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THE LONG-TERM EFFECTS OF INDUSTRIAL POLICY

Jaedo Choi
Andrei A. Levchenko

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ABSTRACT

This paper provides causal evidence of the impact of industrial policy on firms' long-term performance and quantifies industrial policy's long-term welfare effects. Using a natural experiment and unique historical data during the Heavy and Chemical Industry (HCI) Drive in South Korea, we find large and persistent effects of firm-level subsidies on firm size. Subsidized firms are larger than those never subsidized even 30 years after subsidies ended. Motivated by this empirical finding, we build a quantitative heterogeneous firm model that rationalizes these persistent effects through a combination of learning-by-doing (LBD) and financial frictions that hinder firms from internalizing LBD. The model is calibrated to firm-level micro data, and its key parameters are disciplined with the econometric estimates. Counterfactual analysis implies that the industrial policy generated larger benefits than costs. If the industrial policy had not been implemented, South Korea's welfare would have been 22-31% lower, depending on how long-lived are the productivity benefits of LBD. Between one-half and two-thirds of the total welfare difference comes from the long-term effects of the policy.

Jaedo Choi
Department of Economics and
Ross School of Business
University of Michigan
611 Tappan Street
Ann Arbor, MI 48109
jaedohi@umich.edu

Andrei A. Levchenko
Department of Economics
University of Michigan
611 Tappan Street
Ann Arbor, MI 48109
and CEPR
and also NBER
alev@umich.edu

1 Introduction

Many countries at different stages of development have engaged in activist industrial policy.[1] Indeed, policymakers across the political spectrum continue to show a keen interest in shaping the structure of the economy, evident in both the Trump trade war and the Biden administration's objectives of shoring up supply chains in key industries.[2] However, despite their historical and current ubiquity, credible empirical evidence on the long-term effects of industrial policies is still rare.

This paper estimates and quantifies the long-term effects of one of the best-known instances of industrial policy conducted on a national scale: the Heavy and Chemical Industry (HCI) Drive in South Korea between 1973 and 1979. We make two key contributions to the literature. First, using a natural experiment and unique historical firm-level data, we provide causal evidence of industrial policy's effect on firms' long-term performance. Second, we assess the long-term welfare effects of industrial policy in a quantitative general equilibrium heterogeneous firm framework.

Although the long-term effects of industrial policy are far from understood, econometric evidence remains limited for two main reasons. The first is data availability. Detailed data on these policies are difficult to obtain. Assessing the long-term effects of industrial policy requires information for the more distant past, making data collection even more challenging. The second is endogeneity. Industries or firms are not randomly targeted by the government, making it difficult to separate the causal effects of policies from confounding factors.[3] We overcome these empirical challenges by (i) constructing a novel historical panel dataset of firm-level subsidies and balance sheets, that is representative of the Korean economy and (ii) exploiting a natural experiment arising from the historical and institutional setting in which the HCI Drive took place.

South Korea's experience with industrial policy is important to understand, as it is one of the "growth-miracle" economies of the postwar era, well-known for its rapid transformation from a commodity and light manufacturing producer to a heavy manufacturing powerhouse. It has been argued that industrial policy played a central role in this transformation. However, a more complete understanding of how and how much industrial policy contributed to South Korea's development remains elusive.[4]

[1] For example, see Krueger and Tuncer (1982) for Turkey during the 1960s; Head (1994) for steel rail industry of the US between 1885 and 1915; Irwin (2000a), and Irwin (2000b) for the iron industry of the US during the late 19th century; Kalouptsidi (2018) and Barwick et al. (2019) for shipbuilding industry in China; Juhász (2018) for cotton industry in France; Criscuolo et al. (2019) for Regional Selective Assistance of the United Kingdom between 1997 and 2004; Chang (1993), Lee (1996), and Lane (2019) for the HCI Drive of South Korea during the 1970s; Rotemberg (2019) for India during the 2000s.

[2] See `https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf`.

[3] Because of these challenges, existing empirical evidence on long-term effects of industrial policy has been limited to either showing correlations at the sectoral level or focusing on a single sector or a few regions with a well-identified research design. Although the latter studies provide credible evidence, given that industrial policy is designed by policymakers at the national level, empirical evidence confined to a single sector or a few regions may provide limited scope for understanding and evaluating industrial policy at the national level.

[4] Wade (1990), Westphal (1990), Amsden (1989), and Rodrik (1995) argue that industrial policy played a significant

The main industrial policy tool employed by the Korean government during the HCI Drive was the allocation of foreign credit. Under the Foreign Capital Inducement Act, the Korean government strictly regulated domestic firms' direct financial transactions with foreign firms and only selectively allowed targeted firms to borrow from abroad. Once domestic firms got the approval to borrow internationally, the Korean government guaranteed the loan, so that the targeted firms could borrow at more favorable interest rates than those prevailing domestically.[5]

We compile information from various sources to construct a dataset of foreign credit allocations and balance sheets at the firm level. The resulting data set is representative of the Korean economy and covers the universe of foreign credits allocated to each domestic firm. Once domestic firms got approval from the government, they had to report detailed information on the loan contracts and how they plan to use the allocated credit. The reported contract information is our main data source on subsidized credit. The information is hand-collected from the national historical archives and digitized.

Our research design uses two institutional features of the HCI Drive. First, the HCI Drive was suddenly initiated in 1972 and terminated in 1979 by political shocks rather than domestic economic conditions (Lane, 2019). President Nixon declared the withdrawal of the US forces from South Korea, which heavily relied on the US troops for its defense against North Korea. In response, President Park started promoting heavy and chemical industries to modernize military capabilities and become more self-reliant in national defense. The HCI Drive ended after the assassination of President Park in 1979. Second, the HCI Drive had pronounced regional variation. It targeted the southeastern part of the country and developed industrial complexes in these regions. Most of the subsidies were allocated to firms in these industrial complexes. Our research design compares the difference between firms in the HCI and non-HCI sectors in the targeted regions to the difference in the non-targeted regions.

Our main empirical finding is that temporary subsidies had a large and statistically significant effect on firm sales as much as 30 years after subsidies ended. A firm receiving the average subsidy between 1973 and 1979 had a 919% larger sales growth between 1982 and 2009, amounting to a 8.6% higher annual growth rate over this period.[6]

The last exercise of the paper quantifies the long-term welfare impact of the HCI Drive. We set up a general equilibrium heterogeneous firm model and discipline it using the firm-level data and econo-

role in shaping South Korea's development. However, many economists have been skeptical of the effectiveness of industrial policy (e.g. Baldwin, 1969; Lederman and Maloney, 2012). Lee (1996) did not find a positive correlation between sectoral TFP growth and tariff rates in South Korea during the 1970s and interpreted the correlation as the ineffectiveness of industrial policy.

[5]Indeed, Korean firms that borrowed from from abroad paid negative real interest rates. The domestic real interest rates were very high due to the underdevelopment of the financial system during the 1970s.

[6]Between 1982 and 2009, the real GDP of South Korea grew by 578%.

metric estimates. The model rationalizes the reduced-form evidence on persistent effects of industrial policy through a combination of learning by doing (LBD) and financial constraints. There are two periods in the model. A firm's second-period productivity increases in its first-period quantity produced. However, in the first period firms are borrowing-constrained. Therefore, they cannot expand to the optimal scale to internalize the dynamic effects of LBD. Government subsidies in the first period relax these constraints, enabling firms to increase first period output, which in turn increases productivity in the second period through LBD. The model is tightly connected to the data. The key parameters of the model are pinned down by the reduced-form empirical estimates. The quantitative results imply that if the government had not conducted industrial policy, the welfare would have been 22-31% lower, depending on whether we assume that LBD-driven productivity benefits are permanent or temporary. Most of the total welfare effect (between one half and two-thirds) is due to the long-run impact of subsidies on productivity through LBD.

Related Literature. This paper contributes to the empirical literature on industrial policy (see, among many others, Weinstein, 1995; Lee, 1996; Irwin, 2000a,b; Nunn and Trefler, 2010; Kline and Moretti, 2014; Aghion et al., 2015; Alder et al., 2016; Juhász, 2018; Criscuolo et al., 2019; Giorcelli, 2019; Lane, 2019; Rotemberg, 2019; Fan and Zou, 2020; Hanlon, 2020). Harrison and Rodríguez-Clare (2010) provide a review of the literature, and of the conceptual underpinnings of industrial policy. We use the firm-level data that is representative of the national economy and estimate the effect of industrial policy on firms' long-term performance.[7] Lane (2019) studies South Korea's HCI Drive and also finds the persistent effect of the industrial policy of South Korea during the 1970s. While that paper's analysis is at the sectoral level, we study firm-level outcomes and exploit regional variation in South Korea's industrial policy for identification. Contemporaneous work by Kim et al. (2021) also uses similar firm-level balance sheet data to study the HCI Drive. While these authors focus on the relatively short-run impacts of the HCI Drive on misallocation and the plant size distribution, we estimate and quantify the long-run benefits of this policy.

We also contribute to the quantitative literature on industrial policy (see, among many others Head, 1994; Kalouptsidi, 2018; Barwick et al., 2019; Itskhoki and Moll, 2019; Liu, 2019; Bartelme et al., 2020; Lashkaripour and Lugovskyy, 2020; Buera et al., 2021). Our model rationalizes the persistent effect of industrial policy through learning-by-doing and financial frictions, and uses microdata to discipline the relevant elasticities.[8]

The rest of this paper is organized as follows. Section 2 describes the data. Section 3 presents an

[7] While we share the focus on firm-level outcomes with Aghion et al. (2015), Criscuolo et al. (2019), and Rotemberg (2019), we contribute causal estimates of the effect of industrial policies on firms' long-term performance. Giorcelli (2019) studies the long-term effect of the government's policy on managerial training.

[8] Learning-by-doing that is external to firms has been studied in the theoretical trade literature (Arrow, 1962; Krugman, 1987; Young, 1991; Matsuyama, 1992; Melitz, 2005). However, learning-by-doing in our model is internal to firms.

overview of the historical background of South Korea's industrial policy between 1973 and 1979 and discusses the natural experiment used for identification. Section 4 presents the estimation results. Section 5 builds a quantitative model consistent with the empirical findings, and quantifies the welfare benefits of the policy. Section 6 concludes.

2 Data

This section describes the construction of the data set used for the empirical and quantitative analyses. The final dataset combines firm balance sheet data, firm-level subsidy data, and region- and sector-level variables. The data set is annual and covers the period 1970 to 2012. There are 56 regions and 9 manufacturing sectors, 4 of which are classified as HCI sectors.[9] Data construction is described in detail in Appendix A.

Firm Balance Sheets. The firm balance sheet data come from three sources. For the sample period between 1970 and 1982, the information is digitized from the historical Annual Report of Korean Companies published by the Korea Productivity Center. For the period between 1982 and 2012, the data come from KIS-VALUE and FnGuide, which covers firms with assets above 3 billion Korean Won (2.65lmn 2015 USD).[10] We merge the two balance sheet datasets based on firm names. The variables include sales, assets, fixed assets, employment, and locations of establishments. We also supplement our data with chaebol status obtained from the the Center for Economic Catch-Up (CEC).[11]

Foreign Credit. The Foreign Capital Inducement Act required firms to report detailed information on financial contracts with foreign banks or companies once they get government approval. These reports are our main data source for foreign credit allocation. The documents have detailed information on amounts borrowed, interest rate, repayment period, and the names of foreign banks for each financial contract made by a domestic firm. These variables are hand-collected from the National Archives of Korea.[12] The constructed data set covers the universe of credit allocated to firms between 1966 and 1982, covering the HCI Drive period. The foreign credit data are merged with the firm-level balance sheet variables based on firm names.

[9] The 9 manufacturing sectors are chemicals, electronics, metals, machinery, food, textiles, wood, non-metallic mineral, and pharmaceuticals. Chemicals, electronics, metals, and machinery are classified as HCI sectors (Lane, 2019). Industry classification is in International Standard Industrial Classification of All Economic Activities (ISIC) Rev.3. 2-digit or 3-digit codes are aggregated up to 10 broad sectors. See Appendix Table A3 of more detail.

[10] KIS-VALUE and FnGuide cover firms that are either publicly traded or subject to external audit. The 1981 Act on External Audit of Joint-Stock Corporations requires the Korean firms with assets above 3 billion Korean Won to report balance sheet information.

[11] See Center for Economic Catch-up (2007, 2008) for more detailed descriptions of these data.

[12] Examples of the digitized financial contract documents are reproduced in Appendix Figures A1, A2, and A3.

Table 1: Descriptive Statistics of Foreign Credit Contracts

	(1) Loan Size (mln 2015 USD)	(2) Repayment Period (years)	(3) Interest Rate (%)
Mean	48.6	5.99	9.50
Std.	76.6	2.22	2.22

Notes. This table reports the descriptive statistics of approved financial contracts between domestic firms and foreign entities from 1973 to 1979. There are 538 contracts over this period, $N = 538$.

Other Regional and Sectoral Data. Trade data come from Feenstra et al. (2005), which covers the sample period between 1966 and 2000. South Korea's import tariff data are digitized from Luedde-Neurath (1986). Input-Output tables are obtained from the Bank of Korea.

Descriptive Statistics. Table 1 reports the descriptive statistics for the loan contracts between 1973 and 1979 digitized from the archives. Between 1973 and 1979, there are 538 contracts. The average size of the foreign loan is $47M 2015 USD, average repayment period was around 6.17 years, and the average interest rate was around 9%.[13] The average interest is much lower than the average deposit rate around the same time, which was around 20%.[14]

Table 2 reports the descriptive statistics of the firm balance sheet variables. Columns 1 and 2 report the average sales and employment. Column 3 reports the ratio between allocated credit and sales once a firm reports a positive amount of credit. The credit received is sizable, about 1.62 times annual sales on average. Column 4 reports the share of firm-year observations that received credit in the total observations between 1973 and 1979. About 11% of firms in the dataset ever received credit. The data set is representative of the national economy.[15]

3 Historical Background and Identification Strategy

The Korean government initiated the Heavy and Chemical Industry (HCI) Drive in late 1972. The HCI Drive strongly promoted six targeted sectors: steel, non-ferrous metal, electronics, machinery,

[13] Appendix Table A1 reports additional descriptive statistics of the credit data.

[14] Because of the underdevelopment of the financial system, many firms had to rely on illegal underground markets whose average interest rate was around 40%.

[15] On average, the sum of firms' sales in each sector covers 75% of gross output of the sector reported in the Input-Output tables published by Bank of Korea. Coverage by sector is reported in Appendix Figure A4.

Table 2: Descriptive Statistics Firm Balance Sheet Data

	(1) Sales (mln 2015 USD)	(2) Employment (thousands)	(3) Credit/Sales $\|$Credit>0	(4) Ever Received Credit (fraction)
Average	89.84	1.02	1.62	0.11
Std.	278.76	1.98	8.82	0.32

Notes. This table reports the descriptive statistics for the firm-level balance sheet data and credit. The sample is firm-years. "Credit/Sale" is the ratio of credit to sales for firm-year observations with positive amounts of credit. "Ever Received Credit" is the share of firm-year observations who ever reported positive amounts of credit between 1973 and 1979.

chemicals, and shipbuilding. We will call these sectors the HCI sectors. The HCI Drive was temporary, ending after the assassination of President Park in 1979. During the HCI Drive, the structure of the Korean economy fundamentally changed. South Korea transformed itself from a commodity and light manufacturing producer into a heavy manufacturing producer. Between 1973 and 1979, the average annual real GDP growth rate of South Korea was 10.3%, and the average export growth rate was around 28%. The HCI sectors increased their share of manufacturing output from 40% to 56% and their share of total exports from 12.9% to 37%.

Main Policy Instrument: Foreign Credit Allocation. The main industrial policy instrument used by the Korean government was directed foreign credit (Jones and Sakong, 1980; Amsden, 1989; Rodrik, 1995). The government used its discretionary power to allocate foreign credit toward targeted firms in the HCI sectors.[16] Through the Foreign Capital Inducement Act, first enacted in 1962, the Korean government restricted firms' direct foreign financial transactions to prevent deterioration of its balance of payments. However, once the government granted access to foreign credit to targeted firms, the government guaranteed those loans. The government guarantees eliminated the risks of firm default and the exchange rate depreciation. As a result, these firms could borrow at favorable – in fact, negative real – interest rates.[17] Domestic interest rates were much higher than foreign market

[16]The government nationalized the commercial banks from 1961 until the 1980s. In 1961, the Park Military Government enacted the Law for Dealing with Illicit Wealth Accumulation and ended private ownership of banks, which were deemed a part of accumulated illicit wealth. Since then, only a small fraction of banks' shares were sold publicly, and most of the shares were owned by the government, ranging from 35% to 60% during the 1970s. Also, the Temporary Law on Financial Institutions, enacted in 1961, precluded anyone from voting with more than 10% of shares of banks. Through the nationalization of the commercial banks, the government could control the lending practices and decide which industries or firms received credit. See Amsden (1989, p. 72-73) and Jones and Sakong (1980, p. 103).

[17]The Korea Development Bank, the Korea Exchange Bank, or the commercial banks controlled by the government guaranteed for foreign credit contracts. For example, Appendix Figure A3 is the first page of the official contract between Hyundai International Inc, the domestic firm, and several foreign banks. It shows that the Korea Development

interest rates because of the underdevelopment of the financial system. The average interest rate on foreign credits was around 10%, while the average deposit rate in domestic banks was around 20%. Thus, these guaranteed foreign loans constituted a subsidy.

Between 1973 and 1979, the total credits provided this way to the manufacturing firms were about $16bln 2015 US dollars, or 11.4% of the 1972 South Korean real GDP ($101B). This implies that the HCI Drive was a large-scale industrial policy at the national level. Firms used these allocated credits to purchase capital equipment and/or adopt new advanced technology.

3.1 Identifying Variation

This section describes the historical background of the HCI Drive, whose features justify the identification strategy in the econometric estimation. Our identification relies on combining time series, cross-sectoral, and cross-regional variation. First, the sectoral choices of the government and the timing of the HCI Drive were driven by the external political shocks rather than the economic environment (Lane, 2019). Second, the HCI Drive was a place-based policy that disproportionately subsidized HCI sector firms in the targeted regions.

External Political Shocks. The HCI Drive was precipitated by political shocks experienced by South Korea in the late 1960s and early 1970s. The foreign shock was the 1969 Nixon Doctrine, which altered the US foreign and defense policies with respect to Asian countries. In the doctrine, President Nixon declared that the US would restrict its military actions in Asia, and that the Asian allies should take primary responsibility for their self-defense instead of relying excessively on the US.[18] In line with the new US foreign policy, Nixon set up a plan for the full withdrawal of the US forces from South Korea. Although the full withdrawal was not implemented, by early 1971 Nixon removed one-third of US soldiers present in South Korea.[19] However, at the same time, the military tension between South Korea and communist North Korea was rising.[20] South Korea lagged behind North Korea in the size of the military, necessitating heavy reliance on the US forces for national defense against North Korea.[21] The establishment of official diplomatic relations between the US

Bank formally participated in the credit contract as a guarantor.

[18] In Guam on July 25, 1969, President Nixon said "*...in cases involving other types of aggression, we shall furnish military and economic assistance when requested in accordance with our treaty commitments. But we shall look to the nation directly threatened to assume the primary responsibility of providing the manpower for its defense...*"

[19] Nixon removed a division of 20,000 soldiers, decreasing the total US force levels to in South Korea 42,000.

[20] The South Korean government sent about 326,000 soldiers to the Vietnam war between 1964 and 1973. In exchange for South Korea's support in that war, the Johnson administration provided economic and military support to South Korea. North Korea felt threatened by the tighter bonds between the US and South Korea, increased investments in military forces, and escalated military provocations against South Korea. For example, in January 1968 North Korea sent 31 commandos to assassinate President Park. Although the attempt failed, it resulted in 31 casualties and shocked the South Korean government.

[21] South Korea's economic backwardness relative to North Korea restricted South Korea's military expenditures. According to the estimates from the Bank of Korea, South Korea's real GNP per capita was below North Korea's until

and People's Republic of China, which fought against South Korea in the Korean War, further raised South Korean government's level of national security concern (Nixon, 1967).

Faced with the Nixon Doctrine, in late 1972 President Park's administration decided to pursue a self-reliant defense strategy. Achieving it required modernization of military weapons, which necessitated the development of the HCI sectors. Therefore, the government embarked on the HCI Drive.

Place-Based Policy. The HCI Drive was place-based. The government picked nine southeastern regions of the country (Industrial Sites Development Corporation, 1978, p. 28).[22] In these targeted regions, the government developed industrial complexes and disproportionately subsidized firms in these complexes. Panel A of Figure 1 highlights the targeted regions on the map of South Korea.[23] Panel B of Figure 1 illustrates the geographic distribution of allocated foreign credit, concentrated in the southeastern region, and shows substantial though imperfect overlap with the set of targeted regions.

Figure 2 plots the distribution of credit across sectors and regions. Panel A shows total credit allocated to the HCI sector firms in targeted and non-targeted regions. After 1972, the credit going to the HCI sectors in the targeted regions dramatically increased, whereas the credit to HCI firms in the non-targeted regions rose much more modestly. Between 1973 and 1979, the total amount of credit allocated to firms in the targeted regions is about 6–7 times larger than the amount allocated to firms in the non-targeted regions on average. The figure also confirms that the industrial policy was temporary. After 1979, the HCI Drive stopped, and the total credit allocated fell. Panel B plots the sum of all the non-HCI sectors' credit in targeted and non-targeted regions. The total amount of credit allocated to firms in the non-HCI sectors is negligible compared to those in the HCI sectors. Also, there are no differential patterns between firms in targeted and non-targeted regions in the non-HCI sectors.

Figure 2 illustrates the identifying variation. It comes from comparing the difference between HCI sector firms in targeted and non-targeted regions and the difference between non-HCI sector firms in targeted and non-targeted regions.

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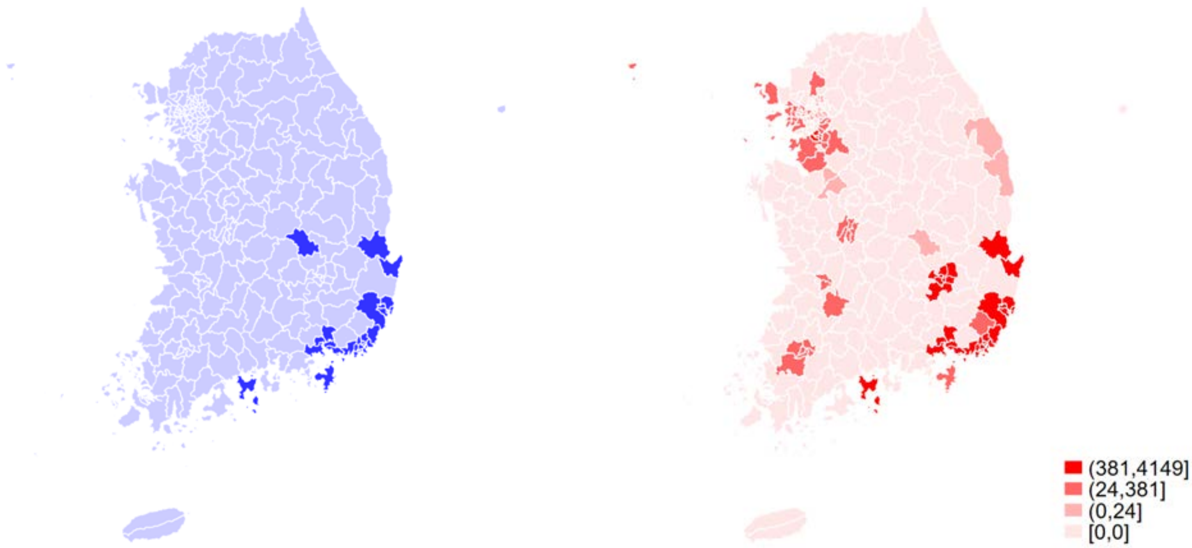
the mid-1970s. In 1972, North Korea's annual military expenditures were about 100% larger than those of South Korea (Moon and Lee, 2009). Only after the late 1970s did South Korea's military expenditures surpass North Korea's.

[22] The targeted regions are Busan, Changwon, Guje, Gumi, Jinhae, Masan, Pohang, Ulsan, and Yeosu (Yeocheon). To support the building up of the manufacturing base in these regions, the Industrial Site Development Promotion Law was enacted in 1973. The industrial complexes in Changwon and Guje were newly constructed after 1973. In other regions, the existing industrial infrastructure was expanded (see Enos and Park, 1988, p. 36). Each industrial complex has its specialized sector. See Appendix Table A2 for more on these targeted regions and complexes.

[23] One of the main reasons why these were targeted is their geographical proximity to the main port in Busan. Two main ports in Korea are Incheon and Busan. Incheon is located in the northwest, and Busan in the southeast of the country.

Figure 1. Targeted Regions and Foreign Credit Allocations

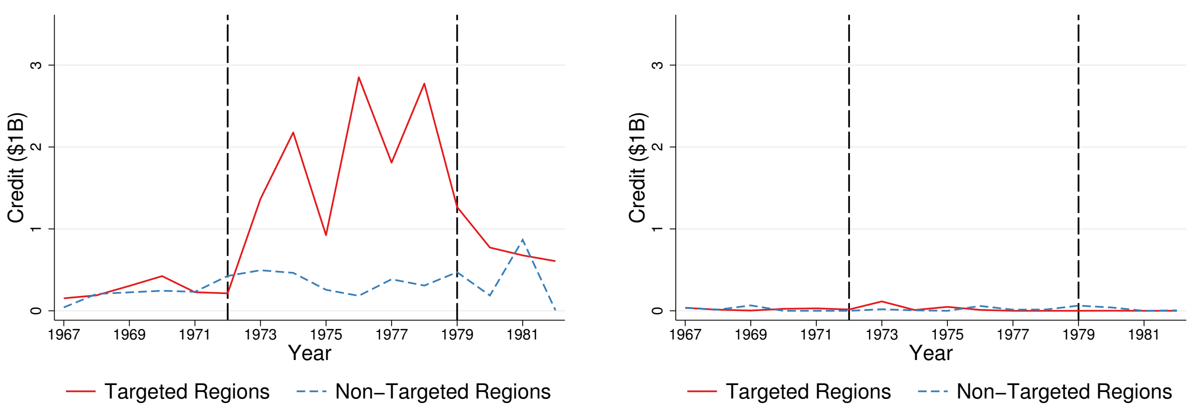


Panel A. Targeted Regions

Panel B. Foreign Credit Allocation, 1973-1979

Notes. Panel A highlights the HCI targeted regions in a darker shade. Panel B illustrates the total credit allocated to each region, in million 2015 USD.

Figure 2. Foreign Credit Allocation by Sector and Region



Panel A. HCI Sectors

Panel B. Non-HCI Sectors

Notes. These figures depict the amount of credit in billions 2015 US dollars in the HCI sectors (Panel A), and non-HCI sectors (Panel B). The vertical lines represent the start and the end of the HCI Drive industrial policy. The red solid and blue dashed line represent the sum of the total credits of in targeted and non-targeted regions.

4 Empirical Framework

To examine the effect of industrial policy on firm outcomes, we estimate the following long-difference regression model:

$$\triangle \log Sales_{fj} = \beta_1 asinh(Credit_f) + \beta_2 \log Sales_{fjt_0} + \mathbf{X}'_{fjt}\boldsymbol{\beta_3} + \delta_n + \delta_j + \epsilon_f, \tag{4.1}$$

where f denotes firm, j sector, and n region. The dependent variable $\triangle \log Sales_{fj}$ is the log change in firm sales, computed for either the 1972-1982, or the 1982-2010 period. The main independent variable, $asinh(Credit_f)$ is the inverse hyperbolic sine transformation of the sum of the total credit received by firm f between 1973 and 1979:

$$Credit_f = \sum_{\tau=1973}^{1979} Credit_{f\tau}. \tag{4.2}$$

Because a large fraction of firm observations have zero credit, we use the inverse hyperbolic sine transformation instead of logs, as suggested by Burbidge et al. (1988). This transformation allows us to include observations with zero credit, while approximating logs for larger values of the credit variable. All specifications include log initial sales $\log Sales_{fjt_0}$ and region and sector fixed effects δ_n and δ_j that absorb any region and sector common shocks. Some specifications control for additional observables $\mathbf{X}_{fjt}$. Long-differences estimation takes out time-invariant firm characteristics. The coefficient of interest is β_1. It captures how much subsidized credit increased firm sales growth. Standard errors are clustered at the regional level throughout.

OLS estimates of (4.1) may suffer from endogeneity because the government's credit allocation rule may depend on firms' unobservables. If the government selectively allocated foreign credit to firms with faster future productivity growth, the credits allocated will be correlated with the firms' unobserved productivity changes in the error term. To address this possibility, following the discussion in Section 3.1 we propose the following instrument for firm credit:

$$D_j^{HCI} \times D_n^{Target}, \tag{4.3}$$

where D_j^{HCI} is a dummy variable that takes on a value of 1 if a firm is in a sector targeted by the HCI Drive, and D_n^{Target} is a dummy variable for whether a firm is in the targeted region. The identifying assumption is that changes in firm unobservables are uncorrelated with the IV. That is, conditional on region and sector fixed effects and the other parametric controls, there were no shocks affecting differentially HCI sector firms in targeted regions.

Another potential source of bias is the sorting of new entrants. After the HCI Drive began, new firms with higher productivity may systematically enter the targeted region. This kind of positive sorting of faster-growing firms into the targeted regions may confound our estimates. Therefore, for both short-run and long-run analyses, we restrict our sample of firms to those that were already operating before the HCI Drive started.

To use the data more efficiently, we employ overlapping long differences. Because standard errors are clustered at the regional level, this is innocuous. We use two 7-year long-run differences for the short-run analysis: 1972-1981 and 1973-1982. For the long-run analysis, we use 28-year long-run differences: 1981-2009 and 1982-2010.[24] The dummies for each set of differences are included in the specifications.

4.1 Baseline Results

Table 3 presents the short-run estimated coefficients, in which the outcome variable is sales growth during and immediately after the HCI Drive, 1972-1982. Table 4 reports the long-run effects, where the outcome variable is sales growth from 1981 of 1982 (after the HCI Drive ended) to 2009 or 2010. The tables have identical structure. Column 1 reports the OLS estimates. The coefficients are significantly positive in both the short and long run. Column 2 presents the baseline second-stage IV estimates. The coefficients become larger. The IV estimate implies that one standard deviation increase of $asinh(credit)$ increases a firm's growth rate by 0.9 standard deviations between 1973 and 1982.[25] The Kleibergen-Papp F-statistic of over 30 indicates that the instrument is strong. Column 3 reports the reduced-form estimate that directly uses the IV as a regressor. The estimated coefficient implies that sales growth of the HCI sector firms in the targeted regions was 102% higher on average than the firms in the control group. The first stage results are reported in Appendix Tables B1 and B2.

Table 4 show continuing effects in the long run. The IV estimate in column 2 implies that a one standard deviation increase of $asinh(Credit)$ increases firms' sales growth by 2.7 standard deviations.

4.2 Robustness

Chaebol Status. One special feature of the Korean economy is that large business groups, chaebols, account for a large fraction of the GDP.[26] Chaebol is a large industrial conglomerate owned and

[24] One may be concerned that if very long-term contracts were made, the 2009 or 2010 sales might be affected directly by such long-term contracts. However, average repayment period was 8.9 years, so after 30 years subsidies no longer directly affect sales.

[25] The standard deviation of $asinh(Credit)$ is around 6.4 for both the short-run and the long-run. The standard deviation of sales growth is 1.36 for the short-run and 1.66 for the long run.

[26] In the mid-1980s, the top 10 chaebols accounted for 70% of the total GDP.

Table 3: Short-Run Effects of Subsidies on Firm Sales Growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.:	$\triangle \log Sales_{it}$: 1972-1981 and 1973-1982							
	OLS	IV						
$asinh(Credit)$	0.06***	0.18***		0.17***	0.18***	0.17***	0.17***	0.17***
	(0.01)	(0.04)		(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
IV			0.98***					
			(0.18)					
$\log(Sales_{t_0})$	–0.53***	–0.68***	–0.47***	–0.69***	–0.68***	–0.68***	–0.67***	–0.69***
	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
$Chaebol$				0.25				0.25
				(0.40)				(0.38)
$\triangle Export\ Demand \times Port$					–0.00			0.11
					(0.07)			(0.08)
$\triangle \log(Import\ Tariff) \times Port$						0.84		–6.21
						(2.19)		(8.70)
$\triangle \log(Input\ Tariff) \times Port$							3.16	19.43
							(3.83)	(15.88)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		39.19		36.80	42.16	37.91	40.11	43.06
Adj. R^2	0.45		0.39					
Num. Clusters	56	56	56	56	56	56	56	56
N	764	764	764	764	764	764	764	764

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1972 and 1981 or between 1973 and 1982. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle Export\ Demand \times Port$ is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle Import\ Tariff \times Port$ is the interaction between changes of import tariffs and the port dummy variable. $\triangle Import\ Tariff \times Port$ is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1972 or 1973. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table 4: Long-Run Effects of Subsidies on Firm Sales Growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.:	$\triangle \log Sales_{it}$: 1981-2009 and 1982-2010							
	OLS	IV						
$asinh(Credit)$	0.02**	0.50***		0.49***	0.47***	0.49***	0.48***	0.47***
	(0.01)	(0.13)		(0.13)	(0.11)	(0.13)	(0.12)	(0.12)
IV			1.58***					
			(0.17)					
$log(Sales_{it_0})$	–0.13**	–1.09***	–0.13**	–0.99***	–1.05***	–1.08***	–1.05***	–0.95***
	(0.05)	(0.31)	(0.05)	(0.27)	(0.26)	(0.30)	(0.28)	(0.26)
$Chaebol$				–1.38				–1.31
				(1.53)				(1.31)
$\triangle$*Export Demand* $\times$ *Port*					–0.19			0.22
					(0.26)			(0.30)
$\triangle \log$(*Import Tariff*) $\times$ *Port*						6.33		–10.01
						(5.98)		(27.21)
$\triangle \log$(*Input Tariff*) $\times$ *Port*							16.05	42.22
							(9.83)	(47.64)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		14.34		14.24	20.34	15.71	17.17	20.55
Adj. R^2	0.15		0.17					
Num. Clusters	54	54	54	54	54	54	54	54
N	738	738	738	738	738	738	738	738

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1981 and 2009 or between 1982 and 2010. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

run by a business family.[27] They were inherently different from other medium or small-sized firms in many dimensions. Chaebols were not only larger but also had a closer political connection with the government. In column 4 of Table 3 and 4, we control for a dummy variable if a firm is affiliated with the top 30 chaebols.[28] Both short-run and long-run coefficients are similar to the baseline results in column 2.

International Trade. After President Park started his first term in 1962, Korea strongly promoted export-oriented development (Westphal, 1990). Given that the targeted regions are located near one of the big ports in Korea, one might be concerned about trade-related shocks correlated with the IV. If confounding factors related to trade differentially affect the targeted regions relative to non-targeted regions, it would be a threat to identification. To show that these factors do not drive our results, we additionally control for trade-related variables.

First, we control for the interaction between the port dummies and export demand shocks. Consider the following variable:

$$\frac{\triangle EX_{jt}^{KOR}}{GO_{j,1970}^{KOR}} \times Port_n, \tag{4.4}$$

where $Port_n$ is a dummy that equals one if a region has its own port, $\triangle EX_{jt}^{KOR}$ is the change in South Korea's sector j exports to the world between 1973 and 1979, and $GO_{j,1970}^{KOR}$ is sector j's gross output in 1970.[29] Changes of export intensity $\triangle EX_{jt}^{KOR}/GO_{j,1970}^{KOR}$ capture the world demand shocks for South Korea's sector j goods. The interaction term captures the possibly heterogeneous effect of the world demand shocks across regions with and without ports. However, $\triangle EX_{jt}^{KOR}$ contains not only world demand shocks but also South Korea's supply shock of sector j, which can be correlated with unobservable productivity shocks in the error terms in Equation (4.1). Therefore, instead of controlling for EX_{jt}^{KOR} directly, we control for

$$\frac{\triangle EX_{jt}^{TWN}}{GO_{j,1970}^{KOR}} \times Port_n, \tag{4.5}$$

where $\triangle EX_{jt}^{TWN}$ is the change in Taiwan's exports to the world other than Korea. This amounts to controlling for the exogenous component of (4.4) as a reduced form.[30] Because Taiwan and South

[27] Chaebol is similar to zaibatsu, Japan's business group during the prewar period. The one key difference is whether a business group could run its affiliated banks. The zaibatsu in Japan could run their affiliated banks, which were their main source of capital. However, chaebols in Korea could not own their banks, so foreign credit allocation was an important source of capital for chaebols.

[28] The top 30 chaebol groups are listed in Appendix A.3.

[29] Busan, Changwon, Guje, Goonsan, Incheon, Masan, Mokpo, Pohang, Ulsan, and Yeosu (Yeocheon) are defined to have a port.

[30] Appendix Tables B3 and B4 report the IV estimates where (4.4) is the regressor instrumented with (4.5). In some specifications, the F-statistics are lower than 10, implying possibly weak instruments. However, the estimated coefficients are similar to those reported in Tables 3 and 4. Appendix Figure B1 graphically illustrates that export

Korea were industrialized during a similar period, their industry structure and exports growth are similar to each other, thus $\triangle EX_{jt}$ and $\triangle EX_{jt}^{TWN}$ are highly correlated with each other. The export shock does not suffer from the endogeneity problem if Taiwan's supply shocks are uncorrelated with the error terms in the second-stage regression. Also, note that common effects of changes of world demands are absorbed by sector effects.

Changes in import tariffs also may differentially affect the intensity of foreign competition across regions with and without ports. Because foreign competitors do not have to incur additional within-country trade costs when selling their products in regions with ports, with lower import tariffs they may have larger cost advantages than when selling in regions without ports. We control for the interaction term between the import tariffs interacted with the port dummies:

$$\triangle \log \text{Import Tariffs}_{jt} \times Port_n, \tag{4.6}$$

which allows firms in regions with ports to experience differential impacts of changes of import tariffs.

We also control for the interaction between the changes of input tariffs and the port dummies. Input tariffs may affect firms' performance through domestic firms' intermediate input usage (Goldberg et al., 2010; Halpern et al., 2015). We construct input tariffs as

$$\text{Input Tariffs}_{jt} = \sum_k \gamma_{j,1970}^k \times \textit{Import Tariffs}_{kt}, \tag{4.7}$$

where $\gamma_{j,1970}^k$ is value share of input k in sector j in 1970.

The results are reported in columns 5, 6, and 7 of Tables 3 and 4. In column 8, we jointly control for all three trade-related variables. In both short-run and long-run estimations, the coefficients are within a standard error of the baseline results in column 2. The estimated coefficients for the export shocks, import tariffs, and input tariffs are statistically insignificant.

Placebo Test. Our empirical strategy compares the difference between non-HCI sector firms in the targeted and non-targeted regions to the difference between HCI sector firms in the targeted and non-targeted regions. Any common unobservables of HCI sector firms in the targeted regions may bias our estimates. For example, if the Korean government selected regions expected to have higher productivity growth in HCI sectors, this may bias our IV estimates. Another concern would be policies other than credit, applied differentially to HCI firms in the targeted regions.

To assess whether the results are driven by confounding factors at the region-sector level, we conduct a placebo test. We run the regression (4.1) with the pre-treatment – from 1970 to 1973 – sales growth

intensity of Korea $\triangle EX_{jt}^{KOR}/GO_{j,1970}^{KOR}$ and export intensity measured by Taiwan's exports $\triangle EX_{jt}^{TWN}/GO_{j,1970}^{KOR}$ are highly correlated.

as the dependent variable. If the results were driven by confounding factors correlated with the IV, and those confounding factors were already present prior to 1973, the IV or allocated credit would be correlated with sales growth between 1970 and 1973.

Table 5 reports the results of the placebo test. In columns 1 and 2, the main independent variables are $asinh(Credit)$, and in columns 3 and 4, the main independent variables are the IV. In columns 5 and 6, we report the IV estimates. In columns 2, 4, and 6, we additionally control for the Chaebol status variable and trade-related variables. Across the specifications, the estimated coefficients on the main independent variables are statistically indistinguishable from zero, supporting our identifying assumption.[31]

Additional Robustness Checks. All specifications include the log of initial sales.[32] This is our preferred specification because it additionally controls for any other channels that potentially affect firms' long-run performance through initial size. The results without controlling for the initial sales are reported in Appendix Tables B5 and B6. The results are robust to omitting the initial size control.

We run the same regression with alternative dependent variables: log of employment and TFP. TFP is computed assuming a value-added Cobb-Douglas production function and using the method proposed by Ackerberg et al. (2015). By relying on the timing assumption of input choices, the TFP measure obtained from the production function estimation method of Ackerberg et al. (2015) addresses input choice endogeneity.[33] Firm value added is calculated as firm sales multiplied with value-added shares obtained from IO tables. The results are reported in Appendix Tables B7 and B8 for log employment and B9 and B10 for TFP.[34] We obtain qualitatively similar results for these alternative variables.

Instead of using the inverse hyperbolic sine transformation, we also use log of one plus credit and a dummy variable which equals one if a firm was ever allocated foreign credit between 1973 and 1979. Appendix Tables B11 and B12 report the results for the positive credit dummy, and Appendix Tables B13 and B14 report the results for log one plus credit.

[31] Appendix Section B.1 conducts an additional placebo test at the regional level with a different data set. Using regional information on manufacturing employment shares from the population census, we run a regression of growth of manufacturing employment shares between 1966 and 1970 and between 1970 and 1985 on total credit allocated at the regional level to the HCI sector firms. The results, reported in Appendix Table B19, are consistent with results in Table 5. We find that the regional total credit is only positively correlated with the growth of manufacturing employment shares between 1970 and 1985, but not with the growth between 1966 and 1970.

[32] The short-run specification between 1972 and 1981 controls for 1972 sales, and between 1973 and 1982, for 1973 sales. The long-run specification between 1981 and 2009 controls for 1981 sales, and for the long difference between 1982 and 2010, controls for 1981 sales.

[33] To apply the method of Ackerberg et al. (2015), we need information on material inputs. For the samples between 1970 and 1982, the material input information is not available. Therefore, we first estimate the production function for the sample between 1982 and 1990 and obtain the coefficients of labor and capital. Using these estimated coefficients, we obtain TFP measures as the residuals for the sample between 1970 and 1982.

[34] The results are robust to applying different production function estimation methods.

Table 5: Robustness. Placebo Test

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.:	$\triangle\log(Sales)$: 1970 and 1973					
	OLS		Reduced Form		IV	
$asinh(Credit)$	–0.01	–0.01			–0.06	–0.04
	(0.01)	(0.01)			(0.04)	(0.03)
IV			–0.31*	–0.26		
			(0.18)	(0.20)		
Firm Controls	N	Y	N	Y	N	Y
Region FE	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y
KP-F					17.16	25.24
Adj. R^2	0.03	0.02	0.02	0.02		
Num. Clusters	34	34	34	34	34	34
N	239	239	239	239	239	239

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the placebo results. The dependent variable is the log sales growth rate between 1970 and 1973. Columns 1-2 report the OLS estimates Columns 3 and 4 report the reduced form, where the main independent variable is the IV defined in (4.3). In columns 2, 4, and 6 control for a dummy variable of Chaebol status and the interaction term between the port dummies and export demand shocks, import tariffs, and input tariffs. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Instead of using the overlapping differences, the results when using only a single difference are reported in Appendix Tables B15 and B16. To examine whether the particular choice of years is driving our long-run results, we use sales growth between 1982 and 1999 and sales growth between 1982 and 2005 as dependent variables. The results are reported in Appendix Tables B17 and B18. Appendix Figure B2 reports the yearly estimates for the yearly differential sales growth between 1982 and 2011. The estimated coefficients increase as time passes.

Omitted Policies. Even if the interaction term between dummies of the targeted regions and targeted sectors is uncorrelated with omitted productivity or demand shocks, the exclusion restriction may not hold if other policies favored firms in the targeted region and sectors. In this case, our estimates would be biased upward. Although controlling for sector fixed effects may mitigate this bias by absorbing common policy components within sector, given the limited availability of other policy variables, we cannot completely rule out this possibility. However, narrative evidence suggests that this is not a major concern because the other policies were conditioned on getting approvals for foreign credit. For example, under the Foreign Capital Inducement Act, tax privileges such as exemption from acquisition or property taxes were only granted to imported foreign capital or raw materials purchased using the approved foreign credit.[35] Even if omitted policy factors induce bias in our IV estimates, our reduced-form estimates in columns 3 of Tables 3 and 4 still capture the average benefits of receiving the bundle of favorable treatments associated with receiving credit, and show that the average benefits were substantial in both the short and the long run.

5 Quantitative Framework

Our main empirical finding is that subsidized credit during the HCI Drive increased firm sales as much as 30 years after the credit stopped. We interpret this as evidence that this temporary policy had persistent long-run effects. This section develops a theoretical framework that captures this pattern and uses it to quantify the long-run welfare benefits of this temporary industrial policy. The main mechanism in the model is learning-by-doing (LBD) within the firm: a firm's current production experience increases its future productivity (Arrow, 1962; Krugman, 1987; Matsuyama, 1992). Firms are also borrowing-constrained. Thus, they cannot expand in the short run to internalize the future benefits of producing more today. These features are consistent with both the formal econometric, as well as narrative historical evidence.[36] In this environment, industrial policy has a role. Government subsidies relax firms' borrowing constraints and increase output in the first period, leading to productivity gains from LBD. We discipline the model by deriving the estimation equation used in the empirical analysis, allowing key parameters of the model to be recovered from the econometric estimates.

[35] See Lee (1980) and Enos and Park (1988, p. 35).

[36] One episode illustrates the underdevelopment of the financial system in Korea during the 1970s. Many Korean firms heavily relied on the domestic informal loan market to borrow for investment and working capital. In 1971, the collapse of the Bretton Woods system and the end the convertibility of dollars into gold resulted in a worldwide economic downturn and a sharp increase in the cost of debt financing of the Korean firms. The average deposit rate of the commercial banks was around 20%, and the average interest rate in the unofficial capital market was 30–40%. Instead of allowing financially troubled firms go bankrupt, the government bailed them out. A Presidential Emergency Decree of August 1972 nullified all the contracts between lenders and borrowers in the informal loan market. The goals of the decree were to bail out firms with large debt burdens and move loans from the informal loan market to the formal loan market. The decree required firms to report total credit borrowed in the informal loan market. The decree also capped the interest rate on the reported contracts from the informal loan market at 8% and gave an option to lenders to convert their credit into shares of borrowing firms. The reported total amount of credit in the informal loan market was 30.1% of the national domestic credit (Cole and Park, 1980). Financial frictions in the early stage of development of East Asian countries were further studied by Song et al. (2011), Itskhoki and Moll (2019), and Liu (2019), among others.

5.1 Model

Preliminaries. There are two periods with time indexed by $t = 1, 2$. There are $\mathcal{J}$ sectors indexed by j and k, partitioned into $\mathcal{J}_M$ manufacturing sectors and $\mathcal{J}_{NM}$ non-manufacturing sectors. Non-manufacturing sectors include commodities and services. Only manufacturing sectors are subject to learning-by-doing. Firms in the manufacturing sectors are monopolistically competitive and heterogeneous in terms of productivity. The non-manufacturing sector is perfectly competitive.

Households. There are H_t households. Each household supplies one unit of labor inelastically and earns wage w_t in each period. Preferences are

$$U(\{C_t\}_{t=1,2}) = \sum_{t=1,2} \beta^{t-1} \log(C_t), \qquad C_t = \prod_{j \in \mathcal{J}} C_{jt}^{\alpha^j} \tag{5.1}$$

where β is the discount factor and C_t is consumption at time t. C_t is Cobb-Douglas with expenditure shares α^j. The ideal price index is

$$P_t = \prod_{j \in \mathcal{J}} \left(\frac{P_{jt}}{\alpha^j} \right)^{\alpha^j},$$

where P_{jt} is the price index of sector j at time t. Households' total income is $E_t = w_t H_t + \Pi_t + T_t$, where $w_t H_t$ is the total labor income, Π_t is the aggregate profits of firms owned by households, and T_t is the lump-sum tax-rebate by the government. Π_t and T_t are divided equally across households.

Sectors. The manufacturing sectors $j \in \mathcal{J}_M$ are populated by firms indexed by $f \in \mathcal{F}_j$. Sector j output is a CES aggregate of firm outputs:

$$Q_{jt} = \left[\sum_{f \in \mathcal{F}_j} q_{fjt}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{5.2}$$

where q_{fjt} is the quantity of firm f output, and σ is the elasticity of substitution across firms of sector j. The sectoral price index is

$$P_{jt} = \left[\sum_{f \in \mathcal{F}_j} p_{fjt}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{5.3}$$

where p_{fjt} is firm f's price. For perfectly competitive non-manufacturing sectors $j \in \mathcal{J}_{NM}$, a representative firm prices at marginal cost, and the sectoral price index is equal to the representative firm's price: $P_{jt} = p_{fjt}$ for $j \in \mathcal{J}_{NM}$.

Firms. Firms in each sector have a Cobb-Douglas production function with constant returns to scale:

$$q_{fjt} = A_{fjt} H_{fjt}^{\gamma_j^H} \prod_k (M_{fjt}^k)^{\gamma_j^k}, \qquad \gamma_j^H + \sum_k \gamma_j^k = 1, \tag{5.4}$$

where A_{fjt} is firm-specific productivity, H_{fjt} is its labor input, and M_{fjt}^k are sector k intermediate inputs used by firm f. The parameters γ_j^H and γ_j^k are common across firms within a sector. Cost minimization implies the cost of the input bundle equal to

$$c_{jt} = \left(\frac{w_t}{\gamma_j^H}\right)^{\gamma_j^H} \prod_{k \in \mathcal{J}} \left(\frac{P_{kt}}{\gamma_j^k}\right)^{\gamma_j^k}. \tag{5.5}$$

A firm in the manufacturing sector faces a downward-sloping demand curve. When a firm charges price p_{fjt}, its sales X_{fjt} are

$$X_{fjt} = \left(\frac{p_{fjt}}{P_{jt}}\right)^{1-\sigma} X_{jt} = \pi_{fjt} X_{jt}, \tag{5.6}$$

where X_{jt} is sector j's total sales, and π_{fjt} is firm f's share in sectoral sales.

Only firms in the manufacturing sectors are subject to learning-by-doing. In particular, firm f's productivities at $t = 1$ and $t = 2$ are:

$$A_{fj1} = \phi_{fj1}, \qquad A_{fj2} = \phi_{fj2}(q_{fj1})^{\xi}, \tag{5.7}$$

where ϕ_{fjt} is firm f's exogenous productivity at t. Productivity in the second period A_{fj2} is increasing in quantity produced in the first period q_{fj1}. Higher ξ implies stronger LBD. If $\xi = 0$, there is no learning-by-doing and the model collapses to the standard static multi-sector heterogeneous firm model with two periods. The value of ξ will be inferred from the econometric estimates presented in Section 4, as discussed below.

Industrial policy in the model is a proportional subsidy on firm purchases of input bundles, denoted by $\kappa_{fj1} \leq 1$. Specifically, to produce quantity q_{fj1}, the subsidized firm incurs production costs of $\kappa_{fj1} \frac{c_{j1}}{A_{fj1}} q_{fj1}$. Industrial policy is firm-specific, and only occurs in the first period.

A firm's problem is dynamic because of LBD. Given downward sloping demand and LBD, a firm maximizes discounted profits:

$$\max_{\{p_{fjt}\}_{t=1,2}} \Bigg\{ \underbrace{\left(p_{fj1} q_{fj1} - \kappa_{fj1} \frac{c_{j1}}{A_{fj1}} q_{fj1}\right)}_{=\Pi_{fj1}(p_{fj1})} + \beta \underbrace{\left(p_{fj2} q_{fj2} - \frac{c_{j2}}{A_{fj2}} q_{fj2}\right)}_{=\Pi_{fj2}(p_{fj1}, p_{fj2})} \Bigg\}$$

$$\text{subject to} \quad q_{fjt} = p_{fjt}^{-\sigma} P_{jt}^{\sigma-1} X_{jt}, \quad A_{fj2} = A_{fj1}(q_{fj1})^{\xi}, \tag{5.8}$$

where κ_{fj1} is a subsidy provided by the government in the first period and there is no subsidy in the second period.[37] $\Pi_{fj1}(p_{fj1})$ and $\Pi_{fj2}(p_{fj1}, p_{fj2})$ are profits in the first and the second periods. A price charged by a firm in the first period affects the second period profits, because the first period price changes quantity produced and this quantity in turn affects productivity in the second period through LBD.

In the second period, given p_{fj1} which in turn pins down q_{fj1} and A_{fj2}, the firm's maximization problem is static. The firm charges the standard constant mark-up over marginal cost:

$$p_{fj2} = \frac{\sigma}{\sigma - 1} \frac{c_{j2}}{A_{fj2}},$$

and its sales are

$$X_{fj2} = \left(\frac{\sigma}{\sigma - 1} \frac{c_{j2}}{A_{j2}} \right)^{1-\sigma} P_{j2}^{\sigma-1} X_{j2}.$$

Second period profits and input expenditures are $\frac{1}{\sigma} X_{fj2}$ and $\frac{\sigma-1}{\sigma} X_{fj2}$ respectively.

Given the pricing decision in the second period, a firm's maximization problem in the first period can be rewritten as

$$\Pi_{fj} = \max_{p_{fj1}} \left\{ \Pi_{fj1}(p_{fj1}) + \beta \tilde{\Pi}_{fj2}(p_{fj1}) \right\}. \tag{5.9}$$

The firm's optimal price in the first period p_{fj1}^{LBD} is the price that satisfies the first order condition of the above maximization problem: $\partial \Pi_{fj} / \partial p_{fj1} = 0$.[38] Denote the price that maximizes the first period static profits by p_{fj1}^{Static}:

$$p_{fj1}^{Static} = \frac{\sigma}{\sigma - 1} \frac{\kappa_{fj1} c_{j1}}{A_{fj1}}. \tag{5.10}$$

This is the price charged by firms in the first period when there is no LBD. Firms always set $p_{fj1}^{LBD} < p_{fj1}^{Static}$ because by dropping the price below p_{fj1}^{Static}, firms internalize LBD by increasing quantity in the first period, which in turn increases productivity in the second period.

Constraints. Firms face borrowing constraints in the first period. Before production occurs, firms have to borrow for working capital to pay their total input expenditures. The constraints restrict borrowing, so firms may not expand the first period production to optimally reap the benefits of learning-by-doing.

We assume that the borrowing constraints take the following form:

$$\kappa_{fj1}(w_1 H_{fj1} + \sum_k P_{k1} M_{fj1}^k) \leq \tilde{\lambda}_{j1} A_{fj1}^{\sigma-1}, \qquad \tilde{\lambda}_{j1} = \lambda_{j1} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} c_{j1}^{1-\sigma} P_{j1}^{\sigma-1} X_{j1}, \tag{5.11}$$

[37] Because households own the firms, firms apply the same discount factor as the households.

[38] The mathematical derivation of the first order condition and p_{fj1}^{LBD} are described in Section C.1.

where the left hand side of the in equality is total input costs inclusive of subsidies and the right hand side is the borrowing limit. If the total costs under the firms' optimal decision without any constraints exceed the borrowing limits, firms become constrained. The sector-specific variable $\tilde{\lambda}_{j1}$ captures tightness of borrowing constraints in sector j. It is determined in equilibrium, and is proportional to market size $P_{j1}^{\sigma-1}X_{j1}$, unit cost c_{j1} and an exogenous industry-specific parameter λ_{j1}. Lower λ_{j1} implies tighter constraints. Expressing the borrowing constraint as in (5.11) is analytically convenient, and captures the notion that when firms face bad economic conditions such as increased unit cost or decreased market size, it becomes more difficult for them to borrow. Firms with higher productivity A_{fj1} are less likely to be constrained.[39] A subsidy provided by the government κ_{fj1} increases a firm's sales directly by reducing input expenditures and indirectly by relaxing the borrowing constraints.

The ratio between the exogenous constraint parameter and firm-specific subsidy $\lambda_{j1}/\kappa_{fj1}$ determines the tightness of the borrowing constraint. When $\lambda_{j1}/\kappa_{fj1} \to \infty$, the borrowing constraints are not binding and firms set the dynamically the optimal price p_{fj1}^{LBD} that internalizes LBD. When the firm's borrowing constraint is binding, its price is pinned down by the constraint:

$$p_{fj1}^{Friction} = \frac{\sigma}{\sigma-1}\left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{-\frac{1}{\sigma}}\frac{c_{j1}}{A_{fj1}}. \tag{5.12}$$

When $\lambda_{j1}/\kappa_{fj1} < 1$, firm price is higher, and output and profits are lower than the static profit-maximizing level: $p_{fj1}^{Friction} \geq p_{fj1}^{Static} \geq p_{fj1}^{LBD}$ and $q_{fj1}^{Friction} \leq q_{fj1}^{Static} \leq q_{fj1}^{LBD}$, and the firm cannot expand its production enough to internalize learning-by-doing.[40] Only for sufficiently high λ_{j1} a firm can charge the optimal price p_{fj1}^{LBD} that fully internalizes dynamic LBD effects.

In what follows, we assume that in Korea all firms are constrained so that $\lambda_{j1}/\kappa_{fj1} \leq 1$ holds for all firms. When firms charge $p_{fj1}^{Friction}$, their revenues are

$$X_{fj1} = \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{\sigma-1}{\sigma}}\left(\frac{\sigma}{\sigma-1}\frac{c_{j1}}{A_{fj1}}\right)^{1-\sigma}P_{j1}^{\sigma-1}X_{j1}, \tag{5.13}$$

and input expenditures are

$$c_{j1}m_{fj1} = \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}}\frac{\sigma-1}{\sigma}X_{fj1}. \tag{5.14}$$

Total costs on inputs inclusive of subsidy are $\kappa_{fj1}c_{j1}m_{fj1}$. First period profits equal sales minus total

[39]Many standard models assume that firms can borrow up to $\tilde{\lambda}_{jt}\text{Assets}_{ft}$, where $\tilde{\lambda}_{jt}$ is a parameter that governs tightness of the borrowing constraints as in our model and Assets_{ft} are firm assets. This formulation of the borrowing constraint can be micro-founded using a limited commitment problem, where firm owner can steal a fraction of $1/\tilde{\lambda}_{jt}$ of total amount and lose her assets. For example, see Kiyotaki and Moore (1997), Buera and Shin (2013), Moll (2014), and Itskhoki and Moll (2019). Our borrowing constraints can also be interpreted within this standard framework, where a firm's assets are proportional to its productivity $A_{fj1}^{\sigma-1}$.

[40]This is formally shown in Appendix Section C.2. When $\lambda_{j1}/\kappa_{fj1} = 1$, $p_{fj1}^{Friction} = p_{fj1}^{Static}$ and $q_{fj1}^{Friction} = q_{fj1}^{Static}$.

costs

$$\Pi_{fj1} = \left[1 - \kappa_{fj1}\left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\right]X_{fj1}. \tag{5.15}$$

Sectoral sales, input expenditures, and profits sum across all firms' in the sector: $X_{jt} = \sum_{f\in\mathcal{F}_j} X_{fjt}$, $c_{jt}m_{jt} = \sum_{f\in\mathcal{F}_j} c_{jt}m_{fjt}$, and $\Pi_{jt} = \sum_{f\in\mathcal{F}_j} \Pi_{fjt}$, $\forall j, t$.

Equilibrium. Goods market clearing is

$$X_{jt} = \sum_k \gamma_k^j \sum_{f\in\mathcal{F}_k} c_{jt}m_{jt} + \sum_{k\in\mathcal{J}_{NM}} \gamma_k^j c_{jt}m_{jt} + \alpha^j\Big(w_tH_t + \Pi_t + T_t\Big), \tag{5.16}$$

where Π_t is aggregate profits:

$$\Pi_t = \sum_{j\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_j} \Pi_{fjt}, \tag{5.17}$$

and T_t is the lump-sum transfers from the government

$$T_t = \sum_{j\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_j} (\kappa_{fjt}-1)c_{j1}m_{fjt}. \tag{5.18}$$

Because there is no subsidies in the second period, $T_2 = 0$. Labor market clearing implies that

$$w_tH_t = \sum_{j\in\mathcal{J}} \gamma_j^H \sum_{f\in\mathcal{F}_j} c_{jt}m_{jt} \tag{5.19}$$

The manufacturing price indices in the first and the second periods are

$$P_{j1} = \left[\sum_{f\in\mathcal{F}_j}\left((\lambda_{j1}/\kappa_{fj1})^{-\frac{1}{\sigma}}\frac{\sigma}{\sigma-1}\frac{c_{j1}}{A_{fj1}}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \qquad P_{j2} = \left[\sum_{f\in\mathcal{F}_j}\left(\frac{\sigma}{\sigma-1}\frac{c_{j2}}{A_{fj2}}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{5.20}$$

and the price indices of non-manufacturing sectors are $P_{jt} = c_{jt}/A_{jt}$ for $t = 1, 2$.

5.2 Counterfactuals

We are interested in the long-term aggregate welfare effects of industrial policy. Thus, our main counterfactual exercise computes the welfare change in the world in which the Korean government had not conducted industrial policy. In our model, this corresponds to setting $\kappa_{fj1} = 1$, $\forall f$.

To perform counterfactuals, we utilize a modification of the Dekle et al. (2008) exact hat algebra. Appendix C describes the procedure in detail. Our modified hat algebra is composed of two parts: short- and long-run. The short-run hat algebra calculates counterfactual changes in the first period. If we feed in counterfactual subsidies into the first-period equilibrium, we obtain the short-run equilibrium allocation changes. For any outcome x, we denote counterfactual changes in the short run as $\hat{x}_1^S = x_{c,1}/x_1$, where the subscript c stands for counterfactual equilibrium allocation and superscript S stands for the short-run. The long-run hat algebra, given the short-run allocation in the first period, calculates counterfactual changes between the first and the second periods (long-run). Suppose we know a firm's long-run productivity changes A_{fj2}/A_{fj1}. We feed in these long-run shocks and calculate long-run equilibrium allocation changes. We denote long-run changes of the second period over the first period as $\hat{x}_2^L = x_2/x_1$, where the superscript L denotes long-run changes.

In our setting, changes in subsidies $\hat{\kappa}_{fj1}$ directly affect the short-run allocation in the first period and indirectly affect the long-run allocation in the second period through LBD. Although short-run allocation changes can be obtained via the standard hat algebra, computing long-run allocation changes is not straightforward because firms' long-run productivity changes are endogenous outcomes affected by the first-period quantity produced through LBD: $\hat{A}_{fj2}^L = A_{fj2}/A_{fj1} = \phi_{fj2} q_{fj1}^{\xi}/\phi_{fj1}$ where q_{fj1} depends on κ_{fj1}.

Under log utility, the welfare levels in the counterfactual equilibrium and the baseline initial equilibrium can be expressed as:

$$U_c = \left(\frac{y_{c,1}}{P_{c,1}}\right)\left(\frac{y_{c,2}}{P_{c,2}}\right)^{\beta} = \left(\frac{y_{c,1}}{P_{c,1}}\right)\left(\frac{\hat{y}_{c,2}^L}{\hat{P}_{c,2}^L}\frac{y_{c,1}}{P_{c,1}}\right)^{\beta}, \qquad U = \left(\frac{y_1}{P_1}\right)\left(\frac{y_2}{P_2}\right)^{\beta} = \left(\frac{y_1}{P_1}\right)\left(\frac{\hat{y}_2^L}{\hat{P}_2^L}\frac{y_1}{P_1}\right)^{\beta}, \quad (5.21)$$

where c denotes counterfactual equilibrium values, and y is the per capita income.[41] The counterfactual welfare change relative to the baseline equilibrium is

$$\frac{U_c}{U} = \underbrace{\left(\frac{\hat{y}_1^S}{\hat{P}_1^S}\right)}_{\substack{\text{Short-run} \\ \text{Welfare Change}}} \times \underbrace{\left(\frac{\tilde{y}_2^L}{\tilde{P}_2^L}\frac{\hat{y}_1^S}{\hat{P}_1^S}\right)^{\beta}}_{\substack{\text{Long-run} \\ \text{Welfare Change}}} \qquad \text{where} \qquad \frac{\tilde{y}_2^L}{\tilde{P}_2^L} = \frac{\hat{y}_{c,2}^L}{\hat{P}_{c,2}^L} \Big/ \frac{\hat{y}_2^L}{\hat{P}_2^L}. \quad (5.22)$$

Thus, $\tilde{x}$ denotes the ratio of long-run changes of an equilibrium variable between the counterfactual and the baseline equilibrium.[42] The overall welfare change U_c/U is composed of the short- and the long-run components.

Suppose we know the vectors of subsidy shocks $\hat{\kappa}_{fj1}^S$ and the actual long-run productivity changes $\hat{A}_{fj2}^L$. (Section 5.3 details the procedure for inferring these from the data). Given these two vectors, our counterfactual proceeds in three steps. In the first step, we apply the $\hat{\kappa}_{fj1}^S$ in the short-run

[41]Per capita income in the first period is: $y_1 = \frac{w_1 H_1 + \Pi_1 + T_1}{H_1}$. In the second period, there are no taxes/transfers ($T_2 = 0$), and the economy is unconstrained, so that total profits are a constant fraction of the wage bill. Thus the second-period per capita welfare is proportional to the real wage.

[42]Caliendo et al. (2019) adopt a similar approach. By computing the ratio of changes, one can compute the counterfactual change without knowing the levels of the shocks. In our application, we do not require information on the initial level of each firm's quantities produced in the first period, which is used to compute long-run productivity changes.

hat algebra, and obtain the $t = 1$ counterfactual equilibrium allocation. This step gives us $\hat{y}_1^S/\hat{P}_1^S$ in (5.22). In the second step, we compute the counterfactual long-run productivity changes, which depend on the counterfactual changes of the first period quantities produced. The counterfactual long-run productivity changes are computed as

$$\hat{A}^L_{c,fj2} = \frac{A_{c,fj2}}{A_{fj1}} = \frac{\phi_{fj2}(q_{c,fj1})^\xi}{\phi_{fj1}} = \underbrace{\frac{\phi_{fj2}(q_{fj1})^\xi}{\phi_{fj1}}}_{=\hat{A}^L_{fj2}\text{ : Data}} \times \underbrace{\left(\frac{q_{c,fj1}}{q_{fj1}}\right)^\xi}_{\substack{=\hat{q}^S_{fj1}\text{ : Short-run} \\ \text{hat algebra}}}, \tag{5.23}$$

where $\hat{A}^L_{fj2}$ will be backed out from the data, and changes of each firm's quantity produced $\hat{q}^S_{fj1} = q^c_{fj1}/q_{fj1}$ come from the short-run hat algebra in the first step.[43] In the last step, we feed in $\hat{A}^L_{c,fj2}$ and $\hat{A}^L_{fj2}$ and apply the long-run hat-algebra to the counterfactual and baseline first period short-run allocation. From the long-run hat algebra applied to the counterfactual equilibrium and the initial equilibrium, we obtain $\hat{y}^L_{c,2}/\hat{P}^L_{c,2}$ and $\hat{y}^L_2/\hat{P}^L_2$. From these long-run changes, we compute relative changes $\tilde{y}^L_2/\tilde{P}^L_2$ in Equation (5.22). For the long-run hat-algebra, we also feed in changes in the population $\hat{H}^L_2$.

5.3 Taking the Model to the Data

To implement our two-step hat algebra, we need values of subsidy shocks $\{\hat{\kappa}_{fj1}\}$, long-run productivity shocks of the observed equilibrium $\{\hat{A}^L_{fj2}\}$, sectoral constraint tightness $\{\lambda_{j1}\}$, and the learning-by-doing elasticity ξ. Because each firm is an object in the model, we need the initial firm-specific market shares of the initial equilibrium, which we take directly from the data. The remaining parameters can be calibrated to standard values in the literature. The summary of the calibrated values is reported in Table 6.

Subsidies and the Learning-By-Doing Parameter. Using the short-run and long-run econometric estimates of (4.1), we back out two key parameters of the model: LBD elasticity ξ and firm-specific subsidies κ_{fj1}. We back out subsidies from the short-run sales changes and pin down ξ from the long-run response of sales to past subsidies.

Log first period firm sales are (see 5.13):

$$\log X_{fj1} = -\frac{\sigma - 1}{\sigma} \log \kappa_{fj1} + C_{j1} + (\sigma - 1) \log \phi_{fj1} \tag{5.24}$$

where C_{j1} absorbs industry common components. We assume that the subsidy κ_{fj1} takes the following

[43] Changes in quantity produced in the short run are expressed as $\hat{q}^S_{fj1} = (\hat{c}^S_{j1})^{-\sigma} \frac{1}{\hat{\kappa}^S_{fj1}} (\hat{P}^S_{j1})^{\sigma-1} \hat{X}^S_{j1}$.

Table 6: Summary of Calibrated Parameters

Param.	Value	Description	Moment	Source
Intertemporal Discount Factor				
β	1.62	Permanent Δproductivity		
β	0.90	Temporary Δproductivity		
Elasticities				
η	0.12	Effective subsidy from credit	IV Estimate	Data
ξ	0.85	Learning by doing	IV Estimate	Data
σ	3	Elast. of subst.		Broda and Weinstein (2006)
Shocks				
λ_{jt}			IV Estimates	Data
$\{\hat{\kappa}^S_{ft}\}$		Subsidy shocks	IV Estimates	Data
$\{\hat{A}^L_{ft}\}$		Long-run productivity changes	Sales	Data & IO table
Production & Consumption				
$\{\alpha^j\}$		Final consumption shares	IO table	IO table
$\{\gamma^H_j, \gamma^k_j\}$		Labor & intermediate shares		

Notes. The table summarizes the calibrated values used for the quantitative analysis.

form:

$$\kappa_{fj1} = exp\big(-\eta \times asinh(Credit_{fj1})\big). \tag{5.25}$$

From (5.24) and (5.25), we derive the following estimable short-run regression model:

$$\log X_{fj1} = \underbrace{\beta^S_1}_{=(\sigma-1/\sigma)\eta} \times asinh(Credit_{fj1}) + \delta_{n1} + \delta_{j1} + \log \phi_{fj1}, \tag{5.26}$$

where any region or sector common variables are absorbed by region-time fixed effects δ_{nt} and sector-time fixed effects δ_{jt}.[44] Unobservable firm productivity in the first period $\log \phi_{fj1}$ is a structural residual. Time-differencing, we can derive the short-run regression model as in Equation (4.1).[45] With the estimated $\hat{\beta}^S_1$ and a value of σ, we can obtain a value of η that connects the credit observed

[44] δ_{jt} absorbs variables that are common within sector: sectoral constraint $\frac{\sigma-1}{\sigma} \log \lambda_{j1}$, costs of input bundles c_{j1}, and market size $P^{\sigma-1}_{j1} X_{j1}$. Although regions are not explicitly modeled in our quantitative framework, δ_{nt} absorbs factors that are common within region.

[45] Strictly speaking, of course, the model only has one first period. To take the short-run time difference inside the model, we can think of period 1 as consisting of several sub-periods identical in every way except for credit given to firms, such that we can take the time difference in sales and credit between the later and the earlier sub-periods.

in the data to the subsidy rate in the model. With this $\hat{\eta}$, firm-specific subsidies are obtained as

$$\kappa_{fj1} = exp\big(-\eta \times asinh(Credit_{fj1})\big). \tag{5.27}$$

Note that these are the levels of the subsidy rate in the first period.

From the long-run changes in firms' sales, we estimate LBD parameter. Second period firm sales can be written as:

$$\log X_{fj2} = (\sigma-1)\xi \log \kappa_{fj1} + \delta_{n2} + \delta_{j2} + (\sigma-1)\log \phi_{fj2} + \sigma \log \phi_{fj1}, \tag{5.28}$$

where δ_{n2} and δ_{j2} are region and industry common components.[46] Because of LBD, subsidies κ_{fj1} and exogenous productivity in the first period $\log \phi_{fj1}$ show up in the sales of the second period. Substituting (5.25) into (5.28) yields the following estimable regression model:

$$\log Sale_{fj2} = -\underbrace{\beta_1^L}_{=(\sigma-1)\xi\eta} \times asinh(Credit_{fj1}) + \delta_f + \delta_{nt} + \delta_{jt} + \epsilon_{ft}, \tag{5.29}$$

where region and sector fixed effects capture similar objects as in Equation (5.26), and firm fixed effects reflect cross-firm differences in period 1 productivity. Differencing this equation with respect to period 1 yields the long-run regression specification (4.1). Using the short-run and long-run estimates from Equations (5.26) and (5.29) and a value of σ, we can obtain the estimated ξ using the following relationship:

$$\sigma\xi = \frac{\beta_1^L}{\beta_1^S} \iff \xi = \frac{1}{\sigma}\frac{\beta_1^L}{\beta_1^S}. \tag{5.30}$$

Intuitively, the short-run regression coefficients in Table 3 pick up the mechanical effect of subsidies on output: giving money to firms to produce naturally increases their sales. The short-run estimates are useful for translating the amount of credit firms received into effective subsidy operating in the model. Then, long-run coefficients in Table 4 tell us the strength of LBD by comparing "period 2" sales of subsidized and non-subsidized firms.

Calibration of the Remaining Parameters. The degree of sectoral financial frictions λ_{j1} is set to:

$$\lambda_{j1} = \min_{f \in \mathcal{F}_j} \{\kappa_{fj1}\},$$

which ensures that even the firm that received the largest subsidy rate (or the lowest input cost) still charges the static profit maximizing price and cannot optimally increase output to take advantage of

[46] δ_{j2} is proportional to $\prod_{h=0}^{1}\left[\left(\frac{\sigma}{(\sigma-1)}c_{j,t-2}\right)^{(1-\sigma)(\sigma\xi)^h} \times (P_{j,2-h}^{\sigma-1}X_{j,2-h})^{(\xi(\sigma-1))^h}\right]$.

LBD. We view this as a conservative value, because even lower values of λ_{j1} would imply firms are more constrained and therefore generate larger gains from the industrial policy. Also, this assumption simplifies the counterfactual analysis using hat algebra.

The long-run productivity changes are calculated from the firm balance sheet data. The sales growth of firm f relative to a reference firm f_0 in the same sector gives us relative long-run productivity changes $\hat{A}^L_{fj2}/\hat{A}^L_{f_0j2}$:

$$\frac{\hat{A}^L_{fj2}}{\hat{A}^L_{f_0j2}} = \frac{1}{\sigma-1}\frac{\triangle \log Sales_{ft}}{\triangle \log Sales_{f_0t}}.$$

Then, we pin down the productivity growth of the reference firm by fitting the mean of the productivity growth of firms weighted by the 1982 value added to the industry-level productivity growth obtained from the IO tables:

$$\hat{A}^L_{f_0j2} = \hat{A}^{L,\text{IO}}_{j12} \bigg/ \left(\sum_{f\in\mathcal{F}_j} \omega_{fj1} \frac{1}{\sigma-1}\frac{\triangle \log Sales_{ft}}{\triangle \log Sales_{f_0t}} \right),$$

where ω_{fj1} is a firm f's share of sectoral value added and $\hat{A}^{L,\text{IO}}_{j12}$ is the labor productivity growth of sector j.[47] Final consumption shares $\{\alpha^j\}$ and production parameters $\{\gamma^k_j\}$ are obtained directly from the 1983 IO table.

Firm market shares π_{fj1} are calculated as follows. We directly observe firm-level sales in 1982 in our main data set. For some observations without information on sales, we impute missing sales using assets.[48] After summing the observed firm-level sales, we calculate the residual of sectoral gross outputs by subtracting the sum of sales in the firm-level data from the gross output in the IO table of 1983. We treat the residuals as a separate firm.[49] Firm-level shares are then obtained as firms' sales divided by the gross output of the IO table.

The model has 2 periods, so we must take some care to set an appropriate value of β between the first and the second period. The first period corresponds to roughly a decade. The second period consists of about 25 years, but the learning-by-doing benefits build slowly (Appendix Figure B2), and our regression estimates reflect the total productivity increment at the end of the period. To be conservative, we assume that the productivity benefits accrue 15 years into the future. At that point they become permanent. Thus, assuming an annual discount rate of 0.96, the decadal discount rate is $0.96^{10} = 0.66$. If the productivity benefit comes 15 years into the future, and is permanent,

[47] $\hat{A}^{L,\text{IO}}_{j12}$ is computed as $\triangle \log(\text{Value Added}_{jt}/\text{Employment}_{jt})$. Both Value Added_{jt} and Employment_{jt} are obtained from the national IO tables.

[48] There are some firms without information on sales, but all firms have information on assets. Appendix C.4 describes the imputation procedure in detail.

[49] In our quantitative analysis, the total number of firms for each sector is the total number of firms in the firm-level data that were operating in 1982 plus one. The residuals are the sum of sales of small-sized firms that are not in our data set.

Table 7: Counterfactual. No Subsidy

Welfare change:	(1) Total (%)	(2) Short-run (%)	(3) Long-run (%)
Productivity change:			
Permanent ($\beta = 1.62$)	-30.96	-10.39	-20.57
Temporary ($\beta = 0.90$)	-22.39	-10.39	-12.00

Notes. The table reports the welfare effects under the counterfactual where the Korean government did not conduct the industrial policy.

then $\beta = 0.66^{1.5}/(1 - 0.66) = 1.62$. Alternatively, to be even more conservative we assume that the productivity benefit starts 15 years in the future and persists for only one more decade. This would be the case, for example, if there is some forgetting, or if the technologies about which LBD took place become obsolete. In that case, $\beta = 0.66^{1.5} + 0.66^{2.5} = 0.90$.

Finally, we set the elasticity of substitution σ to 3 following Broda and Weinstein (2006).

5.4 Welfare Results

Our main counterfactual computes the welfare change in the counterfactual world in which the Korean government did not conduct the industrial policy. We set $\kappa_{fj1} = 1$ for all firms so that no subsidies are given in the first period. The results are reported in Table 7. When there is no subsidy in the first period, and the productivity benefits are permanent, the overall welfare decreases by 31%. In this total, 10.4% is the short-run welfare decrease, and 20.6%, or about two-thirds, is the long-run welfare decrease. The short-run welfare changes come from exacerbated financial frictions in the first period, while the long-run welfare changes are due to lower second-period productivity as a result of less LBD. The industrial policy has quantitatively sizable impacts in the long run, consistent with the empirical finding that subsidies have persistent effects on firms' long-term performance. When we assume the productivity benefits are temporary, the short-run welfare impact is unchanged, but the long-run welfare decrease is 12%. Still, it the long run accounts for over half of the total welfare impact.

6 Conclusion

This paper provides causal evidence of industrial policy on firms' long-term performance. We show that subsidized credit distributed to firms during the 1973-79 HCI Drive in South Korea had persistent effects on firm sales, that are evident as much as 30 years after the subsidies themselves stopped. To rationalize this empirical finding and quantify its importance, we a build a quantitative heterogeneous firm framework with learning-by-doing and financial frictions. In this environment, if the industrial policy had not been implemented, South Korea's welfare would have been noticeably lower.

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ONLINE APPENDIX

(NOT FOR PUBLICATION)

Appendix A Data

A.1 Data Construction

Firm Balance Sheet. For the sample period between 1970 and 1982, firm balance sheet data are digitized from the historical Annual Report of Korean Companies published by the Korea Productivity Center. The annual reports have information on assets, capital, employment, export, fixed assets, and sales. For the sample between 1980 and 2011, firm balance sheet data comes from KIS-VALUE and FnGuide. The two separate data sets are then merged based on firm names.

The coverage of the Annual Report of Korean Companies is broader than KIS-VALUE or FnGuide. KIS-VALUE and FnGuide cover firms with assets above 3 billion Korean Won. In contrast, the Annual Report of Korean Companies (1973-1983) covers firms with capital larger than 50 million Korean Won, including more small and medium-sized firms. Therefore, in the main data set, we restrict our sample to the firms appearing in both KIS-VALUE or FnGuide and Annual Report of Korean Companies.

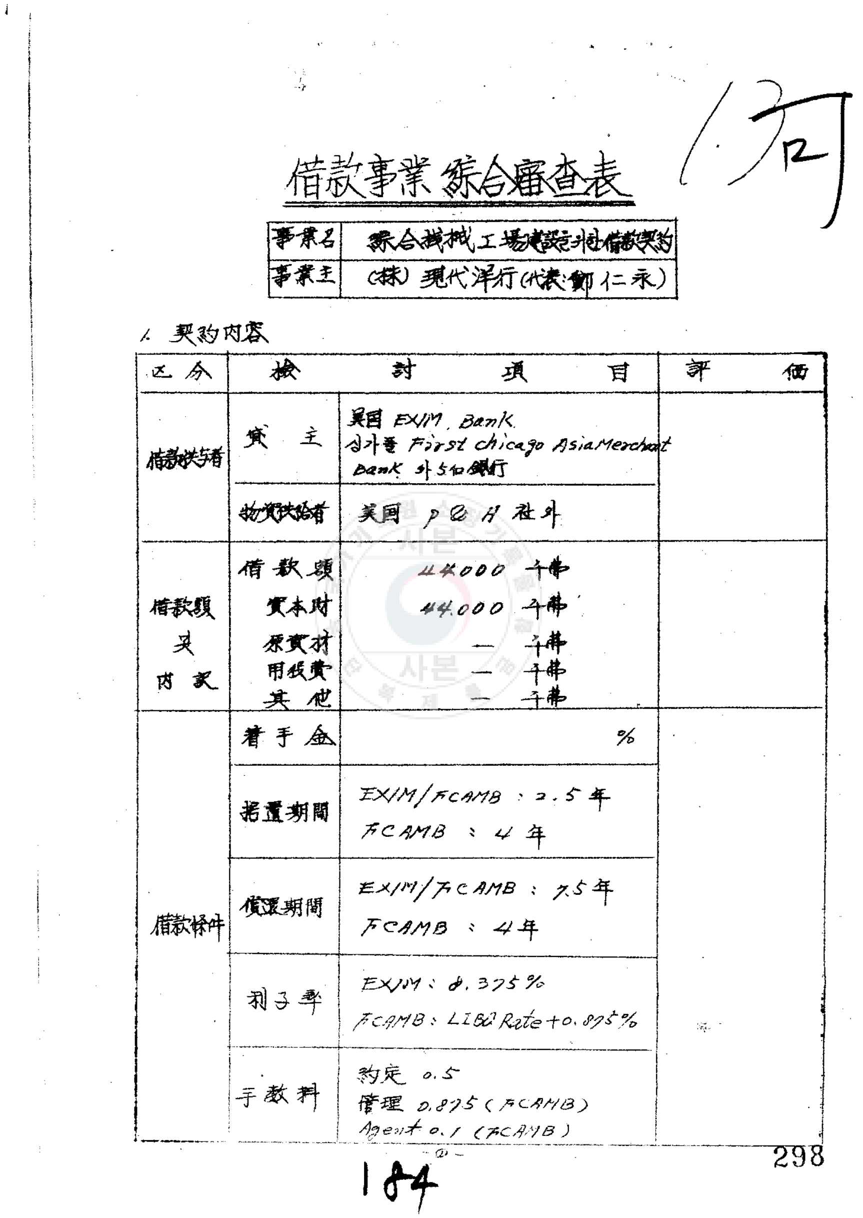
Foreign Credit. The data of foreign credit allocated by the government was hand-collected and digitized from the national historical archives. Key variables are the total amount borrowed, interest rate, and repayment period for each financial contract. Foreign credit data are merged with firm-balance sheet data based on firm names.

Figure A1, A2, and A3 displays the examples of the financial contract documents of Hyundai International Inc., which borrowed from seven foreign banks or companies.[50] Hyundai International INC. borrowed $44M at interest rate 8.375%. Figure A3 is the first page of the formal contract document between Hyundai International Inc. and the foreign banks. Importantly, it shows that the Korea Development Bank, the state-owned policy development bank that was in charge of financing industrial policies conducted by the government, guaranteed the repayment of this contract.

Table A1 reports the descriptive statistics of the collected credits data. The table reports the mean, standard deviation, maximum, and minimum of credit amounts, repayment periods, and interest rates.

[50]These seven foreign banks or companies are First Chicago Hong Kong Ltd., Bank Bumiputra Malaysia Berhad, Credit Lyonnais Hong Kong (Finance) Ltd., Nippon Credit International (HK) Ltd., Toronto Dominion Investments (HK) Ltd., Export-Import Bank of the United States (EXIM), and First Chicago Asia Merchant Bank Ltd..

Figure A1. An Example of a Financial Contract Digitized from the Historical Archive



可

借款事業綜合審査表

事業名	綜合機械工場建設을위한借款契約
事業主	(株) 現代洋行 (代表: 鄭仁永)

1. 契約內容

區分	検討項目		評価
借款提供者	貸主	美国 EXIM. Bank 싱가폴 First Chicago Asia Merchant Bank 外 5個銀行	
	物資供給者	美国 P&H 社 外	
借款額 및 內譯	借款額 資本財 原資材 用役費 其他	44,000 千弗 44.000 千弗 — 千弗 — 千弗 — 千弗	
借款條件	着手金	%	
	据置期間	EXIM/FCAMB : 2.5年 FCAMB : 4年	
	償還期間	EXIM/FCAMB : 7.5年 FCAMB : 4年	
	利子率	EXIM : 8.375% FCAMB : LIBO Rate+0.875%	
	手數料	約定 0.5 管理 0.875 (FCAMB) Agent 0.1 (FCAMB)	

-①-

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Figure A2. An Example of a Financial Contract Digitized from the Historical Archive-cont'd

- ② -

2. 事業性

区分	檢討項目		評価
市場性	需給事情 (76年)	需要 ; 3.272 百万弗 供給 ; 1.723 〃 (国内生産) 過不足 ; 1.549 〃	
	国内販売 (81年)	總額 : 307 〃 物量 : 73 %	
	輸出 (81年)	總額 : 112 百万弗 物量 : 27 %	
製品価格	国内販売価格	— $	
	輸入価格	— $	
	主要産地国価格	— $	
事業效果	国際収支效果 (79年) : 119.872 千弗 雇傭效果 (81年) : 8.830 名		

3. 主要認可條件 및 結論

主要認可條件	
結論	認可함이 可함.

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Figure A3. An Example of a Financial Contract Digitized from the Historical Archive-cont'd

HYUNDAI INTERNATIONAL, INC.
(as Borrower)

THE KOREA DEVELOPMENT BANK
(as Guarantor)

FIRST CHICAGO HONG KONG LIMITED

BANK BUMIPUTRA MALAYSIA BERHAD

CREDIT LYONNAIS HONG KONG (FINANCE) LIMITED

NIPPON CREDIT INTERNATIONAL (HK) LIMITED

TORONTO DOMINION INVESTMENTS (HK) LIMITED

EXPORT-IMPORT BANK OF THE UNITED STATES
(as Lenders)

FIRST CHICAGO ASIA MERCHANT BANK LTD.
(as Agent)

Credit Agreement

Korea **Eximbank Credit No. 6500**

242

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Table A1: Descriptive Statistics of Foreign Credit Data

	(1) Loan Size (mln 2015 USD)	(2) Repayment Period (years)	(3) Interest Rate (%)
Mean	47.0	6.17	8.97
Std.	74.2	2.23	2.01
Max.	540.2	15	16.9
Min.	0.70	0.50	0
N	538	538	538

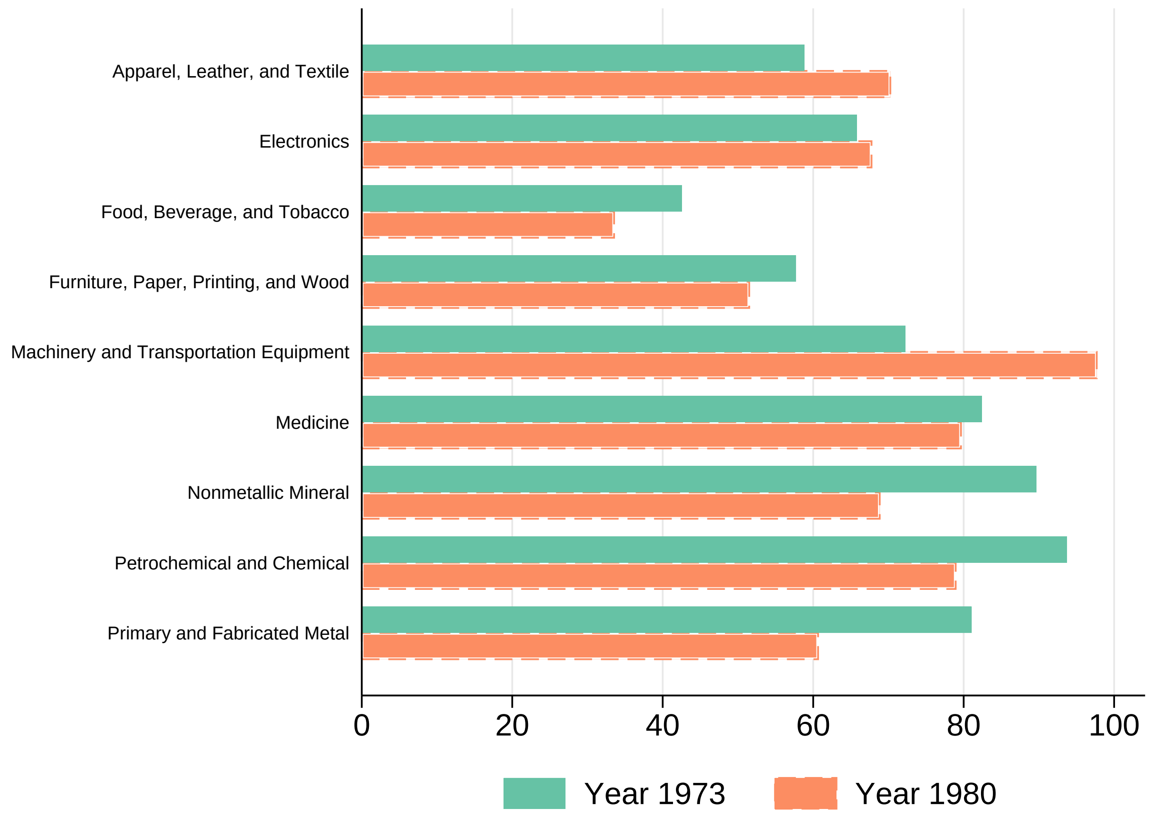
Notes. This table reports the descriptive statistics of approved financial contracts between domestic firms and foreign entities from 1973 to 1979.

Input Output Table. Input-Output tables are obtained from the Bank of Korea. Based on the descriptions of the products, we convert the reported codes into ISIC Rev.3. From the Input-Output table, we obtain value-added shares and intermediate input shares.

Trade and Import Tariffs. Trade data between 1972 and 2000 come from Feenstra et al. (2005), which come in the 4-digit Standard International Trade Classification (SITC) classification. We convert SITC into ISIC Rev 3. Import tariffs data is digitized from Luedde-Neurath (1986), which come in the Customs Co-operation Council Nomenclature (CCCN). We convert CCCN into 4-digit ISIC Rev 3. The average import tariffs are obtained as the averaged import tariffs across 4-digit ISIC sectors, weighted by import values.

A.2 Coverage of the Data Set

Figure A4. Coverage of the Data Set (%)



Notes. This figure depicts the fraction of total sales in each sector that is covered by the firms in the dataset. Total sales in each sector come from the Input-Output tables.

A.3 List of Chaebol Groups

English and Corresponding Korean Names

- Geumho (금호), Kia (기아), Daerim (대림), Daewoo (대우), Taihan Electric Wire (대한전선), Daehan Shipbuilding (대한조선), Dongbu (동부), Dong Ah (동아), Doosan (두산), Lucky (럭키), Lotte (롯데), Miwon (미원), Sammi (삼미), Samsung (삼성), Samhwan (삼환), Sunkyung (선경), Shindongah (신동아), Ssangyong (쌍용), Jinyang (진양), Kolon (코오롱), Taekwang (태광), Hanwha (한국화약), Hanbo (한보주택), Hanyang (한양주택), Hanil Synthetic Fiber (한일합섬), Hanjin (한진), Hyundai (현대), Hyosung (효성)

A.4 Targeted Regions and Sectors

Table A2: Targeted Regions

Region name	Specialized Sectors	Start Year of Industrial Complex
Busan	Rubber, Shipbuilding	No industrial complex
Changwon, Jinhae	Machinery	1975
Guje (Jukdo, Okpo)	Shipbuilding	1974
Gumi	Electronics	1973
Masan	Synthetic fibre	1970
Pohang	Metals, Steel	1967
Ulsan	Chemicals, Motor Vehicles, Petrochemicals, and Shipbuilding	1962
Yeosu, Yeocheon	Chemicals, Petrochemicals	1967

Table A3: Sector Classification

HCI	Aggregated Industry	Industry
HCI	Chemicals, Petrochemicals, and Rubber and Plastic Products	Coke oven products (231) Refined petroleum products (232) Basic chemicals (241) Other chemical products (242) Man-made fibres (243) except for pharmaceuticals and medicine chemicals (2423) Rubber products (251) Plastic products (252)
HCI	Electrical Equipment	Office, accounting and computing machinery (30) Electrical machinery and apparatus n.e.c. (31) Ratio, television and communication equipment and apparatus (32) Medical, precision, and optical instruments, watches and clocks (33)
HCI	Basic and Fabricated Metals	Basic metals (27) Fabricated metals (28)
HCI	Machinery and Transport Equipment	Machinery and equipment n.e.c. (29) Motor vehicles, trailers and semi trailers (34) Building and repairing of ships and boats (351) Railway and tramway locomotives and rolling stock (352) Aircraft and spacecraft (353) Transport equipment n.e.c. (359)
Non-HCI	Food, Beverages, and Tobacco	Food products and beverages (15) Tobacco products (16)
Non-HCI	Textiles, Apparel, Leather	Textiles (17) Apparel (18) Leather, luggage, handbags, saddlery, harness, and footwear (19) Manufacturing n.e.c. (369)
Non-HCI	Wood, Paper, Printing, and Furniture	Wood and of products, cork (20) Paper and paper products (21) Publishing and printing (22) Furniture (361)
Non-HCI	Pharmaceuticals and Medicine Chemicals	pharmaceuticals and medicine chemicals (2423)
Non-HCI	Other Non-Metallic Mineral Products	Glass and glass products (261) Non-metallic mineral products n.e.c. (269)

Appendix B Estimation Results Appendix

Table B1: First Stage. Short-Run Effects of Subsidies on Firms' Sales Growth

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.:			$asinh(Credit)$			
IV	5.58***	5.43***	5.73***	5.58***	5.63***	5.67***
	(0.89)	(0.90)	(0.88)	(0.91)	(0.89)	(0.86)
$\log(Sales_{t_0})$	1.18***	1.00***	1.18***	1.18***	1.18***	1.03***
	(0.19)	(0.21)	(0.19)	(0.19)	(0.19)	(0.21)
Chaebol		3.58*				3.54*
		(1.96)				(1.89)
△Export Demands × *Port*			0.55			0.30
			(0.52)			(0.45)
△ log(Import Tariffs) × *Port*				–0.58		53.83
				(10.16)		(46.21)
△ log(Input Tariffs) × *Port*					–15.87	–120.91
					(20.53)	(88.19)
Adj. R^2	0.26	0.28	0.26	0.26	0.26	0.28
Num. Clusters	56	56	56	56	56	56
N	764	764	764	764	764	764

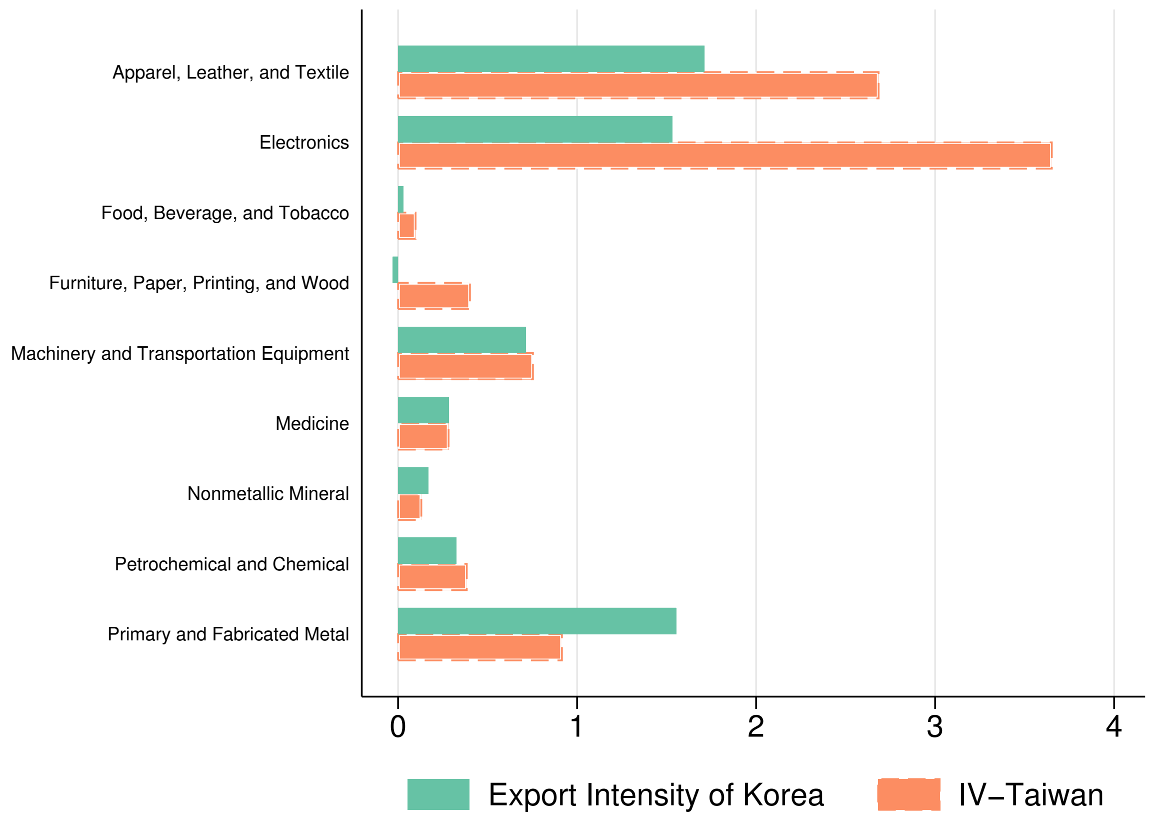
Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the first stage results of the short-run IV regression (4.1). The dependent variable is the inverse hyperbolic sine transformation of credits defined in (4.2). The IV is defined in (4.3). Chaebol is a dummy variable which equals one if a firm is affiliated with the top 30 Chaebol group. △*Export Demand* × *Port* is the interaction between the port dummies with the changes of the world demand shock defined in Equation (4.5). △*Import Tariff* × *Port* is the interaction between changes of import tariffs and the port dummy variable. △*Import Tariff* × *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in Equation (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1972 or 1973. All specifications include region and sector fixed effects.

Table B2: First Stage. Long-Run Effects of Subsidies on Firms' Sales Growth

Dep. Var.:	$asinh(Credit)$					
	(1)	(2)	(3)	(4)	(5)	(6)
IV	3.17***	3.26***	3.53***	3.24***	3.35***	3.53***
	(0.84)	(0.86)	(0.78)	(0.82)	(0.81)	(0.78)
$\log(Sales_{t_0})$	1.93***	1.66***	1.94***	1.93***	1.93***	1.67***
	(0.28)	(0.26)	(0.29)	(0.29)	(0.29)	(0.25)
Chaebol		4.25*				4.21*
		(2.14)				(2.13)
$\triangle$Export Demands $\times$ *Port*			0.85*			0.27
			(0.50)			(0.56)
$\triangle$ log(Import Tariffs) $\times$ *Port*				–17.84*		4.19
				(7.89)		(55.56)
$\triangle$ log(Input Tariffs) $\times$ *Port*					–41.22***	–38.45
					(13.78)	(111.68)
Adj. R^2	0.32	0.35	0.32	0.32	0.32	0.35
Num. Clusters	54	54	54	54	54	54
N	738	738	738	738	738	738

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the first stage results of the short-run IV regression (4.1). The dependent variable is the inverse hyperbolic sine transformation of credits defined in (4.2). The IV is defined in (4.3). Chaebol is a dummy variable which equals one if a firm is affiliated with the top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in Equation (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in Equation (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects.

Figure B1. Changes of Export Intensity of Korea and Export Intensity Measured by Exports of Taiwan



Notes. The figure plots South Korea's log-difference export intensity and the instrumental variable for South Korea's log-difference export intensity. The green bar plots South Korea's log-difference export intensity of sector j defined as the change in total exports divided by gross output in 1970. The orange bar plots the instrumental variable for the export intensity where South Korea's total exports are replaced with Taiwan's total exports of the same sector.

Table B3: Robustness. Instrumenting Export Demand. Short-Run Effects of Subsidies on Firm Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1972-1981 and 1973-1982	
	(1)	(2)
$asinh(Credit)$	0.18***	0.17***
	(0.04)	(0.04)
$\triangle Export\ Demand^{KOR} \times Port$	–0.01	–0.01
	(0.15)	(0.15)
$\log(Sales_{it_0})$	–0.68***	–0.69***
	(0.05)	(0.04)
$Chaebol$		0.24
		(0.40)
Region FE	Y	Y
Sector FE	Y	Y
KP-F	21.20	20.12
SW-$F1$	42.39	40.44
SW-$F2$	146.50	166.19
Num. Clusters	56	56
N	764	764

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the IV estimates of (4.1). The dependent variable is sales growth between 1972 and 1981 or between 1973 and 1982. $asinh(Credit)$ and $\triangle Export\ Demand^{KOR} \times Port$ are instrumented by IVs in (4.3) and (4.5), where $\triangle Export\ Demand^{KOR} \times Port$ is the interaction between the port dummies with the changes of the world demand shock for Korea's exports. Chaebol is a dummy variable which equals one if a firm is affiliated with the top 30 Chaebol group. $\log(Sales_{it_0})$ is log of initial sales in 1972 or 1973. All specifications include region and sector fixed effects. KP-F is the Kleinbergen-Paap F-statistics. SW-$F1$ and SW-$F2$ are Sanderson and Windmeijer (2016) F-statistics for $asinh(Credit)$ and $\triangle Export\ Demand^{KOR} \times Port$ respectively.

Table B4: Robustness. Instrumenting Exports Demands. Long-Run Effects of Subsidies on Firm Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1981-2009 and 1982-2010	
	(1)	(2)
$asinh(Credit)$	0.50***	0.49***
	(0.13)	(0.13)
$\triangle Export\ Demand^{KOR} \times Port$	–0.40	–0.33
	(0.59)	(0.50)
$\log(sales_{it_0})$	–1.09***	–0.99***
	(0.31)	(0.27)
$Chaebol$		–1.37
		(1.48)
Region FE	Y	Y
Sector FE	Y	Y
KP-F	7.59	8.04
SW-$F1$	16.01	16.75
SW-$F2$	20.07	31.70
Num. Clusters	54	54
N	738	738

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the IV estimates of (4.1). The dependent variable is sales growth between 1981 and 2009 or between 1982 and 2010. $asinh(Credit)$ and $\triangle Export\ Demand^{KOR} \times Port$ are instrumented by IVs in (4.3) and (4.5), where $\triangle Export\ Demand^{KOR} \times Port$ is the interaction between the port dummies with the changes of the world demand shock for Korea's exports. Chaebol is a dummy variable which equals one if a firm is affiliated with the top 30 Chaebol group. $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects. KP-F is the Kleinbergen-Paap F-statistics. SW-$F1$ and SW-$F2$ are Sanderson and Windmeijer (2016) F-statistics for $asinh(Credit)$ and $\triangle Export\ Demand^{KOR} \times Port$ respectively.

Table B5: Robustness. No Initial Sales Control. Short-Run Effects of Subsidies on Firms' Sales Growth

Dep.	$\triangle \log Sales_{it}$: 1972-1981 and 1973-1982							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$asinh(Credit)$	0.02*	0.09*		0.09**	0.09**	0.09**	0.09**	0.10**
	(0.01)	(0.04)		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
IV			0.59***					
			(0.22)					
Chaebol				–0.16				–0.21
				(0.33)				(0.35)
$\triangle$*Export Demand* × *Port*					0.11			0.24*
					(0.08)			(0.13)
$\triangle \log(Import\ Tariff) \times Port$						1.99		10.25
						(2.23)		(6.39)
$\triangle \log(Input\ Tariff) \times Port$							1.62	–11.38
							(4.09)	(13.96)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		39.60		36.14	41.91	39.31	40.50	42.21
Adj. R^2	0.09		0.09					
Num. Clusters	56	56	56	56	56	56	56	56
N	764	764	764	764	764	764	764	764

Notes. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1972 and 1981 or between 1973 and 1982. The OLS estimates are reported in column 1. The IV estimates are reported in column 2, 4, 5, 6, and 7, where the IV is defined in Equation (4.3). In column 3, the reduced form estimates of the IV are reported. Chaebol is a dummy variable which equals one if a firm is affiliated with the top 30 Chaebol group. $\triangle$*Export Demand* × *Port* is the interaction between the port dummies with the changes of the world demand shock defined in Equation (4.5). $\triangle$*Import Tariff* × *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* × *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in Equation (4.7). Across all specifications, region and sector fixed effects are controlled. KP-F is the Kleinbergen-Paap F-statistics. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01.

Table B6: Robustness. No Initial Sales Control. Long-Run Effects of Subsidies on Firms' Sales Growth

Dep.	$\triangle \log Sales_{it}$: 1981-2009 and 1982-2010							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
$asinh(Credit)$	0.01	0.23***		0.25***	0.24***	0.23***	0.23***	0.25***
	(0.01)	(0.05)		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
IV			1.39***					
			(0.17)					
$Chaebol$				–1.15				–1.19
				(1.01)				(1.01)
$\triangle$*Export Demand* $\times$ *Port*					0.09			0.43**
					(0.17)			(0.19)
$\triangle \log$(*Import Tariff*) $\times$ *Port*						1.09		–13.43
						(4.73)		(13.66)
$\triangle \log$(*Input Tariff*) $\times$ *Port*							5.42	46.43*
							(8.79)	(23.65)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		27.54		26.45	29.23	27.32	27.96	31.28
Adj. R^2	0.14		0.16					
Num. Clusters	54	54	54	54	54	54	54	54
N	738	738	738	738	738	738	738	738

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1981 and 2009 or between 1982 and 2010. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B7: Robustness. Short-Run Effects of Subsidies on Firm Employment Growth

Dep. Var.:	$\triangle \log Emp_{it}$: 1972-1981 and 1973-1982							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$asinh(Credit)$	0.02***	0.12***		0.12***	0.13***	0.13***	0.13***	0.13***
	(0.01)	(0.04)		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
IV			0.49***					
			(0.16)					
$\log(Emp_{it_0})$	–0.28***	–0.46***	–0.24***	–0.47***	–0.47***	–0.47***	–0.47***	–0.48***
	(0.04)	(0.08)	(0.03)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
$Chaebol$				0.10				0.08
				(0.35)				(0.38)
$\triangle Export\ Demand \times Port$					0.09*			0.06
					(0.05)			(0.15)
$\triangle \log(Import\ Tariff) \times Port$						–2.15*		–2.20
						(1.24)		(5.72)
$\triangle \log(Input\ Tariff) \times Port$							–4.59	1.81
							(3.26)	(18.22)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		26.52		24.05	26.64	25.04	25.96	23.95
Adj. R^2	0.16		0.15					
Num. Clusters	53	53	53	53	53	53	53	53
N	870	870	870	870	870	870	870	870

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is employment growth between 1972 and 1981 or between 1973 and 1982. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle Export\ Demand \times Port$ is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle Import\ Tariff \times Port$ is the interaction between changes of import tariffs and the port dummy variable. $\triangle Import\ Tariff \times Port$ is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Emp_{t_0})$ is log of initial employment in 1972 or 1973. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B8: Long-Run Effects of Subsidies on Firm Employment Growth

Dep. Var.:	$\triangle \log Emp_{it}$: 1981-2009 and 1982-2010							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
$asinh(Credit)$	0.04***	0.11		0.11*	0.12**	0.10	0.10	0.13**
	(0.01)	(0.07)		(0.06)	(0.06)	(0.06)	(0.06)	(0.05)
IV			0.54*					
			(0.32)					
$log(Emp_{it_0})$	–0.59***	–0.68***	–0.54***	–0.70***	–0.70***	–0.67***	–0.67***	–0.70***
	(0.05)	(0.13)	(0.06)	(0.07)	(0.12)	(0.12)	(0.12)	(0.07)
$Chaebol$				0.20				0.12
				(0.86)				(0.84)
$\triangle Export\ Demand \times Port$					0.08			0.38***
					(0.15)			(0.13)
$\triangle \log(Import\ Tariff) \times Port$						1.98		–4.57
						(2.28)		(6.05)
$\triangle \log(Input\ Tariff) \times Port$							5.29	27.17*
							(4.76)	(13.67)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		26.79		25.99	32.91	30.41	31.62	26.71
Adj. R^2	0.37		0.35					
Num. Clusters	54	54	54	54	54	54	54	54
N	873	873	873	873	873	873	873	873

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is employment growth between 1981 and 2009 or between 1982 and 2010. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle Export\ Demand \times Port$ is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle Import\ Tariff \times Port$ is the interaction between changes of import tariffs and the port dummy variable. $\triangle Import\ Tariff \times Port$ is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Emp_{t_0})$ is log of initial employment in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B9: Robustness. Short-Run Effects of Subsidies on Firm TFP Growth

Dep. Var.:	$\triangle TFP_{it}$: 1972-1981 and 1973-1982							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$asinh(Credit)$	0.02***	0.07***		0.07***	0.07***	0.07***	0.07***	0.07***
	(0.01)	(0.01)		(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
IV			0.51***					
			(0.12)					
$\log(TFP_{it_0})$	–0.72***	–0.74***	–0.71***	–0.74***	–0.74***	–0.74***	–0.74***	–0.74***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
$Chaebol$				0.01				0.02
				(0.20)				(0.19)
$\triangle$*Export Demand* $\times$ *Port*					–0.04			–0.05
					(0.05)			(0.08)
$\triangle\log($*Import Tariff*$) \times$ *Port*						0.71		2.03
						(1.19)		(6.26)
$\triangle\log($*Input Tariff*$) \times$ *Port*							1.23	–4.71
							(2.86)	(14.65)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		32.82		26.51	33.30	29.07	31.18	29.00
Adj. R^2	0.60		0.60					
Num. Clusters	50	50	50	50	50	50	50	50
N	595	595	595	595	595	595	595	595

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is TFP growth between 1972 and 1981 or between 1973 and 1982, where TFP is obtained by applying the production function estimation method developed by Ackerberg et al. (2015). The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(TFP_{t_0})$ is log of initial TFP in 1972 or 1973. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B10: Robustness. Long-Run Effects of Subsidies on Firm TFP Growth

Dep. Var.:	$\triangle \log TFP_{it}$: 1981-2009 and 1982-2010							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
$asinh(Credit)$	0.01^{**}	0.21^{***}		0.21^{***}	0.19^{***}	0.20^{***}	0.20^{***}	0.19^{***}
	(0.01)	(0.05)		(0.05)	(0.06)	(0.05)	(0.05)	(0.05)
IV			1.05^{***}					
			(0.14)					
$log(TFP_{it_0})$	-0.75^{***}	-1.04^{***}	-0.77^{***}	-1.03^{***}	-1.03^{***}	-1.04^{***}	-1.0^{***}	-1.01^{***}
	(0.09)	(0.19)	(0.09)	(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
$Chaebol$				-0.93				-0.83
				(0.63)				(0.53)
$\triangle Export\ Demand \times Port$					-0.16			-0.12
					(0.17)			(0.19)
$\triangle \log(Import\ Tariff) \times Port$						1.47		-7.69
						(4.28)		(21.75)
$\triangle \log(Input\ Tariff) \times Port$							5.63	16.38
							(5.80)	(37.90)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		20.00		19.57	20.21	20.77	20.72	23.13
Adj. R^2	0.91		0.92					
Num. Clusters	54	54	54	54	54	54	54	54
N	683	683	683	683	683	683	683	683

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is TFP growth between 1981 and 2009 or between 1982 and 2010, where TFP is obtained by applying the production function estimation method developed by Ackerberg et al. (2015). The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(TFP_{t_0})$ is log of initial TFP in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B11: Robustness. Alternative Transformation of Credit. Short-Run Effects of Subsidies on Firm Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1972-1981 and 1973-1982							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$1[Credit > 0]$	1.04***	3.28***		3.24***	3.28***	3.27***	3.25***	3.22***
	(0.21)	(0.65)		(0.65)	(0.66)	(0.66)	(0.66)	(0.61)
IV			0.98***					
			(0.18)					
$\log(Sales_{t_0})$	–0.53***	–0.67***	–0.47***	–0.68***	–0.67***	–0.67***	–0.67***	–0.68***
	(0.04)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Chaebol				0.29				0.29
				(0.40)				(0.39)
$\triangle Export\ Demand \times Port$				0.29				0.29
				(0.40)				(0.39)
$\triangle \log(Import\ Tariff) \times Port$						0.84		–5.06
						(2.32)		(8.67)
$\triangle \log(Input\ Tariff) \times Port$							2.88	16.55
							(4.10)	(15.65)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		44.26		42.32	46.88	42.80	44.72	48.59
Adj. R^2	0.45		0.39					
Num. Clusters	56	56	56	56	56	56	56	56
N	764	764	764	764	764	764	764	764

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1972 and 1981 or between 1973 and 1982. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle Export\ Demand \times Port$ is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle Import\ Tariff \times Port$ is the interaction between changes of import tariffs and the port dummy variable. $\triangle Import\ Tariff \times Port$ is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1972 or 1973. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B12: Robustness. Alternative Transformation of Credit. Long-Run Effects of Subsidies on Firms' Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1981-2009 and 1982-2010							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
$1[Credit > 0]$	0.36**	8.84***		8.70***	8.41***	8.69***	8.45***	8.49***
	(0.17)	(2.36)		(2.33)	(2.05)	(2.36)	(2.26)	(2.31)
IV			1.58***					
			(0.17)					
$log(Sales_{it_0})$	–0.13**	–1.01***	–0.13**	–0.93***	–0.97***	–1.00***	–0.98***	–0.91***
	(0.05)	(0.27)	(0.05)	(0.25)	(0.24)	(0.27)	(0.26)	(0.26)
Chaebol				–1.11				–1.06
				(1.41)				(1.23)
$\triangle$*Export Demand* $\times$ *Port*					–0.18			0.18
					(0.25)			(0.31)
$\triangle \log(Import\ Tariff) \times Port$						6.61		–4.83
						(6.10)		(28.02)
$\triangle \log(Input\ Tariff) \times Port$							15.39	30.48
							(9.46)	(49.44)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		15.22		15.04	20.64	15.83	17.17	19.03
Adj. R^2	0.15		0.17					
Num. Clusters	54	54	54	54	54	54	54	54
N	738	738	738	738	738	738	738	738

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1981 and 2009 or between 1982 and 2010. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B13: Robustness. Alternative Transformation of Credits. Short-Run Effects of Subsidies on Firms' Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1972-1981 and 1973-1982							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log(1 + Credit)$	0.06***	0.18***		0.18***	0.18***	0.18***	0.18***	0.18***
	(0.01)	(0.04)		(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
IV			0.98***					
			(0.18)					
$\log(Sales_{t_0})$	–0.53***	–0.68***	–0.47***	–0.69***	–0.68***	–0.68***	–0.67***	–0.69***
	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Chaebol				0.24				0.25
				(0.40)				(0.38)
$\triangle$*Export Demand* $\times$ *Port*					–0.00			0.11
					(0.07)			(0.08)
$\triangle \log$(*Import Tariff*) $\times$ *Port*						0.84		–6.26
						(2.18)		(8.70)
$\triangle \log$(*Input Tariff*) $\times$ *Port*							3.18	19.54
							(3.82)	(15.90)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		38.99		36.59	41.97	37.72	39.93	42.85
Adj. R^2	0.46		0.39					
Num. Clusters	56	56	56	56	56	56	56	56
N	764	764	764	764	764	764	764	764

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1972 and 1981 or between 1973 and 1982. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1972 or 1973. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B14: Robustness. Alternative Transformation of Credits. Long-Run Effects of Subsidies on Firms' Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1981-2009 and 1982-2010							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
$\log(1 + Credit)$	0.02**	0.52***		0.51***	0.49***	0.51***	0.50***	0.49***
	(0.01)	(0.14)		(0.14)	(0.12)	(0.14)	(0.13)	(0.13)
IV			1.58***					
			(0.17)					
$log(Sales_{it_0})$	–0.13**	–1.10***	–0.13**	–0.99***	–1.05***	–1.08***	–1.05***	–0.96***
	(0.05)	(0.31)	(0.05)	(0.27)	(0.26)	(0.30)	(0.28)	(0.26)
Chaebol				–1.39				–1.32
				(1.53)				(1.32)
$\triangle$*Export Demand* $\times$ *Port*					–0.19			0.22
					(0.26)			(0.30)
$\triangle \log($*Import Tariff*$) \times$ *Port*						6.32		–10.22
						(5.97)		(27.18)
$\triangle \log($*Input Tariff*$) \times$ *Port*							16.08	42.69
							(9.84)	(47.59)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		10.74		12.10	14.78	12.93	13.57	13.47
Adj. R^2	0.16		0.19					
Num. Clusters	53	53	53	53	53	53	53	53
N	747	747	747	747	747	747	747	747

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1981 and 2009 or between 1982 and 2010. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B15: Robustness. Single Long Difference. Short-Run Effects of Subsidies on Firms' Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1973-1982							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$asinh(Credit)$	0.06***	0.19***		0.19***	0.19***	0.19***	0.18***	0.19***
	(0.01)	(0.04)		(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
IV			1.06***					
			(0.20)					
$\log(Sales_{t_0})$	–0.56***	–0.70***	–0.49***	–0.71***	–0.70***	–0.70***	–0.70***	–0.71***
	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)
Chaebol				0.25				0.24
				(0.46)				(0.44)
$\triangle$*Export Demand* × *Port*					–0.02			0.21*
					(0.08)			(0.12)
$\triangle \log$(*Import Tariff*) × *Port*						2.53		–5.37
						(1.99)		(7.95)
$\triangle \log$(*Input Tariff*) × *Port*							6.76*	24.69*
							(3.96)	(14.39)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		46.49		47.97	51.13	45.85	47.51	48.28
Adj. R^2	0.49		0.42					
Num. Clusters	43	43	43	43	43	43	43	43
N	396	396	396	396	396	396	396	396

Notes. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1973 and 1982. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1981 and 2009 or between 1982 and 2010. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* × *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* × *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* × *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1972 or 1973. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B16: Robustness. Single Long Difference. Long-Run Effects of Subsidies on Firms' Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1982-2010							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$asinh(Credit)$	0.02*	0.48***		0.48***	0.46***	0.48***	0.47***	0.47***
	(0.01)	(0.13)		(0.14)	(0.12)	(0.13)	(0.12)	(0.13)
IV			1.40***					
			(0.19)					
$\log(Sales_{t_0})$	–0.12*	–1.04***	–0.12	–0.97***	–1.01***	–1.05***	–1.02***	–0.95***
	(0.06)	(0.31)	(0.07)	(0.28)	(0.27)	(0.30)	(0.28)	(0.27)
Chaebol				–1.39				–1.34
				(1.67)				(1.43)
$\triangle$*Export Demand* × *Port*					–0.16			0.29
					(0.25)			(0.27)
$\triangle \log($*Import Tariff*$) \times$ *Port*						6.86		–11.21
						(5.96)		(24.97)
$\triangle \log($*Input Tariff*$) \times$ *Port*							17.00	47.44
							(10.17)	(44.28)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		13.77		13.44	17.46	14.89	16.20	21.10
Adj. R^2	0.07		0.09					
Num. Clusters	46	46	46	46	46	46	46	46
N	401	401	401	401	401	401	401	401

Notes. Standard errors clustered at the region level are in parentheses. * $p<0.05$; ** $p<0.01$; *** $p<0.01$. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1982 and 2010. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* × *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* × *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* × *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B17: Robustness. Different Time Horizon. Long-Run Effects of Subsidies on Firm Sales Growth

Dep. Var.:	$\triangle \log Sales_{it}$: 1981-1998 and 1982-1999							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$asinh(Credit)$	0.01**	0.22***		0.22***	0.23***	0.22***	0.22***	0.24***
	(0.01)	(0.05)		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
IV			0.86***					
			(0.13)					
$\log(Sales_{t_0})$	–0.18***	–0.61***	–0.17***	–0.59***	–0.63***	–0.61***	–0.61***	–0.61***
	(0.04)	(0.15)	(0.05)	(0.13)	(0.14)	(0.15)	(0.15)	(0.11)
Chaebol				–0.31				–0.37
				(0.62)				(0.61)
$\triangle$*Export Demand* $\times$ *Port*					0.10			0.16
					(0.13)			(0.21)
$\triangle \log($*Import Tariff*$) \times$ *Port*						–1.16		–1.86
						(2.87)		(11.42)
$\triangle \log($*Input Tariff*$) \times$ *Port*							–2.35	6.81
							(4.88)	(18.05)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F		19.82		18.72	27.35	21.07	22.67	26.25
Adj. R^2	0.18		0.19					
Num. Clusters	53	53	53	53	53	53	53	53
N	848	848	848	848	848	848	848	848

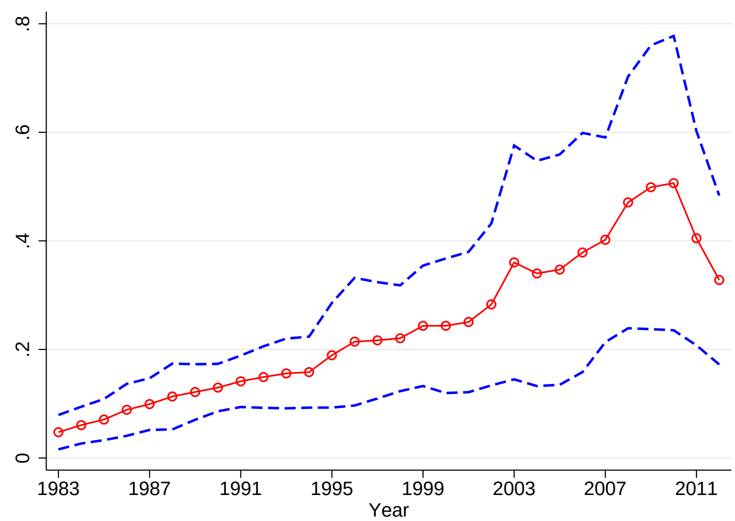
Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1981 and 1998 or 1982 and 1999. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Table B18: Robustness. Different Time Horizon. Long-Run Effects of Subsidies on Firms' Sales Growth

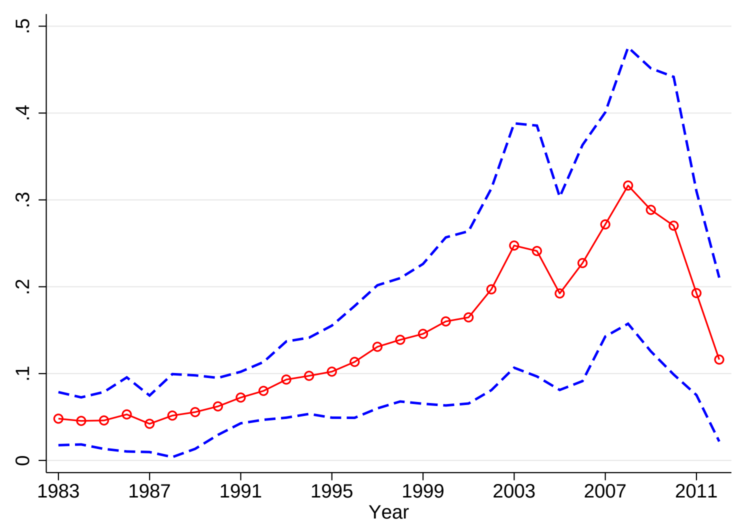
Dep. Var.:	$\triangle \log Sales_{it}$: 1981-2005 and 1982-2006							
	OLS	IV						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$asinh(Credit)$	0.02***	0.35***		0.35***	0.35***	0.35***	0.34***	0.36***
	(0.01)	(0.11)		(0.11)	(0.10)	(0.11)	(0.10)	(0.10)
IV			1.15***					
			(0.12)					
$\log(Sales_{t_0})$	–0.20***	–0.82***	–0.19***	–0.78***	–0.84***	–0.82***	–0.82***	–0.80***
	(0.05)	(0.24)	(0.05)	(0.20)	(0.21)	(0.24)	(0.23)	(0.18)
$Chaebol$				–0.59				–0.65
				(1.17)				(1.08)
$\triangle Export\ Demand \times Port$					0.05			0.26
					(0.21)			(0.28)
$\triangle \log(Import\ Tariff) \times Port$						0.74		–6.58
						(3.84)		(16.36)
$\triangle \log(Input\ Tariff) \times Port$							2.96	25.71
							(7.35)	(26.71)
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y
KP-F	10.80		10.66	16.62	12.16	13.26	16.58	
Adj. R^2	0.18		0.19					
Num. Clusters	54	54	54	54	54	54	54	54
N	784	784	784	784	784	784	784	784

Notes. Standard errors clustered at the region level are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS and IV estimates of Equation (4.1). The dependent variable is sales growth between 1981 and 2005 or 1982 and 2006. The OLS estimates are reported in column 1. The IV estimates are reported in columns 2, and 4-8. The IV is defined in (4.3). Column 3 reports the reduced form estimates. Chaebol is a dummy variable which equals 1 if a firm is affiliated with a top 30 Chaebol group. $\triangle$*Export Demand* $\times$ *Port* is the interaction between the port dummies with the changes of the world demand shock defined in (4.5). $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of import tariffs and the port dummy variable. $\triangle$*Import Tariff* $\times$ *Port* is the interaction between changes of input tariffs and the port dummy variable, where the input tariffs are defined in (4.7). $\log(Sales_{t_0})$ is log of initial sales in 1981 or 1982. All specifications include region and sector fixed effects. KP-F are the Kleinbergen-Paap F-statistics.

Figure B2. Yearly Long-Run Estimates



Panel A. log(Sales)



Panel B. TFP

Notes. This figure plots the yearly estimated coefficients of Equation (4.1). In Panel A, the dependent variable is the sales growth between 1982 and the year on the X-axis. In Panel B, the dependent variable is the TFP growth between 1982 and the year on the X-axis, where TFP is obtained by applying the production function estimation method developed by Ackerberg et al. (2015). The blue dashed lines represent the 95% confidence intervals, using standard errors clustered by region.

B.1 Additional Placebo Tests

This section provides an additional placebo test, based on data at the regional level. Using population census downloaded from Statistics Korea, we construct manufacturing shares of employment and regional population for each region in 1966, 1970, and 1985. We run the following falsification test:

$$\triangle \log \text{Mfg. Emp. Share}_n = \beta_1 asinh(\text{HCI Credit}_n) + \beta_2 X_n + \epsilon_n \tag{B.1}$$

where $\triangle \log \text{Mfg. Emp. Share}_n$ is growth of manufacturing employment shares between 1966 and 1970 and between 1970 and 1985. $asinh$(Regional HCI Credits) is the inverse hyperbolic sine transformation of the sum of credits of all HCI sector firms located in region n between 1973 and 1979, that is,

$$\text{HCI Credit}_n = \sum_{f \in \mathcal{F}_{n,HCI}} \sum_{\tau=1973}^{1979} Credit_{f\tau},$$

where $\mathcal{F}_{n,HCI}$ is the set of HCI sector firms located in region n. X_n is a vector of additional controls. By taking the time difference, any time-invariant regional unobservables are differenced out. Robust standard errors are used for inference.

Under our exclusion restriction, we expect that $asinh$(HCI Credits$_n$) is uncorrelated with the growth of manufacturing employment shares between 1966 and 1970. Suppose the Korean government predicted the productivity growth of HCI sectors in the targeted regions. In that case, our estimates may be driven by unobservable productivity growth rather than by the effects of subsidies. If the productivity growth of HCI sectors is persistent, manufacturing employment share growth between 1966 and 1970 may be positively correlated with the sum of all credits of HCI sectors allocated between 1973 and 1979. One caveat of this data set is that we only observe overall manufacturing shares but not employment shares of sub-sectors within the manufacturing sector. Given that the dependent variables are overall manufacturing share growth, if unobservable productivity of non-HCI sector evolved so that it exactly cancels out HCI sector productivity growth, then overall manufacturing shares may remain stable despite productivity growth of HCI sectors. However, setting knife-edge cases aside, as long as changes of unobservable productivity of HCI sectors affect regional manufacturing shares, the falsification test in Equation (B.1) provides additional support for our identifying assumption.

The results are reported in Table B19. In columns 1 and 2, the dependent variables are manufacturing employment share growth between 1966 and 1970, and in columns 3 and 4, the dependent variables are manufacturing employment share growth between 1970 and 1985. In columns 2 and 4, we additionally control for the log of the total population of 1966. In columns 1 and 2, we find no

Table B19: Placebo Test at the Regional Level

Dep. Var.:	△ log Mfg. Share: 1966-1970		△ log Mfg. Share: 1970-1985	
	(1)	(2)	(3)	(4)
asinh(Regional HCI Loan)	0.01	0.01	0.02***	0.02***
	(0.01)	(0.01)	(0.01)	(0.01)
log of population in 1966		–0.08		–0.17**
		(0.07)		(0.08)
N	61	61	61	61

Notes. Robust standard errors are in parentheses. * p<0.05; ** p<0.01; *** p<0.01. The table reports the OLS estimates of Equation (B.1). In columns 1 and 2, the dependent variable is the log change in regional manufacturing share between 1966 and 1970. In columns 3 and 4, the dependent variable is the log change in regional manufacturing share between 1970 and 1985.

statistically significant correlation between total credit and manufacturing share growth, supporting our identifying assumption. By contrast, in columns 3 and 4, they are positively correlated, with the coefficient significant at the 5% level

Appendix C Theory and Quantification

C.1 Optimal Prices When Firms are Not Constrained

If firms are not constrained in the first period, they will charge the price that maximizes the total discounted profits:

$$p_{fj1}^{LBD} = argmax_{p_{fj1}} \Big\{ \Pi_{fj1}(p_{fj1}) + \beta \tilde{\Pi}_{fj2}(p_{fj1}) \Big\},$$

where

$$\Pi_{fj1}(p_{fj1}) = p_{fj1}^{1-\sigma} P_{j1}^{\sigma-1} X_{j1} - \frac{c_{j1}}{\phi_{fj1}} p_{fj1}^{-\sigma} P_{j1}^{\sigma-1} X_{j1}$$

and

$$\tilde{\Pi}_{fj2}(p_{fj1}) = \frac{1}{\sigma}\left(\frac{c_{j2}}{\phi_{fj2}}\right)^{1-\sigma} P_{j2}^{\sigma-1} X_{j2} \times (p_{fj1}^{-\sigma} P_{j1}^{\sigma-1} X_{j1})^{\xi(\sigma-1)}.$$

P_{fj1}^{LBD} satisfies the following first order condition:

$$0 = (1-\sigma) p_{fj1}^{-\sigma} P_{j1}^{\sigma-1} X_{j1} + \sigma \frac{c_{j1}}{\phi_{fj1}} p_{fj1}^{-\sigma-1} P_{j1}^{\sigma-1} X_{j1} \\ - \beta\sigma\xi(\sigma-1)\left[p_{fj1}^{-\sigma\xi(\sigma-1)-1} (P_{j1}^{\sigma-1} X_{j1})^{\xi(\sigma-1)} \right] \frac{1}{\sigma}\left(\frac{c_{j2}}{\phi_{fj2}}\right) P_{j2}^{\sigma-1} X_{j2},$$

which collapses to the first order condition that maximizes the static profit in the first period when $\xi = 0$.

C.2 Equilibrium in the First Period When Firms are Constrained

In this section, we derive expressions for firm-level variables when all firms are constrained in the first period, that is, $\lambda_{j1}/\kappa_{fj1} \leq 1$, $\forall f$. We first formally show that when $\lambda_{j1}/\kappa_{fj1} \leq 1$ holds, a firm produces at most the quantity that maximizes static profits and charges a higher price than the price that maximizes static profits.

Proposition C.1. *When $\lambda_{j1}/\kappa_{fj1} \leq 1$, firms are constrained, $q_{fj1}^{Friction} \leq q_{fj1}^{Static}$, and $p_{fj1}^{Friction} \geq p_{fj1}^{Static}$, where q_{fj1}^{Static} and p_{fj1}^{Static} are the quantity and price that maximize the static profits.*

Proof. The static profit-maximizing price is

$$p_{fj1}^{Static} = \frac{\sigma}{\sigma-1} \frac{c_{j1}}{A_{fj1}}$$

and $q_{fj1}^{Static} = (p_{fj1}^{Static})^{-\sigma} P_{j1}^{\sigma-1} X_{j1}$. Firms are constrained when

$$\kappa_{fj1} c_{j1} m_{j1} \leq \tilde{\lambda}_{j1} A_{fj1}^{\sigma-1} \tag{C.1}$$

binds with equality. When charging p_{fj1}^{Static}, total input costs are

$$\begin{aligned} \kappa_{fj1} c_{j1} m_{fj1} &= \kappa_{fj1} c_{j1} \times \frac{1}{A_{fj1}} (q_{fj1}^{Static}) = \frac{c_{j1}}{A_{fj1}} (p_{fj1}^{Static})^{-\sigma} P_{j1}^{\sigma-1} X_{j1} \\ &= \kappa_{fj1} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} c_{j1}^{1-\sigma} A_{fj1}^{\sigma-1} P_{j1}^{\sigma-1} X_{j1}. \end{aligned} \tag{C.2}$$

Substituting (C.2) into (C.1) binding with equality, we can establish that when $\kappa_{fj1}/\lambda_{j1} \leq 1$, firms are constrained. When firms are constrained, their prices are pinned down by the constraints:

$$\begin{aligned} \kappa_{fj1} c_{j1} m_{fj1} &= \kappa_{fj1} \frac{c_{j1}}{A_{fj1}} q_{fj1}^{Friction} \\ &= \kappa_{fj1} \frac{c_{j1}}{A_{fj1}} (p_{fj1}^{Friction})^{-\sigma} P_{j1}^{\sigma-1} X_{j1} \\ &= \lambda_{j1} \left(\frac{\sigma}{\sigma - 1} \right)^{-\sigma} c_{j1}^{1-\sigma} A_{fj1}^{\sigma-1} P_{j1}^{\sigma-1} X_{j1}, \end{aligned} \tag{C.3}$$

which gives

$$p_{fj1}^{Friction} = \frac{\sigma}{\sigma - 1} \left(\frac{\lambda_{j1}}{\kappa_{fj1}} \right)^{-\frac{1}{\sigma}} \frac{c_{j1}}{A_{fj1}}$$

and

$$q_{fj1}^{Friction} = (p_{fj1}^{Friction})^{-\sigma} P_{j1}^{\sigma-1} X_{j1}.$$

Because $\lambda_{j1}/\kappa_{fj1} \leq 1$, $p_{fj1}^{Friction} \geq p_{fj1}^{Static}$ and $q_{fjq}^{friction} \leq q_{fj1}^{Static}$ hold. □

We next derive equilibrium allocation when all firms are constrained.

Price. By Proposition C.1

$$p_{fj1}^{Friction} = \frac{\sigma}{\sigma - 1} \frac{c_{j1}}{A_{fj1}} \left(\frac{\kappa_{fj1}}{\lambda_{j1}} \right)^{-\frac{1}{\sigma}}. \tag{C.4}$$

Sales. Demand for firm f's output is $p_{fj1}^{-\sigma} P_{j1}^{\sigma-1} X_{j1}$. After substituting firm price in (C.4) into firm sales $X_{fj1} = p_{fj1} q_{fj1}$, we obtain

$$X_{fj1} = \left(\frac{\kappa_{fj1}}{\lambda_{j1}} \right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\sigma}{\sigma - 1} \frac{c_{j1}}{A_{fj1}} \right) P_{j1}^{\sigma-1} X_{j1}. \tag{C.5}$$

Input Expenditures and Total Input Costs. A firm's input expenditures are expressed as

$$\begin{aligned}\left(w_t H_{fj1} + \sum_k P_{k1} M_{fk1}\right) &= c_{j1} m_{fj1} = c_{j1} \frac{q_{fj1}}{A_{fj1}} \\ &= \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{-1} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \left(\frac{c_{j1}}{A_{fj1}}\right)^{1-\sigma} P_{j1}^{\sigma-1} X_{j1} = \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}} \frac{\sigma-1}{\sigma} X_{fj1}.\end{aligned} \tag{C.6}$$

The first equality comes from a firm's cost minimization such that $w_t H_{fj1} + \sum_k P_{k1} M_{fk1}$ is equal to $c_{j1} m_{fj1}$ where c_{j1} is the price of the input bundle and m_{fj1} is the total quantity of input bundles used by firm f. The second equality comes from a firm's production function. The third equality is derived from the demand curve and prices charged under constraints in (C.4). Input expenditures on each input sector and on labor are

$$\gamma_j^l \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}} \frac{\sigma-1}{\sigma} X_{fj1}, \qquad j = 1, \ldots, J, \quad H. \tag{C.7}$$

A firm's total costs on inputs inclusive of subsidies are obtained as

$$\kappa_{fj1} c_{j1} m_{fj1} = \kappa_{fj1} \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}} \frac{\sigma-1}{\sigma} X_{fj1}. \tag{C.8}$$

Profits. A firm's profits are obtained as sales net of total input costs:

$$\Pi_{fj1} = \left[1 - \kappa_{fj1} \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}} \left(\frac{\sigma-1}{\sigma}\right)\right] X_{fj1}. \tag{C.9}$$

C.3 Equilibrium in the Second Period

There is no subsidy and constraint in the second period, so firms maximize their static profits.The firm charges a constant mark-up over marginal cost:

$$p_{fj2} = \frac{\sigma}{\sigma-1} \frac{c_{j1}}{A_{fj2}}, \tag{C.10}$$

and its sales are

$$X_{fj2} = \left(\frac{\sigma}{\sigma-1} \frac{c_{j2}}{A_{j2}}\right)^{1-\sigma} P_{j2}^{\sigma-1} X_{j2}. \tag{C.11}$$

Because $A_{fj2} = \phi_{fj2} q_{fj1}^{\xi}$ and $q_{fj1} = p_{fj1}^{-\sigma} P_{j1}^{\sigma-1} X_1$, after substituting the firm's first period price (C.4), we can rewrite the second period sales as

$$X_{fj2} = \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{(\sigma-1)\xi} \prod_{h=0}^{1} \left[\left(\frac{\sigma}{\sigma-1} \frac{c_{j,2-h}}{\phi_{fj,2-h}}\right)^{(1-\sigma)(\sigma\xi)^h} \times (P_{j,2-h}^{\sigma-1} X_{j,2-h})^{(\xi(\sigma-1))^h} \right] \tag{C.12}$$

Because there is no subsidy, the total input expenditures and total input costs are identical in the second period. They are expressed as

$$c_{j2} m_{fj2} = \frac{\sigma-1}{\sigma} X_{fj2} \tag{C.13}$$

Profits. Profits in the second period are

$$\Pi_{fj2} = \frac{1}{\sigma} X_{fj2}. \tag{C.14}$$

C.4 Data Construction for the Quantitative Analysis

This section describes the data cleaning procedure for the quantitative analysis. We merge the 1982 firm-level sales to the national IO table for 1983.[51] Let X_{jt}^{IO} denote gross output of sector j, where the superscript reflects the fact that the data come from the IO table. From our firm-balance sheet data, we calculate the sum of sales of all firms in sector j: $X_{jt}^{Firm} = \sum_{f \in \mathcal{F}_j} X_{fjt}^{Firm}$, where the superscript $Firm$ is used to denote that the data comes from micro firm-level data. Then, we calculate the residuals as $X_{jt}^{Resid} = X_{jt}^{IO} - X_{jt}^{Firm}$ and take X_{jt}^{Resid} as a separate firm. X_{jt}^{Resid} accounts for the sum of sales of small-sized firms that are not present in our firm-level data. Firm-level sales shares are then obtained as

$$\pi_{fjt} = \frac{X_{fjt}^{Firm}}{X_{jt}^{IO}}$$

for both actual firms in the data and the residual firm.

For some observations, sales are missing, whereas the assets are available for all observations. For observations with missing sales, we impute sales using assets. We run

$$\log Sales_{it} = \beta_1 Assets_{it} + \delta_t + \epsilon_{it}$$

for each sector, where we use cross-sectional variation in assets to predict sales. Then, we use the predicted values as imputed sales.

[51] The IO table is not available for 1982, so we use the IO table in 1983 instead.

C.5 A Shock Formulation of the Model

This section presents the shock formulation of the model. We express the equilibrium conditions in terms of gross changes $\hat{x} = x^c/x$ where x^c and x are the counterfactual and pre-shock allocations. In the short-run hat algebra, the shocks are $\hat{\kappa}_{fj1}$, and in the long-run hat algebra, the shocks are $\hat{A}^L_{fj2}$.

Short-Run. In the short-run counterfactual, λ_{j1} and ϕ_{fj1} remains constant, but only κ_{fj1} are changed. We set $\hat{\lambda}^S_{j1} = 1$, $\hat{A}^S_{fj1} = 1$, $\hat{\kappa}^S_{fj1} = \kappa_{c,fj1}/\kappa_{fj1}$, where $\kappa_{c,fj1} = 1$.

A firm's price changes are written as

$$\hat{p}^S_{fj1} = \left(\frac{1}{\hat{\kappa}^S_{fj1}}\right)^{-\frac{1}{\sigma}} \frac{\hat{c}^S_{ji1}}{\hat{A}^S_{fj1}}. \tag{C.15}$$

Changes of sectoral price indices are

$$(\hat{P}^S_{j1})^{1-\sigma} = \sum_{f \in \mathcal{F}_j} \pi_{fj1} (\hat{p}^S_{fj1})^{1-\sigma}. \tag{C.16}$$

A firm's counterfactual market share is

$$\pi_{c,fj1} = \frac{(\hat{p}^S_{fj1})^{1-\sigma} \pi_{fj1}}{\sum_{f' \in \mathcal{F}_j} (\hat{p}^S_{f'j1})^{1-\sigma} \pi_{f'j1}}. \tag{C.17}$$

Labor market clearing can be written as

$$w_{c,1} H_1 = \frac{\sigma - 1}{\sigma} \sum_{j \in \mathcal{J}_M} \gamma^H_j X_{c,j1} + \sum_{j \in \mathcal{J}_{NM}} \gamma^H_j X_{c,j1} \tag{C.18}$$

Goods market clearing is expressed as

$$X_{c,j1} = \alpha^j [w_{c,1} H_1 + \Pi_{c,1} + T_{c,1}] + \frac{\sigma - 1}{\sigma} \sum_{k \in \mathcal{J}_M} \gamma^j_k X_{c,k1} + \sum_{k \in \mathcal{J}_{NM}} \gamma^j_k X_{c,k1} \tag{C.19}$$

Firms' sales and profits are expressed as

$$X_{c,fj1} = \pi_{c,fj1} X_{c,j1}, \tag{C.20}$$

and

$$\pi_{c,fj1} = \left[1 - \kappa_{c,fj1} \left(\frac{\lambda_{j1}}{\kappa_{c,fj1}}\right)^{\frac{1}{\sigma}} \frac{\sigma - 1}{\sigma}\right] X_{c,fj1}. \tag{C.21}$$

Aggregate profits are

$$\Pi_{c,1} = \sum_{j \in \mathcal{J}_M} \sum_{f \in \mathcal{F}_j} \Pi_{c,fj1}. \tag{C.22}$$

Lump-sum transfers are

$$T_{c,1} = \frac{\sigma - 1}{\sigma} \sum_{j \in \mathcal{J}_M} \sum_{f \in \mathcal{F}_j} (\kappa_{c,fj1} - 1)\left(\frac{\lambda_{j1}}{\kappa_{c,fj1}} X_{c,fj1}\right). \tag{C.23}$$

The Long Run. In the long-run hat algebra, there are four exogenous changes: $\hat{H}_2^L$, $\hat{A}_{fj2}^L$, κ_{fj1}, λ_j. In the second period, there are no subsidy and no constraints, so we set $\kappa_{fj2} = 1$ and $\lambda_{j2} = 1$. The long-run counterfactual productivity changes are computed as

$$\hat{A}_{c,fj2}^L = \frac{A_{fj2}}{A_{fj1}} \times (\hat{q}_{c,fj1}^S)^{\xi}$$

where A_{fj2}/A_{fj1} is obtained from the data and $\hat{q}_{c,fj1}^S$ is obtained from the short-run hat algebra.

A firm's price changes and market shares are written as

$$\hat{p}_{fj2}^L = \left(\frac{\hat{\lambda}_{j2}^L}{\hat{\kappa}_{fj2}^L}\right)^{\frac{1}{\sigma}} \frac{\hat{c}_{j2}^L}{\hat{A}_{fj2}^L}, \tag{C.24}$$

and

$$\pi_{fj2} = \frac{(\hat{p}_{fj2}^L)^{1-\sigma} \pi_{fj1}}{\sum_{f' \in \mathcal{F}_j} (\hat{p}_{f'j2}^L)^{1-\sigma} \pi_{f'j1}}. \tag{C.25}$$

Labor market clearing can be written as

$$w_2 \hat{H}_2^L H_1 = \frac{\sigma - 1}{\sigma} \sum_{k \in \mathcal{J}_M} \gamma_j^H X_{j2} + \sum_{k \in \mathcal{J}_{NM}} \gamma_k^H X_{j2}. \tag{C.26}$$

Goods market clearing is expressed as

$$X_{j2} = \alpha^j [w_2 \hat{H}_2^L H_1 + \Pi_2 + T_2] + \frac{\sigma - 1}{\sigma} \sum_{k \in \mathcal{J}_M} \gamma_k^j X_{k2} + \sum_{k \in \mathcal{J}_{NM}} \gamma_k^j X_{k2}. \tag{C.27}$$

Firms' sales and profits are expressed as

$$X_{fj2} = \pi_{fj1}^L X_{j2}, \tag{C.28}$$

and

$$\Pi_{fj2} = \frac{1}{\sigma} X_{fj2}. \tag{C.29}$$

Aggregate profits are

$$\Pi_2 = \sum_{j \in \mathcal{J}_M} \sum_{f \in \mathcal{F}_j} \Pi_{fj2}. \tag{C.30}$$

Lump-sum transfers are

$$T_2 = 0. \tag{C.31}$$

C.6 Model Solution and Algorithm

The model solution solves Equations (C.15)-(C.31). To solve the model, we require the following information.

Pre-shock data values in 1982. The data values in 1982 correspond to the first period in the model:

- Gross sales of firms in the manufacturing sectors, $\forall f \in \mathcal{F}_j$ and $\forall j \in \mathcal{J}_M$
- Gross sales of sector j. For $j \in \mathcal{J}$, $X_{j1} = \sum_{f \in \mathcal{F}_j} X_{fj1}$.

Shocks.

- Levels of $\{\lambda_{j1}\}$ in the first period, $\forall j \in \mathcal{J}_M$. In the second period, no firms are constrained, i.e. $\lambda_{j2} = 1$, $\forall j$
- Long-run productivity changes of firms in the manufacturing sectors, $\{\hat{A}^L_{fj2}\}$, $\forall f \in \mathcal{F}_j$ and $\forall j \in \mathcal{J}_M$. For the non-manufacturing sectors, there is a representative firm in each sector, so we only require sectoral long-run productivity changes $\{\hat{A}^L_{j2}\}$, $\forall j \in \mathcal{J}_{NM}$.
- Subsidy level in the first period κ_{fj1}, $\forall j \in \mathcal{J}_M$. In the second, there is no subsidy, i.e., $\kappa_{fj2} = 1$, $\forall f, j$

Parameters.

- The elasticity of substitution σ
- The learning-by-doing parameter ξ
- Final consumption shares α^j, $\forall j \in \mathcal{J}$
- Production parameters γ^H_j and γ^k_j, $\forall j, k\mathcal{J}$

Model Algorithm. Given the values of the parameters, the shocks and the data values in 1982, the model is solved using the following algorithm

- Step 1: Apply short-run hat algebra to the pre-shock data values in 1982
  1. Feed in $\hat{\kappa}^S_{fj1}$
  2. Solve for the short-run equilibrium using Equations (C.15)-(C.23).

3. Calculate counterfactual equilibrium allocation.

- Step 2: Construct the counterfactual long-run productivity changes
  1. From Step 1, calculate the counterfactual changes of quantity produced

$$\hat{q}^S_{c,fj1} = \hat{p}^S_{c,fj1}(\hat{P}^S_{c,j1})^{\sigma-1}\hat{X}^S_{c,j1}$$

  2. Calculate $\hat{A}^L_{c,fj2} = \hat{A}^L_{fj2} \times \hat{q}^S_{c,fj1}$ where $\hat{A}^L_{fj2}$ is backed out from the data.

- Step 3: Long-run hat algebra to the pre-shock data values in 1982
  1. Feed in four shocks: $\hat{A}^L_{fj2}$, $\lambda_{j2} = 1$, $\kappa_{fj2} = 1$, and $\hat{H}^L_2$ to the baseline (pre-shock) data values
  2. Obtain long-run equilibrium allocation changes by solving Equations (C.24)-(C.31).
  3. Calculate the long-run real income changes $\hat{y}^L_2/\hat{P}^L_2$

- Step 4: Long-run hat algebra to the counterfactual data values in 1982
  1. Feed in four shocks: $\hat{A}^L_{c,fj2}$, $\lambda_{j2} = 1$, $\kappa_{fj2} = 1$, and $\hat{H}^L_2$ to the counterfactual data values in 1982
  2. Obtain long-run equilibrium allocation changes under counterfactual by solving Equations (C.24)-(C.31).
  3. Calculate the long-run real income changes $\hat{y}^L_{c,2}/\hat{P}^L_{c,2}$ under counterfactual

- Step 5: Calculate welfare changes under counterfactual
  1. Based on the results obtained under steps 1-4, calculate the following welfare changes under the counterfactual

$$U_c/U = \left(\frac{\hat{y}^S_1}{\hat{P}^S_1}\right)\left(\frac{\tilde{y}^L_2}{\tilde{P}^L_2}\frac{\hat{y}^S_1}{\hat{P}^S_1}\right)^{\beta}$$

where

$$\frac{\tilde{y}^L_2}{\tilde{P}^L_2} = \frac{\hat{y}^L_{c,2}}{\hat{P}^L_{c,2}} \Bigg/ \frac{\hat{y}^L_2}{\hat{P}^L_2}$$

and $\hat{y}^S_1/\hat{P}^S_1$ is obtained from the short-run hat algebra applied to the baseline (pre-shock) data values in 1982, $\hat{y}^L_2/\hat{P}^L_2$ is obtained from the long-run hat algebra applied to the baseline (pre-shock) data values in 1982, and $\hat{y}^L_{c,2}/\hat{P}^L_{c,2}$ is obtained from the long-run hat algebra applied to the counterfactual data values in 1982.

C.7 Satisfying Market Clearing

We require the market-clearing conditions in levels to be satisfied in the pre-shock period to apply the hat algebra. Given $\{\kappa_{fj1}\}$ and $\{\lambda_{j1}\}$, firm-level sales $\{X_{fj1}\}$ and industry-level gross outputs

$\{X_{j1}\}$ should satisfy

$$X_{fj1} = \pi_{fj1}\Bigg[\alpha^j\Bigg\{\underbrace{\sum_{k\in\mathcal{J}_M}\gamma_k^j\frac{\sigma-1}{\sigma}\sum_{f\in\mathcal{F}_k}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)\left(\frac{\sigma-1}{\sigma}\right)X_{fk1}+\sum_{k\in\mathcal{J}_{NM}}\gamma_j^H X_{k1}}_{w_1H_1}$$
$$+\underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\left[1-\kappa_{fk1}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\right]X_{fk1}}_{=\Pi_1}+\underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_j}(\kappa_{fk1}-1)\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)\left(\frac{\sigma-1}{\sigma}\right)X_{fk1}}_{=T_1}\Bigg\}$$
$$+\sum_{k\in\mathcal{J}_M}\frac{\sigma-1}{\sigma}\gamma_k^j\sum_{f\in\mathcal{F}_k}\left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)X_{fk1}+\sum_{k\in\mathcal{J}_M}\gamma_k^jX_{k1}\Bigg],\quad \forall f,j$$

In the data, this condition is unlikely to hold. Therefore, following Costinot and Rodríguez-Clare (2014) and di Giovanni et al. (2020), we introduce sector-specific wedge $\{\zeta_{j1}\}$ that makes the above market clearing condition to hold exactly, that is,

$$X_{fj1} = \pi_{fj1}\Bigg[\alpha^j\Bigg\{\underbrace{\sum_{k\in\mathcal{J}_M}\gamma_k^j\frac{\sigma-1}{\sigma}\sum_{f\in\mathcal{F}_k}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)\left(\frac{\sigma-1}{\sigma}\right)X_{fk1}+\sum_{k\in\mathcal{J}_{NM}}\gamma_j^H X_{k1}}_{w_1H_1}$$
$$+\underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\left[1-\kappa_{fk1}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\right]X_{fk1}}_{=\Pi_1}+\underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}(\kappa_{fk1}-1)\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)\left(\frac{\sigma-1}{\sigma}\right)X_{fk1}}_{=T_1}\Bigg\}$$
$$+\sum_{k\in\mathcal{J}_M}\frac{\sigma-1}{\sigma}\gamma_k^j\sum_{f\in\mathcal{F}_k}\left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)X_{fk1}+\sum_{k\in\mathcal{J}_M}\gamma_k^jX_{k1}+\zeta_{j1}\Bigg],\quad \forall f,j.$$

Then we apply the hat algebra and then feed the shocks $\hat{\zeta}_{j1}^{S}=0, \forall j$ that eliminate the wedges. Other shocks are held constant. We obtain $\{\hat{X}_{fj1}^{S}\}$ and $\{\hat{X}_{j1}^{S}\}$ by solving

$$\begin{aligned}\hat{X}_{fj1}^{S}X_{fj1} = \hat{\pi}_{fj1}^{S}\pi_{fj1}\Bigg[\alpha^{j}\Bigg\{ & \underbrace{\sum_{k\in\mathcal{J}_M}\gamma_k^j\frac{\sigma-1}{\sigma}\sum_{f\in\mathcal{F}_k}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)\left(\frac{\sigma-1}{\sigma}\right)\hat{X}_{fk1}^{S}X_{fk1}+\sum_{k\in\mathcal{J}_{NM}}\gamma_j^H\hat{X}_{k1}^{S}X_{k1}}_{\hat{w}_1^S w_1 H_1} \\
&+\underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\left[1-\kappa_{fk1}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\right]\hat{X}_{fk1}^{S}X_{fk1}}_{=\hat{\Pi}_1^S\Pi_1}+\underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}(\kappa_{fk1}-1)\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)\left(\frac{\sigma-1}{\sigma}\right)\hat{X}_{fk1}^{S}X_{fk1}}_{=\hat{T}_1^S T_1}\Bigg\} \\
&+\sum_{k\in\mathcal{J}_M}\frac{\sigma-1}{\sigma}\gamma_k^j\sum_{f\in\mathcal{F}_k}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)\hat{X}_{fk1}^{S}X_{fk1}+\sum_{k\in\mathcal{J}_M}\gamma_k^j\hat{X}_{k1}^{S}X_{k1}+\hat{\zeta}_{j1}^{S}\zeta_{j1}\Bigg], \quad \forall f, j.\end{aligned}$$

After solving for $\{\hat{X}_{fj1}^{S}\}$, we obtain the new $\{X_{fj1}^{S}\}$ that satisfy the market clearing conditions. We use the new set of $\{X_{fj1}^{S}\}$ as our pre-counterfactual values for the counterfactual analysis.