Joint Ventures and Technology Spillovers in China (Preliminary)

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Abstract

Chinese government promotes joint ventures of state-owned firms with foreign multinational firms. I study the effects of the joint ventures in promoting technology spillovers. Using firm-level data in China, I find that higher joint venture presence in a sector leads to higher productivity of firms in the upstream of that sector, but lower productivity of firms in the downstream of that sector. A quantitative analysis suggests that the joint ventures will on aggregate prevent technology spillovers and cause a significant decline in total industrial output in China.

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1 Introduction

Chinese government actively promotes joint ventures of state-owned firms with foreign multinational firms. A key motivation behind such policies is to promote technology spillovers from the foreign multinational firms (Holmes, McGratten, and Prescott 2015). However, evidence on the effects of such policies in promoting technology spillovers is scarce. The contribution of this paper is to study the effects of the joint ventures in promoting technology spillovers in China.

A joint venture is defined as a firm with both significant state-owned share and foreign share. Using Chinese firm-level data, I construct measures of joint venture presence in each industrial sector, as well as joint venture presence in the upstream and in the downstream of each sector. Empirically, I find that from 2000 to 2007, increased joint venture presence in a sector leads to higher productivity of firms in the upstream of that sector, but lower productivity of firms in the downstream of that sector, and no significant changes in the productivity of firms in the same sector.

To understand the aggregate impact of joint ventures in promoting technology spillovers, I use a quantitative model that features a production network (Acemoglu, Akcigit, and Kerr 2016). Quantitatively, I find that joint ventures' negative impact on the productivity of firms in the downstream is the dominant force. In particular, a counter-factual analysis suggests that increasing the joint venture presence from zero to the level observed in 2005 will lead to decreases in output in all two-digit industrial sectors and cause significant decline in total industrial output in China.

Related Literature

The paper is closely related to the literature on the technology spillover effects of multinational firms (Aitken and Harrison 1999, Javorcik 2004, Harrison and Rodríguez-Clare 2010). Lin, Liu, and Zhang (2009) and Du, Harrison, and Jefferson (2012) use similar regression techniques to study the effects of technology spillovers from multinational firms in China. This paper contributes to the literature by evaluating the effects of a specific industrial policy - the joint ventures of state-owned firms with foreign multinational firms - in promoting technology spillovers in China.

The paper is closely related to the literature on industrial policies (Chang 2003, Harrison and Rodríguez-Clare 2010, Aghion, et al 2015). Holmes, McGratten, and Prescott (2015) finds that *quid pro quo* policies, or policies that require multinational firms to transfer technology in return for market access, bring significant benefits to China. Their paper adopts a structural model with a representative firm and does not consider the technology spillover effects in a production network. Joint venture is a very important component of the *quid pro quo* policies. This paper complements their study by focusing on the technology spillover effects of the joint ventures. I find that due to joint ventures' negative impact on the productivity of firms in the downstream, joint ventures will on

aggregate prevent technology spillovers and hurt total factor productivity.

The paper is also related to the literature on production network. The quantitative model in this paper is based on the model in Acemoglu, Akcigit, and Kerr (2016). The paper finds that increased joint venture presence in a sector leads to higher productivity of firms in the upstream of the sector but lower productivity of firms in the downstream of the sector. The reason behind this finding is worth further study. At the end of the paper, I offer some possible explanations.

2 Empirical Strategy

2.1 Data and Variables

We use firm level data from the Chinese Industrial Survey from 2000 to 2007. The Chinese Industrial Survey covers all state-owned firms and private firms with revenue above 5,000,000 yuan (around $600,000). The survey contains information on firm output, value-added, capital, labor and intermediate inputs, among others. The survey also contains information on paid-up capital owned by state, foreigner and various other sources. I follow the methods from Brandt, Van Biesebroeck, and Zhang (2014) to link firms over time and construct real variables. This gives us an unbalanced panel from 2000 to 2007.

The data covers 425 four-digit industries. For firm i in industry j in year t, we define the foreign share in the firm as the share of paid-up capital owned by foreigners

$$ForeignShare_{ijt} = \frac{ForeignPaidupCapital_{ijt}}{TotalPaidupCapital_{ijt}}$$

Similarly, the state share in the firm is defined as the share of paid-up capital owned by the state

$$StateShare_{ijt} = \frac{StatePaidupCapital_{ijt}}{TotalPaidupCapital_{ijt}}$$

We will define a firm as a state-owned firm (or state-owned enterprise, SOE) if the state share of paid-up capital exceeds 50%.

$$SOE_{ijt} = \begin{cases} 1, & StateShare_{ijt} > 0.5 \\ 0, & \text{otherwise} \end{cases}$$

Notice our results in this paper will be largely unchanged if we define state-owned firms as firms with more than 10% of paid-up capital owned by state. If a firm is a state-owned firm and at the same time has paid-up capital owned by foreigners, we categorize such a firm as a joint venture. For firm i in industry j in year t, the joint venture share in the firm is defined as

$$JVShare_{ijt} = ForeignShare_{ijt} * SOE_{ijt}$$

The presence of multinational firms in industry j in year t, $HorizontalFDI_{jt}$, is defined as the average of firms' foreign shares in industry j weighted by firms' output.

$$HorizontalFDI_{jt} = \frac{\sum_{i \in j} ForeignShare_{ijt} * Y_{ijt}}{\sum_{i \in j} Y_{ijt}}$$

Here Y_{ijt} is the real output of firm i in industry j in year t. Similarly, the presence of joint ventures in industry j in year t, $HorizontalJV_{jt}$, and the presence of state-owned firms in industry j in year t, $HorizontalState_{jt}$, are defined as

$$HorizontalJV_{jt} = \frac{\sum_{i \in j} JVShare_{ijt} * Y_{ijt}}{\sum_{i \in j} Y_{ijt}}$$

$$HorizontalState_{jt} = \frac{\sum_{i \in j} StateShare_{ijt} * Y_{ijt}}{\sum_{i \in j} Y_{ijt}}$$

We also compute the presence of joint ventures in the upstream and downstream of industry j. To do so we use the approach in Javorcik (2004) and rely on the input-output tables. We use the 2002 input-output tables for China. We define the presence of multinational firms in the upstream of industry j as

$$UpstreamFDI_{jt} = \sum_{k \neq j} \sigma_{jk} \frac{\sum_{i \in k} ForeignShare_{ikt} * (Y_{ikt} - X_{ikt})}{\sum_{i \in k} (Y_{ikt} - X_{ikt})}$$

Here X_{ikt} is the real export of firm i in industry k in year t. σ_{jk} is the share of total intermediate inputs used by industry j that is purchased from industry k. Similarly, the presence of joint ventures in the upstream of industry j in year t, $UpstreamJV_{jt}$, and the presence of state-owned firms in the upstream of industry j in year t, $UpstreamState_{jt}$, are defined as

$$UpstreamJV_{jt} = \sum_{k \neq j} \sigma_{jk} \frac{\sum_{i \in k} JVShare_{ikt} * (Y_{ikt} - X_{ikt})}{\sum_{i \in k} (Y_{ikt} - X_{ikt})}$$

$$UpstreamState_{jt} = \sum_{k \neq j} \sigma_{jk} \frac{\sum_{i \in k} StateShare_{ikt} * (Y_{ikt} - X_{ikt})}{\sum_{i \in k} (Y_{ikt} - X_{ikt})}$$

The presence of multinational firms in the downstream of industry j in year t is defined as

$$DownstreamFDI_{jt} = \sum_{k \neq j} \alpha_{jk} Horizontal_{kt}$$

Here α_{jk} is the share of industry j's total output that is supplied to industry k as intermediate inputs. Similarly, the presence of joint ventures in the downstream of industry j

in year t, $DownstreamJV_{jt}$, and the presence of state-owned firms in the downstream of industry j in year t, $DownstreamState_{jt}$, are defined as

$$DownstreamJV_{jt} = \sum_{k \neq j} \alpha_{jk} HorizontalJV_{kt}$$

$$DownstreamState_{jt} = \sum_{k \neq j} \alpha_{jk} HorizontalState_{kt}$$

Notice to use the input-output tables, we map the 425 four-digit industries into 74 two-digit sectors in the input-output tables. As a result, our measures of joint venture presence in the upstream and downstream of industry j in each year t are defined at the two-digit sector level.

2.2 Regression I

The first regression test is as follows:

$$\begin{aligned} lnY_{ijt} &= d_i + d_t + \alpha lnK_{ijt} + \beta lnL_{ijt} + \gamma lnM_{ijt} \\ &+ \theta_1 HorizontalJV_{it} + \theta_2 UpstreamJV_{ijt} + \theta_3 DownstreamJV_{ijt} + \xi X_{ijt} + \epsilon_{ijt} \end{aligned}$$

Here d_i is firm fixed effect and d_t is year fixed effect. K_{ijt} is the real capital stock for firm i in industry j in year t. L_{ijt} is the labor for firm i in industry j in year t.[1] M_{ijt} is the real intermediate inputs for firm i in industry j in year t. X_{ijt} include a set of controls. The controls include the foreign share, state share and joint venture share in the firm ($ForeignShare_{ijt}$, $StateShare_{ijt}$, $JVShare_{ijt}$). The controls also include the presence of multinational firms and state-owned firms in the same industry ($HorizontalFDI_{jt}$, $HorizontalState_{jt}$), in the upstream of the industry ($UpstreamFDI_{jt}$, $UpstreamState_{jt}$) and in the downstream of the industry ($DownstreamFDI_{jt}$, $DownstreamState_{jt}$).

The parameters of interest are θ_1, θ_2 and θ_3. These parameters provides information on how changes in joint venture presence in the same sector (θ_1), in the upstream of the sector (θ_2) and in the downstream of the sector (θ_3) affect firm output and productivity.

2.3 Regression II

Simply regressing output (Y) on various inputs (K, L, M) may produce biased estimates for firm productivity (Olley and Pakes 1996). To address this concern, we estimate a

[1] The empirical results remain unchanged if we use wage payment instead of labor here

Cobb-Douglas production function for each of the two-digit sectors[2]

$$Y_{ijt} = A_{ijt} K_j^{\alpha} L_j^{\beta} M_j^{\gamma}$$

The coefficients α_j, β_j and γ_j will be different for each of the two-digit sectors, and will be read from the share of total output paid to labor, capital and intermediate inputs in that sector. For each of the firm i in industry j in year t, we can then compute the productivity A_{ijt} as the residual

$$lnA_{ijt} = lnY_{ijt} - \alpha_j lnK_{ijt} - \beta_j lnL_{ijt} - \gamma_j lnM_{ijt}$$

The second regression test is as follows:

$$lnA_{ijt} = d_i + d_t + \theta_1 HorizontalJV_{it} + \theta_2 UpstreamJV_{ijt} + \theta_3 DownstreamJV_{ijt} + \xi X_{ijt} + \epsilon_{ijt}$$

Here d_i and d_t are firm and year fixed effects. X_{ijt} include the same set of controls as in the first regression test.

3 Empirical Results

Table 1 shows the results from Regression I. The results indicate the following: First, higher joint venture presence in a sector leads to higher productivity of firms in the same sector. This is reflected by the positive and significant coefficients for $HorizontalJV_{jt}$. Second, higher joint venture presence in the upstream of a sector leads to lower productivity of firms in the sector. This is reflected by the negative and significant coefficients for $UpstreamJV_{jt}$. Third, higher joint venture presence in the downstream of a sector leads to higher productivity of firms in the sector. This is reflected by the positive and significant coefficients for $DownstreamJV_{jt}$.

Table 2 shows the results from Regression II. The results suggest that higher joint venture presence in a sector does not significantly change productivity of firms in the same sector, since the coefficients for $HorizontalJV_{jt}$ are in most cases not significantly different from zero. Since we are using sector-level production functions in Regression II, we deem the results to be more accurate than the results we find in Table 1. We hence conclude that higher joint venture presence in a sector does no significantly change productivity of firms in the same sector.

Table 2 confirms our earlier finding on the effects of joint ventures on the productivity of firms in the upstream and downstream. In particular, we find that higher joint venture presence in the upstream of a sector leads to lower productivity of firms in the sector. This

[2]I have also used the method in Levinsohn and Petrin (2003) and Petrin, Poi and Levinsohn (2004) to correct for bias and compute productivity A_{ijt}. The empirical results remain largely unchanged.

is reflected by the negative and significant coefficients for $UpstreamJV_{jt}$. We also find that higher joint venture presence in the downstream of a sector leads to higher productivity of firms in the sector. This is reflected by the positive and significant coefficients for $DownstreamJV_{jt}$.

Combining the results from Table 1 and Table 2, we conclude that higher joint venture presence in a sector will lead to higher productivity of firms in the upstream of that sector, but lower productivity of firms in the downstream of the sector, and no significant changes in the productivity of firms in the same sector.

As an aside, the coefficients for the control variables in Table 1 and Table 2 are largely consistent with what the literature has previously found. For example, the literature documents an ambiguous effect of technology spillovers from multinational firms to firms in the same sector (Javorcik 2008). We find that the coefficients for $HorizontalFDI_{jt}$ are indeed of ambiguous signs in our various set-ups. The literature has typically found significant positive technology spillovers from multinational firms to firms in the upstream and downstream sectors (Harrison and Rodríguez-Clare 2010). This is consistent with our significant and positive coefficients for $UpstreamFDI_{jt}$ and $DownstreamFDI_{jt}$.

4 Structural Analysis

In Section 3, we show that the presence of joint ventures in a sector will lead to higher productivity of firms in the upstream of the sector but lower productivity of firms in the downstream of the sector. This section aims to study the aggregate impact of such technology spillovers brought by the joint ventures. To do so we use a structural model that features a production network. The model is based on Acemoglu, Akcigit, and Kerr (2016).

4.1 Model

There are N sectors in the economy, $j = 1, 2, ..., N$. The production function of the representative firm in each sector j is

$$y_j = e^{z_j} l_j^{\alpha_j^l} \prod_{i=1}^{n} x_{ji}^{\alpha_{ji}}; \quad \alpha_j^l + \sum_{i=1}^{N} \alpha_{ji} = 1 \tag{1}$$

Here l_j is the labor hired in sector j. x_{ji} is the intermediate input from sector i that is used in the production of sector j. For simplicity, I consider a static model and abstract from capital and saving.

The productivity of the representative firm in sector j, z_j, will be affected by the presence of joint ventures in the same sector j ($HorizontalJV_j$), in the upstream of sector j ($UpstreamJV_j$) and in the downstream of sector j ($DownstreamJV_j$) in the following

simple way:

$$z_j = \bar{z}_j + \theta_H HorizontalJV_j + \theta_D DownstreamJV_j + \theta_U UpstreamJV_j \tag{2}$$

The representative household in the economy has preference

$$u(c_1, c_2, ..., c_N, l) = \gamma(l) \prod_{j=1}^{n} c_j^{\beta_j}; \quad \sum_{i=j}^{N} \beta_j = 1$$

Here $\gamma(l)$ is a decreasing (differentiable) function capturing the disutility of labor.

Market clearing for all sector $j = 1, 2, ..., N$ indicates

$$y_j = c_j + \sum_{k=1}^{n} x_{kj}$$

We have the following Proposition:

Proposition. *Let A denote the matrix of* α_{ij}*'s,* $A =: \begin{bmatrix} \alpha_{11} & \alpha_{12}... & & \\ \alpha_{21} & \alpha_{22}... & & \\ & & \ddots & \\ & & & \alpha_{nn} \end{bmatrix}$ *The impact of a vector of productivity shocks* $dz = (dz_1, dz_2, ..., dz_N)$ *will lead to the following changes in output and consumption:*

$$dlny = dlnc = (I - A)^{-1} dz$$

The proof of the Proposition can be found in Acemoglu, Akcigit, and Kerr (2016). We will rely on this Proposition to measure how productivity changes (dz) brought by increased joint venture presence affect industrial output.

4.2 Quantitative Analysis

We read the matrix A and vector β directly from the 2002 input-output tables for China. We estimate θ_D, θ_U and θ_H in (2) using our regression results in Table 2.[3] In particular, we choose two sets of parameters from Table 2. In the first set, $\theta_D = 1.23$, $\theta_U = -15.7$, $\theta_H = 0$. In the second set, $\theta_D^{'} = 1.77$, $\theta_U^{'} = -13.3$, $\theta_H^{'} = 0$.

[3]Such method of estimating θ_D, θ_U and θ_H is simple but does not take into account how changes in joint venture requirements can affect other variables, which in turn may affect firm productivity. For example, the removal of joint venture requirements may increase FDI and in turn improve productivity of firms. Capturing these complications will require a more complicated model. Here I abstract from these complications to get a first-pass quantitative answer.

We perform the following counter-factual analysis in the model: What will happen to industrial output when joint venture presence is increased from zero to the level observed in 2005?

We find the following quantitative results: First, after the increase in joint venture presence, under both set of parameters, all two-digit sectors in the economy will experience a decline in output, though the magnitude of the declines are different across sectors. Table 3 reports the declines in output in each of the two-digit sectors caused by the increased joint venture presence. Second, under the two sets of parameters, total industrial output is lowered by 2.2% and 3.0% respectively due to the increased joint venture presence.

Such results suggest that on aggregate, joint ventures' negative impact on the productivity of firms in the downstream is the dominant force. The joint ventures will on aggregate prevent technology spillovers and cause significant decline in total industrial output in China.

5 Conclusions

This paper finds that joint ventures prevent technology spillovers and reduce total industrial output in China. In particular, the paper finds that higher joint venture presence in a sector leads to higher productivity of firms in the upstream of that sector, but lower productivity of firms in the downstream of that sector. The exact reason behind such finding is worth further study. Here I offer some possible explanations: Joint ventures are perhaps more likely to source from local firms, impose local content requirements and share blueprints with local firms. As a result, joint ventures could help improve productivity of firms in the upstream. However, the multinational firms may not bring their best technology to the joint ventures for fear of being stolen by local rivals. In addition, the joint ventures may be inefficient in producing goods that supply the downstream firms. Joint ventures may also enjoy monopoly power and reduce competition in the sector. As a result, joint ventures could hurt the productivity of firms in the downstream.

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Table 1: Results from Regression I

	(1) lnY_{ijt}	(2) lnY_{ijt}	(3) lnY_{ijt}	(4) lnY_{ijt}	(5) lnY_{ijt}	(6) lnY_{ijt}
lnK_{ijt}	0.053***	0.048***	0.048***	0.048***	0.048***	0.048***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
lnL_{ijt}	0.137***	0.131***	0.132***	0.131***	0.131***	0.131***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
lnM_{ijt}	0.718***	0.732***	0.732***	0.732***	0.732***	0.732***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$HorizontalJV_{jt}$	0.550***	0.596***	0.696***	0.707***	0.697***	0.651***
	(0.097)	(0.094)	(0.095)	(0.095)	(0.095)	(0.095)
$UpstreamJV_{jt}$	-15.694***	-15.417***	-16.158***	-15.224***	-15.254***	-15.315***
	(0.680)	(0.662)	(0.670)	(0.671)	(0.671)	(0.696)
$DownstreamJV_{jt}$	3.016***	2.836***	2.806***	3.727***	3.719***	2.572***
	(0.264)	(0.257)	(0.257)	(0.259)	(0.259)	(0.274)
$ForeignShare_{ijt}$		0.007**	0.007**	0.008**	0.007**	0.007**
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$HorizontalFDI_{jt}$			0.027***	-0.041***	-0.041***	-0.033***
			(0.006)	(0.007)	(0.007)	(0.007)
$HorizontalState_{jt}$			-0.047***	-0.054***	-0.051***	-0.051***
			(0.006)	(0.006)	(0.006)	(0.006)
$UpstreamFDI_{jt}$				1.114***	1.115***	1.171***
				(0.030)	(0.030)	(0.030)
$DownstreamFDI$				0.246***	0.246***	0.227***
				(0.013)	(0.013)	(0.013)
$JVShare_{ijt}$					0.060**	0.060**
					(0.022)	(0.022)
$StateShare_{ijt}$					-0.016***	-0.015***
					(0.002)	(0.002)
$UpstreamState_{jt}$						0.058***
						(0.017)
$DownstreamState_{jt}$						0.256***
						(0.019)
Firm and Year Fixed Effects	YES	YES	YES	YES	YES	YES

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Results from Regression II

	(1) lnA_{ijt}	(2) lnA_{ijt}	(3) lnA_{ijt}	(4) lnA_{ijt}	(5) lnA_{ijt}	(6) lnA_{ijt}
$HorizontalJV_{jt}$	-0.125	0.136	0.141	0.129	0.089	0.537***
	(0.100)	(0.098)	(0.098)	(0.098)	(0.098)	(0.120)
$UpstreamJV_{jt}$	-12.895***	-14.202***	-13.283***	-13.329***	-15.673***	-20.654***
	(0.703)	(0.692)	(0.694)	(0.693)	(0.719)	(1.063)
$DownstreamJV_{jt}$	0.637*	0.587*	1.767***	1.754***	1.232***	1.411***
	(0.273)	(0.266)	(0.268)	(0.268)	(0.284)	(0.344)
$ForeignShare_{ijt}$		0.004	0.004	0.004	0.004	0.008**
		(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
$HorizontalFDI_{jt}$		0.002	-0.075***	-0.074***	-0.063***	-0.063***
		(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
$HorizontalState_{jt}$		-0.103***	-0.113***	-0.108***	-0.097***	-0.119***
		(0.006)	(0.006)	(0.006)	(0.006)	(0.008)
$UpstreamFDI_{jt}$			1.346***	1.348***	1.396***	1.520***
			(0.031)	(0.031)	(0.031)	(0.037)
$DownstreamFDI_{jt}$			0.242***	0.242***	0.234***	0.244***
			(0.014)	(0.014)	(0.014)	(0.017)
$JVShare_{ijt}$				0.061**	0.060**	0.048
				(0.022)	(0.022)	(0.026)
$StateShare_{ijt}$				-0.023***	-0.023***	-0.019***
				(0.002)	(0.002)	(0.003)
$UpstreamState_{jt}$					0.250***	0.220***
					(0.017)	(0.022)
$DownstreamState_{jt}$					0.149***	0.247***
					(0.020)	(0.025)
$lnA_{ij,t-1}$						-0.015***
						(0.001)
Firm and Year Fixed Effects	YES	YES	YES	YES	YES	YES

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Output Changes in Different Two-digit Sectors After Increased Joint Venture Presence

Two-digit Industry Name	First Set of θs	Second Set of θs
Grain grinding	-0.39%	-0.50%
Feed processing	-0.56%	-0.70%
Vegetable oil processing	-0.40%	-0.54%
Sugar	-0.42%	-0.74%
Slaughter and meat processing	-0.23%	-0.29%
Aquatic products processing	-0.23%	-0.31%
Other food processing and food manufacturing	-0.91%	-1.22%
Alcohol and beverages	-0.90%	-1.16%
Other beverage manufacturing	-1.49%	-1.91%
Tobacco products	-1.89%	-2.34%
Cotton, chemical fiber textile printing and dyeing	-2.18%	-2.72%
Wool, dyeing and finishing	-1.37%	-1.74%
Hemp, silk fine processing	-1.76%	-2.21%
Textile products	-1.99%	-2.57%
Knitwear and its products manufacturing	-2.78%	-3.46%
Textile and garment, shoes, hats manufacturing	-2.03%	-2.59%
Leather, fur, feather (velvet) and its products	-1.27%	-1.64%
Wood, bamboo, rattan, brown, grass products	-1.40%	-1.83%
Furniture manufacturing	-1.91%	-2.46%
Paper and paper products	-2.01%	-2.58%
Printing and recording devices	-2.52%	-3.21%
Culutral products	-2.87%	-3.63%
Toy, sports and entertainment products	-3.22%	-4.05%
Oil and nuclear fuel processing	-0.33%	-0.49%
Coking	-0.43%	-0.64%
Basic chemical raw materials manufacturing	-0.94%	-1.38%
Fertilizer manufacturing	-1.93%	-2.45%
Pesticide Manufacturing	-1.83%	-2.37%
Coatings, paints, inks and similar products	-1.27%	-1.98%
Synthetic materials	-0.93%	-1.33%
Specialized chemical products	-1.33%	-1.86%
Daily chemical products	-1.66%	-2.17%
Pharmaceutical manufacturing	-1.18%	-1.52%
Chemical fiber manufacturing	-2.69%	-3.41%
Rubber products	-0.96%	-1.85%
Plastic products	-3.71%	-4.76%
Cement, lime and gypsum manufacturing	-1.52%	-1.98%
Glass and glass products	-1.12%	-1.64%
Ceramic products	-1.08%	-1.42%
Refractory and fire-proof products	-1.10%	-1.52%
Other non - metallic mineral products	-1.26%	-1.70%
Ironmaking industry	-0.72%	-1.07%
Steelmaking industry	-1.18%	-1.89%
Steel rolling and processing industry	-1.24%	-1.93%

Continuation of Table 3		
Two-digit Sector Name	First Set of θs	Second Set of θs
Ferroalloy smelting	-1.00%	-1.43%
Nonferrous metal smelting	-0.58%	-0.82%
Non - ferrous metal rolling processing	-2.38%	-3.03%
Metal products	-2.20%	-2.94%
Boiler and prime mover manufacturing	-0.98%	-2.37%
Metal processing machinery manufacturing	-2.63%	-3.56%
Other general equipment manufacturing	-2.60%	-3.59%
Agriculture, forestry, animal husbandry and fishery machinery	-6.33%	-8.04%
Other special equipment manufacturing	-2.92%	-3.83%
Railway transportation equipment manufacturing	-3.15%	-4.10%
Automotive Manufacturing	-2.80%	-4.78%
Automobile parts and accessories manufacturing	-1.26%	-4.51%
Ship and floating device manufauring	-4.79%	-6.10%
Other transportation equipment manufacturing	-5.01%	-6.47%
Motor manufacturing	-2.73%	-3.81%
Household utensils manufacturing	-2.49%	-3.35%
Other electrical machinery and equipment manufacturing	-2.34%	-3.12%
Communications equipment manufacturing	-2.89%	-3.70%
Electronic computer manufacturing	-3.05%	-3.87%
Other electronic equipment manufacturing	-3.07%	-3.91%
Electronic components manufacturing	-2.58%	-3.34%
Household audio - visual equipment manufacturing	-3.02%	-3.85%
Other communications, electronic equipment	-3.05%	-3.94%
Instrumentation manufacturing	-2.45%	-3.30%
Culture, office machinery manufacturing	-2.97%	-3.83%
Arts and crafts manufacturing	-1.86%	-2.45%
Other industry	-2.01%	-2.62%
Electricity, heat production and supply	-0.61%	-0.87%
Gas production and supply	-0.42%	-0.58%
Water production and supply	-0.91%	-1.30%
Total Industrial Output	-2.23%	-2.97%