Modelling the potential saturation levels of iron and steel in China: wider economic impacts and circular economy implactions

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Overview

Iron and steel demand in China has been both a huge source of economic growth and carbon dioxide emmisions over the last 15-20 years. China produces around half of the world's crude steel (World Steel Association, 2017). However, concerns about air pollution, future economic development, climate change, resource efficiency, and the circular economy have started positing questions about what the role of steel production in China will be over the coming decades. In particular what will happen as changes in economic structure, production efficiency and environmental standards.

Many global modelling studies extrapolate future demand for materials based on available data of the previous few years or decades. However, this short time frame ignores the longer development pattern undertaken over several decades or most of a century. As countries develop it is likey that their per capita consumption of materials will begin to decrease and that stocks per capita will then saturate.

Figure 1: Stylised apparent consumption and stocks of materials along the development curve.

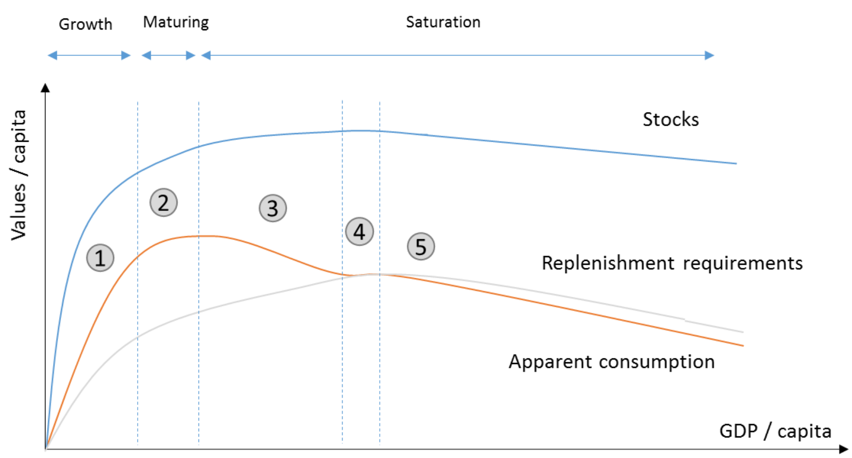


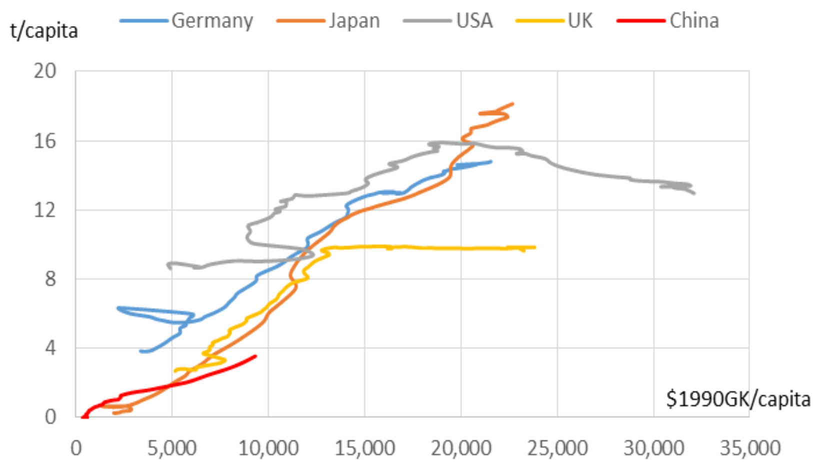
Table 1:Material saturation stages

Stage	ADC	Stocks	Description
Growth	↗	↗↗	Rapid accumulation of stocks (1)
Maturing	→	↗	ADC slowdown (2)
Saturation	↘	→	Start of stock saturation (3)
	→	→	Steady-state (4)
	↘	↘	Material use efficiency adjustments (5)

Sources: Bleischwitz et al (2018)

Recent work undertaken by Bleischwitz et al (2018) suggests that i.e. the USA steel stock saturated at around 16 tonnes per capita when income per capita reached $20,000 but that for the UK steel saturated at lower level and lower income level, perhaps due to earlier development and less infrastructure. The authors therefore suggest there may well soon be a saturation in stocks of steel in China in line with other developed nations, although the level and timing of such saturation is unknown.

Figure 2: Steel stocks per capita



Source: Bleischwitz et al (2018)

Methods

In this analysis we attempt to explore a range of potential saturation levels for steel in China and consider the wider economic impacts of steel saturation on other economic sectors as well as important steel producing and consuming other countries. We use the ENGAGE-materials model (Winning et al, 2017) developed by UCL ISR which is based on GTAP 9 for 2007. Here we keep the additional iron ore sector developed in ENGAGE-materials but simplify the distinction between primary and secondary steel production in order to consider only the the overall effect in the steel industry.

The OMN sector in GTAP is split using national accounts data, where available, for the largest iron mining regions (China, Brazil, India, Australia) and for all other regions both sectoral output and cost structure are taken from EXIOBASE (2007). COMTRADE is also used in order to achieve consistency between the major physical and monetary trade pairings in iron ore. For more details see (Winning et al. 2017). This means it is possible to consider the downstream effects of policies and price changes in the iron mining sector, whereas previously these impacts were lost within the aggregate OMN sector, as well as the effects that circular economy polices may have on iron ore production as an input to steel.

Here we explore scenarios which assume a saturation level compared to the other countries studied in Bleischwitz et al (2018) including USA, and the UK (the final work also includes comparisons with Japan and Germany) and compare these against an (unrealistic) baseline where there is no saturation whatsoever. We also use a China specific study (ERI) by the Energy Research Institute of National Development and Reform Commission (Jiang, K. and X. Hu, 2009) which provides a bottom-up estimated of how the steel sector in China will develop. The satuartion can be achieved in the steel sector through three distinct methods. Firstly, through structural change in the economy and secondly, through impoved efficiency in downstream sectors which use steel as an input e.g. motor vehicle production in China moving to levels of steel input similar to USA, or thirdly, improved efficiency in the steel sector itself. We also consider the opposite of the Wang et al (2018) study, in that we are concerned with the co-benefits of resource use on carbon emissions in China rather than the other way round.

The options for improved efficiency in the downstream sectors are explored below by taking into account differences in steel use intensity between China and other industrialised countries. Table 2 shows that the value of steel as an input into many of the downstream sectors is significantly higher in China suggesting that efficiency improvements are possible.

Table 2: Percentage of I_S as input into downstream sectors in key regions from GTAP

	37 i_s	39 fmp	40 mvh	41 otn	43 ome	59 cns
CHN	28%	26%	8%	9%	11%	11%
JPN	51%	23%	4%	12%	8%	3%
USA	20%	16%	3%	2%	5%	1%
GBR	25%	10%	4%	1%	4%	1%

Source: GTAP (taken from GTAP-Power for 2007)

There is potentially a doubling of efficiency required for the 'Motor vehicles' and 'Other transport' sectors in China to reach similar cost structure as the developed nations. 'Construction' is clearly a sector where China uses significantly more steel in production and therefore is an important sector where efficiency improvements could be made or inputs may well be expected to reduce as the economy becomes more like those of the developed nations here. However, across other sectors, Japan often has and we may well expect China to be similar to Japan given proximity and production techniques.

Results

Initial work on introducing saturation effect shows that there are significant efficiency impovements are required if China was to saturate at the same level of the UK showing that the structure of the Chinese economy means it is already on a path to saturate at a fairly high level. However, the effect on GDP growth is fairly miminal to China for the ERI or USA saturation levels (Figure 4). We also show results on sectoral production and how other countries benefit from the saturation including Japan, Korea and India.

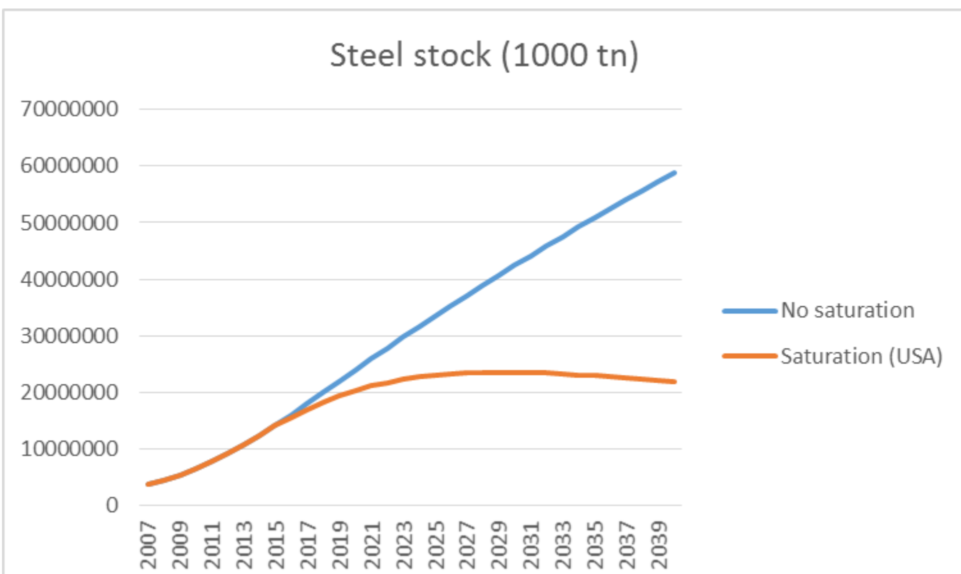


Figure 3: Steel stocks per capita in ENGAGE-materials

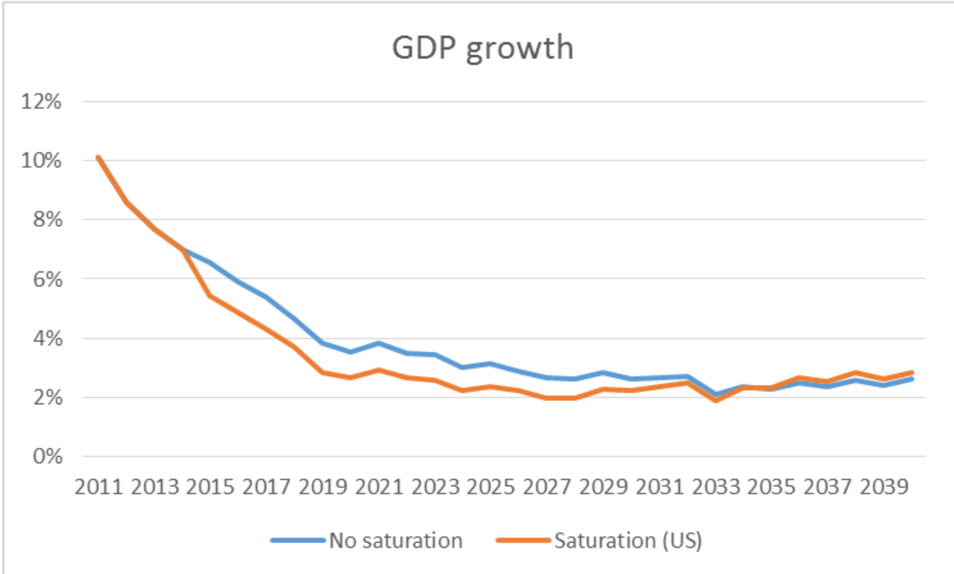


Figure 4: China GDP growth in ENGAGE-materials

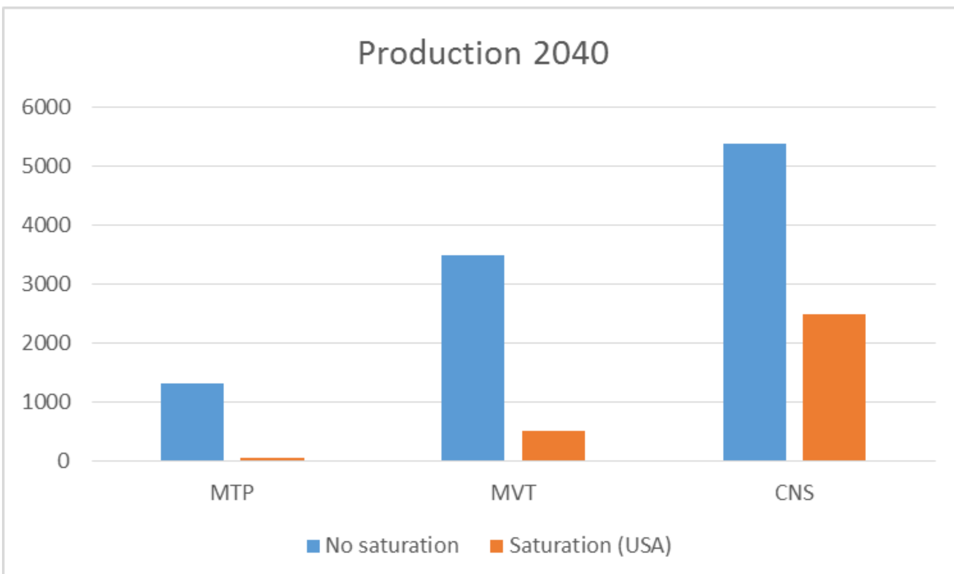


Figure 5: China manufacturing and construction ouput with and without saturation

Discussion

The exploration of baseline development the saturation effect for steel in China, through the use of macro-economic and multi-sector modelling, shows insight into China's current reliance on the current patterns of steel production for continued economic expansion. Reaching the saturation levels observed in industrialised regions will be partially explained by changes in economic structure, whilst the steel efficiency of use for downstream sectors will also likely play an important role.

However, it is hard to determine whether, once China saturates its own stock level, it will continue to produce steel for export globally or whether iron and steel production will move elsewhere and where that will be. Understanding steel demand projections in other regions will also be important. Moreover, once China's in-use stock reaches the end of its life over the coming 20-40 years, there will be a significant increase in scrap availability and how much secondary steel can be produced from that?

There are still significant developments required to the ENGAGE-materials model in order to better capture the reality of the iron and steel sector and scrap use within but the saturation effect implementation represents a major step towards baseline development for iron and steel.

References

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