MATHS SESSION 1: MEASURING INEQUALITY

Age range: 11–16 years

Outline
Learners will investigate a statistic about inequality, published by Oxfam, stating that the world's 80 richest people own the same wealth as the poorest half of the world's population. Learners will then consider what inequality means and how it can exist both between and within countries. They will be introduced to one way of measuring in-country income inequality: the Palma ratio. Finally, learners will calculate the Palma ratio for the UK and the four Young Lives countries (Ethiopia, India, Peru and Viet Nam).

Learning objectives
- To understand that a multiplicative relationship between two quantities can be expressed as a ratio.
- To understand what between- and in-country inequality mean.
- To identify some ways in which in-country inequality can be measured.
- To develop understanding of how the Palma ratio is calculated.

Learning outcomes
- Learners will calculate the cumulative wealth of the world's richest 80 people.
- Learners will learn how one way of measuring in-country inequality (the Palma ratio) is calculated.
- Learners will use the Palma ratio to express a multiplicative relationship between the incomes of the richest 10% of a country's population and the poorest 40%.

Key questions
- What does inequality mean?
- How might people's lives be unequal?
- Is inequality fair?
- How does extreme inequality make you feel?

Resources
- *Maths slideshow A* (slides 2–21)
- Resource sheets:
  - *The richest 80 people in the world – Tables 1* and *2*
  - *Where would you rather live? Complete table*
- Activity sheets:
  - *Sharing out the income*
  - *Where would you rather live? Tables 1* and *2*
  - *Where would you rather live? Blank table*
  - *Palma problems - Tables 1* and *2*

Curriculum links

England
KS3 Mathematics
Pupils should be taught to:
Number
- Use the four operations, including formal written methods, applied to integers.
- Use a calculator and other technologies to calculate results accurately and then interpret them appropriately.

Ratio, proportion and rates of change
- Understand that a multiplicative relationship between two quantities can be expressed as a ratio or fraction.

Wales
KS3 Mathematics
Developing numerical reasoning
- Transfer mathematical skills across the curriculum in a variety of contexts and everyday situations.
- Interpret mathematical information; draw inferences from graphs, diagrams and data, including discussion on limitations of data.

Using number skills
- Read and write numbers of any size and use the four operations and the connections between them.

Ratio, proportion and rates of change
- Use ratio and proportion.

Scotland
Mathematics and Numeracy
- I can solve problems by carrying out calculations with a wide range of fractions, decimal fractions and percentages, using my answers to make comparisons and informed choices for real-life situations.

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Note:

- *These are suggested activities and resources to support your teaching rather than guide it. Additional teaching input may be required to develop learners' knowledge, skills and understanding of some of these concepts.*
- *For this session learners will need an understanding of the term 'inequality', introduced in the* Introductory slideshow*. You might also like to consult the* Background notes for teachers*.*
- *These activities assumes that one billion = 1,000,000,000. Suggested activities for supporting learners to appreciate the value of a billion are provided in the* Further ideas*.*

Activity 1.1 (*30 min*)

The richest 80 people

- Show slide 3. Explain that in January 2015, Oxfam published a statistic stating that the world's richest 80 people owned the same wealth as the poorest half of the world's population. Say that wealth can be thought of as the total value of everything that a country or person owns after any debts have been subtracted.
- Discuss learners' reactions to this statistic:
  - *How does this statistic make you feel?*
  - *Do you think this distribution of wealth is fair?*
  - *Do you think the numbers are reliable?*
  - *How do you think the research was carried out?*
  - *Do you think everyone agrees with these figures?*
- Tell learners that they are going to have a go at calculating this statistic for themselves.
- Explain that we can divide a country's population into ten equal sized groups (deciles) depending on their comparative wealth. Oxfam used data on global wealth from Credit Suisse, a global financial services company, to identify how much wealth was held by each decile (each 10% of the world's population). In 2014 the bottom five deciles, the poorest half of the planet, had a cumulative wealth of US$1,895 billion.
- Explain that each year a company called Forbes publishes a list of the world's richest people. Oxfam then looked at this list. They counted down from the richest person, adding up their cumulative wealth, and found that you need only 80 billionaires to reach US$1,895 billion (the wealth of the poorest half of the planet).
- Organise learners into pairs and give each pair a copy of *The richest 80 people in the world – Tables 1* and *2.* Tell learners that they are going to use this data to check the Oxfam statistic. Ask learners to calculate the cumulative wealth of these 80 billionaires to check that it equals or exceeds US$1,895 billion.

Note:

- *Credit Suisse calculates wealth by looking at the individual net wealth of individuals aged 20 years or above. Individual net wealth is calculated as the value of a person's financial assets (for example housing and land) after any debts have been subtracted. If there is a lack of data in a*

country, estimates are made by using average figures based on the region and income class the country belongs to. Data may be lacking in a country for a number of reasons. Poorer or more isolated communities may lack the infrastructure for reliable data collection. Very rich people may prefer not to declare all their income.

- *Additional background information about how the Oxfam richest 80 people statistic was calculated is provided in the following Oxfam report and accompanying Excel data file:* Wealth: Having it all and wanting more*, Deborah Hardoon, Oxfam, 2014*: policy-practice.oxfam.org.uk/publications/wealth-having-it-all-and-wanting-more-338125

Activity 1.2 *(30 min)*

What is inequality?

Note: Some of the following information about inequality is also provided in English session 2 *and* Geography session 2.

- Distribute a number of sweets, counters or stickers unevenly around the group. Keep the majority of the sweets, counters or stickers for yourself.
- Discuss the following questions:
  - *Do you think this distribution is fair? Why/Why not?*
  - *How do you feel about the number of sweets/counters/stickers that you have?*
  - *Do you think there is a fairer way of distributing the sweets/counters/stickers? If so, what is it and why do you think this would be fairer?*
  - *Do you think it would be fair if everyone had exactly the same number of sweets/counters/stickers or do you think some groups of people should have more?*
- Show slides 4–6 to explore the meaning of inequality, wealth and income.
- Show slide 7 and give learners a few minutes to look at the map showing between-country inequality and then discuss questions such as:
  - *Which regions have the highest average wealth per adult?*
  - *Which regions have the lowest average wealth per adult?*
  - *What wealth category is the UK in?*
  - *Why do you think average wealth is higher in some countries than in others?*
  - *Do you think this wealth distribution is fair?*
  - *How do you think the world's distribution of wealth has changed in the past?*
  - *How do you think the world's distribution of wealth will change in the future?*
  - *Why do you think there is no data for some of the countries?* Data may be lacking in a country for a number of reasons. Poorer or more isolated communities may lack the infrastructure for reliable data collection. Very rich people may prefer not to declare all of their income.
- Show slides 8 and 9 to remind learners about the background to the Young Lives project and to locate the four Young Lives countries (Ethiopia, India, Peru and Viet Nam) and the UK on the world map.

- Return to slide 7 and ask learners to use the map to work out the average wealth per adult in each of the four Young Lives countries (Ethiopia, India, Peru and Viet Nam) and the UK.
    - *Ethiopia, India and Viet Nam (below US$5,000)*
    - *Peru (US$5,000 to US$25,000)*
    - *UK (Over US$100,000)*
- Show slide 10 and explain that there is also often inequality *within* countries, where many people have only a little wealth and a few people have a lot.
- Ask learners to imagine two groups of five people: A and B. Show slide 11 and ask learners what the total wealth of each group is. Agree that each group has a total wealth of £100. Now ask learners what the mean wealth per person is for each group. Agree that it is the same for each group (£20) even though the distribution of wealth among the members of each group is very different. Alternatively, organise learners into groups of five, give each group the data for either Group A or Group B and ask them to calculate the total and mean wealth.

Group A

£20 £20 £20 £20 £20

Group B

£87 £10 £1 £1 £1

- Discuss learners' thoughts about the above example.
    - *Which of these groups do you think is fairer and why?*
    - *Which of the two groups would you prefer to be a part of and why?*
    - *How do you think wealth is usually distributed in a country?*
    - *Wealth is measured in terms of money. Can you think of other ways to measure how 'well off' a person is?*
- Show slide 12 and say that inequality is not just about how much money is shared out between or within countries. Inequality also involves the opportunities that people have. Ask learners to think about other ways in which people's lives and opportunities may be unequal. Discuss their ideas and make the point that there are many ways in which inequality affects people's lives, such as access to water, education and health care, and opportunities for and conditions of employment.
- Explain that the Young Lives researchers are exploring some of the inequalities that exist between young people in poorer communities. Use slides 13 and 14 to introduce Phuoc and H'Mai, two young people from Viet Nam who were interviewed as part of the Young Lives project (profiles of these young people are provided in *English session 1*). Ask learners to identify any inequalities between the lives of Phuoc and H'Mai, as well as between the lives of these young people and learners' own lives. Discuss their ideas using Think, Pair, Share.
- If you have time, use slide 15 as the basis for a discussion of the statement "Everyone in our society should be equal."

Activity 1.3 *(45 min)*

Measuring inequality – Calculating the Palma ratio

Note: The role play part of this activity assumes a class size of 30.

- Explain that in-country inequality can be measured in a number of ways. Say that another measure of inequality is the Palma ratio. This measure is based on the work of Chilean economist Gabriel Palma. Palma looked at how a country's total income was distributed among different groups of people living in a country. Remind learners that income is the amount of money a country or person earns as a result of paid work or investments.
- Tell learners that they are going to use role play to demonstrate how the Palma ratio is calculated. Explain that each learner is going to be given a fictional amount of money. Cut up the boxes from *Sharing out the income* and give one to each learner.
- Ask learners to line up in order of their individual income, with the poorest person at the front of the line and the richest person at the end.
- Now ask the learners, staying in this order, to divide themselves into ten equally sized groups. The first three learners will form the first group, the next three learners will form the second group and so on. Agree that each group of three people equals 10% of the total population. Income increases along the line: the first group in the line is the poorest and the tenth group in the line is the richest.
- Show slide 16 and then ask the learners in the fifth, sixth, seventh, eighth and ninth groups in the line to calculate their combined income (£300).
- Explain that the other half of national income tends to be shared between the richest 10% of society and the poorest 40%. Ask the learners in the first, second, third, fourth and tenth groups to calculate their combined income (£300).
- Show slide 17 and use the ratio to demonstrate that the Palma ratio for this example is 2:

  Combined income of richest 10% (tenth group) is £200

  ———————————————————

  Combined income of poorest 40% (first to fourth groups) is £100

  £200 ÷ £100 = 2

- Ask learners how equal their 'society' is according to the Palma ratio. Agree that the ratio is greater than one and that therefore, according to the Palma ratio, this society is relatively unequal because the richest 10% receives a larger share of income than the poorest 40%. Remind learners that this is a fictional example.
- Organise learners into pairs or groups of three. Cut up the different data sets for each country (A-J) from *Where would you rather live? Tables 1* and *2* and give each group one country data set (there are 10 country data sets in total). Explain that each data set contains the annual incomes for each of the ten deciles of the country's population.
- Ask each group to put their deciles in order from the smallest to the largest. They should then calculate the total income and the Palma ratio for their country. You may need to remind

learners of the calculation for the Palma ratio (slide 17).

- Alternatively, give learners a copy of all the country data sets and the *Where would you rather live? Blank table*. Ask learners to calculate the total income and Palma ratio for each country and record their answers in the table.
- The results for the ten countries are provided in the *Where would you rather live? Complete table.*
- Share and discuss learners' answers as a whole class:
  - *According to the Palma ratio, which of these countries is the most equal?* (Answer: Country F.)
  - *Which of these countries would you most like to live in and why?*
  - *Which of these countries would you least like to live in and why?*

  Note: Learners' answers to these last two questions may not be influenced only by how equal a country is; they may feel that other factors such as the country's total income are important, as well as the potential income they might have if they ended up in the richest decile of a country.
- Make the point that these are imaginary countries and in reality these incomes would be much greater. However the inequality between these fictional countries in their total income is representative of the actual income inequality that exists between countries in the world today. The Palma ratios of these imaginary countries are also similar or equal to the actual Palma ratios of some countries in the world today.
- Show slide 18. Ask learners which country (out of the four Young Lives countries and the UK) they think would be the most unequal:
  - *Which country do you think would be the most equal?*
  - *Why do you think this?*
- Explain that learners are going to calculate the Palma ratio for these countries. Organise learners into pairs and give each pair a copy of *Palma problems - Table 1* or *2* according to their ability. Ask learners to look first at the data and try to predict the value of the Palma ratio for each country. They should then complete the table by calculating the Palma ratio for each country.
- Completed versions of the tables are provided on slides 19 and 20. Discuss learners' responses to the results:
  - *Were you surprised by the results?*
  - *Did you think any countries would be more or less equal? Why did you think this?*
  - *Do you think it is fair that some people in a country have a much larger income than others?*
- Remind learners that the Palma ratio is only one way of measuring inequality. Another measure of inequality is the GINI index. Here countries are given a score between 0 and 1 (or 0 and 100%) to show how equal or unequal they are. A score of 0 would mean that everyone in the country has the same income. A score of 1 would mean that one person has all the income and everyone else has none. Emphasise that no countries are either this equal or this unequal but that all countries fall somewhere between 0 and 1. The lower the number, the more equal the country is.

- Show slide 21 and explain that this world map shows how the countries of the world compare on income inequality according to the GINI index. Countries that are more equal are shaded in green. Countries that are more unequal are shaded in pink, orange and red. Ask learners to locate the four Young Lives countries (Ethiopia, India, Peru and Viet Nam) and the UK. *What colours are these countries? Which is the most unequal according to this map?* (Answer: Peru.)

Differentiation

- *Make it easier: Use* Palma problems - Table 1 *(combined income rounded to the nearest US$ billion).*
- *Make it harder: Use* Palma problems – Table 2 *(combined income rounded to the nearest US$ billion).*

Further ideas

Following on from Activity 1.1

- It is often extremely difficult for learners to appreciate the value of billions and trillions. Here are some ideas to help learners to develop their understanding:
    - Share the fact that based on the data in *The richest 80 people - Table 1*, if Bill Gates were to cash in all his wealth and spend US$1million every single day it would take him 208 years to spend all his money (assuming he wasn't earning any interest on it). Learners could look at other billionaires in *The richest 80 people - Tables 1* and *2* and calculate how long it would take them to spend all their money.
    - Ask learners to calculate the answers to questions such as:
        - *What year will it be one billion minutes from now?*
        - *What area would one billion mm^2 cover?*
        - *How much would one billion pound coins weigh?*
        - *How many times around the world would you travel if you walked one billion steps?*
    - Help learners to visualise large numbers by using counters or sweets to represent populations of towns and cities. For example, one jelly bean = 1 billion, one wrapped sweet = 10 billion and one chocolate bar = 100 billion.
- Learners could use the Forbes rich list (www.forbes.com/billionaires/) to investigate the 80 richest people list in more detail. For example, learners could look at the percentage of the people in the list by country or region in the world.
- Point out that data on income and wealth is usually calculated in US dollars. Learners could convert the incomes of the 80 richest people into pounds sterling as a comparison.

Following on from Activity 1.3

- Look at the data in *Palma problems – Table 1* again and ask the following questions:
    - *For each country, what is the mean income per person in the richest 10%?*
    - *For each country, what is the mean income per person in the poorest 40%?*

  *Note: Learners will need country population data to calculate the answers to these questions: Ethiopia: 97 million; India: 1,295 million; Peru: 31 million; Viet Nam: 91 million; UK: 65 million**.*

- *For each country, how much of the combined income of the richest 10% would need to be redistributed to the poorest 40% to make the Palma ratio equal to1?*
- *How much would the average person in the richest 10% lose?*
- *How much would the average person in the poorest 40% gain?*

Point out to learners that the average income per person in each of these population groups is just that, an average. The average income of people in the poorest 10% will be very different to that of the average income per person of the poorest 40% as a whole. Similarly, the average income per person in the richest 1% will be very different to the average income per person in the richest 10% as a whole.

- Challenge learners to calculate the Palma ratio for other countries using *World Bank Open Data***. Learners will need to use the following indicators to calculate the combined income of the richest 10% and poorest 40%:
  - Income share held by highest 10%
  - Income share held by lowest 20%
  - Income share held by second-lowest 20%
  - GNI, Atlas method (current US$). This is an estimate of the country's total gross national income.

** World Bank Open Data *2014: data.worldbank.org (Population rounded to the nearest million).*

The richest 80 people in the world

Table 1

Ranking	Name	Wealth (millions)	Country
1	Bill Gates	76000	United States
2	Carlos Slim Helu & family	72000	Mexico
3	Amancio Ortega	64000	Spain
4	Warren Buffett	58200	United States
5	Larry Ellison	48000	United States
6	Charles Koch	40000	United States
7	David Koch	40000	United States
8	Sheldon Adelson	38000	United States
9	Christy Walton & family	36700	United States
10	Jim Walton	34700	United States
11	Liliane Bettencourt & family	34500	France
12	Stefan Persson	34400	Sweden
13	Alice Walton	34300	United States
14	S. Robson Walton	34200	United States
15	Bernard Arnault & family	33500	France
16	Michael Bloomberg	33000	United States
17	Larry Page	32300	United States
18	Jeff Bezos	32000	United States
19	Sergey Brin	31800	United States
20	Li Ka-shing	31000	Hong Kong
21	Mark Zuckerberg	28500	United States
22	Michele Ferrero & family	26500	Italy
23	Aliko Dangote	25000	Nigeria
24	Karl Albrecht	25000	Germany
25	Carl Icahn	24500	United States
26	George Soros	23000	United States
27	David Thomson & family	22600	Canada
28	Lui Che Woo	22000	Hong Kong
29	Dieter Schwarz	21100	Germany
30	Prince Alwaleed Bin Talal Alsaud	20400	Saudi Arabia
31	Forrest Mars Jr	20000	United States
32	Jacqueline Mars	20000	United States
33	John Mars	20000	United States
34	Jorge Paulo Lemann	19700	Brazil
35	Lee Shau Kee	19600	Hong Kong
36	Steve Ballmer	19300	United States
37	Theo Albrecht Jr & family	19300	Germany
38	Leonardo Del Vecchio	19200	Italy
39	Len Blavatnik	18700	United States
40	Alisher Usmanov	18600	Russia

Source: Forbes rich list, March 2014. Data available at policy-practice.oxfam.org.uk/publications/wealth-having-it-all-and-wanting-more-338125

The richest 80 people in the world — Table 2

Ranking	Name	Wealth (millions)	Country
41	Mukesh Ambani	18600	India
42	Masayoshi Son	18400	Japan
43	Michael Otto & family	18400	Germany
44	Phil Knight	18400	United States
45	Tadashi Yanai & family	17900	Japan
46	Gina Rinehart	17700	Australia
47	Mikhail Fridman	17600	Russia
48	Michael Dell	17500	United States
49	Susanne Klatten	17400	Germany
50	Abigail Johnson	17300	United States
51	Viktor Vekselberg	17200	Russia
52	Lakshmi Mittal	16700	India
53	Vladimir Lisin	16600	Russia
54	Cheng Yu-tung	16200	Hong Kong
55	Joseph Safra	16000	Brazil
56	Paul Allen	15900	United States
57	Leonid Mikhelson	15600	Russia
58	Anne Cox Chambers	15500	United States
59	Francois Pinault & family	15500	France
60	Iris Fontbona & family	15500	Chile
61	Azim Premji	15300	India
62	Mohammed Al Amoudi	15300	Saudi Arabia
63	Gennady Timchenko	15300	Russia
64	Wang Jianlin	15100	China
65	Charles Ergen	15000	United States
66	Stefan Quandt	14900	Germany
67	German Larrea Mota Velasco & family	14700	Mexico
68	Harold Hamm	14600	United States
69	Ray Dalio	14400	United States
70	Donald Bren	14400	United States
71	Georg Schaeffler	14300	Germany
72	Luis Carlos Sarmiento	14200	Colombia
73	Ronald Perelman	14000	United States
74	Laurene Powell Jobs & family	14000	United States
75	Serge Dassault & family	14000	France
76	John Fredriksen	13600	Cyprus
77	Vagit Alekperov	13600	Russia
78	John Paulson	13500	United States
79	Rupert Murdoch & family	13500	United States
80	Ma Huateng	13400	China

Source: Forbes rich list, March 2014. Data available at: policy-practice.oxfam.org.uk/publications/wealth-having-it-all-and-wanting-more-338125

Sharing out the income

£3.00	**£4.00**	**£5.00**
£6.00	**£7.00**	**£9.00**
£9.50	**£10.00**	**£10.50**
£11.00	**£12.00**	**£13.00**
£13.50	**£14.00**	**£14.50**
£15.00	**£16.00**	**£17.00**
£17.50	**£18.00**	**£18.50**
£20.00	**£22.00**	**£24.00**
£28.00	**£30.00**	**£32.00**
£40.00	**£60.00**	**£100.00**

Where would you rather live? **Table 1**

Country A

£7.50	**£105**	**£50**	**£10**	**£40**
£20	**£30**	**£2.50**	**£25**	**£15**

Country B

£710	**£1,200**	**£240**	**£2,080**	**£2,500**
£3,680	**£1,750**	**£10,000**	**£1,000**	**£550**

Country C

£29,000	**£4,000**	**£10,000**	**£8,410**	**£1,710**
£17,220	**£5,770**	**£3,020**	**£7,000**	**£13,360**

Country D

£8,800	**£1,270**	**£5,660**	**£3,980**	**£3,490**
£2,760	**£2,140**	**£4,650**	**£3,100**	**£1,830**

Country E

£840	**£320**	**£440**	**£220**	**£510**
£2,370	**£280**	**£630**	**£170**	**£120**

Where would you rather live?

Table 2

Country F

£770	£390	£1,190	£570	£510
£440	£170	£630	£290	£340

Country G

£220	£120	£250	£160	£720
£360	£270	£180	£140	£290

Country H

£1.70	£2.90	£2.50	£3.40	£15
£2	£1.30	£5.90	£1	£4.30

Country I

£260	£170	£1,060	£310	£560
£220	£90	£150	£420	£120

Country J

£28,870	£8,850	£11,380	£5,910	£43,500
£22,240	£13,190	£16,660	£18,420	£2,860

Where would you rather live?

Blank table

Country	1st decile	2nd decile	3rd decile	4th decile	5th decile	6th decile	7th decile	8th decile	9th decile	10th decile	Total income	Palma ratio
A												
B												
C												
D												
E												
F												
G												
H												
I												
J												

Where would you rather live?

Complete table

Country	1st decile	2nd decile	3rd decile	4th decile	5th decile	6th decile	7th decile	8th decile	9th decile	10th decile	Total income	Palma ratio
A	£2.50	£7.50	£10	£15	£20	£25	£30	£40	£50	£105	£305	3
B	£240	£550	£710	£1,000	£1,200	£1,750	£2,080	£2,500	£3,680	£10,000	£23,710	4
C	£1,710	£3,020	£4,000	£5,770	£7,000	£8,410	£10,000	£13,360	£17,220	£29,000	£99,490	2
D	£1,270	£1,830	£2,140	£2,760	£3,100	£3,490	£3,980	£4,650	£5,660	£8,800	£37,680	1.1
E	£120	£170	£220	£280	£320	£440	£510	£630	£840	£2,370	£5,900	3
F	£170	£290	£340	£390	£440	£510	£570	£630	£770	£1,190	£5,300	1
G	£120	£140	£160	£180	£220	£250	£270	£290	£360	£720	£2,710	1.2
H	£1	£1.30	£1.70	£2	£2.50	£2.90	£3.40	£4.30	£5.90	£15	£40	2.5
I	£90	£120	£150	£170	£220	£260	£310	£420	£560	£1,060	£3,360	2
J	£2,860	£5,910	£8,850	£11,380	£13,190	£16,660	£18,420	£22,240	£28,870	£43,500	£171,880	1.5

Palma problems

Table 1

Country	Year data collected	Combined income of poorest 40% of population (to the nearest US$ billion)	Combined income of richest 10% of population (to the nearest US$ billion)	Predicted Palma ratio	Actual Palma ratio (to 2 decimal places)
Ethiopia	2010	7	9		
India	2011	351	527		
Peru	2013	26	64		
Viet Nam	2012	24	42		
UK	2012	512	639		

Source: Calculated using *World Bank Open Data*: data.worldbank.org

Palma problems

Table 2

Country	Year data collected	Combined income of poorest 40% of population (to the nearest US$)	Combined income of richest 10% of population (to the nearest US$)	Predicted Palma ratio	Actual Palma ratio (to 2 decimal places)
Ethiopia	2010	6,849,029,613	9,109,874,339		
India	2011	351,142,381,935	526,713,572,902		
Peru	2013	26,291,266,714	63,632,486,106		
Viet Nam	2012	23,889,006,308	41,564,109,240		
UK	2012	512,084,560,603	638,812,557,924		

Source: Calculated using *World Bank Open Data*: data.worldbank.org