The IT-Energy Transportation Revolution: Implications for Urban Form

William Wheaton
Department of Economics,
Center for Real Estate, MIT
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Components of the Current IT-Energy-Transportation Revolution

1. Electric Vehicles, Battery technology. Battery technology has made power storage cheaper each year. With far more improvements on the horizon EV’s will dominate the auto industry.

2. Solar Power: Unlike other green energy, small scale generation is quite efficient – powering homes as well as vehicles.

3. IT, Artificial Intelligence: enables, automation, self driving cars and ride hailing. Renting on demand versus owning cars. Chauffeuring beats driving!

4. IT enabled goods delivery platforms create virtual shopping instead of physical shopping. Delivery versus Driving.
#1: Electric Energy and Electric Vehicles

1. EVs CAN NOW GO 100 MILES ON A $3.50 CHARGE (with power at $.15 Kwh)
2. Internal Combustion cars (ICE) REQUIRE $12 (US), $25 (EU). *EV DRIVING MARGINAL COST DOMINATES ICE AND CAN ONLY GO DOWN.*
3. CONTINUED BATTERY IMPROVEMENTS = LONGER EV RANGE, AND FASTER CHARGING.
4. BATTERIES ACTUALLY LAST! A Tesla with 300k miles of usage has a fully functional battery but just with 50-60% of its original charging capacity.

Current battery technology is just the beginning: forecast of Battery Storage costs: Li-On refinement & New Technologies (Solid-state, Graphene…)

![Graph showing projected cost of Li-On battery storage](image-url)
Electric Vehicles (continued)

1. EV DRIVING IS EVERY BIT AS MUCH “FUN” AS ICE.
2. EVS HAVE 25% OF THE MOVING PARTS OF ICE, NO FLUIDS: MUCH LESS MAINTENANCE (NYC fleet $)
3. EASIER TO PRODUCE, EVENTUALLY THIS HAS TO LOWER PRODUCTION COSTS AND PRICES
4. EASIER CHARGING: 90% of Tesla charging is done at home! Public charging networks can be much less dense than gas stations (20k stations vs 168k)!
5. IMAGINE THE EV ADVANTAGE (AND CONVERSION RATES) WITH CARBON TAXES!
6. UPDATE: GERMANY BANS ICE CARS AFTER 2030? UK AFTER 2040?

#2: The Solar Energy revolution

1. Cost of Solar continues to drop. Soon below fossil fuel generation in most countries. All from improved technology - without (yet) any stimulus from Carbon Taxation.
2. Roof space becomes an electric generating asset! Necessary roof space per structure for self sufficient generation requires lower FAR levels (<2)
3. Battery technology, capacity, electric storage costs continue to drop even faster. Possible for many structures to operate off a grid?
4. Fossil fuel, combustion for buildings….will end. Long live clean, cheap electric energy.
Unsubsidized cost of commercial solar power continues to drop – everywhere.

Where is the EV-Solar Energy Revolution likely to be most felt?

1. Everywhere except for dense cities with high FAR levels (>2.0) and low levels of driving.
2. Dense cities still need grid power. Grid power transmission cost is almost 50% of its price. “Self generated “ Kw can be less expensive.
3. With low VMT/HH already, the impact of EV’s in cities is minimal. Big impact in suburbs
4. EVs, Solar mainly change life in the suburbs and in lower density towns.
#3: ride-hailing, on-demand renting

1). IT enables “matching” – the key to renting.
2). Ride hailing gives you a chauffer – a huge reduction in the value of time-spent-in-vehicle.
3). But Ride Hailing can create urban nightmares!
   - VMT doesn’t fall with Uber use: a trip is a trip.
   - Owners park their cars when not in use, Uber drivers circulate
   - Uber deliveries are less efficient than UPS
   - Ride Hailing drains Public Transit use.
4). On net Ride hailing increases VMT in cities!
   More VMT = more city congestion

#3: What about Autonomous Driving. A cheaper Robot chauffeur?

Are consumers ready for autonomous cars?

Consumers Desire More Automated Automobiles
Consumers Trust Driverless Cars

57% of consumers, globally, trust driverless cars—even more so in emerging markets

- USA: 60%
- Germany: 37%
- UK: 45%
- France: 45%
- Canada: 52%

2.8 b people
Can AD overcome recent doubts?

1). We accept high regular risk when driving because we are in control. Accept much less risk when we are not in control.
2). AD has to deliver huge risk reductions to offset loss in control. How?
3). Vehicle “coordination” (in theory) prevents accidents. Enough?
4). “Coordination” allows shorter headways greater flows, increased road capacities.
5). Will it all work? Highways, Interstate: yes. Cities?

#4: IT Retailing

How people shop is changing: Department stores loosing to Big Box, Everyone moving to E-commerce
E-Com 15%, all stores 3.4%, B Box 3.6%, Departments – 2.8%
What does internet shopping Mean?

- Clicks offer greater choice: world at your fingertip
- Clicks offer greater price transparency = higher firm price elasticities of demand = lower profit margins.
- Bricks offer a “fun” shopping experiences?
- Bricks does offer opportunity to try on, feel, inspect…

Perhaps it will boil down to price, convenience.
- Whose costs are lower?
- Who puts goods in your hands for less?

Transportation impact: **Delivery-versus-Driving**

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Impact of Sales Venue on the Cost Components of major Retailers / Etailers (2017 10K reports) ¹

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>Constant</th>
<th>Ecommerce. %³</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dn. space %</td>
<td>.08*</td>
<td>.83*</td>
<td>.75</td>
</tr>
<tr>
<td>Sales/work (M)</td>
<td>.16*</td>
<td>.33*</td>
<td>.26</td>
</tr>
<tr>
<td>Sales/sqft(000)</td>
<td>.29*</td>
<td>.45*</td>
<td>.16</td>
</tr>
<tr>
<td>COG/Sales²</td>
<td>.63*</td>
<td>.04</td>
<td>.11</td>
</tr>
<tr>
<td>Labor/Sales</td>
<td>.11*</td>
<td>-.06*</td>
<td>.14</td>
</tr>
<tr>
<td>Space/Sales</td>
<td>.11*</td>
<td>-.07*</td>
<td>.23</td>
</tr>
<tr>
<td>Shipping/Sales</td>
<td>.11*</td>
<td>.13*</td>
<td>.24</td>
</tr>
<tr>
<td>EBITA/sales</td>
<td>.05*</td>
<td>-.04</td>
<td>.017</td>
</tr>
</tbody>
</table>

¹. Largest 122 retail firms, US operations only, 2017, complete data, bivariate regressions
². (Cost-of-Goods) / Sales revenue
³. % of Sales Revenue, sample mean = .15, SD = .22, range: 0-1
The Comparative Total Costs of using each Sales Venue

- A good purchased on the internet and delivered by UPS requires just about the same $ (share of sales revenue) to get it from the factory port to your doorstep… as
- Traditional retailers spend getting that same good from the factory port to their store shelf.
- The Greater efficiency of the internet venue in terms of labor and space usage is just about offset by a much greater expenditure on shipping.
- But.. Getting it to the shelf is not the same as getting it to your doorstep. What about your driving to the store. How does that cost compare to delivery?

<table>
<thead>
<tr>
<th>Component</th>
<th>Traditional 1,2</th>
<th>E-Commerce 3,4</th>
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</thead>
<tbody>
<tr>
<td>AOV</td>
<td>$26.00</td>
<td>$84.00</td>
</tr>
<tr>
<td>Total Shipping costs</td>
<td>NA</td>
<td>$11.00</td>
</tr>
<tr>
<td>Last Mile Ship cost</td>
<td></td>
<td>$3-5</td>
</tr>
<tr>
<td>Trip cost</td>
<td>$6.50</td>
<td></td>
</tr>
<tr>
<td>% of purchase</td>
<td>% 24</td>
<td>% 4-5</td>
</tr>
</tbody>
</table>

1. Average Order Value: 2017 BLS average household expenditures on Food, apparel, and goods ($9800). Divided by average HH shopping trips from 2017 NHTS(375).
2. Trip costs: average HH shopping VMT (3100) x $.80 per mile divided by 375 trips (NHTS)
3. Average Online Order Value: Statistica 2016
#4: Transportation Implications

• Average purchase on the internet with UPS delivery requires .66 VMT to get it from the nearest warehouse to your door step. Chain trips are incredibly efficient.

• With an average order value of $84, $1 of internet expenditure generates only .008VMT for delivery.

• On average households makes 380 shopping trips a year with 7.3 VMT per trip. Average household expenditure on food, clothing, furnishings is $9800 or $26 per trip.

• Hence store expenditure of $1 generates .28 VMT.

• Substituting Delivery for Driving (for all retail purchases) would reduce yearly VMT/household for goods “Acquisition” from 2800 to 78 miles!

1. 150 miles for 225 packages on average route

Summary

1. EV’s are looming on the horizon promising green (solar powered) driving at fractions of the cost of petrol based vehicles.

2. IT and AI Technology offer the promise of more hassle free ride-hailed robotic driving as well.

3. Internet shopping is reducing the need to travel to shop. Delivery trumps driving.

4. Historically, what has happened as technology provided cheaper and more convenient forms of travel?

5. People travel more when its easier: an elasticity of travel demand.
Historically, *Transportation Innovations* led to flatter urban land and housing price gradients (Ricardo, 1817) despite rapid urban growth.

![Graph showing land prices/house rent over time with 1850 and 1960 landmarks indicating average travel time remained at 1 hour as speeds improved.]

Average total travel time to the city edge remained at 1 hour as speeds improved – allowing far greater commute distances.

**Historic Transportation improvements** *(that lowered travel costs)*:

- Average commute speeds (walk): 3 mph in 1850.
- Increase to 7 mph with trolley cars (1880).
- Then 15 mph with more modern subways (1910).
- Cars average about 25 mph (1960-Today).
- 8-fold increase in speed exactly offset 8-fold increases in travel distance (3-to-25 miles) as NYC grew from 700,000 to 12 million households!
- Flatter land price-rent gradients led to lower density and suburbanization. Lower density = more travel.
- In the aggregate “Unitary Elasticity of Travel Demand”
- (cut cost/mile in half – double miles driven = VMT)
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The Future? With Rented Robotic Electric Vehicles, Economic theory and Empirics suggest:

- *Longer auto trips* (work while driven) result from increased suburbanization. Most of the increased VMT will be in suburbs where there is still some road capacity.

- *Delivery instead of driving-to-shop* helps alleviate VMT increases from longer trips – in the suburbs.

- *Less* use of public transportation in cities from greater AD/Ride Hailing, results in higher center city VMT - acerbating already high congestion.

- Travel is a far larger share of suburban than city household “budgets”. Travel improvements should significantly benefit Suburban living and have little effect on City living – possibly net negative.

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Urban Form

- Is more complicated, determined not just by where and at what density households want to live.

- Also by the level of firm centrality-decentralization. From “Monocentric” to “Polycentric” cities, to numerous LWP (Live-Work-Play) villages. A continuum of “forms”.

- Households who “Live” further from their places of “Work-Play” get less expensive housing to make up for the longer commutes/greater travel (rent gradients).

- Firms prefer higher productivity from central clustering but pay higher wages if their workers commute further.

- Monocentric cities = long commutes, higher wages, but higher productivity (firm agglomeration)

- LWP villages = short commutes, lower wages, but lower productivity from loss of firm agglomeration
Urban Form

Lower travel costs (---) lead to longer trips, lower residential density but a smaller number of larger, more dense employment sub centers.

Technology and Transportation

- Cheaper, cleaner, more convenient travel always provides households with greater flexibility in choosing where to live. This leads to greater residential decentralization.
- But better transportation also reduces the wage premium firms must pay if they choose central locations where trips are longer, congestion worse.
- So firms centralize because the opportunity cost of achieving the productivity advantages that come from clustering – is lower!
- Households don’t mind the long commutes that come from this centralized pattern, because travel is less onerous.

Thank you: Helsley, Sullivan, McMillan
Recent MIT work on Technology and Real Estate

1). Industrial Automation and industrial space demand.

2). The cost/space efficiency of alternative retail venues

3). Will “CoWorking” actually work?
   [https://mitcre.mit.edu/wp-content/uploads/2018/05/will-coworking-work-II.pdf]

4). Technology and Urban Form