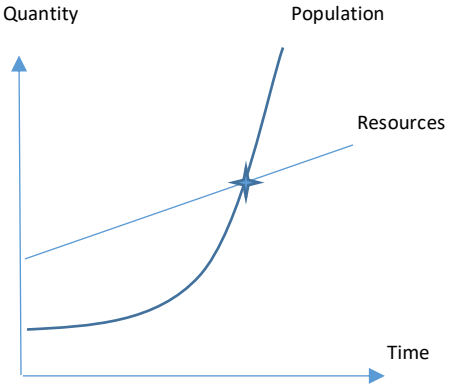
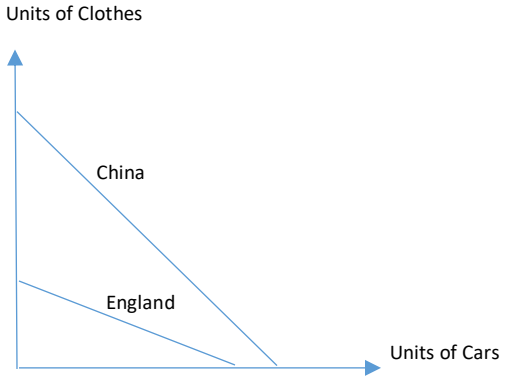
Introduction January 24th, 2021

Thomas Malthus and David Ricardo have been two of the most influential economists over the last 200 years. Ricardo's theory of comparative advantage and that free trade will always produce positive results[1] is now as relevant as it was two centuries ago. The simplified example below shows that a country can either use all its resources to produce clothes or cars at home and it should choose to produce either of the products abroad, in which the comparative advantage is highest. In the example below England should hence produce all its clothes abroad and use its resources to produce cars at home as the comparative advantage for producing cars in England vs. in China is smaller than for making clothes. Malthus has been best known for by his theory of exponential population growth, i.e. a positive, constant per capita rate of increase, and the problems it causes for linear growth of food supply and other resources, also known as Malthusian limits. Malthus hence suggested birth control and postponement of marriage to keep population growth in line with supply of resources[2].



Malthusian Limits



Ricardo's comparative cost advantage

Contrary to the theory of Malthusian limits, however, between 1990 and 2015 malnutrition deaths worldwide halved from more than 500,000 to less than 250,000[3], while the world's population increased by over 38%[4] with a correlation that is negative by 93%. What has changed during this time frame to result in such a negative correlation?

Year	Population in mio	Malnutrition deaths	Malnutrition deaths per mio capita
1990	5,310	511,855	96.40
2015	7,349	231,771	31.54

[1] On the Principles of Political Economy and Taxation by David Ricardo. London: John Murray, 1821. First published 1819

[2] 1798. An Essay on the Principle of Population. 1st ed. 1798, online at the Library of Economics and Liberty, http://www.econlib.org/library/Malthus/malPop.html; 6th ed. 1826, online at the Library of Economics and Liberty, http://www.econlib.org/library/Malthus/malPlong.html.

[3] Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2017 (GBD 2017) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2018

[4] Max Roser, Hannah Ritchie and Esteban Ortiz-Ospina (2013) - "World Population Growth". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/world-population-growth' [Online Resource]

This is where Ricardo's theory of comparative advantage comes into play. The fall of the iron curtain in 1989 and with it the 1990s and 2000s have been characterised by lower tariffs and higher trade, globalisation became the key theme. The weighted mean of all tariff rates applied on all products declined from 8.57% in 1995 to 2.59% in 2017[5]. Trade as % of world GDP has increased from 38.83% in 1990 to 60.27% in 2019. [6] With the reduction in tariffs, the theory of producing in the country where it is cheapest made all more sense and has made China the factory of choice for producers, as labour was cheap and environmental as well as labour regulations were lax. In addition, it enabled producers easier access to sell their products to China, the world's most populous country. China evolved to become the world's largest manufacturing country in the 2010s[7]. This, in part, explains the decline in malnutrition death per capita. For example, China and India, both beneficiaries of globalisation, were able to reduce malnutrition deaths by more than 75% between 1990 and 2015[8]. Furthermore, poverty headcount ratio at $1.90 a day (2011 PPP) has reduced from 36.2% of world population in 1990 to just 10.1% in 2015[9]. However, this came at a cost of increasing CO_2 emissions and higher CO_2 emissions per capita, which has led to global temperatures to rise by more than 1 degree Celsius over the last 50 years.

This brings me to the theme of my essay, which explores answers to the following questions: How relevant are the ideas of Malthus and Ricardo respectively to today's issues of climate change (is this an example of Malthusian limits?) and of limits to markets (is globalisation with free trade and free capital movements an unmixed blessing?)?

First, I will outline how climate change is an example of Malthusian limits and then I will explain how Ricardo's theory of comparative advantage has led to globalisation and hence contributed to the issue of climate change. I will conclude by suggesting a tax on emissions globally with the goal to reduce CO_2 emissions fairly for all.

Climate change as an example of Malthusian limits

Applying Malthus theory of exponential population growth to CO_2 emissions between 1751 and 2015 shows there is a clear positive correlation of over 99%, and in turn CO_2 emissions and a rising temperature have a positive correlation of over 85% between 1950 and 2015[10].

[5] World Bank DataBank (2020), Tariff rate, applied, weighted mean, all products (%), https://data.worldbank.org/indicator/TM.TAX.MRCH.WM.AR.ZS

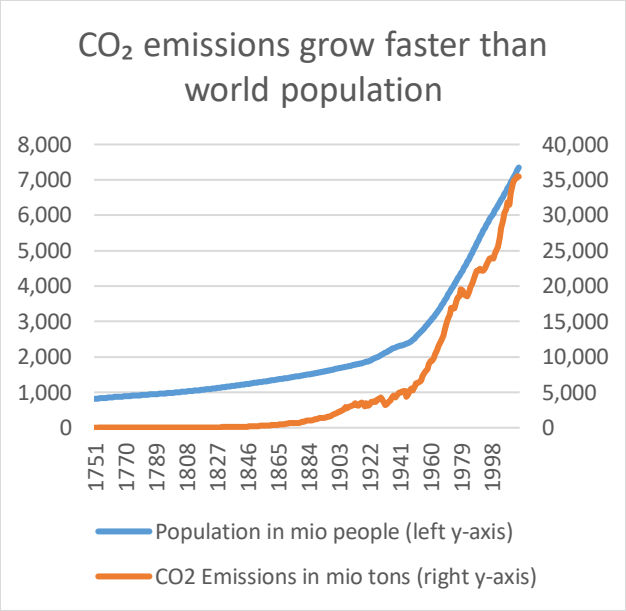
[6] World Bank DataBank (2020), Trade (% of GDP) – World, https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?locations=1W

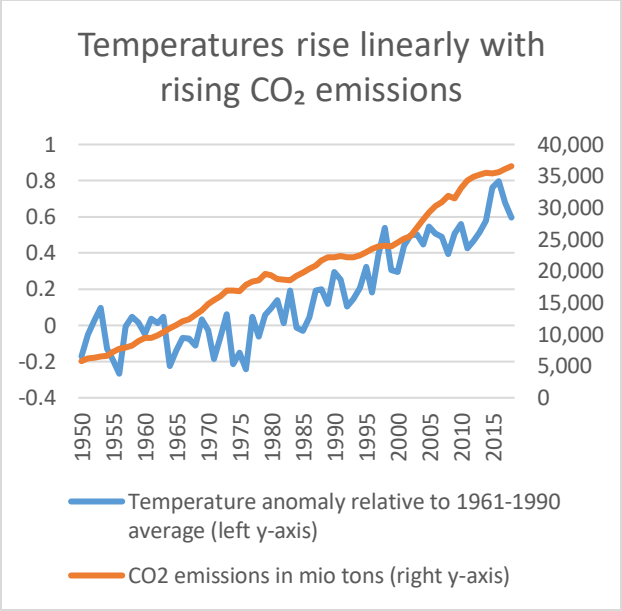
[7] United Nations Industrial Development Organisation, https://stat.unido.org/country/CHN.pdf

[8] Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2017 (GBD 2017) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2018

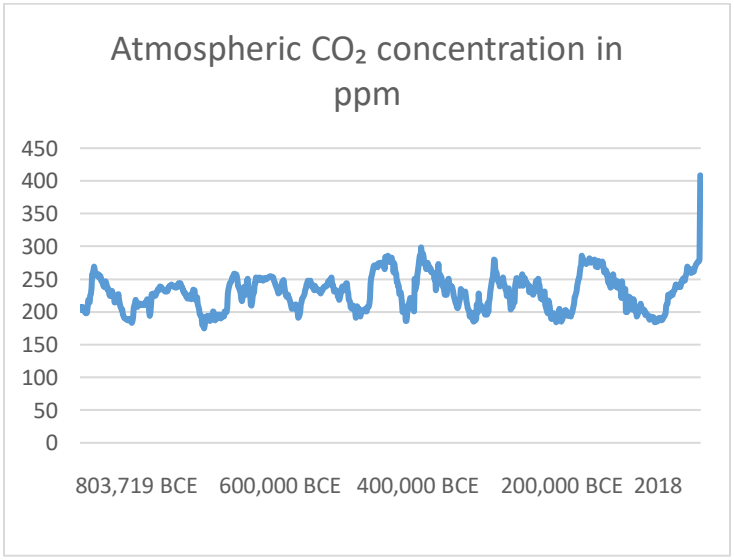
[9] World Bank DataBank (2020), Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population), https://data.worldbank.org/indicator/SI.POV.DDAY

[10] Hannah Ritchie and Max Roser (2017) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions' [Online Resource]





Furthermore, atmospheric CO_2 concentrations, which occur partly naturally and are measured in parts per million (ppm) have been consistently below 300ppm over hundreds of thousands of years. However, CO_2 concentrations began climbing above its norm during the industrial revolution and in 1913 with the rise of the internal combustion engine and turbine, CO_2 concentrations topped 300ppm for the first time and since then grew to over 400ppm in 2018.



Total CO_2 emissions meanwhile increased 10-fold from 1913 to 2015 when the world's population only quadrupled[11]. The average growth of the world's population has been 1.4% annually while the average CO_2 emissions growth has been 2.4% between 1913 and 2015, both exponentially rising, as the growth rate remains stable amid a growing population and higher CO_2 emissions (although the average

[11] Hannah Ritchie and Max Roser (2017) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions' [Online Resource]

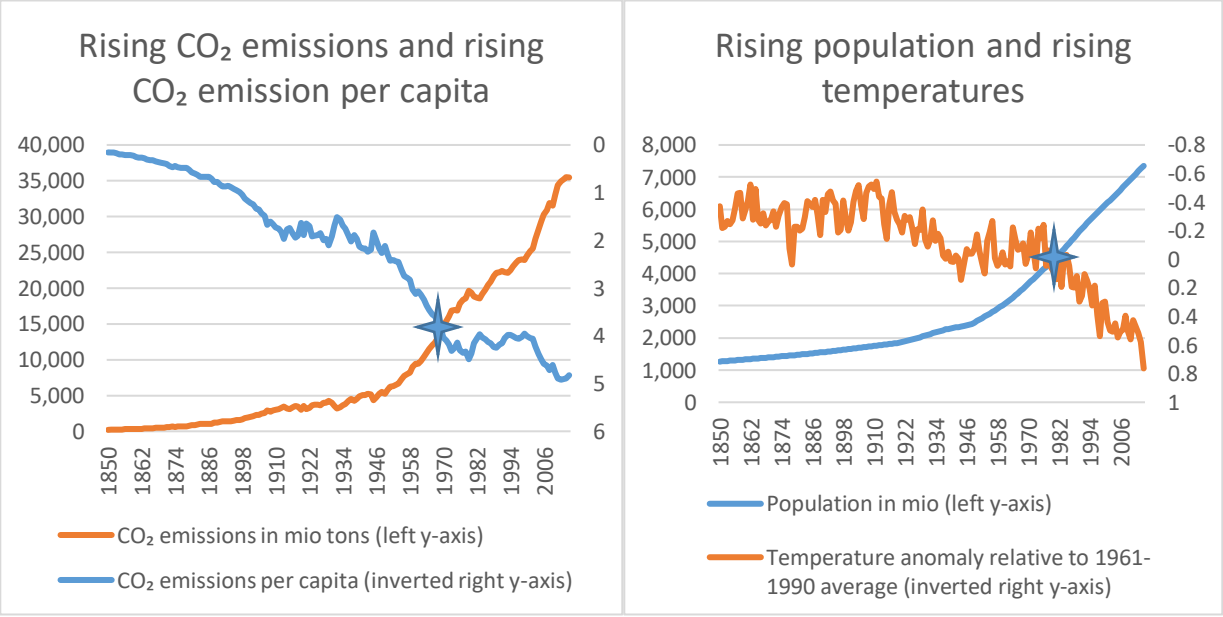
population growth between 1960 and 1990 was 1.9% vs. 1.3% between 1990 and 2015, while the average CO_2 emissions growth between 1960 and 1990 was 3% vs. 1.8% between 1990 and 2015, hence slowing, but still stable in both periods). Nevertheless, this means that emissions per capita are rising and indeed that climate change demonstrates to be an example of Malthusian limits, as temperatures rise with CO_2 emissions linearly.

Year	Population in mio	CO_2 emission in mio tons	CO_2 emission in tons per capita
1913	1,778	3,491	1.96
1990	5,310	22,182	4.18
2015	7,349	35,463	4.83

The exact point from where temperatures started rising linearly with CO_2 emissions and concentrations can be identified at around 1974 with a population of 4bn people, 330ppm CO_2 concentration and 16bn tons emissions of CO_2 per year resulting in CO_2 emission in tons per capita of 4.24.

Year	Population in mio	CO_2 concentration (ppm)	CO_2 emission in mio tons	CO_2 emission in tons per capita	Temperature anomaly compared to 1961-1990 average
1913	1,778	301.3	3,491	1.96	-0.424
1974	3,986	330.18	16,924	4.25	-0.214
1990	5,310	354.39	22,182	4.18	0.296
2015	7,349	400.83	35,463	4.83	0.763

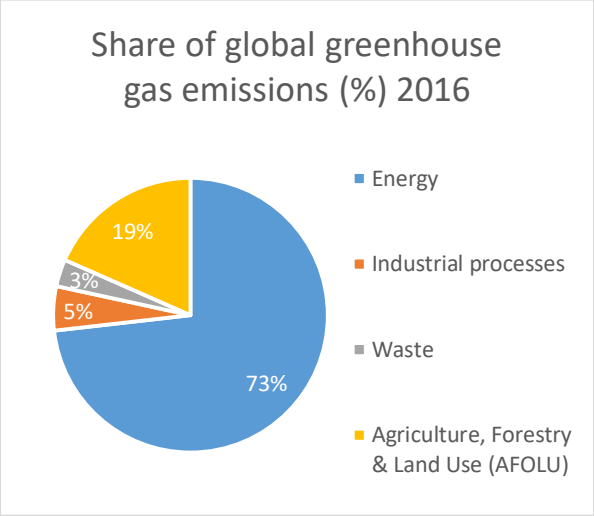
Malthusian Limits reached

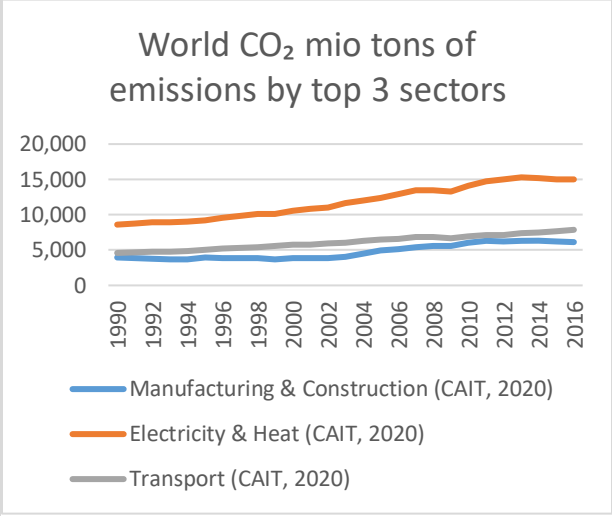


The unmixed blessing of comparative advantage theory and globalisation

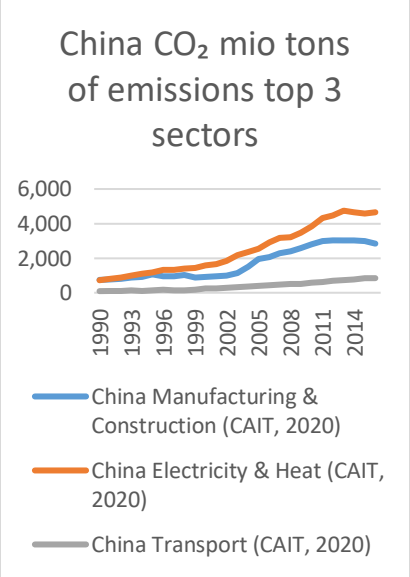
The drivers of higher CO_2 emissions per capita can be identified by looking at the individual sectors and breaking this further down into regions. Energy use represented nearly ¾ of the world's greenhouse gas

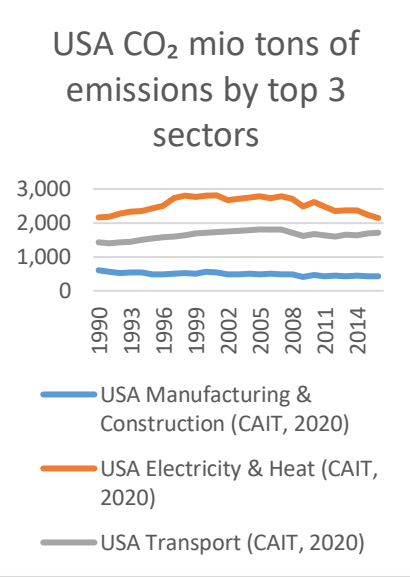
emission in 2016. Energy is particularly used in these three sectors, Electricity & heat, Transport and Manufacturing & constructions, which are the three top CO_2 emitting sectors[12].

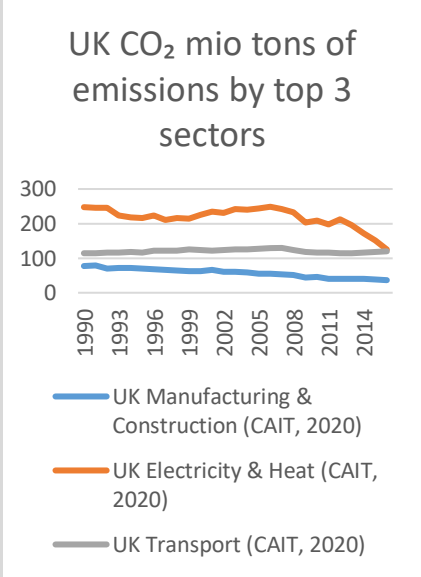




A regional comparison of CO_2 emissions between China, the USA and the UK underlines this development, as it shows shifting trends in CO_2 emissions between these regions. China alone has increased its total CO_2 emissions from 3,350mio tons in 2000 to over 10,000mio tons in 2016. A look at the three top CO_2 producing sectors demonstrates that the USA kept its CO_2 emissions relatively stable at around 4,200mio tons, the UK almost managed to half its emissions to 282mio tons, while China increased its emissions in these sectors from 1,565mio tons in 1990 to 8,330mio tons in 2016[13].







[12] Hannah Ritchie and Max Roser (2017) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions' [Online Resource]

[13] Hannah Ritchie and Max Roser (2017) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions' [Online Resource]

A major difference between the three regions can be explored when comparing the types of energy sources that produce CO_2 emissions. In 2018, China's greenhouse gas emissions from coal alone more than exceeded the total greenhouse gas emissions of the USA from gas, coal, oil, cement and flaring combined. Furthermore, China increased its per capita greenhouse gas emissions from 1.57 tons per capita in 1990 to 6.72 tons per capita in 2016, which is 1.22 tons per capita higher than the United Kingdom in 2016. [14]

	CO_2 emissions in mio tons				
Country	**Gas**	**Coal**	**Oil**	**Cement**	**Flaring**
USA	1,648	1,282	2,367	41	50
United Kingdom	162	32	173	4	5
China	531	7,252	1,500	782	

What has driven China's CO_2 emissions so high, so quickly? As the Soviet Union dissolved in 1991, the world united, tariffs were dropped and global trade began to flourish. Many companies selected China as an attractive place of manufacturing their goods, as China emerged as the winner of Ricardo's comparative cost advantage, and indeed, the table below shows that China emerged from poverty in a matter of less than two decades. Sadly, the reduction in poverty also led to an increase in CO_2 emissions per capita. While at the beginning of the 1990s around 50% of China's population lived on around $1.90 a day (in 2011 PPP), the CO_2 emissions per capita were below 2.0 tons per capita. In 2011, when less than 10% of China's population lived on $1.90 or less a day, CO_2 emissions per capita have risen to above 6 tons per capita[15]. With the decline in poverty, there also came a rise in tertiary school enrolment[16] and with this technological advances. Nuclear energy as a % of total electricity generation climbed from 1.99% in 2012 to over 3.56% in 2016[17], which resulted in CO_2 emissions per capita to decline. The numbers indicate that China shifted its energy consumption from CO_2 heavy emitting coal to nuclear energy beginning from 2012.

Year	**CO_2 emission tons from Coal**	**CO_2 emissions per capita**	**Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)**	**School enrollment, tertiary (% gross)**	**Nuclear energy % of total electricity production**
1990	1,977	1.57	66.30%	2.97%	0.00%
1996	2,660	2.19	41.70%	4.91%	1.00%
2002	2,779	2.65	31.70%	12.62%	1.43%
2005	4,424	4.12	18.50%	19.08%	2.03%

[14] Hannah Ritchie and Max Roser (2017) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions' [Online Resource]

[15] World Bank DataBank (2020), Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population), https://data.worldbank.org/indicator/SI.POV.DDAY

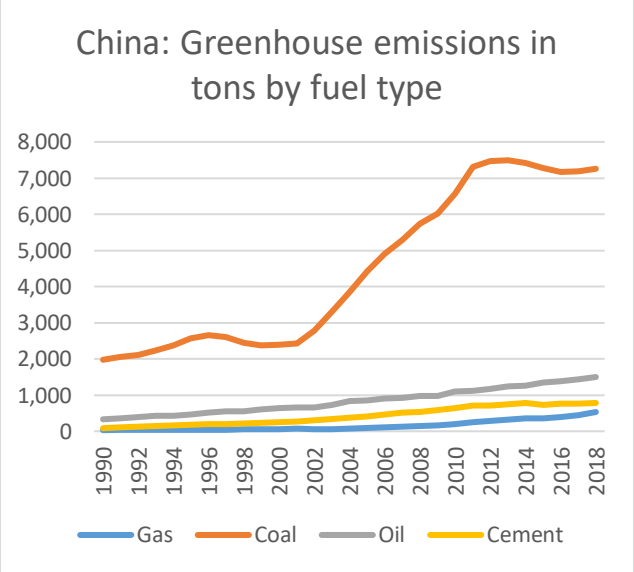
[16] World Bank DataBank (2020), School enrollment, tertiary (% gross) China, https://data.worldbank.org/indicator/SE.TER.ENRR

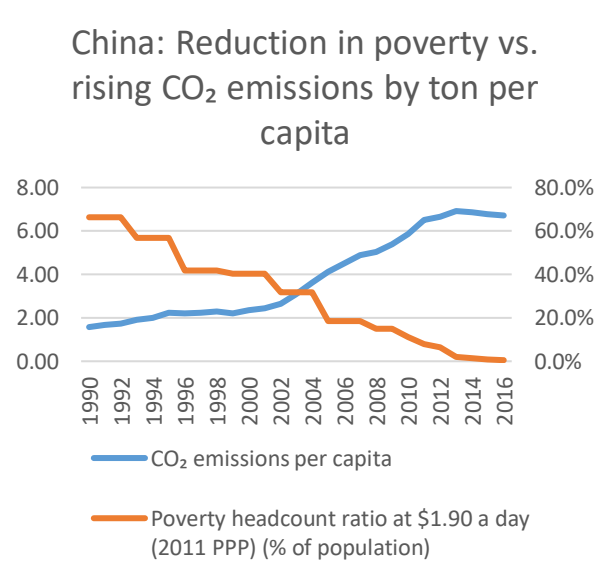
[17] International Atomic Energy Agency. Retrieved from: 'https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=CN' [Online Resource]

2008	5,729	5.02	14.90%	20.68%	2.15%
2010	6,569	5.87	11.20%	24.19%	1.82%
2011	7,310	6.51	7.90%	25.64%	1.85%
2012	7,465	6.66	6.50%	28.72%	1.99%
2013	7,493	6.92	1.90%	32.43%	2.11%
2014	7,425	6.85	1.40%	42.43%	2.39%
2015	7,271	6.77	0.70%	46.04%	3.03%
2016	7,177	6.72	0.50%	48.01%	3.56%

This demonstrates that Ricardo's theory of comparative advantage theory has indeed led to a reduction in poverty and been beneficial for everyone. Everyone except our planet on where we live on. As manufacturing moves to countries with cheap labour forces and fewer regulations, those particular countries are usually developing or emerging countries and do not obtain the technology, such as nuclear power, to provide clean energy for manufacturing. The cheap and reliable alternative is often coal, but in turn coal emits much larger amounts of greenhouse gases.

The unmixed blessing of globalisation





Conclusion

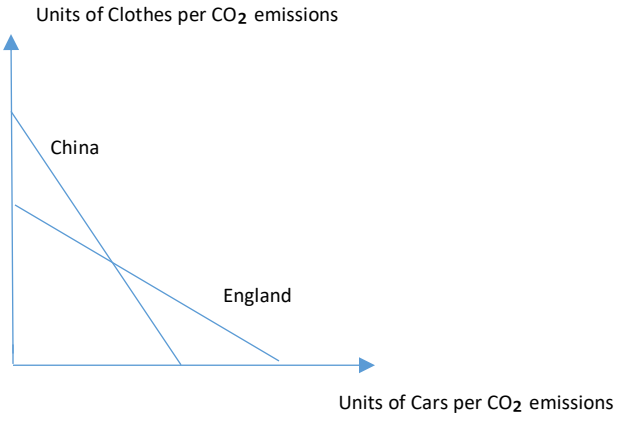
It can be concluded that both, Malthusian limits and Ricardo's comparative advantage theory, are relevant to today's issues of climate change. Is the answer hence to limit population growth and de-globalise in order to keep greenhouse gases, and hence rising temperatures under control? Or do we first need to introduce developing nations to CO_2 neutral energy technologies, such as nuclear power or better renewable solar and wind energy? The global answer has been the Paris Climate Agreement, in which countries lay out to become carbon neutral. However, the Paris Climate Agreement does ask developed nations to take the lead in reducing emissions as well as with regards to assisting developing nations with

financial resources and technology transfer to reduce emissions[18] – the former would be particularly challenging for the US, as the largest CO_2 emitter per capita, double that of China.

While the Paris Climate Agreement is the step in the right direction, it remains vague and difficult to enforce. Some might ask why developed nations need to pay for emerging countries' rising CO_2 emissions. Others will argue that it is the developed nation's companies that began shifting production to developing countries, such as China, hence driving the higher energy demand there. There could even be an argument for those developed nation's companies exporting greenhouse gas emissions to China and other developed nations by moving factories there, reducing emissions per capita at home, but increasing abroad. My suggestion is different from the Paris Climate Agreement, and yes, it includes Malthus' and Ricardo's theories.

In the 18th century Malthus suggested birth controls and later marriages, imagine today Malthus would instead suggest taxes depending on how much CO_2 companies are emitting. Ricardo's comparative advantage model would then shift, as production in countries with high CO_2 emission energy sources would suddenly become more expensive. As factories provide jobs and income, countries would race to prevent companies from moving to the lowest CO_2 emitting energy source by revolutionising their energy grid to ensure the cheapest, carbon-neutral energy is produced in their country. The EU has introduced its Emissions Trading System, but it would need to be enforced globally and free allowances should be eliminated.

Ricardo's absolute cost advantage in a world where CO_2 emissions are part of the production cost equation



[18] Paris Climate Agreement: https://unfccc.int/sites/default/files/english_paris_agreement.pdf