Economic Rebalancing and Carbon Dioxide Emissions in China

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Abstract:

China needs to rebalance away from investment, exports and industry to consumption and services. Since the old growth model is energy- and emissions-intensive, shifting to a new growth model could have profound implications for China's carbon dioxide emissions. This paper uses a general equilibrium model to study the potential impact of successful economic rebalancing in China on the country's CO2 emissions. The results show that economic rebalancing may, by 2030, contribute to 14 per cent reduction in the emissions intensity of GDP. Although these results can only be regarded as indicative, they show the importance of economic rebalancing to China's climate change response.

Key words: China, Structural rebalancing, emission reduction, CGE

JEL: C68, D58, Q43, Q53

1. Introduction

China's economy has been growing rapidly over the past 30 years. This has transformed the country. The poverty gap fell from 39 per cent in 1981 to 2.84 per cent in 2009 (WDI, 2013). Urbanization rate rose from below 20 per cent in late 1970s to more than 50 per cent in early 2010s (ibid). China became a lower-middle-income country in 1997 and a higher-middle-income country in 2010. It is currently the second largest economy in the world.

However, China's fast growth has also led to the accumulation of structural problems. Its economy is unbalanced. The share of consumption (public plus private, hereafter) in GDP (47 per cent) is the lowest in the world, and its share of investment (48 per cent) the highest. Both the service sector and the industry sector make up 45 per cent of total value-added, making the former unusually low and the latter unusually high. Not only is China's growth unbalanced, it is also dirty. China consumes the largest amount of energy in the world – 20 per cent of the global total. China is also the world's largest carbon dioxide emitter. In 2009 it contributed a quarter of the world's total CO2 emissions.

There is a consensus in China that fundamental change is required on both fronts. The official economic policy position is one of rebalancing (The 12th FYP, 2010). Here the aim is to increase the share of consumption to GDP, and of the service sector. The official environmental policy position is one of reducing both local pollution and CO2 emissions, at least relative to GDP growth (ibid).

To date, the link between these two goals has not received much attention. Yet, prima facie, one would expect one goal to affect the other, in particular because the industrial sector is more carbon-intensive than the service sector.

This paper uses a quantitative approach to investigate the potential contribution of economy-wide rebalancing policies to China's Co2 mitigation. Section two reviews the imbalances, their causes, remedies and links with carbon emissions. Section three develops two growth scenarios and a 2-stage simulation used to model these two scenarios. Section four interrogates the simulation results. Section five makes some concluding remarks.

2. Background: imbalances, concerns, causes and remedies

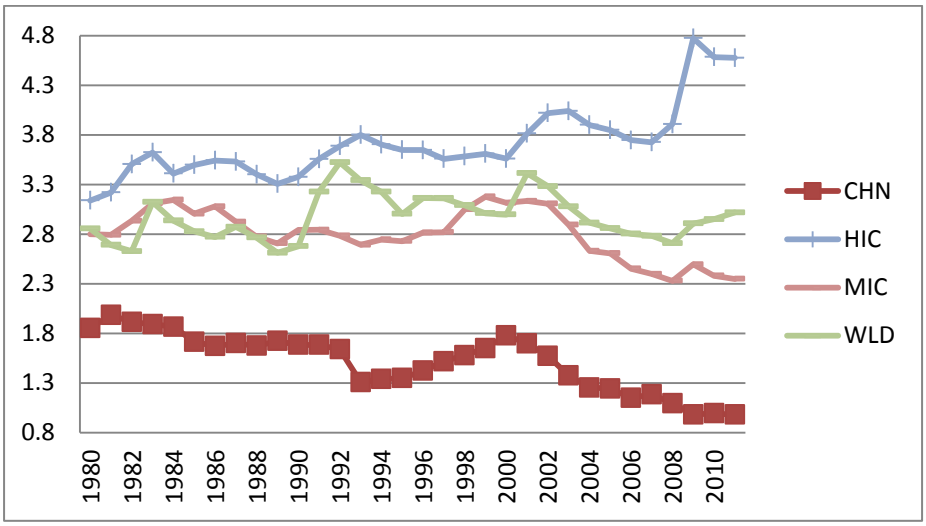
This section examines China's main economic imbalances (2.1), why they have given rise to such concern (2.2), and what their causes are (2.3). It then analyses the future trajectory of these imbalances, and discusses reforms to reduce them (2.4). Finally, it explains the link between economic rebalancing and the country's carbon dioxide emissions (2.5).

2.1 China's economic imbalances

There are three major imbalances in China's economic structure. First, as shows Figure 2.1, China has a high share of investment and a low share of consumption by world standards. Not only is China's C/I ratio consistently lower than that of the world averages, but the

difference is increasing. At the beginning of the 1980s, China's C/I ratio was 1.85 and the world average was 2.85. By 2011, China's C/I ratio has fallen to 0.98 whereas the world average has increased to 3.02.

Figure 2.1: consumption/investment (C/I) ratio, China in the world



Source: (WDI, 2013); *Note*: CHN, HIC, MIC and WLD denote China, high-income-country, middle-income-country and world, respectively.

Second, China's current account shows a large and persistent surplus. China has been running a current account surplus for most of the past 3 decades. As Figure 2.2 shows, since the mid-1980s, China's current account surplus has been on an upward trend. It peaked in 2007 at 10.1 per cent of GDP, but then fell sharply with the Global Financial Crisis. But China's current account still shows a large surplus: it was 2.6 per cent in 2012.

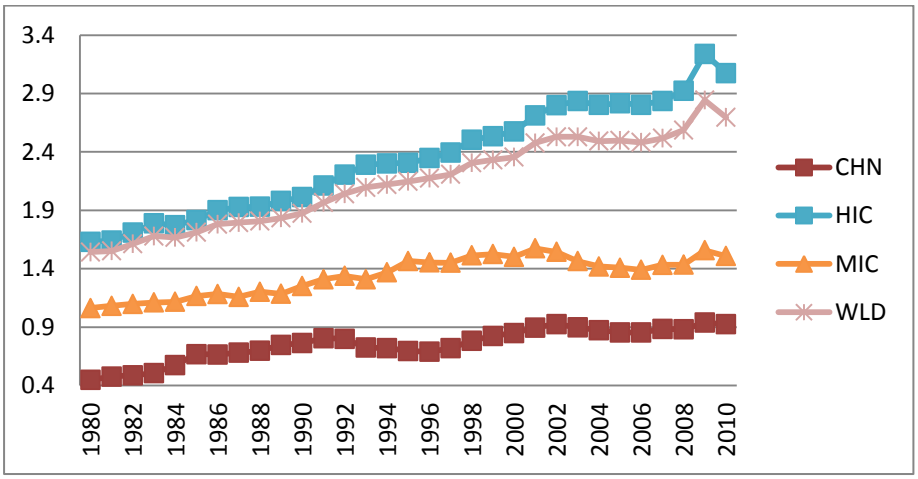
Figure 2.2: China's current account balance

Time period	Current account balance as % of GDP
1982-4	1.3
1985-9	-1.6
1990-4	1.4
1995-9	1.9
2000-4	2.3
2005-8	8.5
2008-11	3.9

Source: Yu (2012)

Third, China has a large industry sector and a small service sector by world standards. Figure 2.3 compares China's service/industry (S/I) ratio with the world average. Again, not only does China have a consistently lower S/I ratio than the world average, but the gap is growing. In 1980 China's S/I ratio was 0.45 and the world average was 1.54. By 2010, China's S/I ratio moved up to 0.92. However the world average has increased by a bigger margin, to 2.70.

Figure 2.3: Service/industry sectorial value added ratio, China in the world



Source: WDI (2013)

2.2 China's economic imbalances as causes for concern

Concerns around China's economic imbalances revolve around eight points. The first is simply that they are highly unusual by world standards. This does not in itself demonstrate that they are sub-optimal. However, international comparisons are instructive. Huang and Wang (2010b) estimated that China's investment share of GDP could be 20 per cent higher than the 'international optimal level'[1] and its consumption share 20 per cent lower (p.295).

The second is that the imbalances may increase China's risks. Historical precedents show that in the past fast-growing countries powered by high investment levels are prone to shocks (Pettis and Lardy, 2012). The Asian Financial Crisis is one such episode. On the one hand China's economy may be subject to less external shock than its East Asian neighbours as it does not have an open capital account. But on the other hand, China's over-investment is even larger than the estimated over-investment in the other Asian economies leading up to the Asian crisis (Lee et al., 2012, p.16).

Third, high investment coupled with low returns may hinder the sustainability of growth. China's rising capital-output ratio indicates falling capital productivity (Qin et al., 2006). China recorded improvement in investment efficiency in the first two decades of reform (Zhang, 2003, p.731)[2], but the trend was reversed sometime in the 1990s (Barnett and Brooks, 2010). Although the return on capital has been found to be comparatively healthy by world standard (Bai et al., 2006), it may be on a dynamically inefficient path (Rawski, 2002). China's growth relies increasingly on investment but investment becomes decreasingly efficient, such a growth model cannot be sustained (Prasad, 2007, p.1).

Fourth, there is strong evidence at the micro level that investment is mis-allocated. Large excess capacities have built up in heavy-industry sectors such as high-end property, steel, cement, coke and aluminium, yet there are equally large short-falls in investments in sectors such as health and education (Lardy, 2007, p.7). Even if there is no clear-cut answer as to

[1] the optimal level estimated by Chenery and Syrquin (1975) from a 101 countries database.
[2] Zhang used data between 1980 and 2000.

whether China is over-investing at the macro-level (Ding et al., 2010, p.6), sectoral misallocation may have been the main reason for the declining productivity growth for the overall economy (Blanchard and Giavazzi, 2006, p.7).

Fifth, the low and declining share of consumption is a concern in itself. Fukumoto and Muto (2012, p.66) argue that giving households a better return from growth is the foremost rationale for rebalancing China's economy. Even if China could be excused for not paying enough dividends (in terms of consumption) to its households (who are the ultimate shareholders) when investment opportunities were more profitable in the earlier years of the reform, it should certainly be paying more dividends now that investment returns have fallen.

Sixth, the welfare loss from China's large current account surplus is a central concern. Yu (2012) pointed out that while China runs sustained current account together with capital account surpluses, it is not taking advantage of the inflow of foreign direct investments to purchase more high-end assets from abroad.

Seventh, a large current account surplus increases the risk of external shocks, both for China and for the world as a whole**.** A large trade surplus draws the attention of the protectionists' (Guo and N'Diaye, 2009); a large foreign exchange reserve in the form of U.S. treasury bills exposes China's investment to U.S. dollar exchange rate as well as inflationary risks (Yu, 2012); and an export-dependent manufacturing sector is vulnerable to external demand shocks (Lee et al., 2013, p.20).

Eighth, and most importantly of all for the purposes of this paper, China's structural imbalances may be contributing to its high and rapidly-growing level of CO2 emissions. We return to this in Section 2.5.

Against the consensus though, Huang (2013) fears it might not be the time for China to embrace structural rebalancing policies yet. He argues that 1) successful economies have all gone through periods of unbalanced growth; 2) China's current income level has not reached the levels of Japan and Korea when they started to rebalance; and 3) rebalancing prematurely risks compromising a productivity edge.

However none of his arguments stand on firm ground. First, many countries indeed have experienced unbalanced growth, but to different extents. China's current structure seems to be beyond the common sense (Krugman, 2013). Regarding his second argument, although there is some validity in this point, the development stage of other countries can only be used as a rough reference. Third, and most importantly, the key impetus to reduce/increase the share of investment/consumption is to move away from the diminishing return and miss-allocation of capital. In this regard rebalancing will induce rather than hinder productivity growth.

Nevertheless, Huang (2013) does provide an important observation regarding the cause of China's imbalances, on which the next subsection focuses .

2.3 Causes of China's imbalances

There are (at least) nine causes for these imbalances. These imbalances are intertwined and themselves mutually reinforcing.

The first and foremost is factor price repression. Capital cost is depressed (Huang and Wang, 2010a). This works as an implicit subsidy to investors. China's exchange rate management also leads to an undervalued currency. This resembles an export-promoting growth strategy (ibid).

Resources prices are also repressed. Land prices are cheap in the countryside due to state-ownership (ibid). The price of energy is low due to price management. The cost of damage to the environment is not internalized because environmental regulations are not adequately enforced.

Labour wages are repressed too. Due to the Household Registration System (HRS), migrant workers are willing to take lesser wages than their city counterparts who do the same job (ibid). Employers are thus able to hire at low wages – this is especially true in the labour-intensive export sectors. Moreover, the HRS excludes migrant workers from receiving equal health care, education and other social benefits as their urban counter-parts do. This is a reflection of the second cause.

These factor price depressions act as implicit subsidies for producers, investors and exporters (ibid). Hence they are responsible for high investment, industrial production and export. And with depressed wage income, on which private consumption depends, consumption is weak. Huang (2010) regards factor market distortions to be the fundamental cause for China's imbalances. It is estimated that the total producer subsidy equivalents (PSEs) to be as high as 10.6 per cent of GDP and 9.6 per cent of current account balance in 2008 (Huang and Tao, 2010).

Yet there are other causes too. Some are related to factor price distortion directly, some indirectly, while others are hardly related. The point is that these other causes are neither mutually exclusive with factor price distortions, nor mutually inclusive. We now turn our attention to these causes.

The second cause relates to the under-provision of social welfare. China's spending on health care and education is low by world standards. Figure 2.4 shows this for total health and education spending, and Figure 2.5 demonstrates it for public spending. This means that many citizens need to maintain a high level of precautionary saving, thereby constraining private consumption (Cristadoro and Marconi, 2012, Liu and Hu, 2013). High savings at the same time also leads to high investment and the high current account surplus.

Figure 2.4: total health and education expenditure shares, a worldwide comparison

	Health expenditure, total, 2011 (% of GDP)	**Adjusted savings: education expenditure*, 2008 (% of GNI)**
China	5.2	1.81
United States	17.9	4.79
World	10.1	4.19

High income	12.3	4.64
Middle income	5.7	3.27
Low income	5.8	2.99

Sources: WDI (2013),

Note: *refers to the current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment.

Figure 2.5: Health care expenditure, a worldwide comparison

	Health expenditure, public, 2011 (% of government expenditure)	**Public spending on education, total*, 2008 (% of GDP)**
China	12.5	4^
United States	19.8	5.50
World	n.a.	4.62
High income	17.2	5.15
Middle income	n.a.	4.60
Low income	n.a.	3.69

Source: WDI (2013); ^Xinhua (2013); *data for 2008, except China, whose data is for 2012.

The third cause of the imbalances regards competition policy in general and corporate saving in particular. At the centre of this cause are China's state-owned enterprises (SOEs). Until recently China's monopolistic/oligopolistic SOEs do not have to pay dividends to the state (Aziz and Cui, 2007, p.27). This leads to a large saving-investment gap, which is ultimately responsible for the current account surplus (Tyers and Lu, 2009). The strong savings at the same time also bolsters these companies' appetite for investment.

The fourth cause is financial repression. China has one of the highest levels of financial repression in the world (Dorn, 2006). Financial repression has also been shown to be an important driver of industry expansion. There are robust evidences showing in conjecture with an export-promoting growth strategy, financial repression constrains factors from moving to the service sector (Anders C and Xun, 2011).

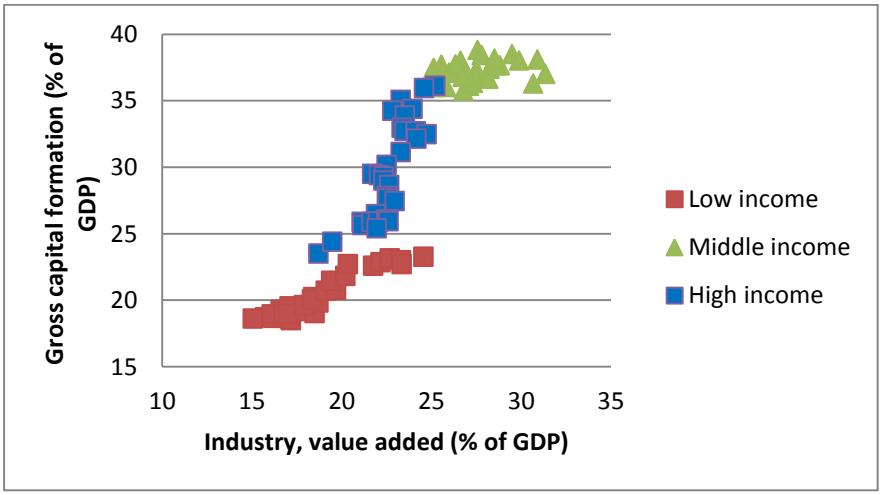
The fifth cause, which again relates to the financial sector, regards the sector's institutional setup. The finance sector is itself dominated by the SOEs. On the one hand these financial SOEs prefer to lend to the SOEs themselves[3] (Huang, 2010, p.75). This provides the SOEs yet stronger financial clout for investment. On the other hand they discriminate against smaller investors (Huang, 2010) and especially the households. This limits households' non-wage income and thus represses consumption.

Sixth, international experience shows that high investment and a dominant industrial sector go together. Figure 2.6 illustrates this point: there is clear positive relationship between the share of industry and the share of investment in GDP, across time and income-groups. This can be explained by the fact that the industry sector is more capital-intensive than either

[3] According to Huang (2010, p.57), 'the state sector accounts for only one-third of the Chinese economy, but accounts for two-thirds of bank loans. SOEs also account for a dominant share of funds raised from the market.

services or agriculture. In fact, China's overinvestment problem tends to concentrate on the heavy-industry sectors, as discussed in section 2.2.

Figure 2.6: Positive relationship between investment and industry share in GDP, between 1980 and 2010



Source: WDI (2013)

Seventh, an undervalued currency also contributes to the current account surplus (Huang and Tao, 2010, Max Corden, 2009). Although the gradual appreciation of RMB since 2005 has erased some of the surpluses, it is projected (as of April 2012) that the surplus is likely to rebound should real exchange rate remains unchanged (Cline, 2012).

Eighth, the dominant industrial sector is export oriented, and this contributes to the large current account surplus.

Ninth, the processes of urbanization and industrialization naturally create structural unbalances. These unbalances are natural because such processes invariably reduce the share of agriculture in GDP. As non-agriculture activities are intrinsically less labour-intensive, the share of labour income, and therefore the share of consumption naturally falls.

Some economists, including Huang (2013) and Krugman (2013), believe this natural process to be the most obvious explanation to China's unbalances. Indeed, the presence of large rural surplus labour might have amplified this effect. It is important to understand the impacts of different causes because they imply different structures in the future and require different policy actions – which is what we discuss in the next subsection.

2.4 China's future economic structure and reforms to reduce imbalances

It is one view that China's economic imbalances, though they have worsened in the past, will reduce in the future (Huang, 2013). Particularly important to this debate is the concept of the Lewis Turning Point, the point at which surplus labour vanishes. Reaching the Lewis-turning point would drive up labour cost, increase wage income, reduce China's labour cost advantage and thus stimulate consumption, reduce trade surplus and promote the service sector. However, till now there is no consensus on whether China has crossed the LTP and what will be the impact if it actually crosses it (Yao and Zhang, 2010, Das and N'Diaye, 2013,

Huang and Jiang, 2010, Wang, 2010). Hence it is uncertain when and to what extent the Lewis turning can reduce China's imbalances.

It is also a natural occurrence that per capita income relates with the importance of the service sector (World Bank, 2004). This can also be observed in Figure 2.6, from which there are clear evidences that for LICs to take off their economies will need to be significantly more investment- and industry-focused; however for MICs to break the middle income trap, their economies need to be more consumption- and service-oriented.

There are two main drivers for this 'servicification' of the economy. With regard to the consumption pattern, as per capita income increases demand for agricultural and durable goods tend to saturate; and at the same time, demand for health care, travel and finance tend to increase (Wu, 2007). With regard to the production process, as the diversification of workforce progresses, firms increasingly outsource services in financing, legal practice, human resources, technology, security and even management and strategy (ibid). In fact, the literature has also observed that the rate of service sector growth has positive relationships with several other determinants, including democratization, openness to trade, proximity to financial centres and level of urbanization (Eichengreen and Gupta, 2013).

Demographic change can be another driver of structural change. China's aging population would require a larger share of age care, health care, social securities and other related services (Wagner, 2013).

In addition to these "natural" economic forces, there are also policy actions which China could take, and indeed is trying to take to reduce its economic imbalances. These involve addressing the causes of the imbalances addressed previously.

First, giving a higher priority to welfare spending in the budget is compulsory. This will increase the supply of social welfares. The effects will be less precautionary saving and more consumption.

Following the first point, secondly, the HRS system needs to be reformed to allow migrant and urban workers equal rights. Hence the incremental welfare spending can be enjoyed by the migrant workers.

Third, SOE reforms should be high on the list. Either through privatization or the establishment of a dividend-paying channel, or preferably both, the savings from the SOEs should be made useful to the general public.

Fourth, financial sector reform is also a necessity. Removing the financial repression would result in the interest rate rising. Assessing borrowers on merit rather than ownership would reduce excessive investment.

Fifth, liberate resources, especially energy prices. Reducing energy subsidies and redirecting the budget towards tax cut or welfare spending could have a double effect on reducing heavy industry and boosting consumption.

Sixth, strengthen the enforcement of environmental regulations. In dealings with externalities, price mechanism should be carefully evaluated and if possible, experimented. A positive example of this is the 7 emissions-trading pilots.

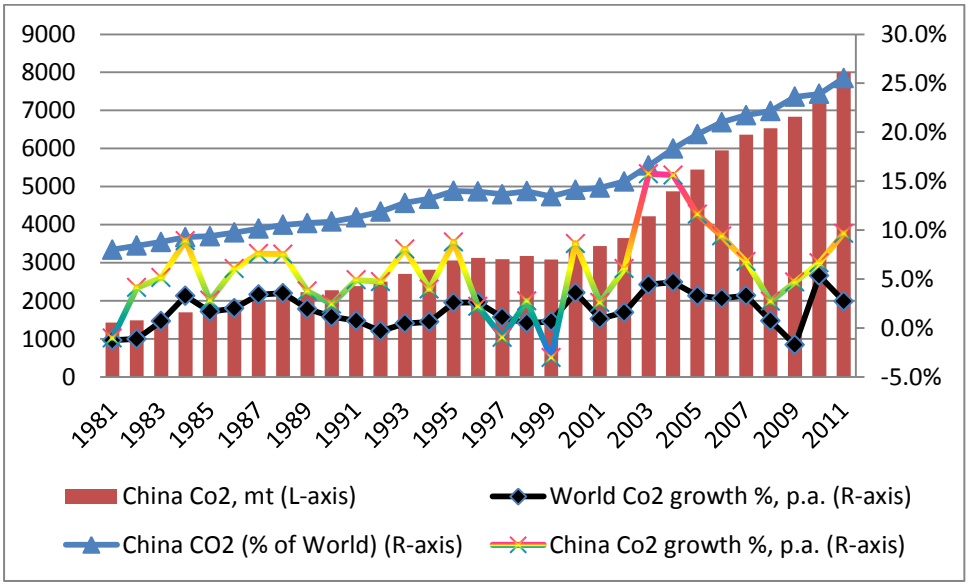
Seventh, the exchange rate policy should also be carefully evaluated. An export-promoting growth strategy is only good to a certain extent.

Eighth, speeds up the post-industrialization process. Although post-industrialization may evolve automatically, the process can be accelerated by reducing the immobility of the labour force (Lee and Wolpin, 2006). Programs such as targeted training and education will help to prepare the labour force for the transition from the industry sector to the service sector.

2.5 China's economic rebalancing and environmental challenges

China has the highest carbon dioxide emissions in the world and its emissions grow faster than the world average. As shown in Figure 2.7: China's carbon dioxide emissions China's annual Co2 emission increased from 1425 million tonnes in 1981 to 8000 million tonnes in 2011. Between these years, China has outpaced the world in Co2 emissions in all but two years. As a result, its share of total world emissions went up from 8 per cent to 25.5 per cent.

Figure 2.7: China's carbon dioxide emissions



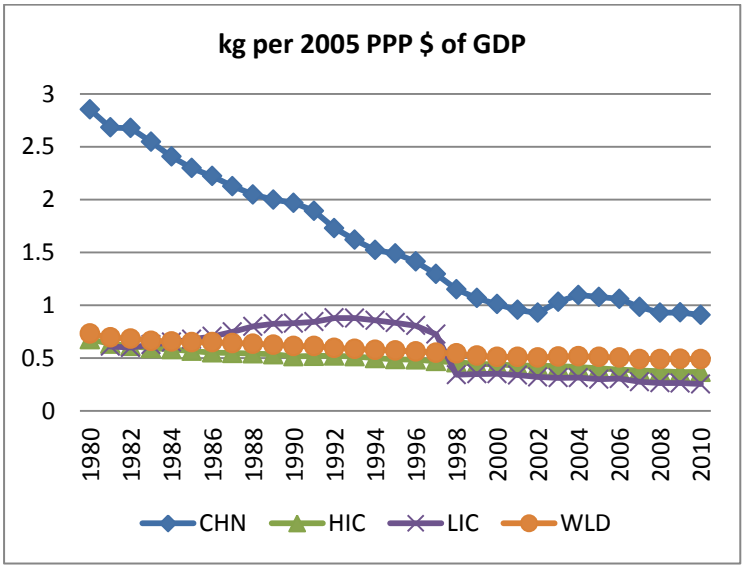
Source: OECD iLibrary4 , author's calculation

Not only China's emission is high in absolute terms, it is also high in terms of emission per unit of GDP (see Figure 2.8). Although it has declined substantially since 1980s, the country's carbon intensity of GDP still ranks near the top of the world. In fact, among the 207 countries recorded in the World Bank dataset, only 9 had higher carbon intensity than China in 2010. The sudden drop of LICs' emission intensity in 1997 crudely outlines China's high

[4] data extracted on 16 Nov 2013 17:55 UTC (GMT) from OECD iLibrary

emission intensity – it was the year in which China graduated from the LIC group to the MIC group.

Figure 2.8: Carbon emission intensity of GDP, China in the world

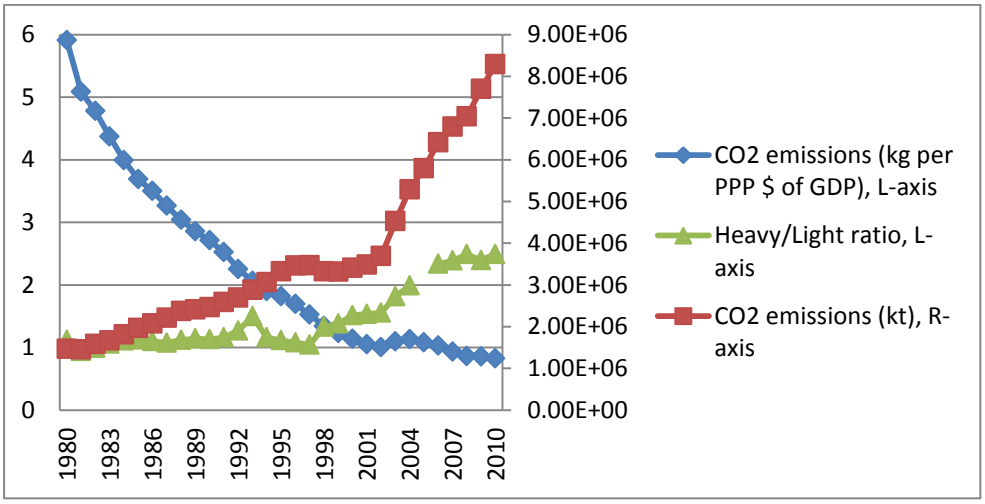


Source: WDI (2013)

There are four closely related reasons as to why China's emission is high, both in absolute and intensity terms. First, the share of the industry sector is high. Several studies have found that the increase of the I/S ratio in the early 2000s has led to the increase in carbon intensity over the same period (Wu, 2011, p.706, Chen, 2011). Li (2011) identified that sector structural shift was the driving factor behind the upward trend in energy intensity between 2001 and 2005.

Second, within the industry sector, the share of the most energy- and carbon-intensive heavy–industry sectors grows faster. Putting China's emission, emission intensity and heavy/light industry ratio together, Figure 2.9 shows that around year 2002 there was a distinct upward movement in each of these three indices.

Figure 2.9: emission and heavy industry



Third, China is highly dependent on energy, due to the strong demand from the industry sector and especially the heavy-industry sector. Like emission intensity, China's energy intensity of GDP in 2010 was significantly higher than the world average, the Europe Union's average and the United States' (See Figure 2.10). In fact, it was even higher than the oil-rich Arab World average.

Fourth, to make the matter worse, China's energy is highly dependent on fossil fuels. Again, by Figure 2.10, fossil fuel contributes to 88 per cent of China's total energy consumption. This was higher than the world average and also larger than the United States'. In fact it was not much lower than fossil-rich Russia.

Figure 2.10 Energy intensity and fossil fuel dependency, a worldwide comparison

	Energy use (kg of oil equivalent) per $1,000 GDP (constant 2005 PPP)	Fossil fuel energy consumption (% of total)
China	265	88
United States	170	84
World	181	81
European Union	123	75
Arab World	213	97
Russian Federation	348	91

Sources: WDI (2013)

3. Modelling the link between rebalancing and emissions: literature survey and approach

3.1 Literature survey

Despite the clear links between rebalancing and emissions, there are only a few studies which have explored the subject (e.g., McKay and Song, 2010, Howes and Dobes, 2010). Even fewer have undertaken forward-looking quantitative analysis in a rigorous manner. Feng et al. (2009)'s regression analysis showed that between 1980 and 2006, a 1 percentage point increase in the share of tertiary industry value added in GDP led to 0.6 per cent decrease in energy intensity in any given year. Howes (2012) used a simple back-of-the-envelope calculation to show that a 10 per cent switch in the GDP composition from industry to service will lead to 14 per cent reduction in energy intensity. Neither set of calculations is based on estimating emissions in a restructured economy, in which both service-industry and investment-consumption levels are very different to their current levels.

Indeed, there are very few efforts to model China's rebalancing even without consideration of the implications for emissions. He and Kuijs (2007) is in fact the only such modelling exercise we are aware of. Theirs is an influential study, providing the underpinning for the modelled results in the WB China 2030 exercise.

He and Kuijs use the DRC-CGE model, a computable general equilibrium model developed by the Development Research Centre of China. They shock a number of parameters to quantify

the impact of rebalancing. In their two growth scenarios, GDP growth is the same, but investment and industry shares in GDP are different. A significant reduction in the investment's share in GDP is projected – almost halving its share compared to a past-trend scenario to an average of 28 per cent of GDP between 2025 and 2035. A less significant reduction in the share of industry in GDP is projected. It falls from 51 per cent of GDP to 36 per cent, by 2035.

Our aims is to understand the emissions implications of the sort of rebalancing which He and Kuijs model, and which the World Bank report highlights. Our basic question is: how China's emissions would be affected by economic rebalancing? To do this, we need a rebalancing and a baseline scenario, a model, and a modelling procedure. These are set out in the subsections which follow.

3.2 Baseline and rebalancing scenarios

Our starting point is World Bank China 2030 report. We use this scenario because they are the highest-profile[5] example of a quantitative set of projections of what a rebalanced economy would look like. The scenario assumes that China steadily rebalances its economy while avoiding major shocks. Under this scenario, consumption's share in GDP will rise and investment's share will fall. The trade surplus vanishes. By 2030, consumption, investment and net export make up 66, 34 and 0 per cent of total GDP, respectively. With regard to sectoral composition, industry sectors' share in GDP fall and service sector's share increase. By 2030, the primary, secondary and tertiary sectors will account for 4, 35 and 61 per cent of GDP, respectively.

GDP growth is assumed to be 7 per cent, 5.9 per cent and 5 per cent in 2014-2020, 2021-2025 and 2026-2030, respectively (see Figure 3.1).

One limitation of the World Bank study is that it lacks a baseline. For meaningful quantitative comparisons, we need a baseline with which we can compare our rebalancing scenario. We assume the broader economic structure remains static. This allows us to compare the emissions saving from the rebalancing scenario against the status quo.

He and Kuijs take as their baseline an extrapolation of past trends. Thus the investment and industry share continue to rise. This strikes us as implausible. Section 2.4 highlighted a number of reasons why, even without significant policy change, some rebalancing might take place. We take as our baseline the maintenance of current shares. Thus the assumption is that the current extent of imbalance remains, rather than that the imbalances further worsen. This would seem to provide a more natural comparison between rebalancing and no rebalancing.

[5] The Rebalancing scenario in this study uses such an outlook because first this outlook can be viewed as being endorsed by the government. The report was jointly written by the World Bank and Development Research Centre (DRC), a policy-advisory body under China's State Council. Second, growth forecasting involves making strong assumptions about the future. The choice of these assumptions requires to a large extent the modellers' discretion. Given it is difficult to verify such assumptions, adopting an existing outlook is a more direct approach than creating a new outlook ourselves

As with He and Kuijs and the World Bank[6], we assume that rebalancing does not affect real GDP. Having real GDP growing at the same rate between the baseline and the policy case also allows us to focus purely on shifts in the way output is produced, rather than on changes to the level of output, when it comes to thinking about emissions.

Putting the two scenarios side by side, Figure 3.1 compares the different economic structures in 2030, and shows the growth rate.

Figure 3.1: Baseline and policy scenario economic strucutres, 2030

	Baseline (Status quo)	Policy (rebalancing)
	Real annual GDP growth (%)	
2014-2020	7	
2021-2025	5.9	
2026-2030	5	
GDP Expenditures	Share of GDP	
C	32%	66%
I	64%	34%
Industries	Share of industrial value-added	
AFF	10%	4%
IND	45%	35%
SRV	45%	61%

Source: WB, WDI

3.3 Model

A recursive dynamic computable general equilibrium (CGE) model, namely CHINAGEM, is employed to conduct the simulation. The model uses the 2002 Chinese Input-Output table as the main database. The core theories of the model are based on the ORANI model ((Dixon et al., 1997), with the theories of dynamism adapted from the MONASH model (Dixon and Rimmer, 2007). An emission accounting framework and an energy accounting framework are incorporated into CHIANGEM as it is done in the MMRF model[7]. A documentation of the CHINAGEM can be found in Mai et al. (2010). For the current study, the economic structure is updated to represent the structure of the economy in 2012.

3.4 Simulation method

The approach we use is to allow a small number of basic economics parameters, normally held constant, to vary so that the desired economic shares and growth rates are achieved. We have seven target variables: the rate of GDP growth, four shares of GDP - private consumption, public consumption, investment, and net exports; and three shares of value added – agriculture, industry and services. To achieve the target variables, we allow the

[6] The World Bank Report finds an unspecified 'small' reduction in output under rebalancing from the baseline over the entire policy span. We thus treat this as close to the baseline GDP figures.
[7] consult Centre of Policy Studies Web archive at http://www.monash.edu.au/policy/mmrf.htm

following six (normally fixed) parameters to be endogenous: total factor productivity; the marginal propensity to consume for both the public and private sector; and the return on capital; and the demand for agricultural, industrial and service inputs.

Clearly, rebalancing requires that the propensity to consume of both the public and private sector rises. Likewise, it requires a higher return on capital, to end financial repression and over-investment. Less investment will, on its own, mean lower growth, but we would expect TFP growth to be higher as a result of rebalancing reforms, which enables growth to be kept constant across the two scenarios. Increasing consumption by more than investment falls causes net exports to fall to zero.

The nominal exchange rate is used as the numeraire, and so is fixed, in both scenarios. World prices are also fixed, but the domestic price level is endogenous which allows for real appreciation consistent with elimination of the current account surplus.

We also fix the budget deficit to nominal GDP ratio in both scenarios. Given in the rebalancing scenario we target a higher total consumption share in GDP, this can potentially create unrealistically high levels of government debts.

In terms of the supply side of the economy, we endogenous the three sectoral "input-demand shifters" to model the "servificiation" of the economy. These allow cost-neutral[8] shifts in the demand for intermediate goods produced by each of the three broad sectors. The expectation is that rebalancing increases demand by producers for services, and reduces it for agriculture and industry.

In terms of actual modelling technique, a two-stage procedure is required. If we shock all three of the shares of agriculture, services and industry at the same time, the model tends not to solve.[9] But if we only shock two of these three, one of the sectoral demand-shifters has to be made exogenous. The choice of shifters influences the results significantly.

To get around this problem, we use a two-stage approach. In the first stage, four variables are targeted: GDP growth, private and public consumption, and investment. Nominal value added is thereby obtained, and used, along with information on target shares, to calculate nominal growth rates for industry, agriculture and services value added. These are then used as targets in a second simulation, along with the industry and consumption shares already used, as well as the real GDP growth rate.

This two stage procedure ensures that the model solves, and gives the target sectoral as well as demand-side shares desired.

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[8] The cost-neutral condition ensures a fall/increase in input use by a producer/investor is matched by a comparable increase/fall in output, such that that the unit cost of production/investment remain the same.

[9] This is partly because the model is solved by linear approximation - it involves approximation errors; and also partly because when externally calculating the rates of change in sector shares it inevitably creates rounding errors. Since when the rate of changes in the three shares are shocked, the sum of the shares of all sector's value-added must add to exactly 1, this becomes an unrealistic request for the model to cope with the errors.

4. Simulation results

In this section we show the cumulative, percentage deviations[10] in the Rebalancing scenario from the Status quo scenario. The results should be read as the overall impacts of the rebalancing policies over the current situation, over the 18 years between 2013 and 2030.

4.1 The macro-economy

Real GDP income is unchanged by assumption. Figure 4.1 shows the simulation results on the income side of GDP. TFP improves[11] as expected: with lower investment, the economy needs higher TFP to maintain rapid growth. Capital employment falls due to the reduced investment. Labour employment increases as a result of the higher share of the labour-intensive service sector. As capital/labour ratio decreases, marginal productivity of capital increases and marginal productivity of labour decreases, leading to a rise in real return to capital and a fall in real wage.

Figure 4.1: GDP income

GDP income			
Real GDP	0	TFP	-9
Capital	-8	real return to capital	67
Labour	7	real wage	-12
Contribution to GDP			
factor accumulation	6	➢ capital ➢ labour	3 3
efficiency	-11	indirect tax	7

Source: CHINAGEM, authors' simulation

Figure 4.1 also decomposes the contributions to the income side of the GDP. The accumulation of labour and capital each accounts for 3 per cent of the GDP, adding to a total contribution of 6 per cent. Notice that although capital employment falls by 8 per cent, capital income still has a positive effect on GDP due to the significant increase in capital return of 67 per cent. The increase of indirect taxes, required to finance the increase in government consumption, adds another 7 per cent to GDP. However efficiency losses, due to the increase in taxes, reduce GDP by 11 per cent.

The composition of GDP changes due to the rebalancing, as Figure 4.2 shows (Demand-side shares under the two scenarios have already been shown in Figure 3.x). Private consumption and public spending increase by 35 per cent and 42 per cent, respectively. Correspondingly, the economy's average propensity to consume out of GNP increases, by 33 per cent.

Figure 4.2: Demand side of GDP

	Quantity	Price	Endogenized variables

[10] Unless otherwise stated

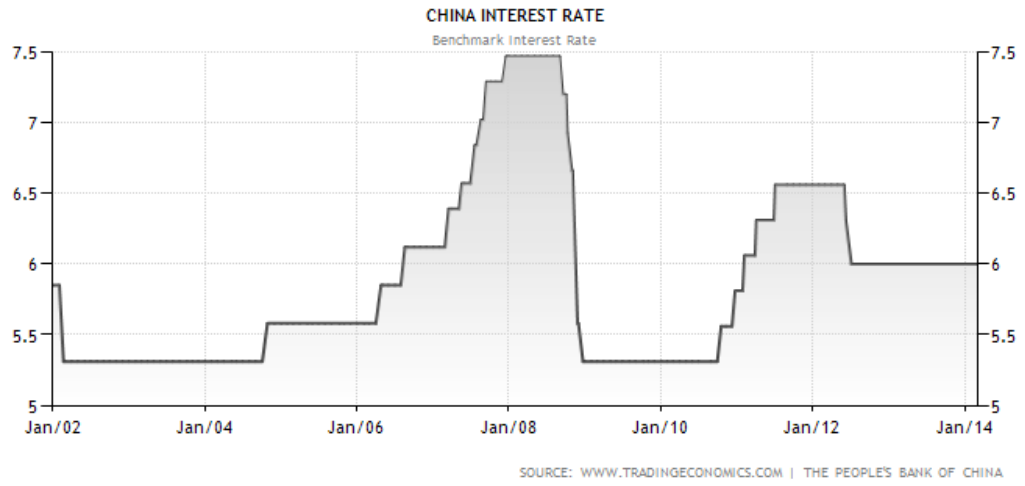
[11] TFP being negative represents an improvement in factor productivity

GDP	0	4.8		
investment	-26	2.5	ERR (real change)	0.022
consumption	35	5.1	APC_GNP	33
government expenditure	42	9.7		
export	-31	-3.5		
import	-6	0		

Source: CHINAGEM, author's simulation.

Real investment falls by 26 per cent. This is facilitated by a 2.2 percentage point increase in the expected rate of return to capital. This is a strong increase by China's standards. As Figure 4.3 shows, between the peak immediately prior to the Global Financial Crisis and the through at the beginning of the GFC, China's interest rate dropped by just above 2 percentage points. Clearly a net increase of 2.2 percentage points between 2013 and 2030 would represent a major policy effort to properly price capital.

Figure 4.3: China benchmark interest rate between Janurary 2002 and January 2014



http://www.tradingeconomics.com/china/interest-rate (accessed 14/03/14)

Net export falls by 94 per cent as the increase in consumption outweighs the decrease in investment. This requires a fall in the competitiveness of China's goods and services. World prices are assumed to be constant, and the nominal exchange rate fixed, but there is a general increase in the domestic price level, by 4.8 per cent. This pushes up China's export price index and in turn reduces the country's export, by 31 per cent. The increase in domestic price level encourages import. However import level falls by 6 per cent. This is because the majority of China's imports are used as intermediate inputs in the manufacturing sector. Import demand falls when the manufacturing sector shrinks – which the next subsection illustrates.

4.2 Sectoral results

Overall sector results are summarised in Figure 4.4. (Sectoral shares under the two scenarios have already been shown in Figure 3.x) Industry sector gross activity decreases by 13 per cent whereas service sector activity increases by 54 per cent. Industrial outputs are 2 per

cents cheaper whereas services are 3 per cents more expensive. The fact that prices move in the same direction as output levels indicates the dominating effects due to shifts in the demand curve. Indeed a strong substitution from industrial outputs to services is shown by the industry-demand-shifter moving leftwards while the service-demand shifter moving rightwards.

Figure 4.4: industry and service sectors

	activity[12]	price	demand-shifter
Agriculture	-62	-16	-183
Industry	-13	-2	-16
Service	54	3	48

Source: CHINAGEM, author's simulation.

Note the very large reduction in demand for agricultural inputs. This seems implausible, and suggests that the targeted agricultural share is too low.

We look at the sector results, in particular those that are related with emissions, in more detail in the following subsection.

4.3 Emissions

Simulation results show that the structural rebalancing will lead to 14 per cent reduction in CO2 emissions. Given that real GDP is constant, emission intensity of GDP also falls by 14 per cent. Figure 4.5 records the emission and emission intensity for industry and service sectors in 2030, under both scenarios.

Figure 4.5: Sectoral Co2 emission and emission intensity (gram/yuan), 2030

	CO2 (mt)		Sector Total Cost (10m yuan)		Co2/Cost (gram/yuan)	
	Base	**Policy**	**Base**	**Policy**	**Base**	**Policy**
IND	24032	18190	18527584	15822947	130	115
SRV	7560	9066	11262469	17846364	67	51

Source: CHINAGEM, authors' simulation.

Two factors have contributed to the fall in emissions. First, the share of the service sector, which is less emission intensive, increases while the share of the industry sector, which is more emission intensive decreases. This is the contribution from sectoral rebalancing we expected.

Second, the emission intensity falls in both the industry and the service sector. We focus on the industry sector, because its emissions are more than twice larger than that of the service sector. A disaggregation of the industry sector into 39 smaller sub-sectors shows the change in more details (See

[12] Activity refers to the real change in the level of sector output. This depends on the changes in input levels plus real changes in indirect taxes.

Appendix A for the full disaggregation). In 2013, the top 10 most emission-intensive sub-industry sectors accounted for 80 per cent of the total sector emissions. Figure 4.6 lists these 10 sub-sectors, ranked by emission-intensity. Most of these industries experience falls in activity levels larger than the industry-sector average (13 per cent). Some major emitters' activity levels fall substantially (e.g. Ferrous Metals and Non-ferrous metal Products). These have strong effects in reducing the industry sector's overall emission intensity.

Figure 4.6: top 10 most emission-intensive sub-industry sectors, 2013

	Co2 (mt)	Total cost (10m yuan)	CO2/Total cost (g/y)	Activity change (cumulative deviation, by 2030)
Gas supply	257	15971	1609	5
Electricity, Power and Heat	4548	534701	851	-15
Non-ferrous metal Product	996	276810	360	-24
Ferrous Metals	1423	592726	240	-31
Mining and Coal washing	511	223865	228	-18
Raw Chemicals	1219	550714	221	-19
Non-ferrous Metal Ore	69	59015	117	-34
Timber production	131	119660	109	-25
Art craft	80	76663	104	-9
Paper	159	173302	92	3

Source: CHINAGEM, authors' simulation and calculation

It is the input-output demand linkages that lead to such outcomes. Notice that most of these emission-intensive industrial sectors are also heavy-industry sectors. The reason their activity levels fall more than the other sub-industry sectors is that a small proportion of their outputs is sold to the fast growing destinations, namely the households and the government; but a large proportion of their outputs are used by the slow-growing heavy industries themselves.

The shrinking share of the heavy-industry sectors is matched by the increasing share of the less-emission-intensive sub-industry sectors. As shown in Figure 4.7, the most fast growing sub-industry sectors are also much less emission-intensive. These industry sectors grow faster because they sell more of their productions to the fast growing destinations, especially consumption. Therefore the rebalancing on the demand side of GDP has an indirect effect in reducing the country's emission intensity by stimulating the growth of less emission-intensive industrial activities through input-output linkages.

Figure 4.7: top 5 fastest growing sub-industry sectors

Co2	Total cost	CO2/Total cost (g/y)		Activity change (cumulative deviation, by 2030)
Beverage Manufacturing	45	71783	63	40
Farm Food Production	46	176936	26	38
Food Manufacturing	78	106990	73	29

Tobacco	5	27556	18	26
Medicines	21	87850	24	19

Source: CHINAGEM, authors' simulation and calculation

Our findings are in general agreement with the literature. Howes (2012) predicts that increasing service sector share by 10 per cent of GDP and reducing industry sector share by the same amount would reduce energy intensity by 14 per cent. Although the bottom line is the same, this finding should be taken far more seriously. The Howes study assumed constant energy-intensities within each sector, and took no account of a changing demand side, or of increased productivity.

Howes (2012) also assumes the entire change in the composition of sectoral value added is achieved by changes in activity levels. We've shown in this study, however, that price changes do contribute to the change in sectoral value-added shares. The fact that all sectoral prices move in the same direction as the level of output means output changes are less than expected – implying an overestimation of emission reduction by Howes (2012). That said, the overestimation is only marginal as price changes are small comparing with output changes.

The regression analysis of Feng et al. (2009) shows that one per cent increase in service sector share had led to 0.6 per cent reduction in energy intensity between 1980 and 2006. If such a relationship is preserved, it will imply a reduction of energy intensity of around 7 per cent over the 18 years between 2013 and 2030. And the reduction is about half of the estimated reduction in the current study.

5. Concluding remarks

China needs to rebalance its economic structure from investment- and export-extensive towards consumption- and service-based. Since the current economic structure is energy- and emission-intensive, rebalancing the economic structure has the potential to reduce the country's emissions.

This paper tries to quantify the contribution of China's structural rebalancing to its emissions reduction. The paper devises two scenarios such that the Chinese economy will either preserve the current structure or successfully rebalance it. A 2-stage simulation method is used to carry out the simulation, allowing a few key parameters to adjust endogenously. Results show that between 2013 and 2030, successful rebalancing will help the country to reduce its emissions by 14 per cent. This is in general agreement with the literature. The macro level and sectoral level results are also generally plausible, though further work is needed on the modelling of agriculture.

In summary, our results suggest non-negligible abatement potential through structural economic rebalancing. On the one hand this gives more currency for rebalancing China's economic structure from the perspective climate mitigation. On the other hand it gives confidence to pursue strong mitigation goals – at least in the short-run since such abatement opportunities will diminish as China's economic structure becomes more mature.

The current study is an attempt on the macro and broad sectoral level. Future studies may pursue further and target more specific structural reforms. China faces other imbalances too. Income-inequality and regional disparity are two such examples. The reform of the SOEs, which is at the centre of these challenges, may need more explicit treatments. Addressing these social, regional and institutional imbalances may have further implications that are not discussed in this paper.

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Appendix A

	QGAS	V1TOT	CO2/Total cost (g/y)	I58x1tot
supplyGas	257	15971	1609	5
ElecPowHeat	4548	534701	851	-15
NonmetalProd	996	276810	360	-24
FerrMetals	1423	592726	240	-31
MinWashCoal	511	223865	228	-18
RawChem	1219	550714	221	-19
NonfeMetOre	69	59015	117	-34
Timber	131	119660	109	-25
ArtcraftOmnf	80	76663	104	-9
Paper	159	173302	92	3
NferMetals	235	260782	90	-29
ChemiFibers	63	70905	89	-21
Rubber	55	68647	80	-13
ManuFood	78	106990	73	29
ManuBever	45	71783	63	40
NonmetOres	45	81816	55	-32
GenpurMac	48	96275	50	-26
SpecialMac	264	561163	47	-23
Textile	166	356358	47	-15
Petrolrefine	291	738101	39	-6
FerMetalOres	22	59978	37	-32
TransEquip	147	466341	32	-7
construction	386	1262219	31	-25
Furniture	16	56493	28	1
supplyWater	6	22339	27	2
ProcFarmFood	46	176936	26	38
MetalProd	72	293697	25	-19
Medicines	21	87850	24	19
PetroGas	95	449728	21	3
Plastic	52	248320	21	-17
Tobacco	5	27556	18	26
CultEduSpArt	9	49805	18	-5
ElecMacEquip	59	338324	17	-13
PrintRecord	15	112511	13	13
TextGarm	16	133165	12	-6
LeathFur	9	92407	10	-9
InstrMeter	7	74935	9	-23
ComEquip	38	615483	6	-12
RecyWaste	0	37545	0	-31
sum	11704	9641879		
CHINAGEM35-DCSB-DRBR-DRBP				