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# Benefits and costs of electric vehicles for the public finances: An integrated valuation model based on input–output analysis, with application to France

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## ABSTRACT

The development of electro-mobility, with electric vehicles (EVs) replacing conventional vehicles (CVs), raises issues relating to the environment, energy and industry. Within a given country, it would have an economic impact in many areas, in particular on governments. Our objective is to quantify the respective impacts on the public finances of an electrically powered or petrol fuelled private car.

In order to do this, we establish an integrated method of valuation, covering both manufacture and use of the vehicle, with location of these two stages within or outside the country concerned. From a “depth” perspective, it incorporates the economic proceeds from the different activities and what they consume, and from a “breadth” perspective it incorporates the fiscal effects (VAT, fuel and energy taxes, tax on production, etc.) and the effects on social accounts (social contributions, unemployment benefits). The valuation method is based on an input–output model of the productive economy within a country, combined with mechanisms of fiscal and social transfer. We hypothesize an additional type of activity for the Manufacture of electric vehicles, and we model it within the intersectorial matrix associated with production.

Application of the method to France reveals first that the impact of a vehicle on the public finances is substantial: manufacture contributes approximately the purchase price excluding VAT, and usage adds an amount of the same order of magnitude. The vast majority of the revenues (approximately 70%) arise from the social contributions associated with production, including the opportunity value of employment; VAT accounts for almost 20%, tax on production around 5%, and energy taxes 9% for a CV vehicle or 1% for an EV. Then, four cases for substitution of EV to CV are set up and assessed, depending on the places either domestic or foreign in which the vehicle is manufactured and used, respectively. In the base case, where the vehicle is both manufactured and used inside the country, substituting an EV to a CV would be financially neutral for public finances – at least before any purchase incentive bonus. The export case, where an EV is substituted to a CV in domestic production but then exported and hence used outside the country, yields an additional revenue of about €8000 to the domestic public finances (without bonus); the import case has an opposite effect. Lastly, the twofold substitution of an imported EV to a domestically manufactured CV for domestic use would entail a loss of about €20,000 (without bonus). Therefore, for France the purchase incentive bonus can be justified mainly by the stakes of energy independence and domestic industry at the national scale or of environmental quality at the urban scale.

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## 1. Introduction

### 1.1. Background

Plans for the industrial development and distribution of electric vehicles (EVs) have recently come to the forefront of transport policies both in developed countries<sup>1</sup> and in fast developing

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<sup>1</sup> United States, Japan, Germany, France, United Kingdom, Italy, Spain, Denmark, etc.

countries (China). The reason for this is the reduced environmental impact of such vehicles compared with internal combustion engine vehicles (CVs for Conventional Vehicles): at global level, fewer greenhouse gas emissions if the electricity comes from low carbon sources, and at local level reductions in traffic pollution and noise for improved quality of life. In a recent paper (Leurent & Windisch, 2011), we showed that national policies to promote the use of electric vehicles are uniform in terms of the environmental claims they make and their scenarios for the diffusion of the electric car, entailing a three stages process: first, mass orders for large corporate fleets, then an extension to taxi fleets and public transport services (e.g. shared car systems), and finally a general diffusion to private households. There are some differences between national policies depending on their specific industrial and energy priorities, which affect the composition of the policy as a particular package of instruments focussing on supply (R&D, industrial support) and those focussing on demand (subsidies for ownership and use, rollout of a battery charging infrastructure); the procurement consortium is a hybrid approach which aims to generate economies of scale on the supply side and reduce prices on the demand side.

Handful of existing economic studies of electro-mobility deal with costs to the user, as a means of deciding which target group to concentrate on in supportive policies.<sup>2</sup> As far as we know, there has been no analysis so far of the overall effects on public finances. In order to shift from the economic impact on the user to that on the public finances, we have to consider the economic impacts on the other parties concerned – in particular transport providers in a broad sense (including car-makers and their suppliers as well as the providers of car-related services) and central government.

## 1.2. Objective

Our objective is to evaluate the financial consequences, for the public finances, of replacing an internal combustion vehicle (CV) with an electric vehicle (EV). These financial consequences are of different kinds: a specific policy to promote electric cars is only the tip of the iceberg; we want to show the hidden part, which includes industrial and fiscal factors as well as social transfers. Industrial factors are here taken in their broad sense, referring to the various activities involved in production, in particular manufacturing and energy production, both in the construction of a vehicle and in the provision of products and services throughout its operating life.

The industrial aspects have economic and social implications for employment, and therefore for salaries, for social contributions by employers and employees and for workers' incomes. We include these social accounts, along with unemployment benefits, in the accounts of the government that sustains them. Moreover, the value added by economic production is taxable and generates tax revenues, both on the consumption side (VAT) and on the production side (various taxes on production). Finally, energy (in particular fuel, but also electricity) is subject to specific taxes, similar in nature to public subsidies for electric vehicles, although the direction of the financial transfers is the opposite.

Obviously, all these effects relate to a particular country, with its own system of production and economic, social and fiscal arrangements at any given time, and also its own local pattern of vehicle use. Slightly less obvious but equally real, in geographical terms the territory defines a *domestic* authority, by contrast with the space beyond. Location is important: in principle, local production is more favourable to domestic governments than imports;

the use of the vehicle, whether domestic or external, also needs to be spatially defined.

We provide generally applicable principles and a methodology of financial valuation, and we apply them to the specific case of the private car in France, taking the year 2007 as our baseline.

## 1.3. Method: vertical economic valuation

We evaluate the replacement of a CV by an EV over their whole life-cycle, considering first the manufacture and then the use of the vehicle and the associated consumption. Usage is quantified by vehicle type (segment B) and annual mileage, which determine the attractiveness of the EV for a candidate owner (Windisch, 2011). We evaluate the industrial aspects for each type of vehicle using an input–output model for production in the country. This model describes production, external trade and consumption for each type of activity. For consumption, we make a distinction between final demand by households and public bodies, final demand by companies for capital goods (capital and depreciation) and intermediate consumption arising from production, specified for each production activity. We adapt the input–output model to the composition and specific consumption requirements of an EV. We also use the production accounts and employment statistics for each type of activity, in order to evaluate the fiscal effects and those on social accounts.

Our evaluation is therefore situated within the general framework of economic and social activity, incorporating direct and indirect economic effects. We go beyond the conventional framework of transport economics (e.g. Quinet, 1998), which focuses exclusively on transport services, by including industrial aspects and social transfers: the major effect is to revisit the notion of cost to a consumer, by identifying the part of this cost that constitutes revenue for a supplier and is therefore no dead loss per se in a wider system. Furthermore, our evaluation is sensitive to location: the “public authority” is an actor located within a geographical space, which determines its situation with respect to social, economic, industrial and energy factors.

## 1.4. Related work in I–O analysis

The input–output (I–O) model of an intersectorial economy was crafted by Leontief to analyze the structure of the American economy (Leontief, 1936). It was then extended to multiple regions by Isard (1951) in order to include the regional location of economic activities and the interregional trade. I–O analysis has become a basic tool in national accountancy to depict the intersectorial linkages and the particular contribution of each activity sector to the economy of a nation or a region (e.g. Eurostat, 1999; Gregoir, 2008). As the outreach of an I–O table is essentially descriptive and static, I–O models have been replaced in many macroeconomic studies by more sophisticated models involving prices adjustments, microeconomic behaviours and time lags in order to assess scenarios of industrial development and economic regulation: for instance the Mesange model for France (Klein & Simon, 2010). Yet I–O analysis is still used to perform first-round estimation of the macroeconomic effects of a sectorial policy (e.g. the multiplier effects of tourism expenditures on a regional economy in Frechtling & Horváth, 1999) or of catastrophic events such as an earthquake (Kim, Ham, & Boyce, 2002) or the Katrina landfall in Louisiana (Hallegatte, 2008): see (Wiedmann et al., 2007) for an overview of principles. Furthermore, in recent years I–O tables have been used in environmental economics in combination with models of environmental impacts in order to assess the land appropriation (ecological footprint, Hubacek & Giljum, 2003) or the carbon footprint (Minx et al., 2009) of the multiregional and intersectorial structure of the economy.

<sup>2</sup> Cf. BCG (2009), CGDD (2011), CE Delft (2011), Deutsche Bank (2009), Draper, Rodríguez, Kaminsky, Sidhu, and Tenderich (2009), Deutsche Bank (2011), ESMT (2011), Nemry and Brons (2011).

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