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Energy intensity and foreign direct investment: A Chinese city-level study

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ABSTRACT

In this paper we investigate the relationship between the energy intensity of Chinese cities and the location of foreign firms employing a unique dataset of 206 of the largest prefecture-level cities between 2005 and 2008. Our results reveal a non linear inverted-U shaped relationship between energy intensity and city-level per capita income with the majority of cities on the downward slope of the curve. We also find evidence of a significant and negative relationship between the foreign direct investment (FDI) flows into a city and energy intensity. However, this effect varies by geographic location reflecting differences in the ability of regions to absorb and benefit from environmental spillovers. The relatively small economic effect of FDI can in part explained by the propensity for foreign firms to invest in energy intensive sectors coupled with the trend for China to invest heavily in capital intensive industries.

1. Introduction

China has experienced rapid economic growth in the last two decades stimulated by significant capital inflows from abroad. China is now one of the largest recipients of foreign investment in the world with inflows of over $95 billion in 2010 (World Development Indicators, 2010). As China has grown so have its energy needs. From 2000 to 2008 China experienced a 70% increase in total energy consumption at 2.91 billion t of standard coal (Chinese National Bureau of Statistics, 2010) and currently accounts for 17.7% of global energy consumption even though it produces just 8% of global output (BP Statistical Review of World Energy, 2011). The first five months in 2011 saw China's imports of oil reaching 55% of consumption, up from 33% in 2009 (Ministry of Industry and Information Technology, 2011). A commonly held view is that China's dependence on imported oil leaves future growth vulnerable to fluctuations in global energy prices and could also be considered an energy security threat.

As a result, an important element of China's sustainable development strategy, as evidenced by the recent Eleventh- (2006–2010) and Twelfth- (2011–2015) Five Year Plans, is the management of energy demand and supply. Between 1978 and 2001, when economic growth in China averaged around 9% a year, the demand for energy rose by just 4% a year and energy intensity fell from nearly 400 t of coal equivalent per million RMB to a little over 100 t of coal equivalent per million RMB. However, after 2001 growth in energy demand began to outstrip GDP growth with an average growth rate of 14% a year (Rosen and Houser, 2007).[1]

Although China's average energy intensity fell between 1980 and 2010 there was a period between 2002 and 2005 when the falling trend was reversed before it again began to fall (albeit at a much slower rate than the period up to 2001). The relatively slow rate of progress on reducing China's energy intensity since 2001 is a concern to China's government given the importance now placed on sustainable development. The lack of progress on reducing energy intensity is despite rapidly increasing household incomes, continued foreign investment and a

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[1] The Twelfth-Five Year Plan states that energy consumption per 10,000 GDP should fall to 0.87 t of standard coal (at 2005 prices) by 2015 which is a decrease of 16% from the 1.03 t of standard coal consumed in 2010 and a decrease of 32% from the 1.28 t of standard coal consumed in 2005. These figures translate into energy savings of 670 million t of standard coal. In 2004 China introduced the “Outline of China's Medium and Long Term Energy Saving Plan 2004–2020” with a goal of energy intensity decreases of 20% for the 2006 Eleventh Five Year Plan. If China can hit its 2020 target of a 20% reduction in energy intensity during the Twelfth-Five Year Plan it would mean a quadrupling of the economy should be accompanied by a mere doubling of energy consumption (Chen, 2011).

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much greater awareness of the damaging effects of pollution on health and the natural environment.[2]

One explanation for the slowing rate of energy intensity improvement in the last decade is the increase in demand for automobiles and air conditioners. However, over the same period China experienced a relative shift in its industrial production patterns towards heavy and energy intensive industries such as cement, iron, and steel and aluminum. In 2007 China accounted for 35% of global steel production, 28% of aluminum production and 48% of global cement production (Rosen and Houser, 2007). Even accounting for a dramatic reduction in energy intensity from 1978 to 2001 China still lags behind the international average energy intensity levels for these industries. The World Bank estimates that Chinese steel, cement and ethylene firms use 20%, 45% and 70% more energy than the developed country averages respectively (New York Times, 2007).[3] Although certain industries experienced reductions in energy intensity, as a result of technological advances, innovation and the adoption of new technologies, it is the change in industrial composition that has kept China's aggregate energy intensity at such relatively high levels. An important negative externality from China's energy consumption is the environmental damage as a result of increases in the emissions of local and global pollutants. In 2008 China's emissions of sulfur dioxide (SO_2) and carbon dioxide (CO_2) were the highest and second highest in the world at 23 million and 2.7 billion t respectively.[4]

Two important determinants of the change in China's industrial structure were the relocation of heavy industry from developed countries and a proliferation of foreign joint ventures in energy intensive industries not just only to satisfy local demand in China but also to serve global export markets where the demand for energy intensive outputs was also increasing. These developments have reopened the debate on the role of foreign firms in China. The motivation of this paper is to understand the relationship between per capita income growth, energy consumption, energy intensity and the role of foreign firms against a background of China's changing industrial structure. Specifically, this paper will allow us to gauge the extent to which foreign direct investment has contributed to changes in China's energy intensity at the national and regional levels.

An early approach to understanding the relationship between GDP growth and energy consumption growth was to use a range of decomposition techniques. This literature searches for evidence of decoupling with the expectation that the growth in energy demand plateaus while economic growth continues on an upward trajectory (see e.g. Ma and Stern, 2008; Wang et al., 2005; Wu et al., 2005; Zhang, 2000; Chen, 2011). According to Fan et al. (2007) in their study of carbon intensity in China between 1980 and 2003 evidence of decoupling is a result of improved energy efficiency in the primary and materials sectors.[5]

A second, related, literature uses time series country-level data to look at the impact of economic growth on energy consumption. This literature is related to the well known environmental Kuznets curve (EKC) literature (Cole et al., 1997; Dinda, 2004; Forsten et al., 2012) which describes a non-linear inverted-U shape relationship between per-capita income and per capita emissions or per capita energy consumption (see e.g. Galli, 1998; Cole, 2006). There are also several studies on the relationship between economic development and environmental quality in China. He (2006) considers the relationship between FDI and the location of firms in Chinese provinces. Cole et al. (2011) investigate the relationship between economic growth and industrial pollution emissions in China using data for 112 major cities between 2001 and 2004 and find that most air and water emissions rise with increases in economic growth at current income levels. He and Wang (2012) analyze the impact of economic structure, development strategy and environmental regulation on the shape of the EKC using a panel of 74 Chinese cities for the period 1990–2001 and find that all three have important implications for the relationship between environmental quality and economic development but that the impact can vary at different development stages. These studies provide empirical evidence for the existence of different slopes for the pollution–income curve.

The literature on the effect of foreign firms on energy intensity is limited. A recent exception is Hübler and Keller (2009) who argue that foreign capital and the transfer of energy-saving technologies from developed countries are a possible channel by which the energy intensity of newly industrializing countries can be reduced (based on the productivity-enhancing technology transfer and spillovers literature e.g. Keller, 2004). The hypothesis that multinational enterprises (MNEs) use less energy per unit of output than their domestic counterparts in developing countries is confirmed by a number of firm-level studies. For example, Eskeland and Harrison (2003) and Cole et al. (2008) show that foreign ownership is associated with more energy-efficient production in the former's analysis of manufacturing plants in Cote d'Ivoire, Mexico and Venezuela and the latter's study of Ghana. One explanation is that MNEs utilize more advanced technologies that also tend to be energy-saving whether by design or simply as a positive externality from using newer materials and processes. However, Hübler and Keller's (2009) study of 60 developing countries for the period 1975–2004 fails to confirm that FDI reduced energy intensity in developing countries. One constraint of their study is the failure to employ micro-level data in terms of foreign investment and energy use. Energy intensity is determined by many cultural, political, and constitutional factors that can differ greatly across countries. Our data is ideally suited to a study of this type as it has regional GDP data and energy intensity data not usually available in studies of this type.

Studies of the relationship between foreign capital and energy intensity in China are scarce. Nevertheless, there are some studies that focus on the effect of foreign capital on environmental quality in China. He (2006) examines industrial SO_2 emissions for 29 Chinese provinces and shows that a one percent increase in FDI inflow increases industrial SO_2 emission by 0.098%. The emission increase caused by the positive FDI effect on economic growth and the structural composition of the economy cancels out any emission reductions due to the energy intensity gains from FDI. In a panel study in 112 cities in China, Cole et al. (2011) find that the share of output of domestic- and foreign-owned firms increases several pollutants in a statistically significant manner while output of firms from Hong Kong, Macao and Taiwan (HTM) either reduces pollution or is statistically insignificant.

[2] In this paper we refer primarily to energy intensity. However, energy intensity is closely related to the concept of energy efficiency and is often used interchangeably in the literature. However, strictly speaking energy efficiency is a parameter that depends primarily on the state of technology and methods of production and determines the amount of energy needed to deliver goods and services at the process level in similar plants, industries or subsectors (Birol and Keppler, 2000). Energy intensity on the other hand is defined by the energy consumption per unit of economic output (GDP). Energy intensity is therefore influenced by energy efficiency and can be used as an indicator of the aggregate level of energy efficiency of an economy, region or city. A reduction of aggregate energy intensity is not equivalent to, but is usually a response to an improvement in energy efficiency in a certain industry, and is typically realized through the use of energy-saving technology. For example, a shift in country's economic structure can also impact economy level energy intensity.

[3] See Fisher-Vanden et al. (2003) and Fisher-Vanden et al. (2006) for an analysis of changes in China's energy intensity.

[4] Environmental degradation in China is now a serious problem with 500 million people lacking access to clean drinking water and only 1% of China's city population of 560 million able to breathe air deemed safe by the European Union (New York Times, 2007). It is now reaching the point where environmental degradation is having a detrimental impact on future growth. The World Bank (2007) estimated the economic costs in 2007 to be in the region of 3.5 and 8% of GDP.

[5] Decomposition techniques include input–output structural decomposition, non-parametric distance functions, and index decomposition. See Ang and Zhang (2000) for a review.