The Effect of Economic Reform and Industrial Policy in a Panel of Chinese Cities*

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Preliminary

Abstract

We use the establishment of Special Economic Zones in China to estimate the effect of economic reforms on GDP. A panel of 270 Chinese cities from 1988 to 2010 allows us to exploit the variation in the establishment of zones across time and space. The results from our baseline fixed effects specification suggest that the establishment of a major zone led to an increase in the level of GDP between 6% and 10%, depending on the type of zone. This result is similar in a sub-sample of inland provinces, where the selection of cities in which zones were established was more transparent. Decomposing GDP into physical capital, efficient labor, and TFP shows that the effect of the zones went mainly through the accumulation of physical capital. Using electricity consumption and light intensity as two alternative measures for economic activity partly confirms these results.

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1 Introduction

China has been the fastest growing economy over the last three decades, sustaining an average annual growth rate well above 8% between 1978 and 2010. This period was characterized by many changes in policy and institutions. Most notably, China has become progressively a market economy. In addition, China has adopted a number of active industrial policies aimed to promote economic development, which were introduced gradually over time and space. Special Economic Zones (SEZ) are a particularly prominent example of such policies. This paper uses the variation in the establishment of different types of SEZ across cities and time to estimate the effect of reforms on economic activity using official GDP data and alternative measures.

While the Chinese economy has grown at unprecedented rates, this progress has been uneven. This was partly due to an important feature of the Chinese development strategy, which is to combine general liberalization and open-up policies with targeted industrial policy. On the one hand, a liberalization of the agricultural sector and the introduction of the Household Responsibility System has led to large increases in output and lifted millions of people out of poverty. Township and Village Enterprises boosted output and the accession to the WTO had further increased openness. On the other hand, the state continues to play an important role in the economy by controlling strategic sectors with state-owned enterprises, investments, and targeted support of certain industries and location inside of SEZ.

Any attempt to assess the impact of this unorthodox policy package faces the challenge of separating the effects of the different aspects of the development strategy. The SEZ provide a unique opportunity to identify these effects because they share many features of the overall development strategy and were established gradually over time and cities. The SEZ were initially meant as experiments with market mechanisms within geographically limited areas along the coast. The policy changes in the SEZ included for example liberalization of labor markets, foreign direct investment, ownership, and export. But the local leadership of the zones also had substantial autonomy in designing their policy packages and often engaged in active industrial policy. After the success of some of these early zones, the SEZ were extended first to other cities along the coast and then starting in the early 1990s also to inland regions. New zones are being established until today.[1]

We use panel data of 270 cities at the prefecture level over 23 years that allow us to compare development across cities and years and compare the effects of different types of zones. We control for time-invariant heterogeneity by using city fixed effects. The dynamics at the national and provincial level are controlled for by province-time fixed effects, which not only absorb reform effects in different years in the whole province or country, but also changes in the provincial price levels. Our baseline empirical approach is a difference-in-difference analysis: we regress log nominal GDP on an indicator that takes value one in all years after a SEZ has been established in a city, controlling for the above mentioned fixed effects. We also control for the size of the city (because the establishment of SEZ often coincided with changes of the borders) and for other time-varying city characteristics such as population and government spending. The results from our baseline specification suggest that the introduction of major zone in a city led to an increase in the GDP level between 6% and 10%, depending on the type of zone. Controlling for population size and government spending reduces the effect but it remains significant for the three most common zone types in our sample which are focusing on high-tech and export.

The SEZ were, especially in the first phase of the reforms, extremely selected. All of the first four SEZ were on the coast and close to potential trading partners like Hong Kong. One attempt to deal with the possible non-random assignment of the zones is to restrict the sample to cities in inland provinces where selection of the zones was largely based on an administrative criterion and therefore more transparent. The results for this sub-sample are overall in line with the results in the full sample and do not suggest that pre-treatment differences are causing the reform effect.

We also use a number of alternative specifications to identify the reform effect. First, we allow the effect of a zone to differ depending on how long ago it was established. We therefore construct indicators for each distance (in years) from the establishment of the zone and we observe that the effects are increasing during about

[1]Some of these later zones are called High-Tech Industrial Development Zones (HIDZ) or Economic and Technological Development Zones (ETDZ) and they had policies similar to the first Special Economic Zones established in 1980. We will use the term Special Economic Zones (SEZ) in a broader sense to refer to all types of zones and label the first set of SEZ as *comprehensive* SEZ.

the first ten years and then stabilize or decrease slightly. This is true both in the full and in the inland sample. Second, we add indicators for the pre-reform years and find that these pseudo-effects before the actual establishment of the zone are insignificant. There is a clear break in the year of the reform when the effects start increasing and become significant after about 3 years. Third, we allow a different time trend for the cities which had a SEZ in any year and we find that the coefficient on reform in the baseline specification remains positive and significant in the full sample, but not in the inland sample. We find a significant trend break in the year of the reform once we allow the post-reform trend to be concave. The results suggest an about 1 percentage points higher growth rates right after the reform and then a declining difference. Fourth, in order to identify the channels through which the reforms affected GDP, we decompose GDP into physical capital, efficient labor, and TFP. We find that the reforms have a strong effect on physical capital, but the effects on efficient labor and TFP are lower or insignificant. Last, we use electricity consumption and light intensity measured by satellites as alternative measures for economic activity. There are concerns about the accuracy of the official GDP data and even a potential systematic bias related to the reforms. The results from these two proxies partly confirm our results. But the interpretation of the reform effects with these variables is subject to uncertainty about the actual relationship between them and the true but unknown GDP.

We interpret these results in the following way: the SEZ that have been characteristic of the Chinese reform process had a significant positive effect on GDP levels, especially by attracting investments in physical capital. However, there is no evidence of permanently higher growth or increases in TFP. What can we learn from the Chinese experience about the role of economic reform and industrial policy during the process of development? Existing theoretical and empirical work suggests that the types of policies that backward countries should follow differ from those of advanced countries. Acemoglu et al. [2006] show that in economies at early stages of development, there is scope for the government to support investment-oriented activities. The types of policies that the Chinese government tested inside the SEZ, and partly implemented later in the rest of the economy, did envisage an active role for the government. Rodrik [2006] argues that this active role of the government was crucial for the Chinese development because it supported a fast move towards more modern and productive sectors which have positive externalities on the whole economy. We contribute to this literature by providing evidence that the active policies indeed had strong positive effects on GDP and therefore can be beneficial for a country like China at an early stage of development. At the same time, our results also point to the limits of differential policy treatments as there is no evidence that GDP growth or TFP in a preferentially treated city is permanently higher.

1.1 Related Literature

There is a long literature studying the institutional changes during China's reform process and their consequences.[2] Part of this literature has attempted to establish a direct link between the performance and economic reforms and our analysis builds particularly on that strand of the literature. The reforms and outcomes which we focus on confirm in a broad sense the positive effects found in previous studies. However, our estimated reform effects are lower than the literature suggested so far and we do not find persistent increases in growth rates or productivity as many previous contributions have done.

Growth of output and consumption per capita have increased substantially after the beginning of reforms and the estimated increase in the growth rate was between three and seven percentage points.[3] The strongest impact on welfare at the outset of reforms was achieved by a liberalization of the agricultural sector, during which a communal system was replaced by a household responsibility system. Several scholars have shown that agricultural productivity and output have increased significantly and the estimated change in the growth rate is around five percentage points.[4]

[2]See Perkins [1988] for an overview of the early literature on reform effects. Xu [2011], Brandt and Rawski [2008], and Naughton [2007] provide a more updated overview and Rodrik [2006] discusses the role of unorthodox industrial policies.

[3]Kuan et al. [1988] and Borensztein and Ostry [1996] find that the Chinese economy has grown between three and four percentage points more after the start of the reforms. Perkins [1988] estimates that the annual growth rate of rural consumption per capita increased from 2.2% in 1951-1978 to 9.7% in 1978-1985 and urban consumption per capita increased from 2.8% to 5.6% during the same periods.

[4]For example, Lin [1992] calculates the annual growth rates of agriculture for the pre- and post-reform period and finds that the annual growth rates increased from 2.9% in the period 1952-1978 to 7.7% in 1978-1984. He estimates that about half of that output growth was due to the introduction of the household responsibility system. McMillan et al. [1989] estimate that

A number of papers have focused on the development of the industrial sector. Jefferson et al. [1992] find that productivity growth in industry in the 1980s was around 2.4% per year, after productivity had previously stagnated for two decades. Based on a panel of 272 state enterprises, Li [1997] argues that this increase in productivity was largely due to improved incentives, product market competition, and factor allocation.[5]

The selective nature of early industrial reform in favor of coastal provinces could have led to considerable differences in regional development. In an early study, Jian et al. [1996] find that real incomes actually converged during the first phase of (mostly agricultural) reforms as some of the poor agricultural regions became richer, but afterwards incomes tended to diverge again when industrial growth surged in coastal provinces.[6] Chen and Fleisher [1996] and Fujita and Hu [2001] find that there is convergence within but divergence across regions.[7]

A number of descriptive studies have looked at SEZ and documented their characteristics and performance. The key factors for success of the SEZ were a gradualist and experimental approach, a strong commitment by the top leadership, and an active and pragmatic facilitation by the state (Zeng [2010]). SEZ focused mostly on the secondary sector and their role in the overall economy increased enormously over time. Xu [2011] documents that the number of SEZ went from four in 1980 to 342 in 2005 and their share in national exports went from 1.5% to 93.1%. Ge [1999] looks at SEZ in more detail and estimates the annual real growth rate of one of the first SEZ, Shenzhen, at 35.5% between 1980 and 1995. The secondary sector was the main driver of growth in that zone, with an average real growth rate of almost 50%

agricultural productivity increased by over 61% from 1978-1984 and that about three quarters of that increase was due to the introduction of the household responsibility system.

[5]Groves et al. [1994] show that improvements in incentives for managers increased workers' income and firm investment. Weitzman and Xu [1994] find even three times higher productivity growth in Township-Village Enterprises compared to state enterprises.

[6]Yao and Zhang [2001] confirm that growth tended to diverge in the 1990s when reforms were focusing more on industry. See also Kanbur and Zhang [2005], Benjamin et al. [2005], and Lee [2000].

[7]Song et al. [2000] analyze inequality between cities and find that there was an increase in inequality from 1985-1991. Coastal cities have benefited more from open-door policies but also experienced more disparity within their region compared to the inland. Unel and Zebregs [2006] decompose labor productivity growth and find that provinces converged in efficiency levels but diverged in capital deepening and that capital deepening accounted for 70% of labor productivity growth.

per year, and its share increased from 26% in 1980 to about 53% in 1995 (at the expense of the primary sector). Initial investment by the state accounted for 48% of fixed capital investment, but over time self-raised funds became the major source for financing and funds were increasingly domestic. Employment in state-enterprises grew at 26% per year and in non-state (mostly foreign) enterprises at 60% per year.

Many empirical studies have attempted to identify the effect of SEZ at the province level. Démurger et al. [2002] separate the effect of policy from geography by constructing separate indicators for policy reforms and for geography (transportation costs). They find that the effects of policy and geography on average growth of GDP from 1979-1998 are similar in magnitude (around 1 percentage point), but that the effects vary strongly across regions and years.[8]

To our knowledge, Wei [1993] was the first to use city-level data to assess the effect of various policies on growth across China. He looks at different aspects of open door policies and finds that a one percent increase in the scale of exports is associated with a 2.5 percentage points higher two-year growth rate from 1988-1990 and a one percent increase in FDI is associated with 1.3 percentage points higher two-year growth rate. He also constructs three separate indicators for cities with different types of deregulation and he finds only a significant effect for the open coastal cities, which grew about 9.2 percentage points faster than other cities over 1988-1990, largely due to increases in FDI. However, the conclusions from his early study are based a relatively short time period. Following Wei [1993], a number of other studies have used the same type of city-level data to estimate the effect of SEZ. Jones et al. [2003] found that SEZ increased annual GDP growth by 5.5 percentage points and Open Coastal Cities increased annual GDP growth by 3 percentage points. They argue that the effect goes largely through FDI. However, neither Wei [1993] nor Jones et al. [2003] deal with the problem that the location of zones was not chosen randomly. A recent paper by Wang [forthcoming] also studies the effect of SEZ in Chinese cities and uses matching to deal with the non-random selection of zones. She finds significant effects of SEZ on FDI per capita, exports, and total factor productivity growth.

The rest of this paper is structured as follows. Section 2 provides an overview of

[8] Instead of long-run GDP growth, Cheng and Kwan [2000] look at the determinants of foreign direct investment and find that provinces with a zone attract significantly more FDI.

the Chinese reform process and the history of SEZ. Section 3 describes the empirical analysis using the official yearbook data. Section 4 discusses the alternative measures electricity consumption and light intensity. Section 5 concludes.

2 China's Economic Reforms and Institutions

2.1 The Economy and Reform before 1980

During the thirty years after 1949, the year when the People's Republic of China was established, the Chinese Communist Party (CCP) built an economic system with the Soviet Union as the primary role model. The economy was a typical socialist planned economy. The State Planning Commission, a division of the State Council, controlled the development of the economy. The history of this period (1949-1978) was also marked with extreme ideology and great political instability. Mao Zedong, the then leader of China, often pushed for unrealistic economic goals in the form of political movement, in order to hurt his political opponents (Naughton [2007]). The Great Leap Forward, followed by the great 1959-1961 famine, was one such dreadful political campaign. Economic policies were manipulated to fit the political agenda, and thus lacked consistency and sometimes even contradicted each other from year to year. Figure 1 shows how the policy instability had lead to economic instability during this period.

Until 1978, the year when Mao's death and Deng Xiaoping's rise to power brought an end to the Cultural Revolution, China had gone through 10 years of economic stagnation and social turmoil. At that time, Chinese leaders were in desperate need for measures to reconstruct the political institutions and revive the economy. There were, however, no existing blueprints showing how to proceed. As a result, as Deng put it, "one has to grope for stepping-stones as he crossed the river". The experiment-then-verify approach became the guideline for almost every policy innovation during China's past 30 years of reform.

The first policy breakthrough happened in rural areas, where agricultural production had until then been carried out in collective communes. Under a new production system which was later called the Household Responsibility System (HRS), farmers were entitled, after fulfilling their procurement quota, to the rest of their agricultural output. The HRS was first implemented in Anhui and Sichuan Province and extended to the whole country by the end of 1982. It was a huge success. The national grain harvest increased from 304.8 million tons in 1978 to 407.3 million tons in 1984.

Figure 1: China's Real GDP Growth Rate: 1953-2010 (Source: New China 60 Years Statistical Collection)

2.2 The History of Special Economic Zones

Many reformist officials believed that changes should also take place in the urban area. Their proposal was to open up China to foreign investment. They believed that foreign investors would not only bring physical capital, but also advanced technology and management skills, enabling China to catch up quickly to the most advanced countries through "learning by doing". Despite Deng's endorsement and local official's desire for urban reform, the reformists' proposal aroused strong resistance from the conservative leaders in CCP's central committee. From the conservative ideologists' point of view, renting China's land to foreign companies and allowing them to exploit China's cheap labor was like selling out China and would expose it to the influence of western ideologies.

1980-1984

The establishment of SEZ was the result of a compromise between the reformist and conservative forces. In the year 1980, four cities in the provinces of Fujian and Guangdong, Shenzhen, Zhuhai, Shantou and Xiamen, were granted the status of SEZ. The SEZ were given special economic treatment, including tax deduction and special tariffs for import and export as well as less regulation on foreign exchange and land use. As documented in Wei [1993], foreign firms that resided inside of the SEZ enjoyed first two years of tax holiday, then three years of a low tax rate of 7.5% and after the initial five years, a tax rate of 15% (outside of the zones, the tax rate for foreign firms was 33% and for state-owned firms 55%).

The location of the zones was carefully and strategically chosen. First of all, they were located on the southeastern coast of China, far away from the political center Beijing. Thus, local officials, facing less political resistance from the conservative leaders in the central committee, had more freedom and flexibility to design and implement innovative policies. And due to their distant location and small scale, if the zones were to fail, they would only have a minor influence on the whole country. Second, the zones were geographically close to Hong Kong, Macau and Taiwan. Over the past several hundreds of years, the people in Guangdong and Fujian province had established deep connections with the oversea Chinese through kinship and trade. By locating the zones in these area, Chinese leaders clearly expected Hong Kong, Macau and Taiwan to be the major source of capital investment, entrepreneurial dynamism and knowledge about the outside world for the newly established SEZ.

The idea of SEZ was not a new invention by China. China's SEZ inherited some essential characteristics of the Export Processing Zones, which had already been established in over 80 countries by 1980 (Naughton [2007], Vogel [2011]). Like the Export Processing Zones, the SEZ were designed to circumvent the complex rules of import and export. China's SEZ were special in the sense that they also bore the responsibility of policy innovation and experimentation. They were the laboratories for the market economy. According to the official document issued by the party center and State Council, "the four Special Economic Zones would carry on systems and policies that are different from other places. The Special Economic Zones will be regulated primarily by the market." (Vogel [2011]:p.399). The local officials of the zones were implicitly encouraged to be innovative in designing economic policies and institutions. Many of the policy innovations inside of the zone, including the establishment of China's first labor market in Shenzhen, were deemed illegal outside of it. They were, however, later extended to the rest of the country after being proved to be successful.

1984-1991

The achievements of the SEZ within a very short period after the establishment were astonishing. The zones grew at an unprecedented rate, among which Shenzhen experienced an annual growth rate of 54% during the period 1980- 1984. In 1984, the four SEZ attracted 26% of China's total FDI. In addition, the zones had developed a set of well-functioning markets for labor, land, capital, transportation and technology (Zeng [2010]). The success of the four early SEZ came in the favor of reformists and softened the position of the conservative leaders. In 1984, 14 coastal cities were extended the rights to build Economic and Technological Development Zones (ETDZ). The ETDZs shared essentially the same policies as the initial four SEZ, with the only difference in the income tax rate (Wei [1993]). Interestingly, many of the 14 cities were old treaty ports that were opened up at the end of the Qing Dynasty. Even before receiving the special status, these cities, with an established industrial base and a well educated labor force, were among the most developed areas in China. According to the official statistics, the 14 coastal cities constituted 21.8% of the national total industrial output in 1985.

1991-2003

During January and February of 1992, Deng made his famous southern tour to the SEZ in southern China, including Shenzhen and Zhuhai, to show his support and dedication for further reform and opening up. Shortly afterwards, the new generation of Chinese leaders opened up Shanghai, the financial and industrial center of China. A new SEZ, called Pudong New Area, was established in Shanghai. In May, the CCP's party center issued document NO.4, announcing the opening up of the five inland cities along the Yangtze River, nine border cities and all thirty of the provincial capital cities and granting them the same privileges as the SEZ (Fewsmith [2001]). Following the instruction, 18 state-level ETDZs were approved during 1992-1993 and 17 more during 2000-2002, all located in inland provinces. Another type of zones, the High-tech Industry Development Zone (HIDZ), was also established during the same period. The establishment of the HIDZs was an essential part of the "Torch Program", a program carried out by the Ministry of Science and Technology to guide and facilitate the development of China's high-tech industries. ETDZs and HIDZs were granted the same preferential policies and administration status. However, they emphasized different goals of the development strategy. The main goal of HIDZ was to help transform domestic research outcomes into profitable high-tech companies. The HIDZs were located in cities with many universities and research institutions. In several cases, the HIDZ and ETDZ were located in the same city, with HIDZ established several years ahead of ETDZ.

2003-present

During the past ten years, the reform of SEZ spread quickly across China. By the year 2005, the system of state-level development zones[9] consisted of 54 ETDZs, 53 HIDZs, 15 Bonded Zones (BZ)[10] and 60 Export Processing Zones (EPZ)[11]. In the

[9] A detailed description of the different types of zones can be found in the appendix.

[10] Bonded Zones were typical free trade zones.

[11] Most of the exports processing zones were established within existing development zones. They were regulated by local customs to assist firms' import and export.

year 2005, the 54 ETDZs contributed 4.49% of the national GDP and 14.93% of national export (Ministry of Commerce [2006]). Establishing a development zone became the prevalent form for the local government to attract FDI and foster local economic growth. Through shuffling of the local officials across different regions, the governments drew on experiences from the early zones to help develop the later ones (Xu [2011]).

Besides the state-level zones, a large number of lower-level zones were also established during the same period. The preferential policies, given by the central government to the state-level zones, did not apply to these lower-level zones. On the other hand, the lower-level zones were not under close monitoring and regulation of the central government. In December 2003, the State Development and Reform Commission, the Ministry of Land and Resources, the Ministry of Construction, and the Ministry of Commerce together issued Document NO. 2343 to request a thorough investigation on development zones at all levels regarding the violation of the land-use plan. Before the investigation, there were a total number of 6866 development zones of all levels (WEFore [2010]). By the end of 2006 when the investigation was finished, only 1568 zones survived and gained offical approval from the state (see State Development and Reform Commission et.al. [2006] for the list of zones). A large number of the development zones failed the investigation and were abolished, which included all zones that were lower than province-level and several unqualified province level zones. After 2006, there existed only two levels of development zones – state-level and province-level. Starting from 2010, a number of province-level zones were promoted to state-level conditional on passing certain standards, including performance in economic growth, production safety and environmental protection. By the end of 2010, the number of state-level EDTZ had increased from 54 to 88.

2.3 Experimentation and Convergence in the Policies of the Zones

During the early stage of the development of SEZ, the policies were intended not only to attract FDI but also to foster institutional innovation. Therefore, except for tax deduction, protection of private property and land-use policies, local governments were given more freedom to design new institutions. Successful innovations were kept and extended to later waves of development zones (Table 1 of Yeung et al. [2009] listed the institutional innovations made by the first five SEZs.). Gradually, the institutional structure of the zones became stable. Policy treatment became uniform across all state-level ETDZs and HIDZs. At the present, the preferential policy treatment for the state-level ETDZs and HIDZs includes: 1) tax and customs duty deduction, 2) discounted land-use price, 3) no regulation on labor contracts and 4) special treatment on bank loans.

2.4 Different Types of the State-level Development Zones

There are five types of state-level development zones: comprehensive Special Economic Zone (SEZ), Economic and Technological Development Zone (ETDZ), High-tech and Industrial Development Zone (HIDZ), Bonded Zones, Export Processing Zone (EPZ) and Border Economic Cooperation Zones (BECZ). The five types of zones share the same preferential treatment in terms of tax deduction, custom duty deduction, reduced land-use price, flexibility in signing labor contract and financing.

The five types of zones differ from each other in several dimensions. Firstly, they are under administration of different government branches. Among them, the comprehensive SEZs, ETDZs and HIDZs are directed by State Council (HIDZ is co-directed by the Ministry of Science and Technology). Bonded Zones and EPZs are directed by customs. BECZ were directed by the State Council before 2008. They are now directed by the Ministry of Commerce.

Secondly, the zones reflect different aspects of the development plan. The comprehensive SEZs, which are located in Shenzhen, Zhuhai, Xiamen, Shantou, Hainan, Shanghai and Tianjin, are the largest in scale and enjoy the most autonomy among all types of the zones. They are expected to play an active role in defining the frontier of economic and social development. The ETDZs shares similar policy with the comprehensive SEZs and development goal, such as attracting FDI and boosting export, only with smaller scales. Although the institutional innovation were more active and frequent in the early stage of the development zones, the comprehensive SEZs and ETDZs nowadays are still encouraged to design and experiment with new institutions and policies. The HIDZs, which are directed by the Ministry of Science and Technology, focus on fostering the domestic Hi-tech industries. The Bonded zones are typical free trade zones, which are small and closed areas where import and export can be proceeded at a faster speed. They are all located in coastal port cities or border cities, which also help to develop the logistics industry. The function of EPZs is "export processing", which means to import raw materials from abroad, process them and export the final goods without entering the real territory of China. Many of the EPZs are established inside of the ETDZs and HIDZs. The BECZs intend to take advantage of the location of the border cities to foster trade with other countries.

2.5 The State-level and Province-Level Zones

State-level and province-level development zones co-existed during the 30 years' history of the economic reform. In some cities, province-level development zones were established before the state-level zones. In fact, a number of the first wave ETDZs were promoted from the original operating province-level development zones. Despite the equally long history of state-level and province-level zones, they must be distinguished.

One reason to differentiate the two levels of zones is that they have received different policy treatments. Preferential economic policies that the province-level zones have enjoyed have been given by the provincial and lower-level government. In other words, these preferential policies have been constrained by the administrative and legislative power of the provincial government. The state council explicitly requested that "the policies given to the province-level development zones should not be comparable to those given the state-level ones.", in order to prevent excessive competitions between the zones and the waste of land resources (see State Administration of Taxation [2004] for details). In reality, the policy package received by the state-level zones often included both the policies from the central government and the ones from the provincial government.

Another reason is that the policies of many province-level zones targeted specifically the industries which the local economy had comparative advantages in. On the other hand, the fundamental policies of the state-level zones, such as tax and custom duty deduction, were generally industry-blind. However, in recent years some of the state-level zones have leaned towards high-tech industries by providing extra economic incentives for the high-tech firms.

In Table 1, we listed the number of state-level and province-level development zones and their average share of industrial output in 3 coastal provinces, where a large fraction of the development zones reside. The data is taken from WEFore [2010] and is for the year 2009. All of the provinces had a larger number of province-level zones than state-level ones. But the state-level zones on average contributed a larger share of industrial output.

Table 1: State(S) and Province(P) Level Zones in 3 Provinces

Province	#S	#P	Avg indus-output share of S	Avg indus-output share of P
jiangsu	12	113	3.13%	0.55%
guangdong	14	56	4.89%	0.56%
zhejiang	8	57	4.09%	1.18%

3 Empirical Analysis Using Official GDP Data

The aim of this paper is to estimate the effects of economic reforms and industrial policy on the performance of the local economy. Our baseline empirical approach is a difference-in-difference analysis that takes advantage of the variation in economic policy across cities and years following the establishment of SEZ. Our main outcome of interest is GDP of the prefecture level cities, but we also use alternative measures for economic activity such as electricity consumption and light intensity, which are discussed in the next section. Some of the SEZ were established before GDP data at the city-level is available to us, but the majority of the zones that constitute a well-defined set of policies were opened after the beginning of the 1990s and we therefore use the sample period from 1988-2010. For this period we have a consistent definition of cities and information on GDP, different types of zones, and controls such as land area and government spending.[12]

3.1 Descriptive Statistics

Table 2 shows the summary statistics of the most important variables for our estimation. Our main object of interest is nominal GDP, for which we have more than 5700 observations from an unbalanced panel of 270 cities and 23 years. Including government spending reduces our sample as it has fewer observations than GDP.

The two most important types of zones are ETDZ and HIDZ with shares reaching 21% and 16% in 2010, respectively. The upper panel in Table 3 shows how the shares of cities with the different types of zones evolved over time (relative to the full unbalanced sample). We see that the early types of zones which existed already in the 1980s were the comprehensive SEZ (established around 1980) and ETDZ (since 1984). The most notable new establishments of zones during the sample period for which GDP data of prefecture-level cities is available were ETDZ and HIDZ. We will also control for Export Processing Zones (EPZ), Bonded Zones, and some other less frequent types, but these zones often were part of the ETDZ or HIDZ. We also control for province-level zones, but we do not combine them with our measures for state-level zones because they are different from the state-level zones and more

[12]See Sections A.1 and A.3 in the Appendix for a more detailed discussion of the sample selection and the data sources.

heterogeneous.

The lower panel in Table 3 shows how real GDP growth evolved over the period from 1988-2010.[13] The solid line refers to cities in which at some point a zone was established (counted as reformers over the full period) and the dashed line to cities that never had a zone. The reformers had higher growth rates in most of the earlier periods, but the overall pattern is similar. We see that growth peaked twice during this period at almost 20% and there was substantial variation in growth rates over time.

Table 2: Mean of key variables over 20 years

	1990	2010
Real GDP (mil)	1587	14227
% Annual growth of real GDP	8	16
Real government spending (mil)	147	1673
Population (th)	857	1196
Land area (th km2)	1386	2004
% share of SEZ	3	2
% share of ETDZ	4	21
% share of HIDZ	0	16
% share of EPZ	0	14
% share of Bonded	0	3
% share of BECZ	0	1
% share of AHIDZ	0	0
% share of Other	1	5
% share of firstprovincelevelzone	2	88
N	181	274

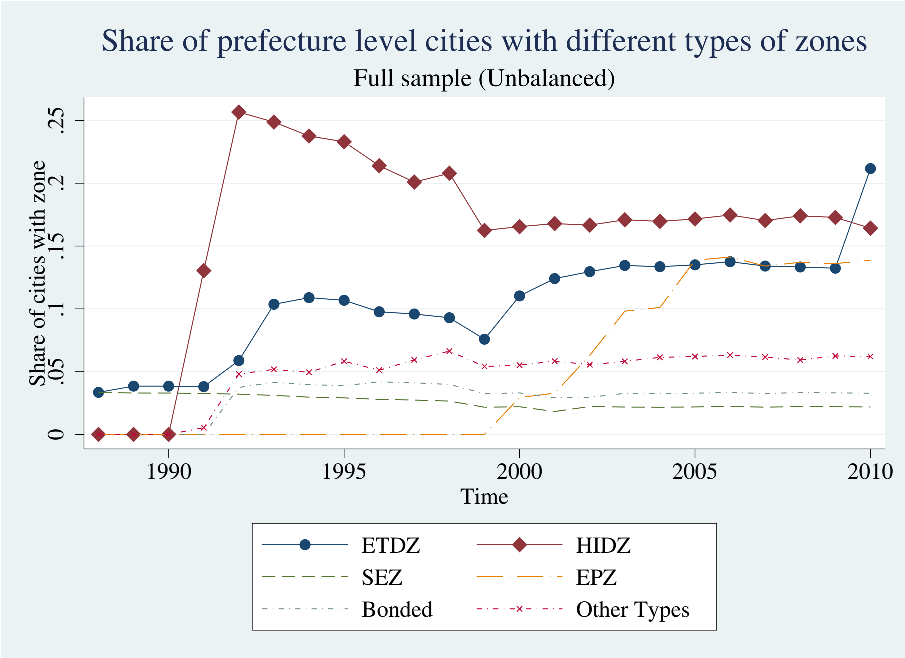
Real numbers are deflated with the Urban Consumer Price Index.

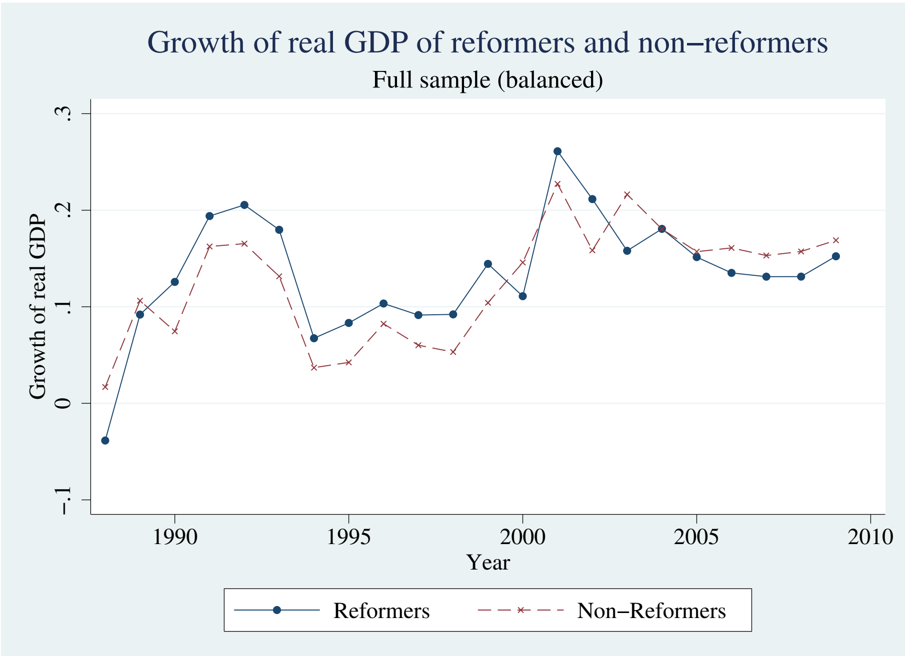
3.2 Empirical Strategy and Results

The Chinese SEZ provide a good opportunity to study the effects of economic reforms on development. Since the special policies applied only to geographically limited areas, we can compare treated and non-treated areas. Furthermore, the SEZ were established at different points in time, allowing us also to exploit the time

[13]We now use a balanced sample to ensure that changes in the averages are not driven by cities entering or leaving the sample.

Table 3: Types of zones and growth in GDP





Upper panel: Share of cities in our sample that have each type of zone. ETDZ refers to Economic and Technological Development Zones. HIDZ refers to High-Tech Industrial Development Zones. SEZ refers to the comprehensive Special Economic Zones like Shenzhen or Pudong. EPZ refers to Export Processing Zones. Bonded refers to bonded (free trade) zones. Other Types refers to less frequent zones like Border Economic Cooperation Zones. Lower Panel: Growth of real GDP in balanced sample (only cities with 23 years of GDP data). Reformers denote cities that have at least one type of zone established in any year.

variation. Our baseline specification will therefore be a city-level panel regression controlling for city fixed effects, province-time fixed effects, and an indicator for post-reform years, which amounts to a difference-in-difference analysis. Then we present the results of several alternative specifications and of a sub-sample where selection of the zones was transparent.

3.2.1 Baseline Specifications

We start with our simple baseline regression where we regress log GDP of the city center (in current prices) on indicators for the establishment of different types of zones in that city. Cities can have several zones of the same or of different types and they have heterogeneous reform effects. The policy package of the different types are discussed in Section 2.4. We focus on state-level zones but control for smaller province-level zones which are less homogeneous in their policies. We control for city fixed effects and province-time fixed effects and we cluster the errors at the city-level. The specification therefore looks as follows:

$$y_{ipt} = \phi_i + \gamma_{tp} + \mathbf{I\_Reform}_{ipt}\alpha + \mathbf{X}_{ipt}\beta + \varepsilon_{ipt} \tag{1}$$

where y_{ipt} is log nominal GDP, ϕ_i is a city fixed effect, γ_{tp} is a province-time fixed effect and I_Reform_{ipt} is a vector of dummy variables for each type of zone, taking value 1 for city i in the year in which the zone was established and in all later years. X_{ipt} is a vector of time-varying controls like land area size. ε_{ipt} is a normal error term. This specification for the reform allows the cities after the reform to have a *higher level* of GDP, i.e. we assume an upward shift in the GDP path. We do not directly allow increases of the growth rate of GDP in the baseline specification, but later specifications will be more flexible. The province-time fixed effects absorb for example provincial price levels and trends. Given the uncertainty about inflation data and the potential for confounding effects with other developments at the province- or state-level, we believe that it is important to control for these fixed effects. City fixed effects absorb all time-invariant city-characteristics like initial development or geographical location.

The results are shown in the first column of Table 5. We observe that the reform effect is statistically significant and also economically large for the more common state-level zones. For example, the coefficient of 0.107 implies that a city after the establishment of an ETDZ has on average a 10.7% higher GDP level than before the reform. Cities were reformed in different years during our sample period and therefore the reform effect as an upward shift in the GDP path is identified by different number of post-reform observations. The coefficient in the baseline specification is an average over different post-reform durations until the end of our sample (on average 10 years) and a later section will consider a more flexible specification. HIDZ have a very similar effect than ETDZ and are equally significant. EPZ show a lower effect and a less precise estimate. Although there are about as many EPZ as HIDZ, they are significantly smaller and often located inside the ETDZ or HIDZ. The remaining zones show a mixed picture and some of the zones have even negative coefficients, but these results are driven by only a few cities. It is noteworthy that the province-level zones do not seem to have a positive effect on the level of GDP. Province-level zones were not allowed the same policy treatment as state-level zones and in particularly less active industrial policy.

In columns 2 and 3 we add government spending and population as further controls since economic activity may have increased due to an inflow of government funds or labor. However, both measures have to be interpreted with caution as both of them may be an outcome of the reform (government spending via tax income and population via attracting labor). Including these variables reduces our sample because we have fewer observations on government spending. The results are qualitatively similar, but the point estimates decrease somewhat. Since there is significant uncertainty about the accuracy of the population data and because it is not consistently measured over the years, we focus on the specifications without controlling for population.

In column 4 we combine different state-level zone types in order to focus on the more frequent types. Except for an increase in the standard error of the HIDZ, the effect of the main zones does not change much. This remains true even when we combine all the state-level zones in column 5. However, combining state-level and province-level zones in one indicator hides any effect of the state-level zones, as is shown in column 6.[14]

[14]Our analysis relies on the time variation in the establishment of the zones may therefore be sensitive to the considered time frame. However, we repeated our baseline analysis in a sub sample

3.2.2 Selection of SEZ in a sub-sample of inland cities

Although one purpose of the SEZ was to experiment with mechanisms of a market economy, they can hardly be viewed as a true experiment in an econometric sense. The first SEZs were established in very privileged locations on the coast close to potential trading partners like Hong Kong and Taiwan. Studying the development of these early SEZ is an interesting exercise on its own because they were so enormously successful and during their development process, a previously agricultural area was turned into a major industrial and financial center. But the results could hardly be generalized to average cities in China because of their extremely selective nature.

The ETDZ, which followed after the first four SEZ and had similar policies, were also chosen in a highly selective way. For example, many of the 14 ETDZ established in 1984 were former treaty ports which were special in several dimensions (Jia [2011]). Besides location, the decision was also based on past growth and potentially a set of other unobserved characteristics specific to each city and relevant for the potential development and response to reform. There is substantial uncertainty and heterogeneity regarding the reasons for selection in the individual cases.

There is one episode during the reform process in which the selection of zones followed a clear-cut administrative criterion: according a CCP document issued in 1992 (see Section 2.2), all inland provincial capitals were granted the same privileges as the initial SEZ. The purpose of this policy was to initiate reforms and economic opening in inland provinces and to reduce the disparity between the coastal and inland regions. As a consequence of this policy, the inland capitals opened a number of ETDZ and HIDZ. The advantage of this episode is that a clear formal criterion assigned fairly homogeneous policies to about 17 major cities over a period of approximately ten years. These characteristics of the inland reform process provide a good opportunity for our empirical exercise.

Clearly, provincial capitals are also a special category of cities. As is shown in Table 4, inland capital cities were initially larger in terms of population and real GDP. The differences increased until the year 2008. Table 4 also shows that inland capitals had more universities, high schools, roads, and health infrastructure (usually

of cities for which we also have reliable GDP on the years before 1988 and find similar results. See Table 21 in the appendix.

both in absolute terms and relative to population). Their collective characteristics were most likely the reason why they were chosen to initiate the reforms in inland provinces. Furthermore, capital cities might have characteristics that make zones particularly successful, such as existing infrastructure and human capital stock.

However, the ways in which the set of inland capital cities differs from non-capitals is much more easily observable than the differences between individual reformed and unreformed cities in the early reform episode when the reasons for selection were diverse. Since the group of capital cities were chosen together, we do not have the problem that the locations of the zones were chosen based on particular characteristics of each individual city. There is thus substantially less uncertainty regarding the differences between treated and non-treated compared to the other regions or reform episodes. Importantly, many ways in which capital cities are likely to differ from non-capitals are captured in the Statistical Yearbooks as reported in Table 4. It is possible that these characteristics have an impact on the effectiveness of reforms and we can take this into account in our estimation by allowing these characteristics to interact with the effects of the zones.

Table 4: Mean values of city characteristics in inland provinces

	1993		2008	
	Capital	Non-capital	Capital	Non-capital
Population (in thousand)	1752	693	2823	808
Land area (in thousand km2)	1320	1916	3029	2233
Real GDP (in mil)	3893	1214	28380	4390
Real GDP p.c.	2203	1900	10055	5779
Real Gov. Spend. (in mil)	318	100	2873	524
Real Gov. Spend. p.c.	188	162	1035	712
# Universities	16	3	27	3
# Universities (per mil residents)	9	4	10	4
# High schools	189	73	156	48
# High schools (per mil residents)	112	113	56	61
Road area	586	211	2786	574
Road area (per mil residents)	338	344	1021	792
# Hospital beds	13727	3594	19564	3720
# Hospital beds (per mil residents)	7830	5405	6929	5098

Real numbers are deflated with the Urban Consumer Price Index.

Table 6 shows that the results are quite similar when restricting to the inland provinces.[15] The main differences are that the coefficient on ETDZ increases and the unknown types of zones show large positive effect. Furthermore, the coefficient on the combined indicator for all zones is negative and becomes weakly significant.

Since in the inland provinces most zones were established in provincial capital cities and we know that capitals differ from other cities, we may expect that these capital cities respond to an economic reform differently. We therefore control in a separate regression (not reported) for a set of interaction terms between the reform indicator and pre-reform values of the characteristics shown in Table 4. More precisely, we interact the reform indicators with the deviation of these city-characteristics in 1988 or 1989 from the provincial average. We can therefore interpret the main effect as the reform effect of an average city (in terms of the characteristics in Table 4). Even when adding these interactions, the main effect is positive and it remains significant. The only significant interaction term is with the number of universities, suggesting that cities with more universities benefit more from a SEZ.

3.2.3 Effects on the Surrounding Area

We have focused so far on the urban center of prefecture-level cities because this is where the zones were established. In order to consider effects which the zones may have on the area surrounding the cities, we run separate regressions with the GDP of the entire prefecture as the dependent variable. The results in Table 7 show that there are only minor differences in the effects.[16]

To further assess the effect on the periphery area only, we construct for each variable (except government spending, for which the data is not available) the difference between the prefecture area and the city center in order to capture the periphery area only. Given that the zones were located in the city center and possibly attracted resources from surrounding areas, one may expect that there could be negative effects of the central zones on the periphery area. The results, shown in Table 8, provide no evidence of negative effects, but neither are there large positive effects. There

[15] Certain types of zones were only established in coastal provinces and therefore the coefficients are missing in this specification.

[16] Most of the control variables are also available for the whole prefecture, except for government spending for which we have to use the center as an approximation.

are, however, some weak positive effects of ETDZ, HIDZ, and state-level zones in general in certain specifications.

Table 5: Fixed effects regression for full sample, city center

	(1) AllZones	(2) GovSpending	(3) Population	(4) ZoneTypes	(5) ZoneLevels	(6) AnyLevel
I_ETDZ	0.107***	0.0755**	0.0662**	0.0773**		
	(2.85)	(2.33)	(2.33)	(2.36)		
I_HIDZ	0.0899**	0.0510*	0.0548**	0.0479		
	(2.58)	(1.70)	(2.09)	(1.59)		
I_EPZ	0.0677*	0.0641**	0.0491*	0.0661**		
	(1.73)	(2.00)	(1.77)	(2.04)		
I_Bonded	-0.0477	-0.0491	-0.0859			
	(-0.63)	(-0.67)	(-1.42)			
I_BECZ	-0.250***	-0.0749	-0.0389			
	(-4.31)	(-1.26)	(-0.67)			
I_Other (various zone types)	0.153**	0.123*	0.122***			
	(2.46)	(1.85)	(2.67)			
I_Firstzone (province-level)	-0.00568	-0.00616	0.00266	-0.00587	-0.00543	
	(-0.24)	(-0.28)	(0.14)	(-0.27)	(-0.25)	
I_RemainingTypes (remaining zone types)				0.0922		
				(1.55)		
I_Firstzone (state-level)					0.107***	
					(4.13)	
I_Firstzone (any level)						-0.0262
						(-1.18)
Log landarea	0.232***	0.206***	-0.0134	0.204***	0.208***	0.210***
	(7.55)	(7.86)	(-0.51)	(7.77)	(8.21)	(8.27)
Log gov. spending		0.267***	0.215***	0.270***	0.278***	0.281***
		(7.43)	(6.68)	(7.51)	(7.88)	(7.93)
Log population			0.558***			
			(9.61)			
N	5280	5005	5004	5005	5005	5005
AR2	0.970	0.972	0.976	0.972	0.972	0.972

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Dependent variable: Log nominal GDP of the city center
Provincial zones, city-FE and province-time-FE omitted from table.
Standard errors are clustered by city.

Table 6: Fixed effects regression for inland sample, city center

	(1) AllZones	(2) Gov	(3) Pop	(4) ZoneLevels	(5) AnyLevel
I_ETDZ	0.134***	0.0983***	0.0676*		
	(3.30)	(2.87)	(1.92)		
I_HIDZ	0.0752*	0.0455	0.0488		
	(1.85)	(1.28)	(1.43)		
I_EPZ	0.0417	0.0616	0.0569		
	(0.69)	(1.22)	(1.20)		
I_Other (various zone types)	0.439***	0.374***	0.249***		
	(7.57)	(7.52)	(5.63)		
I_Firstzone (province-level)	-0.0318	-0.0257	-0.0154	-0.0235	
	(-1.19)	(-1.02)	(-0.62)	(-0.91)	
I_Firstzone (state-level)				0.0930***	
				(3.10)	
I_Firstzone (any level)					-0.0451*
					(-1.67)
Log landarea	0.189***	0.193***	0.00142	0.202***	0.203***
	(5.67)	(6.36)	(0.04)	(6.83)	(6.92)
Log gov. spending		0.200***	0.173***	0.210***	0.212***
		(6.03)	(5.85)	(6.26)	(6.31)
Log population			0.531***		
			(6.45)		
N	3219	3054	3054	3054	3054
AR2	0.969	0.970	0.973	0.970	0.970

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent variable: Log nominal GDP of the city center

Provincial zones, city-FE and province-time-FE omitted from table.

Standard errors are clustered by city.

Table 7: Fixed effects regression for full sample, prefecture area

	(1) AllZones	(2) Gov	(3) Pop	(4) ZoneTypes	(5) ZoneLevels	(6) AnyLevel
I_ETDZ	0.102***	0.0860***	0.0759**	0.0880***		
	(2.92)	(2.69)	(2.48)	(2.77)		
I_HIDZ	0.0888***	0.0663**	0.0820***	0.0642**		
	(2.98)	(2.43)	(2.85)	(2.39)		
I_EPZ	0.0626*	0.0578*	0.0417	0.0619*		
	(1.73)	(1.84)	(1.57)	(1.92)		
I_Bonded	-0.0397	-0.0398	-0.0415			
	(-0.51)	(-0.56)	(-0.74)			
I_BECZ	-0.0213	0.0475	0.0741			
	(-0.38)	(0.80)	(1.33)			
I_Other (various zone types)	0.214***	0.188**	0.109***			
	(2.89)	(2.37)	(2.66)			
I_Firstzone (province-level)	-0.000591	-0.00383	-0.0143	-0.00382	-0.00651	
	(-0.03)	(-0.19)	(-0.84)	(-0.19)	(-0.32)	
I_RemainingTypes (remaining zone types)				0.139**		
				(2.16)		
I_Firstzone (state-level)					0.0811***	
					(3.51)	
I_Firstzone (any level)						-0.0332
						(-1.53)
Log landarea	0.398***	0.341***	-0.166***	0.342***	0.340***	0.342***
	(12.69)	(8.67)	(-3.08)	(8.60)	(8.59)	(8.57)
Log gov. spending		0.164***	0.151***	0.166***	0.180***	0.183***
		(5.45)	(5.29)	(5.50)	(5.97)	(6.12)
Log population			0.852***			
			(9.43)			
N	5335	5025	5024	5025	5025	5025
AR2	0.975	0.976	0.980	0.976	0.975	0.975

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent variable: Log nominal GDP of the prefecture area

Constant, city-FE and province-time-FE omitted from table.

Standard errors are clustered by city.

Table 8: Fixed effects regression for full sample, periphery only

	(1) AllZones	(2) Gov	(3) Pop	(4) ZoneTypes	(5) ZoneLevels	(6) AnyLevel
I_ETDZ	0.0759*	0.0661	0.0696	0.0672		
	(1.78)	(1.50)	(1.56)	(1.51)		
I_HIDZ	0.0633	0.0583	0.105***	0.0647		
	(1.46)	(1.29)	(3.28)	(1.44)		
I_EPZ	-0.0266	-0.0279	-0.00441	-0.0242		
	(-0.65)	(-0.69)	(-0.13)	(-0.60)		
I_Bonded	0.00978	0.0288	0.0508			
	(0.08)	(0.23)	(0.47)			
I_BECZ	0.0787	0.0569	0.0981			
	(1.14)	(0.71)	(1.16)			
I_Other (various zone types)	0.148*	0.138*	0.122*			
	(1.90)	(1.87)	(1.82)			
I_Firstzone (province-level)	0.00363	-0.000880	-0.0117	-0.00168	-0.00535	
	(0.15)	(-0.04)	(-0.55)	(-0.07)	(-0.21)	
I_RemainingTypes (remaining zone types)				0.104		
				(1.43)		
I_Firstzone (state-level)					0.0607*	
					(1.86)	
I_Firstzone (any level)						-0.0244
						(-0.87)
Log landarea	0.936***	0.958***	0.0949	0.960***	0.960***	0.962***
	(15.20)	(14.91)	(1.50)	(14.62)	(15.48)	(16.03)
Log gov. spending		0.0177	0.0517**	0.0195	0.0297	0.0320
		(0.60)	(2.05)	(0.67)	(1.00)	(1.07)
Log population			0.910***			
			(14.95)			
N	4962	4704	4704	4704	4704	4704
AR2	0.963	0.962	0.971	0.962	0.962	0.962

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Dependent variable: Log nominal GDP of the periphery only
Constant, city-FE and province-time-FE omitted from table.
Standard errors are clustered by city.

3.3 Reform Effects over Time

We now allow for a more flexible reform effect that can vary depending on how long ago the reform took place.[17] It could be that the reform effect builds up over time, occurs with a lag, dies out after some time, or that there was an anticipation. The regressions in this section therefore include a variable for each possible yearly time span after reform, starting with zero for the year of reform and ending with 26 for the longest possible span.[18] We build on the regression shown in column 4 of Table 5 where we focus on the three most common zones ETDZ, HIDZ, and EPZ. The individual indicators for these zones are replaced by a set of indicators for each distance from the reform year. The regression equation therefore looks as follows:

$$y_{i,t} = \phi_i + \gamma_{t,p} + \sum_{n=0}^{26} \alpha_n \mathbf{I}^n_{i,t}\{(t - Reformyear_i) = n\} + \mathbf{X}_{it}\beta + \varepsilon_{i,t}. \tag{2}$$

where $\mathbf{I}^n_{i,t}$ is a vector of indicators for the three zone types. We control in $\mathbf{X}_{it}$ for log land area size, log government expenditure and the indicators for the remaining zone types. Table 9 plots the result for the full sample and the inland sample. We show only the indicators for ETDZ because this gives us the longest time span since reform. The regression also includes the full set of post-reform indicators for HIDZ and EPZ and binary controls for the less frequent zone types. We can see for the full sample that the coefficients of ETDZ are significant after the third year and they are first increasing during about 20 years. The interpretation of these coefficients is that for example a city which had a reform 20 years ago has a 22% higher GDP level. This is consistent with a differential yearly growth rate of about one percentage point over the first 20 years after the zone was established. Afterwards the estimates do not increase anymore and even decrease. The standard errors get larger because there are only few cities which have observations for more than ten years after the reform. In the inland sample, the maximum number of years after reform are lower, because reforms in the inland provinces in general took place later. The magnitude

[17] See for example Allison (1994) for an overview of different methods to analyze the effect of events.

[18] We exclude the first wave of SEZ in 1980 because it took place outside of our sample period and the identification of the post-reform years above 26 would rely entirely on that set of cities.

of the effects are comparable but increase faster and stabilize after about then years.

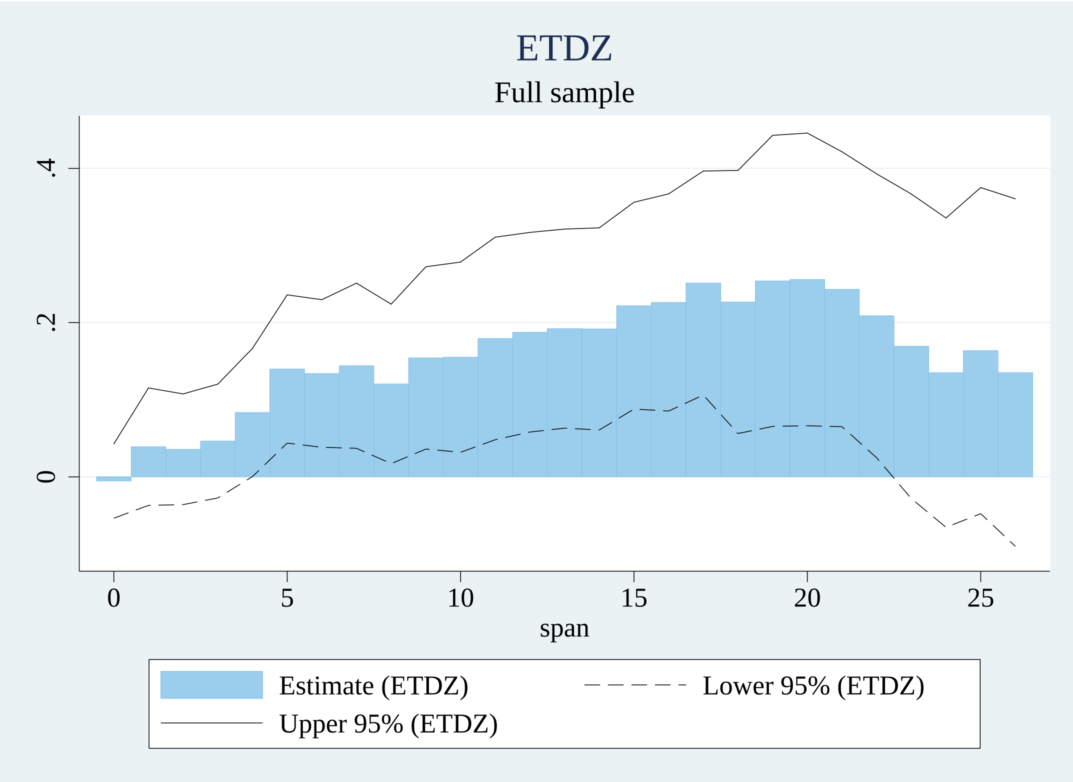
3.4 The Years before Zone Establishment

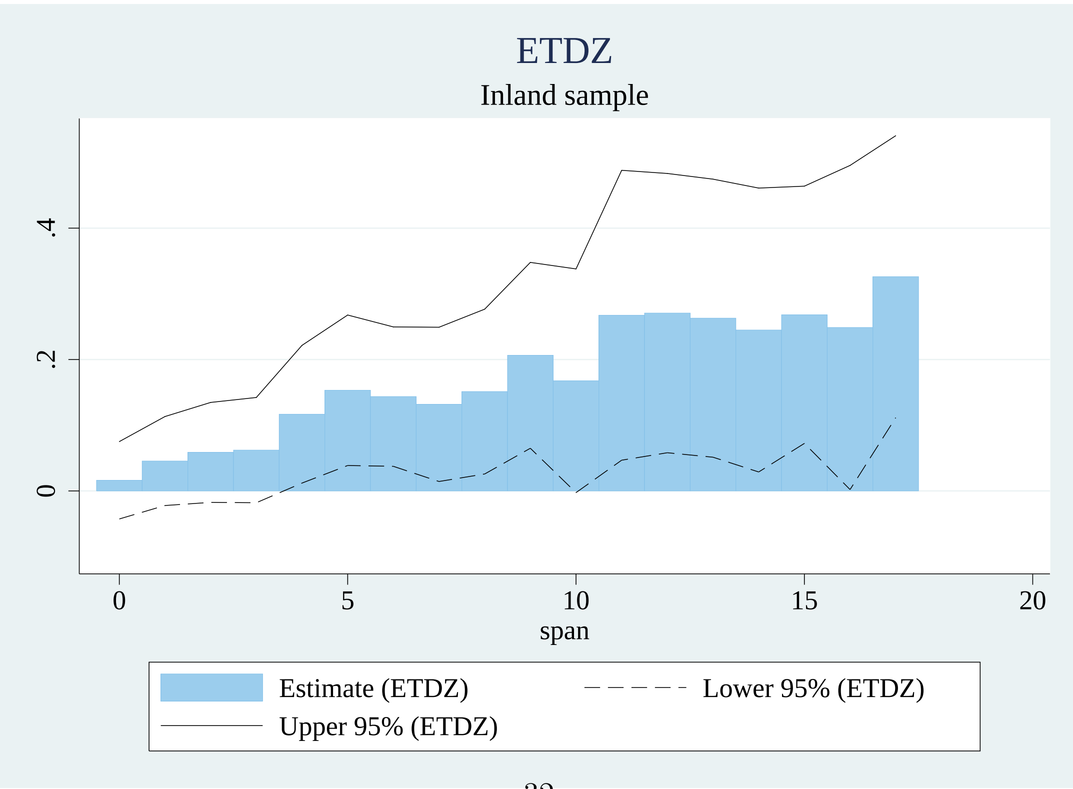
The previous setup allows to test if reformer had a different trend before the reform year by including indicators for years before the zone.[19] The plots in Table 10 show that years before the reform ("pre-spans") are positive but insignificant.[20] In the full sample the spans start increasing around the year of reform and become significant after four years. The standard errors again increase over the spans. In the inland provinces, we observe similar effects. It is noteworthy that for ETDZ the upper 95% confidence interval for the pre-reform years is below the point estimate for most of the post-reform years (with the exception of the third pre-reform year in the inland sample). This is strong evidence that the reform effects have increased substantially and the insignificant pre-reform years are not just due to high standard errors.

[19] The average number of years before the reform is around six, but in some provinces the reforms actually took place before the start of our sample.

[20] We have also tried 3,7, and 9 pre-reform years and get a similar pattern.

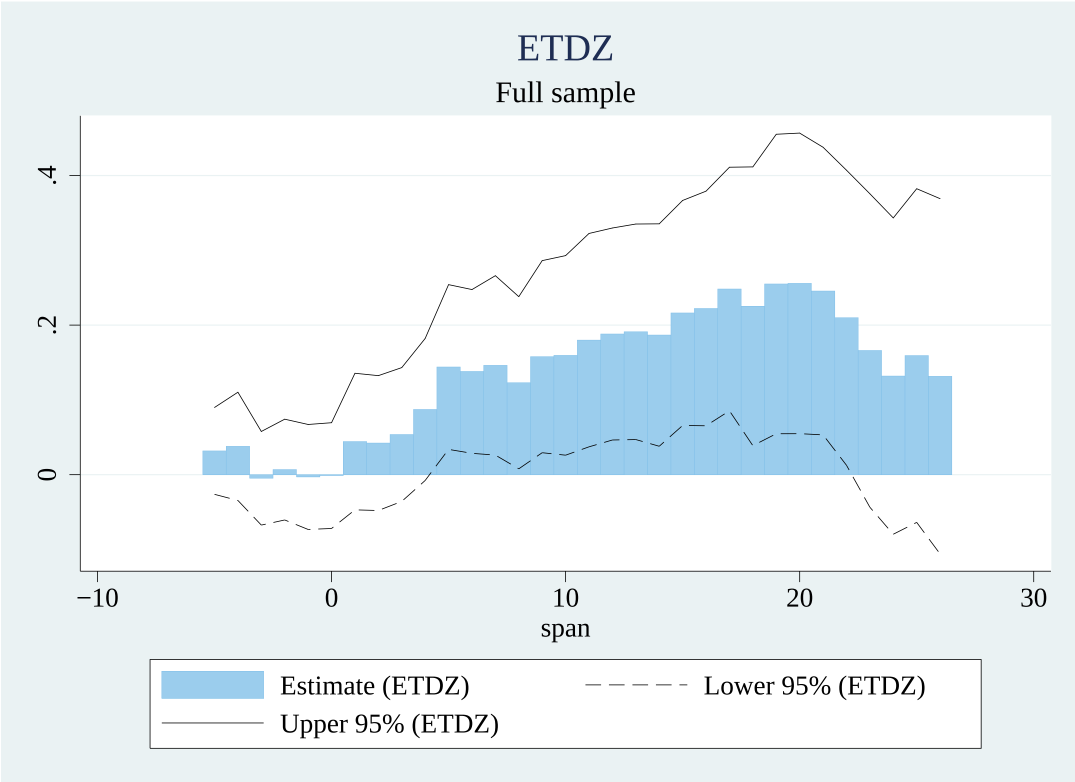
Table 9: Plot of estimates for post reform effects

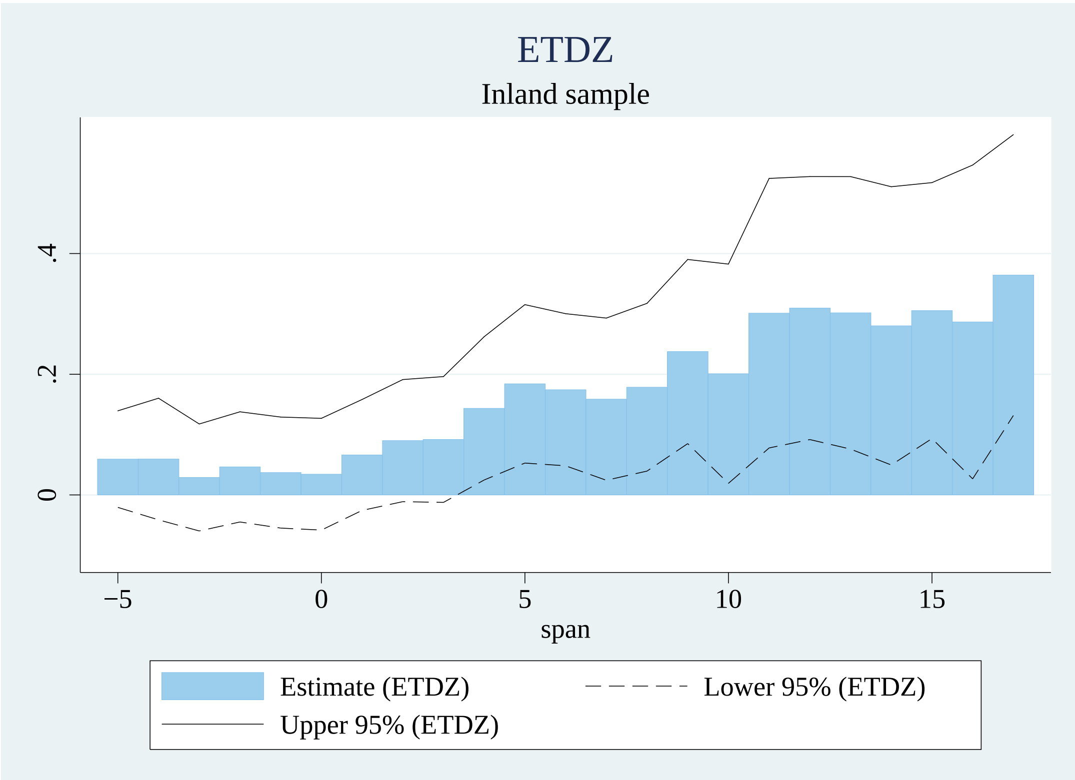




The bars show the coefficients of the indicators for individual years since the establishment of an ETDZ. The full set of indicators is also included for HIDZ and EPZ, but they have much fewer years since establishment and are not shown here. The regressions also control for an indicator for other zone types, province-level zones, land area, log government spending, city fixed effects, and province-time fixed effects. Standard errors are clustered by city.

Table 10: Plot of estimates for pre- and post reform effects





The bars show the coefficients of the indicators for individual years since the establishment of an ETDZ. The full set of indicators is also included for HIDZ and EPZ, but they have much fewer years since establishment and are not shown here. The regressions also control for an indicator for other zone types, province-level zones, land area, log government spending, city fixed effects, and province-time fixed effects. Standard errors are clustered by city.

3.5 Time Trends and Trend-Breaks

An important assumption in the analysis so far has been that reformer cities do not have a different time trend than non-reformers. We now relax this assumption and include a linear time trend specific for cities that have a ETDZ or HIDZ in any year[21] We focus on the time trend of ETDZ and HIDZ because they had similar policies and were often established in the same city, while the other zone types can overlap in various combinations. The results for when we include a time trend specific to ETDZ are shown in column 2 of Table 11. We observe that cities in which at some point a ETDZ or HIDZ was established indeed have a significantly steeper time trend, but the reform indicator is still significant. This specification assumes that a zone leads to an upward shift in the already steeper GDP path of reformers, while the growth rate remains constant. But the reforms may also change the growth rate and we therefore allow for a post-reform trend break at the time of reform as shown in Equation 3.

$$\begin{aligned} y_{i,t} &= \phi_i + \gamma_{t,p} + \alpha_1 I\_Reform_{i,t} + \alpha_2 \left[t \times I\_Reformer_i\right] \\ &+ \alpha_3 PostreformTrend_{i,t} + \mathbf{X}_{it}\beta + \varepsilon_{i,t} \end{aligned} \quad (3)$$

α_2 captures the trend specific to reformers, i.e. how many percentage points the growth rate differs for reformers relative to non-reformers. α_3 measures the percentage point change in this difference at the time of reform. The results in column 3 show that while the indicator on ETDZ and HIDZ is weakly significant, the trend and the trend break are insignificant. However, once we allow a concave post-reform trend, we observe a similar pattern as in plots in Table 10. The inland sample shows the same concave path after reforms. The reform indicator (which captures the effect in the year of reform) becomes negative, but this is compensated by the significantly steeper time trend after reform.

[21]The time-invariant indicator for reformers is absorbed by the city fixed effects and the common time trend is absorbed by the time-province fixed effects. The interaction with the time trend captures how much different the time trend is for reformers relative to non-reformers, i.e. the percentage point difference in the annual growth rates.

Table 11: Time trends, full sample

	(1)	(2)	(3)	(4)
I_FirstETDZHIDZ	0.0888***	0.0513**	0.0487*	0.00484
	(3.32)	(1.99)	(1.90)	(0.18)
I_EPZ	0.0768**	0.0475	0.0426	0.0528
	(2.37)	(1.40)	(1.24)	(1.53)
I_OtherTypes (state-level)	0.0961*	0.0921*	0.0890*	0.0853
	(1.85)	(1.77)	(1.70)	(1.62)
I_Firstzone (province-level)	-0.00624	-0.00646	-0.00703	-0.00445
	(-0.29)	(-0.31)	(-0.33)	(-0.21)
ReformerTrend (ETDZ or HIDZ)		0.00517**	0.00385	0.00421
		(2.00)	(1.11)	(1.21)
Post-ReformTrend (ETDZ or HIDZ)			0.00205	0.0133*
			(0.57)	(1.87)
Sq. Post-ReformTrend (ETDZ or HIDZ)				-0.000520*
				(-1.86)
Log landarea	0.206***	0.203***	0.202***	0.200***
	(7.91)	(7.87)	(7.91)	(7.82)
Log gov. spending	0.274***	0.272***	0.271***	0.265***
	(7.68)	(7.61)	(7.55)	(7.25)
N	5005	5005	5005	5005
AR2	0.972	0.972	0.972	0.972

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent variable: Log nominal GDP of the city center

Controlling for city-FE and province-time-FE.

Standard errors are clustered by city.

Table 12: Time trends, inland sample

	(1)	(2)	(3)	(4)
I_FirstETDZHIDZ	0.0781**	0.0240	0.0183	-0.0840***
	(2.53)	(0.76)	(0.60)	(-2.65)
I_EPZ	0.0956*	0.0601	0.0532	0.0562
	(1.94)	(1.23)	(1.13)	(1.27)
I_OtherTypes (state-level)	0.120	0.143	0.148	0.162
	(1.22)	(1.36)	(1.39)	(1.52)
I_Firstzone (province-level)	-0.0281	-0.0285	-0.0295	-0.0332
	(-1.11)	(-1.13)	(-1.16)	(-1.30)
ReformerTrend (ETDZ or HIDZ)		0.00663*	0.00429	0.00509
		(1.93)	(0.82)	(0.98)
Post-ReformTrend (ETDZ or HIDZ)			0.00378	0.0346***
			(0.68)	(2.97)
Sq. Post-ReformTrend (ETDZ or HIDZ)				-0.00154***
				(-2.81)
Log landarea	0.199***	0.194***	0.193***	0.192***
	(6.62)	(6.25)	(6.25)	(6.17)
Log gov. spending	0.211***	0.204***	0.202***	0.194***
	(6.30)	(6.07)	(5.92)	(5.68)
N	3054	3054	3054	3054
AR2	0.970	0.970	0.970	0.970

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent variable: Log nominal GDP of the city center

Controlling for city-FE and province-time-FE.

Standard errors are clustered by city.

3.6 Placebo Treatment

In order to check if the true effects of the reform or something unobserved is driving our result, we run several placebo regression. We first assign the actual number of new zone establishments in each year to a random selection of cities. The distribution of the new zones over time is thus the same as in reality, but they are now artificially implemented in random cities. We repeat this exercise 1000 times. When looking at the placebo coefficient of the first state-level zone, then we observe that it is significant in about 10% of the cases, but almost never has a higher and significant coefficient than the true reform. The standard errors are always larger in the placebo results. We repeat the same exercise with the previous control variables and find similar results.

3.7 Level Decomposition

We have shown that the establishment of SEZ in a city has a large and significant impact on the GDP of that city. What had contributed to such huge effect? Similar questions on the source of China's growth are raised and answered by previous researchers. Song, Storesletten and Zilibotti [2011] argues that reallocation of resources from urban to rural sector and from low-efficiency SOEs to high-efficiency private firms leads to an increase in aggregate TFP. Li and Liu [2011] performs a growth accounting exercise using China's province-level data and shows that input growth contributed to 80% of China's total growth while TFP contributes less than 20%. The contribution of TFP on growth is even lower in a subgroup of coastal provinces.

In order to answer this question in the context of the SEZ reform, we first decompose GDP into physical capital, efficient labor and TFP. Then we estimate the effect of SEZ on the three decomposed parts to identify the channel(s) through which SEZ have an impact on GDP.

We perform a level-accounting exercise using the log-form of a neoclassical production function.

$$\begin{aligned}\log GDP_{i,t} &= \log TFP_{i,t} + \alpha_k \log PhysicalCapital_{i,t} \\ &+ (1-\alpha_k)\log EfficientLabor_{i,t}. \end{aligned} \tag{4}$$

Log GDP of city i in year t equates the sum of the log TFP, the log of physical capital stock weighted by the capital share in output (α_k), and the log of efficient labor weighted by the labor share in output ($1 - \alpha_k$). [22]

In tables 13 and 14, we display the results of the baseline regression when replacing the dependent variable with physical capital, population, efficient labor and TFP.[23] As shown in column 2 of tables 13 and 14, the effect of SEZ on physical capital in both full and inland sample is significant and positive. The coefficients are rather large, suggesting that the effect of SEZ on GDP goes to a large extent through the accumulation of physical capital. Column 3 displays the effect on population. While the coefficients are mostly positive, they are not as strong as the ones of physical capital. In general, the cities with SEZ attract more population (workers) than the cities without one. When taking into consideration the human capital of the population, column 4 suggests that the effect of SEZ on efficient labor are in general positive in the full sample but not always significant. Column 5 displays the effect of SEZ on TFP. We see that there is no significant difference in TFP between the reformer and non-reformer cities. This result suggests that either SEZ has no effect on TFP or the effect on TFP somehow diffuses to the other non-reformer cities in the same province.

The previous results show that physical capital accumulation is the major channel through which the effect of SEZ takes place. We run a span specification by replacing the LHS of equation 2 with physical capital, in order to see whether the effect of physical capital stock displays a similar pattern in the years after the reform as the effect on GDP. The result, which is shown in Figure 15, confirms that the physical capital stock has a similar post-reform pattern as GDP. In both the full and inland sample, the effect of SEZ becomes significant around 5 years after the establishment of the SEZ and stays significant for about 15 years.

[22] A detailed description on how we construct physical capital stock and efficient labor can be found in the Appendix.

[23] The regression is carried out in the prefecture area. We get similar result when switching to city center. Notice that the educational attainment in city center is missing. Therefore we use educational attainment of the prefecture area as an approximation for it.

Table 13: Decomposing the Effect, Full Sample

	(1) GDP	(2) PhyCap	(3) Pop	(4) EffLab	(5) TFP
I_ETDZ	0.132***	0.172***	0.0573*	0.0459	0.0594
	(3.54)	(3.37)	(2.02)	(1.48)	(0.92)
I_HIDZ	0.0857*	0.0528	0.0536	0.0415	0.0524
	(1.99)	(1.37)	(1.37)	(1.06)	(1.04)
I_EPZ	0.0526	0.103*	0.0629**	0.0581**	-0.0246
	(1.32)	(1.92)	(2.37)	(2.11)	(-0.49)
I_Bonded	0.0213	-0.0280	0.0563	0.0430	0.00515
	(0.57)	(-0.27)	(1.07)	(0.70)	(0.08)
I_OtherType	0.113***	0.0752	0.0720*	0.0867*	0.0229
	(3.48)	(1.11)	(1.71)	(1.97)	(0.69)
I_firstprovincelevelzone	0.0117	0.00252	0.0354*	0.0343*	-0.00185
	(0.60)	(0.10)	(2.06)	(1.98)	(-0.08)
N	4442	4442	4442	4442	4442
AR2	0.979	0.956	0.648	0.667	0.552

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent variable: log level of GDP TFP, physical capital stock,
population and efficient labor in the city area.

Land area, city-FE and province-time-FE omitted from table.

Standard errors are clustered by province.

Table 14: Decomposing the Effect, Inland Sample

	(1) GDP	(2) PhyCap	(3) Pop	(4) EffLab	(5) TFP
I_ETDZ	0.111*	0.212***	0.0929**	0.0737	0.0325
	(1.87)	(3.65)	(2.50)	(1.71)	(0.30)
I_HIDZ	0.0440	0.0504	0.00266	-0.00807	-0.00457
	(1.16)	(1.01)	(0.08)	(-0.25)	(-0.07)
I_EPZ	0.0770	0.207**	0.0224	0.0343	-0.0624
	(1.24)	(2.37)	(0.56)	(0.86)	(-0.75)
I_Bonded	.	.	.	.	.
	.	.	.	.	.
I_OtherType	0.0531	0.277***	-0.0924	-0.0795**	-0.0997**
	(0.71)	(3.73)	(-1.40)	(-2.64)	(-2.34)
I_firstprovincelevelzone	-0.0102	-0.0250	0.0177	0.0160	0.0104
	(-0.33)	(-0.55)	(0.69)	(0.64)	(0.30)
N	2590	2590	2590	2590	2590
AR2	0.981	0.947	0.531	0.552	0.553

t statistics in parentheses

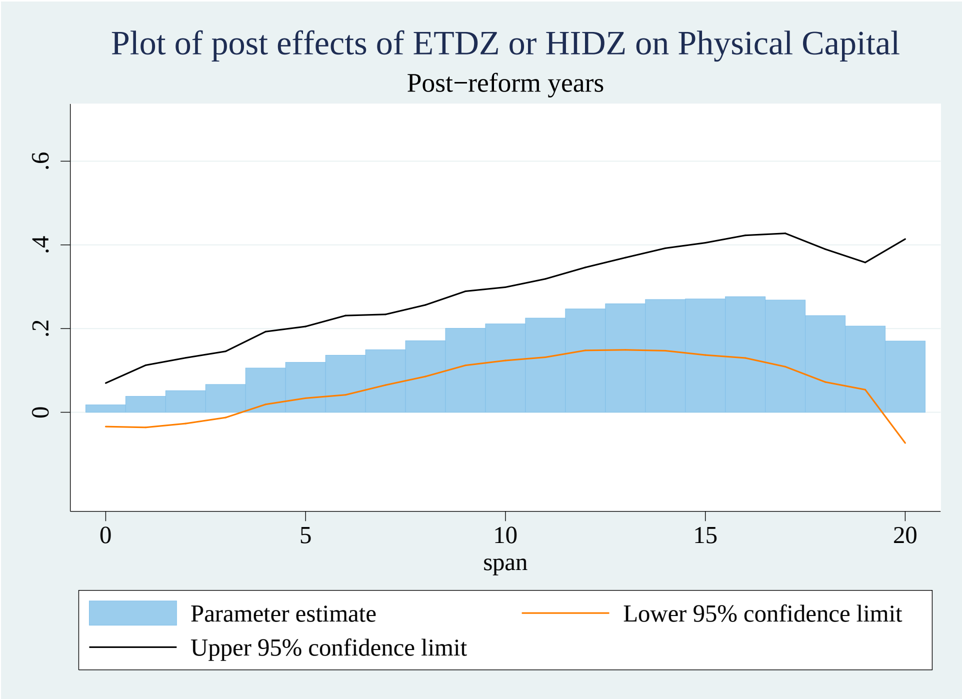
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

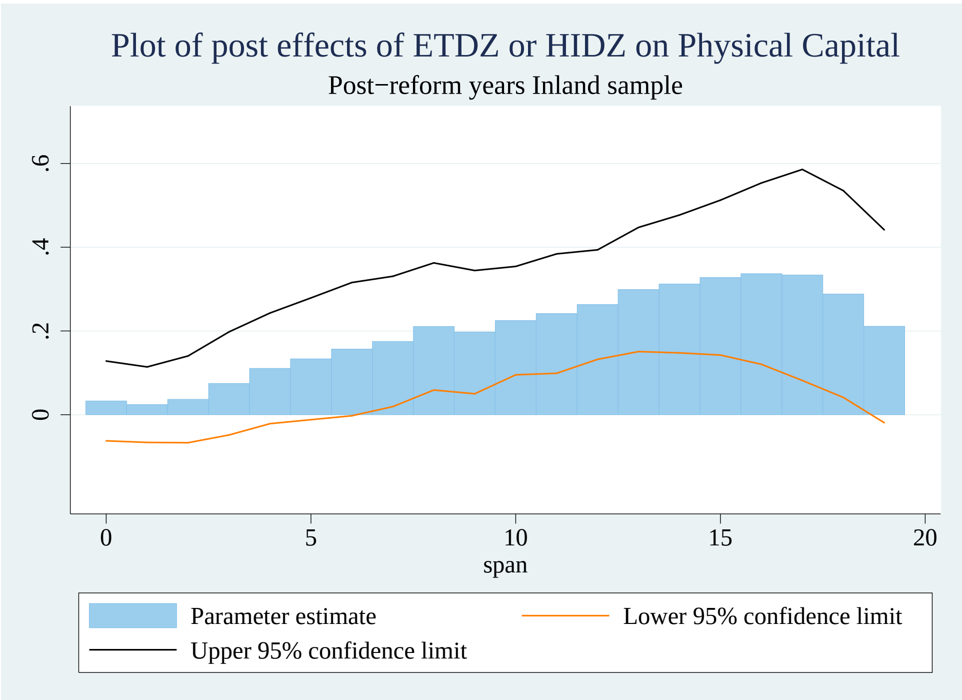
Dependent variable: log level of GDP TFP, physical capital stock, population and efficient labor in the city area.

Land area, city-FE and province-time-FE omitted from table.

Standard errors are clustered by province.

Table 15: Plot of estimates for post reform effects on Physical Capital





4 Alternative Measures for Economic Activity

Several scholars have argued that the Chinese official statistics can be biased (see for example Young [2003]). We are not aware of direct evidence for a systematic bias in the official output figures at the city level and in general at this administrative level, the quality of the data is generally viewed as being better than at other levels. However, data quality remains a concern for several reasons. First, local officials may have incentives to report to the higher administration too high figures because of career concerns (economic performance affects promotion). Second, the incentive to over-state economic performance can be especially important in connection with SEZ, because the assignment of SEZ and further support can depend on the performance. Third, the official inflation measures consistently underestimate price increases and spatial differences (Brandt and Holz [2006]). Fourth, prices may change at the local level in connection with the establishment of a SEZ.

To address these concerns, we use two alternative measures for economic activity. We first use electricity consumption which is available from the same Statistical Yearbooks that we are using for the GDP data. Then we use the intensity of light as measured by weather satellites as another measure for economic activity. The characteristics of these two measures are discussed below.

4.1 Electricity Consumption

Electricity consumption is widely regarded as a good approximation for GDP. People who have doubt over the validity of China's official GDP data often cite the fact that there existed a large discrepancy between growth rate of official GDP and electricity consumption in 1998, when the Asian currency crisis hit the world economy (for example Rawski [2001]). [24]

First, we explore the relationship between the electricity consumption and GDP. Figure 2 displays electricity consumption against GDP (both net of province-time and city fixed effect). The upper panel of Figure 2 is for the full sample and the lower panel is the after dropping outliers.[25] While the correlation between GDP and

[24] Our calculation also shows that growth rate of electricity consumption dipped around 1998 for both reformer and non-reformer cities. See Figure 5 in the Appendix.

[25] We trim the top and bottom percentile of light and gdp net of the fixed effects.

electricity consumption is positive, we do see a clear convex relationship between the two variables. To capture the relationship quantitatively, we regress log GDP on log electricity consumption and its square term. The result is shown in Table 16. Column 1 is the result from a simple log-log regression, suggesting that the elasticity between GDP and electricity consumption is about 0.27. In column 2, 3 and 4, we also control for a squared term of log electricity. The convexity is confirmed with a consistently positive coefficient on the square term. We find that adding a square term significantly changed the coefficient on the linear term (the coefficient drops from being positive to negative.) Also after controlling for land area and population, the coefficients on linear and square terms remain significant.

Table 16: Fixed effects regression for full sample, city center

	(1) Log GDP	(2) Log GDP	(3) Log GDP	(4) Log GDP
Log electricity consumption	0.265***	-0.563***	-0.298**	-0.259*
	(7.72)	(-3.27)	(-2.01)	(-1.96)
Log electricity consumption sq.		0.0358***	0.0225***	0.0191***
		(4.70)	(3.57)	(3.38)
Log land area			0.188***	-0.0331
			(7.82)	(-1.34)
Log population				0.572***
				(9.98)
N	5208	5208	5196	5194
AR2 (within)	0.966	0.969	0.973	0.977

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

There are two competing explanations for the convex relationship between log GDP and log electricity consumption. First, if we believe that the true relationship between log GDP and log electricity should be linear, the convexity we observed in the data can be interpreted as a sign that there exists systematic over-report of GDP among the larger cities. Given that reformer cities are relatively larger than non-reformer cities, the policy analysis using only official GDP data is an over-estimate.

Second, the relationship between GDP and the electricity consumption depends on the industry composition of the local economy. It is well known that the service sector is less electricity-intensive than the manufacturing sector (Orlik [2011]). If the growth of the service sector contributes more and more to the growth of GDP as the city develops, we shall see that one percentage increase in GDP corresponds

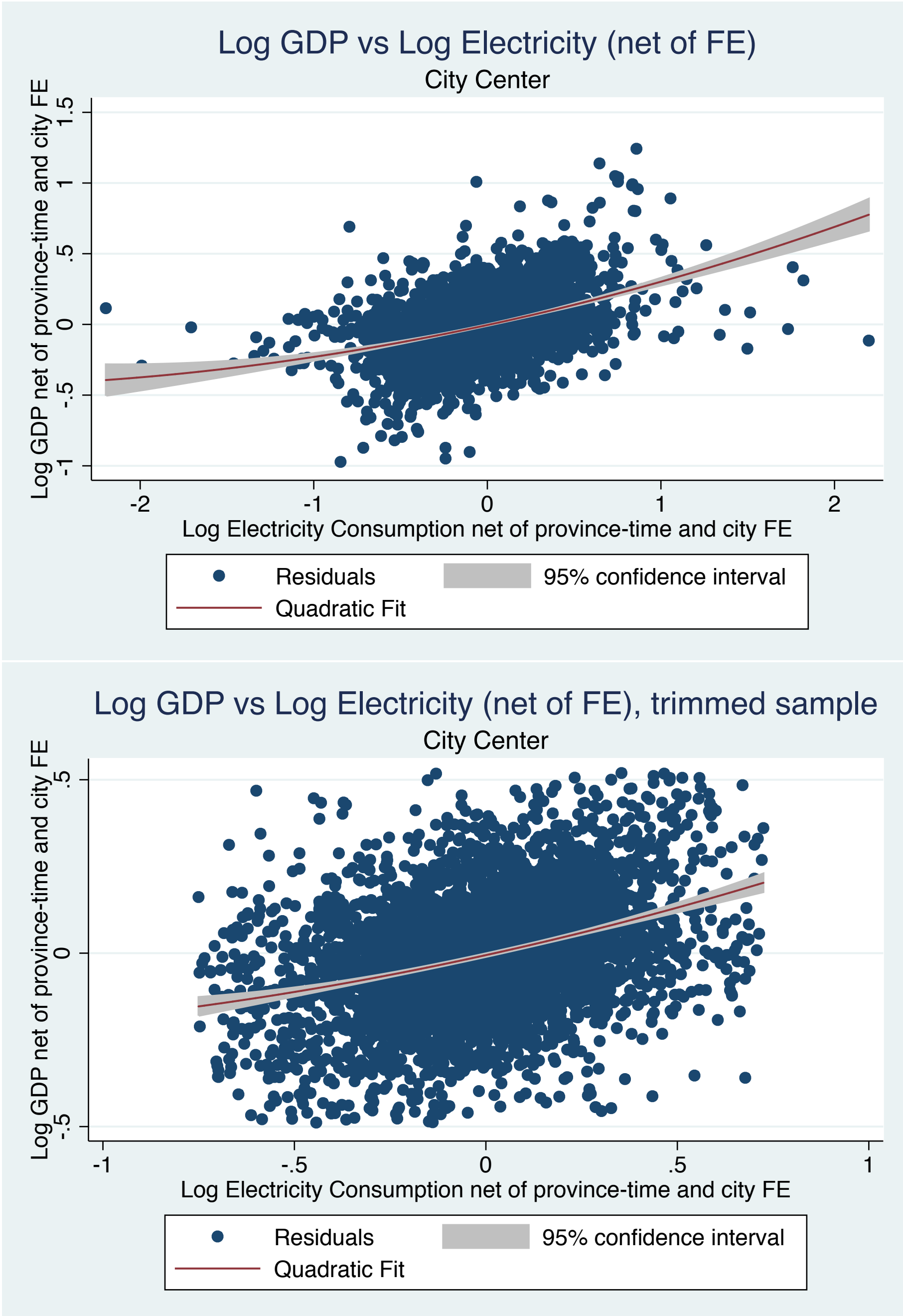


Figure 2: Electricity Consumption v.s. GDP

The scatter plot shows the residuals of a regression of log GDP on province-time and city fixed effects vs the residuals of a regression of log electricity consumption on the same fixed effects. The upper panel shows the full sample, the lower panel after trimming the top and bottom 1 percentile of each variable.

to a lower percentage increase in electricity consumption as GDP increases. The convexity can be driven by the rapidly rising service sector in the large cities but not the over-report of official GDP.

Given that we are uncertain about the correct relationship between true GDP and electricity, we proceed the policy analysis as follows. First of all, we use electricity consumption directly as dependent variable and regress it on the policy indicators. By doing this we assume that there exist a linear relationship between log GDP and log electricity. However, if the true relationship is convex, the estimate for policy effect using electricity would be an underestimate of the true effect. Second of all, we assume that the relationship is convex and the official GDP data on average is reliable. We then predict GDP using the electricity data and estimate the policy effect using the predicted GDP.

We predict GDP from electricity consumption with the estimates from column 1 (linear) and 2 (quadratic) of Table 16. Then we run our baseline regression using the linear and quadratic prediction of GDP, as well as the electricity consumption as the dependent variable. The result is show in Table 17. In column 1, 2 and 3, we combine all state-level zones into one indicator $I\_Firstreform$ and control for the province-level zones $I\_firstprovincelevelzones$. The reform effect of state level zones are significantly positive in all three regressions.[26] In column 4, 5 and 6, we move to a more demanding specification, where we distinguish different types of state-level zones. In column 6, where the dependent variables is the quadratic prediction, the reform effects are comparable to the ones with GDP as dependent variable.[27] In column 4 and 5, the estimated reform effects are much weaker. One possible explanation for this weak result is that due to the convex relationship discussed above, the electricity consumption and the linear prediction underestimate GDP growth, especially for the more developed cities.

[26]The result suggests that having a state level zone would on average increase the electricity consumption by 11.7%, linear prediction of GDP by 3% and quadratic prediction of GDP by 6%.

[27]except for ETDZ, which is not insignificant.

Table 17: Policy Analysis using Electricity and Predicted GDP, city center

	(1) Elec	(2) Linear	(3) Quad	(4) Elec	(5) Linear	(6) Quad
I_Firstreform	0.117**	0.0311**	0.0605***			
	(2.58)	(2.58)	(4.19)			
I_firstprovincelevelzone	0.00481	0.00128	0.00839	-0.00109	-0.000289	0.00785
	(0.15)	(0.15)	(0.75)	(-0.03)	(-0.03)	(0.73)
loglandareac	0.0988***	0.0262***	0.0544***	0.0988***	0.0262***	0.0506***
	(3.00)	(3.00)	(3.88)	(2.93)	(2.93)	(3.46)
loglgovspenccomb	0.296***	0.0787***	0.107***	0.294***	0.0781***	0.0997***
	(6.10)	(6.10)	(5.42)	(5.95)	(5.95)	(4.98)
I_ETDZ				-0.0385	-0.0102	0.0144
				(-0.74)	(-0.74)	(0.87)
I_HIDZ				0.0382	0.0101	0.0596***
				(0.72)	(0.72)	(3.90)
I_EPZ				0.101*	0.0268*	0.0874***
				(1.73)	(1.73)	(4.42)
I_Bonded				-0.129	-0.0343	-0.00277
				(-1.01)	(-1.01)	(-0.06)
I_BECZ				-0.287**	-0.0762**	-0.130**
				(-2.44)	(-2.44)	(-2.55)
I_OtherTypes				0.171*	0.0453*	0.0889**
				(1.96)	(1.96)	(1.97)
N	4949	4949	4949	4949	4949	4949
AR2	0.811	0.993	0.992	0.811	0.993	0.992

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Light Intensity Measured by Weather Satellites

Several recent papers have argued that light intensity can be used as a proxy for real income.[28] Many activities such as production, transport, and consumption produce light as a byproduct and this is observable from space. The light intensity can therefore be measured by weather satellites and this data is freely available since 1992 (see the appendix for further details on the data sources). The intensity of light is captured for each pixel of about 1 square kilometer on a scale from 0 to 63. The pixels within a given administrative unit can then by aggregated to compute the average light intensity per pixel or the sum of light.

Figure 3 shows the light intensity measured by several satellites over time together with real GDP of the prefecture areas. We will focus on the prefecture areas instead of the city centers of the prefecture-level cities (i.e. we include the area around the city centers) because there are many border changes of the city centers which makes it difficult to map the GDP figures for a certain area to the light intensity on the exact same geographical borders. As long as the city border changes occurred within the same prefecture area, the changes cancel out when looking at the whole prefecture area. But the problem is not completely solved by focusing on the whole prefecture area as there were also some border changes at that level, although significantly fewer.

As can be seen in Figure 3, light is measured by different satellites over time and they show different light intensities because of differences in their calibration. These differences do not matter for our empirical analysis as they are absorbed by the year fixed effects, but for the descriptive data we calibrate the values ex-post following Elvidge et al. [2009]. Figure 3 also shows that light intensity (the average light intensity per pixel, ranging from 0 to 63) increased over time also within the same satellites.

Table 18 provides the descriptive statistics of light and GDP in the sample of 270 cities between 1992 and 2010. Sum of light is the aggregated light intensity of all pixels in each prefecture area and average light per pixel is the light intensity. The growth rate of the (calibrated) light averages at around 7%, while real GDP

[28] See Henderson et al. [2012] and Chen and Nordhaus [2011] and the literature cited there on the use of light to measure economic activity. Ma et al. [2012] discusses the use of light data in Chinese prefecture-level cities.

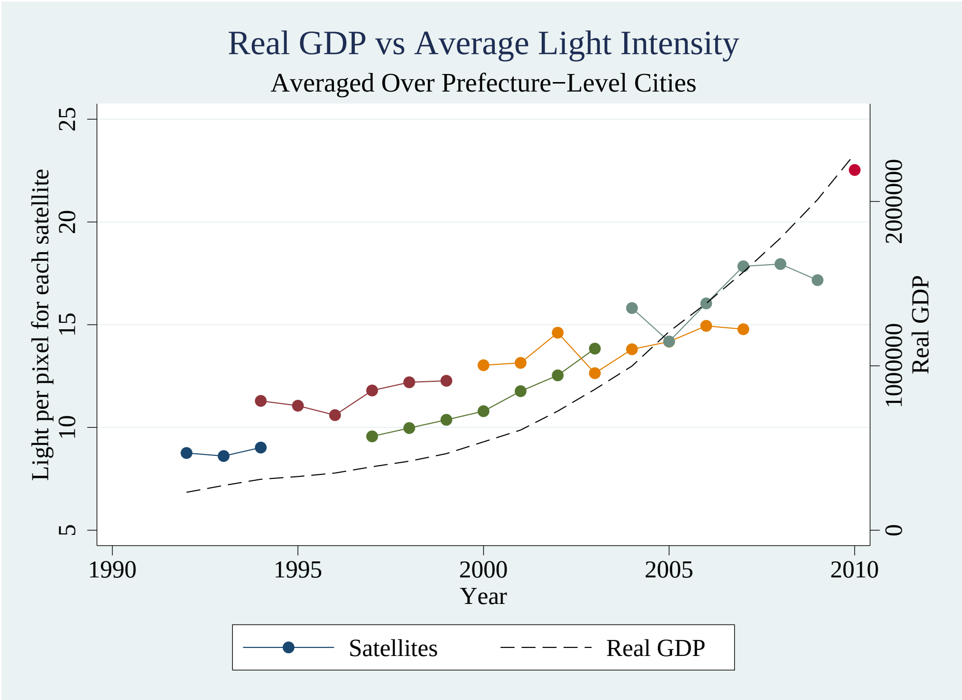


Figure 3: Light intensity measured by various satellites and real GDP

growth was around 14%. GDP growth has a very large range and standard deviation. Part of this variation is due to changes in the land area (as suggested by the high variance on the growth rate of land) but even small changes in the land area can have disproportionately large consequences for GDP if urban areas are affected. We will also look at a sub sample of cities where no reforms took place in order to rule out that we are capturing border changes related to reforms. In the following analysis, we will focus on the provinces with a Han majority, because the other provinces can have very different population densities and economic conditions which affects the measurement of light.

In Figure 4 we plot Log GDP vs Log light intensity net of province-time fixed effects and city fixed effects. The fitted line has a significant positive slope and a significant quadratic term.[29] Table 19 shows the relationship between GDP and light intensity in a panel fixed effects regression framework, using the approach in Henderson et al. [2012]. They report in a cross-country panel fixed effects regression

[29]The figure suggest that there are large outliers. We therefore repeated the analysis after trimming the top and bottom percentiles in each variable and find similar results.

Table 18: Descriptive statistics of light in the prefecture area

Variable	Mean	Std. Dev.	Min.	Max.	N
Sum of Light (cal.)	63234.2	52479.97	2790.97	478281.28	4376
Average Light per Pixel (cal.)	5.52	7.05	0.07	64.38	4376
% Growth of Sum of light (cal.)	6.7	16.66	-59.76	117.27	4005
% Growth of Real GDP	13.93	37.59	-73.87	1951.94	4075
% Growth of land area	18.23	293.29	-76.90	9423.84	4116
% Share of Pixels at DIN 0	53.49	30.33	0	99.29	4376
% Share of pixels at DIN 63	0.11	0.72	0	19.57	4376

of log GDP on log light intensity a elasticity of GDP with respect to light intensity of 0.28. They also include a square term and the share of top coded. While the top coded seem to matter in their sample, they find no evidence for a significant square term. But the existing evidence on the relationship between light and GDP in Chinese cities is mixed. Ma et al. [2012] documented, for a similar sample of Chinese prefecture-level cities as we are using, different relationships depending on the development and industrial structure of each city.

We find strong evidence for a convex relationship in our sample of prefectures. In column 1 of Table 19, we regress log GDP on log light intensity, controlling for province-year fixed effect and city fixed effect. An important difference to Henderson et al. [2012] is that in our sample the area for which GDP is measured can change over the years because of border changes.[30] We therefore control in column 2 for land area, which is available from the same yearbooks as GDP and thus likely to reflect changes in GDP that are due to boundary changes. The resulting coefficient is 0.15, which is significantly lower than reported by Henderson et al. [2012]. In column 3 we include a square term and control for the number of unlit pixels and the number of top coded pixels. There is strong evidence for a non-linear relationship and a significant effect of the number of top coded pixels. The difference to the cross-country evidence is not surprising, since the distribution of light is different in our sample of prefecture areas and Ma et al. [2012] has documented such differences for

[30]The area on which we measure light does not change because we use constant boundaries from 2010. The reason for using constant boundaries is that the digital maps are not available for every year and make it difficult to disentangle the effect of border changes from variation in light intensity.

the prefecture level city centers.[31] In column 4 we further restrict the sample to non-reformer cities in Han provinces. We will focus on this specification because we are concerned that reformer cities may have systematic mismeasurement in their GDP data. The two samples both confirm the convex relationship between GDP and light.

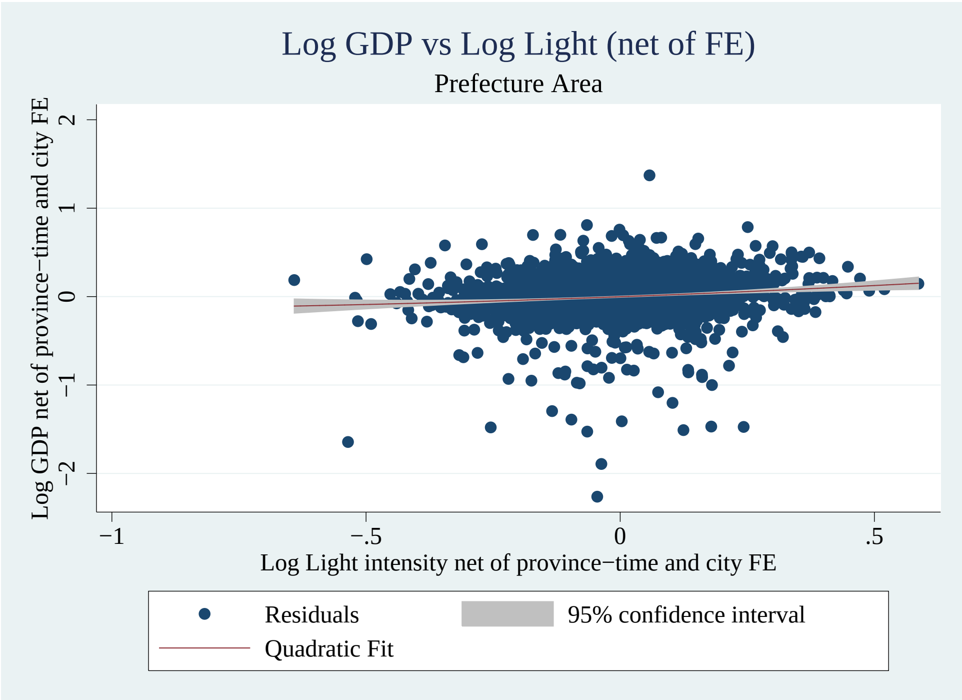


Figure 4: Log GDP vs Log Light, net of province-time and city fixed effects

The form of the relationship between GDP and light has important consequences for our policy analysis and there are different explanations as was discussed in the previous section on electricity. The lower elasticity of light with respect to GDP at higher levels implies that for a given percentage increase in GDP, we observe a lower increase in light at higher levels than at lower levels. Since the cities where SEZ were established were larger than average, this can lead to an underestimation of the reform effect. To deal with this problem, we will predict GDP for each city

[31]We have also done the analysis at the provincial level where we found no evidence for a non-linear relationship. We take this as suggestive evidence that at the lower level of aggregation which we have at the prefecture level, the relationship between log GDP and log light is different than at higher levels of aggregation.

Table 19: Fixed effects regression for full sample, prefecture area

	(1) Han	(2) Han	(3) Han	(4) HanNonreformer
Log light intensity	0.208***	0.152***	0.103**	0.140**
	(3.58)	(3.22)	(2.09)	(2.44)
Log land area		0.456***	0.478***	0.500***
		(13.69)	(15.41)	(13.31)
Log light intensity sq.			0.0814***	0.0823***
			(6.90)	(4.24)
Log number unlit pixels + 1			0.00513	0.0121
			(0.32)	(0.70)
Log number top coded pixels+ 1			0.00867*	0.0225*
			(1.76)	(1.76)
N	4346	4300	4300	2785
AR2 (within)	0.938	0.966	0.969	0.963

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Dependent variable: Log nominal GDP of the prefecture area.
All explanatory variables are also at the level of the prefecture area
The administrative boundaries for aggregating light are constant (from year 2010)

based on lights and its square term.

In column 1 of Table 20 we regress the raw light intensity (average light intensity per pixel) on the policy variables. The coefficient on ETDZ shows for example that light intensity (which lies between 0 and 63) increases by about 0.83. EPZ show a much larger effect. In column 2 we regress the log of light intensity on the policy variables and find no significant effect on the main zones but a negative effect on the other zone types. In column 3 we use the log number of top coded pixels as dependent variable and find a positive effect. The log specification has clearly the highest R^2 of these three, but the interpretation is subject to the above discussion about the convex relationship between light and GDP. Furthermore, in city centers the top coding can lead to an understatement of aggregate light because very bright pixels cannot increase their intensity anymore.

In order take the non-linear relationship into account and to compare the light results with the results from GDP and electricity, we use in the next set of regressions the predicted GDP as dependent variable. We therefore take the coefficients reported above to predict the within variation of each prefecture over the years. Our assumption therefore is that on average there is no systematic measurement error and that we can use the within variation in light to predict the within variation in GDP based on the coefficients of a sub sample. There is of course some uncertainty in this assumption because the relationship between true GDP and light is unknown.[32] In column 4 we use the linear prediction (the second column in Table 19), which differs from the regression in column 2 only in the scaling of the coefficient. In column 5 we use the quadratic prediction and in column 6 we are using the coefficients from non-reformers to predict GDP for the full sample. The differences when using the predicting coefficients from non-reformer cities is small. The coefficients on the policy variables are generally lower than what we found for GDP, but the two most common zone types ETDZ and EPZ show positive effects.[33]

Table 20: Policy Analysis using Light and Predicted GDP

	(1) MeanLight	(2) LogMeanLight	(3) TopCoded	(4) LinearP	(5) QuadraticP	(6) Nonreformer
I_ETDZ	0.828***	0.00608	0.378**	0.000921	0.0615***	0.0674***
	(3.08)	(0.26)	(2.51)	(0.26)	(4.43)	(4.49)
I_EPZ	2.175***	0.0225	0.466***	0.00341	0.0653***	0.0703***
	(5.64)	(1.02)	(4.34)	(1.02)	(6.21)	(6.18)
I_Bonded	0.429	-0.00358	0.280	-0.000542	0.0669	0.0666
	(0.28)	(-0.04)	(0.61)	(-0.04)	(1.61)	(1.33)
I_OtherTypes	0.776	-0.211***	0.345	-0.0319***	-0.0604***	-0.0657***
	(0.72)	(-4.23)	(1.03)	(-4.23)	(-3.67)	(-2.86)
I_Firstreform (province-level)	0.110	-0.0222	-0.0642	-0.00337	-0.00185	-0.00347
	(0.51)	(-1.27)	(-1.09)	(-1.27)	(-0.28)	(-0.50)
Log land area	0.0392	0.0614***		0.465***	0.473***	0.499***
	(0.43)	(3.00)		(150.20)	(75.83)	(75.95)
Log Gov. Spending	1.067***	0.0536***	0.226***	0.00813***	0.0316***	0.0366***
	(3.28)	(3.02)	(2.77)	(3.02)	(4.42)	(4.56)
N	4190	4190	4203	4190	4190	4190
AR2 (within)	0.702	0.883	0.331	0.999	0.997	0.996

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Dependent variable: Light or predicted GDP of the prefecture area.
Province-time fixed effects and city fixed effects omitted from table.
The administrative boundaries for aggregating light are constant (from year 2010)

[32] To fully clarify this issue, one would need to have accurate GDP data at the city level for an economy with comparable characteristics.

[33] Note that the some of the zones discussed earlier do not have time-variation after 1992 and therefore drop out of this analysis. In particular, HIDZ were all established before 1992.

5 Conclusion

China's growth experience during the past 30 years was astonishing. The Special Economic Zones are crucial in understanding this development. As argued by Naughton [2007]: "Bold, fragmented, open to outside investment, but with a strong role for government: Special Economic Zones typify much of the Chinese transition process." We believe that the Chinese Special Economic Zones are an interesting object to study the effect of economic reform and industrial policy. This paper provides estimates for the impact of Special Economic Zones on local economic performance measured by GDP and two alternative measures of economic activity. We use a number of demanding specifications that control for unobserved heterogeneity at the city level and at the province-time level. The evidence using official GDP suggests that there were indeed positive effects of Special Economic Zones on the cities in which they were located. Our estimates are somewhat smaller than most of the literature has reported so far but still economically meaningful. We also find evidence that the effect of the Special Economic Zones on output went mainly through physical capital. Electricity consumption and light intensity measured by satellites show a mixed picture and the effects depend crucially on the assumption of the correct relationship between true GDP and electricity or light.

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A Data Sources and Sample Selection

A.1 Data Sources for Official Statistics

Most of the time series are taken from the *China City Statistical Yearbooks*[34] and we complement them with a few other sources (specified below). For our baseline estimation, we focus on a sample of 270 cities at the prefecture level and thus exclude cities at the county or province level. The sample is unbalanced: in the year 1988 the sample only has 180 prefecture-level cities. Over the sample period, new prefecture-level cities were established by transforming municipal districts into prefecture-level cities or promoting county-level cities (see the appendix for a detailed description). At the administrative level of prefecture cities, we have a consistent definition of the observed units and have a more homogenous sample (see Table **??**). The Statistical Yearbooks distinguish between a city center and the whole area of the prefecture. We restrict our analysis to the so-called city center. We believe that this is the right unit to look at, because state-level zones were mostly established inside these units. The disadvantage is that we do not capture (in our baseline specification) spillover effects of zones to a large surrounding land area. The data for most variables cover the years 1988 to 2010 but some cities have observations only for a sub-period.[35]

The Statistical Yearbooks cover a wide range of indicators, including GDP, FDI, fixed capital investment, transportation infrastructure, size of the city area, schooling, government spending, health infrastructure, population size, and workforce. Our main variable of interest from the Statistical Yearbooks is GDP at current prices for each city center. There are two missing years in the Statistical Yearbooks (1992 and 1993) and we replace the missing years with data from *New China Cities for 50 Years*. We have cleaned the data by deleting observations that deviate (in the same direction) from the preceding year and the following year by more than 50% because these are most likely mistakes in the Statistical Yearbooks.[36] We used two different sources for the yearbook data and dropped observations that differed substantially in their GDP measure across the two sources.[37] Tibet is dropped be-

[34]Provided by China National Knowledge Infrastructure: www.cnki.net.
[35]Some variables such as industrial output are available also for earlier years.
[36]For example an upward jump by 50% from 1990 to 1991 and a downward jump to 1992.
[37]China National Knowledge Infrastructure and China Data Online.

cause we have too few observations and we dropped Chongqing because it became a province-level municipality in 1997. For the descriptive statistics, we deflate the nominal GDP series with the official urban consumer price index of each province.[38] We control for the size of the city by using land area of the city center. In some specification we also use population and government spending, where we again replace the missing years in 1992 and 1993 with data from *New China Cities for 50 Years*. Information on the establishment of the various zones is taken from different sources. The major source is the website of the Ministry of Commerce.[39] We also use the Information Site of China's Development Zones[40] and the Report of the Ministry of Commerce [2006].

Overview of the Data Sources

- China City Statistical Yearbooks (*Zhong Guo Cheng Shi Tong Ji Nian Jian*) (1984-2010).
- China New Cities in 50 Years (*Xin Zhong Guo Cheng Shi 50 Nian*)(published in 1999).
- New China in 60 Years Statistical Collection (*Xin Zhong Guo 60 Nian Tong Ji Zi Liao Hui Bian*)(published in 2009).
- China Population Census (*Zhong Guo Ren Kou Pu Cha Shu Ju*) (1990, 2000, 2010)

A.2 Sources for Light Data

The light data was downloaded from the National Geographical Data center.[41] The data is is available in cleaned form (clouds, forest fires, etc) and available on a yearly basis from 1992 to 2010. Light is measured on each pixel of approximately one square kilometer on an integer scale from 0 (no light) to 63 (maximum light).

[38] Provided by China Data Online: www.chinadatacenter.org.
[39] http://english.mofcom.gov.cn.
[40] http://www.cdz.cn/www/index.asp.
[41] http://www.ngdc.noaa.gov/dmsp/downloadV4composites.html

In order to map the light intensity of pixels to the administrative entities of cities, we us digital maps of the prefecture areas and city cores.[42]

A.3 Sample Selection Criterion

Administration Structure of Chinese Cities During our sampling period (1988-2010), China has gone through major changes. The changes included adjustments in the local government administration structure, especially that of city-level. As was characterized in China's 1982 constitution, the structure of China's local government should consist of 3 layers - province, county and village. However, for practical reasons, there existed another layer called municipal district between the levels of province and county. The counties were under direct administration of their above municipal governments, instead of the province-level government as required by the constitution. In 1983, the state government requested to transform the municipal districts into prefecture-level cities. The transformation first started in Jiangsu Province and spread to the other provinces at an uneven pace. We omitted the description of the details of the transformation here, since it is not directly related to our study. In short, we can treat the newly transformed prefecture-level cities as the layer of administration between the province and the counties. In almost all of the cases, a prefecture-level city government had direct jurisdiction over its urban districts and its counties.

Urban City Center and City Area In our dataset, the *China City Statistical Yearbooks*, the data listed under "Urban City Center" of the prefecture-level cities covers only the economic activities in the urban district while the data listed under "City Area" covers the complete administration area of the city. The distinction between the two statistical areas deserves to be mentioned in the context of our study. In prefecture-level cities, the urban district areas usually are more industrialized than the counties. Most of the SEZs were established in the urban district areas (suburban area of the cities, as described in Zeng [2010]) as well. As a result, focusing on the "Urban City Center" gives us a more direct measurement of the

[42] The digital map data for the administrative units of PR China from 1992 to 2000 were obtained from the Asian Spatial Information and Analysis Network (ACASIAN), where they were produced by Dr. L. W. Crissman.

effects of the SEZs. The disadvantage of this choice is that we might over-estimate the effect of the zones by neglecting the possibility that the other areas of the city became worse off after the establishment of a SEZ.

Prefecture-level and County-level Cities The county-level cities in China have the same administration level as counties. In fact, they were promoted to county-level cities from counties after its population exceed certain level. After the promotion, they were still under jurisdiction of its original prefecture-level city government. Unlike the prefecture-level cities, they do not have urban district areas. In the dataset, the *China City Statistical Yearbooks*, after 1997, the statistics of county-level cities were listed separately. We drop the cities that were county-level throughout the sampling period, and for those cities which were transformed to a prefecture-level city we drop the years before the transformation, because 1) essentially they were no different than other counties, 2) their statistics were covered in the prefecture-level cities and 3) most of the state-level SEZs were established in the urban district areas in the prefecture-level cities.

Sampling Period The *China's City Statistical Yearbooks* goes back to 1984, the year when the state government requested to transform municipal districts into prefecture-level cities. We exclude the period 1984-1987 from our sample because the GDP data are missing in the yearbooks for those years.

B Level Decomposition

Real GDP We obtain real GDP by deflating the nominal GDP using a province specific GDP deflator $deflator_{p,t}$. The Chinese National Bureau of Statistics (NBS) does not report the GDP deflator directly, instead it reports both the current price GDP and the constant price GDP. We obtain an "implicit GDP deflator" by dividing the current price GDP over constant price GDP, following Chow [1993]. Both the constant and current GDP series are taken from *New China in 60 Years Statistical Collection* (NC60).

Physical Capital Stock We apply a perpetual inventory approach to construct the physical capital stock in each city. The formula is as follows

$$PC_{i,t} = (1 - \delta_k)PC_{i,t-1} + I_{i,t}/deflator^{I}_{p,t}, \tag{5}$$

with the physical capital stock of the first year (1988) given. We set δ_k, the annual depreciation rate for physical capital, to be 0.08 (we tried different numbers, ranging from 0.05 to 0.1, the result does not change much).

We take investment in fixed asset $I_{i,t}$ from two sources. One source is the Chinese City Statistical Yearbook 1988-2010, where investment in fixed asset is reported in both the city area and the city center. The other source is the New China 60 Years Provincial Statistical Collection 1978-2008, where the investment in fixed asset is only reported for the city area and only for a subsample of cities. We use the later source whenever it is available.

We take the deflator for investment goods, $deflator^{I}_{p,t}$, from NC60. The deflator is province-specific and is available for the period 1991-2010. We use the GDP deflator instead of investment good deflator for the years before 1991.

We need to have a reasonable guess for the initial capital stock. For the cities whose investment data go back to 1978, we derive the physical capital of 1978 using the formula

$$PC_{i,1978} = \frac{I_{i,1978}}{g_{1978} + \delta_k}, \tag{6}$$

where $I_{i,1978}$ is the investment in year 1978 and g_{1978} is the growth rate of real physical capital stock before 1978. This is the steady state formula for physical capital stock of a Solow-type growth model (Caselli [2005]). The assumption that China was in steady state on 1978 is quite plausible. Notice that we are using the post-1988 data, there is a 10 years gap between the initial year (1978) and the beginning of the sample period. Therefore, the initial physical capital stock would have only marginal impacts on the estimate after 10 years.

For those cities whose investment data begins in 1988, we have to approximate the initial physical capital stock in 1988 using the same formula

$$PC_{i,1988} = \frac{I_{i,1988}}{g_{1988} + \delta_k}, \tag{7}$$

where g_{1988} is calculated as the average growth rate of physical capital stock during 1985-1988 from Li et al. [2009b]. Since quite a lot of important reforms took place during 1978-1988, Chinese economy is less likely to be in steady state in 1988. However, we need an estimate for the initial physical capital in 1988 in those cities and this is the best estimate that we can find.

Efficient Labor Efficient labor is the total number of employment adjusted by the quality of the labor force.

$$EL_{i,t} = HC_{i,t} \times Employment_{i,t}. \tag{8}$$

Ideally, we would use the number of employed person as the measurement for employment in each city. However, the data for the number of employed persons in Chinese city statistical yearbooks has the following drawbacks: 1) The number of employed persons is defined as registered workers in each city, which might exclude the large number of immigrant workers. 2) There is a huge drop in the number of employed persons around year 1998 in almost all cities. Two reasons could potentially contribute to this huge drop. The first reason is that the reform of state-owned enterprises laid off a large number of redundant workers around 1998. [43] The second reason is that the definition of employed persons changes on 1998. Before 1998, the employed persons include people who are registered as workers. After 1998, the number only includes people who are registered and are currently working in that city. [44]

We use population as an approximation for employment. Here is how we construct the approximated number using population census data and the city statistical yearbooks data.

During 1987-2010, our sample period, the population census were conducted in 1990, 2000 and 2010. We take the population of the city area and the city core of

[43] According to Dong and Putterman [2003], the labor redundancy rate of SOEs is 30% in 1992.
[44] Wu [2011] provides detailed discussion about the issues with the employment data.

these three years from the census and interpolate the total population of the years in between using the year-by-year population growth rate, obtained from the city statistical yearbooks. [45]

The population census also reports the educational attainment of population over age of 6 in the city area. For the census years, we use the average educational attainment (years of schooling) as an approximation for human capital per capita. The formula is taken from Hall and Jones [1999],

$$h_{i,t} = e^{\phi_t(s_{i,t})}, \tag{9}$$

where $\phi_t(s)$ is a piece-wise linear function whose slopes are the return to schooling and $s_{i,t}$ is the average years of schooling of city i in year t. The estimate of the return to schooling in China is taken from Li et al. [2009a]. For the years in between the censuses, we do a simple linear interpolation to obtain human capital (extrapolation if needed).

C Robustness Analysis Using Earlier Data

GDP of city area are available for a subsample of cities [46] We incorporate the GDP of these cities into our database and run our baseline regression. Notice that we do not control for change in land area, government spending and population since these data are missing for the earlier years.

[45]The population census data is more accurate compared to the other sources. The population reported in the census is the resident population (registered population and unregistered immigrant workers) while the other sources report registered population only.

[46]Namely the cities in the following provinces: fujian, guizhou, hebei, heilongjiang, henan, innermongolia, jiangsu, shaanxi, shandong and shanxi.

Table 21: Policy Analysis with Earlier GDP, prefecture area

	(1)	(2)
	1	2
I_ETDZ	0.0947*	
	(1.99)	
I_HIDZ	0.184***	
	(2.94)	
I_EPZ	0.0337	
	(0.59)	
I_Bonded	-0.109	
	(-0.79)	
I_OtherType	0.134*	
	(1.82)	
I_firstprovincelevelzone	0.0134	0.00714
	(0.68)	(0.35)
I_Firstreform		0.123***
		(4.12)
N	5409	5409
AR2	0.958	0.957

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Dependent variable: log level of GDP .
City-FE and province-time-FE omitted from table.
Standard errors are clustered by city.

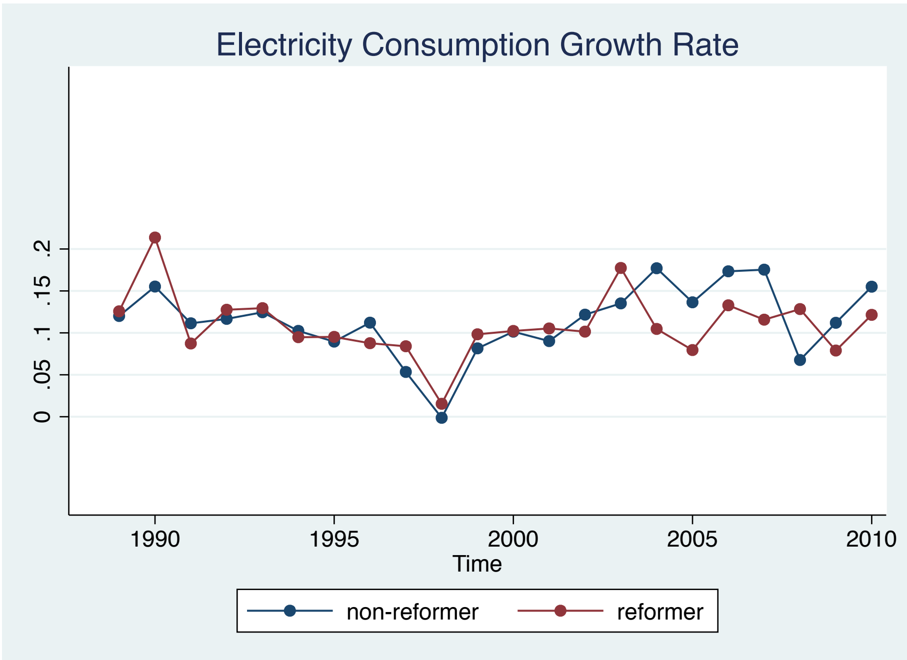

Figure 5: Growth Rate of Electricity Consumption

Table 22: Fixed effects regression on province level, Han provinces

	(1) loggdp	(2) loggdp	(3) loggdp	(4) loggdp	(5) loggdp
logmeanlight2010meansat	0.114***	0.123***	0.107***	0.132***	0.132***
	(0.001)	(0.000)	(0.002)	(0.000)	(0.000)
sqlogmeanlight2010meansat		0.00407	-0.000898	0.00189	0.00189
		(0.356)	(0.860)	(0.657)	(0.657)
lognumberpixels_63			0.00626*		
			(0.067)		
lognumberpixels_0			-0.0555		
			(0.100)		
logpopc				0.607***	0.607***
				(0.000)	(0.000)
loglandareac					-0.216
					(0.247)
_cons	15.84***	15.83***	16.50***	10.59***	13.15***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	399	399	399	399	399
AR2	0.996	0.996	0.996	0.996	0.996

p-values in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$