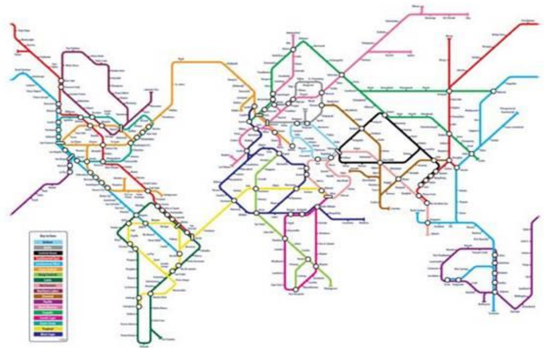
Econometric Benchmarking of Metro Operating Costs. Methods and Applications.



Imperial College London

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European Transport Conference 2015 – Frankfurt, Germany.

Railway and Transport Strategy Centre (RTSC)

Community of Metros CoMET | Nova Group of metros | ISBeRG | ABBG | IBBG

CoMET and Nova Consortia (RTSC)

CoMET metros

Community of Metros
CoMET

Nova metros

Nova
Group of metros

What's a Metro?

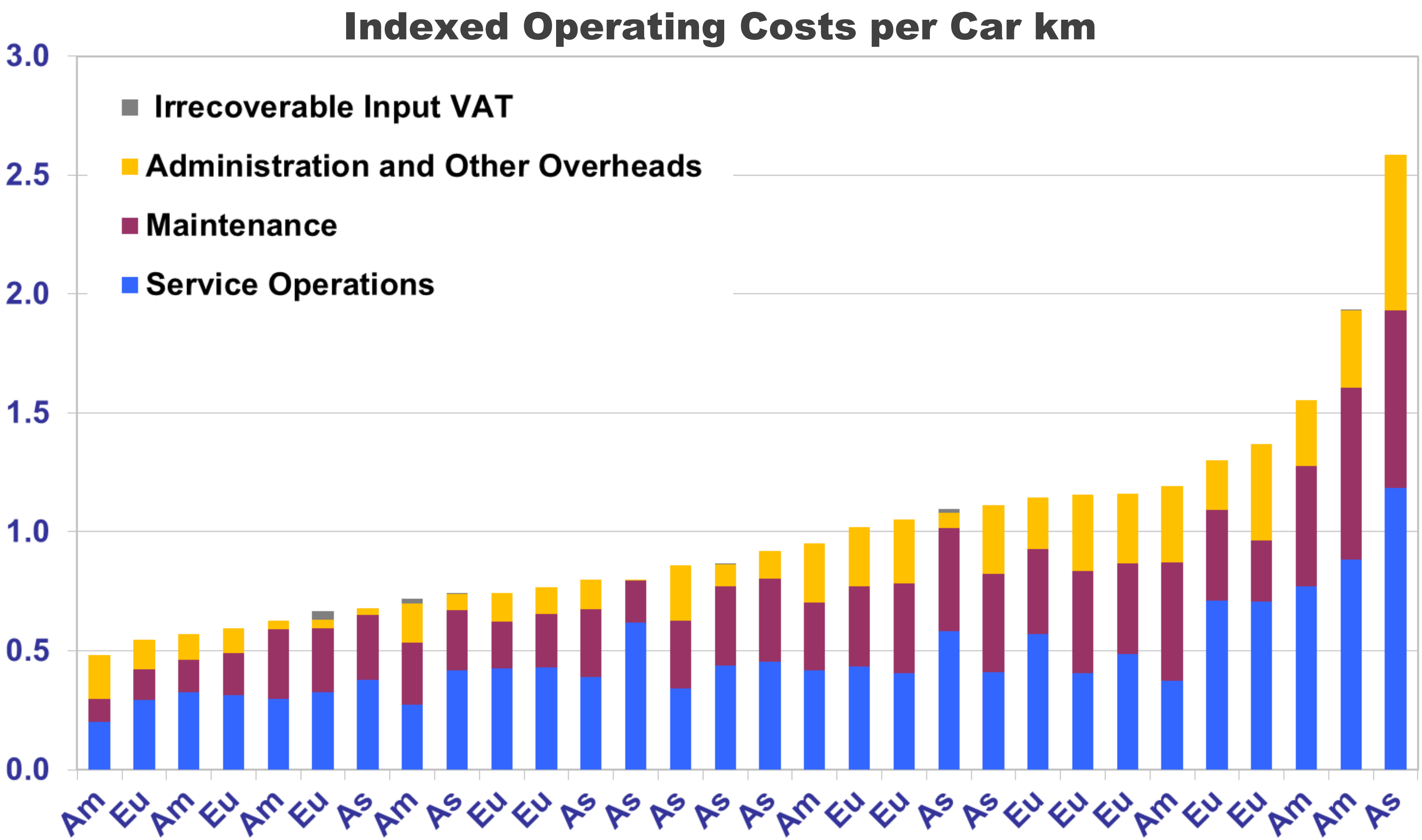
High Capacity

Independent

High Frequency

Operate on Surface and Underground

Introduction



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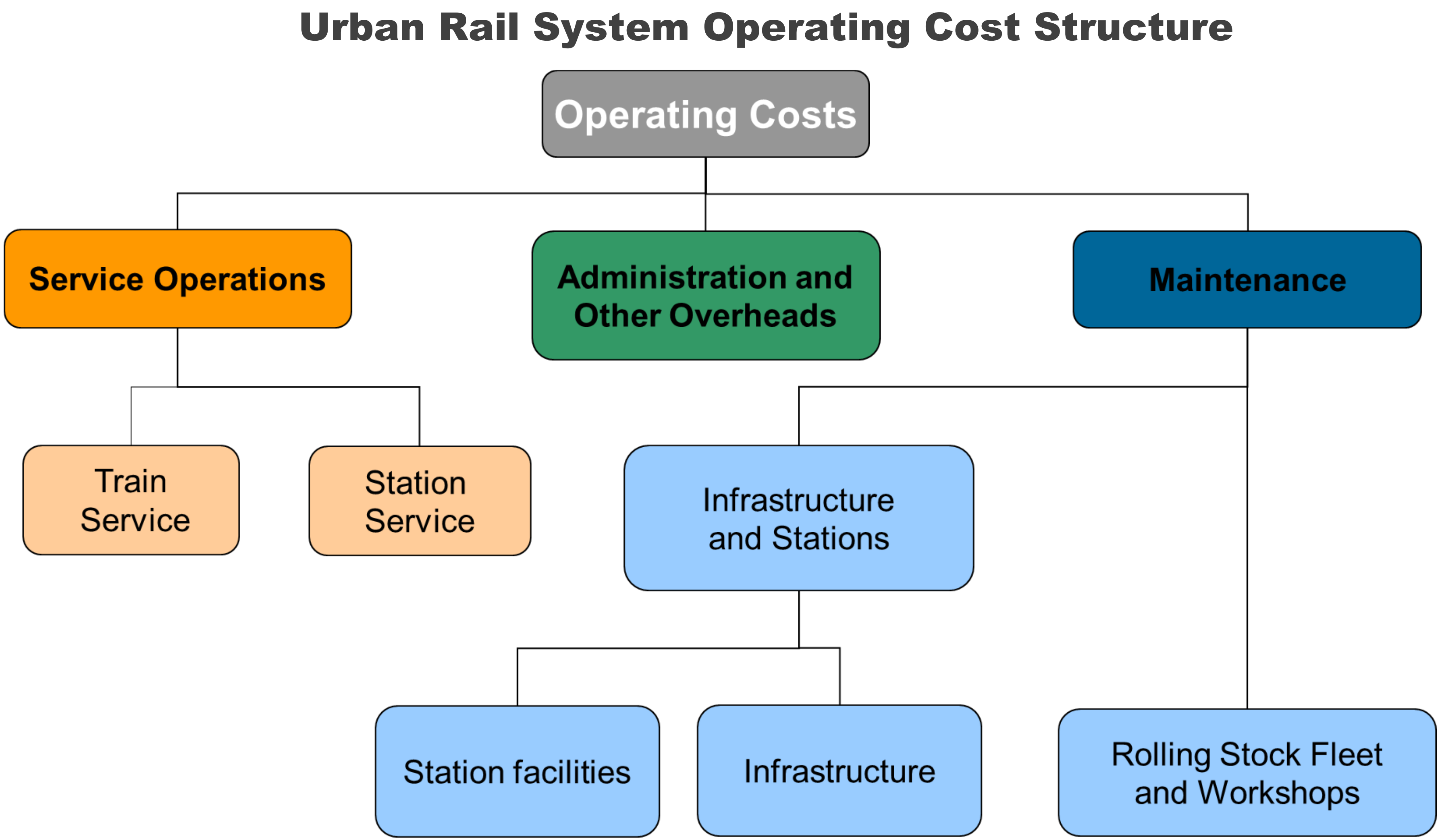
Introduction

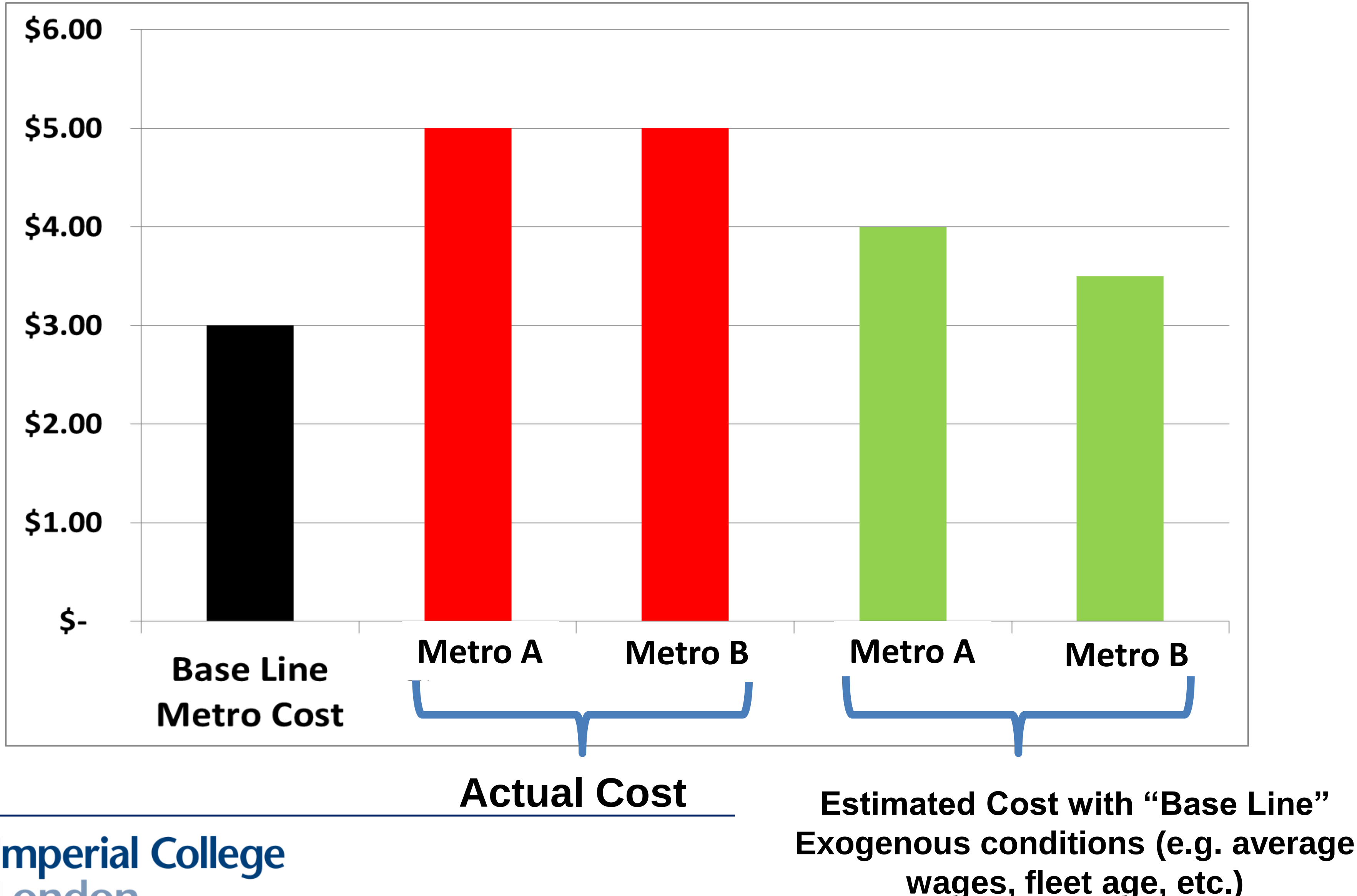


Introduction

- Why are some metros more cost efficient than others? (e.g. operating cost per car km or per passenger journey)

- What are the main factors driving cost-efficiency?
  - Are they external or structural outside of the metro control?
  - Which factors can be more easily changed by metros in order to reduce cost inefficiency?

Ideal Comparison of Costs



Data

- Originates from two consortia within the RTSC
  - Community of Metros (CoMET)
  - The NOVA Group (NOVA)
- High quality panel data set, covering
  - 24 Metros
  - Period between 2005 - 2012

Members:

Nova Group of Metros

CoMET Community of Metros

Method: Econometrics and Regression Analysis

Regression Analysis: Estimation of a cost function including all the factors considered.

$$\begin{aligned}&\boldsymbol{Operating\ Cost}\\&= \beta_1 wages + \beta_2\, contracted\ hours(\%) + \cdots + \varepsilon\end{aligned}$$

Advantages:

Straightforward approach.

Direct quantification of the cost factors.

Useful for cost forecast/evaluation of partial changes.

Factors affecting rolling stock maintenance costs

Rolling stock maintenance cost

- All maintenance of RS and workshops
  e.g.: Routine RS checks.
- Cleaning of RS, regular and in-depth
- Support staff and costs associated
  e.g.: Workshop costs.
- Salaries, training, overtime and any contract labour if exists

Local Operating Environment	Regulatory Environment	Network Characteristics & Asset Reliability	Metro Management Related
Price input factors Peak hour demand Vs off peak hours	Ownership Labour union power	Fleet age Percentage of fleet with AC Types of fleet operating	Contracting out Night only maint.

Degree of Metro Control

Results – Rolling Stock Maintenance Costs

+10% change in:	% change in RS maintenance cost PER	
	Car km	Car
Car km	**-2.4%**	**+6.7%**
Fleet size (number of cars)		**-8.9%**
RS Maintenance staff hours contracted out	**-5.7%**	**-5.6%**
Fleet availability at the peak (%)	**+5.1%**	**+5.8%**
Speed	-0.2%	0.0%
Mean distance between failures	**-1.1%**	**-1.1%**
% Air conditioned rolling stock	+1.9%	+1.9%
Rolling stock age	-0.0%	-0.0%
Own labour wages	**+2.6%**	**+2.6%**
Time trend	**-1.8%**	**-1.6%**

Bold coefficients are statistically significant at a 90% confidence level. Detailed table with all variables and t-values in the paper.

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Key findings – Rolling Stock Maintenance

- Costs appear to be proportional to car kilometres travelled by the fleet (+6.5%) so money can be saved in rolling stock maintenance by reducing car kilometres.
- Small economies of scale. If fleet size and car km increased simultaneously by 10%, costs per car will decrease by 1.8%.
- Higher fleet availability at the peak can be costly.
- Contracting out labour reduces rolling stock maintenance costs.
- Higher reliability linked to lower RS maintenance costs.
- Negative time trend (~ -1.8%). Continuous improvement.

Factors affecting train service cost efficiency

Train service operations cost

- Drivers
- Non-driver onboard operations
- Support staff not on trains (e.g. control centre and crew management)
- Operating costs to support train operations (e.g. energy for traction power and for signalling systems)

Local Operating Environment	Regulatory Environment	Network Characteristics & Asset Reliability	Metro Management Related
Spatial reach Demand profile Urban size / density Price input factors	Ownership Position in organisation Labour union power	Network size % fleet with AC % network driverless Incidents & train delay	% service contracted out Staff level & composition

Degree of Metro Control

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Results – Train Service Costs

+10% change in:	% change in train service cost PER		
	Car km	Passenger Journey	Train hours
Output	**-6.6%** (car km)	**-8.1%** (pax journey)	**-6.1%** (train hours)
Train driver productivity	**-4.7%**	**-4.5%**	**-5.5%**
Train service staff hr. contracted	+0.1%	-0.7%	0.1%
Network length	+1.2%	**+2.7%**	0.1%
% AC Rolling Stock	-1.8%	**-2.5%**	**-2.0%**
Age of the system (per year)	0.0%	-0.0%	-0.0%
Own labour wages	**+4.8%**	**+4.8%**	**+5.1%**
Price of energy	**+2.0%**	1.5%	**+2.1%**
Time trend	-0.0%	-0.0%	-0.0%

ns: Non-significant; * Significant at 1% level; ** Significant at 5% level; *significant at 10% level.**

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Key findings – Train Service Costs

- Significant returns to density in train service costs per car km (6.6%), per passenger journey (-8.1%) and train hours (-6.1%).
- Labour: a 10% increase in wages would be correlated with an average 5% increase in train service costs. Substitution effects.
- Driver productivity, key for lower train service costs.
- Energy prices are relevant but with a moderate influence (~ 2%)
- Time trend: Once other factors held constant, no time trend found.
- Age of the metro operator seems negligible once all other factors are considered.

Factors affecting station service cost efficiency

Station service operations cost

- Station platform supervision and platform assistants and multifunctional staff.
- Station energy and power consumption
- All staff at ticket offices and gate lines

Local Operating Environment	Regulatory Environment	Network Characteristics & Asset Reliability	Metro Management Related
Spatial reach Demand profile (peak ratio) Price input factors	Ownership Labour union power Fare regulation	Number of lifts, escalators and elevators Number of stations Train length – platform size	% service contracted out Staff level & composition

Degree of Metro Control

Results – Station Service Costs

+10% change in:	% change in station service cost PER	
	Passenger Journey	Station
Passenger journeys	**-12.0%**	**-16.0%**
Number of stations	**-6.9%**	**-1.8%**
Station staff hours contracted out	**-1.2%**	**-1.0%**
Number of lifts, elevators and travelators	+2.1%	+2.1%
Train length (per metre)	**+0.6%**	
Age of the system (per year)	**+0.2%**	**+0.2%**
Own labour wages	**+7.8%**	**+2.6%**
Price of electricity	**+2.1%**	**+2.4%**
Time trend	**-0.2%**	**-0.2%**

Bold coefficients are statistically significant at a 90% confidence level. Detailed table with all variables and t-values in the paper.

Key findings – Station Service Costs

- Very significant economies of density. Most passenger-intensive metros have very low costs per passenger.
- More stations, lower costs: Signalling effect for simple stations.
- Contracting out station staff shows moderate effect at lowering costs.
- Age of the system: older metros tend to have higher station costs. Also older metros located in more expensive cities (cross effect).
- Time trend: decreasing time trend for station service costs.

Thank You

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Results – Operating costs aggregate

+10% change in:	% change in total operating cost PER		
	Car km	**Passenger Journey**	**Train hours**
Output	**-9.0%** (car km)	**-9.5%** (pax journey)	**-10.9%** (train hours)
Wage	**+2.8%**	**+2.7%**	**+2.6%**
Total staff hours	**+4.0%**	**+4.1%**	**+4.3%**
Network length	+2.1%	+2.5%	2.3%
Number of stations	**-2.4%**	-2.2%	-2.1%
Incidents per car km	-2.1%	-1.2%	0.0%
% AC Rolling Stock	-1.8%	**-2.5%**	**-2.0%**
Age of the system (per year)	**0.05%**	**-0.05%**	**-0.06%**
Time trend	**-1.1%**	**-1.2%**	**-1.1%**

ns: Non-significant; * Significant at 1% level; ** Significant at 5% level; *significant at 10% level.**