Comparing Energy Efficiency of drivers and vehicles using Data Envelopment Analysis

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Abstract

In this paper, we propose a new methodology to compare and promote efficient driving by providing feedback to the user. The proposed methodology uses Data Envelopment Analysis (DEA) to enable comparisons between drivers and vehicles, by including parameters retrieved from vehicle as inputs or output for DEA method.
Providing feedback to the user is essential in driving eco-systems for changing bad driving habits and not returning back to driving bad-habits. In our case, feedback is provided once the driver has finished some routes, by proposing which corrections or improvement has to deal with for future trips. The required vehicle's telemetry data is obtained through the OBD2 port using an OBD2 adapter.

1 Introduction

The driving style is has a direct effect on the energy consumption of vehicles. The more aggressive a driver is the more waste of energy makes. Energy-saving behaviors include: not exceeding driver speed limits, accelerating and decelerating smoothly, using appropriate gears depending on speed, and keeping constant speeds. These behaviors among others provide a positive contribution in saving fuel and reducing greenhouse gas emissions, up to 25% of fuel could be saved [1] [2]. Moreover, other benefits include improving comfort, reducing risks and increasing the life of vehicle components.

Motivation drivers to change driving style is crucial, but before automated systems should be able to detect these behaviors and compare drivers each other.
Smart cities should provide its citizens of smart information about their behaviors and the behaviors of the rest of the citizens, analyzing data in any form, from any source, merging the more information the better.
In this sense, authors propose the creation of Ranks for comparing citizens' efficiency in several fields such us residential environments, offices and buildings and of course travelling. Among others Ranks, we present in this paper a rank of drivers using their own vehicles by applying DEA to datasets including the parameters meaningful when analyzing driving and drivers efficiency.

2 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a nonparametric method to provide a relative efficiency assessment (called DEA efficient) for a group of decision-making units (DMU) or for productive efficiency (aka technical efficiency) with a multiple number of inputs and outputs. DEA was first proposed in 1978 [Charnes, 1978] and is commonly used in operations research and economics to empirically measure productive efficiency of DMUs. In order to determine whether a DMU is efficient is as easy as checking if the DMU is on the "frontier" of the production possibility set. In this way, DEA identifies a "frontier" on which the relative performance of all utilities in the sample can be compared.
In recent years, a great variety of applications of DEA have appeared for the evaluation of the performances of many kinds of entities engaged in various contexts. DEA is especially useful when examining the nature of complex (often unknown) relations between multiple inputs and multiple outputs. DEA has been used both in private [Emrouznejad, 2008], [Eilat, 2008], [Amirteimoori, 2012], [Chian, 2010] and in public contexts [Gonzalez-Rodriguez, 2010], [Afonso, 2010].
Regarding energy efficiency studies, DEA is commonly applied for the study and comparison of the performance and efficiency of energy industries, above all in the electricity industry, see [Weyman-Jones, 1991], [Pombo, 2006], [Vaninsky, 2006], [Perez-Reyes, 2009] and [Tovar, 2011]. More recently, it has also been applied to IT companies in [Serrano-cinca, 2005] and [Fernández-Montes, 2012]. Recently, it has also been popularized in environmental performance measurement due to its empirical applicability.

In this work, DEA is used as a method to compare energy-consumption efficiency between each various drivers and between various vehicles, where productive efficiency is measured as the energy consumed to make some trips.

3 Inputs and outputs selected

DEA study can be done under two models: CRS and VRS. CRS assumes that the relation between inputs and outputs are constants. That means that relation between inputs and outputs is lineal and can be represented by a rect. On the other hand VRS assumes the relation between inputs and outputs is variable, which is a more realistic model.
Moreover DEA can be performed with three orientations: input oriented, output oriented and input-output oriented. Each of these orientations assumes that we are capable of modifying inputs, outputs or inputs and outputs respectively. Figure 1 shows orientations and models samples.

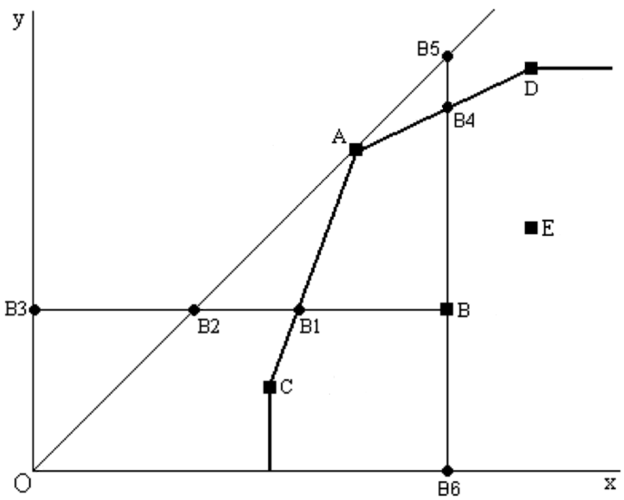

Figure 1: DEA models, orientations and frontiers

Once DEA is performed, it establishes the frontier whether the best efficient DMUs are, and less efficient DMUs has to tend to this frontier. In Figure 1, A belongs to the frontier for both models CRS and VRS. B should improve any inputs or outputs in order to be more efficienct. For example, in VRS, input oriented, it should decrease its inputs while maintaining its outputs in order to be projected in the frontier at B1 point.

In order to compare drivers and vehicles, about one hundred of trips where analyzed from the retrieving of parameters *sensed* by the car. Not every parameter should be taken into account for efficient study so the following parameters where selected:

- Inputs:
  - Number of hard accelerations (greater than 2.5 m/s^2)
  - Times a hard negative acceleration has been made (sharply breaks) (less than $-2.5 m/s^2$)
  - RPM. Revolutions per minute
  - PKI[1] (Relative cinetic power) which is computed by ($currentSpeed^2$-$previousSpeed^2$)/ space
  - Engine load
- Outputs
  - Average fuel consumption
  - Duration of the trip / consumption
  - Total time in movement

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[1] This depends on the number of times accelerations are made, the frequency and the measure of the acceleration. It is usually defined as the aggressiveness of the driver.

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