



# The dual-credit policy: Quantifying the policy impact on plug-in electric vehicle sales and industry profits in China<sup>☆</sup>



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## ABSTRACT

The *Passenger Cars Corporate Average Fuel Consumption and New Energy Vehicle Credit Regulation* (dual-credit policy) was enacted by the Chinese government in 2017 to stimulate the fuel-efficient and electrification technologies in the China's passenger vehicle market. This study summarizes the dual-credit policy and develops the New Energy and Oil Consumption Credits Model to quantify the impacts of this policy on consumer choices and industry profits, where internal subsidies as decision variables are used to represent industry responses to the policy. Scenarios in 2016–2020 are simulated and discussed. Key findings from the model results include: (1) the Corporate Average Fuel Consumption rules alone may stimulate more plug-in electric vehicle (PEV) sales than the dual-credit policy; however, (2) the dual-credit policy could stimulate more battery electric vehicles (BEVs) in market, compared to other policy scenarios; (3) the industry could “lose” approximately \$2122/vehicle by 2020 under the dual-credit policy; (4) battery electric sedans with a range greater than 250 km and plug-in hybrid SUVs could be popular under the dual-credit policy; (5) credit allocations for BEVs in the dual-credit policy can influence the PEV production; and (6) reduction of the fuel-efficient technology costs helps to minimize profit losses impacted by the policy.

## 1. Introduction

According to data provided by the China Automotive Technology and Research Center (CATARC), national annual vehicle sales have reached over 28.88 million units in 2017, reinforcing China's position as the world's largest vehicle market since 2009 (CATARC, 2018; Ou et al., 2017). The rapid growth of the Chinese vehicle market has a profound impact on economics, urban design, energy security, and greenhouse gas (GHG) emissions (Ou et al., 2018, 2011). Chai et al. estimated that the energy consumption of the transportation sector in China has reached 258 million tons of standard oil in 2013, almost double the consumption from 2000. In addition, the road traffic consumes 80% of energy in the transportation sector (Chai et al., 2017). At the same time, imported oil makes up more than 60% of the total oil consumption in China in 2015 (Jiao et al., 2017), and imported oil consumption is anticipated to be greater than 63% by 2020 and as high

as 76% of total oil consumption by 2035 (van Moerkerk and Crijns-Graus, 2016). The growing vehicle population and increasing dependence on foreign oil bring the Chinese government much pressure on the energy security. Another policy motivation for the Chinese government to intervene the vehicle market's technological trend is to mitigate vehicle emissions that contribute to the severe air quality in many metropolitan areas. The third policy driver is related to climate change. Han et al. anticipate that carbon emissions from the road transport sector will reach 6.6 billion tons in China by 2020, which are more than a six fold increase compared with 2014 emissions (Han et al., 2017).

Concerned with energy security and environmental impacts from rapid motorization, the Chinese government has long committed to promoting fuel-efficient technologies in conventional vehicles (CVs) and new energy vehicles (NEVs), which by the official definition include battery electric vehicles (BEVs), plug-in hybrid electric vehicles

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(PHEVs), and fuel cell vehicles (FCVs) (Ou et al., 2017). Since only a few units of FCVs have been sold for the demonstration project in China (Ou et al., 2017), FCVs are not considered in this study, thus NEV in this paper is an equivalent concept to the plug-in electric vehicle (PEV), which is frequently used in the United States (U.S.). In 2009, the Chinese government launched the PEV promotion program, *Ten Cities, Thousand Vehicles Demonstration*, as a component of the *Government Eleventh Five-Year Plan (2006–2010)* (Xu and Su, 2016). Since then, generous governmental subsidies and non-monetary incentives have been adopted to stimulate the demands for PEVs. The total PEV sales in the passenger vehicle segment from 2011 to 2016 were estimated at 616,689 units, which make China one of the largest PEV markets in the world (Block and Brooker, 2017). The excess subsidies brought enormous financial burdens to the government while had the PEV market rely more on government monetary incentives (Ou et al., 2017; Zhou et al., 2015). Therefore, the government has been gradually reducing its direct subsidies on PEV purchase (Ou et al., 2017).

Despite cutting its subsidies, the government is not turning its back on PEVs. In September 2017, a new policy, *Measures for Passenger Cars Corporate Average Fuel Consumption and New Energy Vehicle Credit Regulation* (dual-credit policy), was implemented to take effects starting in 2018 by the Ministry of Industry and Information Technology. To motivate production of the fuel-efficient and electrification technologies by using administrative penalties (as opposed to direct subsidies), China's dual-credit policy consists of two components: the Corporate Average Fuel Consumption credit (CAFC-credit) rules, which set targets for the production-weighted average fuel consumption rate for eligible vehicle manufacturers/importers, and the New Energy Vehicle credit (NEV-credit) rules, which stipulate credits by PEV type and require certain NEV credit quotas. In a sense, the policy can be viewed as combining some features of the Corporate Average Fuel Economy standards in the U.S. and the Zero Emission Vehicle (ZEV) Program in California.

Considering the enormity of the Chinese vehicle market and its design, the dual-credit policy is expected to have a vast influence on the vehicle market structure, company strategic plans, R&D investment, industrial profits, etc. Since the first draft release of the dual-credit policy in 2016, this policy has attracted a great deal of attentions from the stakeholders in the vehicle industry, institutional investors, and academic researchers all round the world, and has stimulated much discussion and public comments. Wang et al. suggested that the CAFC-credit rules should be separated from the NEV-credit rules in the dual-credit policy to avoid confusion to and abuse by vehicle manufacturers (Wang et al., 2017). Some believed that the dual-credit policy was implemented in haste (Wang, 2017). In response, the government postponed the full implementation of the dual-credit policy from the originally-planned 2018 to the year 2019. The current leading PEV automakers are predicted by (Yang et al., 2016) to benefit from the dual-credit policy. Several think tanks also published their opinions about this policy. The Economist Intelligence Unit predicted that the change of game rules in the Chinese vehicle market will affect the global carmakers that dominate the CV segment in China (Economist Intelligence Unit, 2017). iCET (Innovation Center for Energy and Transportation) also suggested the CAFC-credit rules and NEV-credit rules be mutually independent to avoid implementation complexity (iCET, 2016). Although these published studies offer diverse views, few have systematically and quantitatively analyzed this policy and its potential effect on the vehicle market in China.

By using the New Energy and Oil Consumption Credits (NEOCC) model, this study simulates and analyzes the impact of the dual-credit policy with consideration of alternative policy scenarios. The NEOCC model was funded by Aramco Services Company and developed by the Oak Ridge National Laboratory to simulate the vehicle industry's compliance responses under various vehicle policies and incentives. In contrast to other models commonly emphasizing the long-term effects (González Palencia et al., 2017), the NEOCC is more focused on the

short-term impacts of the dual-credit policy, which itself is for the short-term 2017–2020 period. It is certainly important to analyze the continuation and long-term effect of the policy, but that is outside the study scope. Instead, this study aims at addressing the following questions:

- How to calculate the CAFC credits and NEV credits according to the rules in the dual-credit policy?
- How will the vehicle market evolve when the industry complies with the dual-credit policy? What will the vehicle industry profits be under the dual-credit policy?
- Comparing to the CAFC-credit rules only or NEV-credit rules only, is the dual-credit policy the best option to motivate the PEV market?
- What types of PEVs will be more popular in 2016–2020 if the industry complies with the dual-credit policy?
- How will the industrial corporate average fuel consumption change from 2016 to 2020 under different vehicle policies?
- How will the fuel-efficient technology impact the market share of CVs and the industry profits under the dual-credit policy?

This paper consists of five sections. The first section presents the motivations and objectives of this study, and reviews the background and literature on the dual-credit policy. The second section presents the rules and credit calculation in the dual-credit policy. The third section clarifies the assumptions and methodology of the NEOCC model adopted for the policy analysis. Section four focuses on the scenarios analyses of the vehicle market with the implementation of different vehicle policies - the dual-credit policy, CAFC-credit only, and NEV-credit only, no-rules. This section also discusses the sensitivity analysis of fuel-consumption technology in CVs on the industry. The last section presents the conclusions in this study. In this paper, the yearly average currency exchange rate of \$ 1.0 USD = 6.910 CNY in 2016 is used (U.S. Internal Revenue Service, 2017). Besides, the calculated future monetary values in 2017–2020 are discounted to be the present values in 2016 by assuming the annual discount rate to be 4% (Investing.com, 2017).

## 2. Rules of the dual-credit policy

The dual-credit policy consists of two complementary parts: CAFC-credit rules, and NEV-credit rules. The CAFC-credit rules require that an auto firm's actual CAFC should be no larger than the target CAFC. The CAFC credits are calculated based on the difference between the actual CAFC and target CAFC. The NEV-credit rules require that the ratio of produced/imported PEVs to CVs in an auto firm should be no smaller than the required minimum ratio, and the NEV credits are calculated based on the difference between achieved NEV scores and the NEV minimum ratios. To avoid penalties, the original equipment manufacturers (OEMs) need to meet both the CAFC and NEV targets, starting in 2019. In 2018, OEMs only need to meet the CAFC targets.

In the CAFC-credit rules, an auto company's actual CAFC and target CAFC are calculated respectively in Eq. (1) and Eq. (2), which are based on the national standard - GB27999-2014.

$$CAFC = \frac{\sum_{i=1}^K FC_i \cdot V_i}{\sum_{i=1}^K V_i \cdot W_i} \quad (1)$$

$$CAFC_T = \frac{\sum_{i=1}^K FC_i \cdot V_i}{\sum_{i=1}^K V_i} \quad (2)$$

where,  $i$  is the car model;  $K$  is the quantity of the car models in an auto company;  $FC_i$  is the fuel consumption ( $L/100km$ ) of the car model  $i$ ;  $V_i$  is the production (or imports) of car model  $i$ ;  $W_i$  is the multiplier of the production (or imports) of car model  $i$  (intended to amplify the contribution of NEVs to CAFC compliance. E.g.,  $W_i$  is stipulated to be 3 for a BEV model, and 1 for a CV model in year 2018–2019 in the dual-credit policy, which results a larger denominator when calculating the

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