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A framework to quantify the impacts of in-trip work activities on time use, value of time and value of travel time savings

Yu-Tong Cheng, Patricia Lavieri, and Sebastian Astroza

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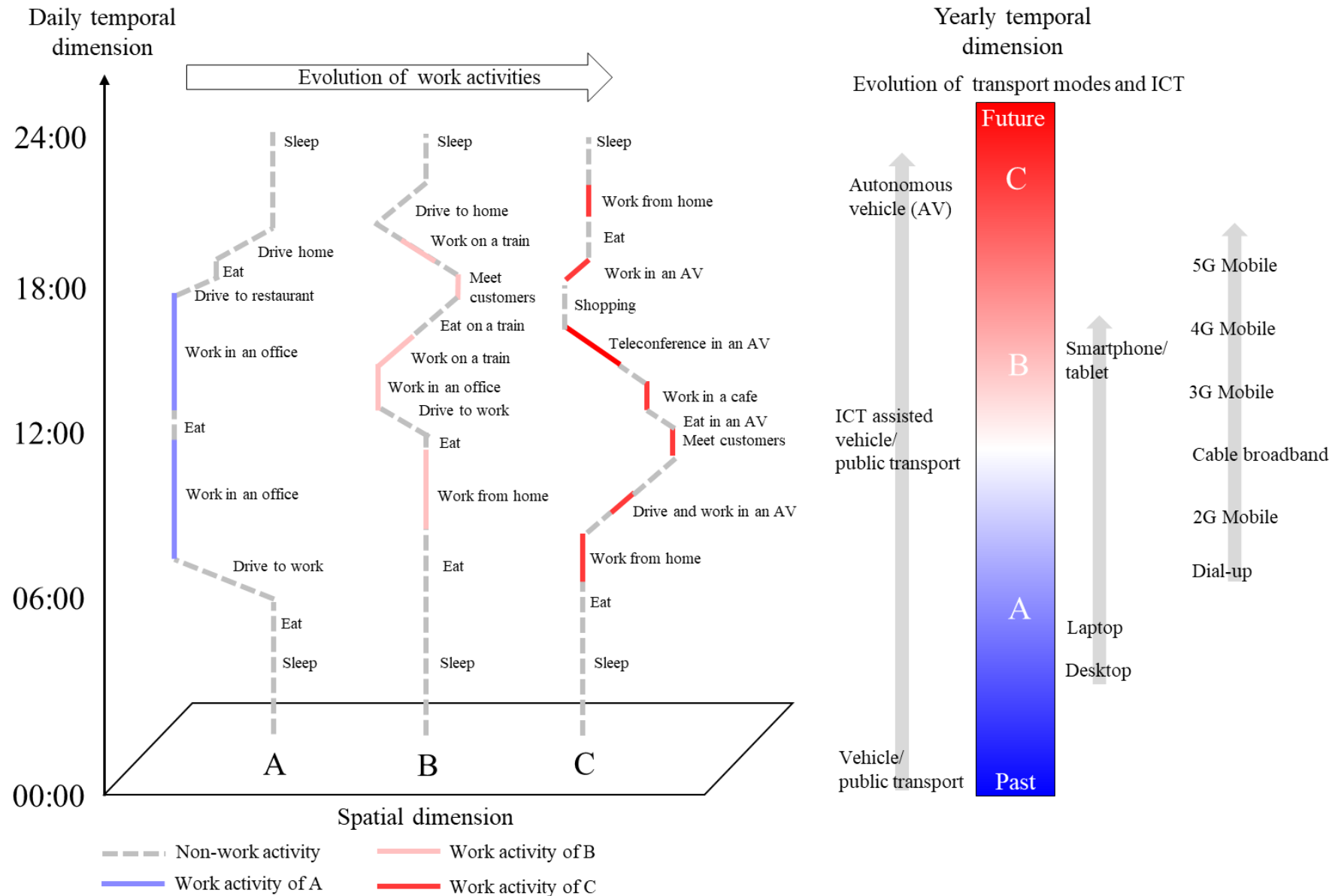
Structure

- Motivation
- Methodology
- (the lack of) Data
- Results
- Conclusions



Motivation

Transition of work activities



In-trip work activities

Conducting work tasks while travelling may change:

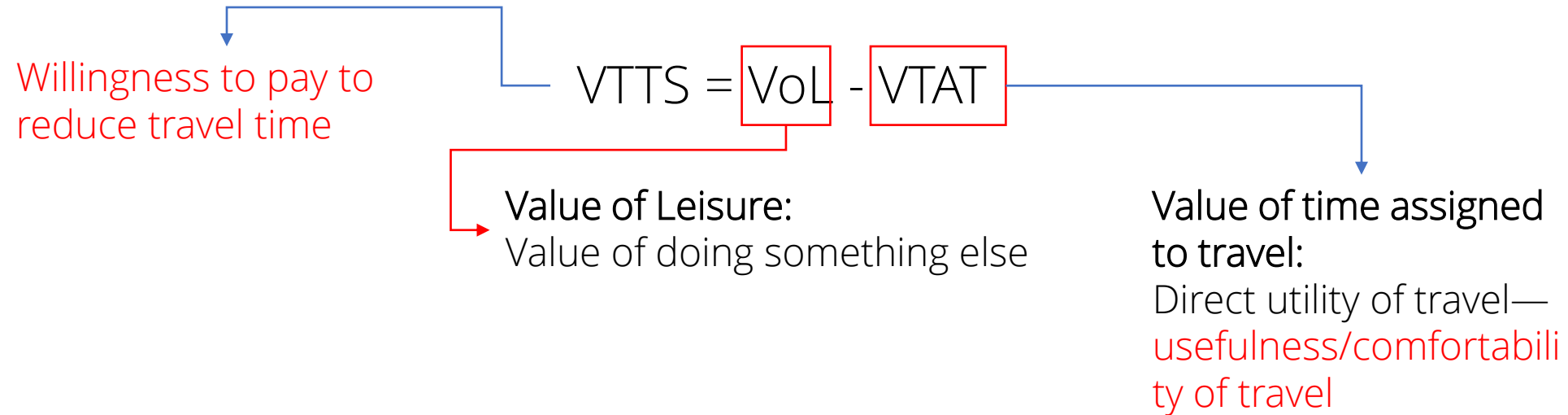
- **daily time use:** in-trip activities can substitute out-of-trip activities (Mokhtarian, 2018)
- **earning pattern:** if in-trip work activities are productive to provide income.
- **the value of travel time savings (VTTS)**

The Value of Travel Time Savings (VTTS)

- Some studies have investigated the **impacts of in-trip activities on VTTS** by comparing different segments of the population (Varghese & Jana 2018; Kouwenhoven & de Jong, 2018; Molin et al., 2020)
- Little attention to the fact that in-trip work activities may change the individual's total earnings, which in turn impacts the trade-off between people's money and time.

VTTS can be decomposed

According to Jara-Díaz (2020):



There is no such framework that take work while travelling into consideration for the estimations of values of time other than VTTS.

Methodology

Jara-Díaz and Guevara (2003)

$$\text{Max } U = \Omega T_w^{\theta_w} T_t^{\theta_t} \prod_{i \in I} T_i^{\theta_i} \prod_{j \in J} X_j^{\varphi_j}$$

Budget constraint

$$\omega T_w - \sum_{j \in J} P_j X_j - c_t \geq 0 \leftarrow \lambda$$

Time constraint

$$\tau - T_w - T_t - \sum_{i \in I} T_i = 0 \leftarrow \mu$$

Technical constraint

$$T_t - T_t^{\min} \geq 0 \leftarrow \kappa_t$$

- Ω : utility constant;
- θ and φ : parameters corresponding to activities (including travel) and goods, respectively;
- \mathbf{X} , \mathbf{P} and \mathbf{T} : vectors of goods consumed, goods prices, and time assigned to activities (including travel), respectively;
- ω and \mathbf{c}_t : wage rate and travel cost, respectively;
- \mathbf{I} : set of all activities but work and travel;
- \mathbf{J} : set of all goods;
- \mathbf{T}_w , \mathbf{T}_t and \mathbf{T}_i : work time, travel time and time spent on other activities, respectively;
- τ is the length of the period considered;
- λ , μ and κ_t are Lagrange multipliers

In our proposed model

$$T_w = T_{ow} + T_{iw}$$

T_{ow} : out-of-trip working time

T_{iw} : in-trip working time

$$T_{iw} = \delta T_t$$

T_t : travel time

δ : proportion of travel time
that is used to work

$$earnings = \omega(T_{ow} + \gamma\delta T_t)$$

γ : productivity of in-trip work
Compared to out-of-trip work.

Proposed model

$$\text{Max } U = \Omega T_{ow}^{\theta_{ow}} T_t^{\theta_t} \prod_{i \in I} T_i^{\theta_i} \prod_{j \in J} X_j^{\varphi_j}$$

Budget constraint

$$\omega(T_{ow} + \gamma \delta T_t) - \sum_{j \in J} P_j X_j - c_t \geq 0 \leftarrow \lambda$$

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Values of time

$$\text{Value of Leisure (VoL)} = \frac{\mu}{\lambda} = \frac{\Psi(w(T_{ow} + \gamma\delta T_t) - c_t)}{H(\tau - T_{ow} - T_t)}$$

$$VTTS = VoL - VTAT - \gamma\delta w$$



(the lack of)
Data

The sample

- “Synthetic” dataset created by retrieving information from the Victorian Integrated Survey of Travel and Activity (VISTA) (State of Victoria, Australia 2016-2017-2018)
- Selected workers who at least spent a portion of their time working
- Selected only workers using car (driver or passenger) or public transport.
- Sample size: 2,206 individuals.
- Google Maps API on travel time and travel cost.

“Work while traveling” patterns

- We do not have information about in-trip work time.
- We “simulate” different patterns.
- Besides productivity (γ), we also consider s : the level of substitution of out-of-trip work by in-trip work.
 - $s=0$. All in-trip work activities are used to generate additional income.
 - $1>s>0$. Part of the in-trip work activities (s) is used as a substitute for out-of-trip work activities, and the other part ($1-s$) is used to generate additional income.
 - $s=1$ All in-trip work activities are used as a substitute for out-of-trip work activities.

“Work while traveling” patterns

	No productivity ($\gamma = 0$)	Medium productivity ($0 < \gamma < 1$)	All productivity ($\gamma = 1$)
No substitution ($s=0$)	Pattern 1	Pattern 2	Pattern 3
Medium substitution ($0 < s < 1$)		Pattern 4	Pattern 5
All substitution ($s=1$)		Pattern 6	Pattern 7

Results

Results: VTTS

- VTTS and VTTS': the value of travel time savings before and after incorporating work while travelling
- $\Delta VTTS = VTTS' - VTTS$: the difference in VTTS before and after incorporating work while travelling
- $|\Delta VTTS|$ = the benefit of conducting work activities while travelling.
- $\frac{|\Delta VTTS|}{VTTS'}$: The proportion of the benefit of conducting work while travelling (from the VTTS)

Results: VTTS

Groups	No in-trip work activities	Unproductive in-trip work activities	In-trip work activities are conducted to increase total earnings		In-trip work activities are conducted to increase total earnings and decrease out-of-trip work time		In-trip work activities are conducted to decrease out-of-trip work time	
	Pattern 0	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6	Pattern 7
		$\gamma=0$; $s=0.5$	$\gamma=0.5$; $s=0$	$\gamma=1$; $s=0$	$\gamma=0.5$; $s=0.5$	$\gamma=1$; $s=0.5$	$\gamma=0.5$; $s=1$	$\gamma=1$; $s=1$
	VTTS [AUD/hr]	VTTS' [AUD/hr] Δ VTTS (t-stats) $\frac{ \Delta\text{VTTS} }{\text{VTTS}'}$						
Low-income workers	22.959	22.959 0.000 (0.00) 0	18.600 -4.359 (-1.18) 0.234	14.241 -8.718 (-2.28) 0.612	18.618 -4.341 (-1.17) 0.233	14.993 -7.966 (-2.02) 0.531	18.976 -3.983 (-1.06) 0.210	15.301 -7.658 (-1.92) 0.500
Medium-high-income private mode	42.755	42.755 0.000 (0.00) 0	28.516 -14.240 (-1.44) 0.499	14.276 -28.479 (-2.77) 1.995	28.571 -14.184 (-1.43) 0.496	14.515 -28.241 (-2.73) 1.946	28.635 -14.120 (-1.42) 0.493	14.911 -27.844 (-2.66) 1.867
Medium-high-income public mode	27.768	27.768 0.000 (0.00) 0	15.169 -12.599 (-2.86) 0.831	2.570 -25.197 (-5.37) 9.803	15.262 -12.505 (-2.83) 0.819	2.952 -24.816 (-5.22) 8.407	15.360 -12.408 (-2.79) 0.808	3.261 -24.507 (-4.95) 7.516

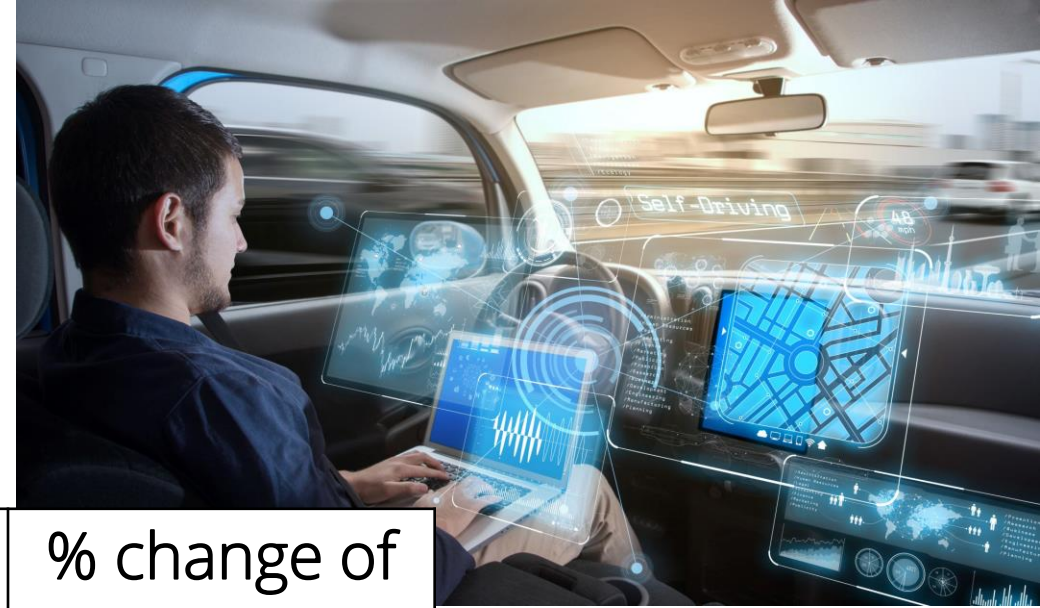
Results: VoL (Value of Leisure)

- VoL and VoL': the value of leisure before and after incorporating work while travelling
- $\Delta\text{VoL} = \text{VoL}' - \text{VoL}$: the differences in VoL estimates before and after incorporating work while travelling.
- $\frac{\Delta\text{VoL}}{\text{VoL}}$: The percentage change after incorporating work while travelling

Results: VoL (Value of Leisure)

Groups	No in-trip work activities	Unproductive in-trip work activities	In-trip work activities are conducted to increase total earnings		In-trip work activities are conducted to increase total earnings and decrease out-of-trip work time		In-trip work activities are conducted to decrease out-of-trip work time	
	Pattern 0	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6	Pattern 7
		$\gamma=0$; $s=0.5$	$\gamma=0.5$; $s=0$	$\gamma=1$; $s=0$	$\gamma=0.5$; $s=0.5$	$\gamma=1$; $s=0.5$	$\gamma=0.5$; $s=1$	$\gamma=1$; $s=1$
	VoL [AUD/hr]	VoL' [AUD/hr] Δ VoL (t-stats) Percentage change: $\frac{\Delta \text{VoL}}{ \text{VoL} } * 100\%$						
Low-income workers	10.461	10.461 0.000 (0.00) 0.00%	10.991 0.531 (2.04) 5.07%	11.522 1.061 (4.00) 10.15%	11.180 0.719 (2.73) 6.87%	11.935 1.474 (5.43) 14.09%	11.361 0.901 (3.37) 8.61%	12.348 1.887 (6.75) 18.04%
Medium-high-income private mode	28.338	28.338 0.000 (0.00) 0.00%	29.527 1.188 (2.48) 4.19%	30.715 2.377 (4.86) 8.39%	30.227 1.889 (3.90) 6.67%	32.211 3.873 (7.74) 13.67%	30.917 2.579 (5.24) 9.10%	33.737 5.399 (10.46) 19.05%
Medium-high-income public mode	30.926	30.926 0.000 (0.00) 0.00%	33.572 2.646 (3.41) 8.56%	36.219 5.293 (6.49) 17.11%	33.860 2.934 (3.77) 9.49%	36.985 6.059 (7.43) 19.59%	34.078 3.152 (4.02) 10.19%	37.552 6.626 (8.01) 21.43%

Transport inequity (for pattern 7)



	% change of VTTS	% change of VoL	% change of VTAT
Low income	-50.0	18.04	76.37
Medium-high-income private mode	-186.7	19.05	115.83
Medium-high-income public mode	-751.6	21.43	985.7

Conclusions

Conclusions

- Preliminary results show that transport equity deteriorated:
 - higher-income workers' work while travelling is worth more than that of low-income workers, and
 - Public-mode travellers' work while travelling is worth more than that of private-mode travellers
- Work while travelling and using AVs further deteriorate the transport equity on top of the existing inequity.
- The increase of usefulness or comfortability of travel is the main source of VTTS reduction and equity deterioration.

Further Research

- “Continuous” patterns.
- Other specifications for productivity.
- Collect actual data.



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