THE MAGLEV REVISITED: PART 4

Maglev riders would come from the wealthiest 2% of the Baltimore-Washington population

A simple calculation suggests that an individual would have to earn at least $363,000 a year for him or her to find the maglev ticket price worth the modest reduction in door-to-door travel time

BY OWEN KELLEY (okelley@gmu.edu), MAY 2, 2021

Common sense tells us that few people would be willing to pay 40 to 80 dollars to save just 8 to 27 minutes. If common sense is right, then the advertised utility of a 17-billion-dollar project would evaporate. The project in question is the proposed Baltimore-Washington magnetic-levitation rail line known as "the maglev." [1]

Here are the facts. In January 2021, the Federal Railroad Administration published the draft environmental impact statement for the proposed maglev. In this document, the agency stated that maglev customers would save on average 8 to 27 minutes of travel time, door to door. The agency also considered various options for the maglev's ticket price but settled on $40 to $80 in the computer simulation that was used to forecast how many trips would be made on the maglev.[2]

Common sense suggests that only a small proportion of the population is wealthy enough to be willing to pay this much money to save so little time. US Census data and the calculation described in the present article suggest that no more than 4% of workers in the Baltimore-Washington region earn this much. Two percent is the most likely figure.

Background

The companies that want to build a maglev between Baltimore and Washington are trying to persuade elected officials and the public that the proposed maglev is for everyone, not just the rich. These companies are Baltimore Washington Rapid Rail (BWRR) and its parent company, The Northeast Maglev. On its website, BWRR states that the maglev would be "highly valued across all travel purposes and income segments." The Northeast Maglev's website states that the company is "looking in to innovative ways to make the train accessible to all." [3]

The question of whether only the wealthy would ride the maglev is ignored in the Executive Summary of the draft environmental impact

[1] $15–17 billion construction cost: DEIS, Appendix D4, Table D4-8, pg. D-21; 8–27 minutes saved travel time: Appendix D4, pg. C-6; $40–$80 ticket price: Appendix D2, pg. D-107, D-108.

[2] The DEIS considered a maglev ticket price as low as $27 but determined the official ridership forecast based on a $40–$80 ticket price: Appendix D2, pg. D-107, D-108, "Final SCMAGLEV Fare Assumptions" section.

[3] BWRR: https://bwrapidrail.com; TNEM: northeastmaglev.com/.

statement published by the Federal Railroad Administration. Buried in an appendix is a limp sentence on this subject: "higher income workers would be the most likely to use SCMAGLEV for commuting" (Appendix D4, pg. D-81). Then again, the draft impact statement also contains a sentence that implies that a majority of the region's residents would find the maglev a good deal:

> The ridership report assumes that about 70.0 percent of business travelers in the defined catchment area and 67.0 percent of non-business travelers, which includes those making personal trips as well as commuters, between Baltimore and Washington, D.C. would choose the SCMAGLEV service if it were available. (Chapter 4.6, pg. 4.6-3)
>
> The anticipated SCMAGLEV services are estimated to reduce travel times by 8 to 27 minutes of travel time savings depending on the trip purpose and length under each of the Build Alternatives. (Appendix D4, pg. C-6)

Putting these two quotes together, the draft impact statement seems to imply that, among the people whose trip origin and destination are close enough to a maglev station that the maglev would save them 8 to 27 minutes, 67% of these people would earn enough money that they would be happy to buy a maglev ticket. If this is the correct interpretation of these two quotes, then the 67% figure seems too high given that a maglev ticket would cost $40 to $80 one way.

Complicating matters, it is unclear exactly what the 67% refers to because its description in the draft impact statement is so brief. The draft impact statement obtained the 67% figure from a ridership report written by the Louis Berger consulting company, but the public is not allowed to read that report. Many of the documents that underlie the draft impact statement are hidden from public view. For all we know, even the Louis Berger report does not adequately explain the meaning and derivation of the 67%.

With the air of a farce, the Federal Railroad Administration released a heavily redacted copy of the Louis Berger ridership report toward the end of the public-comment period on the draft impact statement. The redacted copy is a mere shell, completely hiding the numerical data and the text that would assist in interpreting the 67% figure and other aspects of the maglev's ridership forecast.[4]

To generate a precise forecast of the fraction of the population that would make use of a proposed transportation facility, complicated analysis of carefully constructed surveys is required. It may involve mode-choice analysis of stated-preference surveys, to repeat the jargon used in the maglev's draft environmental impact statement.[5]

But the calculation is much simpler the goal is just an upper and lower bound on the fraction of the population that would find the travel cost and time-savings attractive. This calculation is simple enough to be performed on a hand-held calculator instead of requiring simulation software designed by a team of experts.[6]

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[4] Page 48 of Louis Berger (2018 Nov 08) states the 67% figure, according to the DEIS, Chapter 4.6, page 4.6-3, footnote 9. The FRA released a heavily redacted copy of the Louis Berger report at bwmaglev.info/index.php/project-documents/deis, on 23 April 2021. The DEIS comment period runs January through May 24, 2021.

[5] Appendix D2, pg. C-105.

[6] This topic is discussed in Chapter 12 of Ortuzar and Willumsen (2011).

The calculation described in the present article is this sort of reality check. Mathematical details and supporting data are provided in the appendix of the present article.

Serving the 2%

Before estimating who would ride the maglev, one needs to take care of two preliminaries. First, one chooses an estimate for how much a traveler would be willing to pay to save time. A plausible approximation is that an individual is willing to pay for travel-time savings at a rate similar to the rate at which he or she earns money at his or her job. One variation or other of this idea is encountered in various transportation-modeling studies.

Second, one needs an estimate for the averages of two quantities. These quantities are the price difference and the door-to-door travel-time difference between riding the maglev and driving directly to the destination. The maglev would be more expensive than driving and, in some cases faster, depending on the location of the trip origin and destination. A range for the travel-time difference is stated in the draft impact statement: 8 to 27 minutes. Determining the price difference requires a little math.[7]

The price difference would be $33 to $73 for an individual traveling alone, with a family traveling together considered later. This estimate for an individual traveling alone comes from taking the $40-to-$80 per-person one-way maglev ticket price that is stated in the draft impact statement and subtracting the cost of driving. The per-vehicle cost of driving a car between Baltimore and Washington is about $7, and this estimate may be calculated from two numbers. Start with the draft impact statement where it states that typical car trips between the two cities are 39.6-miles long. Multiple that distance by AAA's estimate of a typical car's per-mile cost for gas and maintenance. One could use a somewhat different value than $7 for the cost of driving and the results would be essentially unchanged, as discussed in the appendix of the present paper.[8]

The middle of the above-mentioned range for the extra cost to ride the maglev is $53, and the middle of the time-savings range is 17.5 minutes.

Someone who finds it a fair deal to pay about $53 to save about 17.5 minutes would be demonstrating a willingness to pay $181.71 per hour. Such a person would most likely earn at least $181.71 per hour, which would mean an annual income of about $363,000. Annual income is about 2,000 times greater than hourly income.[9]

The Census Bureau reports that only about 2% of workers in the Baltimore-Washington region earn at least $363,000 a year. We can draw the conclusion that, for this reason, only about 2% of workers would choose to ride the maglev. As discussed in the appendix of the present article, only 2 to 3 percent of worker earn $363,000 a year in the Washington area and only 1 to 2 percent in the Baltimore area do so. Only 1% of US workers earn this much, which reduces the chance that the average visitor would find the maglev to be a prudent way to travel between Baltimore and Washington.

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[7] 8–27 minutes saved travel time: Appendix D4, pg. C-6.

[8] 7.08 = 39.6 · 0.1787; 39.6 mile trip length: Appendix D4, Table D4-59, pg. E-82; $0.1787/mile for medium sedan: AAA 2020.

[9] $182 h^{-1} = $53 · 60 min. h^{-1} ÷ 17.5 min.

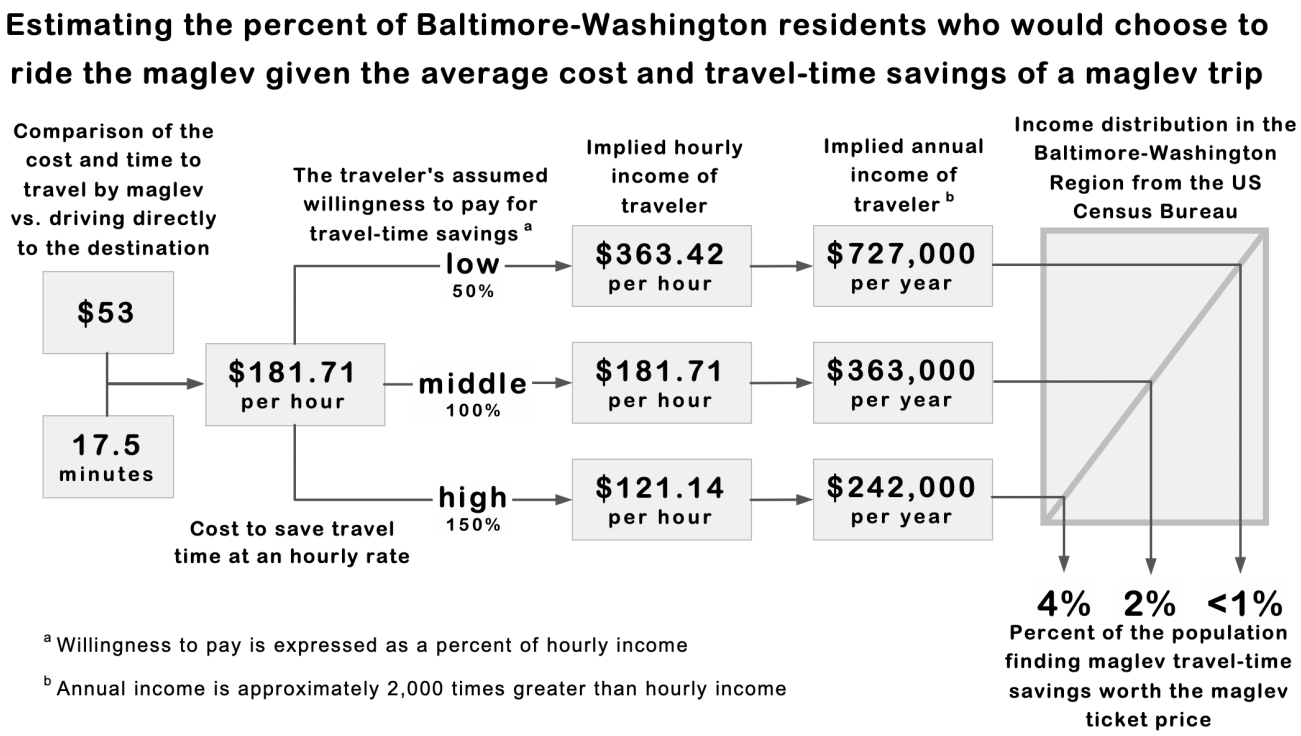

Figure 1. A schematic diagram showing a way to estimate the percentage of the population who would choose to ride the maglev given the average time savings and maglev ticket price. The percent calculated (approximately 2%) applies to an individual traveling alone, not a family traveling together.

The just-described calculation for an individual traveler is shown schematically in Figure 1.

For a family traveling together, the picture is even less rosy than for an individual traveling alone. With more than one wage earner in many families, household income is often greater than individual income, but a family of four would need four maglev tickets. Few families would think that it was a good deal to save a few minute on a trip between Baltimore and Washington by paying $160–$320 for 4 maglev tickets instead of driving and paying about $7 for gas and car maintenance. As shown in the appendix of the present article, annual household income would have to be above $1.6 million for a family of four to consider the maglev reasonably priced under these conditions. Fewer than 1% of households earn this much in the Baltimore-Washington region.

The calculations in the present article have so far assumed that people are willing to pay for travel-time savings at a rate of 100% of their hourly income. The next section varies this assumed value of willingness to pay.

Willingness to Pay

By analyzing many surveys and traffic studies, transportation modelers have found that people are typically willing to pay no more than about 50% to 150% of their hourly income in order to save an hour of travel time.[10]

[10] The appendix of the present article discusses the use of this rule of thumb in the transportation-modeling field.

If one varies the traveler's willingness to pay from 50% to 150%, then one arrives at a range of incomes at which the individual would see the maglev ticket price as worth the travel-time saved. The lower someone's willingness to pay, the higher their income would need to be before the maglev would seem attractive to them. The range of incomes is $242,000 and $727,000, as worked out in the appendix of the present article.

If most Baltimore-Washington residents had a low willingness to pay for travel-time savings, it would result in under 1% of individual workers finding the maglev attractive in the Baltimore-Washington region. If most of the region's residents had a high willingness to pay for travel-time-savings then approximately 4% of them would find the maglev an attractive option. Under no combination of assumptions would anywhere near a majority of the region's residents earn enough that the maglev's travel-time savings would, in their eyes, justify the maglev ticket price.

Serving the 2%, Kind of

In a sense, the 2% figure calculated in the present article overstates the market share of the proposed Baltimore-Washington maglev. The unmentioned issue is that the maglev would serve only a small portion of the region. In an article titled "The maglev would serve a small geographic area," Kelley (2021) showed that the maglev's three stations could save people travel time only on the small fraction of possible trips that happen to start and end fairly close to a maglev station.

Another approach to estimating the maglev's maximum-possible market share is to look at commuter data from the US Census. The Census Bureau has determined that under 1% of the region's workers commute between Baltimore and Washington to reach their job. This means that, even if the maglev could somehow capture all of these commuters, it would still be serving only 1% of the workforce.

The maglev would arbitrarily and disproportionally benefit the small fraction of the region's wealthy who happen to make frequent trips between downtown Baltimore and Washington and whose trips just happen to start and end near maglev stations. The rest of the wealthy would be poorly served by the maglev.

To put this information together, one might say that the maglev serves 1% of the 2%. That is to say, the people who would use the maglev both would be rich (2% of the population) and would also be geographically lucky, i.e., part of the 1% or so of the region's population who frequently travels between the two cities. [11]

Conclusion

The people who would ride the proposed Baltimore-Washington maglev would be drawn from the richest 2% of the region's population. The calculation that supports this prediction has two steps. In the first step, the concept of "willingness to pay" is used to estimate the income that an individual would need before the maglev

[11] The 2015 American Commuter Survey (ACS) of the US Census Bureau reported 1.829 million employed people in the following five jurisdictions: District of Columbia, Alexandria, Arlington County, City of Baltimore, and Baltimore County. The ACS also reported that 13,087 of these employed people either worked in Baltimore and lived in Washington or vise versa. See US Census Bureau 2014, 2015. These 5 jurisdictions are, to a first approximation, the geographic extent of the maglev ridership area as analyzed by Kelley (2021).

would seem like a good deal to them, given the maglev's ticket price and travel-time savings. In the second step, the income distribution reported in the US Census is used to determine what percent of the region's population earns this much.

Someone would have to earn at least $363,000 a year before the maglev's travel-time savings would seem worth its ticket price. Only 2% of workers earn this much in the Baltimore-Washington region.

Varying a person's willingness to pay for travel-time savings would result in a range for the minimum income needed for the maglev be an attractive option: an annual income of $242,000 to $727,000. Approximately 4% of workers in the Baltimore-Washington region reach the bottom of this income range and under 1% reach the top.

Broadly speaking, the people who would choose to ride the maglev would be more than mere millionaires. They would be earning another million dollars every few years.

While small, the 2% figure just described overstates the maglev's market share in one sense. The 2% figure was calculated from the set of travelers contemplating a certain kind of trip. Specifically, a trip in which the maglev would save them time, door to door, compared to other travel options like driving directly to their destination. But few trips start and end close enough to a maglev station to fit in this category, as discussed in the article "The maglev would serve a small geographic area" (Kelley 2021). The maglev does not always save you time especially if you have to drive out of your way to reach the maglev station, wait for the train, and then find a ride from the final maglev station to your actual destination.

The Federal Railroad Administration has mostly avoided the question of what portion of the region's population would make use of the maglev. One would hope, however, that elected officials would want to know if the proposed maglev would serve the region as a whole or if it would only serve a small number of wealthy people lucky enough to be living or working near one of the three maglev stations.

By remaining largely silent on this question, the Federal Railroad Administration has made it easier for maglev proponents to broadcast their message. Both before and after the draft impact statement was published, the website of Baltimore Washington Rapid Rail, the company that wants to build the maglev, has claimed that the maglev would be "highly valued" by "all income segments."

Disclaimer

This analysis was performed by an area resident, acting in his capacity as a individual citizen to examine a non-partisan issue of interest to the public. If errors are suspected, please contact the author at okelley@gmu.edu. Prior installments of this analysis have been published in the Greenbelt Online blog, https://www.greenbeltonline.org/.

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Appendix

This appendix describes Tables 1 and 2. These tables provide evidence for the conclusions drawn by the present article. Table 1 shows the minimum income that a customer would likely have if they found the maglev ticket price to be worth the limited amount of travel-time savings

relative to making the trip by car. Table 2 shows the income distribution for the region's residents. Taken together, these tables support the conclusion that approximately 2% of the region's workers would be wealthy enough to prefer the maglev over driving if contemplating a trip that would start and end close to one of the three proposed maglev stations.

Defining the Income Equation

The following equation calculates the minimum annual income required for someone to find the maglev to be an equally good deal as driving directly to the destination given the maglev ticket price and the limited travel-time savings associated with the maglev.

Equation (1)

$$I = (2{,}000 \text{ h y}^{-1})\ c\ (60 \text{ min. h}^{-1} \div t)\ (100\% \div w)$$

In Equation (1), variable I has units of dollars per year, and c (dollars) is the cost difference between riding the maglev and driving directly to the destination. The amount of travel time saved by riding the maglev is t (minutes). Variable w (percent) is the percent of hourly income that a customer is willingness to pay in order to save an hour of travel time. The initial factor of 2,000 converts from hourly income to annual income based on the round numbers of 40-hour workweeks and 50 workweeks per year.

For an individual traveler, the cost difference c is \$33 to \$73. This estimate is based on a maglev ticket price of \$40 to \$80 one way per person and also based on a \$7 cost of making the trip by car ([33,73] = [40,80] - 7).

A \$40-to-\$80 ticket price is used in the draft environmental impact statement (DEIS) to forecast the maglev's ridership. In this context, ridership is defined as how many one-way trips per year would be made on the maglev in the years 2030 or 2045.[12]

The \$7 cost of driving is calculated as follows. Fuel plus maintenance is \$7.08 for a 39.6-mile-long average trip between Washington and Baltimore. The fuel-plus-maintenance cost is the trip length multiplied by the AAA estimate of \$0.1787 for a typical car's per-mile cost for gas and maintenance (7.08 = 39.6 · 0.1787). Gas alone would cost only about \$3.94. Gas cost may be calculated based on the trip length, a typical car's fuel economy of 25.1 mile per gallon, and a fuel price of \$2.50 per gallon (3.94 = 2.50 · 39.6 ÷ 25.1). The last section of the present appendix discusses alternatives to the \$7 driving cost that is estimated in this paragraph.[13]

The cost difference c in Equation (1) would be greater for a family of four than for an individual traveler because the family would require 4 one-way maglev tickets or could travel together in a single car. For a family of four, the cost difference would be \$153 to \$313 (i.e., 4 · [40,80] - 7). For estimating a family's transportation choice when traveling together, it is plausible to consider their household income, while for an individual traveling alone, it is plausible to consider his or her individual income. At least such assumptions are acceptable when calculating a ballpark estimate to double-check the reasonableness of an official ridership forecast.

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[12] \$40–\$80 ticket price: Appendix D2, pg. D-107, D-108, "Final SCMAGLEV Fare Assumptions" section.

[13] 39.6-mile trip length: Appendix D4, Table D4-59, pg. E-82; miles per gallon: EPA 2019; approximate average dollars per gallon for 2015 to 2021: www.gasbuddy.com; \$0.1787/mile for medium sedan: AAA 2020.

In Equation (1), travel-time saved t is 8 to 27 minutes, a value stated in the DEIS.[14]

The quantity w in Equation (1) is known as "willingness to pay" in the transportation-modeling field. In this text, w is expressed as the percent of hourly earnings that that represents the maximum amount that the customer would be willing to pay in order to save an hour of travel time.

Willingness to Pay

Willingness to pay is an empirical guideline that the transportation-modeling profession has derived by summarizing many transportation studies.

Various studies recommend values for willingness to pay that are typically between 25% and 140% of hourly earnings. The US Department of Transportation (2016, Table 1, pg. 13) recommends 70% of pre-tax household income for commuters traveling on high-speed rail. Whittington and Cook (2017) recommend 25%–75% of after tax individual income. Khattak et al. (1993) suggest 50% of income, but state that the percentage becomes much lower (only 10%) if the new form of transportation is only a small improvement over the consumer's current form of transportation. Boardman et al. (2018, pg. 393) suggest 40%–50% of income as the willingness to pay if the travel is enjoyable. Willumsen (2014, pg. 89) suggests 50%–80% for commuting, 50%-60% for non-work travel, and 110%–130% for travel during work hours. Ortuzar and Willumsen (2011, pg. 511) suggest that commuting and non-work travel time is valued at 25%-43% of the hourly income of individual full-time workers. Meyer et al. (1999) suggest that travelers may be willing to spend more, 140% of hourly earnings, for travel that is either within office hours or occurring in heavy congestion.

Willingness to pay is a quantity that is used to forecast the transportation decision of an individual traveler within a model that forecasts the ridership of a transportation project. Willingness to pay should not be confused with another quantity that is usually called the "equity value of time." Confusion is possible, in part, because both quantitates are sometime referred to by the same acronym, VTTS, which stands for "value of travel-time saved."

Equity value of time is a quantity that is used in cost-benefit analysis. This quantity is used to calculate the total benefit to society of a transportation solution. Federal regulations stipulate that the same dollar value shall be attached to each person's travel time, regardless of that person's income. For the maglev, the DEIS used \$15.20 h^{-1} or \$27.10 h^{-1} as the equity value of time for personal or business travel, respectively. In this context, personal travel is defined as travel outside of office hours.[15]

Because the maglev tickets would be so expensive, the equity value of time just happens to be much lower than the willingness to pay that would be demonstrated by people who choose to ride the maglev (both quantities expressed in units of dollars per hour). There is nothing surprising about this occurring, but it is something to keep in mind to avoid confusion.

Evaluating the Income Equation

Equation (1) is evaluated multiple times to create Table 1. Table 1 shows the lower bound of someone's income if he or she finds that the

[14] 8–27 minutes saved travel time: Appendix D4, pg. C-6.

[15] See discussion in Chapter 5 of Willumsen (2014) and US DOT (2016); \$15.20/h and \$27.10/h: Appendix D4: pg. D-35.

maglev travel-time savings are worth the maglev ticket price. The table shows how the income cutoff varies with cost difference c, travel-time saved t, and willingness to pay w.

Looking at a middle case for travel-time savings and ticket cost, Table 1 reports that the lower bound to annual individual income is \$727,000, \$363,000, and \$242,000 for an individual traveling alone who is willing to pay up to 50%, 100%, or 150% of their individual hourly income to save an hour of travel time.

Table 2 shows that under 1% of workers in the Baltimore-Washington region would make the upper income quoted (\$727,000/year). Table 2 shows that 2%-3% of Washington-area residents and 1%-2% of Baltimore-area residents make the middle income quoted (\$363,000/year). The table shows that about 5% and 3% of Washington-area residents and Baltimore-area residents, respectfully, make the lower income quoted (\$242,000/year). For this reason, the main body of the present article states an average value of 2% or 4% for the fraction of workers in the entire region whose annual income is over \$363,000 or over \$242,000, respectively.

Now switch from considering an individual traveling alone, and consider a family of four traveling together. Because the cost of maglev tickets for a family of four is so much greater than the cost of driving, their household income would have to be truly extreme for them to choose to ride the maglev on a family outing. Table 1 shows that the necessary annual household income would be approximately \$1.6 million. The US Census shows that less than 1% of Washington-area households earn this much, as shown in Table 2 and as discussed in the next section.

US Census Data for Interpreting the Income Equation's Output

The US Census Bureau reports the distribution of individual and household income. Values are reported for the country as a whole and for smaller areas. The two areas used in the present article are called metropolitan statistical areas (MSAs). Washington and its surrounding suburbs constitute an MSA that is separate and not overlapping with the MSA that contains the City of Baltimore and its suburbs.

The Washington MSA has above-average income compared to the rest of the country. The percentiles are shown in Table 2. For example, 1% of Washington-area workers earn at least the amount stated in Table 2 for the 99th percentile of individual income. The income distribution in the Baltimore MSA is also above the national average, but not as high as the income distribution in the Washington MSA.

The income percentiles stated in Table 2 were obtained from the DQYDJ financial blog, https://dqydj.com/. The DQYDJ blog obtained the data from the IPUMS-CPS research center, https:/doi.org/10.18128/D030.V8.0. The IPUMS-CPS research center obtained the data from the US Census Bureau.

The individual income values listed in Table 2 represent pre-tax income per worker, not per capita. The stated value includes income from all sources including wages, investments, and government programs. Workers are included if they are at least 16 years old. The data were published in 2020, and they refer to income earned during the previous year, i.e., the 12 months from January through December, 2019.

Exaggerating the cost of driving would not make much difference

While the present article uses \$60 for the maglev-ticket price and \$7 for the cost of driving between

Baltimore and Washington, other sources suggest a lower maglev-ticket price and a higher estimate of the driving cost. These two possibilities do not alter the conclusions of the present article.

Various hints that maglev tickets would occasionally sell for $27 are not relevant to the maglev's official ridership forecast. The maglev's draft environmental impact statement (DEIS) states explicitly that it used a $40-to-$80 ticket price to calculate the ridership forecast.[16]

It is worth investigating the possibility that the average consumer may perceive a cost that is greater than $7 for making a one-way trip by car between Baltimore and Washington. The DEIS appears to use a cost of $16.24 for this car trip when calculating the maglev's official ridership forecast. The DEIS, however, is vague on this point. The Northeast Maglev is clear about its estimate of the cost of the car trip: $20.38. The Northeast Maglev is the parent company of the company that wants to build the maglev.[17]

These arguments miss the point. It does not matter that the Federal Railroad Administration and The Northeast Maglev can find ways to assign a high cost to driving between the two cities. What matters is whatever cost the consumer perceives for the car trip when that consumer is choosing among the available transportation options. Let's be real: driving between Baltimore and Washington costs just a few dollars for gas plus perhaps a few dollars set aside mentally for future car maintenance. The trip is so short that the needle of your car's gas gauge barely moves.[18]

Whether the consumer perceives that the cost of driving is closer to $7 or $16.24, it doesn't change the fact that riding the maglev would be financially attractive to only a small number of very wealthy people. For example, one can evaluate Equation (1) using $16.24 for the cost of driving and assuming that 83% of hourly income is what the customer is willing to pay for travel-time savings. The result of this calculation is the same as evaluating Equation (1) using a $7 driving cost and a willingness to pay of 100% of hourly income. Both 83% and 100% are within the reasonable range of values for willingness to pay, as discussed earlier in this appendix. [19]

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[16] $27 ticket price considered and rejected for $40–$80 ticket price: Appendix D2, pg. D-107, D-108, "Final SCMAGLEV Fare Assumptions" section.

[17] $16.24 for 39.6 miles or 0.41 per mile: DEIS, Appendix D4, Table D4-82; pg. D-32; $20.38 for 39.6 miles or 0.56 per mile: The Northeast Maglev Website (24 Apr 2021).

[18] A few dollars for gas: appendix of present article.

[19] Use $16.24 driving cost and 83% willingness to pay in Eq. (1) of the appendix of the present article to obtain $357,000 = 2,000 h y^{-1} · {$60 - $16.24} · (60 min. h^{-1} ÷ 17.5 min) · (100% ÷ 83%). This is essentially the same value as the $363,000 when a $7 driving cost and 100% willingness to pay was used earlier in the appendix.

Table 1. The cost of maglev-related travel-time savings (r, dollars per hour) and the income (I, dollars per year) of someone willing to pay that rate to save travel time. The incomes listed in the rightmost three columns are calculated using Equation (1) of the present article.

	Characteristics of a maglev trip, compared to driving			The traveler's minimum annual income for different values of willingness to pay, w [d]		
	Cost difference, c [b]	Travel-time saved, t	Cost per hour, r [c]	w = 50%	w = 100%	w = 150%
			Individual, traveling alone			
worst case [a]	\$73	8 minutes	\$548 h^{-1}	\$2.2 million	\$1.1 million	\$730,000
middle case	\$53	17.5 minutes	\$182 h^{-1}	\$727,000	\$363,000	\$242,000
best case [a]	\$33	27 minutes	\$73 h^{-1}	\$293,000	\$147,000	98,000
			Family of four, traveling together			
worst case	\$313	8 minutes	\$2,348 h^{-1}	\$9.4 million	\$4.7 million	\$3.1 million
middle case	\$233	17.5 minutes	\$799 h^{-1}	\$3.2 million	\$1.6 million	\$1.1 million
best case	\$153	27 minutes	\$340 h^{-1}	\$1.3 million	\$680,000	\$453,000

[a] The worse and best case refer to cases when the maglev is least or most attractive to travelers considering ticket price and the amount of travel-time saved.

[b] Excess cost per trip is the maglev price (the individual ticket price multiplied by the number of travelers) minus the \$7 per-vehicle cost of driving between Baltimore and Washington, as discussed in the present appendix.

[c] Cost per hour of travel-time saved is calculated as c (60 min $h^{-1} \div t$), using the values for c and t in the two columns to the left.

[d] Willingness to pay is the maximum amount of money that a traveler would be willing to pay to save travel time, expressed as a percent of the traveler's hourly income. The incomes stated in the rightmost three columns of this table are intended to represent the individual income of an individual traveling alone or the household income of a family traveling together.

Table 2. Annual income percentiles for individual workers and households in the Washington Metropolitan Statistical Area (MSA), the Baltimore MSA, and the entire United States.[a]

	Washington MSA		Baltimore MSA		United States	
Percentile	Individual[b]	Household	Individual[b]	Household	Individual[b]	Household
99th	$641,000	$910,000	$440,000	$654,000	$363,000	$531,000
98th	$408,000	$660,000	$266,000	$446,000	$257,000	$387,000
97th	$296,000	$522,000	$220,000	$345,000	$217,000	$329,000
95th	$238,000	$387,000	$178,000	$266,000	$176,000	$270,000
92nd	$197,000	$324,000	$149,000	$237,000	$140,000	$221,000
90th	$175,000	$302,000	$135,000	$229,000	$125,000	$201,000
85th	$149,000	$257,000	$116,000	$192,000	$101,000	$166,000
80th	$131,000	$220,000	$100,000	$169,000	$86,000	$142,000
75th	$113,000	$199,000	$90,000	$146,000	$75,000	$124,000
50th	$64,000	$121,000	$51,000	$88,000	$44,000	$68,000
25th	$30,000	$62,000	$25,000	$43,000	$23,000	$34,000
10th	$11,000	$32,000	$10,000	$20,000	$9,000	$16,000

[a] These statistics were published in 2020, and they represent the income reported for the prior 12 months, i.e., January through December, 2019. The data in the table were obtained from the DQYDJ investment blog (https://dqydj.com/income-by-city/) for the Washington and Baltimore MSAs. The statistics for US households were taken from https://dqydj.com/household-income-percentile-calculator/, and for US individual workers from https://dqydj.com/individual-income-by-year/. The DQYDJ blog obtain the data from the IPUMS-CPS research center (https:/doi.org/10.18128/D030.V8.0). The ultimate source of the data is the US Census Bureau.

[b] Individual means "per worker," not per capita.