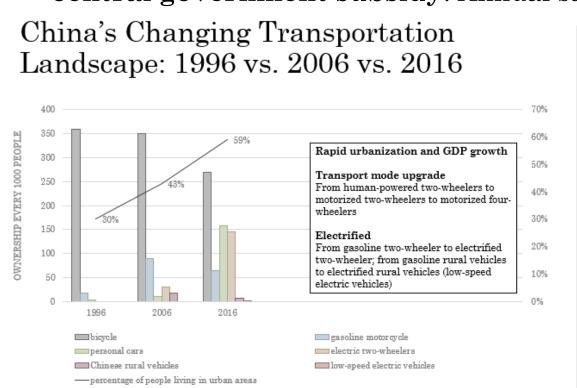
Overview and Total Cost Ownership Analysis of China's Low-speed Electric Vehicles

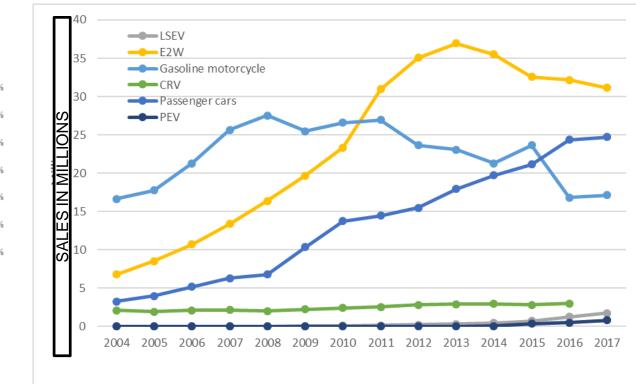
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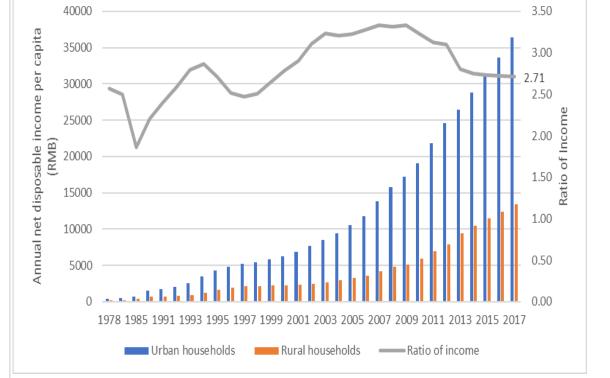
Research Question

Backgrounds

- China is in the process of rapid urbanization. Motor vehicle sales skyrocketed. Chinese government believes PEVs can solve oil dependency, air pollution and GHGs, as well as leapfrogging international automotive companies (Wang, 2017).
- Still 41% living in rural areas and in a need a transport tool upgrade from bike, e-bike, gasoline motorcycles, rural vehicles to fourwheeler cars. However, the **income gap** between urban and rural residents is growing. Aging population is a big issue in China.
- A new low-cost electrified four-wheeler vehicle emerged, and the market grows rapidly than subsidized PEV market even without central government subsidy. Annual sales of LSEVs are double of regular PEVs.







Top speed

Figure 1: China's Changing Transportation Landscape

Features of LSEV Markets

- Bottom-up, market driven, developed in low-tier cities, rural areas
- Local temporary regulations but no central support National regulation being discussed
- Frugal design, poor safety and quality (Chen, 2016)

Research Questions

- What's the present status of LSEV market?
- What is the cost benefit of LSEVs comparted to other replacement options?

Figure 3: Income and Income Ratio between Urban and Rural Areas Figure 2: Skyrocketed Motor Vehicle Sales in China However, Low-speed EVs sales boom without government supports



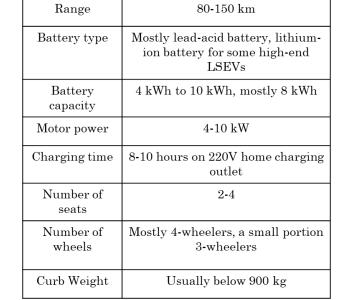


Figure 4: LSEV vs Subsidized PEV sales Figure 5: LSEV Specification (Chen, 2016) Source: PEV numbers from CAAM; LSEV numbers from CATARC and ResearchInChina

Overview of LSEV Market

1. Three categories of LSEVs and micro BEVs



Figure 6: Three Categories of LSEVs vs Micro BEVs

2. Optional adds-up

Air-conditioning, power-assisted steering or some safety equipment (such as ABS) are optional to consumers to reduce the vehicle cost. Optional adds-up include air conditioner (¥2,000, \$290), power steering (¥1,000, \$145), alloy wheels (¥500, \$73) Users can upgrade to range-extended LSEVs (equipped with a 200cc gasoline engine, price increase by \$145, range increase from 95 to 500km)

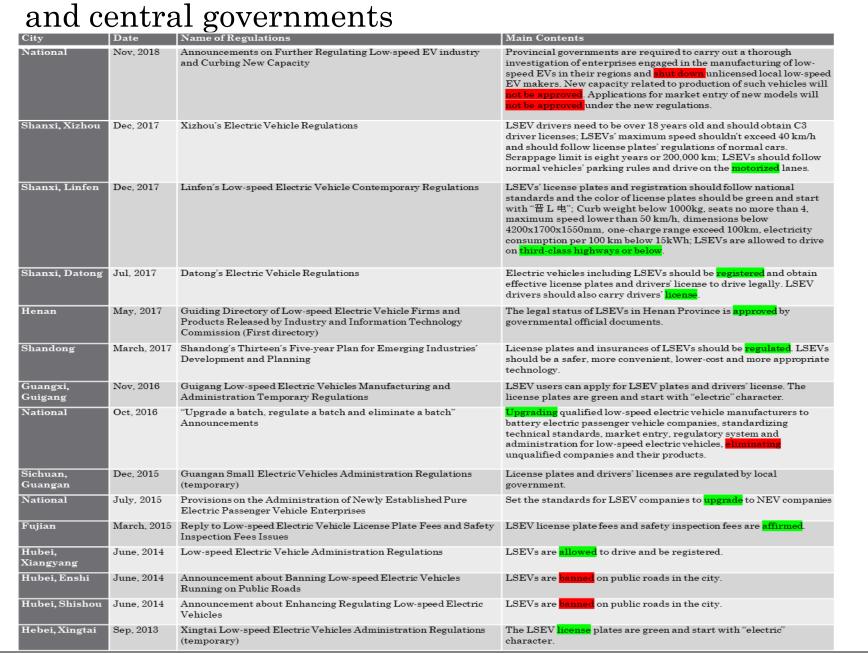
3. Born from Shandong, diffused to neighbor provinces. Sales in Shandong accounts for



4. Users include low-income, elder, women, young generation in rural areas and low-tier cities (Authors' selected interviews)

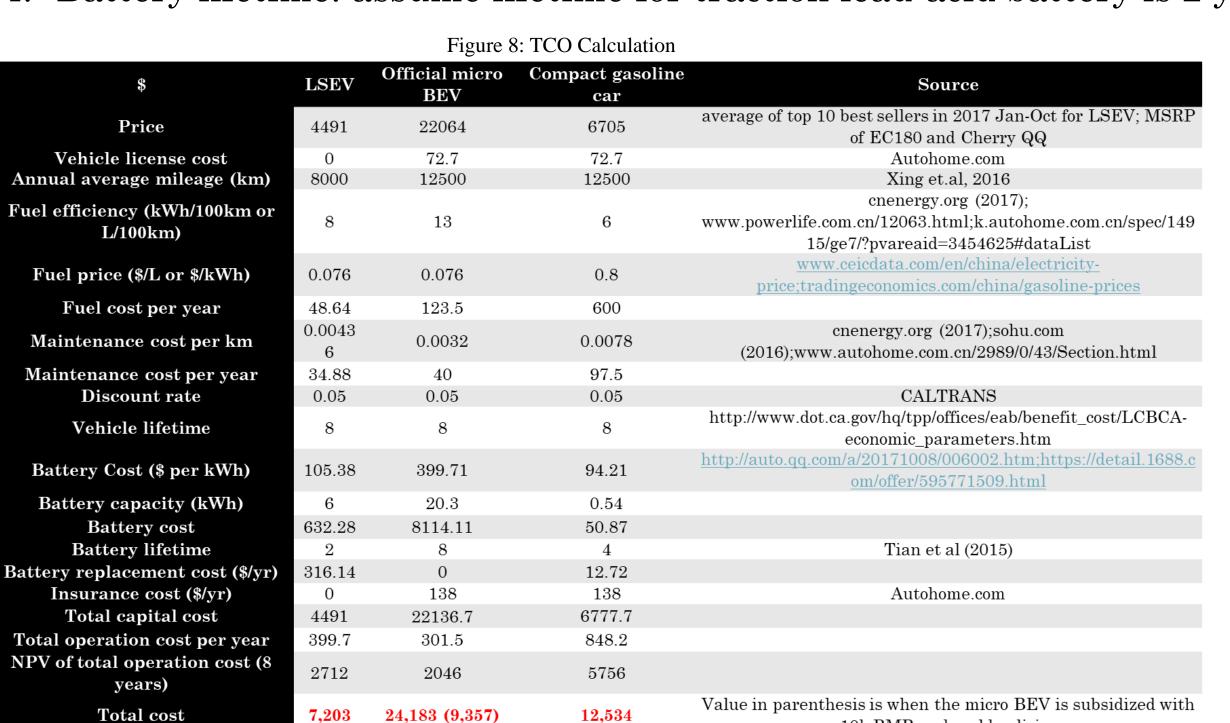
Date	Location	User	Vehicle	Usage
July 2016	Weifang, train station, Shandong	55 years old, female, farmer and black cab driver, middle high school, no driver license	Low-end 3-wheel LSEV no AC, 15k RMB, bought by her husband, already have a Cherry QQ in her family, used to ride E2W.	Mainly used for train station black taxi; Shopping.
July 2016	Weifang city center, shopping mall parking lot, Shandong	67 years old, male, retired worker, high school, have C3 driver license	Medium-end 4-wheel LSEV, Levdeo brand, 35k RMB, bought by his son, used to drive gasoline motorcycles.	Sending grandchild to schools; Leisure and shopping.
Aug 2016	Village Gao, Laizhou, Shandong	49 years old, male, farmer and worker, have C4 driver license	Low-end 4-wheel LSEV, no AC, around 20k RMB, already have a 3-wheel diesel CRV.	Commuting to work; Transporting farm products; Shopping.
Aug 2017	Tsinghua University, Haidian, Beijing	37 years old, female, university assistant researcher, have C3 license	Medium-end 4-wheel LSEV, 30k RMB, no car at her household due to Beijing car purchase lottery. Used to ride bikes and public transit.	Commuting to work; Sending child to schools; Last mile transit to subway stations;

5. Heated debates whether to ban between local



TCO Analysis and Results

- 1. Assumption: 8 years vehicle lifetime due to cheap and low-quality vehicles. Discount rate 5%; Don't consider the residual value of vehicles and carbon related cost.
- 2. Three vehicles in TCO analysis: 2017 Levdeo S50 (LSEV), 2017 BAIC EC180 (Micro BEV, Lithium-ion battery), 2013 Chery QQ (Cheap gasoline car1.0L MT)
- 3. Subsidy for EC180: incentives up to 100k RMB (\$14.8k)
- 4. Battery lifetime: assume lifetime for traction lead-acid battery is 2 years (Tian, 2015)



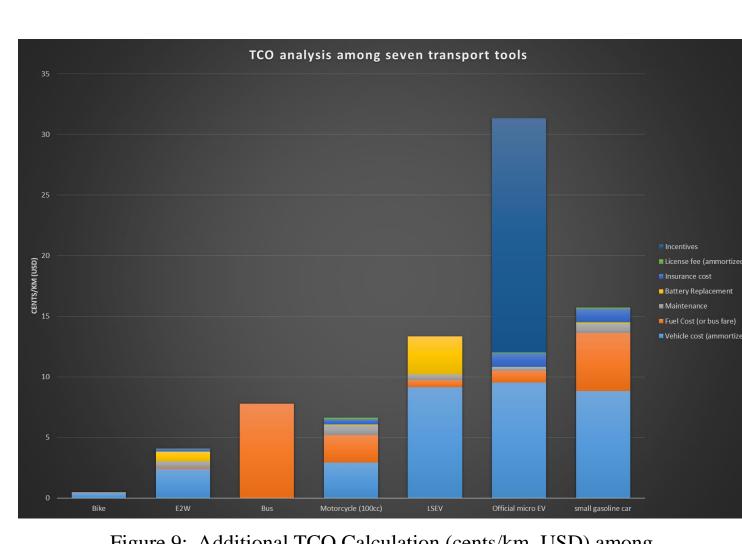
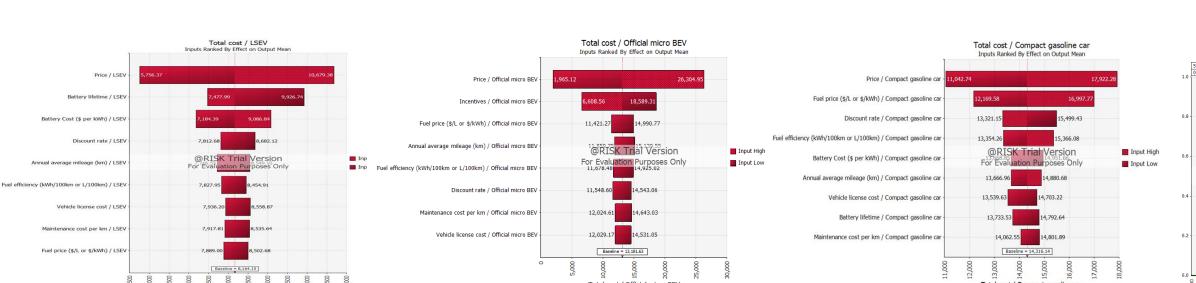


Figure 9: Additional TCO Calculation (cents/km, USD) among Bike, E2W, Bus, Motorcycle, LSEV, Official Micro BEV, small gasoline car



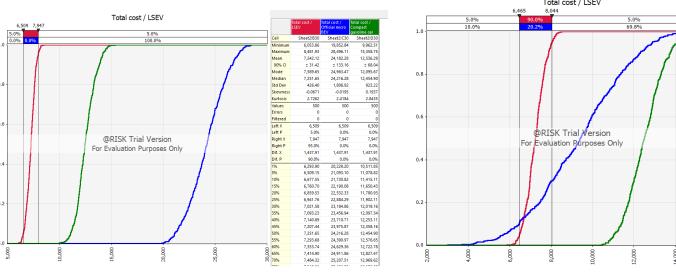


Figure 10: Sensitivity analysis for LSEV, official micro BEV and small gasoline car, [-50%, +100%] input

Figure 11: Monte Carlo Simulation-BEV unsubsidized, input [-20%, +20%] range

Figure 12: Monte Carlo Simulation-BEV subsidized, input [-20%, +20%] range

Findings

• The net present cost for 8-year lifetime are \$7203, \$24183(\$9357), \$12534 for LSEV, official micro BEV and small gasoline car, respectively. The NPV for LSEV is the lowest even with BEV subsidized.

10k RMB under old policies

- From the sensitivity analysis, the top three variables for LSEVs are vehicle price, battery lifetime and battery cost; The top two for official micro BEVs are vehicle price, incentive; The top three for gasoline cars are vehicle price, fuel price and discount rate.
- The Monte Carlo simulation shows that: without subsidy for micro BEVs, cost for LSEVs has stochastic dominance over other two options, small gasoline car also have stochastic dominance over micro BEVs; however, when micro BEV is subsidized, BEV will have stochastic dominance over gasoline cars.
- The TCO analysis among 7 vehicles shows that the cost of owning and operating an LSEV (~13 cents/km) is lower than a small gasoline car and much lower than an official micro EV without subsidies. • The largest portion for LSEV is battery replacement cost besides purchase cost due to the short lifetime of lead-acid batteries.

Discussion

1. Pros and Cons for LSEVs

\mathbf{Pros}	Cons	
"0" tail-pipe emissions	76% of electricity in China produced from coal (Huo 2015)	
Energy efficient (~8 kWh/100km) Can be "refueled" at home/work	Lead-emissions from battery production & recycling	
Inexpensive	Lead-acid battery short lifetime (around 2 years)	
Transport mode upgrade from previous modes	Safety concerns when mixing with regular vehicle flows	

2. Implications:

- EV is not only for rich people. LSEV provides a low-cost "clean" electrified mode for low-income, elder, women and rural residents.
- Help China to achieve fully electrified passenger transportation system
- in a smoother transition. Substitute E2Ws, rural vehicles and cheap gasoline cars. · Provide lessons for transportation tool upgrade for developing countries, such as India,

Southeast Asian with large population of two-wheelers.

3. Future work

- Undergoing surveys about purchase behaviors and use characteristics of LSEV users
- Life cycle analysis of LSEVs in terms of energy use, emissions and pollutions (lead pollution)

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