Multinational Corporations and Technology Transfers in Developing Countries: Evidence from China

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Abstract

Technology and innovatory capabilities are key sources of competitive strength for firms and countries. As a developing country, China seems to build its capabilities for technology and innovation through foreign direct investment (FDI) by multinational corporations. Do multinational corporations transfer technology? While the topic is quite important, the quantitative analyses on the issue in the literature have been limited. This paper attempts to close the gap by empirically investigating the issue with the Chinese industrial data. The estimates indicate that the Chinese industries benefit from the presence of FDI mainly from spillovers and no obvious technology transfers are made directly from multinational corporations. The results also suggest a key role of an industry's absorptive capability in capturing potential benefits from FDI.

JEL Code: F21; F23; O30; O53

Keywords: Multinational corporations (MNCs), FDI, and Technology spillovers

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We wish to thank Yufei Liu, Zheng Xu, Husniddin Mustafaev, and Wayne Jiao for valuable assistance in data entry. Of course, the usual caveat applies.

1. Introduction

In the recent literature on international economics and economic growth, the link between technology transfers and foreign direct investment (FDI) made by multinational corporations (MNCs) seems to have been prominent. Theoretically, there is a widely shared view that technology may be transferred to host developing economies through (a) MNCs' backward and forward linkages with indigenous firms and customers; (b) imitation of domestic firms by "learning by watching" in the presence of MNCs; (c) induction of trained workers and managers by MNCs; and (d) relocation of MNCs' R&D activities to host economies. On the other hand, however, it is sometimes suggested that MNCs may (a) restrict diffusion of technology (especially advanced ones) to their subsidiaries abroad; (b) transfer technologies that are inappropriate for the host country's factor proportions; (c) prefer imports of key components/parts from parent factories to local suppliers, reducing linkage effects; and (d) maintain their technological advantage by forcing host economies to follow strict rules of intellectual property rights. Although further theoretical insights would be valuable, empirical analyses of the issue are needed as well for a better understanding of relationship between FDI and technology transfers.

While cross-country studies are useful, single-country research, despite its shortcomings, yields a better indication of the detailed picture for each case and provides practical policy implications. In this context, it is useful to note that three recent single-country studies, which used industry- or firm-level data for small developing economies or developed countries for the 1970s and 1980s, reached fairly divergent conclusions (Aitken and Harrison, 1999; Blomstrom and Sjoholm, 1999; and Potterie and Lichtenberg, 2001). No study has been conducted for a large developing country with substantial FDI inflows for the 1990s. Thus there is a need for further empirical research.

This article seeks to fill this gap by using the Chinese industrial data for the 1990s. The case of China is important empirically because of its huge magnitude of FDI inflows and the issue being largely unexplored.[1] Besides the use of a large sample of 187 industries and the focus on the 1990s, this study has several distinctive features. First, it specifies empirically two channels through which FDI might transfer technology to local industries: direct effects are proxied by foreign participation in an industry, and spillovers are measured by foreign participation in the sector to which the industry belongs. Second, it studies the host country's absorptive capability to capture benefits from FDI, which is believed to be one of the key factors influencing technology transfers. Third, it employs a fairly straightforward specification that includes most major influences on technology transfers from FDI. Last, in addition to the entire sample, it considers estimates for the subgroup of labor- and capital-intensive industries to detect if the FDI-technology transfer nexus depends on an industry's factor intensity.

2. The Model

As noted in Section 1, the nexus between FDI and technology transfers has been explored empirically by several scholars. For instance, B. Aitken and A. Harrison (1999) used firm-level data for Venezuela over the period 1976-89 to study if technology "spillovers" existed from foreign to domestic firms in case of different foreign equity participation. They concluded that technology "spillovers" seem to be small from foreign to small local enterprises or even negative

[1] The cumulative FDI into China over the period 1979-2005 is $620 billion, with over $60 billion inflows annually in 2004 and 2005 (SSB, 2006). China has been the largest FDI host country in the developing world since the early 1990s, with a share of over one third. For a few years in the early 2000s, China even surpassed the US and received the largest amount FDI inflows in the world (UNCTAD, 2005). While there have been some discussions on technology transfers from multinational corporations in China (for example, UNCATD, 2002), they are limited to qualitative descriptions. Few studies have been devoted to quantitative analyses of the issue.

from joint ventures to local firms. Based on Indonesian micro data of 1991, M. Blomstrom and F. Sjoholm (1999) found that domestic establishments benefit from technology spillovers of foreign establishments' high productivity, and that foreign ownership does not affect the spillovers. B. Potterie and F. Lichtenberg (2001) used the country-level data of inward and outward FDI for US, Japan and EU over the period 1971-90 and indicated that inward FDI does not transfer technology to host economies and outward FDI transfers technology only if a country invests in R&D-intensive foreign countries.

The models used in the aforesaid studies are broadly similar, and we also employ a parsimonious specification that resembles the ones adopted by these researchers. We start with a simple production function, in which technology is assumed to be separable between value-added and intermediate goods, and technical changes are value-added-augmenting. Therefore a value-added production function for an industry may take the following form:

$$Q_i = A_i L_i^{\beta_1} K_i^{\beta_2} \qquad (1)$$

where Q_i denotes the value-added in industry i, L_i and K_i are the input of labor and capital, A_i represents technical factors associated with FDI, and β_1 and β_2 are the elasticities of labor and capital, respectively. The production function can be expanded to incorporate technological externalities by allowing FDI to affect productivity of industry through two channels. Specifically, the technical factor term (A_i) can be decomposed into three technological components as follows: [2]

$$A_i = F_i^{\beta_3} S_i^{\beta_4} R_i^{\beta_5} \qquad (2)$$

[2] The term technology used here refers to the knowledge that is embodied in products, processes and practices. Products comprise the knowledge of how things work, their design, and their interface with other products. Processes comprise the knowledge on how a product can be produced or changed. Practices consist of the routines necessary to manage the product-process combination and the knowledge regeneration process.

where F_i is the technical factor associated with direct effects of technology transfers from FDI in industry i, S_i is the technical factor associated with spillovers of FDI in the industrial sector, and R_i is the technical factor associated with FDI absorptive capacity in the industry. Being the elasticities of F, S, and R, respectively, β_3 thus measures the direct impact of FDI on the technology of industry i, β_4 captures externalities of FDI in the sector on the technology of the industry, and β_5 indicates the technological catch-up ability in the industry and its complementarities with FDI. Replacing A_i in Eq. (1) with Eq. (2), we get the production function with the technological effects of FDI:

$$Q_i = L_i^{\beta_1} K_i^{\beta_2} F_i^{\beta_3} S_i^{\beta_4} R^{\beta_5} \tag{3}$$

Addition of a constant term and a stochastic component to Eq. (3) yields the following econometric specification in logarithm:

$$\ln Q_i = \beta_0 + \beta_1 \ln L_i + \beta_2 \ln K_i + \beta_3 \ln F_i + \beta_4 \ln S_i + \beta_5 \ln R_i + \varepsilon_i \tag{4}$$

Eq. (4) constitutes the basis for our econometric analysis of the FDI-technology transfer link with the Chinese industrial data. The rationale of the FDI-technology transfer link for the specification is based on the direct and indirect impact of MNCs on the technological development in host industries (Caves, 1996; Das; 1987; Markusen and Venables, 1999; and Teece, 1977). The direct transfers take place by introducing capital goods (equipment), new processing practices, new products, and new management skills. The indirect transfers are what MNCs may not intend to do, or spillovers. Such spillovers include backward and forward linkages, demonstration and competition effects, and trained worker migration.

While the potential for MNCs to transfer technology exists, the benefits to host countries do not automatically accrue. The magnitude and extent of technology transfers may be related to host industry characteristics. Especially the level of absorptive capability is needed to acquire and work with the technology. For example, technologies from MNCs may not be appropriate for local firms and industry and thus may not enable them to compete effectively in the global market. Local firms and industries have to make a variety of investment to actually benefit from technology inflows. Therefore the host capability to absorb foreign technology turns out to be an important determinant of the size of realized spillovers.

It is possible for host technological capability even to be worse off with inward FDI. The technology provided by MNCs may have little impact on domestic technological development and may in fact inhibit their development by stifling the growth of indigenous entrepreneurship as a result of the MNCs dominance of local markets. Thus local development in technology may be suppressed by MNCs and "crowding-out" effects may occur. Moreover, MNCs may not intend to transfer technology to host countries because they wish to maintain their status of technological monopoly.

3. The Data and the Main Results

All data employed in the work are taken directly from *The Third National Industrial Census of People's Republic of China* (SSB, 1997). This is the most recent industrial survey that followed the international standard classification and covered all industries in China. The industrial survey was conducted by China's State Statistic Bureau in 1995, and the data collected from the survey were published in 1997. The 191 industries are categorized into 37 sectors.[3] The dependent variable (Q) is measured by current value added of an industry, and L is taken as total number of employees in the industry. Domestic capital stock (K) is taken as the current value of total domestic capital formation in the industry. Effects of direct technology transfers from FDI

[3] The 37 sectors and 191 industries are listed in Appendix.

(*F*) are measured by percentage of current FDI stock in total capital stock. Spillovers of FDI (*S*) are proxied by the average share of foreign equity participation in the industrial sector to which the industry belongs, weighted by the industry's output. The absorptive capacity (*R*) is measured by the product of the industry's R&D spending and FDI stock.

In addition to the estimation of Eq. (4) for the full sample, we run regressions for two sub-samples (labor-intensive and capital-intensive ones) to capture some details of how technology transfers from FDI may be different due to factor intensity in industries. The criteria used for the division is the capital-labor ratio of ¥23,000 (RMB of the Chinese currency) per worker, which is consistent with the Chinese government's classifications of industries as well as international standards.[4]

For the purpose of comparison, we run an additional regression in each case, which includes three FDI indices as the sole explanatory variables to show to what extent FDI may affect technology transfers in the Chinese industries.

Before regression estimates of Eq. (4) are presented, it is appropriate to provide some descriptive statistics for the sample on which the regressions are based. Although the total number of industries covered in the study is 191, missing data reduce the sample size slightly to 178. Every industry for which data for the relevant variables are available in the source cited has been included. Thus, there is no direct selection bias in the sample. Table 1 contains descriptive statistics for all of the variables corresponding to 178 observations of the full sample and the two sub-samples (79-observation capital-intensive and 99-observation labor-intensive industries).

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[4] For examples, the capital-intensive industries include crude oil extraction, crude oil processing, organic chemicals, chemical pharmaceutical preparation, chemical pharmaceutical products, biological products, synthetic fibers, automobiles, aerospace, electrical industrial apparatus, communication equipments, electronic computers, electronic apparatus, and office instrument machinery. The labor-intensive industries include coal extraction and washing, canned food, cooking sauces, cotton textiles, woolen and silk textiles, clothes, hats, footwear, wood furniture, paper processing, paper products, toys, and game equipment.

The Appendix lists the sample industries by 37 sectors and identifies the capital-intensive industries with asterisks.

Table 1 may be inserted here

Table 2 presents the main regression results for the full sample and the two sub-samples. For each case, estimates are also reported for the regression with the three FDI indicators as the sole explanatory variables. The following points seem worthy of notice.

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(1) The explanatory power of these models is quite high for the diverse cross-industry sample. All of the three models (with the full sample, the capital-intensive sample, and the labor-intensive sample) explain nearly all variability across industries, as indicated by the high level of R^2 (0.98). The fit of the regressions is good with F-statistics being significant at the 1% level in all cases.

(2) The three FDI variables seem to be important in explaining China's industrial performance. The explanatory power is high ($R^2 = 0.92$) for the three regressions that include only the FDI variables, suggesting that over 90% of the variance in the value-added of industrial output can be explained by the FDI variables.

(3) The evidence in favor of direct technology transfers from MNCs is lacking, instead, we found the opposite impact. In all estimates, the term for direct FDI effects (F) has the "wrong" (negative) sign with significance at the 1% level. The estimates suggest that the large (small) share of foreign investment in an industry is associated with low (high) productivity of the industry. One possible explanation is that inward FDI yields a net negative effects on the Chinese industries due to the strong MNC market power and "crowding-out" effects. The other explanation is that the positive FDI-technology transfer

link found in some studies may reflect the tendency that MNCs generally locate and invest in more productive industries (Aitken and Harrison, 1999). In fact, the industrial composition of inward FDI in China is different from the pattern in many host economies. By 1995, majority of MNCs' investment went to labor-intensive industries, and their products were mainly for exports (Zhang, 2000; 2001a; 2001b; and 2004).[5] Therefore, the negative effects from the estimation may not suggest a decline in domestic productivity with the foreign participation in industries, but the correlation of FDI with the Chinese industries characterized by low productivity.

(4) The contribution of MNCs to technology transfers in China seems to be mainly through indirect effects (spillovers). In all cases, the parameter for the FDI spillovers term (*S*) is robustly positive, as many scholars have reported (for example, Blomstrom and Sjoholm, 1999). The positive effects are large and statistically significant at the 1% level. The results suggest that the Chinese industries indeed benefit from the presence of foreign firms through demonstration, labor training, forward and backward linkages, and increased competition.

(5) The coefficients of absorptive capability (*R*) are positive and statistically significant at the 5% level in four of the six cases. In the other two cases, these are is positive but not significant at the conventional levels (although being close to the significance at 10% level). Thus domestic industry's R&D seems to play some role in capturing the benefits from FDI.

(6) It is instructive to note differences in effects of FDI variables on capital- and labor-intensive industries. The FDI absorptive capability term (*R*) has a robustly positive parameter for the capital-intensive sample, but insignificant for the labor-intensive

[5] Aitken and Harrison (1999) found a similar result at the firm level for Venezuela.

industries. The results seem to be consistent with the following view: the certain level of domestic R&D in the capital-intensive industries is required as a threshold to capture technological diffusions from FDI; but the requirement may not be necessary for the labor-intensive industries because of either the small technology gap between MNCs and this type of Chinese industries, or little variation in R&D over the labor-intensive industries. In addition, the size of FDI direct effects (*F*) and spillovers (*S*) in general is larger for the capital-intensive sample than the labor-intensive one, suggesting that the capital-intensive industries are more responsive to the inflows of FDI and the presence of MNCs.

(7) As expected, the domestic capital (*K*) parameter is robustly positive in all cases, suggesting that domestic investment promotes industrial performance in both labor- and capital-intensive industries. The parameter of labor input (*L*) shows a somewhat variable pattern. For the entire sample, the parameter clearly lacks significance and even has the wrong sign. For the labor-intensive sample, the sign is positive and the estimate is significant at the 1% level, while the parameter turns to robustly negative for the capital-intensive sample. This scenario seems generally consistent with those suggested by some studies (for example, Barro and Sala-i-Martin, 1995), that reported varying effects of labor on economic growth and industrial output.

Although the explanatory power of the model specified in Eq. (4) is good, one may worry about the possibility of heteroscedasticity in the disturbance term and feedback from the dependent variable to the independent variables. The White test (White, 1980) thus is used to check whether our model may have a major specification error.[6] The result of White test

[6] The test is explained by White (1980, pp.824-825). The procedure consists of running a test regression of the squares of OLS residuals from the original model on the squares and cross-products of the model regressors. Then

indicates that the values of the test statistic are too small to justify non-acceptance of the null hypothesis of heteroscedasticity and correct model specifications, suggesting absence of both heteroscedasticity and other major specification errors.

4. Concluding Remarks

Technology transfers perhaps are the most important benefit that could be brought by multinational corporations to host economies, but they are not either guaranteed, automatic, or free. How does a host country benefit in technology from the presence of multinational corporations? By reporting cross-industry estimates of a plausible model on the basis of the Chinese data for the 1990s, this study seeks to advance the earlier research on the FDI-technology transfer nexus in several ways. Besides working with a fairly large sample of 178 industries in the 1990s, we model two channels of direct effects and spillovers, through which FDI may transfer technology to the local industries. We also directly test how host country's R&D may affect the technology transfers. Moreover, we take a closer look at the differential in the impact of FDI on the labor- and capital-intensive industries.

The main outcome of the work may be summarized in the following statements. Technology transfers from FDI to local industries do not take place through direct effects, but spillovers. It is so perhaps because majority of FDI received in China by the mid-1990s was in labor-intensive industries with low technology, or multinational corporations transferred little advanced technology to the Chinese industries. Benefits from the presence of multinational corporations seem mainly from backward and forward linkages, "learning by watching," competition effects, and induction of trained workers. How much technology may be transferred

under the null hypothesis, nR2, where n is the number of observations and R2 is from the test regression, is distributed as a chi-square with degree of freedom equal to the number of regressors in the rest regression.

seems to be influenced by China's absorptive capability. An industry with strong R&D ability may capture more technological spillovers from FDI.

Table 1 Descriptive Statistics of the Variables Used in the Study

Full Sample (N = 178)						
	Q	*K*	*L*	*F*	*R*	*S*
Mean	81.75	113.33	43.60	19.11	10.73	7.68
Std. Deviation	133.44	190.75	66.97	14.77	24.51	10.51
Maximum	909.76	1753.99	588.62	61.27	174.11	67.14
Minimum	0.28	0.25	0.22	0.00	0.00	0.02
Capital-Intensive Industries (N = 79)						
	Q	*K*	*L*	*F*	*R*	*M*
Mean	116.80	162.72	38.55	22.72	16.09	10.40
Std. Deviation	173.98	255.07	44.31	16.59	28.12	12.22
Maximum	909.76	1753.99	224.14	61.13	130.15	49.08
Minimum	0.37	0.59	0.22	0.00	0.00	0.04
Labor-Intensive Industries (N = 99)						
	Q	*K*	*L*	*F*	*R*	*M*
Mean	55.88	76.86	47.33	16.43	6.78	5.66
Std. Deviation	84.92	111.65	79.69	12.69	20.72	8.56
Maximum	587.83	729.06	588.62	55.87	174.11	67.14
Minimum	0.28	0.25	0.33	0.01	0.00	0.02

Notes: *Q* = value added of industrial output, *K* = capital input, *L* = labor input, *F* = foreign direct investment (FDI), measured by the share in total capital stock in an industry, *S* = average share of foreign equity participation in a manufacturing sector, weighted by output, *R* = FDI absorptive capacity of industry, measured by products of R&D and FDI in an industry. *Q*, *K*, and *R* are in millions of the Chinese currency (RMB), *F* and *S* is in percentage, and *L* is in thousands.

Table 2 Estimates of Technology Transfers by FDI

Variable	Full Sample		Capital-Intensive Sample		Labor-Intensive Sample	
Constant (*C*)	2.15***	1.18***	2.15***	1.26***	2.17***	1.09***
	(55.99)	(12.78)	(35.69)	(9.49)	(45.75)	(8.65)
Capital Stock (*K*)		0.38***		0.47***		0.23***
		(10.46)		(7.70)		(3.26)
Labor Force (*L*)		-0.02		-0.23***		0.23***
		(-0.71)		(-3.51)		(3.69)
Direct Effects of FDI (*F*)	-0.13***	-0.11***	-0.16***	-0.13***	-0.10***	-0.07***
	(-10.58)	(-11.42)	(-8.12)	(-8.49)	(-6.88)	(-7.28)
Spillovers of FDI (*S*)	0.93***	0.60***	0.91***	0.67***	0.94***	0.51***
	(39.46)	(16.34)	(23.09)	(12.00)	(34.13)	(11.19)
FDI Absorptive Capability (*R*)	0.02**	0.01**	0.02**	0.03***	0.02	0.01
	(2.46)	(2.08)	(2.14)	(2.67)	(1.37)	(1.20)
Adjusted R^2	0.92	0.98	0.92	0.98	0.92	0.98
F-Statistic	2039***	2124***	607***	923***	1053***	1655***
Sample (*N*)	178	178	79	79	99	99

Notes: The dependent variable is value-added of industrial output (*Q*) in an industry. Figures in parentheses are t-statistics. The asterisks *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

Appendix: List of Industries in the Sample by 37 Sectors

1 Coal
Coal extraction
Coal washing
2 Crude oil
Crude oil extraction*
3 Iron mining
Iron mining*
Other mining industries
4 Metal mining
Heavy metal mining
Light metal mining
Precious metal mining
Rare metal mining
5 Non-metal mining
Stone mining
Chemical mining
Salt mining
Other non-metal mining
6 Timber
Timber & timber transporting
7 Food processing
Grain & feed material processing*
Vegetable oil processing*
Sugar processing*
Meat & egg processing
Aquatic product processing*
Salt processing*
Other food processing*
8 Food producing
Candy & cakes*
Dairy products*
Canned food
Yeast products*
Cooking sauces
Other food products*
9 Beverage
Alcohol*
Soft drink
Tea products
Other beverage
10 Tobacco
Tobacco leaf*
Cigarette*
Tobacco processing
11 Textiles
Fiber material processing
Cotton textiles
Woolen textiles
Linen textiles
Silk textiles
Knit products
Other textiles*
12 Clothing
Clothes
Hats
Footwear
Other fiber
13 Leather
Leather tanning*
Leather & leather products*
Furs & products
Feather products
14 Timber
Timber processing
Man-made board
Wood products
Bamboo & cane products
15 Furniture
Wood furniture
Bamboo furniture
Metal furniture
Plastic furniture*
Other furniture*
16 Paper
Paper pulp
Paper processing
Paper products
17 Printing
Printing
Copying*
18 Stationery and toys
Stationery products
Sports products*
Musical instruments
Toys
Game equipment
Other products excluding toys
19 Oil processing
Crude oil processing*
Petroleum products*
Petroleum refining
20 Chemicals
Basic chemical material
Chemical fertilizer
Agricultural chemicals*
Organic chemicals*
Synthetic materials*
Special chemical products*
Daily used chemical products*
21 Pharmacies
Chemical pharmaceutical preparation*
Chemical pharmaceutical products*
Chinese medicine processing*
Medicine for animals*
Biological products*
22 Chemical fibers
Chemical fibers*
Synthetic fibers*
Fishing tools*
23 Rubbers
Rubber tire products*
Special tire products
Rubber belt & tubes
Rubber spare parts
Recycling rubber products
Rubber footwear products
Daily used rubber products
Rubber product repair
Other rubber industries
24 Plastics
Plastic film*
Plastic board & tube*
Plastic strings & knitting

products
Foamed plastic & synthetic leather*
Plastic packaging materials & containers*
Plastic footwear products
Daily used plastic products*
Plastic spare parts*
Other plastic products*

25 Non-metal minerals
Cement products*
Cement & asbestos products
Brick & light building materials
Glass & glass products*
Pottery products
Fire resistance products
Gypsum products
Mineral fiber products
Other products excluding mineral non-metallic products

26 Iron refining
Refining iron
Refining steel*
Steel processing*
Refining Iron alloy

27 Metal refining
Heavy metal refining*
Light metal refining*
Precious metal refining
Rare metal refining*
Ferrous metal alloy
Ferrous metal processing*

28 Metal products
Metal structure
Iron casing tubes
Metal tools
Metal containers & packaging materials*
Metal wires
Metal products for construction
Metal surface processing
Daily used metal products
Other metal products

29 Machinery
Boilers & engines
Metal processing machinery
General equipment
Bearing & valve
Others in general spare parts
Forging products*
General industrial machinery & equipment
Other ordinary machinery

30 Special equipments
Special equipment for refining & mining
Special equipment for petroleum
Special equipment for textiles
Equipment for agriculture, forestry & fishing
Medical equipment*
Other special equipment
Special equipment machinery repair

31 Transportation
Equipment for railway transporting*
Automobiles*
Motorcycle*
Bicycles*
Shipping
Aerospace*
Transport equipment repair
Other transport equipment

32 Electrical machinery
Electrical machinery
Equipment for controlling & transmitting electricity
Electrical industrial apparatus*
Daily used electrical equipment*
Lighting equipment
Electrical equipment repair
Other electrical machinery

33 Electronics
Communications equipment*
Radar equipment
Radio & TV equipment*
Electronic computers*
Electronic apparatus*
Electronic components*
Daily used electronic apparatus & tools*
Electronic equipment repair*
Other electronic equipment*

34 Instruments
General apparatus & meter equipment
Special apparatus & meter equipment
Electronic measurement equipment
Calculators
Office instrument machinery*
Watches & clocks
Instruments for testing of electricity& electrical signals
Other apparatus & meters

35 Electricity
Generation of electricity*
Electricity supply*

36 Gas
Gas production*
Gas delivery*

37 Water
Water supply*
Water delivery*

Note: An asterisk indicates a capital-intensive industry.

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