Natural Resource Shocks and Entrepreneurship: Evidence from Coal Productions in China*

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Abstract

This paper studies how the dependence on natural resource shapes entrepreneurship in the Chinese context. We exploit the sharp decline of global coal price from 2012 to 2014 as an exogenous shock to identify the sector-specific impact of domestic coal production on entrepreneurship. Using a comprehensive data set of firm registration, the paper finds a strong negative effect of coal production on the establishment of firms. Thus, a weak coal price provided an opportunity for the Chinese economy to pull out of the resource dependence trap. In response to the declining coal sector, potential and existing entrepreneurs take advantage of the decreased opportunity cost and lower entry barriers to establish firms. Induced entrepreneurial activities are more vigorous in sectors with a higher level of downstreamness relative to, and of higher proximity with, the coal sector in the production network.

Keywords: Entrepreneurship, Resource Shocks, Production Network, Serial Entrepreneur

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1 Introduction

Entrepreneurship is a key engine of growth (Leibenstein, 1968; Leff, 1979; Schmitz, 1989). Economic growth takes off in transition societies when individuals are encouraged to invest on productive purposes (Acemoglu, 1995; Banerjee and Newman, 1993; McMillan and Woodruff, 2002), and it gets stuck in stagnation when entrepreneurial talents are otherwise spent on rent-seeking (Baumol, 1990; Murphy et al., 1991). This paper studies a fundamental factor responsible for the arrest of entrepreneurship: dependence on natural resources. We understand natural resource rents as an opportunity cost for individuals to become a productive entrepreneur. A sizeable body of literature has shown that, by raising the opportunity cost of productive entrepreneurs, resource boom may crowd out existing firms in other sectors and deter new entries in the market (Caselli and Cunningham, 2009; Mehlum et al., 2006; Sachs and Warner, 2001). However, little attention has been paid to the reverse channel of the so-called "resource curse": Will shrinking resource rents stimulate entrepreneurial activities?

To answer this question, we examine whether the downward shock to the global coal price between 2012 and 2014 alleviates the resource curse to entrepreneurship in the Chinese context. We focus on the coal sector in China for two reasons. First, coal-production constitutes the largest bulk of energy sectors in China. About 67 percent of China's energy consumption relies on the coal sector (BP Group, 2014). Compared with other fuels, such as oil and gas, coal is a more important energy and income source for its abundance and wide spread across the country. Hence, external shocks to the coal sector have far-reaching impacts on investing choices across the domestic market. Second, a body of literature show that the extraction of natural resources rents is conducive to misgovernance (Ayyagari et al., 2010; Brunnschweiler, 2008; Mehlum et al., 2006), and China is no exception. In particular, the business of coal production often involves a collusion with the local government (Fisman and Wang, 2015; Jia and Nie, 2015; Shi and Xi, 2018). The profitability of the coal sector depends more on the price of natural resources than on entrepreneurial skills. This implies a further misallocation of talents in the spirit of Baumol (1990) and Murphy et al. (1991) and a repression of entrepreneurship in regions economically dependent on coal. External demand-side shocks thus provide us an opportunity to examine whether, and how, entrepreneurship can be unbound.

China provides a suitable case for studying entrepreneurship in emerging economies.

During the past decade, the Chinese market has been witnessing a (surprising) burst of entrepreneurial economy and innovations despite a protracted global economic downturn due to the 2008 global financial crisis (Lardy, 2014; Wei et al., 2017). Although China's GDP growth underwent an adjustment, down from 14% to less than 7% on annual growth, the registered firms grew at an annual rate of 21.9% between 2012 and 2014. The increase predominantly came from the private sector. The vigorous private sector in China presents a particularly puzzling case in view of an expanding public sector and ubiquitous financial distortions due to the stimulus package of 2008 (Ayyagari et al., 2010; Bai et al., 2014; Brandt et al., 2013). While many factors, from entrepreneurship-encouraging policies to structural transformations in the national economy, may have contributed to the growth in private firms, this paper shows that the growth was speeded up by negative external shocks to the coal sector.

The challenge to identification lies in the fact that the resource sector is endogenously shaped by factors correlated with entrepreneurship. Entrepreneurs face liquidity constraints. When the economy is booming, potential entrepreneurs have more cash-in-hand, it is easier for them to establish new businesses. This mechanism leads to a positive correlation between the resource sector and entrepreneurial activities, as resource price normally follows a procyclical trend. On the other hand, countries and regions rely more on resource extraction when they suffer from a lack of entrepreneurship. In either case, estimation on the effect of resource production is biased. To deal with the endogeneity problem, we adopt an instrumental variable strategy exploiting external coal price shocks. Although China produces the largest volume of coals around the world, most of the output supplies the domestic, rather than the international, market. Moreover, the domestic price was higher than the average of imported coals due to the high transportation cost within China (Cornot-Gandolphe, 2014). As a result, China is a price-taker in the global coal market. The fluctuation of global coal price has a large impact on the Chinese market, but not vice versa.[1]

The global commodity market witnessed a secular decreasing trend of coal price in the past decade. The economic meltdown in the Western markets triggered the initial drop in 2009. Although the price picked up in the 2010-2011 period, the development of shale oil pushed down fuel prices, including those of oil and coal, again, after 2012. The global coal price decrease in this period posed severe challenges to the Chinese economy,

[1]See Section 3.4 for a discussion on the exogeneity of the global coal price.

hitting regions that are heavily dependent on coals.[2] To capture the idea that different regions were exposed differently to the impact of coal production shocks, we take the interactive term between the international coal price index and the preexisting level of coal production in each city as an instrumental variable for the actual coal production, and estimate its impact on the number of firm registrations.

The empirical results are consistent with the existence of a natural resource curse in terms of a repression on entrepreneurship, and importantly, show how a declining coal sector spurred entrepreneurship. According to the instrumental variable estimation, a one percentage point decrease in the global coal price corresponds to a 2.4 percentage points increase in the number of new firms and a 4.8 percentage points increase in the volume of firms' paid-in capital. Moreover, we take into account sector heterogeneity and separately estimate the effect of coal price shocks for different sectors. The analyses find that the effect is more sizable in agriculture, heavy industry, and production service sectors, but not significant for consumption service sectors.

In addition to the channel of changing opportunity cost due to resource price shocks, we explore the possibility that firm entry decisions in a sector are related to changes in input cost and derived demands from coals. Specifically, when coal price drops, a firm intensively relying on coals as inputs faces a downward variable cost, which tend to reduce entry costs. By contrast, a firm producing input-goods for the coal sector would be adversely affected by a decreasing coal price. A shrinking demand side tends to neutralize the rise of entrepreneurship due to decreasing opportunity cost. As a result, the upstream sectors of coal productions tend to observe less growth of new firms during the coal price downturns.

To incorporate the mechanisms through intersector production linkage, we compute two indices indicating sectoral upstreamness and downstreamness with regard to the coal sector based on the input-output table, and estimate their interactive effects with coal production. Consistent with the reasoning of production linkage, we find that the degree of downstreamness of a sector renders more acute increase in new firms following a negative shock. Meanwhile, the degree of upstreamness neutralizes the increase of firm entries when coal price decreases. We also show that the decline in coal production translates

[2] A typical case where the economy was severely hurt by a coal price crash is Ordos, a coal-abundant city with fast growth in GDP and real estate investments before 2012. During the coal price downturns in the 2012-14 period, however, the house price plummeted and Ordos became the so-called largest "ghost city". (https://www.forbes.com/sites/wadeshepard/2016/04/19/an-update-on-chinas-largest-ghost-city-what-ordos-kangbashi-is-like-today/#24e0a5882327)

into faster firm growth in sectors with a smaller distance to coal production in the value chain.

We discriminate the effects between coal production shocks on first-time and serial entrepreneurs. Serial entrepreneurs refer to existing entrepreneurs in the market who subsequently established firms. As existing firms in the coal sector incur more severe losses from the price decline, they are likely to adjust and switch to other types of investment more quickly. In accordance with this reasoning, we find that the effect is strong for firms established by serial entrepreneurs from the coal-producing sector. However, we do not observe a significant effect for firms established by serial entrepreneurs from non-coal sectors. This finding further supports the premise that dependence on coal revenue extraction is a major channel of entrepreneurial repression. Relatedly, we find that with the decline of coal price, more firms dropped out of business in the coal sector. However, firm exits in the non-coal sectors were not significantly affected.

The findings in this paper shed lights on how entrepreneurial activities evolve with business cycles in the emerging markets. The literature characterizes entrepreneurs as those endowed with managerial skills, innovative ideas, and high risk tolerance, but are short of capitals (Acemoglu et al., 2006; De Meza and Southey, 1996; Doepke and Zilibotti, 2008; Evans and Jovanovic, 1989; Falkinger and Grossmann, 2013; Schultz, 1975). Echoing with these assumptions, Bernanke and Gertler (1989) study the co-movements of entrepreneurial activities and the business cycle in a standard neoclassical framework, in which credit-constrained entrepreneurs rely on net worth to finance new investments. Rampini (2004) models the problem of occupational choice in a circumstance where agents differ only in their risk attitudes and show a similar pattern. Both models predict a procyclical movement of entrepreneurial investments, which is consistent with empirical evidence from the Western economies (Bilbiie et al., 2012; Koellinger and Thurik, 2012).

Entrepreneurial activities, however, need not be procyclical. One possibility for firm growth to change counter-cyclically is that self-employment increases during recessions (Shapiro, 2014). The second mechanism is that business cycle may be induced by public spending, thus it crowds out private investment. The third and most relevant mechanism is that dismantling resource-dependent environments facilitates a correction on talent misallocation. Similar as in the problem studied by Bernanke and Gertler (1989), private firms in China face borrowing constraints (Song et al., 2011). Entrepreneurs, however, may circumvent adverse financial and regulatory environments by bribing and colluding with powerful regulators (Jia and Nie, 2015). As a result, talents may be attracted to sectors convenient for grabbing rents, but not to those with a high potential of productivity growth and innovations.

This third mechanism implies that a fast economic growth could be associated with capital misallocation, as manifested by the firm-level growth of total factor productivity (Hsieh and Klenow, 2009). Paradoxically, economic downturns may provide a "big push" for entrepreneurship. The rent reduction for incumbent firms thus becomes a process of Schumpeterian "creative destruction", triggering more productive entrepreneurs who would not have entered during economic booms. A logical implication then is that new entrants under a business environment with institutional imperfectness have a faster TFP growth than incumbent firms do. This last conjecture contradicts the neoclassical models but is consistent with empirical evidence from China (Aghion et al., 2015; Brandt et al., 2012).

Moreover, the arguments presented above can be viewed as a reversal of "resource curse" in the case of entrepreneurship. The preponderance of the literature on resource-dependence in economics and political science take the endowment of natural resources as given. Empirical evidence from cross-country or subnational studies generally hold that resource dependence hinders development and living standards (Bornhorst et al., 2009; Caselli and Michaels, 2013; Corden and Neary, 1982; Rodriguez and Sachs, 1999; Sachs and Warner, 2001), undermines state capacity and the efficiency of public service (Borge et al., 2015; Brollo et al., 2013; Chen and Kung, 2016; Hong, 2018), and aggravates political instability (Arezki and Brückner, 2012; Caselli and Tesei, 2016; Mehlum et al., 2006; Ross, 1999). Apart from that, a line of recent researches exploits commodity price shocks as the source of exogenous variation to study the impact of resource windfalls on economic and social outcomes (Acemoglu et al., 2013; Bazzi and Blattman, 2014; Brückner and Ciccone, 2010; Dube and Vargas, 2013). This paper adopts a similar approach of using price shocks to identify the effect of resource revenue but applies it to a new context of entrepreneurship and structural transformation in China. The empirical results highlight that entrepreneurship may be endogenously structured by external conditions, a point that is underplayed in the previous literature.

Finally, this paper contributes to the literature on firm dynamics by illustrating how entrepreneurial talents reallocate among regions and across different sectors. By exploiting sector-specific production linkage to the coal sector, the paper documents various tangible mechanisms of firm dynamics in response to external shocks. The finding of heterogeneous effects of resource revenue conditional on the relative upstreamness and downstreamness speaks to the trade literature emphasizing value chains (Antràs et al., 2012; Antràs and Chor, 2013; Fan and Lang, 2000; Wang et al., 2017). The relevance of sectoral distance to coal attests to the importance of knowledge spillover in nurturing entrepreneurship (Acs et al., 2009). The results based on serial entrepreneurs are consistent with the literature that external shocks may induce exits from nonviable sectors and reallocate talents to more productive uses (Pe'er and Vertinsky, 2008).

The remainder of this paper proceeds as follows. Next section derives hypotheses on the relationship between coal dependence and entrepreneurship. Section 3 describes data and empirical strategy. Section 4 presents empirical results in line with the hypotheses. We first report the baseline results using ordinary least squares (OLS) and instrumental variable (IV) estimation, we then investigate sectors' heterogeneous responses to coal production shocks, and present evidence on firm exits from the coal sector, firms by serial entrepreneurs, and the outflow of entrepreneurial activities. Section 5 concludes.

2 Conceptual Framework

In this section, we sketch the economic logic on the interplay between coal price shocks and entrepreneurial activities. As in Banerjee and Newman (1993), we assume the decision to establish one's own business to be a choice between two occupations: wage earner or entrepreneur. Wage depends on the business cycle, but not on individual attributes. Wage earners in resource-abundant regions enjoy fast income growth during price booms, either through participating in resource sectors, or benefiting indirectly from redistribution. By contrast, the payoff to a productive entrepreneur depends more on entrepreneurial skills and idiosyncratic productivity shocks. For the time being, suppose that the return to non-coal sectors is orthogonal to the coal price, then, the payoff of becoming an entrepreneur is determined by individuals' entrepreneurial skills only. Individuals with sufficiently high entrepreneurial skills become entrepreneurs. In this case, the expansion of the coal sector due to positive price shocks increases the opportunity cost of establishing one's own business, and a contracting coal sector may be a blessing for entrepreneurship.[3]

[3]The impact of a coal price shock to entrepreneurial activities in the coal sector itself is more ambiguous. On the one hand, the increase of reserved income resulting from business upturns deters new firms by raising the opportunity cost of becoming entrepreneurs. On the other hand, resource booms tend to attract more new investments into the coal sector due to a ballooning profitability. The overall effect of a

In sum, we obtain Hypothesis 1 for the first-order impact of coal-production shocks on entrepreneurship.

Hypothesis 1 (Opportunity cost and investment opportunity) *Contraction (expansion) of the coal sector is positively (negatively) associated with the amount of new firms in non-coal sectors.*

In the second step, we allow coal price to determine the profitability of non-coal sectors. Now, the impacts of coal production on entrepreneurial activities need to be reconciled with sector-specific production linkage with coal. An increase in coal price consists a negative supply-side shock to industries intensively using coals as inputs. In contrast, the expansion of the coal sector due to a positive price shock boost its downstream sectors. Hence, the economic impact of coal production shocks is amplified by production linkage with downstream sectors. For upstream sectors, the two effects may mitigate with each other.

Another source of sectoral heterogeneity stems from the proximity of a sector with the coal sector in the production network. The proximity with the coal sector determines entrepreneurial activities in other sectors through knowledge spillovers. For example, the farming industry has a relatively weak production linkage with coal-production. However, the proximity between the farming industry and the coal sector is high in the production network, simply because they share a large common set of upstream industries, such as transportation and heating, and downstream industries, such as food processing. The "closeness" between two sectors provides entrepreneurs and employees in one sector an opportunity of exposure to the other's business, and allow them to accumulate local business knowledge for future. When the coal industry suffers, these close sectors may observe a faster growth in redirected investments by the entrepreneurs and more spin-off employees from the coal sector. Hypothesis 2 summarizes the reasoning on sectoral heterogeneity in view of production network.

Hypothesis 2 (Production network) *The effect of coal production shocks on new firms is amplified by a sector's downstreamness with respect to the coal sector, and the effect is mitigated by its upstreamness with respect to the coal sector (production and demand*

positive resource price shock on entrepreneurship in the resource sector itself becomes positive when the increase in profit margin dominates the rising opportunity cost. When we consider a negative price shock to coal, the reasoning is exactly the opposite.

shocks); moreover, sectors with a higher proximity to the coal sector in the production network are affected more intensively (knowledge spillover).

Furthermore, the effect of coal production shocks may lead to different patterns of firms exits and serial entrepreneurship in the coal and non-coal sectors. When the price of coal declines, existing coal-producing firms, especially those small private enterprises operating on financial leverage, would find it increasingly difficult to materialize benefits from resource rent extraction, and they are more likely to drop out. By contrast, existing firms in non-coal sectors need not suffer immediate losses from coal price declines. This reasoning implies that the expansion in the coal-producing sector is negatively associated with exits from the coal sector, but not from non-coal sectors, as stated in Hypothesis 3. Relatedly, veteran entrepreneurs in the coal sector may try to recoup their loss by reinvesting in other businesses during the price downturns. Section 4.2 provides anecdotal evidence in consistence with this observation.

Hypothesis 3 (Firm exits and serial entrepreneurs) *Negative coal production shock is positively associated with firm exits in the coal sector; meanwhile it induces more existing entrepreneurs from the coal sector to establish new firms in other sectors.*

3 Data and Empirical Strategy

3.1 Dependent Variable

We employ a unique firm registry database to measure the number of new firms. China's Corporation Law requires that all firms register at the State Administration of Industry and Commerce (SAIC). Our database, which are obtained from the SAIC, covers all small manufacturing enterprises as well as enterprises from agricultural and service sectors. The data include firm level information of the starting date, 4-digit industry code, location, amount of paid-in capital, legal representatives, shareholders, and ownership structure. We use firm registration data at the SAIC for its comprehensive coverage on all registered firms. By contrast, other commonly used firm-level databases, such as the Chinese Annual Survey of Industrial Firms, covers manufacturing firms with annual sales over 5 million RMB ("above-scale" firms). In our data, the entries of "above-scale" enterprises account for only a small portion of all firm entries. Hence, our data provides an arguably more representative picture of entrepreneurial growth in China.

The main dependent variable throughout the paper is **Log(New Firms)**, which is the logarithm of the number of newly registered firms. A notable contribution of this paper is the analysis on the sectoral heterogeneity in responding to coal production shocks. To this end we conduct our analysis at both the city level (throughout this paper, "city" refers to prefecture-level cities, prefectures, and autonomous prefectures) and city-sector level. Using the starting date information, we aggregate the number of new firms for 135 sectors in concordance with the 4-digit industry code provided by the 2007 Chinese Input-Output Table (IO Table).

An alternative dependent variable is **Log(Capital)**, which measures the logarithm of total amount of paid-in capital by new firms. For each firm, the paid-in capital equals the sum of equity of all shareholders, it also equals the current paid-in capital. This allows us to measure the paid-in capital of new firms, in addition to the number of new firm entry. For our purpose, we also investigate the pattern of **Log(Exits)**, the number of firm exits in each year. In the data, a firm is classified as exiting if it cancels the business license by itself or the license is revoked by the SAIC. We are able to identify whether a firm has exited or not in year t based on the information about the exiting date documented in the data.

We also use information on the citizenship ID of each shareholder to calculate the amount of new firms established by **serial entrepreneurs**. We identify the largest shareholder as the controller of a firm, and sort all firms controlled by a private person according to the registry date. This allows us to identify whether a newly established firm is controlled by anyone who had owned a firm in the coal sector.

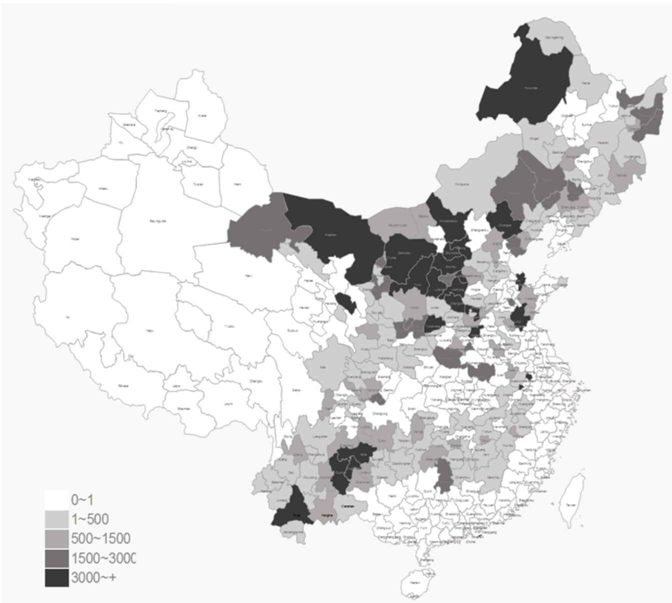
3.2 Independent Variable

We focus on coal-producing cities in China to investigate the pattern of new firms. Note that our estimation for the impact of coal sector on entrepreneurship is a local effect, thus, it does not provide a counterfactual inference for coastal cities not producing coals. Restricting the sample of analysis to coal-producing cities controls for city heterogeneity in institutional quality and alleviates the problem of reverse causality. The main explanatory variable throughout this paper is **Log (Coal)**, the logarithm of coal production at the city level. As in Shi and Xi (2018), we use a two-step selection procedure to decide the sample for analysis. First, we select provinces with annual coal productions larger than 10 millions, excluding four direct-controlled municipalities (Beijing, Shanghai, Tianjin, and

Chongqing) and the Xinjiang Uyghur Autonomous Region for their relatively different administrative and economic structures. Then, in the second step, we keep the cities producing positive amount of coals throughout the sample period between 2012 and 2014. The information of coal-productions are obtained from the Yearbooks of Coal Mining Industry published by provincial regulators on coal mine industries. Figure 1 shows graphically sample cities being included for empirical analysis.

For the purpose of instrumental variable estimation, we retrieve the data on coal productions to the 2007-2009 period and compute the average annual productions at the city level. We interpret the pre-existing level of coal-productions before the global coal price decline as a proxy of the capacity of resource extraction. We use the product of the 2007-09 average coal production and the logarithm of Australian thermal coal price (yearly average) as the instrumental variable for the actual production. The logic for the instrumental variable is further discussed in Section 3.4.

Figure 1: Coal-producing cities covered in the sample



Notes: The shaded areas show the prefecture-level cities used for the empirical analysis. Cities are differentiated by the average annual coal productions (10,000 tons) between 2012 and 2014.

3.3 Control Variables

The main control variables we use are the gross domestic product (GDP) and the per capita GDP at the city level. We obtain data from China Statistical Yearbooks and

Table 1: Summary Statistics

	Observations	Mean	Standard Deviation	Max	Min
Log(New Firms)-city	420	7.842	0.928	10.85	4.615
Log(Coal)-city	420	6.594	1.718	11.07	0.971
Log(Price-Coal)	420	4.488	0.131	4.637	4.319
Log(Price-Coal) $\times$ $\overline{\text{Coal07}-09}$	420	0.0816	0.143	1.240	0.001
Log(GDP)	420	25.41	0.758	27.39	23.42
Log(GDP per capita)	420	10.47	0.525	12.19	9.262
Log(Firms by Serial Entrepreneurs)	420	0.524	0.815	3.332	0
Coal07-09(Trillion tons)	140	0.0182	0.0319	0.267	0.000
Upstreamness	135	0.0121	0.0337	0.341	0
Downstreamness	135	0.0103	0.0338	0.341	0
Distance	135	0.224	0.184	0.695	0
Log(Number of new firms)-city sector	33,247	2.038	1.595	10.09	0
Log(Capital)-city sector	33,247	2.920	2.292	11.65	-4.605
Log(Exiting Firms)-city sector	33,247	0.981	1.279	8.862	0
Log(Capital of exiting firms)-city sector	33,247	0.902	1.884	10.30	-6.908

Notes: The coal production is in 10,000 tons. Price-Coal is the NEWC index of Australian thermal coal price (yearly average). $\overline{\text{Coal07}-09}$ is the average annual coal production in the 2007-2009 period. Log(Capital) is the logarithm of total capital of new firms in registry.

Statistical Yearbooks for each province. We interpret the total GDP as a determinant of entrepreneurship through cities' agglomeration effect (market potential), and interpret the influence of the per capita GDP on entrepreneurship as through individuals' income effect.

In addition to the control variables, we use a set of intermediate factors related to sectors' position in the production network based on the Input-Output table. For each sector, we construct three indices measuring the upstreamness, the downstreamness, and the distance relative to the coal-production sector. We discuss the construction of these measures in further details in Section 4.2. Table 1 provides the summary statistics for the key variables.

3.4 Empirical Strategy

The benchmark model estimates the number of new firms at the city-sector level as a function of local coal-revenue. We specify that

$$\log \mathrm{NewFirms}_{\mathrm{rijt}} = \theta \log \mathrm{R}_{\mathrm{it}} + \mathrm{X}_{\mathrm{rit}}\mathrm{b} + \mathrm{u}_{\mathrm{ij}} + \psi_{\mathrm{t}} + \epsilon_{\mathrm{ijt}} \tag{1}$$

In equation (1), the dependent variable is $\log \mathrm{NewFirms}_{\mathrm{rijt}}$, the logarithm of newly registered firms belonging to sector j in city i (of province r) during year t. $\mathrm{X}_{\mathrm{rit}}$ is a set of city-level control variables described in Section 3.1. u_{ij} stands for city-sector fixed effects. ψ_{t} indicates year fixed effects. ϵ_{ijt} is the term of random disturbance. The key variable of interest, $\mathrm{R_{it}} = \mathrm{P_{it}} * \mathrm{coal_{it}}$, stands for local coal revenue. Suppose that the price of coal produced by city i in year t, $\mathrm{P_{it}}$, is multiplicatively separable in regional variation and temporal price shocks (say the global coal price index), $\mathrm{P_{it}} = \mathrm{G_t} * \delta_{\mathrm{i}}$, we can rewrite Equation (1) as:

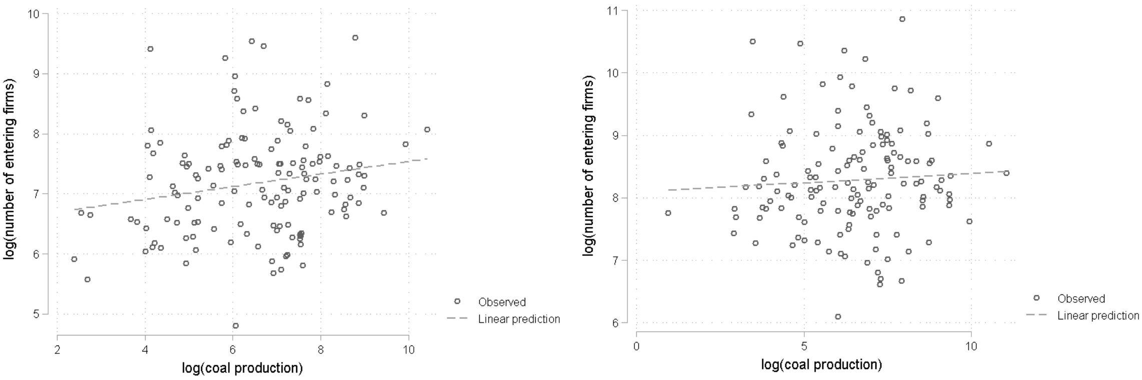
$$\log \mathrm{NewFirms_{rijt}} = \theta \log \mathrm{coal_{it}} + \mathrm{X_{rit}} \mathrm{b} + \mathrm{a_{ij}} + \phi_{\mathrm{t}} + \epsilon_{\mathrm{ijt}} \tag{2}$$

where $\mathrm{a_{ij}} = \mathrm{u_{ij}} + \theta \log \delta_{\mathrm{i}}$ absorbs the time-invariant region specific component of price shocks, and $\phi_{\mathrm{t}} = \psi_{\mathrm{t}} + \theta \log \mathrm{G_t}$ incorporates all temporal price shocks at time t. The coefficient θ is the key parameter of interest, which is expected to have a negative sign according to hypothesis 1. However, the amount $\mathrm{coal_{it}}$ may be endogenously affected by unobserved factors that were simultaneously correlated with coal productions and entry of new firms. One ostensible omitted variable is the time-varying local business environment. If cities with a deteriorating business environment became more dependent on natural resources, the estimate of θ would be more negative than the true value. An opposite scenario is that residents in coal-abundant cities are paid well during economic booms, and so revenue-in-hand ease their capital constraints and facilitate more investments. This case leads to an upward bias in the estimate of θ (more positive than the true value) when coal consumption increases during economic booms. Because of the omitted variable problems, simple OLS regression of new firms against coal production may be misleading for identifying the effect of coal dependence on entrepreneurship. As Figure 3 shows, the number of newly registered firms and coal production at the city level have a weak positive correlation in 2009, and the correlation is not distinguishable from zero in 2013.

To deal with the endogeneity problem, we exploit exogenous variation in resource revenue due to external price shocks as an identification strategy. Dube and Vargas (2013) study the impact of commodity price shocks on civil conflicts in Colombia in a reduced-form manner.[4] They distinguish two types of resource revenue shocks: oil and coffee, and construct a measure of revenue shocks based on the interactive term between preexisting level of oil or coffee productions and an aggregate measure of commodity price shocks. Brückner and Ciccone (2010) investigate country-specific impact of international commodity price shocks on civil war onsets for Sub-Saharan African countries which are

[4]Dube and Vargas (2013) use rainfall and temperature to construct an instrumental variable for the pre-existing intensity of coffee cultivation.

Figure 2: Coal production and new firms



(a) Coal production and new firms in 2009 (b) Coal production and new firms in 2014

Notes: In each figure, the horizontal line presents the logarithm of coal production in a year, the vertical line presents the logarithm of new firms. Each dot corresponds to a prefecture-level city. A linear fitting line is included in each figure (OLS using log(coal) as the only explanatory variable).

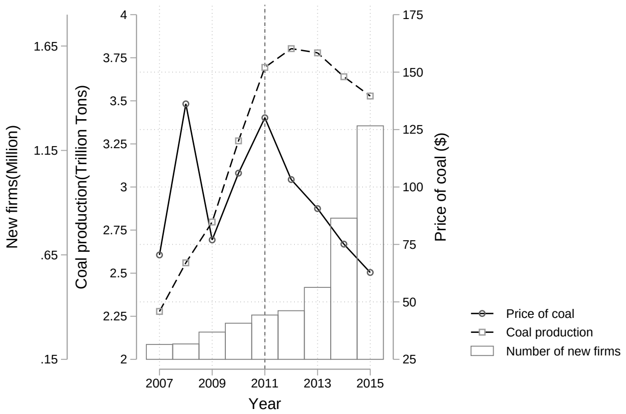
highly dependent on exporting natural resources. Acemoglu et al. (2013) estimate the income elasticity of health expenditure by instrumenting the region-level income with the interaction between aggregate oil price index and local oil reserves. In the spirit of these studies, we adopt a similar instrumental variable strategy to estimate the effect of revenue shocks on entrepreneurship. The first-stage equation is specified as follows.

$$\log \widehat{\mathrm{coal}}_{\mathrm{it}} = \gamma(\overline{\mathrm{coal07-09}}_{\mathrm{i}} \times \log \mathrm{P}_{\mathrm{t-1}}) + \mathrm{X}'_{\mathrm{rit}}\beta + \mathrm{v}_{\mathrm{i}} + \mu_{\mathrm{t}} + \sigma_{\mathrm{it}} \tag{3}$$

In the first stage, $\overline{\mathrm{coal07-09}}_{\mathrm{i}}$ is the average coal production in city i between 2007 and 2009, and $\log \mathrm{P}_{\mathrm{t-1}}$ is the NEWC index of Australian price for thermal coal during year $t-1$ for the period between 2011 and 2014. The average coal production between 2007-2009 could be viewed as a proxy for the production capacity of coal in each city. $\mathrm{X}'_{\mathrm{rit}}$ is a set of city-level control variables, including all economic and social variables in equation (2), city fixed effects v_i, and year fixed effects μ_t. Note that the estimation should account for the effects of both $\overline{\mathrm{coal07-09}}_{\mathrm{i}}$ and $\log \mathrm{P}_{\mathrm{t-1}}$, which we expect to be positive in both cases. These two terms, however, are not separately identified in equation (3) as they are perfectly correlated with city and year fixed effects. This specification grants more flexibility in estimating city-level coal productions. We relegate the first-stage results of the instrumental variable estimations to Table A.3 in the appendix.

Figure 3 presents the temporal trends of NEWC index of coal price, the total amount

Figure 3: Trends of coal price and new entrants



Notes: Price of coal is the yearly average of Australian thermal coal Monthly Price in Dollars. Number of new firms is the total number of new established firms of our sample cities from 2007 to 2015. Coal production is the total amount of domestic coal productions. The production in 2015 is extrapolated based on the data reported by National Bureau of Statistics.

of domestic coal production in China, and the number of new firms in the 2007-2015 period. Two facts can be observed. First, the number of new firms synchronized with coal productions between 2007 and 2011, and diverted from the trend of coals after 2012. Second, the global coal price leads China's domestic coal productions by one year for the 2011-2015 period: the domestic coal production chased the trend of the NEWC index in the previous year. We attribute this pattern to the lack of pricing power by Chinese producers and consumers in the international coal market. Unlike the case in other energy and power sectors, such as oil and electricity, the state management over coal-production is decentralized, and the price is largely market-driven (Liu et al., 2013). China turned into a net importer of coals in 2009. Since then, domestic coals set a price cap, rather than a lower bound, for the coal price.[5] Consequently, the negative shocks to the international market tended to drive down the domestic coal price, but not vice versa. Ample evidences from recent research suggest that the large coal price decrease since 2012 was triggered by a down-trend in oil price due to the adoption of shale oil technology (Bauer et al., 2016; Covert et al., 2016; Wolak, 2016). This allows us to form a plausible instrumental variable strategy using the differentiated impacts of coal price fluctuations on coal producing cities.

[5] In China, the preponderance of high-quality coal is produced in Northern provinces, such as Shanxi and Inner Mongolia. The Southern provinces consist a much larger bulk of economy and have a larger demand for coals. As a result, Southern firms sometimes need to pay a higher transportation cost for using domestic coals than for importing coals.

We focus on the firm registration between 2012 and 2014 for empirical analysis. During the 2009-2011 period, both infrastructure investments and coal production surged under the massive stimulus plan implemented by the central government (Bai et al., 2016). Hence, the estimation on firm growth may not be adequate to reflect real investments in that period. After 2015, firm growth accelerated due to the uniserial reform implemented by the State Council to streamline the business registration procedure.[6] Again, the number of firm registration becomes a noisy measure of real investments. Including the post-2015 period may dilute the estimated impact of coal production on entrepreneurship. Since the purpose of this paper is to examine the relationship between resource dependence and entrepreneurship, but not the effect due to changes in the registration system, we do not include the post-2015 period for the empirical analysis.[7]

4 Results

4.1 Main results

We start with city level analysis on the impact of coal price shocks on entrepreneurship. Column (1) of Table 2 uses the index of international coal price at time $t-1$ as the only explanatory variable, and include a set of city fixed effects. The increase in the international coal price induces a demand-side expansion in the domestic coal market, which tends to oppress new entrepreneurial activities. Consistent with Hypothesis 1, the estimated coefficient reported by Column (1) is -1.95, and it is statistically significant at 0.01 level. The coefficient implies that an increase in the level of international coal price by one percent at time $t-1$ is associated with a reduction in the number of new registered firms at t by nearly 2%, and vice versa.

In Column (2), we use coal production as a measure of resource dependence. The baseline estimation using the logarithm together with city fixed effects obtains a negative coefficient of -0.123. That is, a one percent increase (decrease) in coal production is associated with a 0.12% decrease (increase) in the number of new firms within the same year. Column (3) presents the same estimation with two additional control variables, the per capita GDP and the total GDP at the city level. Per capita GDP is a proxy for the stage of economic development, which may have a confounding effect on entrepreneurship

[6]http://english.gov.cn/state_council/state_councilors/2015/12/25/content_281475260327912.htm

[7]Bruhn (2013) provides an empirical investigation on the effect of registration reform on entrepreneurial activities and the informal sector.

Table 2: Coal Production and New Firms (City Level Results)

Dependent variable:	Log(New Firms)					log(Capital)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(Coal)		-0.123***	-0.126***	-0.629	-0.465	-1.569**	-1.201**
		(0.041)	(0.040)	(0.385)	(0.328)	(0.660)	(0.509)
Log(GDP per capita)			0.026		0.035		0.157
			(0.062)		(0.085)		(0.171)
Log(GDP)			0.166		0.187**		0.208**
			(0.107)		(0.095)		(0.085)
Lag. Log(Price)	-1.954***						
	(0.062)						
Model	FE	FE	FE	IV	IV	IV	IV
Observations	420	420	420	420	420	420	420
City fixed effects	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	NO	YES	YES	YES	YES	YES	YES
Kleibergon-Paap F statistic	NA	NA	NA	5.313	7.089	5.313	7.089
Anderson-Rubin χ^2 statistic	NA	NA	NA	6.265	4.374	18.850	13.350
p-value for A-R test	NA	NA	NA	0.0123	0.0365	0.0001	0.0003

Notes: Log(New Firms) is the natural logarithm of the number of new firms in a city in each year between 2012 and 2014. Log (Capital) is the logarithm of the total amount of capital by registered firms in a city during each year. The instrumental variable for Log(Coal), the coal production at the city level, is the interaction between $\underline{\text{Lag. Log(Price)}}$, the natural logarithm of yearly average of Australian thermal coal, and $\overline{Coal07-09}$, the average coal production in the 2007-2009 period. The standard errors clustered at the city level are reported in the parentheses. * Significant at 10%, ** 5%, *** 1%.

through shaping consumer preference for product variety (Kongsamut et al., 2001). Total amount of GDP is a proxy for the market potential of a city, which tends to have an impact on entrepreneurship through agglomeration effects (Melitz and Ottaviano, 2008). The estimate of coal production is robust to the inclusion of the two economic control variables, as Column (3) shows.

In Columns (4) and (5), we proceed to present the estimates for new firms, using the interaction between lagged international coal price and the pre-existing level of coal production at the city level as an instrumental variable. In the first stage regression, global coal price and its interaction with the 2007-09 average local coal production are positively associated with the coal production afterwards, however, the impact of global coal price shocks decreased with the preexisting scale of coal production for the 2007-09 period (Table A3 in the appendix). Moreover, the Anderson-Rubin test for the 2SLS estimations with clustered standard errors report a p-value of 0.012 when the dependent variable is the logarithm of new firms and a p-value of 0.0001 when the dependent variable is the logarithm of total paid-in capitals. Both p-values reject the null hypothesis that the test statistics is not significantly different from zero even in the circumstance of a weak instrument (Finlay and Magnusson, 2009). As Columns (4) and (5) show, the coefficients are negative and more sizeable than those obtained by OLS, although the standard errors of the estimated coefficients are relatively larger. We attribute the relatively large standard errors reported here to cross-sectoral variation in firm growth. Columns (6) and (7) report the instrumental variable estimations with the logarithm of total registry capital by all new firms at the city level in place of the dependent variable. The coefficients range from -1.569 (without economic controls) to -1.201 (with economic controls), and are both statistically at 0.05 level. Overall, the empirical analysis on the city level data shows that coal revenues adversely affect the growth of new firms, notwithstanding that the impacts of coals may be diluted due to sectoral heterogeneity.

We then break down the unit of analysis from the city into the city-sector level. Because the main variation in the explanatory variable occurs at the city-year level, we allow the standard errors of all estimates to be arbitrarily correlated within each city.[8] Because firm growth in different sectors vary enormously across cities, this approach leaves a certain group of city-sector cells with zero entries throughout the sample period

[8]Alternatively, we could allow the standard errors of estimates to be clustered at the city-sector level. This leads to higher statistical significance for all estimates.

Table 3: Instrumental Variable Estimates (City-Sector Level Results)

Dependent variable:	Log(New Firms)					Log(Capital)				
Sample:	Positive Entrants			Exclude Coal	Full Sample	Positive Entrants			Exclude Coal	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log(Coal production)	-0.676**	-0.554**	-0.626**	-0.526**	-0.488**	-1.366**	-0.967**	-1.043**	-0.906**	-1.116**
	(0.310)	(0.246)	(0.294)	(0.240)	(0.195)	(0.645)	(0.453)	(0.500)	(0.442)	(0.452)
Log(GDP per capita)		0.043	0.056**	0.042	0.045**		0.226***	0.234***	0.224***	0.200***
		(0.115)	(0.120)	(0.112)	(0.071)		(0.182)	(0.185)	(0.175)	(0.133)
Log(GDP)		0.137***	0.123***	0.133***	0.042**		0.193*	0.195**	0.202**	0.064
		(0.061)	(0.069)	(0.061)	(0.038)		(0.127)	(0.140)	(0.118)	(0.103)
City-Sector fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	NO	YES	YES	YES	YES	NO	YES	YES
Year-Sector fixed effects	NO	NO	YES	NO	NO	NO	NO	YES	NO	NO
Kleibergon-Paap F statistic	5.277	6.936	6.745	6.910	7.157	5.277	6.936	6.745	6.910	7.157
Anderson-Rubin χ^2 statistic	11.300	9.662	9.430	9.010	9.210	23.370	12.130	12.270	10.330	22.530
p-value for A-R test	0.001	0.002	0.0021	0.003	0.002	0.000	0.000	0.000	0.001	0.000
Observations	33,247	33,247	33,247	33,012	56,700	33,247	33,247	33,247	33,012	56,700

Notes: Log(New Firms) is the natural logarithm of the number of new firms in each city-sector during each year between 2012 and 2014. Log (Capital) is the logarithm of the total amount of capitals by registered firms in each city-sector each year. The instrument variable for Log(Coal), the coal production at the city level, is the interaction between Lag. Log(Price), the natural logarithm of yearly average of Australian thermal coal, and $\overline{Coal07-09}$, the average coal production in the 2007-2009 period. The first-stage estimation follows the specification of Column (3) in Table A3, with observations expanded to the city-sector level. The standard errors clustered at the city level are reported in the parentheses.
* Significant at 10%, ** 5%, *** 1%.

being investigated. To deal with this issue, we first estimate the partial effect of coal production for the sample with positive entries. Column (1) of Table 3, which is obtained through instrumental variable estimation without economic controls, reports a coefficient of -0.676. The coefficient is close to the one found in Column (4) of Table 2 but with a higher statistical power. In turn, a one percentage point decrease in the global coal price translates into a 2.4 percentage points increase in the number of new firms for a city with average coal-production.[9] Column (2) of Table 3 reports the estimation results along with economic controls. The estimated coefficient is qualitatively similar to Column (1) and significant at the conventional level. Once again, the Anderson-Rubin test seems to support the validity of the instrumental variables ($p < 0.01$), as is the case for all the rest Columns in Table 3.

In Column (3), we allow for a set of sector-specific time fixed effects to account for the possibility that different industries may be exposed to different temporal shocks. The coefficient remains at the same level of magnitude and statistical significance. The baseline results in Columns (1) - (3) are followed by two robust checks. In Column (4), we exclude the coal-producing sector from the sample to deal with the potential problem of reverse causality that the variation in new firms in the coal sector may affect coal production. The coefficient reported in Column (4) is close to that in Column (2) using the same specification. We also estimate Equation (2) using the full sample by assigning a value of zero to the dependent variable (log New Firms) for all cells with zero entry. The coefficient only slightly drops in magnitude but remains at the same significance level ($p < 0.05$). The results obtained from instrumental variable estimations provide a reliable range for firm growth elasticity to coal production. According to the coefficients reported by Columns (1) to (5), a one percent increase (decrease) in coal production translates into a decrease (increase) of new firms by approximately 0.4-0.7 percent. In turn, the annual drop of coal production by roughly 7% in China from 2012 to 2014 arguably contributes to 2.8-4.9% of new firms by each city-sector-year.

In Columns (6) to (10), we use the total paid-in capital of new firms as an alternative measure of firm growth to capture the total increase of paid-in investment. The coefficients are aligned with the expectation for all specifications. The size of the coefficients is similar to that obtained from city-level analyses. A one percentage point decrease in the global

[9] In the first stage regressions, the coefficient for Lag.Log (Coal Price) $\times \overline{\text{Coal}_{07-09}}$ is 3.5. The magnitude of the impact of global coal price decrease on new firms is approximately $0.676 \times 3.5 \approx 2.4$.

coal price led to approximately 4.8 percentage points increase in paid-in capital for an average coal-producing city.[10] Consistent with Hypothesis 1, the expansion (contraction) of the coal-producing sector is coupled with significant reduction (growth) in the spirit of entrepreneurship as measured by new firms.

4.2 Sector Heterogeneity

Table 4: Coal Production and New Firms, by Sector

Dependent variable:	Log(New Firms)				
Sector	Agriculture	Heavy Industry	Light Industry	Production Service	Consumption Service
	(1)	(2)	(3)	(4)	(5)
Log(Coal production)	-1.763***	-0.393	-0.159	-1.224***	-0.408
	(0.670)	(0.286)	(0.287)	(0.427)	(0.388)
Log(GDP per capita)	0.174	0.029	0.024	0.174	-0.046
	(0.222)	(0.125)	(0.076)	(0.177)	(0.089)
Log(GDP)	0.265**	0.064	0.069	0.191	0.101
	(0.135)	(0.086)	(0.081)	(0.120)	(0.078)
City-sector Fixed Effect	YES	YES	YES	YES	YES
Year Fixed Effect	YES	YES	YES	YES	YES
Observations	2,023	11,174	7,710	6,832	5,088

Notes: This table reports the effects of coal production on the new firms by five different categories: agriculture, heavy industry, light industry, production service, and consumption service. Log(New Firms) is the natural logarithm of the number of new firms in each city-sector during each year between 2012 and 2014. The instrument variable for Log(Coal), the coal production at the city level, is the interaction between Lag. Log(Price), the natural logarithm of yearly average of Australian thermal coal, and $\overline{Coal07-09}$, the average coal production in the 2007-2009 period. The standard errors clustered at the city level are reported in the parentheses. * Significant at 10%, ** 5%, *** 1%.

Does coal revenue deter new firms uniformly across all sectors? Or rather that the impact of coal production is concentrated in specific sectors? In the context of coal price decline from 2012 to 2015, it is reasonable to expect that new firm growth should be most telling in those sectors that would gain most from the coal price decline or would suffer the least negative demand-side shocks during economic downturns. For this purpose, we aggregate firm growth into five broad sectors: agriculture, heavy industry, light industry, production service, and consumption service. The agricultural sector includes farming, forestry, husbandry, and fishery. Heavy manufacturing industries produce heavy and large equipments that become input for other sectors. They are normally capital intensive and consume lots of energy. By contrast, light manufacturing industries tend to be more labor intensive, and they produces more final consumption goods than equipments. We also

[10] The economic impact of global coal price decrease on the capitals in registration is computed as $1.366 \times 3.5 \approx 4.8$.

distinguish between production service and consumption service sectors. The category of production service include transportation, storage, postal, logistics, telecommunication, computer and software service, environmental service, public facility management, and other sectors that provide service as intermediate inputs. Consumption service tend to reach the end of the demand side more directly, such as entertainment, education, art, sport, hotel, restaurant, and tourism. Table A2 in the appendix presents further details on the classification of the categories.

Table 4 suggests considerable heterogeneity in the impact of coal production on new firms across different industrial categories. The instrumental variable estimates are more sizeable and statistically significant in agriculture and production service sectors, with the elasticity respectively being -1.763 and -1.224 ($p < 0.01$). By contract, the impact seems to be ambiguous for manufacturing sectors, notwithstanding that the coefficient of coal production is large for heavy industries than for light industries. Finally, the coefficient for consumption service sectors is also negative and insignificant.

The econometric results presented by Table 4 are consistent with anecdotal evidences. Many coal-dependent cities made their ways to an industrial transformation in the recent price downturns. Among newly emerging businesses, technology-intensive agriculture is a fast growing area attracting entrepreneurs. Fuyuan, a coal-abundant county in Qujing city, Yunnan province, is a quintessential case of transition from coal-extraction to more productive investments. It is reported that the negative shocks to the coal sector in Fuyuan was offset by a robust growth of private investments in orchards[11] and the pork industry.[12] In Leiyang county of Hunan province, Cao Ligu, formerly a private owner of coal mine, switched his investments to mechanized farming and expanded at a large scale.[13]

Why the coal-production shocks led to more robust firm growth in certain areas? We offer two conjectures for the discrepancy. First, some industries may have higher entry barriers in terms of capital, land, and bureaucratic red tapes. Economic downturns alleviate these constraints by making the resources cheaper. For example, the farming industry typically involves a large investment in fixed assets and land leasing.[14] Apart from that, investors need to exert efforts to acquire permission and negotiate on rent-sharing with

[11] https://baijiahao.baidu.com/s?id=1570342675218514&wfr=spider&for=pc

[12] http://www.qjfy.gov.cn/html/2017/sjwy_1023/3085.html

[13] http://news.sina.com.cn/o/2016-03-25/doc-ifxqsxic3202867.shtml

[14] The sample average of paid-in capital for agricultural firms is 3.2 million RMB, larger than that for light industry (2.71 million) and consumption service (2.40 million).

farmers and local regulators. When the economy is confronted by a decreasing resource price, both physical assets and the access to a regulated market become less expensive due to a shrinking demand side. Thus, there are quicker recovery of investments in the sectors that are more heavily repressed before. This conjecture is consistent with Hypothesis 1 on the mechanism of lowering opportunity costs.

Second, consistent with Hypothesis 2, declines in coal price may lead to faster firm growth in some industries because these industries share more local business knowledge with the coal sector (proximity), or because they are closely linked to downstream sector of coals (production linkage). Agriculture is arguably close to the coal sector because they share many upstream and downstream businesses, such as transportation. The cases quoted above show that quite a number of newly emerging agricultural entrepreneurs have business experience in the coal sector. Meanwhile, the discrepancy between heavy and light industries, as well as that between production service and consumption service sectors may be attributed to production linkage. Heavy industries use more coal as input than light industries do, so they benefit more from saved costs.

Table 5: Heterogeneous Effects in Production Network

Dependent variable:	Log(new firms)			Log(capital)		
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Coal production)	-0.734**	-1.169*	-1.575*	-1.452**	-2.466**	-3.408**
	(0.339)	(0.600)	(0.816)	(0.645)	(1.115)	(1.548)
Log(Coal)∗ Upstreamness	0.364*		0.495*	0.931**		1.222**
	(0.212)		(0.289)	(0.415)		(0.551)
Log(Coal)∗ Downstreamness	-0.248		-0.309	-0.682**		-0.809**
	(0.157)		(0.194)	(0.312)		(0.373)
Log(Coal)∗ Distance		0.026*	0.032*		0.061**	0.075**
		(0.015)	(0.018)		(0.028)	(0.035)
Log(GDP per capita)	0.042	0.040	0.039	0.201	0.199	0.191
	(0.117)	(0.118)	(0.122)	(0.196)	(0.196)	(0.208)
Log(GDP)	0.137**	0.136**	0.136**	0.201	0.199	0.198
	(0.061)	(0.061)	(0.061)	(0.130)	(0.128)	(0.129)
City-Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	33,247	33,247	33,247	32,876	32,876	32,876

Notes: This table reports the interactive effects of coal production with its position in the production network on the new firms. Log(New Firms) is the natural logarithm of the number of new firms in each city-sector during each year between 2012 and 2014. Log (Capital) is the logarithm of the total amount of capitals by paid-in firms in each city-sector each year. The instrument variable for Log(Coal), the coal production at the city level, is the interaction between Lag. Log(Price), the natural logarithm of yearly average of Australian thermal coal, and $\overline{\text{Coal07} - 09}$, the average coal production in the 2007-2009 period. The standard errors clustered at the city level are reported in the parentheses. * Significant at 10%, ** 5%, *** 1%.

To formally examine the mechanism suggested by Hypothesis 2, we estimate the effects of coal production together with its interaction with sector-specific production linkage to coal production. As Hypothesis 2 maintains, a downturn of coal price tends to cut cost for sectors on the downstream of the coal sector, and it may hinder the demand for outputs produced by the upstream sectors. For a specific sector, its production linkage with the coal-producing sector may go either way. For example, the electricity sector produces intermediate goods for coal production, and it also uses coals as an input. As a result, one cannot readily identify all sectors as an upstream or downstream sector of coal production. We adopt a flexible approach of interacting coal production with a sector's upstreamness index as well as its downstreamness index, following the approach of Fan and Lang (2000). The index of upstreamness of a sector s with regard to the coal sector is computed by the following equation.

$$\mathrm{U_s} = \frac{\mathrm{p_s x_{s,coal}}}{\sum_{\mathrm{j \in M}} (\mathrm{p_i x_{j,coal}})} \tag{4}$$

In Equation (4), $\mathrm{x_{s,coal}}$ is the goods produced by sector s that is required for producing one unit of coal according to the 2007 Chinese I-O table. p_s is the average price of products from s. M represents the set of all sectors whose products are used for producing coals. So $s \in M$. In turn, $\mathrm{x_{j,coal}}$ is the amount produced by sector j being used for one unit of coal production. $\mathrm{U_s}$ is the expenditure share of products from sector s that is used for producing one unit of coal. By a similar token, the index of sector s's downstreamness with respect to the coal-producing sector is computed as in Equation (5), where D_s is the expenditure share of coals in producing one unit of goods in sector s.

$$\mathrm{D_s} = \frac{\mathrm{p_{coal} x_{coal,s}}}{\sum_{\mathrm{i \in Q}} (\mathrm{p_i x_{i,s}})} \tag{5}$$

Hypothesis 2 also accommodates the possibility of knowledge spillover. Entrepreneurs are more likely to succeed when their entrepreneurial skills and personal networks acquired from the coal sector are useful in new businesses. The local knowledge is more portable among industries similar to each other. In turn, the "migrants" from the coal sector are more likely to move to sectors closely linked to coal production in the production network. We use Antràs and Chor (2013)'s measure of absolute downstreamness in the value chain to capture this idea. Specifically, the vector of downstreamness index for all $N = 135$ sectors is computed as:

$$Y = [I - D]^{-1}F \quad (6)$$

where $[I-D]^{-1}$ is the Leontief inverse matrix, and the matrix D represents the $N \times N$ direct requirements matrix with the $i-j$ entry being i's expenditure share in j according to the 2002 US I-O Table, and F is the N-dimensional vector of F_i, the share of i's outputs for final use. The difference in the absolute downstreamness Y_i is a suitable measure of the distance between any sector and the coal sector. The smaller the difference is, the more can new entrants from the neighboring sectors benefit from knowledge spillovers and make transition smoother. Hence, the effect may be stronger for spin-off entrepreneurship in sectors closely related to coal-production.

Table 5 presents the tests against Hypothesis 2. Column (1) reports the city-sector level estimates for the number of registered firms in which the coal production is interacted with the indices of upstreamness and downstreamness.[15] We find that the interaction between coal production and the upstreamness of a sector is positive and significant at 0.1 level. The coefficient for the interaction term of coal production with the downstreamness index is negative but insignificant. On top of that the estimate for the coal production per se remains negative and statistically significant. This finding is consistent with the mechanism through production network discussed by Hypothesis 2. Column (2) employs the distance index as a mediative channel for the impact of coal production, and finds that sectors farther away from coal-production in the value chain are less likely to be affected. In Column (3), we include three interactions together. The result is consistent with those shown in Columns (2) and (3).

The estimates presented in Columns (4) through (6) are obtained by replacing the number of firms with the total amount of paid-in capital of the newly registered firms. The estimates are qualitatively similar but have higher statistical power, and the estimated elasticities are larger. Aside from the coefficients of coal production, its interactions with the sectoral relative upstreamness and downstreamness indexes are both significant. In the I-O table, downstream sectors closely linked to coal production mostly pertain to heavy manufacturing sectors, such as coking and cement production. Thus, a comprehensive industrial structure may have contributed to burgeoning firm growth in China during

[15] In the IV estimations we treat the interactions between the coal production and the index on upstreamness, downstreamness, and distance as exogenous variable. See Bun and Harrison (2014) for the validity of assuming the interaction between an endogenous regressor and an exogenous variable to be exogenous in IV estimations.

economic downturns. We attribute the discrepancy between the estimates for the number and total paid-in capital of firms to large-scale investment in heavy manufacturing sectors. As a result, coal production shocks may lead to significant growth in the total scale of investments, but not the number of new firms.

4.3 Firm Exits, Serial Entrepreneurs, and Outflows

Entrepreneurial growth can be further divided into two kinds: those who start up the business for the first time, and the serial entrepreneurs who reallocate the investments between different sectors. The analysis in Section 4.2 based on distance in the value chain suggests that the reallocation of entrepreneurial talents to other business sectors by the insiders in the coal sector may be one mechanism responsible for the faster firm growth during coal price declines. Those moving-out individuals may include previous entrepreneurs as well as former employees in the coal sector who seek opportunities to establish their own businesses. The registration data does not provide occupational information for private investors. Thus, it is infeasible to tell whether a new firm was established by spinoffs from the coal sector. With this caveat in mind, we provide two tests on the mechanism of reallocation from the coal sector. First, we study how coal production shocks are correlated with firm exits in the coal and other sectors. Secondly, we examine the association between coal productions and the behaviors of serial entrepreneurs.

Table 6: Firm Exit

Dependent variable:	Log(Firms)		Log(Capital)	Log(Firms)		Log(Capital)
Sector:	Coal			Non-Coal		
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Coal production)	-7.409**	-5.401**	-9.802**	1.739	1.794	2.450
	(3.097)	(2.236)	(4.239)	(1.590)	(1.442)	(1.616)
Log(GDP per capita)	–	0.840	1.437	–	0.059	0.067
		(0.652)	(1.205)		(0.248)	(0.319)
Log(GDP)	–	1.182	1.521*	–	-0.064	0.071
		(0.721)	(0.889)		(0.399)	(0.533)
City Fixed Effect	YES	YES	YES	YES	YES	YES
Year Fixed Effect	YES	YES	YES	YES	YES	YES
Observations	420	420	420	420	420	420

Notes: This table reports the effects of coal production on firm exits. Log(Exiting Firms) is the natural logarithm of the number of exiting firms, that is, a firm which canceled the business license by itself or the license was revoked by the SAIC in a specific city-sector during each year between 2012 and 2014. Log (Exiting Capital) is the logarithm of the total amount of capitals by exiting firms in a specific city-sector during each year between 2012 and 2014. The instrument variable for Log(Coal), the coal production at the city level, is the interaction between Lag. Log(Price), the natural logarithm of yearly average of Australian thermal coal, and $\overline{\text{Coal07}-09}$, the average coal production in the 2007-2009 period. The standard errors clustered at the city level are reported in the parentheses. * Significant at 10%, ** 5%, *** 1%.

Table 7: Serial Entrepreneurs from Coal Sector

Dependent variable:	Log(New Firms by Serial Entrepreneurs)			
	From Coal		From Non-coal	
	(1)	(2)	(3)	(4)
Log(Coal production)	-1.390*	-1.389*	-0.594	-0.177
	(0.842)	(0.739)	(0.536)	(0.571)
Log(GDP per capita)		-0.059		0.369***
		(0.190)		(0.126)
Log(GDP)		0.162		-0.283
		(0.156)		(0.177)
City fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Observations	420	420	420	420

Notes: This table reports the effects of coal production on the pattern of new firms by serial entrepreneurs at the city level. Log(New Firms by Serial Entrepreneurs) is the natural logarithm of the number of new firms in a city by a serial entrepreneur during each year between 2012 and 2014. The instrument variable for Log(Coal), the coal production at the city level, is the interaction between Lag. Log(Price), the natural logarithm of yearly average of Australian thermal coal, and $\overline{\text{Coal07} - 09}$, the average coal production in the 2007-2009 period. The standard errors clustered at the city level are reported in the parentheses. * Significant at 10%, ** 5%, *** 1%.

Table 6 documents the pattern of firm exits in response to coal production shocks. Because firm exits occur at a much smaller scale at the city-level compared with firm growth, we aggregate the number and scale of exiting firms at the city level. Column (1) shows, perhaps unsurprisingly, that the amount of coal production at the city level is negatively correlated with the number of firm exits in the coal sector. The effect is preserved in the estimation controlling for economic variables, as Column (2) shows. The pattern is similar using the total amount of paid-in capital of exiting firms as dependent variable (Column (3)). The patterns from the non-coal sector, on the other hand, are different. Columns (4) to (6) report insignificant effects of coal production on firm exits from the non-coal sector. The negative shock on the coal sector may have enhanced creative destruction by failing existing investments on coal revenue extraction.

Table 7 assesses the prevalence of serial entrepreneurship. Because serial entrepreneurs consists of a small proportion of the whole sample, we aggregate the number of new firms at the city level as in Table 6. As Columns (1) and (2) show, contraction in the coal sector does trigger investments from existing investors and entrepreneurs from the coal sector. Meanwhile, the non-coal sectors do not witness a similar pattern for serial entrepreneurs. The coefficients of coal production are insignificant and the magnitude is much smaller

Table 8: Entrepreneur Outflows

Dependent variable:	Log("outflowing" firms)		Log("outflowing" capital)	
	(1)	(2)	(3)	(4)
Log(Coal production)	-0.630*	-0.311	-1.646**	-1.179**
	(0.376)	(0.203)	(0.812)	(0.554)
Log(GDP per capita)	–	0.213***	–	0.235
		(0.071)		(0.147)
Log(GDP)	–	-0.028	–	0.167*
		(0.026)		(0.087)
City Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	420	420	420	420

Notes: "Outflowing firms" measure the total number (scale) of new firms, which were established by a natural person originally from city i, in a different city $\neg i$ in each year. The instrument variable for Log(Coal), the coal production at the city level, is the interaction between Lag. Log(Price), the natural logarithm of yearly average of Australian thermal coal, and $\overline{Coal07-09}$, the average coal production in the 2007-2009 period. The standard errors clustered at the city level are reported in the parentheses. * Significant at 10%, ** 5%, *** 1%.

than for those from the coal sector. The findings on serial entrepreneurship reinforce the premise that economic downturns may alleviate resource and talent misallocation and enhance productive entrepreneurships.[16]

We conclude the empirical investigation with a caveat. The econometric model of Equation (2) estimates a local effect, but not the spillover effects of coal production shocks on the entrepreneurial activities in other cities. In theory, the impact of resource shocks needs not be limited locally. The negative shocks on coal in one region may induce more outflows of existing and potential entrepreneurs to other non-coal producing regions. To capture this mechanism, we construct a measure of "outflowing" firms at the city level, which is the total number (scale) of new firms established by a natural person originally from city i in a different city j in each year.[17] As Columns (1) to (4) of Table 8 show, a contraction in the coal economy in one city prompted more outward entrepreneurial activities. So, natural resource shocks do have a spillover impact. This result does not contradict our main argument, however. The negative coefficients of coal production in the baseline estimations show that lowering entry cost may have preceded the outflow of entrepreneurs. Indeed, the general equilibrium effects of coal production shocks should

[16]Note that the set of exits from the coal sector and that of serial entrepreneurs from the coal sector do not coincide. An entrepreneur withdrawing from the coal sector may not choose to make any further investments. A serial entrepreneur previously in the coal sector may not have closed the business in the coal sector. However, it is natural to suppose that the two sets are highly correlated, as the results in Table 7 and Table 6 suggest.

[17]The origin of the legal representative of a firm is identified by the first six digits of his or her national ID number.

be larger when taking the cross-city moves of entrepreneurs into account.

5 Conclusion

Development economists enroll all kinds of things that are purported to liberate or strangle entrepreneurship, such as finance, law, industrial policies, institutions, culture, and so on. Among many proposed explanations, dependence on natural resources stands out as a foremost determinant, because resource revenues are what many other factors hinge on. Thanks to mineral endowments or price shocks, resource revenue contains a component orthogonal to the incentive of becoming an entrepreneur. This feature grants a reliable empirical strategy for identifying the impact of resource dependence in the Chinese context.

Using a unique dataset to exploit the city-sector level variation in newly registered firms, and employing global coal price and preexisting productions as the instrumental variable of actual coal production, this paper documents a robust negative effect of coal production on new firm registrations. To interpret the findings in the context of sharp global coal price decline between 2012 and 2014, negative shocks to coal productions account for nearly 2.8-4.9% of annual firm growth in this period. Further investigation on production network helps identify mechanisms behind the firm growth in response to coal production contraction. Specifically, the effect is amplified (mitigated) by a sector's downstreamness (upstreamness) relative to the coal sector, and stronger in the industries close to the coal sector in the value chain.

Policy implications are twofold. First, natural resource needs not to be a perpetuated curse to entrepreneurship even in a circumstance with severe institutional frictions. The solution, of course, cannot be to cut the coal price. A viable option for policy makers to encourage entrepreneurship is to create conditions for entrepreneurs to divert investments from resource extraction. Increasing energy import and cutting production capacity in the natural resource sectors may be such policies, as the Chinese government adopted in the recent years. Changes, however, are costly. External resource price shocks help make a case for policy makers to undertake reforms by lowering the opportunity costs of changes.

The second lesson is that countries with a more diversified industrial structure do a better job at escaping from a resource curse and kicking off a burst in entrepreneurship.

As this paper shows, when the dependence on natural resource is alleviated, a wide spectrum of industrial sectors, from agriculture to production service, benefit. Unlike China, which hosts comprehensive industrial sectors, similar growth of entrepreneurship may be infeasible in a different country that relies on a single natural resource sector. This may explain why structural adjustments in developing countries often did not have the intended effects of market facilitation.

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Table A1: Prefecture Cities Included in the Sample

Province	City	Province	City	Province	City
Hebei	Shijiazhuang	Anhui	Huainan	Sichuan	Ya'an
Hebei	Tangshan	Anhui	Huaibei	Sichuan	Bazhong
Hebei	Handan	Anhui	Fuyang	Guizhou	Guiyang
Hebei	Xingtai	Anhui	Suzhou	Guizhou	Liupanshui
Hebei	Zhangjiakou	Anhui	Bozhou	Guizhou	Zunyi
Hebei	Chengde	Jiangxi	Pingxiang	Guizhou	Anshun
Shanxi	Taiyuan	Jiangxi	Jiujiang	Guizhou	Bijie
Shanxi	Datong	Jiangxi	Xinyu	Guizhou	Tongren
Shanxi	Yangchuan	Jiangxi	Ganzhou	Guizhou	Qian Xinan
Shanxi	Changzhi	Jiangxi	Ji'an	Guizhou	Qian Dongnan
Shanxi	Jincheng	Jiangxi	Yichun	Guizhou	Qian Nan
Shanxi	Shuozhou	Jiangxi	Shangrao	Yunnan	Kunming
Shanxi	Jinzhong	Shandong	Zibo	Yunnan	Qujing
Shanxi	Xinxian	Shandong	Zaozhuang	Yunnan	Yuxi
Shanxi	Linfen	Shandong	Jining	Yunnan	Baoshan
Shanxi	Luliang	Shandong	Taian	Yunnan	Zhaotong
Inner Mongolia	Huhehaote	Shandong	Laiwu	Yunnan	Lijiang
Inner Mongolia	Baotou	Shandong	Linyi	Yunnan	Simao
Inner Mongolia	Wuhai	Shandong	Dezhou	Yunnan	Lincang
Inner Mongolia	Chifeng	Shandong	Heze	Yunnan	Chuxiong
Inner Mongolia	Tongliao	Henan	Zhengzhou	Yunnan	Honghe
Inner Mongolia	Eerduosi	Henan	Luoyang	Yunnan	Wenshan
Inner Mongolia	Hulunbeier	Henan	Pingdingshan	Yunnan	Dali
Inner Mongolia	Xinganmeng	Henan	Anyang	Shanxi	Tongchuan
Inner Mongolia	Xilinguole	Henan	Hebi	Shanxi	Baoji
Inner Mongolia	Alashan	Henan	Xinxiang	Shanxi	Xianyang
Liaoning	Shenyang	Henan	Jiaozuo	Shanxi	Weinan
Liaoning	Fushun	Henan	Xuchang	Shanxi	Yanan
Liaoning	Benxi	Henan	Sanmenxia	Shanxi	Hanzhong
Liaoning	Dandong	Henan	Shangqiu	Shanxi	Yulin
Liaoning	Jinzhou	Hunan	Changsha	Shanxi	Ankang
Liaoning	Fuxin	Hunan	Zhuzhou	Gansu	Lanzhou
Liaoning	Tieling	Hunan	Shaoyang	Gansu	Wuwei
Liaoning	Chaoyang	Hunan	Chenzhou	Gansu	Changye
Liaoning	Huludao	Hunan	Lianyuan	Gansu	Pingliang
Jilin	Changchun	Hunan	Changde	Ningxia	Yinchuan
Jilin	Jilin	Hunan	Dayong	Ningxia	Shizuishan
Jilin	Siping	Hunan	Chenzhou	Ningxia	Yinnan
Jilin	Liaoyuan	Hunan	Lingling	Ningxia	Guyuan
Jilin	Tonghua	Hunan	Huaihua		
Jilin	Baishan	Hunan	Loudi		
Jilin	Yanbian Korean	Hunan	Xiangxi		
Heilongjiang	Harbin	Sichuan	Zhigong		
Heilongjiang	Jixi	Sichuan	Dukou		
Heilongjiang	Hegang	Sichuan	Luzhou		
Heilongjiang	Shuangyashan	Sichuan	Nanchong		
Heilongjiang	Qitaihe	Sichuan	Leshan		
Heilongjiang	Mudanjiang	Sichuan	Yibin		
Heilongjiang	Heihe	Sichuan	Daxian		
Heilongjiang	Daxing'anling	Sichuan	Dazhou		

Table A2: List of Sectors

Group	Sector
Agriculture	Agriculture industry
Agriculture	forestry
Agriculture	livestock industry
Agriculture	fishery
Agriculture	service industry related to Agriculture, forestry, livestock industry and fishing
Heavy Industry	coal mining,washing and selection
Heavy Industry	Petroleum and natural gas extraction
Heavy Industry	ferrous metal mining and selection
Heavy Industry	nonferrous metal mining and selection
Heavy Industry	non-metallic ores mining and selection
Heavy Industry	wood processing and products made out of wood, bamboo, rattan, coir and grass
Heavy Industry	oil, coking and nuclear fuel processing
Heavy Industry	coking
Heavy Industry	making of basic chemical raw materials
Heavy Industry	making of fertilizers
Heavy Industry	pesticides production
Heavy Industry	synthetic material production
Heavy Industry	special chemical products production
Heavy Industry	rubber and plastic manufacturing
Heavy Industry	plastic products manufacturing
Heavy Industry	making of cement, limestone and plaster stone
Heavy Industry	limestone, cement goods and similar goods production
Heavy Industry	making of construction materials like bricks and stone materials
Heavy Industry	glass making and glass products
Heavy Industry	ceramic goods production
Heavy Industry	fire-resistant products
Heavy Industry	products made from black lead and other non-metallic mineral resources
Heavy Industry	iron smelting
Heavy Industry	steelmaking
Heavy Industry	steel rolling
Heavy Industry	ferroalloy
Heavy Industry	smelting and rolling of common nonferrous metals
Heavy Industry	rolling of non-ferrous metal
Heavy Industry	metal products manufacturing
Heavy Industry	manufacturing of boilers and driving devices
Heavy Industry	manufacturing of machinery for metal processing
Heavy Industry	production of equipment for carrying objects
Heavy Industry	production of pumps, valves and compressors
Heavy Industry	other general equipment manufacturing
Heavy Industry	mining, metallurgy, construction equipment manufacturing
Heavy Industry	chemical, wood, non-metallic processing equipment manufacturing
Heavy Industry	manufacturing of machine for agricultural, forestry, livestock and fishing industries
Heavy Industry	manufacturing of other equipment
Heavy Industry	railway transportation equipment manufacturing
Heavy Industry	automobile manufacturing industry
Heavy Industry	ships and related equipment manufacturing
Heavy Industry	manufacturing of other unspecified transport equipment
Heavy Industry	motor manufacturing
Heavy Industry	transmission,distribution and control equipment manufacturing
Heavy Industry	electric wire, cable, optical cable and electrical equipment manufacturing
Heavy Industry	other unlisted electrical machinery and equipment manufacturing

Table A2 continued

Heavy Industry	communication equipment manufacturing
Heavy Industry	radio and television equipment manufacturing
Heavy Industry	computer manufacturing industry
Heavy Industry	electronic device manufacturing
Heavy Industry	other electronic equipment manufacturing
Heavy Industry	Instrument and meter manufacturing industry
Heavy Industry	comprehensive utilization of waste resources
Heavy Industry	electricity, heat production and supply industry
Heavy Industry	gas production and supply industry
Light Industry	grain grinding
Light Industry	fodder processing
Light Industry	processing of plant oil
Light Industry	sugar industry
Light Industry	slaughtering and meat processing
Light Industry	aquatic products processing
Light Industry	processing of other types of agricultural by-products
Light Industry	making of instant food
Light Industry	making of dairy products
Light Industry	flavorings and fermented products production
Light Industry	other types of food production
Light Industry	liquor production
Light Industry	non-alcoholic drinks production
Light Industry	tobacco products manufacturing
Light Industry	cotton spinning, printing and dyeing
Light Industry	wool spinning, weaving, knitting, dyeing and finishing
Light Industry	fibre and silk weaving, dyeing and finishing
Light Industry	finished weaved or knitted products
Light Industry	weaving, knitting and relevant products
Light Industry	clothes and accessories
Light Industry	leather, fur, feather products and shoe-making business
Light Industry	furniture making
Light Industry	papermaking and paper products
Light Industry	printing and recording media replication industry
Light Industry	production of articles for education, culture, sports and entertainment purposes
Light Industry	coating, printing ink, pigment, and similar products
Light Industry	production of chemical products for daily use
Light Industry	pharmaceutical industry
Light Industry	chemical fibre manufacturing
Light Industry	household electric and non-electric appliances manufacturing
Light Industry	audio-visual equipment manufacturing
Light Industry	production of cultural and office equipment
Light Industry	other unlisted manufacturing
Light Industry	water production and supply industry

Table A2 continued

Production Service	construction business
Production Service	railway transportation industry
Production Service	road transportation industry
Production Service	urban public transport
Production Service	water transport industry
Production Service	air transport industry
Production Service	pipeline transportation industry
Production Service	handling and transportation agency
Production Service	warehousing industry
Production Service	postal service
Production Service	telecom and other information transportation industry
Production Service	information technology services
Production Service	software development
Production Service	bank and securities market services
Production Service	insurance industry
Production Service	leasing industry
Production Service	Production Services
Production Service	research and experimental development
Production Service	professional technical service industry
Production Service	science and technology promotion and application service industry
Production Service	geological prospecting
Production Service	water conservancy management
Production Service	ecological protection and environmental management
Production Service	public facilities management
Consumption Service	wholesale and retail
Consumption Service	lodging industry
Consumption Service	catering business
Consumption Service	real estate industry
Consumption Service	travel services
Consumption Service	resident service industry
Consumption Service	other service
Consumption Service	education
Consumption Service	hygiene
Consumption Service	social insurance industry
Consumption Service	social welfare industry
Consumption Service	journalism and publishing
Consumption Service	radio, television, film and television sound recording industry
Consumption Service	culture and arts industry
Consumption Service	sports
Consumption Service	entertainment
Consumption Service	social organization

Table A3: Correlation between Global Coal Price and Coal Production

Dependent variable:	Log (Coal)		
	(1)	(2)	(3)
Lag. Log(Coal Price)	0.532***		
	(0.118)		
Lag. Log(Coal Price) $\times \overline{\text{Coal}_{07-09}}$		3.528*	-4.884**
		(1.906)	(2.122)
Observations	420	420	420
Prefecture fixed effects	YES	YES	YES
Year fixed effects	NO	NO	YES

Notes: This table shows the correlation between global coal price and domestic coal productions at the city level. Log(coal) is the natural logarithm of coal production (in million tons) produced in a city. It is collected by author from Yearbook of Coal Production. Log(Coal Price) is the natural logarithm of average of Australian thermal coal Price. $\overline{\text{Coal07} - 09}$ is the average coal production in the 2007-2009 period. The standard errors clustered at the city level are reported in the parentheses. * Significant at 10%, ** 5%, *** 1%.