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Who Owns China's Carbon Emissions?

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Summary

China is now believed to be the world's largest emitter of carbon dioxide (CO_2), the most important contributor to global climate change. The evidence that China has overtaken the United States to take the number one spot has led to renewed calls for China to act to reduce the environmental impact of its phenomenal growth. Such calls have been resisted inside and outside China on the grounds that industrialised countries are responsible for the majority of emissions to date. Furthermore, it has been argued that the steep rise in China's emissions has been fuelled by exports of cheap goods from its factories to Western consumers.

This briefing note aims to illuminate this debate. It has been prepared as part of an ongoing Tyndall Centre and Sussex Energy Group project to examine future carbon emissions pathways for China[2]. The briefing note sets out an initial assessment of the emissions from the goods and services that China exports. It concludes that in 2004 – the most recent year in which comprehensive data is available – net exports from China accounted for 23% of its total CO_2 emissions. This is due to China's trade surplus, but is also due to the relatively high level of carbon intensity within the Chinese economy. This figure is comparable to Japan's total CO_2 emissions, and is more than double the UK's emissions in the same year. The equivalent emissions figures for 2005 and 2006 could be larger since China's trade surplus has continued to rise more rapidly than growth in emissions or the economy.

The analysis in this briefing note cannot be regarded as definitive since it is subject to range of simplifications. However, the extent of 'exported carbon' from China should lead to some rethinking by government negotiators as they work towards a new climate change agreement. It suggests that a focus on emissions within national borders may miss the point. Whilst the nation state is at the heart of most international negotiations and treaties, global trade means that a country's carbon footprint is international. Should countries be concerned with emissions within their borders (as is currently the case), or should they also be responsible for emissions due to the production of goods and services they consume?

This briefing note also strengthens the case for early action by the developed world in two respects. First, it lends further weight to the view that OECD countries should take the lead in reducing emissions. Their historical responsibility for the majority of the carbon emissions is joined by some responsibility for more recent emissions growth in the developing world. Second, it supports the expansion of efforts to help developing countries to reduce the carbon emissions from economic growth through technical assistance and finance.

Background

Figures from the Dutch Environmental Assessment Agency in June suggested that China overtook the USA as the world's largest emitter in 2006. Its carbon emissions now exceed those of the USA by 8%[3]. The most immediate reasons cited by the Dutch report were growth in coal-fired electricity generation and cement production in China coupled with a 1.4% fall in US emissions.

The speed at which China reached this point has caught the world by surprise. Predictions from the International Energy Agency (IEA) had previously suggested that China's emissions would overtake those of the USA

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[2] See http://www.tyndall.ac.uk/research/programme2/task_2.1.html.

[3] See http://www.mnp.nl/en/service/pressreleases/2007/20070622ChineseCO2emissionsinperspective.html

by end of 2009[4]. One driver of this acceleration has been the construction of coal-fired power plants to meet rising electricity demand, which is itself a product of rapid economic expansion. In 2006, construction activity reached record levels which even surpassed the expectations of officials in the Chinese government[5].

This acceleration in China's emissions has strengthened calls from some quarters for China to sign up to an emissions cap from 2012 – the year the current phase of the Kyoto Protocol expires. The United States in particular has resisted the idea that industrialised countries should reduce their emissions in the absence of similar action by China and other large developing countries. The US National Security Adviser recently argued that:

> 'There are some people who think that the G8 countries ought to set the goal … Well, that's a little bit inconsistent with the notion that it needs to … reflect a broader community, particularly all the emitting countries and some of the key emitting countries like India and China don't sit with the G8'[6]

This argument has been rejected by senior officials in both China and India. For example, Lu Xuedu of the Chinese Ministry of Science and Technology told a UK Parliamentary Committee that 'it is not the time' for China to commit to cuts in its emissions[7].

Current international agreements for controlling greenhouse gas emissions through the UN Framework Convention on Climate Change and the Kyoto Protocol focus on nation states. Those countries with targets that have ratified the Kyoto Protocol are responsible for reducing emissions within their national borders. In discussions about what kind of framework should follow the current phase of Kyoto after 2012, important questions are being debated about how future emissions reductions should be shared.

Within this, many in the developed world accept the argument that their countries should take the lead in reducing emissions due to their responsibility for the majority of historical emissions. It is also accepted that the developed world should also help developing countries to shift towards a lower carbon development path, for example through technology agreements and the Clean Development Mechanism. For some, an additional question arises: to what extent should developed countries take responsibility for emissions growth in large developing countries such as China?[8] Some of this growth – particularly in China - is due to demand from industrialised countries for cheap goods that are manufactured in developing countries. Without this demand, China would not have developed so rapidly and its emissions would not have risen so sharply. Therefore, should responsibility for emissions be allocated to countries that *produce* goods and services or should countries be responsible for emissions from the products and services they *consume*?

The purpose of this briefing note is to bring some initial empirical evidence to bear on this debate. It analyses recent trade data to provide an estimate of the proportion of China's emissions that can be attributed to its net exports of goods and services. It also includes a qualitative commentary on the main contributors to these export-led emissions.

China's Economic Growth and Trade

China has been called the world's manufacturing hub. An increasingly large quantity of labour and energy intensive goods "made in China" are being exported to developed countries, whilst large amounts of waste are exported to China. The arrival of the world's largest cargo ship - the *Emma Maersk* - in December 2006 loaded with

[4] International Energy Agency (2006) World Energy Outlook 2006 Paris: IEA.
[5] McGregor, R. (2007). 'China's Power Capacity Soars.' *Financial Times*. 6th February
[6] Press Briefing by National Security Advisor Steven Hadley on the President's Trip to the G8 Summit and Europe, White House, 1st June 2007; http://www.whitehouse.gov/news/releases/2007/06/20070601-11.html.
[7] Lu Xuedu. Uncorrected transcript of oral evidence to the Joint Committee on the Climate Change Bill, 5th July 2007; http://www.publications.parliament.uk/pa/jt200607/jtselect/jtclimate/uc542-viii/uc54202.htm.
[8] For example, a recent study by WWF in Sweden has assessed emissions due to Sweden's imports from China and India. See Peng Lei et al (2007) The import of CO2 emissions from China and India: Sweden's contribution to reduction of CO2 emissions - a global dimension. WWF and Global Footprint Network.

45,000 tonnes of Christmas goods for UK consumers[9] is just one high profile manifestation of this trend.

China's GDP has increased by over 9% per year during the past two decades. Trade is an important element of China's economic growth. Of particular importance is 'processing trade' which accounts for almost half of China's total international trade since 1995. Processing trade is the business of "importing all or part of the raw and auxiliary materials, parts and components ... from abroad ... and re-exporting the finished products after processing or assembly"[10]. In 2004, China's exports contributed 34% to the total GDP, compared with 18% for Brazil, 19% for India and 25% for the UK. Whilst a significant proportion of China's exports are not energy or carbon intensive (e.g. consumer electronics and textiles), its exports also include some energy and resource intensive products. For instance, the Netherlands Environmental Assessment Agency has pointed out the rapid growth in cement production as one important driver of China's recent CO_2 emissions growth. In fact, the cement production in China increased by 10% from 2004 to 2005, but at the same time its cement exports increased more than 200% from 7 to 21 million tonnes[11]. Similarly, China's exports of rolled steel increased by 44% between 2004 and 2005. It is important to note, however, that these exports represent a small proportion of production even though they are continuing to grow rapidly – the vast majority of China's steel and cement are consumed domestically.

The Chinese government has tried to slow down the expansion of energy intensive sectors due to fears of economic overheating. However, a report from the Chinese National Development and Reform Commission (NDRC) has revealed that investments in these areas have continued to rise rapidly during the first quarter of 2007. Investments in the processing and production of non-ferrous metals and cement were 56.5% and 43.8% higher respectively than they were the same period in 2006.

China's imports are also increasing with economic growth, but at a much slower rate than exports. China's exports increased more than 28% between 2004 and 2005, while imports increased by just under 18%. As a result, China's trade surplus tripled in 2005 to a record high of $102 billion, up from $32 billion a year before. Since then, records have continued to be broken. China's trade surplus in 2006 climbed to $177 billion backed by another 27% surge in exports[12]. The current figure for 2007 is on target to be even higher – it was over $100 billion for the first 6 months of 2007. This is despite the government's latest efforts to eliminate or cut tax rebates on thousands of energy intensive export products[13].

Estimating Emissions from Traded Products

There are a number of ways to estimate the CO_2 emissions from the manufacture of goods exported from a country. These vary in their level of detail and accuracy. Much research of this kind has used some form of input/output (I/O) modelling[14]. An I/O model provides a tool to identify all life cycle effects of production within an economy, including the impact of international trade. Ideally, a world-wide I/O model is required that can relate different countries' exports and imports and assign CO_2 emissions to countries based on their net consumption of goods and services. This analysis would distinguish between different trading partners and different goods and services, and the amount of CO_2 they emit per unit of output.

A full analysis of this kind is a data intensive and time consuming process, which is beyond the scope of this briefing note. As a first step, this note uses the same principles to reach estimated results based on available, aggregated data. It estimates the direct CO_2 emissions from products that are exported from China and subtracts from this the direct

[9] Vidal, J (2006) 'How world's biggest ship is delivering our Christmas - all the way from China' *The Guardian* 30th October.
[10] Hong Kong Trade Development Council (2006) 'Guide to Doing Business in China'.
[11] National Bureau of Statistics of China China Statistical Yearbook 2006.
[12] Reuters (2007) 'China's 2006 trade surplus jumps 74 percent'; http://www.iht.com/articles/2007/01/10/business/yuan.php
[13] Gong (2007) 'Tax rebates removed, cut to curb exports' *China Daily*, Beijing; http://www.chinadaily.com.cn/china/2007-06/20/content_897889.htm
[14] See for example, Shui, B and R.C. Harriss (2006) 'The role of CO2 embodiment in US–China trade' *Energy policy* 34, 4063–4068.

emissions avoided by China through imports. This focus on direct emissions excludes important indirect emissions that originate from inputs used in the production of these traded goods. A fuller analysis would include indirect emissions but are beyond the scope of our first order analysis.

Our analysis focuses primarily on the year 2004, the most recent year for which comprehensive figures are available. It uses official Chinese data for export and import values. It combines these values with average figures from the International Energy Agency for CO_2 emissions per unit of GDP for China and for China's trading partners[15]. The trade values used here are expressed in actual terms, not in terms of purchasing power parity (PPP). This is because the monetary value of internationally traded goods is recorded at international prices. So it makes sense to use a consistent monetary unit across countries.

One important methodological issue for this analysis is that China's imports and exports are concentrated. According to the China Statistical Yearbook 2006[16], the top 5 exporters to China in 2004 were Japan, South Korea, Taiwan, US and Germany. Goods and services from these countries accounted more than half of China's total imports. The next 5 largest exporters to China only accounted for a further 12%. Similarly, China's top 5 exporting destinations in 2004 (the USA, Hong Kong, Japan, South Korea and Germany) constituted 59% of China's total exports, while the including the next 5 pushed the total up to 71%. Because of this dominance, the analysis focused mainly on the largest 10 exporters to China. For these countries, individual figures for CO_2 emissions per unit of GDP were used. For other exporters to China, we used a world average figure for CO_2 emissions per unit of GDP.

It is also important to note that Hong Kong is China's second export destination after the USA. Although Hong Kong has been part of China for a decade, Hong Kong still has an independent trading system of its own. Many of the goods exported to Hong Kong from mainland China are re-exported to other countries such as the UK after value-added processes have been performed. The major destinations of Hong Kong's re-exports, besides the Chinese mainland itself, are the USA, Japan, Germany and the UK. To complicate matters, Hong Kong's re-exports to mainland China are included in the data for China's imports from origin countries, but mainland China's exports via Hong Kong to other countries are not clear from the data. A similar situation can also be found for Singapore, China's 7th largest import origin and 8th largest export destination. This means that it is difficult to allocate China's CO_2 emissions from exported goods to individual destination countries. In this briefing note, a figure for emissions from China's exports is calculated without attempting such an allocation.

Emissions from China's Traded Products

The analysis finds out that in 2004, China 'avoided' emitting around 381 million tonnes of CO_2 due to the import of goods and services. At the same time, goods that were exported from China generated approximately 1490 million tonnes of CO_2. The overall effect was that around 1109 million tonnes of CO_2 were emitted by China as a result of net exports. This accounted for **23% of China's total CO_2 emitted in that year** (4732 million tonnes). To put this figure into context, it is slightly less than the total emissions from Japan in that year. It is almost as high as Germany and Australia combined, and more than twice the national emissions from the UK (See Figure 1).

Since 2004, China's emissions have continued to grow rapidly. As stated earlier, China's trade surplus has also increased from $32bn in 2004 to $177bn in 2006. These trends suggest that the proportion of China's emissions from net exports is also likely to have increased beyond 23% over the same period.

If we look into the details of China's imports and exports, some further insights are possible. To do this, Chinese trade figures for the major sub categories of goods and services are used. The ten largest commodity categories of China's trade by value in 2004 are listed in Table 1 with their net export values. The final column shows our judgements of the carbon or energy intensity of goods within each category (see further discussion below).

[15] IEA (2006) Key World Energy Statistics. International Energy Agency, Paris.
[16] National Bureau of Statistics of China op. cit.

Figure 1. CO_2 emissions from China's net exports in 2004 in comparison with selected national emissions figures

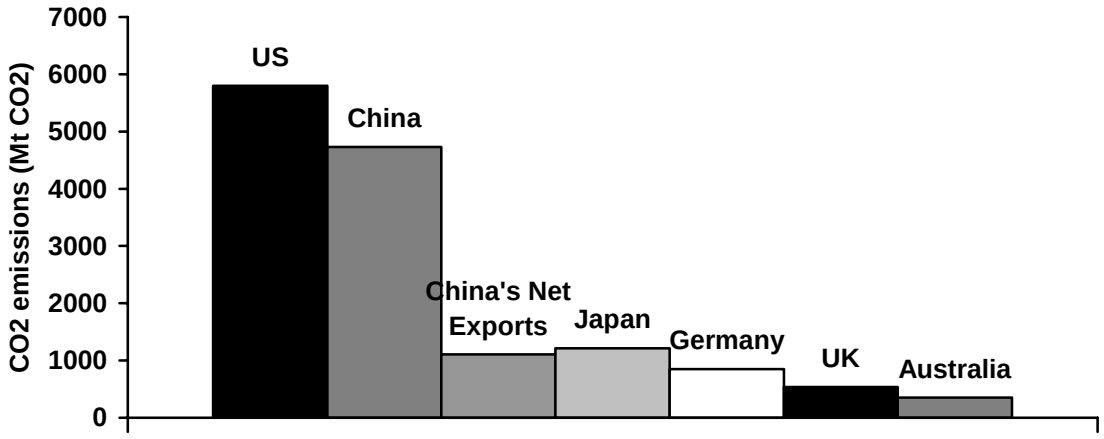

Table 1. China's 10 largest categories of traded product in 2004 by export value ($bn).
Source: China Statistical Yearbook 2006

Categories	Exports		Imports		Net Export (value)	Relative Energy Intensity
	Value	Share	Value	Share		
Machinery; electric equipment and accessories; video recorders etc	247.8	41.76%	233.9	41.68%	13.9	low
Textile materials and products	88.8	14.96%	23.0	4.10%	65.8	low
Base metals and related products	43.7	7.37%	48.5	8.65%	-4.8	high
Others	36.7	6.18%	3.5	0.62%	33.2	medium
Chemicals and related products	24.6	4.14%	42.6	7.59%	-18.0	medium
Locomotives; vehicles; aircraft; ship and transport equipment	21.0	3.54%	19.5	3.47%	1.5	low
Optical; measuring; precision instruments and related	19.1	3.22%	41.3	7.37%	-22.2	low
Footwear; headgear; umbrellas; canes; etc	18.4	3.10%	0.6	0.11%	17.8	low
Plastics and rubber related	16.9	2.85%	32.8	5.84%	-15.9	medium
Minerals	16.6	2.79%	67.1	11.96%	-50.5	high
- Crude oil / refined products	5.3	0.89%	43.2	7.69%	-37.9	medium / high
Subtotal (top ten)	**533.5**	**89.92%**	**512.9**	**91.39 %**	**20.6**	
Overall total	**593.3**	**100%**	**561.2**	**100%**	**32.1**	

In 2004, China's single largest export category was machinery & electrical equipment which accounted for more than 40% of the total exports. This category was followed by textiles and then base metals. But the largest net export came from textiles, followed by machinery & electrical equipment and a category called 'others' which is not explained in detail in the Yearbook. The largest three import categories are machinery & electrical equipment, minerals and base metals. But the largest net import comes from minerals, largely due to crude oil imports which have grown rapidly in recent years.

To analyse this data further, these sectors can be divided into four groups. The first group includes low value-added and labour intensive products. Within this group, textiles, footwear and related products are a major source of revenue for China, due to large exports and very small imports. Similarly, some products within the machinery and electrical equipment category (e.g. consumer electronics) are exported in large numbers. These products tend to have a relatively low energy and CO_2 emissions intensity.

The second group consists of energy and resource intensive products. The most important category in this group is base metals and related products which has similar values for both exports and imports. The sector is a marginal net importer in 2004 and marginal net exporter in 2005. But the revenue generated from processing metals is at the expense of substantial pollution and energy consumption. Considering the recent over-investment in this sector, the net flow could have varied significantly since 2004.

The third group is high-tech and high value-added products. This group includes chemicals and optical and measuring instruments, two categories with relatively high net imports. It also includes transport equipment, for which China is a small net exporter. A significant proportion of exports within this group stem from multinationals that have shifted their manufacturing bases to China. Chinese firms still lack the capacity to manufacture some of the products in this group. Even for transport equipment, the position of net exports could be reversed in 2006 due to the multi billion dollar aircraft orders to Boeing and Airbus[17]. This group might also include some products within the machinery and electrical equipment category, but is difficult to determine how important these are without more detailed data.

The fourth group is minerals, plastics and rubber. These consist mainly of raw materials and products made from oil. China's insufficient domestic supply is outpaced by demand. This contributes the largest net import to China. More than 60% of the mineral imports consist of oil imports. The share rose to nearly 70% in 2005. This has been acknowledged as an important contributor to recent increases in world oil prices. Emissions from the combustion of imported oil, as well as other fossil fuels are already included in China's national emissions. But the CO_2 emissions from extracting oil in the country of origin are not. These latter emissions have been included in our results through the value of imported crude oil.

Although it is difficult to obtain data for carbon emissions intensity for goods and services within each of these groups, some previous studies provide some useful pointers. For example, a group of Chinese researchers have recently conducted an analysis of the embodied energy in China's traded goods and services[18]. This analysis used energy intensities of different products that include both the direct use of energy in production and the indirect energy embodied in other inputs to production processes.

The figures from this study provide an indication of which sectors are the most or least energy intensive. The direct energy intensity figures have been used in this briefing note to assign a high, medium or low energy intensity to the export value of each category in Table 1. Since the Chinese energy supplies are overwhelmingly dominated by fossil fuels, these assignments have been used as a proxy for relative carbon intensity. The results suggest that those sectors that account for the largest export values (e.g. machinery and textiles) are likely to have a low or medium level of

[17] e.g. http://www.iht.com/articles/2006/10/26/business/chirac.php

[18] Li Hong et al (2007) 'Evaluating the effects of embodied energy in international trade on ecological footprint in China' *Ecological Economics* 62, 136-148.

carbon intensity. The exception is base metals which is the third largest category of exports by value, and is more likely to have a high carbon intensity. The overall impact of these observations is that the CO_2 emissions figure for China's net exports might be an over-estimate. However, the margin of error due to this particular issue is likely to be relatively small.

Conclusions

The preliminary analysis in this briefing note suggests that the proportion of China's CO_2 emissions that are due to net exports of goods and services is large and significant. This is due to China's trade surplus, but is also due to the relatively high level of carbon intensity within the Chinese economy. Therefore consumption in OECD countries that import goods from the developing world does not only generate emissions within those countries – but also contributes to growing emissions in the developing world.

Using average CO_2 emissions factors, an initial estimate has found that net exports accounted for 1109 million tonnes of CO_2 (23% of Chinese emissions) in 2004. This is comparable to Japan's total CO_2 emissions, and is more than double the UK's emissions in the same year. The equivalent emissions figures for 2005 and 2006 could be larger since China's trade surplus has continued to rise rapidly – much faster than the rate of growth of emissions or the economy as a whole.

This briefing note has also emphasised some of the methodological challenges of conducting a more accurate, nuanced analysis of this issue. It is difficult to obtain accurate data for the carbon emissions intensity of different traded products. However, a qualitative investigation of the key contributors to China's trade surplus suggests that the 23% figure for 2004 could be an over estimate – but not by a significant margin. This is because the biggest contributors to exports are likely to have lower than average or average carbon intensities. A more comprehensive Input/Output analysis is required to substantiate this. A further issue is that the intensities used in this briefing note only measure direct emissions, and neglect significant indirect emissions from inputs to manufacture for example.

This briefing note tends to strengthen two arguments within the current debate about the appropriate international framework to reduce carbon emissions. First, it lends further weight to the view that OECD countries should take the lead in reducing emissions. Their historical responsibility for the majority of the carbon emissions is joined by some responsibility for more recent emissions growth in the developing world. Second, it supports the expansion of efforts to help developing countries to reduce the carbon emissions from economic growth through technical assistance and finance.

This analysis has also highlighted the imperfections of an approach which focuses on emissions within national borders. Whilst the nation state is at the heart of most international negotiations and treaties such as those for combating climate change, global trade means that a country's carbon footprint is open to some interpretation. Should countries be concerned with emissions within their borders (as is currently the case), or should they also be responsible for emissions due to the production of goods and services they consume? The scale of emissions from exports from countries such as China *and* the neglect of emissions from international transport provide some arguments for the latter approach.

Within the discussions about what should follow the current phase of the Kyoto Protocol in 2012, there is space to debate this and to think about alternatives to national targets such as targets for industrial sectors. The most important objective is to reduce emissions. This briefing note has highlighted some issues that will hopefully contribute to the necessary political debate about how this should be achieved.