Supplementary Information:

*The world’s user-generated road map is more than 80% complete*

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These resources are permanently housed at:
https://alum.mit.edu/www/cpbl/publications/PL0S2017roads
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A  Database road length models

We use the following functions to model the evolution of total mapped road length in each country (or region). In each case, \( y \) is the cumulative total street length in the database, while \( t \) represents the date, starting in March 2006. Except where specified in the case of Gompertz, all other parameters of each function are free parameters in the numerical optimization. Also, except for the linear function, which does not predict a saturation level nor date, \( y_{\text{max}} \) represents the predicted actual road length, towards which the road length in the OSM database converges.

**Linear:** This function is zero until some time \( t_0 \), after which it represents simple linear growth.

\[
y(t; t_0, m) = I(t > t_0) m (t - t_0)
\]

Here, and below, \( I(\cdot) \) is an indicator function, giving value 1 when its argument is true and 0 otherwise.

**Logistic function:** This is the classic “sigmoid” curve.

\[
y(t; k, y_{\text{max}}) = \frac{y_{\text{max}}}{1 + e^{-k(t - t_0)}}
\]

**Logistic with up to four jumps:** We introduce up to four jumps superposed on the logistic curve.

\[
y(t; t_0, k, y_{\text{min}}, y_{\text{max}}, \{t_i\}, \{\delta_i\}) = y_{\text{min}} + \sum_{i=1}^{4} I(t > t_i) \delta_i + \frac{[y_{\text{max}} - y_{\text{min}} - \sum_{i=1}^{4} \delta_i]}{1 + e^{-k(t - t_0)}}
\]

Here \( i \) ranges from 1 to 4 and the \( t_i \) are dates on which the road network length underwent a discontinuous increase. We also allow for 1, 2, or 3 jumps, rather than 4, as separate specifications.

**Gompertz:** The Gompertz function is another sigmoid curve which allows for asymmetry between the concave and convex regions.

\[
y(t; t_0, t_1; y_{\text{max}}, b, c) = y_{\text{max}} \exp \left( -b \exp \left( -c \frac{t - t_0}{t_1 - t_0} \right) \right)
\]

where \( t_0 \) and \( t_1 \) are fixed to be the first and last times in the time series.

The best fit is almost always obtained through the sigmoid functions with jumps. The linear fit produces the lowest mean-square error for just 1 country (Estonia), and the Gompertz function for 19 countries. The remaining countries are fit with a sigmoid function with no jump (2 countries), one jump (41), two jumps (44), three jumps (58), four jumps (84), or one ramp (4).

Where the model suggests that completeness is greater than one (i.e., the asymptote lies slightly below the maximum observed value), we code completeness as 1.0. In 22 countries, the model estimated completeness to be greater than 1.05. These are: Syrian Arab Republic, Ghana, Afghanistan, Burkina Faso, Malawi, Yemen, Haiti, Montenegro, Swaziland, New Caledonia, Gambia, Timor-Leste, Martinique, Cabo Verde, Brunei Darussalam, Barbados, Virgin Islands (U.S.), Dominica, Saint Vincent and the Grenadines, Kiribati, Liechtenstein, and Holy See. These countries tend to have experienced relatively recent rapid growth in the road network, and thus the parametric fit is likely to be less reliable—highlighting the value of using two independent methods to estimate completeness.

B  Sensitivity check: the lengths of missing edges

We analyzed the length of existing vs missing edges formally for five randomly selected countries: Great Britain, Malta, Angola, French Guiana, and Djibouti. We compared the edge length of ways that existed in the OSM database on January 1, 2016, and compared that to a version of the OSM database from November 7, 2016. In both cases, we used the osm2po segmenter (osm2po.de) and restricted the database to the OSM tags described in the section “Saturation of contributions” of the main text. In each country, the average edge length became shorter over the ~10-month period, implying that missing ways are also shorter. This makes sense given that longer edges are easier to include when tracing aerial imagery, and are less likely to be overlooked. Specifically, the reduction in length was 1.6% (Great Britain), 0.7% (Malta), 18.1% (Angola), 7.1% (French Guiana), and 11.2% (Djibouti). Note that the reduction in edge length is not solely due to newly added roads being shorter, but also arises when an existing edge is split by a newly added intersecting street.
## Table of estimated values

| Country   | Length (10^3 km) | Per capita (m) | Best | Multilevel model | Parametric fits |
|-----------|-----------------|----------------|------|-----------------|-----------------|
| World     | 40000           | 0.83           | 0.83 | (0.81–0.84)     | 0.97 (Logistic+2J) 0.87 | 0.95 |
| United States | 9100   | 29             | 0.99 | 0.99 (0.98–1.00) | 0.94 (Logistic+1J) 1.00 | 0.98 |
| China     | 6300            | 0.24           | 0.24 | (0.19–0.32)     | 0.72 (Logistic+4J) 0.74 | 0.69 |
| Russia    | 3600            | 0.42           | 0.42 | (0.40–0.51)     | 0.95 (Gompertz) 0.99 | 0.93 |
| India     | 2800            | 0.36           | 0.36 | (0.33–0.41)     | 0.91 (Logistic+4J) 0.89 | 0.92 |
| Japan     | 1300            | 1.00           | 0.97 | (0.95–0.97)     | 1.00 (Logistic+3J) 0.99 | 1.00 |
| Brazil    | 1200            | 1.00           | 1.03 | (1.00–1.06)     | 0.83 (Logistic+1J) 0.72 | 0.82 |
| France    | 1200            | 1.00           | 0.99 | (0.97–1.00)     | 1.00 (Logistic+4J) 0.98 | 0.97 |
| Canada    | 1100            | 0.99           | 0.99 | (0.98–1.00)     | 0.94 (Logistic+1J) 1.00 | 0.96 |
| Iran      | 1000            | 0.25           | 0.25 | (0.27–0.23)     | 0.54 (Logistic+1J) 0.68 | 0.37 |
| Pakistan  | 980             | 0.14           | 0.14 | (0.13–0.16)     | 0.51 (Logistic+2J) 0.30 | 0.31 |
| Australia | 750             | 1.00           | 1.04 | (1.02–1.05)     | 0.94 (Logistic+3J) 0.97 | 0.89 |
| Germany   | 740             | 1.00           | 1.00 | (0.99–1.00)     | 1.02 (Gompertz) 1.00 | 1.00 |
| Nigeria   | 670             | 0.36           | 0.36 | (0.31–0.42)     | 0.16 (Logistic+4J) 0.43 | 0.14 |
| Mexico    | 620             | 0.80           | 0.80 | (0.80–0.81)     | 0.87 (Logistic+3J) 0.48 | 0.37 |
| Turkey    | 600             | 0.79           | 0.82 | (0.81–0.82)     | 0.79 (Logistic+1J) 0.87 | 0.79 |
| Argentina | 600             | 1.00           | 1.03 | (1.02–1.03)     | 0.92 (Logistic+1R) 0.88 | 0.91 |
| Italy     | 580             | 1.00           | 0.98 | (0.97–1.00)     | 1.01 (Logistic+4J) 0.98 | 0.97 |
| DR Congo  | 560             | 0.34           | 0.34 | (0.22–0.52)     | 0.75 (Logistic+4J) 1.00 | 1.00 |
| Egypt     | 520             | 0.17           | 0.17 | (0.16–0.19)     | 1.00 (Gompertz) 1.00 | 1.00 |
| Kazakhstan| 520             | 0.29           | 0.29 | (0.22–0.39)     | 0.84 (Logistic+4J) 0.58 | 0.87 |
| Indonesia | 510             | 0.52           | 0.52 | (0.51–0.55)     | 0.93 (Logistic+4J) 0.84 | 0.91 |
| Spain     | 500             | 0.99           | 0.99 | (0.97–1.00)     | 0.93 (Gompertz) 0.97 | 0.94 |
| Afghanistan| 470             | 0.10           | 0.10 | (0.10–0.09)     | 1.32 (Logistic+1J) 1.07 | 1.00 |
| United Kingdom | 440     | 1.00           | 1.00 | (0.99–1.00)     | 1.00 (Gompertz) 0.99 | 1.00 |
| Ukraine   | 430             | 0.94           | 0.95 | (0.89–1.00)     | 0.94 (Logistic+3J) 0.93 | 0.96 |
| South Africa | 410      | 0.81           | 0.81 | (0.77–0.85)     | 1.00 (Logistic+3J) 1.00 | 1.00 |
| Uzbekistan| 360             | 0.26           | 0.26 | (0.22–0.31)     | 0.68 (Logistic+4J) 0.81 | 0.70 |
| Poland    | 350             | 1.00           | 1.01 | (1.01–1.02)     | 0.92 (Logistic+4J) 0.96 | 0.98 |
| Thailand  | 340             | 0.77           | 0.77 | (0.73–0.82)     | 0.89 (Logistic+3J) 0.90 | 0.89 |
| Sweden    | 290             | 0.91           | 0.94 | (0.91–0.98)     | 0.91 (Gompertz) 0.94 | 0.83 |
| Finland   | 210             | 1.00           | 1.01 | (0.99–1.04)     | 1.02 (Logistic+3J) 0.98 | 1.00 |
| Saudi Arabia | 210       | 0.84           | 0.84 | (0.79–0.89)     | 0.70 (Gompertz) 0.81 | 0.97 |
| Viet Nam  | 200             | 0.47           | 0.47 | (0.45–0.50)     | 0.92 (Logistic+2J) 0.90 | 0.93 |
| Tanzania  | 190             | 0.59           | 0.59 | (0.46–0.76)     | 1.02 (Logistic+2J) 0.82 | 0.31 |
| Bangladesh| 180             | 0.19           | 0.19 | (0.15–0.24)     | 0.84 (Logistic+1J) 0.64 | 0.89 |
| South Korea | 180        | 0.64           | 0.64 | (0.60–0.69)     | 0.99 (Logistic+4J) 0.97 | 0.92 |
| Philippines| 170           | 1.00           | 1.06 | (1.03–1.09)     | 0.92 (Logistic+3J) 0.97 | 0.91 |
| Mongolia  | 170             | 0.38           | 0.38 | (0.35–0.55)     | 0.92 (Logistic+4J) 0.98 | 0.92 |
| Ethiopia  | 170             | 0.42           | 0.42 | (0.33–0.55)     | 0.86 (Logistic+4J) 0.84 | 0.87 |
| Colombia  | 170             | 0.73           | 0.73 | (0.68–0.81)     | 0.91 (Gompertz) 0.94 | 0.82 |
| Algeria   | 160             | 0.98           | 0.98 | (0.96–1.01)     | 0.85 (Logistic+4J) 0.69 | 0.79 |
| Belarus   | 160             | 0.90           | 0.90 | (0.83–0.95)     | 1.01 (Logistic+3J) 0.99 | 0.98 |
| Romania   | 160             | 1.00           | 1.00 | (0.98–1.02)     | 0.46 (Gompertz) 0.73 | 0.75 |
| Greece    | 160             | 0.94           | 0.94 | (0.92–0.96)     | 0.89 (Logistic+3J) 0.76 | 0.86 |

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| Country       | Total (10^3 km) | Per capita (m) | Length (km) | Fraction complete |
|--------------|-----------------|----------------|-------------|------------------|
| Myanmar      | 160             | 3              | 0.47        | 0.47 (0.44–0.50) |
| Bolivia      | 150             | 14             | 1.00        | 1.12 (1.09–1.14) |
| Chile        | 150             | 8.5            | 1.00        | 1.00 (0.99–1.01) |
| Portugal     | 150             | 14             | 0.99        | 1.02 (1.01–1.03) |
| Peru         | 140             | 4.6            | 1.00        | 1.05 (1.03–1.07) |
| Mozambique   | 140             | 5.3            | 0.55        | 0.55 (0.45–0.70) |
| Netherlands  | 140             | 8.1            | 1.00        | 0.97 (0.96–0.98) |
| Iraq         | 130             | 4              | 0.65        | 0.65 (0.60–0.71) |
| Morocco      | 130             | 3.9            | 0.80        | 0.80 (0.79–0.82) |
| Austria      | 130             | 15             | 1.00        | 0.99 (0.99–1.00) |
| Venezuela    | 130             | 4.3            | 0.68        | 0.68 (0.69–0.68) |
| Norway       | 120             | 25             | 1.00        | 1.03 (1.00–1.05) |
| Ghana        | 120             | 4.9            | 0.45        | 0.45 (0.43–0.48) |
| Uganda       | 120             | 3.5            | 0.55        | 0.55 (0.44–0.67) |
| Czech Rep.   | 120             | 11             | 0.93        | 0.93 (0.89–0.96) |
| Kenya        | 110             | 2.6            | 0.71        | 0.71 (0.63–0.80) |
| Ireland      | 110             | 24             | 0.98        | 1.00 (1.00–1.01) |
| New Zealand  | 110             | 25             | 0.93        | 0.93 (0.88–0.97) |
| Angola       | 110             | 4.7            | 0.60        | 0.60 (0.59–0.62) |
| Belgium      | 1e+02           | 9.3            | 1.00        | 0.98 (0.98–0.99) |
| Zimbabwe     | 1e+02           | 7.1            | 0.68        | 0.68 (0.55–0.82) |
| Mali         | 99              | 6.2            | 0.94        | 0.94 (0.93–0.96) |
| Cote d’Ivoire| 98              | 4.6            | 0.61        | 0.61 (0.60–0.62) |
| Denmark      | 97              | 17             | 0.99        | 1.00 (1.00–1.00) |
| Sri Lanka    | 96              | 4.7            | 0.57        | 0.57 (0.50–0.64) |
| Malawi       | 91              | 5.8            | 0.32        | 0.32 (0.26–0.39) |
| Hungary      | 90              | 9.1            | 1.00        | 1.00 (1.00–1.01) |
| Malaysia     | 90              | 3.1            | 0.99        | 0.99 (0.96–1.01) |
| Syria        | 88              | 4.1            | 1.00        | 1.03 (1.00–1.07) |
| Cameroon     | 86              | 4              | 1.00        | 1.08 (0.99–1.17) |
| Libya        | 85              | 14             | 0.75        | 0.75 (0.72–0.80) |
| Ecuador      | 80              | 5.2            | 0.98        | 1.02 (0.99–1.04) |
| Sudan        | 78              | 2.1            | 0.87        | 0.87 (0.82–0.94) |
| Bulgaria     | 78              | 11             | 0.97        | 0.97 (0.94–1.00) |
| Madagascar   | 74              | 3.3            | 0.59        | 0.59 (0.50–0.71) |
| Zambia       | 74              | 5              | 0.72        | 0.72 (0.64–0.86) |
| Taiwan       | 73              | 0.91           |             | 0.91 (0.91–0.91) |
| Switzerland  | 73              | 9.1            | 1.00        | 1.00 (0.99–1.00) |
| Lithuania    | 72              | 24             | 0.97        | 0.97 (0.94–0.99) |
| Nepal        | 68              | 2.5            | 1.00        | 2.46 (2.32–2.57) |
| Croatia      | 62              | 15             | 0.94        | 0.95 (0.92–0.98) |
| North Korea  | 62              | 2.5            | 0.66        | 0.66 (0.55–0.77) |
| Botswana     | 61              | 29             | 0.61        | 0.61 (0.57–0.67) |
| Azerbaijan   | 61              | 6.6            | 0.71        | 0.71 (0.66–0.78) |
| Guatemala    | 61              | 4              | 0.47        | 0.47 (0.42–0.53) |
| Namibia      | 60              | 26             | 0.93        | 0.93 (0.90–0.95) |
| Cuba         | 60              | 5.3            | 1.00        | 0.95 (0.94–0.97) |

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| Country          | Length | Fraction complete | Country | Parametric fits |
|------------------|--------|-------------------|---------|-----------------|
| Latvia 1         | 54     | 0.99              | Latvia 1 | 0.99 (Logistic+1J) |
| Georgia 1        | 54     | 1.00              | Georgia 1 | 1.01 (Logistic+1J) |
| Serbia 1         | 53     | 1.00              | Serbia 1 | 1.00 (Logistic+3J) |
| Chad 1           | 53     | 0.58              | Chad 1   | 1.05 (Logistic+2J) |
| Tajikistan 1     | 52     | 0.37              | Tajikistan 1 | 0.37 (Logistic+4J) |
| Tunisia 1        | 52     | 0.93              | Tunisia 1 | 0.93 (Logistic+4J) |
| Paraguay 1       | 52     | 1.00              | Paraguay 1 | 1.00 (Logistic+4J) |
| South Sudan 1    | 52     | 0.58              | South Sudan 1 | 0.22 (Logistic+3J) |
| Guinea 1         | 51     | 1.00              | Guinea 1 | 0.84 (Logistic+4J) |
| Cambodia 1       | 49     | 0.75              | Cambodia 1 | 0.91 (Logistic+2J) |
| Estonia 1        | 45     | 0.96              | Estonia 1 | 0.86 (Gompertz) |
| Kyrgyzstan 1     | 44     | 0.85              | Kyrgyzstan 1 | 0.94 (Logistic+1J) |
| Burkina Faso 1   | 44     | 0.93              | Burkina Faso 1 | 1.23 (Logistic+4J) |
| Senegal 1        | 44     | 0.70              | Senegal 1 | 1.03 (Logistic+3J) |
| Dominican Rep. 1 | 43     | 0.76              | Dominican Rep. 1 | 0.89 (Logistic+1J) |
| Oman 1           | 42     | 0.86              | Oman 1   | 0.66 (Logistic+4J) |
| UAE 1            | 42     | 1.00              | UAE 1    | 0.93 (Logistic+3J) |
| Slovakia 1       | 41     | 1.00              | Slovakia 1 | 1.01 (Logistic+1J) |
| Benin 1          | 40     | 0.82              | Benin 1  | 0.31 (Logistic+1J) |
| Yemen 1          | 38     | 0.73              | Yemen 1  | 1.10 (Logistic+4J) |
| Bosnian & Herz. 1| 37     | 0.97              | Bosnian & Herz. 1 | 0.97 (Logistic+2J) |
| Sierra Leone 1   | 36     | 0.84              | Sierra Leone 1 | 0.84 (Logistic+2J) |
| Puerto Rico 1    | 35     | 0.99              | Puerto Rico 1 | 0.99 (Logistic+2J) |
| Honduras 1       | 35     | 0.64              | Honduras 1 | 0.64 (Logistic+2J) |
| Costa Rica 1     | 34     | 0.93              | Costa Rica 1 | 1.03 (Logistic+4J) |
| Laos 1           | 33     | 0.78              | Laos 1   | 0.78 (Logistic+4J) |
| Moldova 1        | 33     | 1.00              | Moldova 1 | 1.02 (Logistic+1J) |
| Rwanda 1         | 32     | 0.44              | Rwanda 1  | 1.01 (Logistic+1J) |
| Turkmenistan 1   | 32     | 0.77              | Turkmenistan 1 | 0.62 (Logistic+2J) |
| Jordan 1         | 31     | 1.00              | Jordan 1  | 1.03 (Logistic+4J) |
| Slovenia 1       | 31     | 1.00              | Slovenia 1 | 0.90 (Gompertz) |
| Niger 1          | 30     | 0.91              | Niger 1  | 1.03 (Logistic+1J) |
| Somalia 1        | 29     | 0.98              | Somalia 1 | 0.98 (Logistic+1J) |
| Israel 1         | 29     | 0.98              | Israel 1  | 0.98 (Gompertz) |
| Albania 1        | 29     | 0.75              | Albania 1 | 0.88 (Logistic+3J) |
| Uruguay 1        | 28     | 1.00              | Uruguay 1 | 1.00 (Logistic+1J) |
| C. African Rep. 1| 25     | 0.99              | C. African Rep. 1 | 0.99 (Logistic+3J) |
| Togo 1           | 25     | 0.77              | Togo 1    | 0.50 (Logistic+1J) |
| El Salvador 1    | 25     | 0.75              | El Salvador 1 | 0.69 (Logistic+4J) |
| Nicaragua 1      | 24     | 0.86              | Nicaragua 1 | 0.47 (Logistic+2J) |
| Liberia 1        | 23     | 0.87              | Liberia 1 | 0.98 (Logistic+2J) |
| Bhutan 1         | 22     | 0.17              | Bhutan 1  | 0.78 (Logistic+2J) |
| Armenia 1        | 22     | 0.94              | Armenia 1 | 0.94 (Logistic+4J) |
| Burundi 1        | 22     | 0.87              | Burundi 1 | 0.96 (Logistic+3J) |
| Papua New Guinea | 22     | 0.75              | Papua New Guinea | 0.75 (Logistic+4J) |
| Congo 1          | 21     | 0.92              | Congo 1   | 0.58 (Logistic+2J) |
| Iceland 1        | 20     | 0.95              | Iceland 1 | 1.03 (Logistic+1J) |

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| Country        | Length Total ($10^3$ km) | Length Per capita (m) | Best Multilevel model | Fraction complete Country-level From sub-geography | Parametric fits From quintiles |
|---------------|--------------------------|-----------------------|-----------------------|--------------------------------------------------|--------------------------------|
| Lebanon       | 18                       | 4.2                   | 0.79 (0.75–0.83)      | 0.97 (Logistic+1J)                                | 0.26                           |
| Mauritania    | 18                       | 4.8                   | 0.80 (0.72–0.96)      | 0.80 (Logistic+3J)                                | 0.90                           |
| Panama        | 17                       | 4.6                   | 0.94 (0.85–0.94)      | 0.94 (Logistic+4J)                                | 0.94                           |
| Haiti         | 17                       | 1.6                   | 0.94 (0.93–0.96)      | 1.05 (Logistic+2J)                                | 0.95                           |
| Macedonia     | 14                       | 7                     | 1.00 (1.02–1.04)      | 0.88 (Logistic+4J)                                | 0.75                           |
| Palestine     | 14                       | 3.4                   | 1.00                  | 1.01 (Logistic+4J)                                | 1.00                           |
| Lesotho       | 13                       | 6.5                   | 0.99 (0.93–1.05)      | 0.59 (Logistic+4J)                                | 0.32                           |
| Kosovo        | 13                       | 7.2                   | 0.94 (0.87–0.97)      | 0.94 (Logistic+4J)                                | 1.00                           |
| Jamaica       | 13                       | 4.7                   | 1.00 (1.04–1.10)      | 0.59 (Logistic+4J)                                | 0.49                           |
| Cyprus        | 12                       | 11                    | 0.97 (0.98–0.99)      | 0.97 (Logistic+2J)                                | 1.00                           |
| Samoa         | 12                       | 61                    | 0.10 (0.01–0.22)      | 0.96 (Logistic+3J)                                | 0.96                           |
| Kuwait        | 11                       | 3.3                   | 1.00 (0.94–0.97)      | 1.04 (Logistic+3J)                                | 1.00                           |
| Gabon         | 11                       | 6.8                   | 1.00 (1.07–1.13)      | 0.30 (Logistic+2J)                                | 0.80                           |
| Montenegro    | 11                       | 17                    | 1.00 (1.05–1.09)      | 1.08 (Logistic+2J)                                | 0.99                           |
| Guinea-Bissau | 11                       | 6.3                   | 0.27 (0.25–0.30)      | 0.79 (Logistic+4J)                                | 0.80                           |
| Qatar         | 11                       | 5.3                   | 0.92 (0.91–0.93)      | 0.99 (Logistic+2J)                                | 0.98                           |
| Swaziland     | 10                       | 8.4                   | 0.82 (0.74–0.89)      | 1.07 (Logistic+1J)                                | 1.00                           |
| Trinidad      | 9.9                      | 7.4                   | 1.00 (0.98–0.99)      | 1.05 (Logistic+1J)                                | 1.00                           |
| Gambia        | 7.7                      | 4.2                   | 0.61 (0.59–0.64)      | 1.08 (Logistic+4J)                                | 1.00                           |
| Western Sahara| 7.5                      |                       | 0.98                  | 0.98 (Logistic+1J)                                | 0.99                           |
| Eritrea       | 7.1                      | 1.5                   | 0.82 (0.77–0.86)      | 1.03 (Logistic+2J)                                | 0.86                           |
| Fiji          | 7.1                      | 8.1                   | 0.70 (0.69–0.84)      | 0.99 (Logistic+3J)                                | 1.00                           |
| Eq. Guinea    | 7                        | 9                     | 0.61 (0.49–0.81)      | 0.99 (Logistic+4J)                                | 1.00                           |
| Luxembourg    | 6.2                      | 12                    | 1.00 (0.98–1.00)      | 1.03 (Logistic+4J)                                | 0.98                           |
| Reunion       | 6.1                      |                       | 0.97                  | 0.97 (Logistic+1J)                                | 0.99                           |
| Suriname      | 5.7                      | 11                    | 0.97 (0.99–1.00)      | 0.97 (Logistic+2J)                                | 0.97                           |
| Belize        | 5.5                      | 16                    | 1.00 (0.93–1.02)      | 1.00 (Logistic+2J)                                | 1.00                           |
| Bahamas       | 5.4                      | 15                    | 1.00 (1.01–1.03)      | 1.02 (Logistic+4J)                                | 0.92                           |
| Timor-Leste   | 5.1                      | 4.4                   | 0.69 (0.63–0.77)      | 1.05 (Logistic+3J)                                | 0.99                           |
| Guyana        | 4.8                      | 6.3                   | 1.00 (1.14–1.17)      | 1.04 (Logistic+3J)                                | 0.79                           |
| New Caledonia | 4.7                      | 18                    | 1.00                  | 1.05 (Logistic+4J)                                | 1.00                           |
| N. Cyprus     | 4.6                      |                       | 0.99                  | 0.99 (Logistic+3J)                                | 1.00                           |
| Mauritius     | 4.4                      | 3.5                   | 0.71 (0.65–0.78)      | 0.97 (Logistic+3J)                                | 0.97                           |
| Guadeloupe    | 4.3                      |                       | 1.00                  | 1.04 (Logistic+2J)                                | 1.00                           |
| Djibouti      | 4.2                      | 5                     | 0.42 (0.39–0.52)      | 0.97 (Logistic+2J)                                | 1.00                           |
| Singapore     | 4.2                      | 0.79                  | 1.00 (1.01–1.01)      | 1.02 (Logistic+3J)                                | 1.00                           |
| Bahrain       | 3.8                      | 2.8                   | 0.98 (1.01–1.02)      | 0.98 (Logistic+3J)                                | 0.92                           |
| Hong Kong     | 3.4                      | 0.48                  | 0.98                  | 0.98 (Logistic+1J)                                | 0.98                           |
| Martinique    | 3.1                      |                       | 1.00                  | 1.10 (Logistic+2J)                                | 1.00                           |
| Solomon Isl.  | 2.9                      | 5.3                   | 0.51 (0.40–0.72)      | 1.02 (Logistic+4J)                                | 0.99                           |
| Brunei        | 2.6                      | 6.4                   | 0.88 (0.84–0.92)      | 1.08 (Logistic+4J)                                | 1.00                           |
| Cabo Verde    | 2.3                      | 4.6                   | 1.00 (1.08–1.11)      | 1.09 (Logistic+4J)                                | 0.97                           |
| Vanuatu       | 2.3                      | 9.2                   | 1.00 (1.32–1.60)      | 0.87 (Logistic+4J)                                | 0.78                           |
| Comoros       | 2.2                      | 3.1                   | 0.56 (0.35–0.82)      | 1.02 (Logistic+4J)                                | 0.99                           |
| Malta         | 2.2                      | 5.3                   | 1.00 (1.03–1.04)      | 1.04 (Logistic+2J)                                | 1.00                           |
| Barbados      | 2.1                      | 7.3                   | 1.00                  | 1.14 (Logistic+2J)                                | 1.00                           |
| Fr. Polynesia | 1.9                      | 7.1                   | 1.00                  | 1.00 (Logistic+3J)                                | 1.00                           |

Continued on next page
| Country              | Length | Fraction complete | Best | Multilevel model | Parametric fits |
|---------------------|--------|-------------------|------|-----------------|-----------------|
|                     | Total  | Per capita |       |                 | Country-level | From sub- | From quintiles |
|                     | (10^3 km) | (m)        |      |                 | From geography | quintiles |
| Fr. Guiana          | 1.9    | 1.00        | 1.00 | 1.03 (Logistic+2J) | 1.00           | 1.00       |
| Curacao             | 1.7    | 0.99        | 0.99 | 0.99 (Logistic+2J) | 0.99           | 0.95       |
| Guam                | 1.7    | 1.00        | 1.00 | 1.01 (Logistic+2J) | 1.00           | 1.00       |
| Aland Islands       | 1.5    | 1.00        | 1.00 | 1.02 (Logistic+4J) | 0.96           | 1.00       |
| US Virgin Isl.      | 1.5    | 1.00        | 1.00 | 1.06 (Logistic+4J) | 1.00           | 1.00       |
| St. Kitts & Nevis   | 1.4    | 0.41        | 0.41 | 0.41 (Logistic+2J) | 1.00           | 1.00       |
| Falkland Isl.       | 1      | 0.98        | 0.98 | 0.98 (Logistic+1J) | 0.98           | 0.99       |
| Saint Lucia         | 0.99   | 0.93        | 0.93 | 0.93 (Logistic+4J) | 1.00           | 0.40       |
| Dominica            | 0.98   | 1.14 (1.14–1.15) | 1.06 (Logistic+4J) | 1.00 | 1.00       |
| Aruba               | 0.98   | 0.95        | 0.95 | 0.95 (Logistic+3J) | 0.95           | 1.00       |
| Isle of Man         | 0.98   | 1.00        | 1.00 | 1.02 (Logistic+1R) | 1.00           | 1.00       |
| Maldives            | 0.93   | 1.40 (1.37–1.43) | 1.05 (Logistic+4J) | 1.00 | 1.00       |
| Faroe Islands       | 0.92   | 1.00        | 1.00 | 1.03 (Logistic+1J) | 1.00           | 1.00       |
| Grenada             | 0.92   | 0.98 (0.95–1.00) | 0.94 (Logistic+1J) | 0.81 | 0.94       |
| N. Mariana Isl.     | 0.76   | 0.94        | 0.94 (Logistic+4J) | 0.00 | 0.98       |
| Cayman Isl.         | 0.74   | 1.00        | 1.01 (Logistic+4J) | 0.95 | 0.99       |
| Akrotiri Dhekelia   | 0.67   | 0.96        | 0.96 (Logistic+3J) | 1.00 | 0.99       |
| Jersey              | 0.63   | 0.98        | 0.98 (Logistic+1J) | 0.93 | 0.96       |
| Turks & Caicos      | 0.62   | 1.00        | 1.00 (Logistic+3J) | 0.02 | 1.00       |
| St. Vincent         | 0.57   | 1.12 (Logistic) | 1.00 | 1.00 | 1.00       |
| Bonaire             | 0.57   | 0.92        | 0.92 (Logistic+3J) | 1.00 | 1.00       |
| Mayotte             | 0.55   | 1.00        | 1.02 (Logistic+4J) | 1.00 | 1.00       |
| Sao Tome            | 0.51   | 0.99        | 0.99 (Logistic+2J) | 0.99 | 0.94       |
| Greenland           | 0.49   | 0.94        | 0.94 (Logistic+3J) | 1.00 | 0.79       |
| Guernsey            | 0.48   | 1.00        | 1.02 (Logistic+1J) | 1.00 | 1.00       |
| Bermuda             | 0.47   | 1.00        | 1.02 (Logistic+4J) | 0.99 | 1.00       |
| Seychelles          | 0.46   | 1.05 (1.01–1.09) | 1.00 (Logistic+3J) | 0.02 | 0.97       |
| Andorra             | 0.43   | 1.00        | 1.05 (Logistic+4J) | 1.00 | 0.98       |
| Macao               | 0.4    | 1.00        | 1.04 (Logistic+3J) | 1.00 | 0.99       |
| Micronesia          | 0.39   | 1.00        | 1.07 (1.03–1.09) | 0.92 (Logistic+4J) | 0.96 | 1.00       |
| Liechtenstein       | 0.37   | 1.00        | 1.06 (Logistic+1J) | 0.00 | 1.00       |
| Am. Samoa           | 0.36   | 0.87        | 0.87 (Logistic+4J) | 0.89 | 0.13       |
| Br. Virgin Isl.     | 0.34   | 0.98        | 0.98 (Logistic+2J) | 0.93 | 0.95       |
| San Marino          | 0.32   | 1.00        | 1.00 (Gompertz) | 0.50 | 0.86       |
| Cook Isl.           | 0.31   | 1.00        | 1.05 (Logistic+3J) | 1.00 | 0.98       |
| Palau               | 0.3    | 1.01 (1.01–1.01) | 1.00 (Logistic+4J) | 0.91 | 0.96       |
| Anguilla            | 0.24   | 0.90        | 0.90 (Logistic+4J) | 0.90 | 0.91       |
| Wallis & Futuna     | 0.22   | 0.98        | 0.98 (Logistic+3J) | 0.98 | 1.00       |
| St. Maarten         | 0.22   | 0.95        | 0.95 (Logistic+3J) | 0.95 | 0.92       |
| St. Helena          | 0.21   | 1.00        | 1.01 (Logistic+1J) | 1.00 | 1.00       |
| Marshall Isl.       | 0.18   | 1.00        | 1.01 (1.00–1.02) | 1.02 (Logistic+4J) | 1.00 | 0.92       |
| St. Martin          | 0.18   | 1.00        | 1.01 (Logistic+3J) | 1.00 | 0.93       |
| Montserrat          | 0.14   | 1.00        | 1.01 (Logistic+4J) | 1.00 | 0.90       |
| St. Pierre          | 0.13   | 0.95        | 0.95 (Logistic+1J) | 1.00 | 0.99       |
| Niue                | 0.13   | 1.00        | 1.00 (Logistic+4J) | 1.00 | 1.00       |
| Svalbard            | 0.12   | 0.76        | 0.76 (Logistic+3J) | 0.76 | 0.87       |
| St. Barthelemy      | 0.1    | 1.00        | 1.05 (Logistic+4J) | 1.00 | 0.97       |

Continued on next page
| Country                          | Length           | Fraction complete | Best   | Multilevel model | Parametric fits |
|---------------------------------|------------------|-------------------|--------|------------------|-----------------|
|                                 | Total (10^3 km)  |                   |        |                  | Country-level   | From sub-        | From quintiles  |
|                                 | Per capita (m)   |                   |        |                  | geography       | quintiles       |                |
| US Outlying Isl.                | 0.08             | 0.52              |        | 0.52 (Logistic+4J) | 0.02            |
| Christmas Isl.                  | 0.08             | 1.00              |        | 1.03 (Logistic+2J) | 1.00 0.25       |
| Norfolk Isl.                    | 0.079            | 0.99              |        | 0.99 (Logistic+2J) | 0.99 0.97       |
| Gibraltar                       | 0.073            | 0.97              |        | 0.97 (Logistic+4J) | 0.97 0.94       |
| Br. Ind. Ocean Terr.            | 0.068            | 0.94              |        | 0.94 (Logistic+3J) | 0.94            |
| Monaco                          | 0.056 (1.5)      | 0.98              |        | 0.98 (Logistic+3J) | 0.98 0.94       |
| Tuvalu                          | 0.052 (5.2)      | 1.00 1.39 (1.38–1.39)|    | 0.81 (Logistic+2J) | 0.00 0.80       |
| Nauru                           | 0.046            | 0.95              |        | 0.95 (Logistic+4J) | 1.00 0.76       |
| Cocos Isl.                      | 0.021            | 1.00              |        | 1.02 (Logistic+2J) | 1.00 0.94       |
| Fr. S. Terr.                    | 0.0065           | 0.93              |        | 0.93 (Logistic+1J) | 1.00            |
| Holy See                        | 0.0058           | 1.00              |        | 1.05 (Logistic+2J) | 1.00 0.68       |
| Paracel Isl.                    | 0.0056           | 0.98              |        | 0.98 (Logistic+4J) | 0.98            |
| Tokelau                         | 0.004            | 0.63              |        | 0.63 (Logistic)   | 0.00 0.00       |
| Spratly Isl.                    | 0.00064          | 1.00              |        | 1.00 (Gompertz)   | 1.00            |
| Antigua                         | 0.00 (0.00–0.01) | 0.00 (0.00–0.01)  |        | 1.05 (Logistic+1J) | 0.94 0.84       |
| Kiribati                        | 0.04 (0.00–0.09) | 0.04 (0.00–0.09)  |        | 1.14 (Logistic+1J) | 1.00 1.00       |
| Pitcairn                        | 0.05             | 0.05              |        | 0.05 (Logistic+1R) | 0.05 0.06       |
| S. Georgia                      | 0.00             | 0.00              |        | 0.00 (Logistic+1R) | 0.00            |
| Tonga                           | 0.01 (0.00–0.02) | 0.01 (0.00–0.02)  |        | 0.82 (Logistic+4J) | 0.99 0.74       |
D Comparison of fits by country
Fraction complete, January 2016

Visual assessment
Point estimate
Bootstrap (95pc CI)
Multilevel model (95pc CI)
Parametric model
Country-level fit
Sub-country fit
Density quintile fit
E  Parametric fits
Iran
Nigeria
Finland
DR Congo
Saudi Arabia
Philippines
Algeria
Romania
Kazakhstan
Greece
Bolivia
Chile
Belarus
Portugal
Peru
Pakistan
Netherlands
Austria
Norway
Colombia
South Korea
Czech Rep.
Tanzania

Actual
Density quintiles
Predicted
Asymptote
Visual assessment:
Multilevel estimate
95% CI
Actual
Density quintiles
Predicted
Asymptote
Visual assessment:
Multilevel estimate
95% CI
Guam
Curacao
Aland Islands
US Virgin Isl.
Solomon Isl.
Comoros
Tonga
Antigua
Samoa
Falkland Isl.
Dominica
Isle of Man
Maldives
Aruba
Saint Lucia
Faroe Islands
Grenada
Cayman Isl.
N. Mariana Isl.
Akrotiri Dhekelia
Jersey
Turks and Caicos
St. Kitts and Nevis

Actual
Density quintiles
Predicted
Asymptote
Visual assessment:
Multilevel estimate
95% CI
F  Parametric fits by decile and world region
Low income

All deciles

Density decile 1

Density decile 2

Density decile 3

Density decile 4

Density decile 5

Density decile 6

Density decile 7

Density decile 8

Density decile 9

Density decile 10

 sigmoid-with-3-jumps

 sigmoid-with-2-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-3-jumps

 sigmoid-with-2-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps

 sigmoid-with-1-jumps

 sigmoid-with-4-jumps
Heavily indebted poor countries (HIPC)
Upper middle income

- All deciles
- Density decile 1
- Density decile 2
- Density decile 3
- Density decile 4
- Density decile 5
- Density decile 6
- Density decile 7
- Density decile 8
- Density decile 9
- Density decile 10

- sigmoid-with-2-jumps
- gompertz
- Density decile 1
- gompertz
- Density decile 2
- sigmoid-with-1-jumps
- Density decile 3
- sigmoid-with-jumps
- Density decile 4
- sigmoid-with-1-jumps
- Density decile 5
- sigmoid-with-2-jumps
- Density decile 6
- sigmoid-with-3-jumps
- Density decile 7
- sigmoid-with-1-jumps
- Density decile 8
- sigmoid-with-2-jumps
- Density decile 9
- sigmoid-with-3-jumps
- Density decile 10
- sigmoid-with-4-jumps

- Actual
- Predicted
- Asymptote
IDA blend

All deciles

Density decile 1

Density decile 2

Density decile 3

Density decile 4

Density decile 5

Density decile 6

Density decile 7

Density decile 8

Density decile 9

Density decile 10
Least developed countries: UN classification

- **All deciles**: 
  - sigmoid-with-4-jumps
  - Density decile 1: sigmoid-with-2-jumps
  - Density decile 2: sigmoid-with-4-jumps
  - Density decile 3: sigmoid-with-2-jumps
  - Density decile 4: sigmoid-with-4-jumps
  - Density decile 5: sigmoid-with-1-jumps
  - Density decile 6: sigmoid-with-4-jumps
  - Density decile 7: sigmoid-with-4-jumps
  - Density decile 8: sigmoid-with-3-jumps
  - Density decile 9: sigmoid-with-4-jumps
  - Density decile 10: sigmoid-with-2-jumps

- **Actual**, **Predicted**, and **Asymptote**

**Least developed countries: UN classification**
Fragile and conflict affected situations

All deciles

Density decile 1

Density decile 2

Density decile 3

Density decile 4

Density decile 5

Density decile 6

Density decile 7

Density decile 8

Density decile 9

Density decile 10

Actual

Predicted

Asymptote

Fragile and conflict affected situations
Central Europe and the Baltics

All deciles
Density decile 1
Density decile 2
Density decile 3
Density decile 4
Density decile 5
Density decile 6
Density decile 7
Density decile 8
Density decile 9
Density decile 10

 sigmoid-with-3-jumps
 sigmoid-with-2-jumps
 sigmoid-with-3-jumps
 sigmoid-with-2-jumps
 sigmoid-with-3-jumps
 sigmoid-with-2-jumps
 sigmoid-with-3-jumps
 sigmoid-with-2-jumps
 sigmoid-with-4-jumps
 sigmoid-with-2-jumps

Actual
Predicted
Asymptote

2009 2012 2015

Central Europe and the Baltics
Other small states

All deciles

Density decile 1

Density decile 2

Density decile 3

Density decile 4

Density decile 5

Density decile 6

Density decile 7

Density decile 8

Density decile 9

Density decile 10

- Actual
- Predicted
- Asymptote
Europe and Central Asia (all income levels)

All deciles

Density decile 1

Density decile 2

Density decile 3

Density decile 4

Density decile 5

Density decile 6

Density decile 7

Density decile 8

Density decile 9

Density decile 10

2009  2012  2015

Actual

Predicted

Asymptote

Europe and Central Asia (all income levels)
Africa

All deciles

Density decile 1

Density decile 2

Density decile 3

Density decile 4

Density decile 5

Density decile 6

Density decile 7

Density decile 8

Density decile 9

Density decile 10

Actual

Predicted

Asymptote

Africa
East Asia and Pacific (all income levels)

**All deciles**

- Density decile 1
- Density decile 2
- Density decile 3
- Density decile 4
- Density decile 5
- Density decile 6
- Density decile 7
- Density decile 8
- Density decile 9
- Density decile 10

2009 2012 2015

Actual
Predicted
Asymptote
Caribbean small states

All deciles

Density decile 1

Density decile 2

Density decile 3

Density decile 4

Density decile 5

Density decile 6

Density decile 7

Density decile 8

Density decile 9

Density decile 10

Actual
Predicted
Asymptote

Caribbean small states

gompertz

sigmoid-with-3-jumps

Density decile 1

sigmoid-with-2-jumps

Density decile 2

sigmoid-with-1-jumps

Density decile 3

sigmoid-with-3-jumps

Density decile 4

sigmoid-with-3-jumps

Density decile 5

sigmoid-with-4-jumps

Density decile 6

sigmoid-with-3-jumps

Density decile 7

sigmoid-with-3-jumps

Density decile 8

sigmoid-with-1-jumps

Density decile 9

sigmoid-with-3+jumps

Density decile 10

sigmoid-with-1-jumps

2009 2012 2015
Middle East and North Africa (all income levels)

- All deciles
- Density decile 1
- Density decile 2
- Density decile 3
- Density decile 4
- Density decile 5
- Density decile 6
- Density decile 7
- Density decile 8
- Density decile 9
- Density decile 10

Actual
Predicted
Asymptote

Middle East and North Africa (all income levels):

gompertz
Density decile 1
gompertz
Density decile 2
gompertz
Density decile 3
gompertz
Density decile 4
gompertz
Density decile 5
sigmoid-with-4-jumps
Density decile 8
sigmoid-with-3-jumps
Density decile 9
sigmoid-with-4-jumps
Density decile 10
Arab World

All deciles

gompertz

Density decile 1

gompertz

Density decile 2

gompertz

Density decile 3

gompertz

Density decile 4

justaline

Density decile 5

justaline

Density decile 6

gompertz

Density decile 7

gompertz

Density decile 8

sigmoid-with-3-jumps

Density decile 9

sigmoid-with-4-jumps

Density decile 10

sigmoid-with-4-jumps

Actual

Predicted

Asymptote

2009 2012 2015
| model                     | coefficient | variable       | posterior-mean | 5th-percentile | 95th-percentile |
|--------------------------|-------------|----------------|----------------|----------------|-----------------|
| Fraction-complete        | intercept   | intercept      | 1.13           | 0.656          | 1.65            |
| Fraction-complete        | intercept   | log-GDP-pc     | 0.0425         | -0.839         | 0.893           |
| Fraction-complete        | intercept   | internet       | 1.18           | 0.281          | 2.1             |
| Fraction-complete        | intercept   | log-pop        | -0.565         | -1.08          | -0.0336         |
| Fraction-complete        | intercept   | governance     | 0.917          | 0.28           | 1.5             |
| Fraction-complete        | log-density | intercept      | 0.453          | -0.295         | 1.21            |
| Fraction-complete        | log-density | log-GDP-pc     | 0.0459         | -1.1           | 1.22            |
| Fraction-complete        | log-density | internet       | -0.556         | -1.84          | 0.662           |
| Fraction-complete        | log-density | log-pop        | 0.302          | -0.487         | 1.07            |
| Fraction-complete        | log-density | governance     | -0.0162        | -0.847         | 0.888           |
| Fraction-complete        | log-density-sq | intercept   | 0.939          | 0.579          | 1.31            |
| Fraction-complete        | log-density-sq | log-GDP-pc   | -0.204         | -0.82          | 0.409           |
| Fraction-complete        | log-density-sq | internet     | 0.366          | -0.266         | 1.01            |
| Fraction-complete        | log-density-sq | log-pop       | -0.117         | -0.53          | 0.29            |
| Fraction-complete        | log-density-sq | governance   | -0.063         | -0.5           | 0.385           |
| N-segments               | intercept   | intercept      | 2.56           | 2.42           | 2.7             |
| N-segments               | intercept   | log-GDP-pc     | 0.395          | 0.133          | 0.656           |
| N-segments               | intercept   | internet       | 0.316          | -0.00503       | 0.629           |
| N-segments               | intercept   | log-pop        | -0.113         | -0.249         | 0.0259          |
| N-segments               | intercept   | governance     | 0.103          | -0.0791        | 0.29            |
| N-segments               | log-density | intercept      | 3.1            | 2.88           | 3.34            |
| N-segments               | log-density | log-GDP-pc     | -0.441         | -0.87          | -0.0119         |
| N-segments               | log-density | internet       | -0.479         | -0.977         | 0.0132          |
| N-segments               | log-density | log-pop        | 0.341          | 0.109          | 0.571           |
| N-segments               | log-density | governance     | 0.000787       | -0.31          | 0.293           |
| N-segments               | log-density-sq | intercept   | -0.765         | -0.889         | -0.641          |
| N-segments               | log-density-sq | log-GDP-pc   | 0.154          | -0.0874        | 0.397           |
| N-segments               | log-density-sq | internet     | 0.173          | -0.0965        | 0.439           |
| N-segments               | log-density-sq | log-pop       | -0.158         | -0.28          | -0.0292         |
| N-segments               | log-density-sq | governance   | 0.0216         | -0.146         | 0.189           |
Multilevel model fits: diagnostics and distribution
I  Data release

We provide both the data set corresponding to the published paper, and a 2017 update. In the 2017 update, both our methods find an 89% completion rate for roads, overall, planet-wide. Within each, three separate components are provided:

1. a compiled country-level dataset
2. the visual assessment data
3. the OpenStreetMap history, aggregated by density, national and sub-national boundaries.

These data are openly available at https://alum.mit.edu/www/cpbl/publications/PLOS2017roads

J  2017 update

We updated our analysis to use the OSM contribution history up to May 2017. Using these updated data, both our methods find an 89% completion rate for roads, overall, planet-wide. Below are our fits corresponding to Figure 4 in the paper.

K  Open source Python code

Our code to reproduce the data and analysis is released under the GNU General Public License v3.0 as an open source project, permanently available at:

https://alum.mit.edu/www/cpbl/publications/PLOS2017roads/osm-completeness

A direct link to a description of the code is at:
https://github.com/cpbl/osm-completeness/blob/master/README.md
L Citation

For any use of data or code, cite the original PLOS One paper

Barrington-Leigh, Christopher and Millard-Ball, Adam (2017), "The world’s user-generated road map is more than 80% complete," [citation to be updated...]

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