and Saudi Arabia	12 - 34%
Fuel efficiency standards for HDV	Japan, China, United Stated, Canada, South Korea, Russia, European Union	11 - 14%
Low carbon/sulfur fuels	United States, Brazil, China	10% carbon and 10-50 ppm limit sulfur content
Tax credit	Brazil	12-19%
Direct investments	China and Japan	2-14%

Concerning the fuel-efficient tyres, the importance of this policy lays on the significant quantity of motor vehicle's fuel consumption used to overcome rolling resistance of the tyres, about 20% (IEA, 2005). Additional fuel is required when tyres are underinflated. In most real-world driving conditions, tyres are underinflated compared to their optimum performance level. It is generally understood that it corresponds to an increase in energy consumption and CO_2 emissions of approximately 1% to 2.5% for passenger cars, and 1% for trucks (IEA, 2010). Tyre pressure monitoring systems are a valuable tool for both car safety and fuel economy purposes. The fitting of the best replacement tyres and the more effective maintenance of tyre pressures could save about 3% of the fuel used in LDVs (equivalent to around 70 Mtoe and 190 Mt CO_2 in the medium term worldwide).

Accordind to de Mello Santana (2017), fuel-efficient tyres mechanism is classified as a market-control policy, since it is mandatory by government and it increases private profits. In the absence of policy intervention, there would be very weak incentives for both manufacturers and consumers, because tyre inflation pressure in the real world and rolling resistance of replacement tyres are not subjected to current fuel economy standards. As a result, efficient measures for tyres are important complementary measures to fuel economy standards. United States, Europena Union, Canada and Japan have been successful in implementing fuel efficient tyres measures such as tyre pressure monitorying systems

(TPMS), low rolling resistance tyres and tyre labelling, reaching a estimated energy saving of 5% (IEA, 2010). To date, there are no fiscal incentives to complement the labelling schemes and incentivise the purchase of fuel-efficient tyres, which would improve market uptake.

Fuel economy of light-duty vehicles policy embraces mechanisms and programs to improve and accelerate the deployment of more fuel efficient vehicle technologies. The scope of policies is vast, going from voluntary programmes to strict mandatory regulations. It is difficult to compare the fuel economy standards between regions due to the difference in test measurement cycles, which means that each standard is based on different parameters such as vehicle speed, acceleration, load, etc (IEA, 2010). However, it is interesting to see the recent developments in most countries, which have tightened fuel economy and CO_2 emissions standards for passenger cars. Therefore, although different regions have different starting points in terms of current fleet average fuel economy, all regions are tightening standards by relatively similar amounts.

National efficiency standards for HDVs have a much briefer regulatory history than LDV standards. Compared to passenger vehicle regulations, heavy-duty vehicle fuel economy standards are at a much earlier stage of development, since setting HDV efficiency standards is significantly more challenging than for LDVs. Firstly, it is difficult and costly to measure heavy-duty vehicle emissions due to the size of the test equipment required and the number of model variations available on the market for each vehicle type; and secondly, heavy-duty vehicles were until recently considered to be part of commercial operations where the technology had already been optimised for fuel efficiency to reduce operating costs. Both of these issues are now being addressed. Only four governments—the US, Canada, China, and Japan— have adopted HDV fuel economy standards, and those markets account for only about one-quarter of world truck sales (ICCT, 2015).

According to 2008 IEA study, voluntary fuel economy measures have not being successful in achieving their targets, encouranging coutries such as Korea, Japan, EU and Canada to move from voluntary to mandatory LDV standards programmes in recent times. Following de Melo Santana (2007) approach, fuel efficiency standards for ligh and duty vehicles can be either a market control-policy or an open-market policy, since it has the potential to increases private profits and can be mandatory or voluntary, respectively. Although market incentive policies are more easily accepted by the market, those policies are normally less effective than a command-and-control policy portfolio because they are not mandatory. However, because binding policies are usually costly due regulatory enforcement and market opposition, they are harder to implement and therefore have been less adopted by countries.

Internationally, most major economies regulate their vehicle markets with some type of vehicle tailpipe emissions and fuel economy standards. There have been a number of significant low-carbon fuel policy developments in recent years. United States, Brazil and China are example of countries that have established policies to stimulate increase and improvement of low-carbon fuels. As a result of the relatively early nature of global low-carbon policies, the estimated energy savings are based on limited scenarios for the potential GHG reductions that could result from such policies. The technical potential scenario considers a 10% reduction in the lifecycle GHG intensity of on-road fuels between 2020-2030 (ICCT, 2014).

Reducing the sulfur content of diesel and gasoline is also a key to supporting the introduction of advanced vehicle emission controls. Limiting the sulfur content of on-road gasoline and diesel to a maximum of 10 to 15 ppm (ultralow-sulfur) is an essential component of best-practice vehicle emissions control programs in both fuel-importing and fuel-producing countries (ICCT,2014). Such improvements provide immediate emission benefits from the existing vehicle fleet and enable the progression of emission standards.

Another energy policy type analysed in this paper is tax credit. In line with de Melo Santana (2017), this mechanism is classified as a techno-conomic policy, since it is technology-push and market incentive because it has the potential to reduce private costs and are not mandatory. By reducing private costs it stimulates technology innovation in energy sector. Brazil is an example of country that have implemented a consolidated tax credit programme that has an estimated energy saving of 12% to 19%.

In October 2012, the Brazilian government approved "Inovar-Auto," a progamme to encourage vehicle technology innovation. The program fosters industry competitiveness by encouraging automakers to produce more efficient, safe, and technology-advanced vehicles while investing in the national automotive industry. Inovar-Auto provides incentives in two ways. It first increases a tax on industrialized products (IPI) by 30 percent for all light-duty vehicles (LDVs) and light commercial vehicles (LCVs). Second, it imposes a series of requirements for automakers to qualify for up to 30 percent discount in the IPI (portuguese abbreviation for Taxes on Industrialized Products). In other words, IPI taxes will remain unchanged for those manufacturers that meet the requirements, thus incentivizing investments in vehicle efficiency, national production, research and development (R&D), and automotive technology. The program is limited to vehicles manufactured between 2013 and 2017, after which IPI rates return to pre-2013 levels unless modifications to the decree are made (ICCT, 2013).

Finally, direct investment is one of the most used policy mechanism to promote clean energy technologies. This mechanism is technology-push and market incentive, because it reduces private costs and it is not mandatory, therefore it is classified as techno-economic policy by de Mello Santana (2017). Direct government investments provide grands to demonstrate or deploy clean energy technologies. Full grants are usually provided to demonstration plants, and cost sharing is used to promote commercial deployment facilities. In the commercial deployment case, the share amount is usually given so the investment is feasible to investors, according to with to de Mello Santada (2017). China and Japan are exemple of countries that have successfully adopted direct government investments in the energy sector, expecting a estimated energy saving between 2 and 14%.The effectiveness of this policy mechanism is usually high because it can make a technology economically feasible, depending only on the amount of investiment provided.

Energy demand forecasting model for the transportation sector

Modelling energy consumption for the transportation sector in the long term will consider ruptures that is likely to happen in the upcoming decades due to efficiency improvements, mode and fuel changes. Econometric relations in the project will provide a baseline scenario for the transportation sector to simulate these ruptures. Value added, passenger.km, mode of transportation, unit fuel/electricity consumption are commonly used as independent variables for passenger transportation. Gross domestic product, tones.km, mode of transportation, unit fuel/electricity consumption are normally used in freight transportation. Sectoral disaggregation will be used to simulate different scenarios in mode, fuel and efficiency changes. Equations 1 and 2 show the sectoral disaggregation models that will be used in both passenger and freight transportation, respectively.

$$\frac{CE_{j,i}}{VA_i} = \frac{PKM_i}{VA_i} \bullet \frac{CE_i}{PKM_i} \bullet \frac{CE_{j,i}}{CE_i}$$ equation 1

$$\frac{CE_{j,i}}{VA_i} = \frac{TKM_i}{VA_i} \bullet \frac{CE_i}{TKM_i} \bullet \frac{CE_{j,i}}{CE_i}$$ equation 2

Where,

j: fuel type/electricity
i: transportation category
CE: energy consumption
VA: value added
PKM: passengers . km
TKM: tones . km

Conclusions

The main energy policies implemented in the transportation sector around the world were classified according to de Mello Santana (2017) and detailed in Table 1. Those policies are designed to improve the efficiency of the transportation sector. However, they are normally isolated and actions that are not coordinated. Those policies should be part of a broader agenda, which includes policies envisaging basic R&D and commercial implementation of transportation technologies and mode change. Transportation companies, policymakers and academia should make an effort work closely together to build a future agenda to achieve better results in the low carbon economy.

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