

# What is the Cost of Building a Subway?

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# Introduction

In the 2010s, New York opened two subway extensions (7 extension, Second Avenue Subway) for \$1.3-1.6 billion/km.

This decade, Paris has built several Métro extensions (M4, M12 in service; M1, M11, GPX under construction) for around \$250 million/km.

The most recent Madrid Metro extensions (L2, L9) cost \$85 million/km.

The big question: **why?**

## What does this mean?

New York is planning to have spent around \$35 billion between 2005 and 2030 on subway and commuter rail expansion. But it's only getting 15 km of new tunnel!

Paris is spending a similar amount over the same period: €40 billion, for a total of 228 km, 187 underground.

Madrid, a much smaller city, spent €10 billion in 1995-2015 on 234 km, around 180 underground.

The limiting factor to subway expansion is cost.

# Why?

This is the \$2 billion question! The data can help answer important questions:

- ▶ Is New York building inherently more difficult projects?
- ▶ Where else are costs high? Where are they low?
- ▶ Are high costs caused by geological and geographic factors?
- ▶ Are deep institutional factors (e.g. health care, legal system) involved?
- ▶ Is this about cheaper construction methods?
- ▶ Can anything be done about the problem?

Good news: it appears the problem is, at least in theory, solvable!

## Lit review: cost overruns

There has been extensive study of cost *overruns* from the initial budget:

- ▶ Pickrell 1990, 1992: American urban rail; see more recent revision by Hardy-Doh-Yuan-Zhou-Button 2009.
- ▶ Fouracre-Allport-Thomson 1990: developing-world metros.
- ▶ Flyvbjerg on strategic misrepresentation (i.e. lying): Flyvbjerg-Bruzelius-Rothengatter's *Megaprojects and Risk* 2003, Flyvbjerg-Holm-Buhl 2002-5, etc.

These studies find that costs tend to run over, but don't compare absolute costs. But they give us one caution: we should be wary of old *ex ante* data.

## Lit review: absolute costs

Some studies of *absolute* costs of urban rail:

- ▶ Flyvbjerg-Bruzelius-van Wee 2008: small  $N$ , all in developed countries, mixed subways/els. This study finds a small US premium, but the US lines compared are easier to build than some of the European lines.
- ▶ Gordon-Schleicher 2015: bigger  $N$ , covering poor and rich countries, about 1990-2015. They find a large US premium and a small but significant positive regression of GDP per capita on costs.
- ▶ RPA 2018: several case studies in North America and Europe.

## Madrid's formula

Manuel Melis Maynar was president of Madrid Metro in 1998-2009. In 2003, he gave a report on how Madrid expanded its Metro for such low cost:

- ▶ Contracts are awarded based on a technical score (50%), speed (20%), and cost (30%).
- ▶ Designs are streamlined, conservative, and reused between different lines.
- ▶ Stations are built as shallow as possible.
- ▶ Contracts are itemized, not awarded by lump sum, so change orders come pre-negotiated (see also Ryan 2019 on Indian power plants).
- ▶ Design and construction are awarded to different firms—no design-build.
- ▶ In-house oversight—no consultants.

# The data

The primary source for this talk is a new dataset of different urban rail lines and their costs. Some key attributes:

- ▶ The table covers 205 distinct items totaling 3,600 km of urban rail.
- ▶ About 40 countries are represented. The dataset is fairly complete in the developed world for lines built since the 1990s but has gaps elsewhere, especially in China.
- ▶ Most lines are recent: about 2/3 are still under construction or in planning, forcing the use of *ex ante* and *in medio* sources.
- ▶ The sources are predominantly popular and trade media, and secondarily agency plans and public documents.
- ▶ Figures exclude rolling stock whenever possible.

## Important line characteristics

The data table focuses on cost/km, but mentions three additional characteristics to avoid confounders:

- ▶ The proportion of the line that is in tunnel.
- ▶ Number of stations: stations are a key part of construction costs, esp. at the high end (about 75% of SAS's costs).
- ▶ Whether the line is regional rail (RR) or metro: RR consistently costs more (RER vs. Métro, Crossrail vs. Underground, Gateway/ESA vs. SAS, etc.).

The analysis focuses on metros, since few items in the table are RR.

## Line centrality

Two additional characteristics, not mentioned in the table:

- ▶ Line centrality: hard to define precisely, but tunnels cost more in city center (inc. RR) than in outlying areas. One potential metric: number of crossings of older lines.
- ▶ Construction method: cut-and-cover is cheaper than bored tunnel with cut-and-cover stations (by a factor of 1.5-2), which is cheaper than bored tunnel with mined stations. But this data isn't available in every city.

These are related: city center costs are higher partly because it's harder to cut-and-cover. Paris M1 and M12 extension stations cost €90 million apiece, but RER E La Défense is €450 million.

SAS Phase 1 stations were deep-mined at around \$750 million each, but they could have been built as shallow cut-and-cover!

## Analysis: preliminary observations

Several preliminary observations:

- ▶ Costs are **citywide**, that is similar across subways in the same city.
- ▶ Costs are to some extent **national**, that is similar between different cities in the same country.
- ▶ Costs are **rising**: more recent subways in the same city cost more than older ones.
- ▶ RR is more expensive than metros.

Because costs are national, the explanation should be **institutional** and not geologic or geographic. This is difficult and requires qualitative research, since  $N$  is about 40.

## Who's cheap and who's expensive?

- ▶ The Anglosphere is expensive, around \$500+ million/km ex-New York: US, Canada, Australia, Singapore, UK.
- ▶ Western Europe: Germany and NL cost \$300-400 million/km, France is \$250 million/km, Mediterranean and Nordic and Swiss costs average \$90-150 million/km.
- ▶ Eastern Europe runs the gamut from Romania at \$100 million/km to Hungary and Russia circa \$500 million/km.
- ▶ East Asia: Korea is about \$100 million/km, China perhaps \$250 million, Taiwan and Japan are expensive.
- ▶ Ex-colonies: all are expensive—subways tend to run at \$500 million/km and Manila has one at \$1 billion/km.
- ▶ Other developing: Turkey averages \$100 million/km, Ecuador and Chile are about \$150 million/km, Iran maybe \$200 million/km, Mexico and Brazil costlier (\$330 million/km in São Paulo), Thailand \$300-650 million/km.

## Costs are rising

For the most part, if there are multiple items in the same city, more recent ones cost more. Exception: if the most recent items are suburban extensions and the older line is in city center (e.g. Warsaw).

This is also true historically. Approximate construction costs per km, in millions of 2019 dollars:

Era	New York	London	Paris
1900s	40	30	30
1910s	55		?
1930s	140	35	30
1960s-70s	600-800	110-190	?
1990s-	1,500	500	250

But: some places (Canada, Singapore) have had higher recent cost growth, others less growth (Korea, Spain).

## Common but probably wrong explanations

Standard political institutions don't seem like good explanations:

- ▶ Health care costs: the US has expensive health care, but the UK has a cheap public system and SG has a cheap private one.
- ▶ Unionization: in developed countries union density correlates with *lower* costs thanks to Scandinavia, but really there is not much correlation either way beyond the fact that the Anglosphere is expensive.
- ▶ GDP per capita: unlike in Gordon-Schleicher, the GDP-cost correlation vanishes if we correct for the tendency of poorer countries to build more els and fewer subways.
- ▶ Corruption perception: the cleanest countries include low-cost Scandinavia and high-cost CA, NL, SG, UK; Europe's most corrupt are low-cost ES, GR, IT and high-cost HU, PL, RU.

# The Anglosphere premium

The Anglosphere has several common features, all of which are in correlation, and therefore correlate with high costs:

- ▶ Common law. But Québec has civil law and the same costs as Toronto.
- ▶ Winner-take all elections. But New Zealand uses proportional representation, and Auckland's City Rail Link is \$850 million/km.
- ▶ High inequality, no collective bargaining. But Canada and Australia are comparable in inequality to Southern Europe.

What if the cause is not as political? The Anglosphere tends to mostly learn from other Anglo countries. Maybe the root cause is lack of knowledge about non-English-speaking practices?

## Anglosphere insularity

Some examples of Anglosphere insularity suggesting the region does not learn from others, and New York is especially insular:

- ▶ In SF, officials at Caltrain and TJPA had no idea Germany even has commuter rail. One TJPA consultant, re Japanese designs: “Asians don’t value life the way we do.”
- ▶ MTA Chair Pat Foye, last week: “New York has a more built-out commuter rail network than London.”
- ▶ American conversation on transit reforms (RPA on costs, fare capping, etc.): references to London, few to none to Continental Europe or East Asia.
- ▶ US and Canadian proposals for reform propose more design-build, the opposite of what Spain and France do.

So what can be done to fix this, concretely?

# Synthesis: how New York can reduce costs

## **Imitate, don't innovate!**

New York needs to do what the Spaniards and Koreans and Italians and Swiss and Nordics do, with some sanity-check assistance from medium-cost countries like France.

This covers differences in engineering, contracts, and political institutions.

## Build simpler stations

The cost difference seems to be mostly in stations.

SAS tunneling and systems together are a factor of 2 over Paris (and LA has no premium at all), stations are a factor of 4-8 premium. To simplify stations, use the following methods:

- ▶ Shallow cut-and-cover construction, disrupting the street for about 18 months. No mining except at undercrossings.
- ▶ No mezzanines. All circulation, including fare barriers, should be on the platform level or at street level.
- ▶ An island platform, ideally accessed from a street median, to avoid duplicating elevators, stairs, etc.
- ▶ No signature architecture. Station designs should be reused systemwide. If art is desired, put on exhibits.

## Improve contracting practices

Rosenthal 2016: contractors say that there is a premium of 30% just for working with the MTA's byzantine process, in addition to any profit margin from lack of competition.

Instead, contracts should be flexible and strictly separate design and construction. **No design-build.**

- ▶ An in-house team should oversee the design and project management, and have the authority to reject bids. If only 1-2 contractors bid, restart the bidding process.
- ▶ Let the designers choose their own materials, methods, etc.—give them a technical score and make that 50% of the weight of the bid. Do not blindly award to the lowest bidder. Standards should be about performance, not methods.
- ▶ No lump sum contracts. Bills should be itemized to prevent change order litigation.

## Do not privatize the state

Overheads account for 27% of SAS costs, vs. 15% of Paris M1 and M14 extensions and 8% of Madrid L9.

Agencies must hire adequate in-house project management, in lieu of relying on consultants who tend to be less likely to be willing to take a stand and propose inexpensive but disruptive techniques.

“Disruptive” includes politically disruptive, e.g. forcing different agencies to work together. California HSR is full of agency turf clashes leading to unnecessary tunnels.

In-house workers tend to cost  $1/3$  to  $1/2$  as much as consultants.

In-house engineers and managers must be paid competitively, in cash and current benefits, not a pension that vests in 23 years.

## Further research: fill in gaps in data

The data has significant gaps in quantity and quality, and filling them is a priority to get a more accurate picture:

- ▶ Add more current and historic items to the table, esp. in China, since so much (average-cost) work happens there.
- ▶ Add more granular information about station vs. tunnel costs, overheads, environmental review process, etc.
- ▶ Look at ancillary costs, e.g. elevator retrofits for wheelchair accessibility.
- ▶ Compare other infrastructure: HSR, electrification, airports, highways, water works, sewage—institutional factors should impact all of these equally.

## Further research: comparative institutions

More granular research on legal, political, etc. institutions should explain how the US got to this point of being so behind in infrastructure. Potential examples:

- ▶ Kagan's theory of American adversarial legalism vs. European bureaucratic legalism.
- ▶ Schleicher's work on subnational governance and the American local democratic deficit.
- ▶ Labor activists' notion of a siege mentality among unions in the US (and UK?) leading to resistance to productivity improvements.
- ▶ Research on regulatory capture and civil service quality in comparative politics.

## Further research: other methods

The value of the principles laid out in Melis 2003 suggests that qualitative methods (e.g. case studies) are of great value.

Preliminary interviews are revealing a wealth of information about how different countries oversee public contracts.

Interviews in Rosenthal 2016 and design standards show some differences in staffing levels in New York versus Western Europe.



Thank you!