Trade in Equipment and Capital Quality:

Evidence from the Sino-Soviet Split

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Abstract

How does access to imported capital goods affect the quality of investment in poor countries? From 1949 to 1957, China imported most of its industrial plants from the Soviet Union, but in the late 1950s a series of political disputes ended their trading relationship. In 1960, China entered a period of autarky which persisted until 1978. In market settings, closure to capital goods imports should increase the investment-consumption price ratio. However, state-set prices barely moved from 1952 to 1978. When prices are fixed, quality changes provide an alternative adjustment mechanism. I analyze plant-level data for the iron and steel industry covering 1949 to 1978 to assess how the trade shock affected the quality of investment. Using a production function in which imported and domestically-supplied investment enter as perfect substitutes with different implicit prices, I estimate that the shift to domestic sources of capital goods increased investment costs by a factor of 10. The findings suggest that autarky severely constrained Chinese capital accumulation and income growth.

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I. Introduction

For much of the twentieth century, the dominant view among development economists and policymakers was that tariff barriers promoted the development of manufacturing industries in less developed countries (Edwards 1993). In the 1980s and 1990s, recognition that the outward-oriented developing economies in East Asia had grown faster than inward-oriented developing economies in Latin America, South Asia, and Africa led to a reappraisal of tariff-based industrialization. One of the most important features of the East Asian economies was their very high rates of real capital formation relative to other developing economies (Young 1997). Lower rates of real capital formation in countries which pursued tariff-based industrialization may have been due to distortions in the ratio of investment and consumption prices (Taylor 1998). Poor countries tend to be more efficient at producing consumer goods than producer goods. This implies that barriers to trade in these economies increase the investment-consumption price ratio as measured in PPP terms (Eaton and Kortum 2001). This is important because much of the variance in per capita income growth across countries appears to be explained by differences in the investment-consumption price ratio (Hsieh and Klenow 2007). Countries which can efficiently produce capital goods or tradable goods tend to have higher rates of capital formation and economic growth.

One key problem in the literature on how openness affects the investment-consumption price ratio and real rates of capital accumulation is the difficulty of comparing macroeconomic series across countries. Even among OECD countries, data on the capital stock is not well-adjusted for quality differences across countries and over time, and the problem is much more severe for developing countries. The literature so far has been focused on comparisons of crosscountry macroeconomic data, but it is very difficult to correct for variation in data collection methods when using these series. A large fraction of the variation in investment and consumption prices across countries and over time is likely due to changes in the quality of investment goods, and it is not feasible to account for these changes in macroeconomic studies. An alternative is to estimate quality adjustments for investment goods directly from longitudinal plant-level data. The estimates can then be used to measure the effects of shocks to openness on capital formation.

All previous studies of China's long-run economic performance have followed China's official macroeconomic series (Hsueh and Li 1999). These series imply that investment prices were approximately constant between 1949 and 1978. A major problem with the use of official investment price indices is that investment prices are computed using the prices of inputs in the producer goods sector, such as the prices of construction materials and equipment. This procedure is acceptable as long as productivity in the transformation of investment inputs into plants and equipment remains constant over time. In 1960, China shifted from overwhelming reliance on foreign sourcing of equipment and plant-design to domestic sourcing. This had a catastrophic effect on the quality of equipment: data show explicitly that a large fraction of equipment was scrapped immediately after installation. Since changes in structure and equipment quality are most likely ignored in official investment price series, their use can impart enormous biases in the measurement of the capital stock. The primary contribution of this paper is to provide rough estimates of the magnitude of these biases using microeconomic data. The results show that China's loss of access to imported capital goods led to a dramatic increase in quality-adjusted investment prices and that this price shift had a large and persistent negative effect on China's industrial development.

The remainder of this paper is devoted to the analysis of two datasets which provide evidence for quality differences between imported and domestically-produced capital goods. In the next section, I begin by offering a brief historical background which explains how China's industrial development during the period of major Soviet assistance, 1952 to 1957, differed greatly from other periods of China's historical experience. I then use production statistics and data on capital imports in 12 sectors to show that most industrial investment from 1952 to 1957 was composed of imported industrial plants. I also perform regression and factor accounting analyses which show that productivity grew much more rapidly in sectors which imported plants on a large scale. In 1960, the Soviet Union unilaterally broke off trade relations with China, and since China did not have normal trading relations with other countries, imports of foreign plants became infeasible. The third section evaluates the effects of loss of access to imported capital goods through a study of the iron and steel industry. Using annual plant-level data which covers the period from 1949 to 1978, I show that the efficiency of capital construction in iron and steel suffered a catastrophic decline after 1960 and had not recovered as of 1978. I also present growth accounting results which show that the loss of access to imported capital goods led to an overall decline in productivity. The results imply that poor performance in the industry was entirely due to negative capital-embodied technological progress. Finally, I conclude the paper with a discussion of some of the study's implications, and an exploration of promising avenues for future research.

II. Plant Imports and Productivity Growth in Chinese Industry, 1949 to 1957

When the Communists took control of China in 1949, they inherited a pre-modern economy which employed about only one to two percent of its population in modern mines and factories. Industrial employment was overwhelmingly concentrated in the coal mining, textile, and food processing sectors. Though some heavy industry had been constructed in Japanese-occupied Manchuria during the 1930s and 1940s, these facilities were largely destroyed during WWII due to the combined effects of allied bombing, sabotage during the Japanese retreat, and Soviet looting (Lardy 1995). Nevertheless, Chinese industry recovered quickly during the early 1950s, and by 1952 the output of most industrial commodities had surpassed prewar peaks realized during the early 1930s. From 1953 to 1957, China embarked on the First Five Year Plan (FFYP), an ambitious development project fueled by technical assistance from the Soviet Union and massive imports of capital goods. During these five years, China's GDP per capita, agricultural output per capita, and industrial output per capita grew at average annual rates of 6.5 percent, 1.4 percent, and 16.3 percent, respectively. The total increase in per capita output during this period was roughly equal to the entire increase realized during the preceding fifty years, and China did not achieve similar growth rates again until it began to open its economy to trade in 1978. The period is also unusual in the degree to which China relied on imported capital goods. This reliance on imports is shown in Figure 1, where I graph the share of imports of equipment in total equipment investment for 1953 to 1984. The figure shows that about half of China's investments in equipment were imported from 1952 to 1957, and that this level declined to around 15 percent from 1958 to 1977, but increased dramatically after 1978.

The success of the First Five Year Plan was principally due to the importation of technology embodied in Soviet capital goods. The core of the FFYP strategy was the importation of 156 large-scale Soviet plants, which accounted for half of aggregate industrial investment. In Table 1, I show data on output and inputs across 12 industrial sectors for 1952 and 1957, together with two estimates which provide lower and upper bounds for the share of imported plants in the capital stock.[2] The first estimate is based on investment in 101 of the large-scale plants which fell within these 12 sectors. The data give the total amount invested in each plant as of 1957, in addition to the date when foreign investment began. To estimate the amount spent on imported plants in each sector, I divide the total amount invested in each plant evenly across each year in which the plant underwent construction. This provides an estimate of the share of large-scale plants imports in the capital stock for each sector from 1952 to 1957. China also imported 228 small- and medium-scale plants from the Soviet Union, and as a result consideration of large-scale plants alone understates the true contribution of capital imports and should be regarded as a lower bound. As an alternative, I use trade statistics which give the total amount spent on imported plants by ministries of the Chinese government between 1950 and 1959. I pool investment and capital data for the ministries of chemicals, metallurgy, coal, petroleum, power, light industry, and textiles, and compute one ratio of expenditure on plant imports to the capital goods for each pooled sector. Since ministry-level expenditure data includes imports occurring in 1958 and 1959, it overstates the true volume of importations and should be regarded as an upper bound.

The data show that sectors in heavy industry relied primarily on imported plants, while light industries used primarily domestically-designed plants. In the ferrous metals, nonferrous metals, chemicals, and electricity sectors, the capital stock circa 1957 was composed almost entirely of imported plants. In the construction materials, metal processing, fuels, and pulp and paper sectors, both domestically-designed and imported plants played an important role. In the

[2] The data used in this section come from tables *in Selected Archival Materials on the People's Republic of China's Economy: Fixed Capital Investment and Construction Volume 1953-1957* (1996) and *Selected Archival Materials on the People's Republic of China's Economy: Industry Volume 1953-1957* (1996). For data on the amount of investment in imported plants built by 1957, I use information in Dong and Wu's (2004) book on the history of China's capital imports from the Soviet Union.

food processing, rubber, lumber, and textile sectors, plants relied on almost entirely on domestic capital inputs.

To assess how plant imports affected productivity change in each sector, I estimate production functions using annual sector-level data from 1952 to 1957. I include the share of large-scale imported plants in the capital stock as a proxy for the share of imported capital goods in each sector. Since the data is too limited to estimate flexible, sector-specific production functions, I impose constant returns to scale and assume that the capital and labor shares are identical across sectors. The regression specification is shown in Equation 1, where dy_{it} is the change in log gross output per worker in sector *i* in year *t*, K_{it} is the capital-labor ratio, s_{it} is the share of large-scale imported plants in the capital stock, γ_t is a time dummy which is common to each sector, dt^2 is the change in the square of the current year, and μ_i and μ_{i2} are parameters which control for linear and quadratic sector-level time trends.

$$dy_{it} = \beta \ln \frac{K_{it}(1+\theta s_{it})}{K_{it-1}(1+\theta s_{it-1})} + \gamma_t + \mu_i + \mu_i^2 dt^2 \quad (1)$$

Here, the parameter θ measures the inverse ratio of the price of capital invested in large-scale imported plants to that of investment in all other types of capital. Since I am only able to account for imports of large-scale plants, the estimates are likely to underestimate the true effect of all capital imports on productivity growth. To enable Equation 1 to be estimated as a linear regression, I use the approximation $ln(1+\theta x) \approx \theta x$ for $\theta x \approx 0$, and rewrite Equation 1 as shown in Equation 2, where dk_{it} is the change in the log capital-labor ratio and ds_{it} is the change in the share of large-scale imported plants in the capital stock.

$$dy_{it} = \beta d\mathrm{k}_{\mathrm{it}} + \beta\theta ds_{it} + \gamma_t + \mu_i + \mu_i^2 dt^2 \quad (2)$$

Equation 2 could be poorly specified because it imposes constant capital and labor shares across sectors with very different capital-labor ratios. As an alternative, I also estimate specifications which impose plausible factor shares for each industry. To do this, I set the factor shares in aggregate industry to 0.4 for capital and 0.6 for labor. I then use the 1952 capital-labor ratios in each sector to estimate the share of capital and labor costs in each industry under the assumption of constant wages and rental rates across sectors. I set the elasticities of capital and labor equal to these cost shares and use these to compute productivity. I use the observations of productivity to estimate the regression shown in Equation 3, where dA_{it} is the change in log total factor productivity, β_i is the assumed factor share in sector i, and all the other variables are the same as those defined previously.

$$dA_{it} = \beta_i \theta ds_{it} + \gamma_t + \mu_i + \mu_i^2 dt^2 \qquad (3)$$

The results from these estimations, shown in Table 2, demonstrate that capital imports had a positive and significant effect on sector-level productivity. In Specifications (1) to (3), I estimate Equation 1 under the assumption of constant capital-labor ratios across sectors. The only difference between the three specifications is the type of control for sector-level time trends. Specification (3) includes controls for quadratic time trends, Specification (2) has controls for linear time trends, and Specification (1) omits both of these controls. The results imply that expenditure on imports of large-scale plants yielded 2.8 to 3.7 times as much effective capital as other forms of investment. In Specifications (4) to (6), I estimate Equation 3 which is based on assumed factor shares. Again, the only difference across the three is the type of control used for sector-level time trends. The results here are quite similar to those in Specifications (1) to (3), and imply that investments in large-scale plants imported yielded from 2.2 to 3.1 times as much effective capital as other forms of investment.

To aid in the interpretation of results, I use Specifications (1) to (6) to construct growth accounts for aggregate, heavy, and light industry. I define the seven industries in which the capital labor ratio exceeded the median capital labor ratio in either 1952 or 1957 as heavy, and the remaining five industries as light. Imports of large-scale plants were confined to heavy industry, and the accounting exercises, shown in Table 3, indicate that they contributed two to four percentage points of annual productivity growth in this sector. Even after accounting for productivity change due to imports of capital goods, the accounting study shows very rapid residual productivity growth in heavy industry with estimated growth rates ranging from 5.9 percent to 9.3 percent per year. In light industry where plant imports were much less important, productivity growth was much slower, with estimated growth rates ranging from 1.3 percent to 2.5 percent per year. Since much of the residual investment in heavy industry was composed of imports of small- and medium-scale plants, the gap in productivity growth rates across heavy and light industries could be due to the effects of these unobserved capital goods imports.

The success of the First Five Year Plan did not last, however. Disagreements over key political and economic issues such as Khrushchev's denunciation of Stalin in 1956 and Mao's initiation of the Great Leap Forward in 1958 severely damaged the Sino-Soviet Relationship. In 1960, the Soviet Union cancelled contracts for technological aid and withdrew Soviet engineers and administrators from China. Many Soviet-led projects were left in an unfinished state and frequently the Chinese lacked even the blueprints necessary to complete these projects. The results presented thus far suggest that this political break would have an adverse impact on

China’s subsequent industrial development. In the next section, I use annual panel data from the Chinese iron and steel plants to measure this effect in one industry.

III. Implicit Prices of Imported and Domestic Investment Goods in Iron and Steel

This section uses plant-level data to measure the relative efficiency of domestic and imported capital goods in the iron and steel industry. The results show that domestically produced capital goods were grossly inferior to imported ones and imply that closure to capital imports greatly undermined China’s economic performance from 1960 to 1978. Before discussion of the estimation strategy, it is useful to quickly review the history of China’s iron and steel industry from 1949 to 1978.

From 1949 to 1957, the Chinese iron and steel capital stock grew at a rate of over 20 percent per year, and nearly all of this new investment was imported from the Soviet Union. Aggregate statistics show that total factor productivity in iron and steel grew at around 10 percent per year between 1952 and 1957, indicating that the new imported plants were transforming technology in the industry (Clark 1973, Jefferson et al. 1990). In 1958, planners shifted from a focus on technology imports to a two-track development strategy, called the Great Leap Forward, which developed both modern plants and plants based on traditional technology. This approach seemed attractive because capital goods for the traditional plants could be supplied domestically. Unfortunately, these plants were extremely inefficient and the pace of their expansion exceeded China’s capacity to supply labor and raw materials. Between 1957 and 1958 aggregate employment in iron and steel increased from around 400,000 to 4 million. Withdrawal of labor from agriculture caused a massive famine which discredited the use of traditional technology and by 1963 nearly all of the traditional facilities had been scrapped

(Clark 1973). Since China had only very limited access to foreign technology markets after 1960, investment efforts from 1963 to 1978 shifted to the installation of domestic copies of Soviet capital goods. Concurrently, the industry's aggregate total factor productivity levels declined, and by 1978 these levels were significantly lower than they had been in 1957 (Jefferson et. al 1990).

I use plant-level data to assess the role of changes in the quality of capital goods in this productivity deterioration. The data come from internally published government statistical manuals printed in 1979 and 1990. The 1979 data, *Smelting Industry Enterprise Financial Statistical Materials, 1949-1978* (1979), provide firm-level information on gross output in current prices, gross revenue in current prices, annual investment, profit, total production costs, and employment at 111 large-scale plants which operated in 1978. These data suffer from a very high rate of typographical errors, but the numbers they report are consistent with those in other sources and the errors appear to be inadvertent.[3] To correct erroneous observations, I exploit redundant information in the dataset which allow investment, output, and profit to be calculated using several different series.[4] In the case that the different series fail to be internally consistent, I retain whichever observation seems most plausible in light of relationships with other variables in the dataset. The 1990 data, *Chinese Smelting Industry Labor and Wage Statistics, 1949-1988* (1990), provide comparatively accurate information on output in constant 1980 prices, total wages in nominal prices, and total employment. Since I believe the 1990 data to be more reliable, I use this source for data on output, labor, and wages, and rely on the 1978 data for total

[3] For a list of some additional sources of plant-level data, see my previous paper, "Short-run Incentives and Myopic Behavior: Evidence from State-owned Enterprises in China."

[4] For example, the data report the ratio of profit to gross output and the ratio of profit to cumulative past investment. Cross-referencing these redundant series with the raw profit, output, and investment data allows for the correction of the vast majority of errors in the dataset.

production costs and information on the capital stock.[5] I calculate material costs as the difference between the total production cost recorded in the 1979 data and the total wage expenditure recorded in the 1990 data.[6]

Based on casual inspection of the plant-level data, it is obvious that the plants constructed after 1957 performed worse than the older generation of plants constructed with Soviet aid. To show this, I graph the mean rate of return on total gross investment for the two groups of plants in Figure 2. The older generations of plants are profitable in every year from 1949 to 1978, and typically earn returns on total gross investment of around 10 to 20 percent. The newer plants make losses in most years, and suffer average annual losses on total gross investment of around negative 4 percent. Since all plants faced the same state-set prices for output and materials and drew from a similar population of workers, differences in capital quality are the most plausible reason for these performance disparities.

To estimate the relative efficiency of capital goods in the two groups of plants, I divide each firm's past investment into two components. The first component, denoted K_{it}^{49-57}, is the sum of all past investment occurring between 1949 and 1957.[7] The second component, denoted K_{it}^{58-78}, is the sum of all past investment occurring between 1958 and 1978. I expect that the quality of the 1949-1957 investment greatly exceeded that of the 1958-1978 investment and I use

[5] Since plant closures and mergers were extremely rare during the 1980s, I am able to match 110 out of the 111 plants from the 1979 data with the 1990 data. I perform the matches based on the name and location of the plants, and I also compare the output data in 1980 prices with the data on output in current prices from 1949 to 1978. The comparison shows that official prices were very stable throughout this period.

[6] In some cases, large year-to-year changes in the ratio of total production costs to gross output suggest errors in the total production cost series. Total production costs only appear once in the dataset and thus it is impossible to check them for errors. Where I suspect errors, I replace the total production cost observations with the difference between gross revenue and profit. For the vast majority of observations, the gap between gross revenue and profit is within a few percentage points of the figure for total production costs.

[7] For firms which began construction after 1957, I define $K_{it}^{1949-1957}$ as zero.

this division to test this hypothesis. Since I include fixed effects in the regressions, identification of the relative efficiency of the two types of capital comes from differences in the effects of new investment on the older and newer plants. Among older plants, the addition of substandard capital goods to the capital stock lowers total factor productivity. For newer plants, the capital stock is already substandard and thus new investment should not affect productivity. This difference in the effects of new investment across cohorts allows vintage effects to be identified separately from time effects and firm age effects.

The treatment of depreciation is important here because it affects estimates of the relative performance of firms using newer and older capital. In general, the estimated TFP of firms using older capital equipment increases with the assumed depreciation rate. Given the imperfect quality of the dataset, it makes sense to adopt a conservative depreciation assumption which biases the procedure against finding that the older, imported capital goods were more productive. Accordingly, I assume a depreciation rate of zero. Since 1950s-era imported equipment still formed the core of many firms' capital plant in the 1980s, and continued to be used even into the 1990s (Steinfeld 2000), the true depreciation rate for these goods was probably quite low. It seems preferable to use a lower bound than to assume an arbitrary number which might generate a spurious finding.

The objective of the analysis here is to estimate a parameter $\theta \in [-1, \infty)$, which is the ratio of the value of the new vintage per unit of investment to that of the old vintage minus one. To estimate θ, I embed the two vintages in a gross value Cobb-Douglas production function, which is shown in Equation 3.

$$y_{it} = \beta_k \ln\left(K_{it}^{58-78} + (1+\theta)K_{it}^{49-57}\right) + \beta_l l_{it} + \beta_m m_{it} + \omega_i + \gamma_t + f(a_{it}) + \varepsilon_{it} \quad (3)$$

In Equation 3, y_{it} is log of the gross value of output measured in 1980 prices, l_{it} is log employment, m_{it} is log material costs in current prices, ω_i represents a fixed effect which captures both productivity differences and firm-specific price distortions, γ_t represents a time dummy, $f(a_{it})$ represents a flexible function of the firm's age, a_{it}, and ε_{it} is an error term. On average, material prices did not vary significantly between 1949 and 1978 and the use of current prices as opposed to constant prices is unlikely to have a significant effect on the estimates. The age function, shown in Equation 4, is meant to capture learning by doing within firms, and is included as a control for an alternative reason why older firms might be more productive than younger firms.

$$f(a_{it}) = \alpha_0(2 \leq a_{it} \leq 3) + \alpha_1(4 \leq a_{it} \leq 10) + \alpha_2(11 \leq a_{it} \leq 20) + \alpha_3(21 \leq a_{it}) \quad (4)$$

To allow Equation 3 to be estimated in a linear regression framework, I use the approximation, $ln(1 + \theta x) \approx \theta x$ for $\theta x \approx 0$, and rewrite the capital term in the production function as shown in Equation 5.[8]

$$\ln\left(K_{it}^{58-78} + (1+\theta)K_{it}^{49-57}\right) \approx \theta \frac{K_{it}^{1949-1957}}{K_{it}^{1949-1957} + K_{it}^{1958-1978}} + \ln\left(K_{it}^{58-78} + K_{it}^{49-57}\right) \quad (5)$$

I redefine the two terms in Equation 5 as shown in Equation 6, where $\mathrm{s_{it}}$ is the share of the early vintage in the capital stock, and k_{it} is log gross cumulative investment.

$$\mathrm{s_{it}} = \frac{K_{it}^{49-57}}{K_{it}^{49-1957} + K_{it}^{58-78}} \ : \ k_{it} = \ln\left(K_{it}^{58-78} + K_{it}^{49-57}\right) \quad (6)$$

[8] The log approximation becomes increasingly accurate as $\theta \mathrm{s_{it}}$ approaches zero. In the regressions, identification is based solely on variation in the composition of capital between 1958 and 1978. During these years, $\mathrm{s_{it}}$ is less than 0.32 for 75 percent of the observations for the cohort of firms founded prior to 1958. Accordingly, the linear approximation should be reasonably accurate. I also estimated second-order approximations which yield similar results, but I do not report them for brevity.

I substitute the definitions in Equation 5 and the approximation in Equation 6 into Equation 3 to yield the linear regression shown in Equation 7. I present parameter estimates from both the fixed effects regression shown in Equation 7 and an OLS specification which omits fixed effects.

$$y_{it} = \theta\beta_k \mathrm{s}_{\mathrm{it}} + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_i + \gamma_t + f(a_{it}) + \varepsilon_{it} \qquad (7)$$

One potential concern in the estimation of Equation 7 is that other unobserved shifts in economic policy could also have affected the productivity of capital construction. The most important policy change was a shift in the location of investment over time. During the 1960s and 1970s, the focus of investment shifted from more industrialized regions in the Northeast to less industrialized regions in Southwest China. Investment in urban provinces, which had been minimal during the 1950s, also increased at this time. To capture regional productivity effects, the OLS regression includes dummies for the Northeast region, the Southwest region, and urban provinces.[9]

These fixed regional effects may be inadequate if regional productivity varies over time. To eliminate bias introduced by possible time-varying regional differences, I estimate a specification which measures the dependent and independent variables as deviations from province-year means. The specification is shown in Equation 8, where j indexes the firms in province J, the superscript j indicates deviations in each variable from the provincial mean, J_t is the total number of these firms at time t, and ν_{it}^j is a redefinition of the error term which incorporates the average fixed effect of other firms in the province at time t.

$$y_{it}^j = \theta\beta_k \mathrm{s}_{\mathrm{it}}^{\mathrm{j}} + \beta_k k_{it}^j + \beta_l l_{it}^j + \beta_m m_{it}^j + f\left(\boldsymbol{a}_{it}^j\right) + \omega_i + \nu_{it}^j : \ \nu_{it}^j = -\frac{1}{J_t}\sum_{j=1}^{J_t}\omega_j + \varepsilon_{it}^j \ (8)$$

[9] I define the Northeast as Inner Mongolia, Heilongjiang, Jilin, and Liaoning. I define the Southwest as Guangxi, Guizhou, Sichuan, and Yunnan. The major city dummy includes Beijing, Shanghai, and Tianjin.

To deal with serial correlation in ν_{it}^{j}, I estimate Equation 8 using first-differences rather than fixed effects.[10]

Another potential concern is the presence of price distortions which vary across firms producing different types of products. In the Chinese economy, raw materials prices tended to be set at very low levels, so that firms engaged in mining and the early stages of raw material processing were on average less profitable than those producing finished goods. These effects are controlled for with fixed effects if price distortions are constant over time, but could bias the results if they vary over time. To remove potential bias associated with changes in relative prices, I divide firms in the dataset into 12 groups which correspond roughly to 4 digit ISIC codes, and redefine the dependent and independent variables as deviations from category-year means. This specification is identical to Equation 8 except that product types are used as the grouping variable instead of provinces, and it is also estimated in first-differences.

A remaining problem in the estimations which I am unable to address is correlation between the use of material and labor inputs and the firm's unobserved productivity. Firms with higher productivity are likely to be assigned more labor and process more materials. This generates upward bias in the coefficients on variable inputs such as materials and labor, and downward bias on less flexible inputs such as capital and the vintage of equipment. Structural methods of correcting for this problem, such as those introduced in Levinsohn-Petrin (2003) and Olley and Pakes (1996), are based on the assumption that firms choose inputs to maximize profit

[10] ν_{it}^{j} is serially correlated because it includes the average fixed effects for all firms in the province at time t. Except for years where a new firm enters the unbalanced panel, these average fixed effects are identical to the average fixed effects for the previous year and thus movement in the error term is likely to follow a random walk. Under random walk autocorrelation, estimation in first-differences is preferable to estimation with fixed effects because it reduces downward bias in standard errors.

and operate in common input markets. In planned economies, firms' maximization criteria deviate significantly from profit maximization and it is not clear that these methods are appropriate. An alternative is the use of dynamic panel estimators due to Arrelano and Bond (1991). These estimators use firms' lagged input levels as an instrument for current changes in input use, and are based on the assumption that firms' past input choices are uncorrelated with future changes in their productivity. This assumption is also implausible in a planned economy setting.[11] Accordingly, I employ the OLS, fixed effects, and first-difference estimators because these seem the best suited to the dataset at hand. Importantly, the upward bias in variable input coefficients implicit in these estimators is likely to work against the finding of a significant, positive coefficient on inputs which vary slowly over time such as the vintage composition of capital.

Regression estimates shown in Table 4 demonstrate that imported capital goods were of much higher quality than domestic imitations. In Specification (1), I report OLS estimates of Equation 7. This regression suffers from the common problem of downward bias in the capital coefficient, which is estimated to be very close to zero. Despite this evidence of downward bias in the estimated effects of fixed inputs, the estimator does generate a significant and very large estimate of the effect of early vintage capital on output. The estimate implies that a 10 percent increase in the share of high quality capital would increase output by 0.09 log points. In these regressions, estimates of the parameter θ, are equal to the estimated effect of the vintage share on log output divided by the estimated capital elasticity of output. In Specification (1), the small

[11] In state-owned industry labor allocations are irreversible and tend to increase when firms reveal themselves to be productive. Since the accumulation of redundant labor decreases firm's future productivity, past input allocations are correlated with future changes in productivity. This correlation violates the assumptions of the dynamic panel class of estimators.

size of the estimated capital elasticity inflates the estimate of θ, and an implausibly high value of 60 is obtained. This would imply that one yuan of investment in 1949-1957 yielded as much capital as 61 yuan of investment in 1958-1978.

In Specification (2), I include fixed effects in the regression. The estimated effects of vintage on output are very similar to Specification (1), and again imply that a ten percent increase in the share of high quality capital would increase output by 0.09 log points. The only important difference between the two specifications is the estimate of the capital coefficient, which is now positive and significant, but may still be biased downwards. The estimate of the parameter θ in Specification 2 implies a ten-fold difference in the quality-price ratio of the two vintages, but the coefficient may be biased upwards if the capital coefficient is biased downwards. While this is a valid concern, the parameter estimates here are very similar to those in other studies of the Chinese iron and steel industry. For example, Kalirajan and Yong (1993) use cross-sectional data from 1988 to estimate a stochastic frontier Cobb-Douglas production function and obtain the following coefficient estimates: 0.45 for materials, 0.29 for labor, and 0.14 for capital. These are quite similar to the estimates reported in Specification (2) and the use of these alternative estimates would not significantly affect the results.

In Specifications (3) and (4), I show that the results are robust to controls for variation in provincial productivity over time (Specification 3) and variation in relative prices over time (Specification 4). Parameter estimates in these specifications are very similar to those in Specification (2), and this indicates that changes in plant locations and in the relative prices of different product groups are not important sources of bias.

In Table 5, I use the results from Specifications (1) through (4) to decompose total factor productivity change into capital-embodied and disembodied components. This accounting exercise sheds light on why Chinese economic performance was poor during the 1960s and 1970s, but dramatically improved after China resumed large-scale imports of capital goods in 1978. The results show that Chinese iron and steel firms' disembodied productivity increased by between 85 and 112 log percentage points between 1953 and 1978, which implies an annualized productivity growth rate of around four percent. However, over this same period, the shift in vintage composition decreased capital-embodied productivity by between 83 and 117 log percentage points. This decline completely offset growth in disembodied technology, leaving the average firm no more productive in 1978 than it had been in 1953.

The distinction between embodied and disembodied technological progress is very important because they imply different predictions about future performance. If poor performance was due to domestic production of capital goods, then one would expect renewed imports of capital goods to generate rapid productivity growth after China opened to trade in 1978. Though I have yet to analyze data from this period, results from other studies suggest that this occurred. From 1980 to 1985, China imported 43 percent of its investment iron and steel equipment, so capital quality should have improved significantly during this period. Jefferson (1990) reports that total factor productivity grew at a rate of 2.5 percent per annum from 1980 to 1985, indicating a reversal of adverse productivity trends experienced from 1958 to 1978. During the 1980s and 1990s, iron and steel firms imported foreign technologies. For example, by 1997, 73 percent of the China's steel output was smelted in basic oxygen furnaces, a 1960s-era technology which arrived in China in the early 1980s. From 1988 to 1997, aggregate total factor productivity continued to improve, growing at a rate of around three percent per year (Ma et al. 2002).

Most studies argue that productivity growth in Chinese industry accelerated during the 1980s and 1990s because reforms made state-owned firms more autonomous and market-oriented. However, the one study which measured the autonomy and market-orientation of state-owned firms directly, Groves et al. (1994), failed to find any significant relationship between these variables and productivity. My findings suggest that the quality of the capital stock was of overwhelming importance to firm productivity, and that imports of capital goods could explain major productivity improvements during the 1980s and 1990s even in the absence of any type of management reform. Shifts in the effects of vintage on factor productivity over time provide evidence which corroborates this story. Circa 1978, firms with newer capital goods had grossly inferior productivity to firms with older capital goods. Ma et al. (2002)'s analysis of firm-level data from 1995 shows that this relationship had reversed by the 1990s, which is what one would expect given the resumption of capital imports.

IV. Conclusion

This paper has shown that imports of capital goods during the 1950s made a tremendous contribution to the development of a wide range of industries. In the iron and steel industry, the shift to the installation of domestic capital goods production explains poor performance during the 1960s and 1970s. Moreover, the results predict that replacement of the capital stock during the 1980s and 1990s would dramatically improve performance even in the absence of other changes in state-enterprise policy. The broader significance of these results depends on whether they extend to other sectors of state-owned industry. If other sectors of industry experienced similarly large increases in investment costs during the 1960s and 1970s, then loss of access to capital imports could explain much of the variation in China's long-run industrial performance. Importantly, the finding that total factor productivity grew during the 1960s and 1970s, but that extensive growth was constrained by a lack of access to imported capital goods suggests a new interpretation of China's growth acceleration after 1978. Growth accounting studies have shown that rapid growth in China's economy was driven by high rates of real accumulation and that growth in total factor productivity played only a minor role in growth in per capita output. Since Chinese planners did their utmost to maximize investment during the 1960s and 1970s, the causes behind the acceleration in China's real accumulation rate are unclear. The findings here suggest that the acceleration in real accumulation could have been caused by a fall in the investment-consumption price ratio when China resumed large-scale imports of capital goods. Future work should try to verify this by extending the analysis of iron and steel into the 1980s and 1990s and collecting long-run plant-level data for other industries.

A final important point to make is that other developing countries have also experienced major fluctuations in access to imported capital goods during the twentieth century. For example, India imposed administrative regulations which prohibited the import of capital goods with domestic substitutes, while many countries in Latin America imposed very high tariffs on imports of producer goods. Another path for future work would be to compare the effects of shocks to openness across countries, and in particular, to explore how they vary as a function of country's level of development. One would expect the most extreme negative effects in countries which lacked the capacity to produce modern capital goods without foreign assistance.

FIGURES AND TABLES

Figure 1: China's Imports of Capital Equipment, 1953-1984

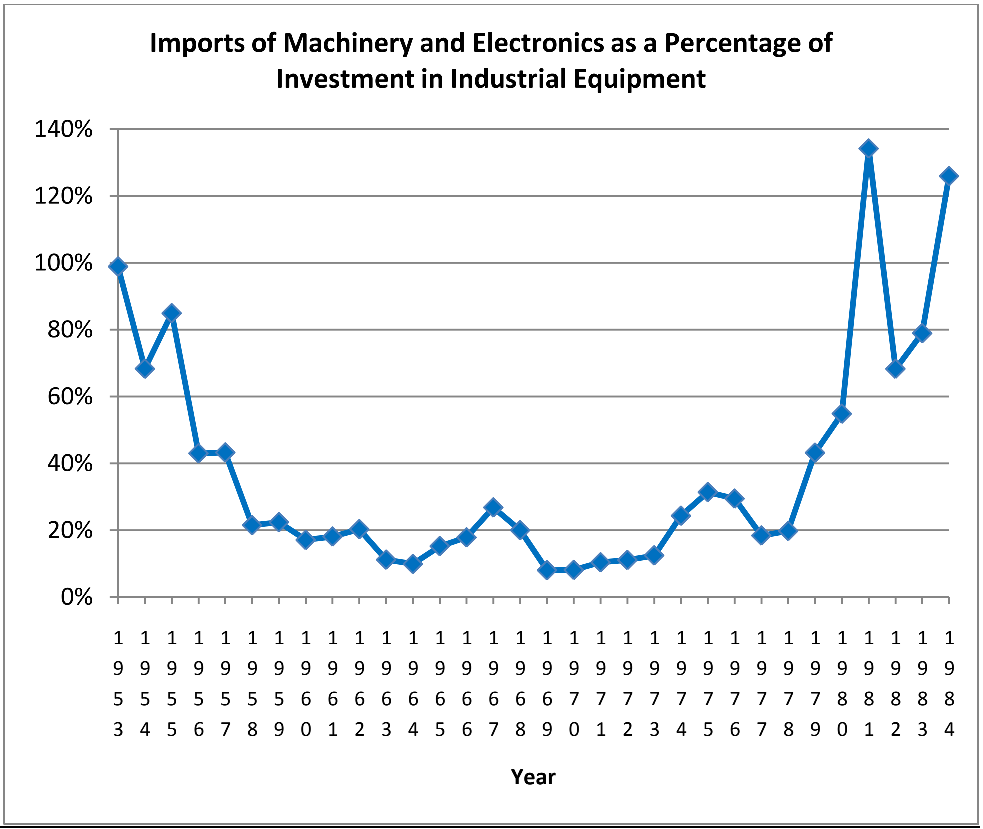

Figure 1 shows that China's openness to imports of capital goods underwent a major negative shock in 1958 and a positive shock in 1978. The figure graphs the percentage of installations of industrial equipment accounted for by imports of machinery. From 1953 to 1957, an average of 68 percent of China's equipment investment can be accounted for by machinery imports. From 1958 to 1978, this figure decreased to an average of 18 percent, and recovered only in 1979. The data may overstate growth in capital goods imports after 1978 because they include imports of consumer electronics in the numerator. Consumer electronics imports may have been significant after 1978, but were likely negligible in earlier years. The data are taken from *Chinese Machinery and Electronics Industrial Statistical Materials, 1949-1984* (1985), which also records of purchases of complete plants by industry. The data indicate that several purchases of complete iron and steel plants occurred prior to 1958 and after 1977, but than none occurred in the intervening period. Data on imports of equipment by industry are unavailable, but work using by Clark (1973) using CIA digests of Chinese newspapers suggests that iron and steel machinery imports were negligible from 1960 until at least 1970. Accordingly, I assume that all capital installed between 1958 and 1960 was produced domestically.

Figure 2: Mean Returns to Gross Investment By Cohort

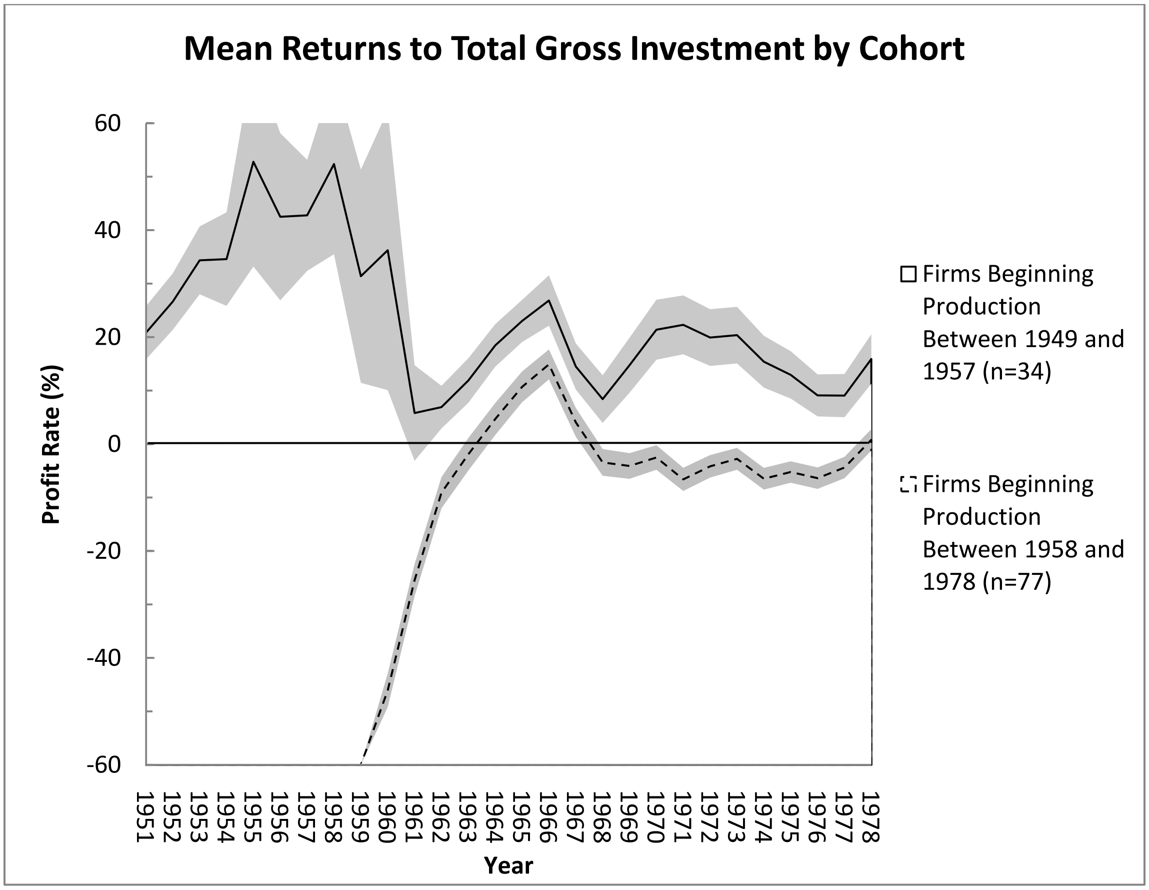

Figure 2 shows mean firms' rates of returns to total gross investment by their date of entry into production. The solid and dotted lines show mean returns in each year and the shaded region shows a standard deviation interval around the estimated mean. Firms which benefitted from investment during the period of Soviet technological assistance (1949-1957) remained profitable throughout the 1950s, 1960s, and 1970s. However, their profit rates tended to decline over time due to the addition of domestic investment goods to their capital stocks and the depreciation of their imported equipment. Firms which entered production after China embarked on its self-reliance technology policy (1958-1978) were usually loss-making.

Table 1: Output, Labor, Capital, and Capital Goods Imports Across Industrial Sectors, 1952-1957

Industrial Sector (1)	Year	Gross Output 1952 Prices (10^9 Yuan) (2)	Labor (10,000s) (3)	Capital (10^9 Yuan) (4)	Share of 101 Large Scale Soviet Complete Plants in Capital Stock (5)	Ratio of Total Expenditure on Imports of Soviet Plants up to 1959 to 1957 Capital) (6)
Heavy Industry						
Chemicals K 46% L 54%	1952	9.1	12.3	5.2	0%	---
	1957	44.3	26.6	9.4	36.5%	122%
	Annual Growth	37.2%	16.7%	12.5%	---	---
Electricity K 85% L 15%	1952	4.3	7.4	20.8	5.0%	---
	1957	10.9	11.4	41.5	23.8%	110%
	Annual Growth	20.4%	9.0%	14.8%	---	---
Ferrous Metals K 60% L 40%	1952	13.9	21.2	15.8	12.9%	---
	1957	52.4	38.7	43.7	60.5%	105%
	Annual Growth	30.4%	12.8%	22.6%	---	---
Fuels K 45% L 55%	1952	10.9	55.7	22.7	7.2%	---
	1957	27.5	76.6	49.2	19.3%	34%
	Annual Growth	20.3%	6.6%	16.7%	---	---
Metal Processing K 37% L 63%	1952	39	89.2	25.9	0.2%	---
	1957	143	173.6	79.6	20.7%	46%
	Annual Growth	29.7%	14.2%	25.2%	---	---
Nonferrous Metals K 37% L 63%	1952	6.3	10.6	3	21.5%	---
	1957	20.2	21.2	13.9	72.2%	105%
	Annual Growth	26.2%	14.9%	35.9%	---	---
Pulp and Paper K 48% L 52%	1952	7.6	7.7	3.5	0%	---
	1957	18.2	11.1	6.7	14.3%	14%
	Annual Growth	19.1%	7.6%	13.9%	---	---
Light Industry						
Construction Materials K 19% L 81%	1952	7.8	35.1	4.1	0%	---
	1957	18.8	54.9	8.6	0%	29%
	Annual Growth	20.2%	9.4%	16.0%	---	---
Food Processing K 27% L 73%	1952	81.4	60.8	11.1%	0%	---
	1957	152.4	93.5	21.7%	0%	4%
	Annual Growth	13.4%	9.0%	14.4%	---	---
Lumber K 11% L 89%	1952	22.3	26.2	1.6	0%	---
	1957	42.4	42.1	7.4	0%	8%
	Annual Growth	13.7%	10.0%	35.8%	---	---
Rubber K 36% L 64%	1952	5.9	4.7	1.3	0%	---
	1957	11.8	6.6	2	0%	4%
	Annual Growth	14.9%	7.0%	9.0%	---	---
Textiles K 35% L 65%	1952	94.3	97	25.2	0%	---
	1957	142.5	131.5	42.5	0%	1%
	Annual Growth	8.6%	6.3%	11.0%	---	---
Aggregates						
Heavy Industry K 51% L 49%	1952	91.1	204.1	96.9	5.6%	---
	1957	316.5	359.2	244	31.5%	97%
	Annual Growth	28.2%	12.0%	20.3%	---	---
Light Industry K 28% L 72%	1952	211.8	223.8	43.3	0%	---
	1957	368.9	328.6	82.2	0%	6%
	Annual Growth	11.7%	8.0%	13.7%	---	---

Table 1 presents growth in gross output and factor inputs in state-owned industry across 12 industrial sectors, and also lower and upper bounds for the share of imported plants in each sector. To show that China pursued different technology policies in heavy and light industry, I divide the 12 sectors into heavy and light based on their capital-labor ratios. The 7 sectors with capital labor ratios greater than the median capital labor ratio in either 1952 or 1957 are classified as heavy, and the remaining 5 sectors are classified as light. In Column (1), I list the capital and labor cost shares in each industry implied by the assumption of constant returns to scale, constant wage and rental rates across industries, and capital and labor cost shares in aggregate industry of 0.4 and 0.6. The shares for each sector are calculated using the sector-level capital-labor ratios for 1952 as described in the text. Columns (2), (3), and (4) document growth in the gross value of output, the labor force, and the capital stock, and show that heavy industry developed more rapidly than light industry during this period. Columns (5) and (6) provide lower and upper bounds for the share of imported plants in the capital stock. I describe how these are calculated in the text. The data used to generate the table comes from *Selections of Materials from the People's Republic of China Economy Archive: 1953-1957, Fixed Capital Investment and Construction Volume*, (1998), *Selections of Materials from the People's Republic of China Economy Archive: 1953-1957, Industry Volume*, (1998), and Dong and Wu's (2004) book on the history of China's capital imports from the Soviet Union.

Table 2: Estimated Effects of Imported Plants on Sector Level Productivity Trends, 1952-1957

Independent Variable / Dependent Variables	Change in Log Gross Output Per Worker (1)	Change in Log Gross Output Per Worker (2)	Change in Log Gross Output Per Worker (3)	Change in Imputed TFP (4)	Change in Imputed TFP (5)	Change in Imputed TFP (6)
Change in Log Capital Per Worker (β_k)	0.21** (0.11)	0.31** (0.26)	0.42** (0.21)			
Change in Share of Imported Plant Capital in Total Capital ($\theta\beta_k$)	0.58*** (0.17)	0.57** (0.26)	0.93* (0.50)	[0.3]	[0.59]	[0.84]
Ratio of Value of Imported Plants to Other Capital - 1 (θ)	2.73** (1.24)	1.81*** (0.60)	2.17*** (0.49)	1.20*** (0.23)	1.48*** (0.31)	2.10*** (0.34)
Industry Time Trends	None	Linear	Quadratic	None	Linear	Quadratic
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
# of Observations	60	60	60	60	60	60
# of Industrial Sectors	12	12	12	12	12	12

Standard errors are clustered at the sector level. *10% Significance **5% Significance ***1% Significance

Table 2 shows regressions which demonstrate a positive relationship between growth in total factor productivity and the share of large-scale imported plants in the capital stock. The specifications all assume constant returns to scale and that the share of value-added in gross output is constant within sectors. The estimated coefficients imply that investment dollars spent on the importation of large-scale plants yielded 2.2 to 3.7 times as much effective capital per unit of expenditure as other forms of investment. In Specifications (1) to (3), I regress the change in log gross output per worker in each sector on change in the log capital-labor ratio, change in the share of capital accounted for by investment in large-scale imported plants, and time dummies. Results from Specifications (1) to (3) may be biased because they assume identical factor shares across sectors with different capital-labor ratios. As an alternative, I impute factor shares in each sector based on their capital-labor circa 1952 and the assumption of aggregate factor shares in all industry of 0.4 for capital and 0.6 for labor. I use these assumed factor shares to calculate change in total factor productivity for each sector-year observation from 1953 to 1957. In Specifications (4) to (6), I regress change in total factor productivity on change in the product of the share of imported plants in each industry and the assumed capital share, a set of time dummies, and controls for sector-specific trends. I include controls for quadratic sector-level productivity trends in Specifications (3) and (6), linear sector-level productivity trends in Specifications (2) and (5), and omit controls for time trends in Specifications (1) and (4). In general, estimated effects of imported capital on output in Specifications (4) to (6) are similar to those in Specifications (1) to (3). In specifications (4) and (6), the magnitude of the effects of imported plants on output increases when controls for quadratic time trends are added, but there is no obvious reason to prefer these estimates to those in other specifications.

Table 3: Growth Accounting For Aggregate, Heavy, and Light Industry, 1952-1957

Aggregate Industry	Table 2 (1)	Table 2 (2)	Table 2 (3)	Table 2 (4)	Table 2 (5)	Table 2 (6)
Total Annualized % Growth in Output	20.8%	20.8%	20.8%	20.8%	20.8%	20.8%
Annualized % Growth Due to Labor Input	8.5%	7.3%	6.0%	6.2%	6.1%	6.1%
Annualized % Growth Due to Capital Input	3.9%	5.7%	7.7%	7.5%	7.4%	7.4%
Annualized % Growth Due to Technology Embodied in Imported Large-Scale Plants	1.2%	1.4%	2.1%	1.5%	1.8%	2.4%
Annualized % Growth Due to TFP Residual	6.7%	5.8%	4.2%	5.0%	4.7%	4.2%
Heavy Industry						
Total Annualized % Growth in Output	26.4%	26.4%	26.4%	26.4%	26.4%	26.4%
Annualized % Growth Due to Labor Input	9.9%	8.5%	6.9%	6.4%	6.3%	6.3%
Annualized % Growth Due to Capital Input	4.4%	6.6%	8.8%	9.9%	9.9%	9.8%
Annualized % Growth Due to Technology Embodied in Imported Large-Scale Plants	2.0%	2.2%	3.4%	2.5%	3.0%	3.9%
Annualized % Growth Due to TFP Residual	9.3%	8.2%	6.1%	6.6%	6.1%	5.3%
Light Industry						
Total Annualized % Growth in Output	12.2%	12.2%	12.2%	12.2%	12.2%	12.2%
Annualized % Growth Due to Labor Input	6.3%	5.4%	4.5%	5.8%	5.8%	5.8%
Annualized % Growth Due to Capital Input	3.0%	4.5%	6.1%	3.6%	3.6%	3.6%
Annualized % Growth Due to Technology Embodied in Imported Large-Scale Plants	0%	0%	0%	0%	0%	0%
Annualized % Growth Due to TFP Residual	2.6%	1.9%	1.3%	2.5%	2.5%	2.5%

Table 3 presents growth accounts for aggregate, light, and heavy industry. Each column presents a division of output growth between increases in labor input, capital input, imported capital-embodied technology, and residual productivity growth based on regression specifications (1) to (6) in Table 4. The growth accounts show that productivity growth accounted for between 36 and 44 percent of output growth in heavy industry with the exact number varying depending on which specification is used to compute the estimate. Technology embodied in imports of large-scale plants accounted for between 18 and 42 percent of productivity growth in heavy industry, indicating that these imports made a significant contribution to China's technological development during the 1950s. Importantly, these calculations underestimate the role of capital imports because they measure the effects of large-scale imported projects relative to all other forms of investment. In heavy industry, the majority of other investment took the form of medium- and small-scale imported plants, and a more complete accounting would probably show that these unobserved capital imports contributed to productivity growth.

Table 4: Production Function Estimates for the Ferrous Metals Industry

Dependent Variable	OLS (1)	Fixed Effects (2)	Within-Province Year First-Differences (3)	Within-Product Type-Year First Differences (4)
Log Total Investment (β_k)	0.01 (0.10)	0.10** (0.05)	0.11*** (0.04)	0.10** (0.04)
Labor (β_l)	0.29** (0.13)	0.28*** (0.05)	0.37*** (0.05)	0.25*** (0.05)
Materials (β_m)	0.65** (0.07)	0.55*** (0.04)	0.54*** (0.04)	0.60*** (0.04)
Returns to Scale (β_k+β_l+β_k-1)	-0.04 (0.04)	-0.07 (0.06)	0.03 (0.04)	-0.05 (0.07)
Effect of 1949-1957 Vintage on Output ($\theta\beta_k$)	0.87*** (0.31)	0.93*** (0.26)	1.05*** (0.19)	1.23*** (0.18)
Ratio of Value of 1949-1957 Vintage to 1958-1978 Vintage (θ)	60 (371)	9.0* (4.7)	9.3*** (3.4)	12.6** (5.3)
Age 2 to 3	0.12 (0.08)	0.11* (0.06)	0.01 (0.06)	0.09 (0.07)
Age 4 to 10	0.38*** (0.13)	0.29*** (0.08)	0.05 (0.09)	0.06 (0.08)
Age 11 to 20	0.53*** (0.15)	0.27*** (0.08)	0.06 (0.09)	0.07 (0.09)
Age 21 plus	0.64*** (0.19)	0.19** (0.09)	0.03 (0.10)	0.03 (0.09)
Location : Northeast	0.07 (0.10)	[0.15]	[0.12]	[0.08]
Location : Coastal City	0.50*** (0.10)	[0.69]	[0.69]	[0.60]
Location : Southwest	-0.23* (0.13)	[-0.25]	[-0.23]	[-0.22]
Time Dummies	Yes	Yes	---	---
# of Observations	1852	1852	1531	1650
# of Firms	110	110	104	107

Standard Errors are clustered at the firm level. * 10% Significance **5% Significance ***1% Significance

Table 4 shows production function specifications estimated using firm-level data from the Chinese ferrous metals Industry. The specifications show that a 10% increase in the share of 1949 to 1957 vintages in investment was associated with an increase in total factor productivity of between 0.050 and 0.105 log points. In specifications (1) and (2), the coefficient on capital is implausibly small because positive correlation between firm's unobserved productivities and their use of variable inputs biases the estimates. More reasonable estimates—though these may still be biased downwards—are obtained in specifications (3) and (4), perhaps because the removal of location-based and product-type based differences and fixed effects reduces the variance in the firm's unobserved productivity. For comparison, the average ratios of wage and material costs to output from 1970-1978 were 84.5 percent for materials and 14.7 percent for labor, leaving a residual profit share of just 0.8 percent. Since materials, wages, and output prices were very stable throughout the period, the low returns to capital reflect the very low price-quality ratio of capital goods used during the 1970s. During the 1950s, when prices for materials, labor, and output were initially established and capital goods were of much higher quality, returns to capital were significantly higher, with factor shares averaging 53.7 percent, 17.7 percent and 28.6 percent from 1953 to 1957 for materials, wages, and the profit residual, respectively.

Table 5: Interpretation of Productivity Change in Iron and Steel from 1949 to 1978

Interpretation of Effects on Mean Log Output, Dependent Variables Evaluated at Sample Means	OLS (1)	Fixed Effects (2)	Within-Province Year First-Differences (3)	Within-Product Type-Year First Differences (4)
(a) Vintage Effect at 1953 (Mean Share = 1)	0.87*** (0.31)	0.93*** (0.26)	1.05*** (0.19)	1.23*** (0.18)
(b) Age Effect at 1953 (Mean Age = 2.8)	0.24*** (0.08)	0.19*** (0.06)	0.03 (0.06)	0.05 (0.05)
(c) Location Effect at 1953 NE = 0.27 CC=0.23 SW = 0.17	0.09** (0.05)	[0.15]	[0.15]	[0.12]
(d) Time Dummy at 1953	[set to 0]	[set to 0]	[set to 0]	[set to 0]
(e) Vintage Effect at 1978 (Mean Share = 4.8%)	0.04*** (0.02)	0.04*** (0.02)	0.05*** (0.01)	0.06*** (0.01)
(f) Age Effect at 1978 (Mean Age = 17.8)	0.54*** (0.16)	0.25*** (0.08)	0.05 (0.09)	0.06 (0.09)
(g) Location Effect at 1978 NE = 0.18 CC = 0.14 SW = 0.17	0.04 (0.04)	[0.08]	[0.08]	[0.06]
(h) Time Dummy at 1978	0.55* (0.32)	[0.88]	[0.94]	[1.11]
Mean Cumulative Productivity Change 1953-1978 By Source				
(1) Total Change in Mean Firm TFP = (2)+(3)+(4)	-0.03	-0.02	-0.11	-0.11
(2) TFP Change Due to Vintage = (e) – (a)	-0.83	-0.89	-1.00	-1.17
(3) TFP Change Due to Location = (g) – (c)	-0.05	-0.07	-0.07	-0.06
(4) Disembodied TFP Change = (4a)+(4b)	0.85	0.94	0.96	1.12
Of Disembodied TFP Change:				
(4a) TFP Change Due to Age = (f) – (b)	0.30	0.06	0.02	0.01
(4b) Residual Disembodied TFP Change = (h) – (d)	0.55	0.88	0.94	1.11

Table 5 shows a decomposition of TFP growth in ferrous metals between 1953 and 1978 based on the regressions shown in Table 4. The decomposition is created using 1953 and 1978 ‘representative firms’ which have age structures, capital vintages, and locations equal to the sample means of these variables in 1953 and 1978. TFP effects are calculated by multiplying these variables by the coefficients estimated in specifications (1) to (4) in Table 4. The results, shown at the bottom of the table, indicate a major decline in capital quality associated with China’s shift to domestic manufacture of capital goods. Row (4) shows that disembodied technological progress was positive between 1953 and 1978. Row (1) shows that these gains were offset by the productivity decline accompanying the installation of domestically produced investment goods, which is calculated in Row (2). Row (3) shows that the construction of plants in less productive regions also had a negative effect on productivity growth, but this effect is very small in comparison with the capital vintage effect.

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