The Long-Term Effects of Industrial Policy*

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May, 2024

Abstract

This paper provides causal evidence on the impact of a large-scale industrial policy – South Korea's Heavy and Chemical Industry (HCI) Drive – on firms' long-term performance and quantifies its long-term welfare effects. Using unique historical data on the universe of firm-level subsidies and a natural experiment, we find large and persistent effects of this industrial policy. Subsidized firms grew faster than those never subsidized for 30 years after subsidies ended. We build a quantitative heterogeneous firm model that rationalizes these effects through a combination of learning-by-doing and financial frictions. The model is calibrated to firm-level data, and its key parameters are disciplined with the econometric estimates. The HCI Drive generated larger benefits than costs. If it had not been implemented, South Korea's welfare would have been 3-4% lower. The majority of the total welfare impact comes from the long-term productivity benefits of learning-by-doing.

Keywords: industrial policy, South Korea, HCI Drive, learning-by-doing, financial frictions, welfare
JEL Codes: O14, O25

*The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the research staff or the Board of Governors of the Federal Reserve System. We are grateful to Dominick Bartelme, Javier Cravino, Alessandro Ferrari, Sara Heller, Nir Jaimovich, Isabelle Mejean, Dimitrije Ruzic, Sebastian Sotelo, Yongseok Shin (discussant), Basit Zafar, and seminar participants at Aarhus, the Asia Pacific Trade Seminar, Bank of Italy, Barcelona Summer Forum, the CEPR Paris Symposium, Duke, EIEF, INSEAD, JGU-Mainz, the Lausanne Conference on Conflict and Nation Building, LMU Munich, Michigan, the NBER SI EFEG, the NBER ITI Fall Meeting, the Paris Trade Seminar, Sant'Anna School of Advanced Studies, the TPR Forum, UBC, UCL, the UK Foreign, Commonwealth & Development Office, Yonsei, and Zurich for helpful comments. Email: `jaedo.choi@frb.gov`, `alev@umich.edu`.

1. Introduction

Many countries at different stages of development have engaged in activist industrial policy.[1] Indeed, governments 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 initiatives to shore up supply chains in key industries and promote clean energy manufacturing (The White House, 2021, 2022). However, despite their historical and current ubiquity, credible econometric evidence on the long-term effects of industrial policies remains limited, due primarily to lack of systematic and detailed data on these policies. The key question for industrial policy is whether temporary interventions have permanent (or at least very long-lived) effects. Thus, it is especially important to accumulate formal evidence on the long-run impacts of temporary industrial policies. This requires information for the more distant past, making data collection even more challenging.

This paper studies 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. Understanding South Korea's industrial policy experience is important, 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 industry powerhouse. It has been argued that government interventions played a central role in this transformation. However, a more complete understanding of the efficacy of South Korea's industrial policy remains elusive.[2]

We make two contributions to the literature. First, we construct a novel historical panel dataset of firm-level industrial policy interventions and balance sheets spanning 40 years. This allows us, for the first time, to provide causal estimates of this temporary policy's impact on firms' long-term performance (up to 30 years after the policy ended). Second, we assess the long-term welfare effects of this industrial policy in a quantitative general equilibrium heterogeneous firm framework.

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 obtain credit internationally, the Korean government guaranteed the loan, enabling the targeted firms to borrow at more favorable interest rates than those prevailing domestically. The firms that got the government approval had to report detailed information on the loan contracts and how they planned to use the allocated credit. These reports are our main data source on subsidized credit at the firm level. The

[1] See, among many others, Head (1994) for the US steel rail industry, 1885-1915; Irwin (2000a,b) for the late 19th century US iron industry; Krueger and Tuncer (1982) for Turkey during the 1960s; Kalouptsidi (2018) and Barwick et al. (2023) for China's shipbuilding industry; Juhász (2018) for France's cotton industry; Criscuolo et al. (2019) for the UK's Regional Selective Assistance, 1997-2004; Chang (1993), Lee (1996), and Lane (2022) for South Korea's 1970s HCI Drive; Rotemberg (2019) for India during the 2000s.

[2] Amsden (1989), Wade (1990), Westphal (1990), and Rodrik (1995) argue that industrial policy played a significant role in shaping South Korea's development. However, many economists have been skeptical of the effectiveness of industrial policy (e.g. Baldwin, 1969; Lee, 1996; Lederman and Maloney, 2012).

information is hand-collected from the national historical archives and digitized. We combine the loan contract data with firm balance sheet data from various sources. The resulting dataset is representative of the Korean economy and covers the universe of foreign credit allocated to the domestic firms.

Our identification strategy exploits 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. President Nixon proposed to withdraw US forces from South Korea, which relied heavily on the US military presence for its defense against North Korea. In response, President Park started promoting heavy and chemical industries to modernize South Korea's military capabilities and become more self-sufficient 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 the temporary subsidies had a large and statistically significant effect on firm sales as much as 30 years after subsidies ended. A doubling of the subsidy between 1973 and 1979 led to a 8.3 percentage points higher sales growth between 1982 and 2009, amounting to a 0.3 percentage point difference in the annual growth rate over this period. This finding is robust to controlling for a large battery of potential threats to identification and confounding variables: (i) cross-firm spillovers; (ii) industrial complexes; (iii) preferential tax or tariff treatments; (iv) chaebol affiliation; (v) export market access; (vi) input and output tariffs; and (vii) KOTRA trade promotion activities, in addition to location and sector fixed effects.

The positive effect on sales comes from improvements in firm performance rather than reduced competition. Subsidized firms did not have higher long-run markups, but had higher TFP. In addition, the 1970s' subsidies improved the post-subsidy export performance of these firms. Since South Korea is a small open economy, it is unlikely that these firms' greater success in world markets was driven by higher export markups.

We then quantify the long-term welfare impact of the HCI Drive. We set up a general equilibrium multi-sector small open economy heterogeneous firm model and discipline it using the firm-level data and the econometric 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.[3] 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.

[3] Lucas (1993) argued that LBD played an important role in the growth performance of the East Asian miracle economies.

We highlight two features of our model quantification. First, the key novel structural parameter in our model is the LBD elasticity. We show that this elasticity is a simple function of the regression coefficients estimated in the empirical section. Our calibration thus connects the model to the empirical results in a tight and transparent way. Second, the model is implemented directly on the firm-level data: firms inside the model are actual South Korean firms in our dataset. This allows us to examine the impact of the subsidies knowing exactly which firms received it and which did not. Modeling the full heterogeneity is important to accurately reflect the general-equilibrium consequences of firm-specific interventions. Our exercise captures the cross-firm reallocations induced by the HCI Drive, for instance the business-stealing effect whereby subsidized firms get bigger at the expense of non-subsidized firms. Relatedly, Kim et al. (2021) argue that the HCI Drive led to greater misallocation. Since we have information on which firms were subsidized and which were not, our counterfactuals capture any misallocation consequences of the policy.

The quantitative results imply that had the government not conducted this industrial policy, welfare would have been 3-4% lower, depending on whether we assume that LBD-driven productivity benefits are permanent or temporary. Most of the total welfare effect (60-75%) 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, 2022; Rotemberg, 2019; Hanlon, 2020; Fan and Zou, 2021; Moretti et al., 2021; Manelici and Pantea, 2021; Cox, 2022; Giorcelli and Li, 2021). Harrison and Rodríguez-Clare (2010) and Juhász et al. (2023) review the literature and discuss the conceptual underpinnings of industrial policy. We use a firm-level dataset that is representative of the national economy and estimate the effect of industrial policy on firms' long-term performance.[4] Lane (2022) and Kim et al. (2021) study South Korea's HCI Drive, in part using similar firm-level balance sheet data. Both of these papers end their analyses in 1986-7. Relative to these studies, we make three contributions. First, we estimate and quantify the long-run effects of the policy, up to 2010. This is important: the key question in the economics of industrial policy is whether temporary interventions can have permanent effects. Since 1987 is only 8 years after the end of the HCI Drive, it is too soon to establish whether the policy had long-run effects. Second, we collect data on firm-level subsidies, which allows us to use firm-level within-industry variation in the HCI policy treatment, rather than the industry-level variation used in these studies. Firm-level subsidy information allows us to address another substantive question of long-standing interest in the economics of industrial policy: distinguishing direct effects on the treated firms from linkages/spillovers from other firms. This is inaccessible to studies that have no information on firm-level policy interventions, and thus use purely industry-level variation. Third, we provide a

[4] 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.

model-based quantification of the HCI Drive's welfare effects. Choi and Shim (2022) use another dataset to study foreign technology adoption by Korean firms in the 1970s. Adoption of foreign technology was one particular channel through which some of the firms targeted by industrial policy grew in the 1970s. While that paper focuses on the 1970s, our analysis examines outcomes in the long run.

Our work makes tangential contact with the vast literature on place-based policies, reviewed by Neumark and Simpson (2015), especially the studies that document long-run persistence of past interventions (e.g. Kline and Moretti, 2014; Ehrlich and Seidel, 2018; Lu et al., 2019; Atalay et al., 2022; Schweiger et al., 2022). In this literature, the policy treatment is at the location level. Though our identification strategy exploits the geographic dimension, ours is not a study of place-based policies. Our variation in the policy treatment is at the firm level, and thus we exploit variation across firms *within* places to estimate the impact of the industrial policy.

We also contribute to the quantitative literature on industrial policy (see, among many others Head, 1994; Gaubert, 2018; Kalouptsidi, 2018; Itskhoki and Moll, 2019; Liu, 2019; Bartelme et al., 2019; Buera et al., 2021; Barwick et al., 2023; Ferrari and Ossa, 2023; Lashkaripour and Lugovskyy, 2023). Our model rationalizes the persistent effect of industrial policy through LBD and financial frictions, and uses microdata to discipline the relevant elasticities.[5]

The rest of this paper is organized as follows. Section 2 describes the historical background of South Korea's industrial policy between 1973 and 1979 and our data. Section 3 discusses the empirical strategy and identification. Section 4 presents the estimation results. Section 5 builds a quantitative model consistent with the empirical findings and evaluates the welfare effects of the policy. Section 6 concludes. The Appendix collects further details on data, estimation, and quantification.

2. Historical Background and Data

2.1 Background

The South Korean government initiated the HCI Drive in late 1972. The HCI Drive strongly promoted 4 targeted sectors: chemicals, electronics, metals, and machinery. We will refer to these as the HCI sectors. Appendix Table A1 provides a more detailed description of these sectors. The HCI Drive was temporary, ending with 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 13% to 37%.

[5] LBD that is external to firms has been studied in the theoretical trade literature (Arrow, 1962; Krugman, 1987; Young, 1991; Matsuyama, 1992; Melitz, 2005). Our main focus is LBD internal to firms.

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). Through the 1962 Foreign Capital Inducement Act, the Korean government restricted firms' direct foreign financial transactions in order to exercise greater control over the balance of payments. However, once the government granted access to foreign credit to targeted firms, it guaranteed those loans.[6] The government guarantees eliminated the risk of firm default, enabling these firms to borrow at favorable interest rates. The government used its discretionary power to allocate foreign credit to targeted firms in the HCI sectors.

The government-backed foreign credit was valuable to firms because domestic financial markets were quite underdeveloped. 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. After that only a small fraction of banks' shares were sold publicly, and controlling stakes – ranging from 35% to 60% during the 1970s – were owned by the government. 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). As a result, many firms had to rely on illegal underground markets to access credit.

While in a credit rationing environment interest rates are not necessarily a good indication of (lack of) access to financing, in the 1970s the average deposit rate in domestic banks was around 20%, and the lending rate in the unofficial capital market was 30–40%. The average inflation rate in South Korea over the period of these loans was 14.5%, implying that domestic real interest rates were higher than the roughly 1% real rate the firms paid on the subsidized loans (see Section 2.2 below). Thus, the guaranteed foreign loans constituted a subsidy.[7]

2.2 Data

Our dataset combines firm-level subsidy data, firm balance sheet data, and region- and sector-level variables. The dataset is annual and covers the period 1970 to 2012. There are 55 regions and 9

[6] Formally, the Korea Development Bank, the Korea Exchange Bank, or the commercial banks controlled by the government guaranteed the foreign credit contracts. For example, Appendix Figures A1-A2 depict a scan of an original loan document and the translation of the first page of the official contract between Hyundai International Inc (a domestic firm) and several foreign banks. It shows that the Korea Development Bank participated in the credit contract as a guarantor.

[7] Financial frictions in the early stage of development of the East Asian countries were further documented by Song et al. (2011), Itskhoki and Moll (2019), and Liu (2019), among others. 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 dollar convertibility into gold resulted in a worldwide economic downturn and a sharp increase in the cost of debt financing of the Korean firms. Instead of allowing financially troubled firms go bankrupt, 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 also capped the interest rate on the reported contracts in the informal loan market at 8% and gave an option to lenders to convert their credit into shares of borrowing firms. The decree required firms to report total credit borrowed in the informal loan market. The reported total amount of credit in the informal loan market was 30.1% of the national domestic credit (Cole and Park, 1980).

manufacturing sectors, 4 of which were targeted by the HCI Drive.[8] Data construction is described in further detail in Appendix A.

Foreign credit. The Foreign Capital Inducement Act required firms to report details of financial contracts with foreign banks or companies once they received government approval. These reports are our main data source for foreign credit. They contain information on amounts borrowed, the interest rate, the repayment period, and the names of foreign banks for each financial contract made by a domestic firm. The documents are hand-collected from the National Archives of Korea and digitized. The resulting dataset covers the universe of credit allocated to firms between 1967 and 1982, encompassing the HCI Drive period. The foreign credit data are merged with the firm-level balance sheet variables based on firm names.

Firm data. The firm balance sheet data come from two sources. For the 1970-1982 period the information is digitized from the historical Annual Report of Korean Companies published by the Korea Productivity Center. For the 1982-2012 period the data come from KIS-VALUE, which covers firms with assets above 3 billion Korean Won (2.65mln 2015 USD).[9] We merge the two balance sheet datasets based on firm names. The variables include sales, assets, fixed assets, employment, and locations of establishments. The final firm-level dataset is representative of the national economy. On average, the sum of firms' sales in a sector covers 67% of gross output of the sector according to the Input-Output tables published by Bank of Korea. Appendix Figure A3 reports coverage by sector.

Other regional and sectoral data. International trade data come from Feenstra et al. (2005) for 1966-2000 and WTO for 2001-2012. South Korea's import tariff data are digitized from Luedde-Neurath (1986) for 1966-1982 and obtained from the Korea Customs Service and the WTO for 1983-2011. Input-Output tables are obtained from the Bank of Korea.

Descriptive statistics. Columns 1-3 of Table 1 report the descriptive statistics for the loan contracts. Between 1973 and 1979, there are 369 contracts in the manufacturing sector. The average size of a foreign loan was \$51mln 2015 USD, the average repayment period was 6 years, and the average interest rate was 9%. The loans were denominated in USD. The average US CPI inflation over the period of these loans was about 8%, so the dollar-denominated real interest rate was about 1%. Between 1973 and 1979, the total credit provided this way to the manufacturing firms was about \$18.7bln 2015 US dollars, or 17% of the 1972 South Korean real GDP. This implies that the HCI Drive was a large-scale industrial policy at the national level. Columns 4-7 report the descriptive statistics of the firm balance sheet variables. Columns 4 and 5 report the average sales and employment. Column 6 reports the ratio between allocated credit and sales conditional on a firm reporting a positive amount

[8]The 9 manufacturing sectors are chemicals, electronics, metals, machinery, food, textiles, wood, non-metallic mineral, and pharmaceuticals. See Appendix Table A1 for more detail.

[9]KIS-VALUE covers 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.

Table 1: Descriptive Statistics of Foreign Credit Contracts and Firm Balance Sheets, 1973-79

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Foreign Credit Contracts			Firm Balance Sheets			
	Loan Size (mln 2015 USD)	Repayment Period (years)	Interest Rate (%)	Sales (mln 2015 USD)	Employment (thousands)	Credit/Sales |Credit> 0	Ever Received Credit (fraction)
Mean	50.8	6.1	9.0	78.75	1.02	0.21	0.09
Std.	74.2	2.2	2.1	256.34	2.01	0.55	

Notes. Columns 1-3 report the descriptive statistics of approved financial contracts between domestic firms and foreign entities from 1973 to 1979. There are 369 contracts over this period. Columns 4-7 report the descriptive statistics for the firm-level balance sheet data and credit. The sample is firm-years. "Credit/Sales" is the ratio of credit to sales for firm-year observations with positive amounts of credit. "Ever Received Credit" is the share of firms that ever reported positive amounts of credit between 1973 and 1979.

of credit. The total credit received is sizable, about 0.21 times total sales on average. Column 7 reports that about 9% of firms in the dataset ever received credit.

3. Empirical Strategy

3.1 Estimating Equation

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

$$\triangle \ln Sales_f = \beta_1 \text{asinh}(Credit_f) + \beta_2 \ln Sales_{ft_0} + \mathbf{X}'_{ft}\boldsymbol{\mu} + \delta_n + \delta_j + \varepsilon_f, \tag{3.1}$$

where f denotes firm, j sector, and n region. The dependent variable $\triangle \ln Sales_f$ is the log change in firm sales, computed for either the 1972-1982, or the 1982-2010 period. The main coefficient of interest is β_1. It captures how much subsidized credit increased firm sales growth. 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:

$$Credit_f = \sum_{\tau=1973}^{1979} Credit_{f\tau}. \tag{3.2}$$

We use the inverse hyperbolic sine transformation as a substitute for logs because a large fraction of firm observations have zero credit. This transformation allows us to include observations with zero credit, while approximating logs for larger values of the credit variable (Burbidge et al., 1988).

Long-differences estimation takes out time-invariant firm characteristics. All specifications include log initial sales ($\ln Sales_{ft_0}$) and region and sector fixed effects δ_n and δ_j that absorb any region and sector common shocks. We control for initial log sales both because it is well documented that larger firms grow less fast, and to account for any correlation between firm size and the subsidy treatment conditional on fixed effects. We also control for additional observables $\mathbf{X}_{ft}$ as detailed below. Standard errors are clustered at the regional level throughout.

Early in the period, the coverage is incomplete and not every firm appears in every year. To use the data more efficiently and catch more firms, we employ overlapping long differences. Because standard errors are clustered at the regional level, this is innocuous. We use two 9-year log-differences for the short-run specification: 1972-1981 and 1973-1982. For the long-run specification, we use 28-year log-differences: 1981-2009 and 1982-2010. The dummies for each set of differences are included in the specifications.

Our empirical model (3.1) highlights the substantive advantages of our approach relative to the short-run studies using industry variation such as Lane (2022) or Kim et al. (2021). First, those studies end in 1986-7. The central question in the industrial policy literature is whether temporary interventions can have permanent effects. Since 1987 is only 8 years after the end of HCI Drive, it may simply be too soon to estimate long-run effects. Second, using industry-level variation in the policy it is not possible to separate the effects on directly treated firms from linkages/spillovers. Firm-level data on subsidies and our empirical strategy that controls for spillovers (see below) can isolate the direct effects of the policy.

3.2 Identification

OLS estimates of (3.1) 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 differential future productivity growth, credit will be correlated with the firms' unobserved productivity changes in the error term. Our identification strategy relies on combining time series, cross-sectoral, and cross-regional variation. First, the timing of the HCI Drive and the choice of sectors to be targeted were driven by external political shocks rather than the economic environment. Second, the HCI Drive was a place-based policy that targeted selected 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 the Asian countries. In the doctrine, President Nixon declared that the US would limit its military presence in Asia, and that the Asian countries should assume the primary responsibility for their self-defense instead of relying excessively on the US.[10] In line with the new US foreign policy, Nixon set up a plan for a full withdrawal of the US forces from South Korea. Although the full withdrawal was not implemented, by the early 1971 Nixon removed one-third of US soldiers stationed in South Korea.[11] At the same time, the military tensions

[10] 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...*"

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

between South Korea and communist North Korea were rising.[12] South Korea lagged behind North Korea in the size of the military, necessitating a heavy reliance on the US forces for the national defense against North Korea.[13] The establishment of official diplomatic relations between the US and the People's Republic of China, which fought against South Korea in the Korean War, further raised the government's level of national security concern (Nixon, 1967).

Faced with the Nixon Doctrine, in the late 1972 the President Park administration decided to pursue a self-reliant defense strategy. Achieving it required a modernization of the weapons capabilities, 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. According to the 1973 Industrial Site Development Promotion Law, 9 southeastern regions of the country were targeted for development (Industrial Sites Development Corporation, 1978, p. 28). In these targeted regions, the government developed industrial complexes and disproportionately subsidized firms in these complexes.[14] Panel A of Figure 1 highlights the regions ex ante targeted by the 1973 Industrial Site Development Promotion Law on the map of South Korea. Panel B of Figure 1 illustrates the geographic distribution of actual allocated foreign credit, and shows substantial though imperfect overlap with the set of targeted regions.

Why these regions were targeted is not explicitly documented, as the government decision process was not transparent during this period. However, narrative evidence suggests that they were chosen based on considerations orthogonal to future productivity growth. Some scholars have conjectured that part of the reason was national security. These southeastern regions are farthest from the North Korean border, and were the last line of defense against the North Korean invasion during the Korean War (Yoo, 1998, p. 267). Another potential reason was political ties to the Park government (Yoo, 1998, p. 243, 291; Kim and Vogel, 2013, p. 298). The president and many core government officers were born in the southeast, and voters in these regions supported the president in the 1971 election.[15] Finally, market access has also been mooted as a potential reason. Many of the targeted regions are close to the main port of Busan. (The two main ports in South Korea are Incheon and Busan. Incheon is located in the northwest close to the border with North Korea, and Busan in the southeast of the country.)

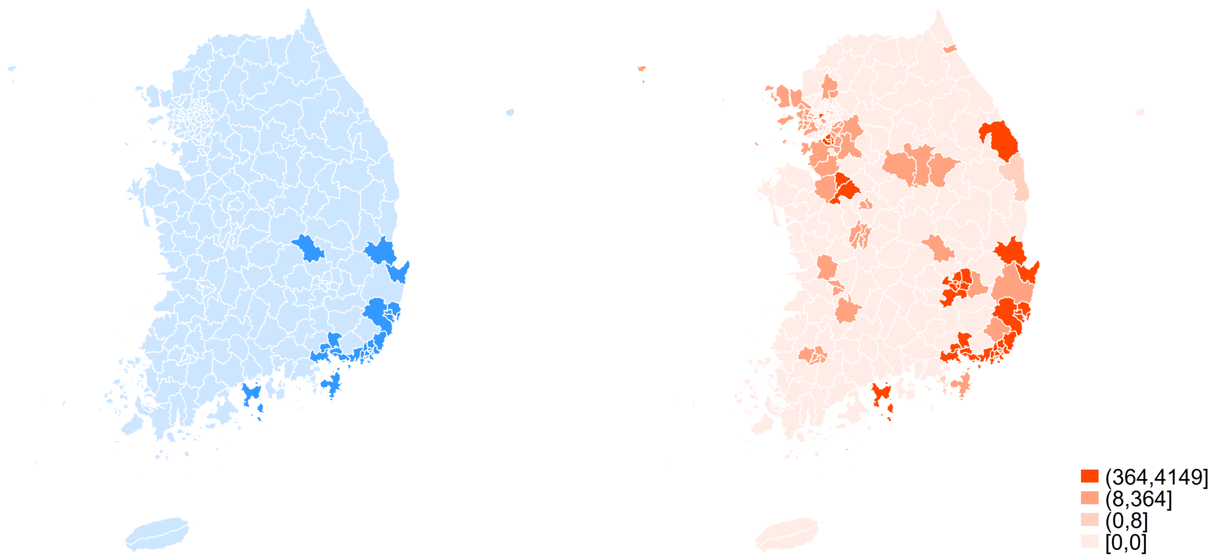
[12] The South Korean government sent about 326,000 soldiers to the Vietnam war between 1964 and 1973. In exchange for South Korea's support in that war, the Johnson administration provided economic and military support to South Korea. North Korea felt threatened by the tighter bonds between the US and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

[13] South Korea's economic backwardness relative to North Korea limited 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 the mid-1970s. In 1972, North Korea's annual military expenditures were about 100% larger than South Korea's (Moon and Lee, 2009). Only in the late 1970s did South Korea's military expenditures surpass North Korea's.

[14] The targeted regions were Busan, Changwon, Guje, Gumi, Jinhae, Masan, Pohang, Ulsan, and Yeosu (Yeocheon). The industrial complexes in Changwon and Guje were newly constructed after 1973. In the other regions, existing industrial infrastructure was expanded (see Enos and Park, 1988, p. 36). Each industrial complex had its specialized sector (Appendix Table A2).

[15] The president himself was born in the inland targeted region, Gumi.

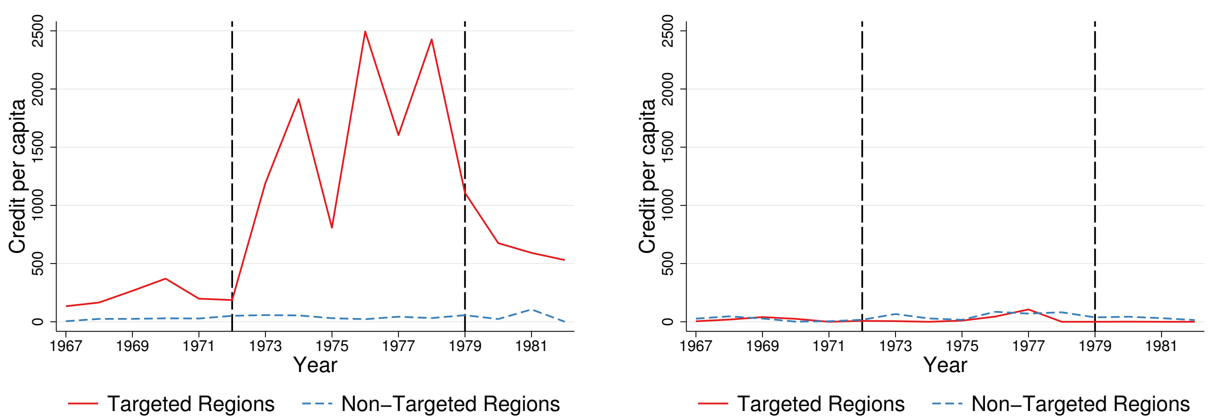
Figure 1: Targeted Regions and Foreign Credit Allocations



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 per capita in 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 lines represent the targeted and non-targeted regions, respectively.

Instrument. Our instrument for firm credit is:

$$\mathrm{IV}_{nj} = D_j^{HCI} \times D_n^{Target}, \tag{3.3}$$

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 the firm is in a targeted region.

We stress that our identification assumption is conditional on both sector and region fixed effects throughout (see eq. 3.1). Thus, to the extent that some of the historical features discussed above – such as political support for the Park administration or market access – could have had an independent effect on the growth of all firms in the region, that would be absorbed by the region effects. Ties to the Park administration are also unlikely to be responsible for the long-run results, which pertain to the post-1981 firm growth, whereas president Park was assassinated in 1979. Below we also control for differential sector-level trade exposure of port regions, and the results remain unchanged. Similarly, any effects of the policies that affect sectors as a whole – such as the overall increased demand for military equipment – are absorbed by sector effects.

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

While both sales and credit vary at the firm level, our instrument (3.3) varies at a coarser level, location-sector. It is of course very common that the instrument varies at a coarser level than the treatment variable of interest. In fact, because (3.3) is a dummy, our research design is a version of the Wald estimator, one of the oldest and most established IV designs (see Angrist and Pischke, 2008, esp. pp. 127-133). The Wald estimator uses the variation in the outcome variable (sales in our case) and the endogenous regressor (credit) across cells in which the instrument takes the values of 1 and 0. One may wonder then about the incremental value of the firm-level data in our setting, relative to a research design that uses only location-sector level data. Aside from the basic point that computing location-sector level credit and sales would still require firm-level data since the primary sources are at the firm level, there are the following substantive advantages. First, our credit data is the first time we observe information on actual firm-level policy interventions undertaken during HCI. This allows us to estimate the effects of a specific policy, which is inaccessible to studies that regress outcomes on HCI dummies. Second, because we observe policy interventions at the firm level, we can identify the direct effects of credit on the treated firms, controlling for spillovers from other firms. In the presence of potential cross-firm spillovers, research designs that use sector-location data cannot separate the effects on treated firms from local spillovers. Third, while the instrument varies by location-sector, many of the controls used below (chaebol status, industrial complex, international trade, KOTRA activities participation) vary at the firm level, increasing the reliability of the causal estimates.

Identifying variation. Figure 2 plots the distribution of credit across sectors and regions. Panel A shows the per capita credit allocated to the HCI sector firms in the 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 sectors in the non-targeted regions stayed constant at near-zero levels. The figure also confirms that the industrial policy was temporary. After 1979, the HCI Drive stopped, and the amounts of credit allocated fell. Panel B plots the non-HCI sectors' credit per capita in the targeted and non-targeted regions. The amounts of credit allocated to non-HCI sector firms were negligible compared to those in the HCI sectors. Also, in the non-HCI sectors there are no differential patterns in credit per capita between targeted and non-targeted regions. Figure 2 illustrates the identifying variation. We will compare the difference between HCI sector firms in the targeted and non-targeted regions and the difference between non-HCI sector firms in the targeted and non-targeted regions.[16]

SUTVA. Even if credit assignment itself were as good as random, there remains an important worry that firms that did not receive credit were still affected by the policy indirectly. This would violate the Stable Unit Treatment Value Assumption (SUTVA) required to estimate the effects of the credit treatment by comparing firms receiving credit to those not receiving it. While there may be others, the two prominent possibilities that would violate SUTVA are input-output linkages and Marshallian knowledge spillovers. If firms treated with credit expand output, firms supplying inputs to, or buying inputs from, the treated firms may also expand output. In addition, if firms receiving credit become more productive, nearby (along some dimension) firms may learn from them and become more productive themselves.

Note that the fixed effects already control for some simple versions of these mechanisms. For example, to the extent that in the tradeable sector input and output markets are national, greater availability of inputs or expanded markets for outputs due to the growth of subsidized firms will be absorbed by the sector fixed effects. To the extent that Marshallian knowledge spillovers are either sector-specific, or purely location-specific, sector and location fixed effects will control for these. However, we also know that both trade and knowledge spillovers decay with distance. So it might be important that subsidized firms are nearby.

To account for the proximity of subsidized firms, we control for three measures of local exposure: horizontal (within-sector), upstream, and downstream. We use geographical distance at the firm-pair level and input-output linkages to construct firm-level controls for whether nearby same-sector forms, or nearby upstream or downstream firms were treated with credit. Appendix B.1 describes the construction of these variables in detail and provides formulas. We use these three exposure indicators as controls throughout, helping buttress the SUTVA assumption.

[16]The HCI sectors in targeted regions received a modestly larger amount of credit per capita prior to 1973. This does not present a threat to identification because we do not compare post- and pre-1973 outcomes. Rather, our strategy exploits differential treatment across sector×locations. The placebo tests in Section 4.2 show that the HCI sectors in the targeted regions did not grow faster than the rest of the Korean economy prior to 1973. This suggests that the impact of pre-1973 credit was limited at most.

4. Empirical Results

4.1 Baseline Results

Table 2 presents the short-run estimates, in which the outcome variable is sales growth during and immediately after the HCI Drive, 1972-1982. Column 1 reports the OLS results. The coefficient is significantly positive. Column 2 presents the baseline second-stage IV estimates without the exposure controls. The coefficient becomes larger. The Kleibergen-Paap F-statistic (KP-F) of over 20 indicates that the instrument is strong. Column 3 reports the results after adding the exposure controls. They reduce the main coefficient of interest somewhat, but it is still positive and significant at the 5% level. However, the value of KP-F decreases below 10 (the standard rule of thumb value), raising potential weak instrument concerns.[17] Therefore, following the recommendation in Andrews et al. (2019), we conduct inference based on the weak-instrument robust Anderson-Rubin test and report its p-value as well as the weak-instrument-robust 90% confidence intervals developed by Andrews (2018).[18] Both the AR test statistics and the confidence interval reject the null that the coefficient is zero at the 10% level.

Table 3 reports the long-run estimates, where the outcome variable is sales growth from 1981 or 1982 (after the HCI Drive ended) to 2009 or 2010.[19] The results show continuing effects in the long run. Column 2 reports the IV results without the exposure controls, with the KP-F statistic value of 15.51. Column 3 adds the exposure controls. The coefficient falls to 0.14, but remains significant. Although the KP-F decreases to 6.96, both the AR test statistics and the weak-instrument robust confidence interval reject the null that the coefficient is equal to zero at the 1% level. Appendix Table B1 reports the first stage results for the short run and the long run.

4.2 Robustness

Industrial complexes, preferential tax treatment, and chaebol status. Over this period, South Korea promoted its industries through setting up industrial complexes. To control for this potential omitted policy, we collect data on industrial complexes from the 1980 and 1985 Yearbooks of Industrial Complexes published by the Korea Industrial Complex Corporation.[20] The yearbooks report information on which sector firms can be located in each complex, and years of tax exemption for firms located in these complexes. Using information on firms' geographic location, we construct a dummy variable for whether each firm was located in a complex and use it as a control. Also, using the information on tax

[17] In the just-identified models with a single endogenous regressor, the KP-F is equal to the effective F-statistic developed by Montiel Olea and Pflueger (2013) which is robust to heteroskedasticity, serial correlation, and clustering.

[18] We compute the weak-instrument-robust 90% confidence using the Stata package `twostepweakiv` developed by Sun (2018).

[19] One may be concerned that if very long-term loan contracts were made, the 2009 or 2010 sales might be affected directly by such long-term loans. However, the average repayment period was 6 years, so after 30 years subsidized loans no longer directly affect sales.

[20] The Korea Industrial Complex Corporation is an affiliate of the Ministry of Trade, Industry, and Energy that manages the national industrial complexes.

Table 2: Short-Run Effects of Subsidies on Firm Sales Growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.:	$\triangle \ln Sales_f$: 1972-1981 and 1973-1982							
	OLS	IV						
asinh($Credit_f$)	0.06***	0.18***	0.10**	0.09*	0.10**	0.08*	0.08**	0.07**
	(0.01)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)	(0.03)
Exposure Controls			✓	✓	✓	✓	✓	
Exposure Controls (LASSO)								✓
Complex Controls				✓			✓	✓
Chaebol Controls					✓		✓	✓
Trade Controls						✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓	✓	✓
Sector FE	✓	✓	✓	✓	✓	✓	✓	✓
KP-F		23.56	6.13	5.80	7.54	8.02	10.54	10.51
AR-p		0.00	0.08	0.09	0.02	0.09	0.02	0.03
AR-CI 90%		[0.05, 0.34]	[0.01, 0.21]	[0.01, 0.20]	[0.04, 0.20]	[0.00, 0.16]	[0.03, 0.15]	[0.02, 0.14]
Num. Clusters	55	55	55	55	55	55	55	55
N	762	762	762	762	762	762	762	762

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: p<0.01. The table reports the OLS and IV estimates of Equation (3.1). 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 2-8. The IV is defined in (3.3). Columns 3-7 control for horizontal, downstream, and upstream exposure (see Appendix B.1 for definitions and details). Column 4 controls for a complex dummy and tax favors provided for firms located in complexes. Column 5 controls for a dummy variable that equals 1 if a firm is affiliated with a top 30 Chaebol group. Column 6 controls for the interactions between the log distance to the nearest port and the 1972/73 to 1981/82 changes in the world demand shock defined in (B.14), the changes in import tariffs, and changes in input tariffs (defined in 4.1), the interaction between the initial export status and the 1972/73 to 1981/82 input tariff changes, and the inverse hyperbolic sine transformation of the export values made in trade fairs hosted by KOTRA over the period 1972/1973 to 1981/1982. Column 7 controls for all these additional variables. All specifications include log of initial sales in 1972 or 1973, and region and sector fixed effects. In column 8, we select exposure controls using LASSO, where $\mathrm{IV}^{\mathrm{H}}_{fj}(0.9)$ and $\mathrm{IV}^{\mathrm{U}}_{fj}(0.1)$ were selected (see Appendix B.1 for definitions and details). KP-F is the Kleibergen-Paap F-statistics. AR-p and AR-CI 90% are p-value associated with the Anderson-Rubin test statistics and the weak-instrument-robust 90% confidence interval developed by Andrews (2018), corresponding to the null hypothesis that the coefficient of asinh($Credit_f$) is zero.

exemptions we control for the favorable tax treatment, calculated as years subject to tax exemptions T_c interacted with log sectoral effective marginal corporate tax r_{jt}: $R_{ft} \equiv T_c \times \ln r_{jt}$. The sectoral effective marginal corporate tax rates are obtained from Kwack (1985). Column 4 of Tables 2 and 3 reports the results adding the firm-level controls for belonging to a complex and favorable tax treatment. They do not have a material impact on any of the coefficients of interest.[21]

One special feature of the Korean economy is that large business groups – chaebols – account for a large fraction of GDP. A chaebol is a large industrial conglomerate owned and run by a business family.[22] They were inherently different from other medium- or small-sized firms in many dimensions. Chaebols were not only larger but also had a closer connection with the government. In column 5

[21] The results are robust to allowing for sector-specific effects of industrial complexes on sales growth, $\beta_j \times \text{Complex}_f$.

[22] A chaebol is similar to a zaibatsu, a business group in Japan during the pre-WW2 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 was an important source of capital for chaebols.

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.:	$\triangle \ln Sales_f$: 1981-2009 and 1982-2010							
	OLS	IV						
asinh($Credit_f$)	0.04***	0.48***	0.14**	0.14***	0.14**	0.12***	0.12***	0.14**
	(0.01)	(0.15)	(0.05)	(0.05)	(0.06)	(0.04)	(0.04)	(0.05)
Exposure Controls			✓	✓	✓	✓	✓	
Exposure Controls (LASSO)								✓
Complex Controls				✓			✓	✓
Chaebol Controls					✓		✓	✓
Trade Controls						✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓	✓	✓
Sector FE	✓	✓	✓	✓	✓	✓	✓	✓
KP-F		15.52	6.96	6.88	6.25	10.99	9.51	12.81
AR-p		0.00	0.01	0.01	0.01	0.00	0.00	0.01
AR-CI 90%		[0.05, 0.34]	[0.06, 0.29]	[0.07, 0.25]	[0.07, 0.31]	[0.06, 0.22]	[0.06, 0.22]	[0.07, 0.25]
Num. Clusters	53	53	53	53	53	53	53	53
N	741	741	741	741	741	741	741	741

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: p<0.01. The table reports the OLS and IV estimates of Equation (3.1). 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 2-8. The IV is defined in (3.3). Columns 3-7 control for horizontal, downstream, and upstream exposure (see Appendix B.1 for definitions and details). Column 4 controls for a complex dummy and tax favors provided for firms located in complexes. Column 5 controls for a dummy variable that equals 1 if a firm is affiliated with a top 30 Chaebol group. Column 6 controls for the interactions between the log distance to the nearest port and the changes in the world demand shock defined in (B.14), the changes in import tariffs, and changes in input tariffs (defined in 4.1), *both* over the period 1972/73 to 1981/82 *and* the same variables over the period 1981/82 to 2009/10, the interaction between the initial export status and the 1972/73 to 1981/82 input tariff changes, the inverse hyperbolic sine transformation of the export values made in trade fairs hosted by KOTRA over the period 1972/1973 to 1981/1982, and the inverse hyperbolic sine transformation of the number of trade fairs attended between 1982 to 1996. Column 7 controls for all these additional variables. All specifications include log of initial sales in 1981 or 1982, and region and sector fixed effects. In column 8, we select exposure controls using LASSO, where $\mathrm{IV}^{\mathrm{H}}_{fj}(0.7)$ and $\mathrm{IV}^{\mathrm{D}}_{fj}(2.9)$ were selected (see Appendix B.1 for definitions and details). KP-F is the Kleibergen-Paap F-statistics. AR-p and AR-CI 90% are p-value associated with the Anderson-Rubin test statistics and the weak-instrument-robust 90% confidence interval developed by Andrews (2018), corresponding to the null hypothesis that the coefficient of asinh($Credit_f$) is zero.

of Tables 2 and 3, we control for a dummy variable for affiliation with a top 30 chaebol, listed in Appendix A.1. Firms' chaebol status is obtained from Center for Economic Catch-up (2007, 2008). Both short-run and long-run coefficients are similar to the baseline results in column 3.

International trade. After President Park started his first term in 1962, South Korea strongly promoted export-oriented development (Westphal, 1990). Economywide changes in the external environment are absorbed by sector fixed effects in estimation. However, since the targeted regions are located near one of the major ports in Korea, trade shocks may have had a differential effect on the targeted regions relative to non-targeted ones, presenting a potential threat to identification. To show that uneven exposure to trade shocks does not drive our results, we additionally control for several trade-related variables.

First, we add an interaction between export demand shocks and the log distance to the nearest port. The construction of this variable is detailed in Appendix B.3. Second, import tariff changes also may differentially affect the intensity of foreign competition across regions close and far from ports. A given import tariff reduction may represent a greater increase in foreign competition in the port regions compared to interior ones, due to within-country trade costs. We thus control for the changes in import tariffs interacted with the log distance to the nearest port:

$$\triangle \ln\left(\textit{Import Tariff}_{j}\right) \times \ln \textit{Dist}_{n}^{Port}.$$

Third, tariffs on imported intermediates may also affect firm performance (Goldberg et al., 2010; Halpern et al., 2015). We control for the interaction between the changes in input tariffs and the log distance to the nearest port. We construct input tariffs as

$$\textit{Input Tariff}_{jt} = \sum_{k} \gamma_{j}^{k} \times \textit{Import Tariff}_{kt}, \tag{4.1}$$

where γ_j^k is value share of input k in sector j. In the short-run regressions, we control for the contemporaneous (1970s) changes in market access, output tariffs, and input tariffs. In the long-run regressions, we control for *both* the HCI period (1970s) *and* contemporaneous (1981/82 to 2009/10) changes in market access, output tariffs, and input tariffs.

Fourth, one of the main activities of Korea's Trade Promotion Agency (KOTRA), established in 1962, was to facilitate Korean firms' export market access (Barteska and Lee, 2023). KOTRA selected firms to attend international trade fairs, depending on the specifics of the demand by local buyers and the marketability of Korean firms' products. We digitized KOTRA's Annual Reports on International Trade Fairs, the data source first used by Barteska and Lee (2023). These reports contain information on firms that attended these fairs between 1970 and 1996, as well as firm-level values of the resulting export contracts with foreign buyers from 1970 to 1985. In both the short- and long-run specifications, we control for each firm's total contract values over the period 1972-1982. For the long run, we additionally control for the number of fairs attended between 1982 and 1996 (as the contract values are not available after the mid-1980s). We use the inverse hyperbolic sine transformation of both of these control variables, as many firms in the sample did not have any KOTRA-facilitated contracts or fair attendance.

Fifth, in the early 1960s the government implemented policies that provided tariff exemptions on intermediate input imports for exporting firms (Connolly and Yi, 2015). To control for these firm-specific trade policies, we include a dummy that equals 1 if a firm ever exported between 1970 and 1973, and an interaction between this dummy and the HCI period changes in input tariffs.

Column 6 of Tables 2 and 3 report the results when including these 5 variables. In both the short-run and the long-run specifications, the coefficients of interest are similar to the baseline results in column 3. Including these additional controls also strengthens the first stage.

All controls together and economic significance. To convey the economic magnitude of the estimates, we use the most conservative coefficients in column 7, that includes the industrial complex, chaebol, and trade controls together. Note that in this specification, the KP-F statistics are around 10, mitigating weak instrument concerns. In the short run, the estimate implies that a doubling of credit raised a firm's growth rate between 1973 and 1982 by 5.5 percentage points, a 0.6% higher annual growth rate. In the long run, a doubling of credit led to 8.3 percentage points higher growth between the early 1980s and the late 2000s, equivalent to a 0.3% percentage point higher annual growth rate over this period.

As is common in empirical settings, the IV coefficients are larger than OLS. There could be two reasons for this. First, credit was channeled to firms with lower residual productivity growth compared to similar non-treated firms. While this is not directly testable, Kim et al. (2021)'s finding that the HCI Drive increased misallocation is suggestive that this may have been the case. The second reason is possible measurement error in the right-hand side variable, which is a generic concern in empirical work. It is well-known that measurement error on the right-hand side produces attenuation bias in OLS coefficients, that IV can correct.

Using LASSO to select exposure controls. Because theory offers little guidance on whether and how cross-firm spillovers of these industrial policies occurred, our baseline exposure measures posit a functional form for horizontal, upstream, and downstream spillovers that decay in distance between each firm and the treated ones (see Appendix B.1 for details and formulas). However, the rate of decay of these spillovers in distance is not known. Our baseline approach takes a value from the trade gravity literature. Alternatively, we use the post-double-selection LASSO method (Belloni et al., 2014a,b). Appendix B.1 describes the details. Briefly, we create a set of horizontal, upstream, and downstream spillover terms, that vary widely in the distance decay elasticity. We then use LASSO to select the spillover terms that are the most powerful as controls. Intuitively, the method searches for the distance elasticities that render the spillover terms as significant as possible. Column 8 of Tables 2 and 3 reports the results of using exposure controls selected by this method. The main coefficient of interest is very similar in size and significance, and the instrument becomes slightly stronger.[23]

Placebo/pre-trends. Our empirical strategy is based on the assumption that there were no other unobserved shocks affecting HCI sectors located in the targeted regions. While this assumption is not testable directly, we could check whether the targeted sectors in the targeted regions already behaved differently prior to the policy, by means of a placebo test. We run the regression (3.1) with the pre-treatment – 1970 to 1973 – sales growth 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 the allocated credit would be correlated with the 1970-1973 sales growth. Table

[23]The LASSO procedure selects a horizontal spillover with a slightly slower decay with distance (χ = 0.7-0.9) than the baseline (χ = 1.1). It also selects an upstream spillover with a low distance elasticity (χ =0.1) for the short run, and a downstream spillover with a high distance elasticity (χ = 2.9) for the long run.

Table 4: Robustness. Placebo Test

	(1)	(2)	(3)	(4)
	Dep. Var.: $\triangle \ln Sales_f$ 1970-1972 and 1971-1973			
	OLS		IV	
asinh($Credit_f$)	0.01	0.01	0.02	−0.02
	(0.01)	(0.01)	(0.03)	(0.04)
Exposure Controls		✓		✓
Firm Controls		✓		✓
Region FE	✓	✓	✓	✓
Sector FE	✓	✓	✓	✓
KP-F			7.26	5.15
AR-p			0.64	0.52
AR-CI 95%			$(-\infty, 0.16]$	$(-\infty, \infty)$
Num. Clusters	50	50	50	50
N	705	705	705	705

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: 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 and 3-4 report the OLS and the IV estimates. All specifications include log of initial sales in 1970 or 1971, and region and sector fixed effects. KP-F is the Kleibergen-Paap F-statistics. AR-p and AR-CI 90% are p-value associated with the Anderson-Rubin test statistics and the weak-instrument-robust 90% confidence interval developed by Andrews (2018), corresponding to the null hypothesis that the coefficient of asinh($Credit_f$) is zero.

4 reports the results of the placebo test. The main independent variables are the 1973-1979 credit, and the upstream and downstream exposures in 1973-1979. Columns 1-2 report the OLS, and columns 3-4 the IV. Across the specifications, the estimated coefficients on the main independent variables are statistically indistinguishable from zero, supporting our identifying assumption.[24]

Because the placebo is implemented on pre-1973 data, it is a test for pre-trends. Our finding that the treated sector-locations did not experience differential growth prior to the onset of the policy is consistent with Kim et al. (2021), who also do not find any evidence of pre-trends in this episode.

Markups and other outcomes. One possibility that would substantially affect the interpretation of our results is that firms may have used these subsidies to increase their market power. After 1982 information on firms' variable input expenditures is available, which allows us to estimate firm-level markups based on the production function approach (De Loecker and Warzynski, 2012). Appendix B.5

[24] Appendix Section B.4 conducts an additional placebo test at the regional level with a different dataset. Using regional information on manufacturing employment shares from the population census, we run a regression of growth in 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 in 1973-79. The results, reported in Appendix Table B2, are consistent with the results in Table 4. We find that the regional total credit is only positively correlated with the growth in manufacturing employment shares between 1970 and 1985, but not with the growth between 1966 and 1970.

describes the procedure in detail. We then estimate the baseline empirical model (3.1) with markups as the outcome variable. Column 5 of Appendix Table B4 reports the results. The impact of the subsidies on post-1981 markup change is a precisely estimated zero. It is thus not the case that the higher sales growth of treated firms was due to markup increases.

Another way to assess whether market power is responsible for our results is to look at exports. Since South Korea is a small open economy, these firms' market power in world markets is unlikely to have been substantially affected by the domestic subsidies. Appendix Table B4 reports the results for the inverse hyperbolic sine transformation of export values and the export-to-sales ratio. In the short run the effect of subsidies on exports is not significant, suggesting that it took longer than a decade for the treated firms to translate the advantage given to them by the subsidies into export success. However, subsidies significantly increased exports in the long run.[25]

We next estimate the empirical model with alternative dependent variables: firm assets and TFP. TFP is computed assuming a value-added Cobb-Douglas production function and using the method proposed by Ackerberg et al. (2015).[26] Firm value added is calculated as firm sales multiplied with value-added shares obtained from IO tables. Appendix Table B4 reports the results. In the short run, subsidies increased firm fixed assets, but not TFP. By contrast, in the long run there is a significant TFP impact, but the effect on fixed assets is more muted.

Firm exit. If subsidized and non-subsidized firms had a different propensity to exit, our coefficients could be biased.[27] To account for the exit margin, we use the DHS growth rates (Davis et al., 1998) instead of log-differences:

$$\frac{Sales_{f,t+1} - Sales_{ft}}{0.5(Sales_{f,t+1} + Sales_{ft})}.$$

The DHS growth is well-defined for exiting firms ($Sales_{f,t+1} = 0$). Thus, when using the DHS growth rate, exiting firms are part of the estimation sample. Column 10 of Appendix Table B4 reports the results for the long run. We find that the coefficient on credit is virtually unchanged compared to the baseline. Column 11 estimates a linear probability model with the exit dummy over the 1982-2010 period as the dependent variable. Credit did not have a significant effect on the exit probability. All in all, our results are robust to accounting for the exit margin.

Further tests of instrument validity. We next provide 2 checks for potential violations of the exclusion restriction. Appendix B.6 describes the procedures in detail. First, we run the "zero-first-stage"

[25] This timing is consistent with anecdotal evidence of South Korean firms' export experience in major foreign markets. For example, Hyundai Motors began exporting to the US for the first time in 1986, 7 years after the policy ended.

[26] Applying the Ackerberg et al. (2015) method requires information on material inputs. 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 labor and capital elasticities. Using these estimated coefficients, we obtain TFP measures as the residuals for the sample between 1970 and 1982. The results are robust to applying different production function estimation methods.

[27] There does not appear to be a meaningful disparity in the post-HCI exit probability between subsidized and non-subsidized firms. Of the subsidized firms in existence in 1982, 22.5% exited prior to 2010. Among the non-subsidized firms, that exit rate is 23.5%.

regressions (Bound and Jaeger, 2000; Angrist et al., 2010). We estimate the reduced form in which firm outcomes are regressed directly on the instrument, but only for the subsample of firms that did not actually receive any credit. If the exclusion restriction is violated, we expect the IV for own credit to be statistically significantly correlated with growth of these non-subsidized firms. The intuition for this test is that in this subsample of firms, the first stage IV coefficient is 0 (since the first-stage LHS credit variable always takes on the value of 0). Thus the reduced-form coefficient on the instrument should also be statistically zero. Appendix Table B3 reports the results. Reassuringly, the estimated coefficients on the own credit instrument (IV_{nj}) are statistically insignificant. Second, we perform the plausibly exogenous IV estimation proposed by Conley et al. (2012) that allows for possible deviations from the exclusion restriction. Their methodology requires prior information on the direct effects of the own credit IV on outcome variables. We discipline this prior information using the zero-first-stage following van Kippersluis and Rietveld (2018). The results suggest that our findings are robust to plausible deviations from the strict exclusion restriction.

Alternative estimation strategies. Appendix Table B5 reports a number of alternative estimation strategies. Columns 1-6 cover the short run, while columns 7-12 the long run. Columns 1 and 7 show what happens when instead of controlling for exposure IVs in reduced-form, we estimate a specification with the three exposure terms instrumented by their corresponding IVs. Doing so shows a positive horizontal spillover in both the short and the long run, but upstream and downstream spillovers change significance. Columns 2 and 8 use the limited information maximum likelihood (LIML) estimator, which is known to be more robust to the weak instrument problem than two-stage least squares (Stock and Yogo, 2005). The results are virtually identical. Columns 3 and 9 report the reduced-form results, showing positive and statistically significant coefficients for IV_{nj} in both the short and the long run. The remaining columns present variations on the LASSO strategy for selecting controls. Columns 4 and 10 use the square-root LASSO (Belloni et al., 2014c). Columns 5-6 and 11-12 expand the set of exposure controls to include 2nd- and 3rd-order polynomials the exposure variables. The results are unchanged.

Spatial correlation and alternative clustering. The baseline specifications cluster at the region level. Appendix Table B6 reports the standard errors under several alternatives. Column 3 reports the results of clustering by region-sector instead. To alleviate potential concerns about spatially correlated errors, we conduct three types of robustness checks. First, columns 4-6 report results using spatial heteroskedasticity autocorrelation consistent (HAC) standard errors following Conley (1999) with different bandwidths. Second, columns 7-9 report standard errors constructed using spatial correlation principal components (SCPC) following Müller and Watson (2022). In addition, columns 10-12 assess the presence of spatial correlation in the baseline regression residuals using Moran's I statistics. Low z-scores from the Moran test reveal that spatial correlation is unlikely to be an issue.[28] Finally, we

[28] Kelly (2019) shows that previous studies that are sensitive to spatial correlation tend to have high z-scores of the Moran test. The median (mean) size of our regions is 205km^2 (729km^2). According to the Moran test, spatial auto-correlation is

control for quadratics of latitude and longitude and re-run these additional analyses following the recommendation by Kelly (2019). Adding these geographic location controls is inconsequential to the results.

Additional robustness. Appendix Table B7 presents robustness checks for alternative functional forms or using a single long difference. Instead of using the inverse hyperbolic sine transformation, columns 1 and 5 report the results for log one plus credit, and columns 2 and 6 report the results using an indicator variable that equals 1 if a firm was ever allocated foreign credit between 1973 and 1979. Columns 3 and 7 report the results of not controlling for log initial sales in the regressions. Instead of using the overlapping log differences, the results when using only a single log difference are reported in Columns 4 and 8. As noted above, in the early data not every firm appears in every year, so when we use a single long difference, the number of observations shrinks by more than 50% and the number of regions falls from 55/53 to 41/40.

5. Quantification

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 the temporary policy had persistent long-run effects. We now develop a theoretical framework that captures this pattern and use it to quantify the long-run welfare benefits of the policy. The main mechanism in the model is learning-by-doing (Arrow, 1962; Krugman, 1987; Young, 1991; Matsuyama, 1992; Lucas, 1993): a firm's current production quantity increases its future productivity.[29] 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. 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 estimating equations used in the empirical analysis, allowing the key parameter of the model to be recovered from the econometric estimates.

5.1 Model

Preliminaries. A small open economy, labeled Home, trades with the rest of the world labeled Foreign. There are two periods with time indexed by $t = 1, 2$. Each period should be viewed as 10 years or more. There are $\mathcal{J}$ sectors indexed by j and k, partitioned into $\mathcal{J}_M$ manufacturing sectors and $\mathcal{J}_{NM}$ non-manufacturing sectors. Firms in the manufacturing sectors are monopolistically competitive

insignificant from zero at distances of 50 km, 100 km, and 150 km. This suggests that our level of clustering exceeds the extent of spatial correlation present in the data.

[29] Learning-by-doing is emphasized in the narrative accounts of the process innovation and quality improvements through accumulation of experience by engineers and managers in the South Korean heavy manufacturing firms. See, for instance, Amsden (1989, p. 276-286, 305-318) for accounts of the experience of the key firms in the shipbuilding and steel industries, Hyundai Heavy Industries and POSCO, respectively.

and heterogeneous in productivity. The non-manufacturing sectors include commodities and services and are perfectly competitive.

Households. The representative household maximizes:

$$\begin{aligned} \max \quad & \sum_{t=1,2} \beta^{t-1} \ln\left(\prod_j C_{jt}^{\alpha^j}\right) \\ s.t. & \\ \sum_j P_{jt} C_{jt} \quad &= \quad w_t \mathcal{L}_t + \Pi_t + T_t \qquad t = 1, 2, \end{aligned}$$

where β is the discount factor, C_{jt} is the sector j consumption bundle, and P_{jt} is the sector j price index at time t. Households' total income comprises of the factor income $w_t \mathcal{L}_t$, the aggregate firm profits Π_t, and government lump-sum transfers T_t. We assume that trade is balanced each period, so total consumption expenditure equals total income. Note that $\mathcal{L}_t$ should be considered "equipped labor" (Alvarez and Lucas, 2007), and thus captures the supply of all the primary factors.

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

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

where q_{fjt} is the quantity of firm f output and σ is the elasticity of substitution across firms within a sector. The price of Home's sectoral output is

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

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

The sector j output used by Home for final consumption and intermediate use is a CES aggregate of Home and Foreign sector j outputs:

$$Q_{jt} = \left[(Q_{jt}^H)^{\frac{\rho-1}{\rho}} + (Q_{jt}^F)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}},$$

where Q_{jt}^F is the quantity of Foreign sector j output demanded by Home and ρ is the elasticity of substitution between Home and Foreign sectoral outputs. The sectoral price index is

$$P_{jt} = \left[(P_{jt}^H)^{1-\rho} + (P_{jt}^F)^{1-\rho}\right]^{\frac{1}{1-\rho}},$$

where P_{jt}^F is the Foreign sector j price that Home takes as exogenous. The share of imports in total sector j Home expenditure is $\pi_{jt}^F = (P_{jt}^F/P_{jt})^{1-\rho}$.

The Home sector j faces foreign demand for its output given by $Q_{jt}^X = (P_{jt}^H)^{-\rho}D_{jt}^F$, where D_{jt}^F is an exogenous foreign demand shifter that also includes iceberg trade costs. The Home sector j total export revenues are $EX_{jt} = (P_{jt}^H)^{1-\rho}D_{jt}^F$.

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

$$q_{fjt} = A_{fjt}\mathcal{L}_{fjt}^{\gamma_j^{\mathcal{L}}}\prod_k (M_{fjt}^k)^{\gamma_j^k}, \qquad \gamma_j^{\mathcal{L}} + \sum_k \gamma_j^k = 1,$$

where A_{fjt} is firm-specific productivity, $\mathcal{L}_{fjt}$ is its primary factor input, and M_{fjt}^k are sector k intermediate inputs used by firm f. The parameters $\gamma_j^{\mathcal{L}}$ and γ_j^k are common across firms within a sector. Cost minimization implies the cost of the input bundle equal to

$$c_{jt} = \left(\frac{w_t}{\gamma_j^{\mathcal{L}}}\right)^{\gamma_j^{\mathcal{L}}}\prod_k \left(\frac{P_{kt}}{\gamma_j^k}\right)^{\gamma_j^k}.$$

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

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

where X_{jt} is Home 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 LBD. In particular, firm f's productivities at $t = 1$ and $t = 2$ are:

$$A_{fj1} = \phi_{fj1}, \qquad A_{fj2} = \phi_{fj2}(q_{fj1})^{\xi}, \tag{5.1}$$

where the ϕ_{fjt} are exogenous. The second period A_{fj2} is increasing in the first period quantity produced with elasticity ξ. If $\xi = 0$, there is no internal LBD 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 in Section 4, as discussed below.

Industrial policy. In the model, there is a proportional subsidy on firm purchases of input bundles, denoted by $\kappa_{fj1} \le 1$. (That is, the government pays for a fraction $1 - \kappa_{fj1}$ of the firm's input expenditures.) This formulation replicates parsimoniously our empirical finding that firms receiving the credit expanded production when the policy was in place.[30]

Financial 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 subject to the following constraint:

$$\kappa_{fj1}(w_1\mathcal{L}_{fj1} + \sum_k P_{k1}M^k_{fj1}) \leq \tilde{\lambda}_{j1}A^{\sigma-1}_{fj1}, \qquad \tilde{\lambda}_{j1} = \lambda_{j1}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} c^{1-\sigma}_{j1}(P^H_{j1})^{\sigma-1}X_{j1}, \tag{5.2}$$

where the left-hand side of the inequality is total input costs inclusive of subsidies and the right-hand side is the borrowing limit. Firms with higher productivity A_{fj1} can borrow more in absolute terms. Firm sales scale with $A^{\sigma-1}_{fj1}$, thus this borrowing constraint formulation amounts to assuming that the firms can pledge a fraction of their ex post sales, following Stiglitz and Weiss (1981) and Kiyotaki (1998).[31] Borrowing constraint tightness $\tilde{\lambda}_{j1}$ is proportional to market size $(P^H_{j1})^{\sigma-1}X_{j1}$, unit cost c_{j1} and an exogenous industry-specific parameter λ_{j1}. Expressing the borrowing constraint as in (5.2) is analytically convenient, and reflects the notion that when firms face bad economic conditions such as increased unit costs or decreased market size, it becomes more difficult for them to borrow. The subsidy κ_{fj1} increases a firm's sales directly by reducing input expenditures and indirectly by relaxing the borrowing constraints.

A firm's profit maximization problem is dynamic because of LBD. An unconstrained firm will increase its $t = 1$ quantity produced and lower its price relative to the static profit-maximizing levels in order to benefit from LBD. Appendix C.1 lays out the details of the unconstrained firm problem. At the same time, financial constraints imply that firms cannot increase to the optimal size. The ratio between the exogenous constraint parameter and the 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 optimal price that internalizes LBD. When $\lambda_{j1}/\kappa_{fj1} \leq 1$, the firm's price is higher than the static profit-maximizing level:

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

and its output and profits are lower. Appendix C.2 shows this formally and discusses the relationships between the severity of the borrowing constraints, and the unconstrained, statically optimal, and constrained prices. In what follows, we assume that at $t = 1$, $\lambda_{j1}/\kappa_{fj1} \leq 1$ holds for all firms. When

[30] Barwick et al. (2023) analyze various industrial policies, and find that production and investment subsidies (closest in spirit to our subsidy modeling approach) have very different effects than entry subsidies. Since our subsidy data are at the firm level, we can be precise about which firms received it and which did not. Also, all the firms that got subsidies in our data existed prior to the subsidy, so we cannot quantify entry subsidies and compare them to production subsidies in our setting.

[31] This type of financial constraint is referred to as "cash flow based," to distinguish it from the alternative, "asset based" formulation in which firms can pledge up to a fraction of their current assets. Lian and Ma (2021) and Drechsel (2023) provide empirical evidence that cash flow based constraints are a better description of the data than asset based constraints.

firms charge $p_{fj1}^{Friction}$, their revenues are

$$X_{fj1} = \left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{\sigma}{\sigma-1}\frac{c_{j1}}{A_{fj1}}\right)^{1-\sigma} (P_{j1}^H)^{\sigma-1} X_{j1}, \tag{5.3}$$

and input expenditures are

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

The total post-subsidy input costs are $\kappa_{fj1} c_{j1} m_{fj1}$. First period profits equal sales minus total costs

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

Equilibrium. A monopolistically competitive equilibrium is a set of prices $w_t, \{P_{jt}^H, P_{jt}\}_{j\in\mathcal{J}}, \{p_{fjt}\}_{f\in\mathcal{F}_j, j\in\mathcal{J}}$ and factor allocations $\{Q_{jt}^H, Q_{jt}\}_{j\in\mathcal{J}}, \{q_{fjt}\}_{f\in\mathcal{F}_j, j\in\mathcal{J}}$ such that at $t = 1, 2$, (i) consumers maximize utility; (ii) firms maximize profits, (iii) all goods and factor markets clear, (iv) the government budget is balanced; and (v) trade is balanced.

We will assume that at $t = 1$, firms face financial constraints and some firms receive subsidies. At $t = 2$, there are no financial constraints or subsidies, so the model collapses to a textbook small open economy with monopolistically competitive firms. Sectoral sales, input expenditures, and profits sum across all firms' in the sector: $X_{jt} = \sum_{f\in\mathcal{F}_j} X_{fjt}$, $c_{jt} m_{jt} = c_{jt} \sum_{f\in\mathcal{F}_j} m_{fjt}$, and $\Pi_{jt} = \sum_{f\in\mathcal{F}_j} \Pi_{fjt}$, $\forall j, t$. Goods market clearing is

$$X_{jt} = (1 - \pi_{jt}^F)\left[\alpha^j \left(w_t \mathcal{L}_t + \Pi_t + T_t\right) + \sum_k \gamma_k^j c_{kt} m_{kt}\right] + EX_{jt} \quad \forall j,$$

where the aggregate profits are:

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

and the lump-sum taxes used to pay for the subsidies are:

$$T_t = \sum_{j\in\mathcal{J}_M} \sum_{f\in\mathcal{F}_j} (\kappa_{fjt} - 1) c_{j1} m_{fjt}. \tag{5.4}$$

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

$$w_t \mathcal{L}_t = \sum_j \gamma_j^{\mathcal{L}} c_{jt} m_{jt}.$$

The prices of Home sectoral output in manufacturing at $t = 1, 2$ are

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

and the Home non-manufacturing output prices are $P^H_{jt} = c_{jt}/A_{jt}$ for $t = 1, 2$. The ideal consumption price index is

$$P_t = \prod_j \left(\frac{P_{jt}}{\alpha^j} \right)^{\alpha^j}.$$

Discussion. The quantification below will implement the model directly on the firm-level data, such that the manufacturing firms inside the model are actual South Korean firms in our dataset. We also have data on the policy treatment at the firm level. As such, our quantification of the HCI Drive policy will accurately reflect the general-equilibrium consequences the intervention in which some firms are treated but not others. In particular, in our quantification the HCI Drive induces reallocations across firms. One example of this is business-stealing, whereby subsidized firms get bigger at the expense of non-subsidized firms. The within-sector business-stealing effect is governed by the elasticity σ. Note that the LBD effect operates also on the non-subsidized firms: those that shrink at $t = 1$ experience less LBD and are less productive at $t = 2$. Relatedly, Kim et al. (2021) argue that the HCI Drive led to greater within-sector misallocation. Since we have information on which firms were subsidized and which were not, our counterfactuals capture any misallocation effects of the policy.[32] The cross-sectoral reallocation consequences of the subsidy are governed by the Cobb-Douglas upper-tier aggregation in consumption and intermediate input use. We view this as a conservative choice. Our sectors are coarse (9 manufacturing and a composite of the rest of the economy), and the elasticity of substitution between them is unlikely to be high.[33] Note that while the non-HCI manufacturing sectors are assumed to experience the same strength of LBD as the HCI manufacturing sectors, we assume that services and agriculture have no LBD. In the absence of data or an identification strategy for estimating the existence or extent of LBD in non-manufacturing sectors, we view this as the most neutral choice.

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

[32] When some firms are subsidized and not others, they will face different marginal costs, leading to marginal revenue product dispersion across firms, and appearing as misallocation in the data.

[33] Importantly, while Cobb-Douglas keeps expenditure shares constant, relative price changes do affect quantities. Since LBD is tied to quantities rather than revenues, the HCI Drive should have a GE impact on the LBD of firms outside of the HCI sectors. The typical finding is that the elasticity of substitution between services, manufacturing and agriculture is below unity (Herrendorf et al., 2013; Cravino and Sotelo, 2019).

Table 5: Calibration

Param.	Value	Description	Moment	Source
Elasticities				
η	0.13	Effective subsidy from credit	IV estimates	Data
ξ	0.48	Internal LBD	IV estimates	Data
σ	3	Elast. of subst. varieties		Broda and Weinstein (2006)
ρ	2	Elast. of subst. Home vs. Foreign		Boehm et al. (2023)
Shocks				
λ_{j1}		Financial frictions	IV estimates	Data
$\{\hat{\kappa}^S_{f1}\}$		Subsidy shocks	IV estimates	Data
$\{\hat{A}^L_{fj2}\}$		Long-run productivity shocks	Sales, PPI	Data, OECD STAN
$\{\hat{D}^{F,L}_{j2}\}$		Long-run Foreign demand shocks	Exports	IO table
$\{\hat{P}^{F,L}_{j2}\}$		Long-run Foreign import price shocks	Import shares	IO table
Production & Consumption				
$\{\alpha^j\}$		Final consumption shares	IO table	IO table
$\{\gamma^{\mathcal{L}}_j, \gamma^k_j\}$		Value added & intermediate shares	IO table	IO table
Intertemporal Discount Factor				
β	1.62	Permanent Δproductivity		
β	0.90	Temporary Δproductivity		

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

counterfactuals, we utilize a modification of the Dekle et al. (2008) exact hat algebra. In our setting, changes in subsidies affect the $t = 1$ allocation directly, and the $t = 2$ allocation indirectly through LBD. The computation of the counterfactual proceeds in three steps. First we obtain the $t = 1$ counterfactual changes via the standard hat algebra. Second, we obtain the counterfactual $t = 2$ productivity changes, which are endogenous outcomes affected by the $t = 1$ quantities produced through LBD. In the last step, we feed in both the factual and counterfactual productivity shocks into the long-run hat algebra to obtain the ratio of welfare changes in the counterfactual relative to the factual.[34] Appendix C.4 details the exact hat formulation, and Appendix C.5 describes the solution algorithm.

5.3 Taking the Model to the Data

To implement the counterfactual, we need the LBD elasticity ξ, the values of the subsidy shocks ($\{\hat{\kappa}_{fj1}\}$), the long-run productivity shocks in the observed equilibrium ($\{\hat{A}^L_{fj2}\}$), the sectoral constraint tightness ($\{\lambda_{j1}\}$), the long-run foreign demand and import price shocks ($\{\hat{P}^{F,L}_{jt}\}$ and $\{\hat{D}^{F,L}_{jt}\}$), and the structural parameters β, σ, and ρ. Because each firm is an object in the model, we also need the

[34] 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.

firm-specific market shares in the initial equilibrium, which we take directly from the data. Table 5 summarizes the calibration. Appendix C.6 details the required data construction.

The LBD parameter. Using the short-run and long-run econometric estimates of (3.1), we back out the key parameter of the model: the LBD elasticity ξ. Log first period firm sales are (see 5.3):

$$\ln X_{fj1} = -\frac{\sigma-1}{\sigma}\ln\kappa_{fj1} + \tilde{\delta}_{j1} + (\sigma-1)\ln\phi_{fj1} \tag{5.5}$$

where $\tilde{\delta}_{j1}$ absorbs industry common components. We assume that the subsidy κ_{fj1} takes the following form:

$$\kappa_{fj1} = exp\big(-\eta\times\text{asinh}(Credit_{fj1})\big). \tag{5.6}$$

Combining (5.5) and (5.6) yields the following estimable short-run regression model:

$$\ln X_{fj1} = \underbrace{\beta_1^S}_{=\frac{\sigma-1}{\sigma}\eta}\times\text{asinh}(Credit_{fj1}) + \delta_{n1} + \delta_{j1} + (\sigma-1)\ln\phi_{fj1}, \tag{5.7}$$

where any region or sector common variables are absorbed by region-time fixed effects δ_{n1} and sector-time fixed effects δ_{j1}.[35] Unobservable firm productivity in the first period $\ln\phi_{fj1}$ orthogonalized with respect to the fixed effects and other controls is a structural residual. Time-differencing, we can derive the short-run regression model as in equation (3.1).[36] With the estimated $\hat{\beta}_1^S$ and a value of σ, we can obtain a value of η that connects the credit observed in the data to the subsidy rate in the model.

Second period firm sales can be written as:

$$\ln X_{fj2} = (\sigma-1)\xi\ln\kappa_{fj1} + \delta_{n2} + \delta_{j2} + u_{fj2}, \tag{5.8}$$

where δ_{n2} and δ_{j2} are region and industry common components, and u_{fj2} is the error term that is a function of the firms' exogenous productivity.[37] Because of LBD, subsidies κ_{fj1} and exogenous productivity in the first period $\ln\phi_{fj1}$ appear in the second period sales. Substituting (5.6) into (5.8) yields the following estimable regression model:

$$\ln X_{fj2} = \underbrace{\beta_1^L}_{=(\sigma-1)\xi\eta}\times\text{asinh}(Credit_{fj1}) + \delta_{n2} + \delta_{j2} + u_{fj2}, \tag{5.9}$$

[35] Sector-time fixed effects absorb variables that are common within a sector: sectoral constraint $\frac{\sigma-1}{\sigma}\ln\lambda_{j1}$, costs of input bundles c_{j1}, and market size $(P_{j1}^H)^{\sigma-1}X_{j1}$. Although regions are not explicitly modeled in our quantitative framework, δ_{n1} absorbs factors that are common within region, such as average productivity differences.

[36] 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.

[37] Specifically, δ_{j2} is proportional to $\prod_{h=0}^{1}\left[\left(\frac{\sigma}{(\sigma-1)}c_{j,2-h}\right)^{(1-\sigma)(\sigma\xi)^h}\times((P_{j,2-h}^H)^{\sigma-1}X_{j,2-h})^{(\xi(\sigma-1))^h}\right]$, and $u_{fj2} = \sigma\xi(\sigma-1)\ln\phi_{fj1} + (\sigma-1)\ln\phi_{fj2}$.

where region and sector fixed effects capture similar objects as in equation (5.7). Subtracting initial period sales from both sides yields the long-run regression specification (3.1). Since firm sales are proportional to firm productivity, initial sales also control for the initial productivity $\ln \phi_{fj1}$ in u_{fj2}. Combining the short-run and long-run estimates from (5.7) and (5.9) and a value of σ, we can obtain a value of ξ as follows:

$$\xi = \frac{1}{\sigma} \frac{\beta_1^L}{\beta_1^S}. \tag{5.10}$$

Thus, we can infer the LBD parameter ξ from the ratio of the long-run to the short-run responses of firm sales to the credit treatment and the upstream exposure. Intuitively, the short-run regression coefficients in Table 2 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 the effective subsidy rate in the model κ_{fj1}, pinning down η in (5.6). Then, the long-run coefficients in Table 3 contain information on the strength of LBD, as they compare the post-subsidy sales of subsidized and non-subsidized firms.

Using the most conservative coefficients in column 7 of Tables 2 and 3, the ratio β_1^L/β_1^S is about 1.43. A common elasticity of substitution σ of 3 (Broda and Weinstein, 2006) yields a value of $\xi \approx 0.48$. Comparison to prior estimates in the literature is not straightforward, as existing papers tend to focus on individual industries or even plants for which they have detailed production line data, as well as different time horizons and assumptions about knowledge depreciation. With these caveats in mind, our value is well within range of previous estimates. For instance, Irwin and Klenow (1994) report values of 0.3–0.5 for the semiconductor industry in the US and Japan, Benkard (2000) of 0.5–1.0 for US passenger aircraft, Thompson (2001) of 0.3–0.5 for US WWII shipbuilding, and Levitt et al. (2013) of 0.3 for US auto assembly. Thus, our implied values of ξ are broadly consistent with existing evidence.

Subsidies and financial constraints. Given the value of η backed out from the short-run estimates, the firm-specific subsidies κ_{fj1} are obtained from (5.6). We winsorize the 1% highest subsidy rates to make the results robust to outliers within each sector.[38]

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

[38] Our model quantification assumes that the subsidies κ_{fj1} entailed a direct fiscal cost (eq. 5.4). However, the actual policy was a government loan guarantee. The full fiscal cost of these government guarantees is not transparent. In some cases these guarantees entailed directly observable government expenditures. For example, the 1979 Second Oil Crisis created difficulties for some of the treated firms, and in 1981 the Bank of Korea had to set up a special fund in the amount of 1,899 billion Korean Won ($688.5mln 2015 USD) for bailing out these firms (The National Archives of Korea, 1981, p. 78). More broadly, these government guarantees could have entailed other costs that would not be easy to quantify, such as increased sovereign spreads. Our approach of assuming the full taxpayer-borne cost of these subsidies is conservative. To the extent the guarantees did not entail the full fiscal cost, the welfare gains from these policies are even higher than what we report below.

charges the static profit maximizing price and cannot optimally increase output to take advantage of LBD.

Assuming that all firms are financially constrained has three helpful consequences. First, this assumption simplifies the counterfactual hat algebra, as it removes the forward-looking component from the $t = 1$ firm decisions. When all firms are constrained, they do not set prices to maximize the profits from future LBD-driven productivity. If firm price-setting decisions at $t = 1$ were instead forward-looking, we would have to find a fixed point between all the firms' $t = 1$ pricing decisions and the $t = 2$ equilibrium, and thus the short-run hat algebra would not be separable from the long-run hat algebra.

Second, when all firms are constrained, κ_{fj1} translates (log-)linearly into firm sales during the subsidy period. This allows us to pin down the parameter η using (5.6)-(5.7).[39] Third, since the most subsidized firm is constrained in the baseline, it follows directly that all firms remain constrained in the no-subsidy counterfactual. This means that the change in the financial constraint due to the subsidy removal fully pins down the $t = 1$ counterfactual change in quantity produced by each firm, and therefore pins down the change in the LBD that carries into $t = 2$, as in (C.9). Thus, the contribution of LBD to the $t = 2$ productivity is independent of the assumptions about the severity of financial constraints at $t = 2$. Recall that in the baseline we assume financial constraints disappear at $t = 2$, reflecting the substantial financial development that occurred in South Korea post-1980. However, we acknowledge that our procedure cannot separately identify $t = 2$ financial constraints from the exogenous component of $t = 2$ productivity ϕ_{fj2} (see 5.1). Thus in the robustness checks we instead adopt the opposite extreme assumption that the financial constraints are the same at $t = 2$ as at $t = 1$. The welfare impact of the HCI drive changes very little.

Calibration of the remaining parameters and data inputs. The long-run productivity changes, foreign demand shifters, and import price changes are jointly calibrated. Our procedure is designed so that the baseline of our model matches perfectly the evolution of (i) sectoral output; (ii) sectoral imports and exports; and (iii) sales of each firm in our dataset over the time span of our quantification. Appendix C.7 describes the details.

The model has 2 periods, so we must take some care to set an appropriate discount rate β between the first and the second period. The first period corresponds roughly to the decade between 1973 and 1982. The second period is the future. In order to discount the future to the present, we must take a stand on how quickly the LBD benefits materialize, and how long they last. The LBD benefits appear to build slowly, and our regression estimates reflect the total productivity increment after about 30 years. To be conservative, we assume that the productivity benefits accrue 15 years into the future. Then, we make two alternative assumptions on how long the productivity benefits last.

[39] In principle, (5.6) could have an intercept such that even firms that receive zero credit have some positive subsidy. This intercept would not be distinguishable from λ_{j1}, but would not affect the strategy for pinning down η in (5.7), since it would end up in the intercept of the regression. While this is cosmetic, we view it as most natural to assume no constant term in (5.6), since firms not receiving credit are not being treated with any subsidy that is reflected in our data.

Table 6: Counterfactual: No Subsidy

Welfare change (%):	(1) Short-run	(2) Long-run	(3) Total
Productivity change:			
Permanent ($\beta = 1.62$)	−1.0	−2.91	−3.91
Temporary ($\beta = 0.90$)	−1.0	−1.62	−2.62

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

The first is that they are permanent. Assuming an annual discount rate of 0.96, the decadal discount rate is $0.96^{10} = 0.66$. If the productivity increase comes 15 years into the future and is permanent, 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 elasticities of substitution σ and ρ to 3 and 2 following Broda and Weinstein (2006) and Boehm et al. (2023), respectively.

5.4 Main Welfare Results

Table 6 reports the welfare change in the counterfactual world in which the Korean government did not conduct the industrial policy ($\kappa_{c,fj1} = 1$ for all firms). When there is no subsidy in the first period, and the productivity benefits of the policy are permanent, the overall welfare decreases by 3.91%. In this total, 1.0% is the short-run welfare decrease, and 2.91%, or about 74%, 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 had 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 2.62%. Still, the long run accounts for 62% of the total 2.62% welfare impact.

Statistical uncertainty. While confidence intervals or standard errors are not typically reported in quantitative counterfactuals, calibrations are usually based on econometric estimates that come with some uncertainty. In our setting, the key parameter – the LBD elasticity ξ – is based on regression coefficient estimates. To provide an assessment of how statistical uncertainty affects the quantitative welfare results, we undertake a bootstrapping exercise in which we re-estimate our short- and long-run regression based on a block-bootstrap by region, collect the coefficients, and re-do the quantification based on each bootstrap estimate. Appendix C.9 describes the procedure in detail. The kernel densities of the resulting welfare changes are reported in Figure C1. The range of the total welfare effects is from 0 to 8%, appropriately centered around the 4% baseline results.

5.5 Alternative Exercises and Robustness

Having reported the main welfare results, we next detail a number of alternative implementations and sensitivity checks.

Financial constraints at $t = 2$. The baseline model assumes that financial constraints disappear at $t = 2$. Though South Korea's financial system developed rapidly post-1982, it may be that firms were still constrained in this period. To check how this assumption affects the results, Appendix Table C1 imposes instead that financial constraints bind equally strongly at $t = 2$. Doing so has little impact on the results. If anything, the welfare benefits are larger when financial constraints persist at $t = 2$, though quantitatively this is a small effect.

Distortionary taxation. The baseline model assumes that the government levies a lump-sum tax to raise money for subsidies. However, it could be that the government only has access to distortionary tax instruments. In that case, in an attempt to fix one distortion, the policymaker would have to exacerbate another. To capture this possibility, we extend the model to allow for variable labor supply and a tax levied on labor income instead of lump-sum. The combination of these two assumptions makes taxation distortionary: taxing labor income discourages workers from supplying labor. The details of the model are laid out in Appendix C.10, and the welfare results are reported in Appendix Table C2. Indeed, in the short run introducing distortionary taxation leads to smaller real consumption gains from the subsidy. But the long-run benefits are a bit higher than the baseline. There are two opposing effects of introducing flexible labor supply and distortionary taxation. On the one hand when taxes discourage labor, the subsidy increases output by less in the short run, the LBD effects are weaker, and thus the $t = 2$ productivity is lower. On the other hand, at $t = 2$, a given increase in productivity leads to higher output when labor is flexible. These two effects appear to largely cancel out.

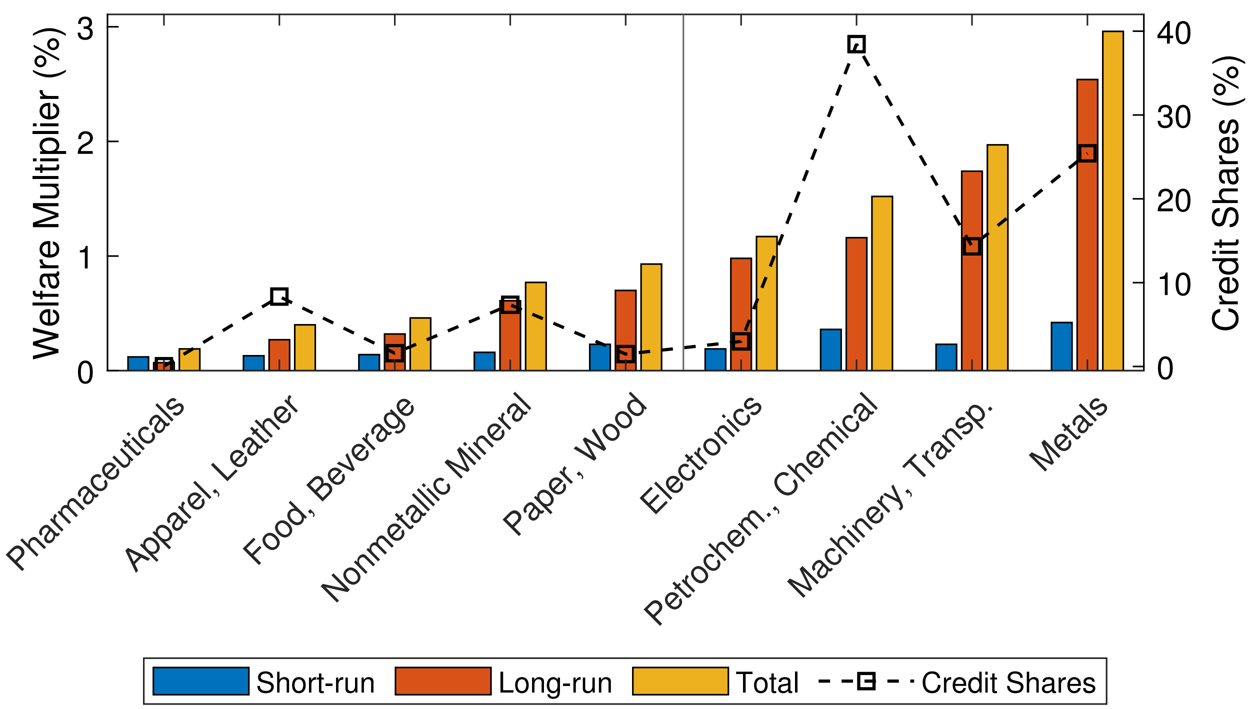
Cross-firm spillovers. The empirical estimation controls for the possible horizontal, downstream, and upstream cross-firm spillovers from the subsidies. These controls are important to make the SUTVA credible. We do not include the cross-firm spillovers in the baseline model quantification for two reasons. First, conceptually, those coefficients cannot be given an unambiguous structural interpretation because they conflate mechanical input-output effects (a firm grows because it sells more to subsidized firms) with Marshallian learning externalities (a firm grows because it becomes more productive by observing subsidized firms). Second, practically, the spillover coefficients do not survive all the robustness checks, and thus there is more uncertainty about the true size of these spillovers in the data. Nonetheless, in an extension we model cross-firm LBD, in which a firm's productivity depends not only on its own quantity produced, but also on the quantities produced by horizontal, upstream, and downstream nearby firms. The model extension and calibration are detailed in Appendix C.11. The welfare results are reported in Appendix Table C3. The welfare impact of the HCI drive is considerably larger when we add cross-firm spillovers. This is natural as the spillover coefficients used for the calibration are positive.

Alternative substitution elasticities. Table C4 reports the results under different values of substitution elasticities σ and ρ. We restrict attention to cases in which the elasticity of substitution between domestic and foreign goods ρ is smaller than the elasticity of substitution between domestic firms σ, as is typically assumed. Both the short- and the long-run gains from the subsidies decrease in σ and tend to increase in ρ. Since the LBD parameters are identified up to the value of σ, changing σ also entails a change in ξ (see eq. 5.10). Higher σ implies lower values of ξ, and thus leads to lower long-run productivity benefits of subsidies. With higher ρ, the positive terms of trade effects of removing subsidies and of lower productivity are weaker, and thus it is more costly for the Home country to have low domestic production in the short run (due to removing subsidies) and in the long run (through lower productivity).

Were the right sectors targeted?. The central objective of our quantitative exercise is to evaluate the welfare effects of the actual industrial policy undertaken by South Korea. A related and equally important question is what would have been the optimal industrial policy? A full treatment of this question would require more theoretical structure and data than we currently have. On the theory side, we would need to be precise on potential non-linearities in the effects of the subsidies, in order to establish at which subsidy levels the costs begin to outweigh the benefits. We do not have the data to impose sufficient discipline on these non-linearities. In addition, for a credible treatment of optimal subsidies it would be desirable to pin sector-specific LBD parameters as well as sector-specific σ's, since our estimation procedure does not pin down ξ separately from σ. Estimating both by sector is challenging, and we do not have sufficient data to do it in our setting. Thus, tackling the optimality of industrial policy remains a fruitful avenue for future research (for some recent work on this, see, e.g. Liu, 2019; Bartelme et al., 2019, 2024).

Nonetheless, we can answer a more limited question, namely, did the actual policy appear to target broadly the right sectors? To do this we evaluate the following hypothetical scenario. We take a fixed pot of subsidy funds, equal to 1% of the initial South Korean GDP, and give it to an individual sector. We assume that all firms in the sector receive the same proportional subsidy (same κ_{fj1}), in such a way that the absolute subsidy cost is always 1% of the initial South Korean GDP. We then record the welfare change due to this hypothetical policy. We repeat this for each of our 9 manufacturing sectors. This exercise in effect computes sector-specific "welfare multipliers" of the industrial policy. It answers the question, how much would welfare change if only sector X were targeted by the subsidy? Because

Figure 3: Welfare Multiplier across Sectors



Notes. This figure plots the changes in welfare in the short run (blue bars), long run (red bars), and in total (orange bars) from giving each sector a subsidy in the amount of 1% of the initial GDP (left axis), and the share of the aggregate credit received by each sector (dashed line, right axis).

we apply the same absolute subsidy amount to each sector, the welfare changes due to sector-specific subsidy scenarios are directly comparable as well.

Figure 3 plots the short-run, long-run, and total welfare benefits from subsidizing each individual sector sorted in ascending order of the welfare change. It also displays the share of the aggregate credit received by each sector with a dashed line. Appendix Table C5 reports the numbers. Remarkably, it appears that along the sectoral dimension the Korean industrial policy got it broadly right. The HCI sectors have strictly larger welfare multipliers than the non-HCI sectors, and the welfare multiplier is correlated with actual credit, albeit imperfectly. In our parsimonious model all sectors, including non-HCI, have the same LBD parameters ξ and substitution elasticities σ and ρ. Thus, the sectoral heterogeneity in the welfare multiplier is driven by the position of these sectors in the input network, a notion explored in detail by Liu (2019).

6. Conclusion

This paper estimates the effects of South Korea's 1973-79 HCI Drive on firms' long-term performance. We show that subsidized credit distributed to firms had a persistent positive impact on firm sales, that is evident as much as 30 years after the subsidies themselves stopped. To rationalize this empirical finding and quantify its importance, we 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.

Our analysis contributes to the growing literature on the very long-run effects of industrial policy (see e.g. Kline and Moretti, 2014; Juhász, 2018, among others), and dovetails with the recent findings by Barwick et al. (2023) that production subsidies may be beneficial in industries with (static or dynamic) returns to scale. As the rest of the industrial policy literature, our analysis is *ex post*, and as such we cannot speak directly to external validity. Identifying *ex ante* circumstances that justify industrial policy interventions remains a promising avenue for future research.

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ONLINE APPENDIX

(NOT FOR PUBLICATION)

A. Data

A.1 Data Construction

Foreign credit. Information on 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.

Figures A1 and A2 display the examples of the financial contract documents of Hyundai International Inc., which borrowed from seven foreign banks or companies.[40] Hyundai International Inc. borrowed \$44M at interest rate 8.375%. Figure A2 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.

Firm balance sheets. 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. The two separate datasets are then merged based on firm names.

The coverage of the Annual Report of Korean Companies is broader than KIS-VALUE. KIS-VALUE covers 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 dataset, we restrict our sample to the firms appearing in both KIS-VALUE and Annual Report of Korean Companies.

Foreign credit data and firm balance sheet data are merged manually based on firm names. Only 6.2% of firms for whom credit data are available were not merged to the balance sheet data. (Of course, many more firms with balance sheet data did not appear in credit data, since credit was only received by a minority of firms.)

Industrial complex information. Data on national-level industrial complexes comes from the 1980 Yearbooks of Industrial Complexes published by the Korea Industrial Complex Corporation. There were 13 complexes, 9 of which were located in the targeted regions. Among the 4 complexes in non-targeted regions, two of them were located in Incheon and Seoul, of which construction began in 1965 before the policy was implemented. The remaining two were located in Ansan and Iksan, of which construction began in 1978 and 1974, respectively, in the middle of the policy. We collect information on which sector firms can be located in each complex and years of corporate income tax exemptions for firms located in complexes. For the complexes in Gumi, Incheon, Pohang, Seoul, Ulsan, and Yeosu, we obtain the information on which sector firms can be located from the 1985 yearbook, because the 1980 yearbook only had vague descriptions of this information on these complexes.

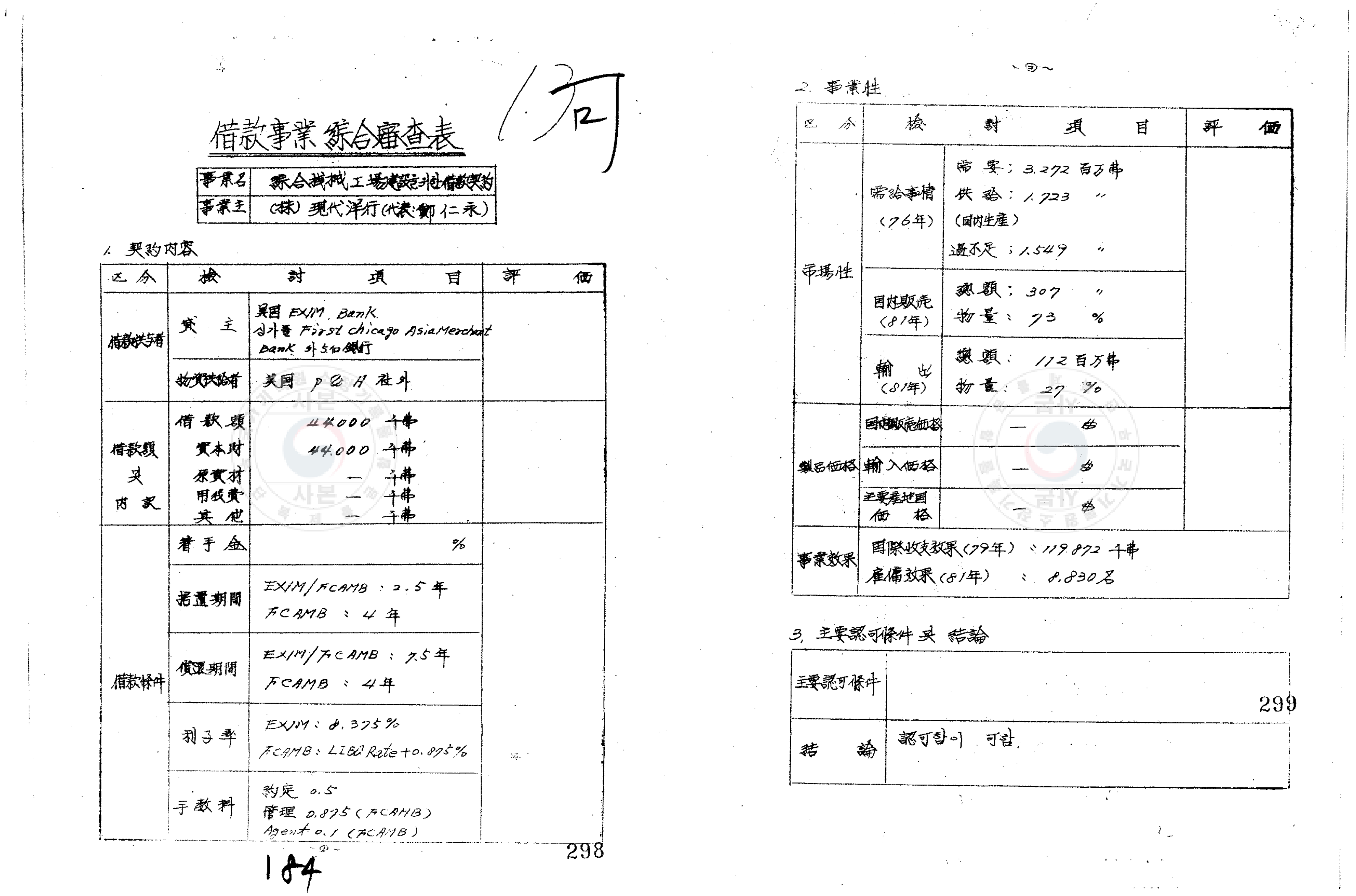
[40] These were First Chicago Hong Kong Ltd., Bank Bumiputra Malaysia Berhad, Credit Lyonnais Hong Kong (Finance) Ltd., Nippon Credit International (HK) Ltd., Toronto Dominion Investments (HK) Ltd., Export-Import Bank of the United States (EXIM), and First Chicago Asia Merchant Bank Ltd..

Input-Output table. Input-Output tables are obtained from the Bank of Korea. We concord the sectoral classification in which the IO table is reported into ISIC Rev.3 based on the descriptions of the sectors. From the Input-Output table, we also 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 reports it in the 4-digit Standard International Trade Classification (SITC) classification. We convert SITC into ISIC Rev 3. Import tariffs data are digitized from Luedde-Neurath (1986). These 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.

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).

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



(可)

借款事業 綜合審查表

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

1. 契約內容

区分	檢討項目		評價
借款供與者	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 內訳	借款額	44,000 千弗	
	資本財	44,000 千弗	
	原資材	— 千弗	
	用役費	— 千弗	
	其他	— 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)	

-②-

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-③-

2. 事業性

区分	檢討項目		評價
市場性	需給事情 (76年)	需要 : 3,272 百万弗 供給 : 1,723 " (国內生産) 過不足 : 1,549 "	
	国內販売 (81年)	金額 : 307 " 物量 : 73 %	
	輸出 (81年)	金額 : 112 百万弗 物量 : 27 %	
製品価格	国內販売価格	— 弗	
	輸入価格	— 弗	
	主要產地国価格	— 弗	
事業效果	国際收支效果 (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 A2: 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)

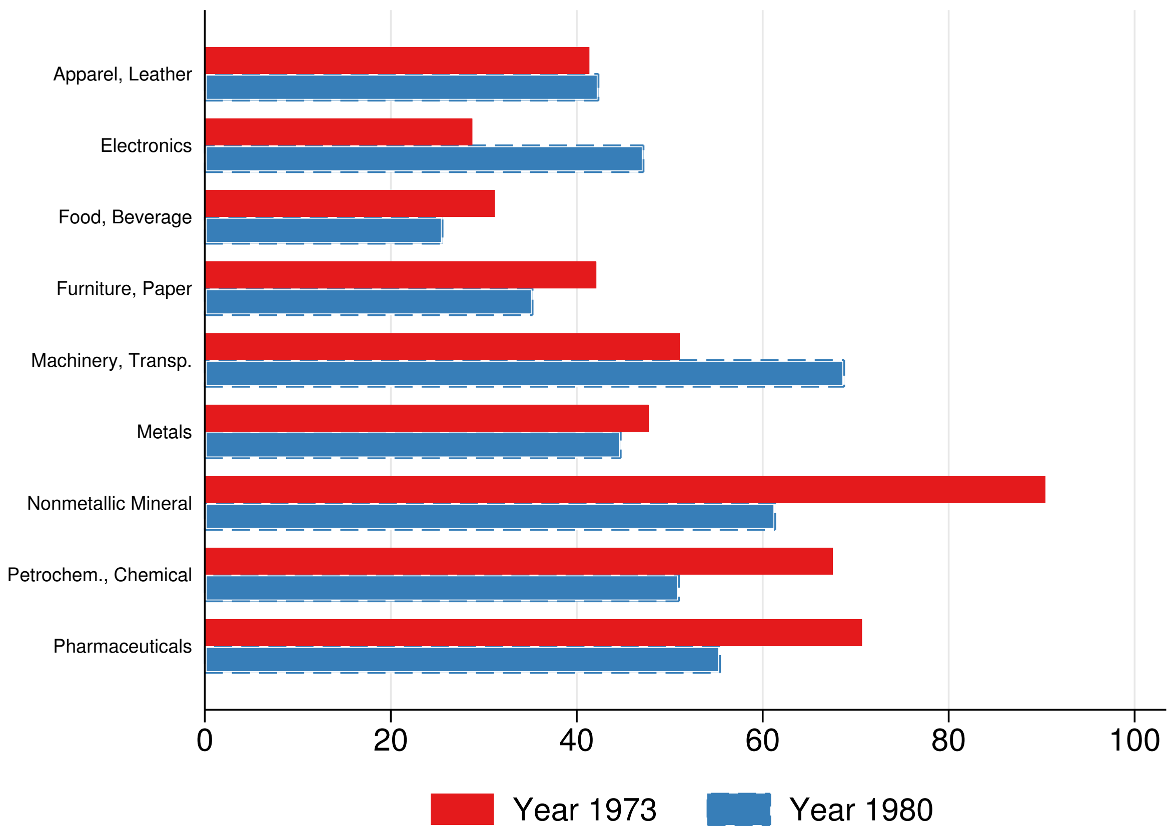
FIRST CHICAGO ASIA MERCHANT BANK LTD.
(as Agent)

Credit Agreement

Korea | Eximbank Credit No. 6500

~~242~~ 390

Figure A3: Coverage of the Dataset (%)



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.

Table A1: 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)
	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)
	Basic and Fabricated Metals	Basic metals (27) Fabricated metals (28)
	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)
	Textiles, Apparel, Leather	Textiles (17) Apparel (18) Leather, luggage, handbags, saddlery, harness, and footwear (19) Manufacturing n.e.c. (369)
	Wood, Paper, Printing, and Furniture	Wood and of products, cork (20) Paper and paper products (21) Publishing and printing (22) Furniture (361)
	Pharmaceuticals and Medicine Chemicals	pharmaceuticals and medicine chemicals (2423)
	Other Non-Metallic Mineral Products	Glass and glass products (261) Non-metallic mineral products n.e.c. (269)

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 (Onsan)	Chemicals, Motor Vehicles, Petrochemicals, and Shipbuilding	1962
Yeosu (Yeocheon)	Chemicals, Petrochemicals	1967

B. Estimation

B.1 Controlling for Spillovers Across Firms

To account for any consequences of proximity to subsidized firms, we introduce three measures of local exposure, capturing horizontal, upstream, and downstream channels. Horizontal exposure of firm f producing in sector j is:

$$\text{Horizontal}_{fj} = \sum_{g \in \mathcal{F}_{(-f)j}} \omega_g^{f,\text{H}} \times \text{asinh}(Credit_g), \tag{B.1}$$

where $\mathcal{F}_{(-f)j}$ is the set of sector j firms other than firm f. The weights $\omega_g^{f,\text{H}}$ vary at the f-g firm-pair level:

$$\omega_g^{f,\text{H}} = \frac{\text{Dist}_{fg}^{-\chi} \times Sales_g}{\sum_{g' \in \mathcal{F}_{(-f)j}} \text{Dist}_{fg'}^{-\chi} \times Sales_{g'}}, \tag{B.2}$$

where χ governs the rate of spatial decay. Firm f's horizontal exposure will be high if it is located in geographic proximity to large firms that received credit. The weight $\omega_g^{f,\text{H}}$ increases in the size of the firm receiving credit, and decreases in the bilateral distance between the treated firm g and the exposed firm f.

Upstream exposure of firm f producing in sector j is defined as

$$\text{Upstream}_{fj} = \sum_{k \neq j} \sum_{g \in \mathcal{F}_{(-f)k}} \omega_g^{f,\text{U}} \times \text{asinh}(Credit_g). \tag{B.3}$$

The weights $\omega_g^{f,\text{U}}$ are

$$\omega_g^{f,\text{U}} = \frac{\text{Dist}_{fg}^{-\chi} \times \gamma_k^j Sales_g}{\sum_{k'} \sum_{g' \in \mathcal{F}_{(-f)k'}} \text{Dist}_{fg'}^{-\chi} \times \gamma_{k'}^j Sales_{g'}}, \tag{B.4}$$

where γ_k^j is the share of sector j in sector k's total input expenditure. The firm experiencing this upstream exposure supplies inputs to potential customers indexed by g. Upstream_{fj} reflects the extent to which f is likely to supply inputs to firms receiving credit. The weight $\omega_g^{f,\text{U}}$ of each potential customer g increases in its total predicted spending on sector j inputs, $\gamma_k^j Sales_g$, and decreases in the distance between g and f. Firm f is more likely to supply inputs to credit-receiving firms if they are large and/or close geographically.

Downstream exposure of firm f producing in sector j is:

$$\text{Downstream}_{fj} = \sum_{k \neq j} \gamma_j^k \sum_{g \in \mathcal{F}_{(-f)k}} \omega_g^{f,\text{D}} \times \text{asinh}(Credit_g), \tag{B.5}$$

where $\omega_g^{f,\mathrm{D}}$ are:

$$\omega_g^{f,\mathrm{D}} = \frac{\mathrm{Dist}_{fg}^{-\chi} \times Sales_g}{\sum_{g' \in \mathcal{F}_{(-f)k}} \mathrm{Dist}_{fg'}^{-\chi} \times Sales_{g'}}. \tag{B.6}$$

In words, $\mathrm{Downstream}_{fj}$ captures how likely firm f is to buy inputs from the firms receiving credit. It is an aggregation across input sectors k of the input use intensities γ_j^k and a weighted credit received by potential input-supplying firms. The weight $\omega_g^{f,\mathrm{D}}$ rises with the potential supplier's sales to capture its market share, but falls in the distance between firm f and that potential supplier to capture the fact that trade decays with distance.

Because the indicators (B.1), (B.3), and (B.5) use actual credit, they may be endogenous. To sidestep this problem, the controls used in the baseline specifications are the IVs for the horizontal, upstream, and downstream exposure measures, constructed as weighted averages or sums of other firms' IV_{nj}

$$\mathrm{IV}_{fj}^{\mathrm{H}} = \sum_{g \in \mathcal{F}_{(-f)k,t_0}} \omega_{g,t_0}^{f,\mathrm{H}} \times \mathrm{IV}_{n(g)k} \tag{B.7}$$

$$\mathrm{IV}_{fj}^{\mathrm{U}} = \sum_{k \neq j} \sum_{g \in \mathcal{F}_{(-f)k,t_0}} \omega_{g,t_0}^{f,\mathrm{U}} \times \mathrm{IV}_{n(g)k}, \tag{B.8}$$

and

$$\mathrm{IV}_{fj}^{\mathrm{D}} = \sum_{k \neq j} \gamma_j^k \sum_{g \in \mathcal{F}_{(-f)k,t_0}} \omega_{g,t_0}^{f,\mathrm{D}} \times \mathrm{IV}_{n(g)k}, \tag{B.9}$$

where $n(g)$ denotes region in which firm g is located, and $\omega_{g,t_0}^{f,\mathrm{U}}$ and $\omega_{g,t_0}^{f,\mathrm{D}}$ are f-g pair-specific weights built analogously to (B.2), (B.4) and (B.6), but using the set of firms operating before the policy $\mathcal{F}_{(-f)k,t_0}$ and their sales in the initial year t_0. Therefore, these weights are pre-determined before the policy.

The intuition behind these instruments is that firms initially located closer to larger firms (ω_{g,t_0}^{f}) in the targeted sector-regions ($\mathrm{IV}_{n(g)k} = 1$) are more likely to be near firms treated with credit, and thus more likely to buy from and sell to them. Note that our information on firm location is at a finer level than district n and these exposure measures exploit spatial variation in distance between firms in a continuous way. Thus, while the instrument for the own credit IV_{nj} varies at the region-sector level, (B.7), (B.8), and (B.9) will vary across firms even within the same region and sector.

Discussion. As an alternative strategy, we also implement 2SLS estimation in which (B.1), (B.3), and (B.5) are used as endogenous regressors and (B.7), (B.8), and (B.9) as instruments for those. The results are reported in Table B5. They reveal that the main coefficient of interest on own credit is virtually unchanged. There is some presence of horizontal spillovers are both horizons, and some evidence of upstream spillovers in the short run and downstream spillovers in the long run.

We do not adopt this version as the baseline because it is a specification with 4 endogenous variables and 4 instruments, which is usually impractical. Also, the spillover terms are not always robust, making it difficult to make unambiguous claims about them. Nonetheless, the spillover indicators are important as controls and are used throughout the empirical analysis.

Constructing spillover terms requires specifying the rate of spatial decay. Following the gravity literature (Disdier and Head, 2008; Head and Mayer, 2014), we set $\chi = 1.1$ in the baseline analysis. Relatedly, while the exposure measures capture simple input-output effects fairly straightforwardly, there is less guidance from either theory or data on the shape of Marshallian knowledge externalities. In principle, if we knew the sectoral or geographical dimensions along which Marshallian externalities operate, we could construct a second set of indicators to capture those, distinct from the input-output exposure indices. As a concrete example, it may be that the knowledge spillovers have a different rate of spatial decay χ than input-output linkages.

Constructing separate indicators for input linkages and Marshallian effects is not feasible in practice both because we do not really know the precise functional forms of those externalities, and because with finite variation available in our data we would have trouble separating them from the IO linkages in estimation. To address both the uncertainty about χ, and potential heterogeneity in χ across various types of spillovers, we turn to LASSO.

B.1.1 Post-Double Selection LASSO

Penalized regression methods such as LASSO accommodate a very large set of potential controls (including situations with more potential controls than observations), and are used to select the "best" controls among the set of potential ones. Our approach is to construct a vector of controls that includes the three spillover terms under a wide variety of spatial decay elasticities χ: $\{\text{IV}^H_{fj}(\chi), \text{IV}^U_{fj}(\chi), \text{IV}^D_{fj}(\chi)\}^{2.9}_{\chi=0.1}$. We use 14 values of χ, ranging from almost no spatial decay ($\chi = 0.1$) to very high decay ($\chi = 2.9$). Since we have 3 spillover variables, we have 42 potential controls from which LASSO can select.

The procedure is free to select only certain types of spillovers, and it is also free to select multiple versions of the same spillover (e.g., horizontal), that differ in their χ. This way, we use the data to answer which χ's result in the most statistically significant spillover controls, while at the same time allowing for multiple types of spillovers to coexist. For example, if the simple input-output spillover did not decay much with distance (input markets were national), whereas the Marshallian knowledge spillover operated only at very short distances, and both were important, LASSO would select multiple spillovers with different χ's.

Because ours is a 2SLS research design with other controls, we rely on the post-double selection LASSO method of Belloni et al. (2014a,b). Specifically, we consider the following IV model:

$$\triangle \ln Sales_f = \beta_1 \text{asinh}(Credit_f) + \sum_{\chi=0.1}^{2.9} \sum_{s\in\{\text{H,U,D}\}} \vartheta^{s,\chi} \text{IV}^s_{fj}(\chi) \\ + \beta_3 \ln Sales_{ft_0} + \mathbf{X}'_{ft}\boldsymbol{\mu} + \delta_n + \delta_j + \varepsilon_f, \quad \text{(B.10)}$$

$$\text{asinh}(Credit_f) = \tilde{\alpha}\text{IV}_{fj} + \sum_{\chi=0.1}^{2.9} \sum_{s\in\{\text{H,U,D}\}} \tilde{\vartheta}^{s,\chi} \text{IV}^s_{fj}(\chi) + \tilde{\beta}_3 \ln Sales_{ft_0} + \mathbf{X}'_{ft}\boldsymbol{\mu} + \tilde{\delta}_n + \tilde{\delta}_j + \tilde{\varepsilon}_f \quad \text{(B.11)}$$

The second equation is the first stage, where we instrument asinh($Credit_f$) using IV_{nj}. We control for spillover terms in reduced-form, so $\text{IV}^s_{fj}(\chi)$ are IVs for the exposure terms defined in equations (B.7), (B.8), and (B.9) for different values of χ.

The second stage in equation (B.10) can be re-written in reduced-form:

$$\triangle \ln Sales_f = \bar{\beta}_1 \mathrm{IV}_{fj} + \sum_{\chi=0.1}^{2.9} \sum_{s\in\{\mathrm{H,U,D}\}} \bar{\vartheta}^{s,\chi} \mathrm{IV}^{s}_{fj}(\chi) + \bar{\beta}_3 \ln Sales_{ft_0} + \mathbf{X}'_{ft}\boldsymbol{\mu} + \bar{\delta}_n + \bar{\delta}_j + \bar{\varepsilon}_f. \tag{B.12}$$

The Belloni et al. (2014a,b) method consists of running LASSO on both equations (B.11) and (B.12). Each of the two equations will yield a set of selected controls. The ultimate control set to be used is the *union* of the controls selected in the two equations.

We do not penalize, or select among, region and sector fixed effects; the IV for own credit; log initial sales; and the additional short-run and long-run controls for industrial complex, chaebol, and international trade in column 7 of Tables 2 and 3. That is, all of these variables present in the baseline estimation are "protected" controls that are always included in all specifications. Column 8 of Tables 2 and 3 reports the results. An interesting side question is which controls LASSO selects. In the short run, it selected $\mathrm{IV}^{\mathrm{H}}_{fj}(0.9)$ and $\mathrm{IV}^{\mathrm{U}}_{fj}(0.1)$. That is, LASSO favors a slightly lower distance elasticity for the horizontal spillover than our baseline of 1.1, and an upstream spillover that does not decay much in distance. In the long-run, LASSO selected $\mathrm{IV}^{\mathrm{H}}_{fj}(0.7)$ and $\mathrm{IV}^{\mathrm{D}}_{fj}(2.9)$. That is, a very similar horizontal spillover, and a much more distance-sensitive downstream spillover.

In further extensions, we use the Square-root LASSO method proposed by Belloni et al. (2014c); and admit a much larger set of potential controls that contains 2nd and 3rd order polynomials of the spillover terms $\{\prod_{p_1+p_2+p_3\leq 2}(\mathrm{IV}^{H}_{fj}(\chi))^{p_1}(\mathrm{IV}^{U}_{fj}(\chi))^{p_2}(\mathrm{IV}^{D}_{fj}(\chi))^{p_3}\}^{2.9}_{\chi=0.1}$, or $\{\prod_{p_1+p_2+p_3\leq 3}(\mathrm{IV}^{H}_{fj}(\chi))^{p_1}(\mathrm{IV}^{U}_{fj}(\chi))^{p_2}(\mathrm{IV}^{D}_{fj}(\chi))^{p_3}\}^{2.9}_{\chi=0.1}$. Those results are reported in Table B5.

B.2 Baseline First Stage

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

Dep. Var.:	asinh($Credit_f$)			
	Short-run		Long-run	
	(1)	(2)	(3)	(4)
IV	5.56***	7.22***	2.86***	9.58***
	(1.15)	(2.22)	(0.73)	(3.11)
Exposure Controls		✓		✓
Firm Controls		✓		✓
Region FE	✓	✓	✓	✓
Sector FE	✓	✓	✓	✓
Adj. R^2	0.27	0.33	0.32	0.39
Num. Clusters	55	55	53	53
N	762	762	741	741

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: p<0.01. The table reports the first stage results of the long-run IV regression (3.1). Columns 1-2 present the short-run first stage, columns 3-4 present the long-run first stage. Firm controls include a complex dummy, tax favors provided for firms located in complexes, a dummy variable that equals 1 if a firm is affiliated with a top 30 Chaebol group, the interaction between the log distance to the nearest port and the changes in the world demand shock defined in (B.14), the interaction between changes in import tariffs and the log distance to the nearest port, the interaction between changes in input tariffs and the log distance to the nearest port, where the input tariffs are defined in (4.1), the interaction between the initial export status interacted with the short- and long-run input tariff changes, the inverse hyperbolic sine transformation of the export values made in trade exhibitions hosted by KOTRA over the period 1972/1973 to 1981/1982, and the inverse hyperbolic sine transformation of the number of trade fairs attended between 1982 to 1996 (long run only). All specifications include region and sector fixed effects and log of initial sales.

B.3 Construction of the World Demand Control

Consider the following variable that captures changes in South Korea's export opportunities:

$$\frac{\triangle EX_{jt}^{KOR}}{GO_{j,1970}^{KOR}} \times \ln Dist_n^{Port}, \tag{B.13}$$

where $\ln Dist_n^{Port}$ is log distance to the nearest 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.[41] 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 term in Equation (3.1). Therefore, instead of using EX_{jt}^{KOR}, in Tables 2 and 3 we control for

$$\frac{\triangle EX_{jt}^{TWN}}{GO_{j,1970}^{KOR}} \times \ln Dist_n^{Port}, \tag{B.14}$$

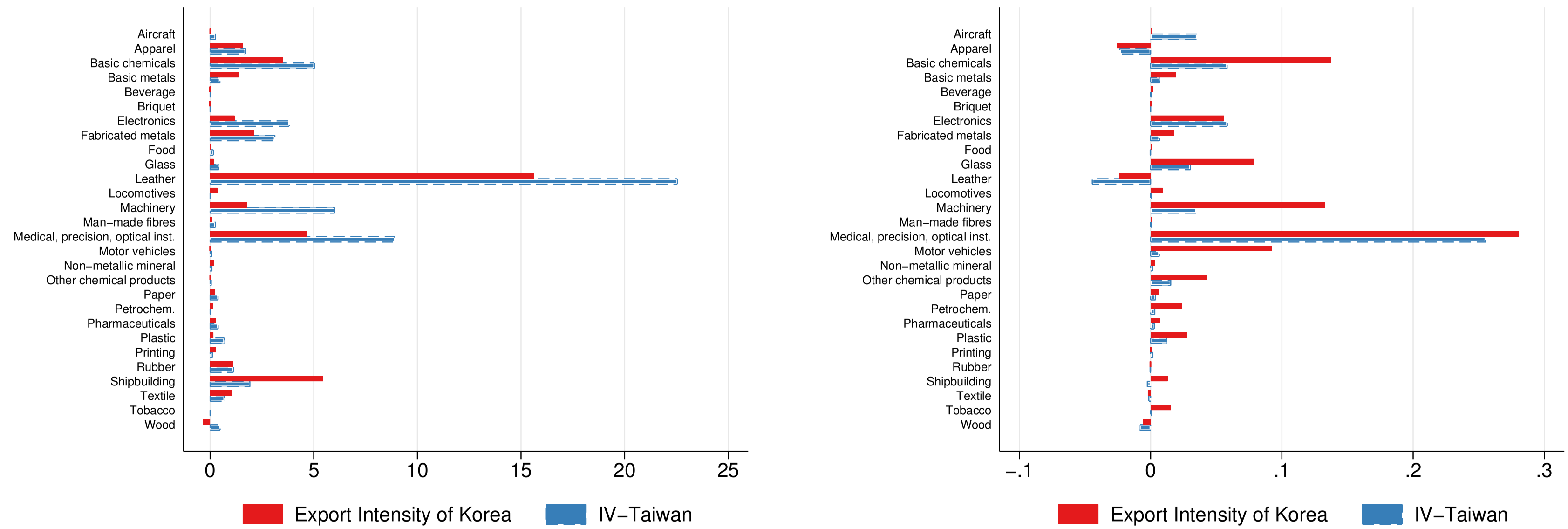
where $\triangle EX_{jt}^{TWN}$ is the change in Taiwan's exports to the world other than Korea. This amounts to controlling for the exogenous component of (B.13) as a reduced form. Appendix Figure B1 graphically illustrates that changes in the export intensity of Korea $\triangle EX_{jt}^{KOR}/GO_{j,1970}^{KOR}$ and export intensity of Taiwan $\triangle EX_{jt}^{TWN}/GO_{j,1970}^{KOR}$ are highly correlated. The export shock (B.14) does not suffer from the endogeneity problem if Taiwan's supply shocks are uncorrelated with the error term in the second-stage regression.

For the long-run export shocks, we use gross output of Korea in 1980 and export changes of Taiwan between 1981 and 2009 or 1982 and 2010:

$$\frac{\triangle EX_{jt}^{TWN}}{GO_{j,1980}^{KOR}} \times \ln Dist_n^{Port}.$$

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

Figure B1: Changes in Export Intensity of Korea and Export Intensity as Measured by Exports of Taiwan



A. 1972–1981

B. 1981–2009

Notes. The figure plots the log-difference in South Korea's export intensity (B.13) (red bar) and the instrumental variable for the log-difference in South Korea's export intensity (B.14) (blue bar).

B.4 Alternative Placebo Test

This section provides an alternative 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 estimate the following specification:

$$\triangle \ln \text{Mfg. Emp. Share}_n = \beta_1 \text{asinh}(\text{HCI Credit}_n) + \beta_2 X_n + \varepsilon_n \tag{B.15}$$

where $\triangle \ln \text{Mfg. Emp. Share}_n$ is growth of manufacturing employment shares between 1966 and 1970 and between 1970 and 1985. The right-hand side is the inverse hyperbolic sine transformation of the sum of credits of all HCI sector firms located in region n between 1973 and 1979:

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

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 should expect that asinh(HCI Credit$_n$) 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 the productivity growth in the residual rather than by the effects of subsidies. If the productivity growth of HCI sectors is persistent, the change in the manufacturing employment share 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 dataset 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 in unobservable productivity of HCI sectors affect regional manufacturing shares, the falsification test in (B.15) provides additional support for our identifying assumption.

The results are reported in Table B2. In columns 1-2, 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 2-4, we additionally control for the log of the total population of 1966. In columns 1-2, we find no statistically significant correlation between total credit and manufacturing share growth, supporting our identifying assumption. By contrast, in columns 3-4, they are positively correlated, with the coefficient significant at the 5% level.

Table B2: Placebo Test at the Regional Level

Dep. Var.:	$\triangle$ ln Mfg. Share: 1966-1970		$\triangle$ ln Mfg. Share: 1970-1985	
	(1)	(2)	(3)	(4)
asinh(Regional HCI Loan)	0.01	0.01	0.03***	0.03***
	(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<0.1; **: p<0.05; ***: p<0.01. The table reports the OLS estimates of Equation (B.15). In columns 1-2, the dependent variable is the log change in the regional manufacturing share between 1966 and 1970. In columns 3-4, the dependent variable is the log change in the regional manufacturing share between 1970 and 1985.

B.5 Markups

If the allocated credit systematically affected firms' markups, the long-term effects of credit on firms' sales may come from increased markups rather than increased productivity. In this subsection, we provide empirical evidence that is subsidized credit was not associated with higher markups. This evidence supports our interpretation of the long-term effects as due to LBD in our quantitative framework.

Following De Loecker and Warzynski (2012) and De Loecker et al. (2020), we use information on firms' inputs and output to measure firm-level markups based on the production function approach. This approach utilizes firms' minimization of variable input costs that can be freely adjusted each period. Consider firm f with the following production function:

$$Q_{ft} = Q_{ft}(A_{ft}, V_{ft}, K_{ft}),$$

where A_{ft} is productivity, V_{ft} are variable inputs such as labor or intermediate inputs that can be freely adjusted each period, and K_{ft} is the capital stock, which can only be adjusted with some lag. The Lagrangian of firm f's cost minimization problem is as follows:

$$\mathcal{L}(V_{ft}, K_{ft}, \lambda_{ft}) = P^V_{ft} V_{ft} + r_{ft} K_{ft} + \lambda_{ft}(Q_{ft}(A_{ft}, V_{ft}, K_{ft}) - \bar{Q}_{ft}),$$

where P^V_{ft} is the price of the variable input, r_{ft} is the user cost of capital, $\bar{Q}_{ft}$ is a scalar, and λ_{ft} is the Lagrange multiplier. The first-order condition with respect to V_{ft} is expressed as:

$$\frac{\partial \mathcal{L}_{ft}(\cdot)}{\partial V_{ft}} = P^V_{ft} - \lambda_{ft} \frac{\partial Q_{ft}(\cdot)}{\partial V_{ft}} = 0.$$

After multiplying both terms by V_{ft}/Q_{ft} and rearranging the terms, we can obtain that

$$\theta^V_{ft} \equiv \frac{\partial Q(\cdot)}{\partial V_{ft}} \frac{V_{ft}}{Q_{ft}} = \frac{1}{\lambda_{ft}} \frac{P^V_{ft} V_{ft}}{Q_{ft}},$$

where θ^V_{ft} is the output elasticity of the variable input. The Lagrange multiplier is a direct measure for the marginal cost c_{ft}. The markup is the ratio of the output price to the marginal cost: $\mu_{ft} \equiv P_{ft}/c_{ft}$. Then, rearranging the term yields

$$\mu_{ft} = \theta^V_{ft} \frac{P_{ft} Q_{ft}}{P^V_{ft} V_{ft}}.$$

Once we have the estimate of the output elasticity θ^V_{ft} and the revenue share of the variable input $\frac{P_{ft}Q_{ft}}{P^V_{ft}V_{ft}}$, we can calculate firm-level markups.

The structure of our firm-level data resembles Compustat. Therefore, we closely follow De Loecker et al. (2020) for estimating θ^V_{ft} and calculating $\frac{P_{ft}Q_{ft}}{P^V_{ft}V_{ft}}$. Similar to Compustat, our dataset has information on sales, costs of goods sold (COGS), and fixed assets, but has a limitation that only a small number of firms report wage bills. Therefore, we use COGS as the variable input expenditure variable and fixed assets as a measure for capital stock.

For each sector, we assume the Cobb-Douglas production function:

$$y_{ft} = \theta^V v_{ft} + \theta^K k_{ft} + a_{ft} + \varepsilon_{ft},$$

where lowercase letters denote logs, $y_{ft} \equiv \ln\big(Q_{ft} exp(\varepsilon_{ft})\big)$ is measured output, and ε_{ft} is measurement error in output. There are two main concerns with estimating this production function. The first is simultaneity bias which arises from firms endogenously choosing their variable inputs based on their productivity unobservable to the econometrician. We deal with this problem using the control function approach. By inverting input demands, we can write a_{ft} as a function of firms' state variables and a control variable:

$$a_{ft} = w(h_{ft}, k_{ft}, z_{ft}),$$

where h_{ft} is a control variable, and z_{ft} captures input and output market factors that generate variation in factor market demands conditional on k_{ft} and a_{ft}. We use v_{ft} (COGS) as a static control: $h_{ft} = v_{ft}$.

Our estimation proceeds in two steps. In the first step, after plugging in the control function, we nonparametrically estimate the following function:

$$y_{ft} = \phi(v_{ft}, k_{ft}, z_{ft}) + \varepsilon_{ft}.$$

From this step, we can soak out measurement error ε_{ft} and obtain $\hat{\phi}_{ft}$.

In the second step, we assume that the productivity follows first-order Markov process: $a_{ft} = g(a_{f,t-1}) + u_{ft}$ and that firms can adjust their variable inputs after observing a_{ft}, but capital stock cannot be adjusted contemporaneously. With the assumed productivity process and the timing structure, we can construct the following moment conditions:

$$\mathbb{E}_t\left(u_{ft}(\theta^V, \theta^K)\begin{bmatrix} v_{f,t-1} \\ k_{ft} \end{bmatrix}\right),$$

where u_{ft} is obtained by projecting $\hat{a}_{ft}$ on $\hat{a}_{f,t-1}$. While projecting $\hat{a}_{ft}$ on $\hat{a}_{f,t-1}$, we use polynomial expansion of $\hat{a}_{f,t-1}$ up to the third order.

The second issue is that only firms' input expenditures and revenues are observed rather than physical quantities of input use and output. The use of revenues and expenditures induces bias due to unobserved input and output prices and thus implies the following structural error term:

$$\omega_{ft} + p_{ft} - \theta^V P^V_{ft} - \theta^K r_{ft},$$

where P_{ft} is the price of the output, P^V_{ft} is the price of the variable input, and r_{ft} is the user cost of capital. P_{ft}, P^V_{ft}, and r_{ft} may vary across firms.

Following De Loecker et al. (2016) and De Loecker et al. (2020), we model the price wedge between the output and input prices as a function of demand shifters and productivity differences. The productivity differences are captured by the control function. We control for the demand shifters by controlling for market shares as z_{ft} in the first stage regression. De Loecker et al. (2016) shows that when the demand system is a nested logit, market shares are be an exact control conditional on productivity differences.

With the estimated $\hat{\theta}^V$ and $\hat{\theta}^K$, we compute markups as

$$\mu_{ft} = \theta^V \frac{exp(\ln(Sales_{ft} - \hat{\varepsilon}_{ft}))}{\text{COGS}_{ft}},$$

where we adjust for the measurement error obtained from the first-stage regression as $\ln(Sales_{ft}) - \hat{\phi}(\nu_{ft}, k_{ft}, z_{ft})$. We trim the 1% tails of $\frac{exp(\ln(Sales_{ft}-\hat{\varepsilon}_{ft}))}{\text{COGS}_{ft}}$ of each sector-year. The average of the estimated $\hat{\theta}^V$ across sectors is 0.86 and the mean of the estimated markups is 1.09. These numbers are comparable to 0.88 and 1.4–1.5 which are the average of the estimates of θ^V and markups from De Loecker et al. (2020) calculated based on the US Compustat data.

We estimate the long-run specification in Equation (3.1) using estimated markups as a new dependent variable. Columns 1-2 of Table B4 report the results. The estimated coefficients are statistically insignificant and close to zero across different specifications.

B.6 "Zero-first-Stage" and Plausibly Exogenous IV

Zero-first-stage. For the zero-first-stage tests, we run the following reduced-form specification for a subsample of firms not receiving any credit:

$$\triangle \ln y_f = \beta_1 \text{IV}_{nj} + \beta_2 \text{IV}^{\text{U}}_{fj} + \beta_3 \text{IV}^{\text{D}}_{fj} + \beta_4 \ln y_{ft_0} + \mathbf{X}'_{ft}\boldsymbol{\mu} + \delta_n + \delta_j + \varepsilon_f, \tag{B.16}$$

where y_f is an outcome variable such as sales, employment, or TFP. If the exclusion restriction is violated, IV_{nj} would be statistically significantly correlated with dependent variables among the firms that received no subsidies. Table B3 reports the reduced-form estimates. Except for short-run employment growth, the estimated coefficients of IV_{nj} are statistically insignificant in all specifications.

Plausibly exogenous IV. Following the notation of Conley et al. (2012), consider the following system of equations:

$$Y = X\beta + Z\varrho + \varepsilon$$
$$X = Z\Pi + V,$$

where X denotes an endogenous variable, Z is an IV that satisfies $\mathbb{E}[Z'\varepsilon] = 0$, Y is the dependent variable, β is a treatment parameter of interest, Π is a first-stage coefficient, and ϱ is a parameter that measures the plausibility of the exclusion restriction. The exclusion restriction is perfectly satisfied if $\varrho = 0$.

Suppose a researcher has a prior information on the bound of ϱ, $\varrho_0 \in \mathcal{G}$. Given ϱ_0, we can estimate

$$(Y - Z\varrho_0) = X\beta + \varepsilon$$

and calculate a $(1 - \alpha)$ confidence interval for β, $CI_N(1 - \alpha, \varrho_0)$, for a given value of ϱ_0. Conley et al. (2012) construct a $(1 - \alpha)$ confidence interval for β as the union of calculated confidence intervals for each ϱ_0:

$$CI_N(1 - \alpha) = \bigcup_{\varrho_0 \in \mathcal{G}} CI_N(1 - \alpha, \varrho_0)$$

The question is how to set the prior of ϱ. Following van Kippersluis and Rietveld (2018), we use the estimates of β_1 from the zero-first-stage regression (B.16) from columns 1 and 4 of Table B3 for the short-run and the long-run, respectively. We set the lower bound of $\mathcal{G}$ to zero, because the place-based policy is likely to increase firms' sales growth and negative values of priors imply that our baseline short- and long-run estimates understate the true effects. We can reject the null that the short-run estimate is zero at the 10% level up to the point in which the upper bound of $\mathcal{G}$ is set to a 350% larger value of the short-run zero-first-stage coefficient. Also, we can reject the null that the long-run estimate is zero up to a upper bound by 72% of the long-run zero-first-stage coefficient.

Table B3: Zero-First-Stage Regressions

Dep. Var.	Sales	
	Short-run	Long-run
	(1)	(2)
IV	0.04	0.43
	(0.25)	(0.47)
Exposure Controls	✓	✓
Firm Controls	✓	✓
Region FE	✓	✓
Sector FE	✓	✓
Adj. R^2	0.49	0.25
Num. Clusters	50	46
N	603	589

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: p<0.01. Columns 1 and 2 report the short-run and long-run reduced-form estimates of Equation (B.16) for the sample of firms that did not receive any credit. The IV is defined in (3.3). All specifications control for the vector of variables used in column 7 of Tables 2-3, initial log sales, and region and sector fixed effects.

B.7 Additional Robustness Tables

Table B4: Robustness. Alternative Dependent Variables. Long-run Firm Exit.

Robustness	Alternative dependent variables									Long-run firm exit	
	Short-run, 1972–1981 & 1973–1982				Long-run, 1981–2009 & 1982–2010					1981–2009 & 1982–2010	
Dep.	TFP	Fixed Assets	asinh(Export)	asinh($\frac{\text{Export}}{\text{Sales}}$)	Mark-up	TFP	Fixed Assets	asinh(Export)	asinh($\frac{\text{Export}}{\text{Sales}}$)	DHS Sales Growth	Exit Status
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
asinh($Credit_f$)	0.02	0.18***	−0.24	−0.07**	0.01	0.07*	0.07*	0.73*	0.02*	0.11*	−0.02
	(0.04)	(0.06)	(0.41)	(0.03)	(0.01)	(0.04)	(0.04)	(0.38)	(0.01)	(0.06)	(0.02)
Exposure Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Firm Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
KP-F	4.58	7.53	8.04	9.77	5.76	8.46	9.31	10.26	8.16	13.58	13.58
AR-p	0.49	0.00	0.51	0.02	0.66	0.03	0.10	0.01	0.02	0.14	0.37
Num. Clusters	50	56	56	55	46	53	54	54	53	55	55
N	562	1131	1220	762	493	665	902	949	741	971	971

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: p<0.01. The table reports the IV estimates of Equation (3.1). In columns 1 and 6, the dependent variable is TFP growth, where TFP is obtained by applying the production function estimation method developed by Ackerberg et al. (2015); in columns 2 and 7, fixed assets growth; in columns 3 and 8, changes in inverse hyperbolic sine transformation of export values; in columns 6 and 9, changes in inverse hyperbolic sine transformation of export/sales ratio; in column 5, changes in markups, obtained by applying the methodology developed by De Loecker et al. (2020); in column 10, DHS sales growth (Davis et al., 1998); and in column 11, dummy variables which equal one if the firm exits before 2010. All specifications control for the vector of variables used in column 7 of Tables 2-3, initial levels of dependent variables, and region and sector fixed effects. KP-F is the Kleibergen-Paap F-statistics. AR and AR-p are the Anderson-Rubin test statistics and its p-value.

Table B5: Robustness. Alternative Estimation Strategies.

	Short run, 1972–1981 and 1973–1982						Long run, 1981–2009 and 1982–2010					
	Exposure IV	LIML	Reduced-Form	Lasso			Exposure IV	LIML	Reduced-Form	Lasso		
				Sqrt	2nd poly.	3rd poly.				Sqrt	2nd poly.	3rd poly.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
asinh($Credit_f$)	0.11**	0.08**		0.08**	0.10**	0.09**	0.11**	0.12***		0.11**	0.16***	0.16**
	(0.05)	(0.03)		(0.04)	(0.05)	(0.04)	(0.05)	(0.04)		(0.05)	(0.06)	(0.07)
Horizontal	0.17***						0.22***					
	(0.06)						(0.07)					
Upstream	0.21*						0.07					
	(0.12)						(0.06)					
Downstream	−0.08						0.25**					
	(0.13)						(0.12)					
IV			0.61**						1.15***			
			(0.27)						(0.39)			
Exposure Controls		✓	✓					✓	✓			
Exposure Controls (Lasso)				✓	✓	✓				✓	✓	✓
Firm Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
KP-F	3.83	10.54		6.46	4.86	4.10	1.69	9.51		10.08	13.39	10.31
SW-F, IV	33.08						38.52					
SW-F, IV^{H}	36.05						35.41					
SW-F, IV^{U}	18.27						89.18					
SW-F, IV^{D}	193.28						286.78					
AR-p	0.00	0.02					0.00	0.00				
Num. Clusters	55	55	55	55	55	55	53	53	53	53	53	53
N	762	762	762	762	762	762	741	741	741	741	741	741

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: p<0.01. This table reports results of robustness checks for alternative estimation strategies. In columns 1 and 7, we instrument the exposure terms (B.1), (B.3), and (B.5) with the corresponding IVs (B.7), (B.8), and (B.9). SW-F denotes the Sanderson-Windmejier F-statistics associated with each endogenous variable (Sanderson and Windmeijer, 2016). In columns 2 and 8, we estimate the regression models using LIML. In columns 3 and 9, we present the estimation results from the reduced-form specifications. In columns 4 and 10, we select the exposure controls using the square-root Lasso (Belloni et al., 2014c). In columns 5 and 11, and 6 and 12, we select the exposure controls among the possible combinations up to the second- or third-order polynomials of the exposure controls. All specifications control for the vector of variables used in column 7 of Tables 2-3, initial sales, and region and sector fixed effects. KP-F is the Kleibergen-Paap F-statistics. AR and AR-p are the Anderson-Rubin test statistics and its p-value.

Table B6: Robustness. Short- and Long-Run. Alternative Clustering

	Coef.	Clustered SE		Conley SE			Müller-Watson SE			Moran's I		
		Region (baseline)	Region-sector	50km	100km	150km	$\rho = 0.03$	$\rho = 0.03$	$\rho = 0.03$	50km	100km	150km
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A. Short run. Baseline Model											
asinh($Credit_f$)	0.08	0.03	0.04	0.03	0.03	0.02	0.02	0.02	0.02	−1.23	-0.84	−0.66
		0.01	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.22	0.40	0.51
	Panel B. Short run. Longitude & Latitude Controls											
asinh($Credit_f$)	0.10	0.03	0.04	0.04	0.03	0.03	0.02	0.02	0.02	−1.33	−0.91	−0.67
		0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.18	0.37	0.50
	Panel C. Long run. Baseline Model											
asinh($Credit_f$)	0.12	0.04	0.06	0.05	0.04	0.03	0.03	0.03	0.03	−1.05	−1.02	−1.03
		0.01	0.07	0.02	0.00	0.00	0.01	0.01	0.01	0.28	0.30	0.32
	Panel D. Long run. Longitude & Latitude Controls											
asinh($Credit_f$)	0.12	0.04	0.06	0.05	0.04	0.03	0.03	0.03	0.03	−1.05	−1.02	−1.03
		0.01	0.07	0.02	0.00	0.00	0.01	0.01	0.01	0.29	0.31	0.30

Notes. This table reports results of alternative clustering and allowing for spatial correlation in the error term. In each panel, the first row is the standard error/Moran's I, and the second row is the p-value. Column 1 reports the IV coefficient estimates from equation (3.1). Column 2 reports the baseline standard errors (clustering by region). Column 3 reports standard errors clustered by region-sector. Columns 4–6 report spatial HAC standard errors following Conley (1999) with various bandwidths. Columns 7–9 report standard errors based on SCPC following Müller and Watson (2022) with various values of the maximal average pairwise correlation ρ. Columns 10–12 report z-scores for Moran's I statistics, which test for spatial correlations of residuals, based on binary spatial weight matrix with various bandwidths. Panels A and C report short- and long-run results with the additional controls corresponding to column 7 of Tables 2 and 3, respectively. Panels B and D additionally control for quadratics of latitude and longitude.

Table B7: Robustness. Alternative Functional Forms, No Initial Sales Control, and Single Long Difference

Dep. Var.: $\triangle \ln Sales_f$	Short run				Long run			
	1972-1981 and 1973-1982			1972-1981	1981-2009 and 1982-2010			1981-2009
	$\ln(1 + Credit_f)$	$\mathbb{1}[Credit_f > 0]$	No y_{ft_0}	Single diff.	$\ln(1 + Credit_f)$	$\mathbb{1}[Credit_f > 0]$	No y_{ft_0}	Single diff.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
asinh($Credit_f$)	0.09**	1.58**	0.06	0.10*	0.13***	2.28***	0.10**	0.14***
	(0.03)	(0.61)	(0.05)	(0.05)	(0.04)	(0.78)	(0.04)	(0.04)
Exposure Controls	✓	✓	✓	✓	✓	✓	✓	
Firm Controls	✓	✓	✓	✓	✓	✓	✓	
Region FE	✓	✓	✓	✓	✓	✓	✓	
Sector FE	✓	✓	✓	✓	✓	✓	✓	
KP-F	10.53	10.67	9.45	4.56	9.29	9.30	8.28	7.78
AR-p	0.02	0.02	0.14	0.01	0.00	0.00	0.00	0.00
Num. Clusters	55	55	55	41	53	53	53	40
N	762	762	762	341	741	741	741	318

Notes. Standard errors clustered at the region level are in parentheses. *: p<0.1; **: p<0.05; ***: p<0.01. The table reports the OLS and IV estimates of Equation (3.1). The dependent variable is sales growth over various horizons. In columns 1 and 5, log one plus credit $\ln\left(1 + Credit_f\right)$ is the main independent variable. In columns 2 and 6, a dummy of positive credit $\mathbb{1}[Credit_f > 0]$ is the main independent variable. Columns 3 and 7 omit the initial sales control. Columns 4 and 8 use a single long difference for either 1972-81 or 1982-2010 as the estimation sample. All specifications control for the vector of variables used in column 7 of Tables 2-3, initial sales (except columns 3 and 7), and region and sector fixed effects. KP-F is the Kleibergen-Paap F-statistics. AR and AR-p are the Anderson-Rubin test statistics and its p-value.

C. Theory and Quantification

C.1 Profit Maximization When Firms are Not Constrained

Given downward-sloping demand and LBD, a firm maximizes discounted profits:

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

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

where κ_{fj1} is a subsidy provided by the government in the first period and there is no subsidy in the second period.[42] $\Pi_{fj1}(p_{fj1})$ and $\Pi_{fj2}(p_{fj1}, p_{fj2})$ are profits in the first and the second periods.

In the second period 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

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

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

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

where

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

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: $\partial\Pi_{fj}/\partial p_{fj1} = 0$. This first-order condition is:

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

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

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

Denote the price that maximizes the first period static profits by p_{fj1}^{Static}:

$$p_{fj1}^{Static} = \frac{\sigma}{\sigma-1}\frac{\kappa_{fj1}c_{j1}}{A_{fj1}}. \tag{C.2}$$

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.

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

This section derives 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 $\lambda_{j1}/\kappa_{fj1} \leq 1$, a firm produces at most the quantity that maximizes static profits and charges at most 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 $q_{fj1}^{Static} = (p_{fj1}^{Static})^{-\sigma}(P_{j1}^{H})^{\sigma-1}X_{j1}$. Firms are constrained when

$$\kappa_{fj1}c_{j1}m_{j1} \leq \tilde{\lambda}_{j1}A_{fj1}^{\sigma-1} \tag{C.3}$$

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

$$\begin{aligned}\kappa_{fj1}c_{j1}m_{fj1} = \kappa_{fj1}c_{j1}\times\frac{1}{A_{fj1}}(q_{fj1}^{Static}) &= \frac{c_{j1}}{A_{fj1}}(p_{fj1}^{Static})^{-\sigma}(P_{j1}^{H})^{\sigma-1}X_{j1}\\ = \kappa_{fj1}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}&c_{j1}^{1-\sigma}A_{fj1}^{\sigma-1}(P_{j1}^{H})^{\sigma-1}X_{j1}.\end{aligned} \tag{C.4}$$

Substituting (C.4) into (C.3) 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:

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

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

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

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.

Prices and sales. By Proposition C.1

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

Demand for firm f's output is $p_{fj1}^{-\sigma}(P_{j1}^{H})^{\sigma-1}X_{j1}$. After substituting firm price in (C.5) into firm sales $X_{fj1} = p_{fj1}q_{fj1}$, we obtain

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

Input expenditures and total input costs. A firm's input expenditures are expressed as

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

The first equality comes from a firm's cost minimization such that $w_t\mathcal{L}_{fj1} + \sum_k P_{k1}M_{fk1}$ 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.5). Input expenditures on each intermediate input and on labor are

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

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

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

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

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

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:

$$p_{fj2} = \frac{\sigma}{\sigma-1}\frac{c_{j1}}{A_{fj2}},$$

and its sales are

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

Because $A_{fj2} = \phi_{fj2}q^{\xi}_{fj1}$ and $q_{fj1} = p^{-\sigma}_{fj1}(P^H_{j1})^{\sigma-1}X_1$, after substituting the firm's first period price (C.5), we can rewrite the second period sales as

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

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

$$c_{j2}m_{fj2} = \frac{\sigma-1}{\sigma}X_{fj2}$$

Profits. Profits in the second period are

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

C.4 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. For any outcome x, let the subscript c stand for the counterfactual equilibrium allocation, and $\hat{x}^S_1 = x_{c,1}/x_1$ denote the gross proportional difference between the counterfactual and the baseline at $t = 1$. Denote by $\hat{x}^L_2 = x_2/x_1$ the changes between the first and second periods in the baseline. Finally, let $\hat{x}^L_{c,2} = x_{c,2}/x_{c,1}$ denote the changes between the first and second periods in the counterfactual.

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

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

where y is the per capita income.[43] The counterfactual welfare change relative to the baseline equilibrium is

$$\frac{U_c}{U} = \underbrace{\left(\frac{\hat{y}_1^S}{\hat{P}_1^S}\right)}_{\substack{\text{Short-run}\\ \text{welfare change}}} \times \underbrace{\left(\frac{\tilde{y}_2^L}{\tilde{P}_2^L}\frac{\hat{y}_1^S}{\hat{P}_1^S}\right)^{\beta}}_{\substack{\text{Long-run}\\ \text{welfare change}}} \qquad \text{where} \qquad \frac{\tilde{y}_2^L}{\tilde{P}_2^L} = \frac{\hat{y}_{c,2}^L}{\hat{P}_{c,2}^L}\Big/\frac{\hat{y}_2^L}{\hat{P}_2^L}, \tag{C.6}$$

with $\tilde{x}$ denoting the ratio of long-run changes between the counterfactual and the baseline equilibrium. The overall counterfactual welfare change U_c/U is thus composed of the short- and the long-run components.

The short run. In the short-run counterfactual, the shocks are $\hat{\kappa}_{fj1}$, whereas λ_{j1}, P_{j1}^F, D_{j1}^F, and ϕ_{fj1} remain constant. We set $\hat{\lambda}_{j1}^S = 1$, $\hat{A}_{fj1}^S = 1$, $\hat{P}_{j1}^{F,S} = 1$, $\hat{D}_{j1}^{F,S} = 1$, $\hat{\mathcal{L}}_1^S = 1$, and $\hat{\kappa}_{fj1}^S = \kappa_{c,fj1}/\kappa_{fj1}$, where $\kappa_{c,fj1} = 1$.

A firm's price changes are written as

$$\hat{p}_{fj1}^S = \left(\frac{\hat{\lambda}_{j1}^S}{\hat{\kappa}_{fj1}^S}\right)^{-\frac{1}{\sigma}}\frac{\hat{c}_{j1}^S}{\hat{A}_{fj1}^S}. \tag{C.7}$$

Changes of Home sectoral price indices are

$$(\hat{P}_{j1}^{H,S})^{1-\sigma} = \sum_{f\in\mathcal{F}_j}\pi_{fj1}(\hat{p}_{fj1}^S)^{1-\sigma}.$$

Changes of final price indices are

$$(\hat{P}_{j1}^S)^{1-\rho} = (1-\pi_{j1}^F)(\hat{P}_{j1}^{F,S})^{1-\rho} + \pi_{j1}^F(\hat{P}_{j1}^{H,S})^{1-\rho}.$$

A firm's counterfactual market share is

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

[43] Per capita income in the first period is: $y_1 = \frac{w_1\mathcal{L}_1+\Pi_1+T_1}{\mathcal{L}_1}$. 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.

A counterfactual import share is

$$\pi^F_{c,j1} = \frac{(\hat{P}^{F,S}_{j1})^{1-\rho}\pi^F_{j1}}{(\hat{P}^{H,S}_{j1})^{1-\rho}(1-\pi^F_{j1}) + (\hat{P}^{F,S}_{j1})^{1-\rho}\pi^F_{j1}}$$

Counterfactual exports are

$$EX_{c,j1} = (\hat{c}^S_{j1})^{1-\rho}\hat{D}^F_{j1}EX_{j1}$$

Labor market clearing can be written as

$$\hat{w}^S_1\hat{\mathcal{L}}^S_1 w_1\mathcal{L}_1 = \frac{\sigma-1}{\sigma}\sum_{j\in\mathcal{J}_M}\gamma^{\mathcal{L}}_j X_{c,j1} + \sum_{j\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j X_{c,j1},$$

where

$$w_1\mathcal{L}_1 = \frac{\sigma-1}{\sigma}\sum_{j\in\mathcal{J}_M}\gamma^{\mathcal{L}}_j X_{j1} + \sum_{j\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j X_{j1}$$

Goods market clearing is expressed as

$$X_{c,j1} = (1-\pi^F_{c,j1})\left[\alpha^j(\hat{w}^S_1\hat{\mathcal{L}}^S_1 w_1\mathcal{L}_1 + \Pi_{c,1} + T_{c,1}) + \frac{\sigma-1}{\sigma}\sum_{k\in\mathcal{J}_M}\gamma^j_k X_{c,k1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^j_k X_{c,k1}\right] + EX_{c,j1}$$

Firms' sales and profits are expressed as

$$X_{c,fj1} = \pi_{c,fj1}X_{c,j1},$$

and

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

Aggregate profits are

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

Lump-sum transfers are

$$T_{c,1} = \sum_{j\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_j}(\kappa_{c,fj1}-1)\left(\left(\frac{\lambda_{j1}}{\kappa_{c,fj1}}\right)^{\frac{1}{\sigma}}\frac{\sigma-1}{\sigma}X_{c,fj1}\right). \tag{C.8}$$

The long run. In the long-run hat algebra, there are six exogenous changes: $\hat{A}^L_{fj2}$, $\hat{\kappa}^L_{fj2}$, $\hat{\lambda}^L_{j2}$, $\hat{\mathcal{L}}^L_2$, $\{\hat{P}^{F,L}_{jt}\}$ and $\{\hat{D}^{F,L}_{jt}\}$. In the second period, there are no subsidy and no constraints, so we set $\kappa_{fj2} = 1$ and $\lambda_{j2} = 1$. Then, the long-run changes of subsidies and constraints are given as $\hat{\kappa}^L_{fj2} = 1/\kappa_{fj1}$ and $\hat{\lambda}^L_{j2} = 1/\lambda_{j1}$. The value of $\hat{\mathcal{L}}^L_2$ comes from changes in the population. The import prices and foreign demand shifters are backed out from the data on the evolution of imports and exports as described in Section C.7. Gross changes in subsidies, financial constraints, foreign demand/supply, and population are the same in both the long-run factual hat algebra and the long-run counterfactual hat algebra.

The long-run factual productivity change equals $\hat{A}^L_{fj2} = A_{fj2}/A_{fj1} = \phi_{fj2} q^{\xi}_{fj1}/\phi_{fj1}$. Its construction is described in detail in Section C.7. To construct counterfactual productivity, we combine the factual productivity change with the outcome of the short-run hat algebra. The counterfactual productivity change is computed as

$$\hat{A}^L_{c,fj2} = \frac{\phi_{fj2} q^{\xi}_{c,fj1}}{\phi_{fj1}} = \underbrace{\frac{\phi_{fj2} q^{\xi}_{fj1}}{\phi_{fj1}}}_{=\hat{A}^L_{fj2}\text{ : Data}} \times \underbrace{\left(\frac{q_{c,fj1}}{q_{fj1}}\right)^{\xi}}_{\substack{=\hat{q}^S_{fj1}\text{ : Short-run} \\ \text{hat algebra}}}, \tag{C.9}$$

where 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.

We feed in $\hat{A}^L_{c,fj2}$ and $\hat{A}^L_{fj2}$ and apply the long-run hat algebra to the counterfactual and factual long-run changes to 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 (C.6).

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

$$\hat{p}^L_{fj2} = \left(\frac{\hat{\lambda}^L_{j2}}{\hat{\kappa}^L_{fj2}}\right)^{-\frac{1}{\sigma}} \frac{\hat{c}^L_{j2}}{\hat{A}^L_{c,fj2}}, \tag{C.10}$$

and

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

Changes in Home sectoral price indices are

$$(\hat{P}^{H,L}_{j2})^{1-\sigma} = \sum_{f\in\mathcal{F}_j}\pi_{fj1}(\hat{p}^L_{fj2})^{1-\sigma}.$$

Changes in final price indices are

$$(\hat{P}^L_{j2})^{1-\rho} = (1-\pi^F_{j1})(\hat{P}^{F,L}_{j2})^{1-\rho} + \pi^F_{j1}(\hat{P}^{H,L}_{j2})^{1-\rho}.$$

Import shares are

$$\pi^F_{j2} = \frac{(\hat{P}^{F,L}_{j2})^{1-\rho}\pi^F_{j1}}{(\hat{P}^{H,L}_{j2})^{1-\rho}(1-\pi^F_{j1}) + (\hat{P}^{F,L}_{j2})^{1-\rho}\pi^F_{j1}}. \tag{C.11}$$

Exports are

$$EX_{j2} = (\hat{c}^L_{j2})^{1-\rho}\hat{D}^{F,L}_{j2}EX_{j1} \tag{C.12}$$

Labor market clearing can be written as

$$\hat{w}_2^L \hat{\mathcal{L}}_2^L w_1 \mathcal{L}_1 = \frac{\sigma-1}{\sigma} \sum_{j \in \mathcal{J}_M} \gamma_j^{\mathcal{L}} X_{j2} + \sum_{j \in \mathcal{J}_{NM}} \gamma_j^{\mathcal{L}} X_{j2},$$

where

$$w_1 \mathcal{L}_1 = \frac{\sigma-1}{\sigma} \sum_{j \in \mathcal{J}_M} \gamma_j^{\mathcal{L}} X_{j1} + \sum_{j \in \mathcal{J}_{NM}} \gamma_j^{\mathcal{L}} X_{j1}$$

Goods market clearing is expressed as

$$X_{c,j2} = (1 - \pi_{c,j2}^F) \left[\alpha^j (\hat{w}_2^L \hat{\mathcal{L}}_2^L w_1 \mathcal{L}_1 + \Pi_2 + T_2) + \frac{\sigma-1}{\sigma} \sum_{k \in \mathcal{J}_M} \gamma_k^j X_{k2} + \sum_{k \in \mathcal{J}_{NM}} \gamma_k^j X_{k2} \right] + EX_{c,j2}.$$

Firms' sales and profits are expressed as

$$X_{fj2} = \pi_{fj2} X_{j2},$$

and

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

Aggregate profits are

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

Lump-sum transfers are

$$T_2 = 0. \tag{C.13}$$

C.5 Model Solution and Algorithm

The model solution solves Equations (C.7)-(C.13). 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 $j \in \mathcal{J}$, $X_{j1} = \sum_{f \in \mathcal{F}_j} X_{fj1}$
- Sectoral import shares π_{j1}^F
- Sectoral export values EX_{j1}
- Distance between firms Dist_{fg} ($d_{fg} = \text{Dist}_{fg}^{\chi}, \forall f, j \in \mathcal{F}$)

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. $\lambda_{j2} = 1, \forall j$
- Subsidy level in the first period κ_{fj1}, $\forall j \in \mathcal{J}_M$. In the second, there is no subsidy, i.e., $\kappa_{fj2} = 1$, $\forall f, j$

- 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 $\{\hat{A}^{L}_{j2}\}$, $\forall j \in \mathcal{J}_{NM}$.
- Long-run Foreign demand shocks $\{\hat{D}^{F,L}_{j2}\}$
- Long-run Foreign import price shocks $\{\hat{P}^{F,L}_{j2}\}$

Parameters.

- The elasticity of substitution σ and ρ
- The learning-by-doing parameters ξ and γ
- The spatial decay rate parameter δ
- Final consumption shares α^j, $\forall j \in \mathcal{J}$
- Production parameters $\gamma^{\mathcal{L}}_j$ and γ^k_j, $\forall j, k \in \mathcal{J}$

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.7)-(C.8).
  3. Calculate the counterfactual equilibrium allocation.

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

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

  2. Calculate $\hat{A}^L_{c,fj2} = \hat{A}^L_{fj2} \times (\hat{q}^S_{c,fj1})^{\xi}$ 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 six shocks: $\hat{A}^L_{fj2}$, $\hat{D}^{F,L}_{j2}$, $\hat{P}^{F,L}_{j2}$, $\lambda_{j2} = 1$, $\kappa_{fj2} = 1$, and $\hat{\mathcal{L}}^L_2$ to the baseline (pre-shock) data values
  2. Obtain long-run equilibrium allocation changes by solving Equations (C.10)-(C.13).
  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 six shocks: $\hat{A}^L_{fj2}$, $\hat{D}^{F,L}_{j2}$, $\hat{P}^{F,L}_{j2}$, $\lambda_{j2} = 1$, $\kappa_{fj2} = 1$, and $\hat{\mathcal{L}}^L_2$ to the counterfactual data values in 1982
  2. Obtain long-run equilibrium allocation changes under counterfactual by solving Equations (C.10)-(C.13).
  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

$$U_c/U = \left(\frac{\hat{y}_1^S}{\hat{P}_1^S}\right)\left(\frac{\tilde{y}_2^L}{\tilde{P}_2^L}\frac{\hat{y}_1^S}{\hat{P}_1^S}\right)^{\beta}$$

where

$$\frac{\tilde{y}_2^L}{\tilde{P}_2^L} = \frac{\hat{y}_{c,2}^L}{\hat{P}_{c,2}^L} \Bigg/ \frac{\hat{y}_2^L}{\hat{P}_2^L}$$

and $\hat{y}_1^S/\hat{P}_1^S$ is obtained from the short-run hat algebra applied to the baseline (pre-shock) data values in 1982, $\hat{y}_2^L/\hat{P}_2^L$ is obtained from the long-run hat algebra applied to the baseline (pre-shock) data values in 1982, and $\hat{y}_{c,2}^L/\hat{P}_{c,2}^L$ is obtained from the long-run hat algebra applied to the counterfactual data values in 1982.

C.6 Data Construction for the Quantitative Analysis

This section describes the data cleaning procedure for the quantitative analysis. Firm market shares π_{fj1} are calculated as follows. We directly observe the 1982 firm-level sales in our main dataset. For some firms we impute missing sales using assets.[44] After summing the observed firm-level sales, we calculate the residual of the sectoral gross output by subtracting the sum of sales in the firm-level data from the gross output in the 1980 IO table. We treat the residual output as a separate firm and assign its geographic position to be the sectoral sales-weighted average latitude and longitude.[45] In this way, the model matches perfectly the output in each sector and time period. This procedure also implies that post-1980 firm entry is absorbed into the residual firm.[46] Firm-level shares are then obtained by dividing firm sales by the sectoral gross output from the IO table. Import shares π_{j1}^F and export values EX_{j1} are obtained from the 1980 IO table.

Sectoral import shares and exports are obtained directly from the IO tables. We merge the 1982 firm-level sales to the national IO table for 1980.[47] 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 these come 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

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

[44] There are some firms without information on sales, but all firms have information on assets. Appendix C.6 describes the imputation procedure in detail.

[45] By assigning the weighted averages, we can compute distance between all firms and the residual firm. Also, because of the weights, the residual firms are located closer to other larger-sized firms, consistent with observed sectoral geographical concentration.

[46] In the quantitative analysis, the total number of firms in each sector is the total number of firms in the firm-level data that were operating in 1982 plus 1. The residuals are the sum of sales of small-sized firms that are not in our dataset.

[47] The IO table is not available for 1982.

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

$$\ln Sales_{ft} = \beta_1 \ln Assets_{ft} + \varepsilon_{ft}$$

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

C.7 Backing Out the Long-Run Shocks

The sales growth and changes in subsidies of firm f relative to a reference firm f_0 in the same sector gives us the relative long-run factual productivity changes:

$$\frac{\hat{A}^L_{fj2}}{\hat{A}^L_{f_0j2}} = \left(\frac{\widehat{X}^L_{fj2}}{\widehat{X}^L_{f_0j2}}\right)^{\frac{1}{\sigma-1}} \left(\frac{\widehat{\kappa}^L_{fj2}}{\widehat{\kappa}^L_{f_0j2}}\right)^{\frac{1}{\sigma}}, \tag{C.14}$$

where the firm-level sales X_{fjt} come from the data and the baseline subsidies κ_{fjt} are backed out above. Then, we pin down the long-run productivity growth of the reference firm $\hat{A}^L_{f_0j2}$, the foreign demand $\hat{D}^{F,L}_{j2}$, and the import price changes $\hat{P}^{F,L}_{j2}$ by matching the changes in the producer price index, the export values, and the import shares exactly to the data between 1980 and 2010.

To implement the long-run hat algebra, we next have to compute the long-run shocks $\{\hat{A}^L_{f_0j2}, \hat{D}^{F,L}_{j2}, \hat{P}^{F,L}_{j2}\}$. This matrix of shocks is of dimension $3\times J$. We compute these shocks by exactly matching the model to the observed data on changes in producer price indices, import shares, and exports between 1980 and 2010. Import shares and exports are obtained from the IO tables. Producer price indices are obtained from the OECD Stan database. When fitting the price changes, we normalize price changes across sectors by price change of one sector, which pins down $\hat{A}^L_{f_0j2}$ relative to the reference sector. Without loss of generality, we use the first sector (Food, Beverages, & Tobacco) as our reference sector ($j = 1$). Then, we use real output changes of the reference sector to pin down $\hat{A}^L_{f_0j2}$ of the reference sector.

We compute these shocks using the following algorithm:

- Step 1: Guess $\{\hat{A}^{L,0}_{f_0j2}, D^{F,L,0}_{j2}, P^{F,L,0}_{j2}\}$
- Step 2: Compute the firm-level long-run productivity shock based on the guess:

$$A^{L,0}_{fj2} = \hat{A}^{L,0}_{f_0j2} \times \underbrace{\left(\frac{A_{fj2}/A_{f_0j2}}{A_{fj1}/A_{f_0j1}}\right)}_{\text{Data}}.$$

  The changes in relative productivity are taken directly from the data, see (C.14).
- Step 3: Given the guess, compute prices.
- Step 4: Update $\hat{P}^{F,L,0}_{j2}$ using Equation (C.11) and observed import share changes between 1980 and 2010.

- Step 5: Update $\hat{D}^{F,L,0}_{j2}$ using Equation (C.12) and observed exports changes between 1980 and 2010.
- Step 6: Compute price changes. Update $\hat{A}^{L,0}_{f_0 j2}$ for $j = 2, \ldots, J$ until $\hat{P}_{jt}/\hat{P}_{1t}$ fits the PPI changes relative to the reference sector ($j = 1$).
- Step 7: Update $\hat{A}^{L,0}_{f_0 j2}$ for $j = 1$ until $\hat{X}^{L}_{jt}/\hat{P}^{L}_{jt}$ fits the real output changes of the data.
- Step 8: Iterate Steps 2-7 until the convergence.

C.8 Satisfying Market Clearing

We require the market-clearing conditions in levels to be satisfied in the first and second periods to apply the hat algebra and to back out the shocks. Given $\{\kappa_{fj1}\}$ and $\{\lambda_{j1}\}$, in the first period, firm-level sales $\{X_{fj1}\}$ and industry-level gross outputs $\{X_{j1}\}$, exports $\{EX_{j1}\}$, and import shares $\{\pi^F_{j1}\}$ should satisfy

$$
\begin{aligned}
X_{fj1} = \pi_{fj1}(1-\pi^F_{j1})\Bigg[\alpha^j \Bigg\{ & \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^{\mathcal{L}}_k\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j X_{k1}}_{w_1\mathcal{L}_1} \\
& + \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\left(1-\kappa_{fk1}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\right)X_{fk1}}_{=\Pi_1} \\
& + \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_j}(\kappa_{fk1}-1)\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)X_{fk1}}_{=T_1}\Bigg\} \\
& + \sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^j_k\left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}}\frac{\sigma-1}{\sigma}X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^j_k X_{k1}\Bigg] + \pi_{fj1}EX_{j1}, \quad \forall f, j.
\end{aligned}
$$

Similarly, in the second period, the following equation should be satisfied:

$$
\begin{aligned}
X_{fj2} = \pi_{fj2}(1-\pi^F_{j2})\Bigg[\alpha^j \Bigg\{ & \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^{\mathcal{L}}_k\left(\frac{\sigma-1}{\sigma}\right)X_{fk2} + \sum_{k\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j X_{k2}}_{w_2\mathcal{L}_2} + \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\frac{1}{\sigma}X_{fk2}}_{=\Pi_2}\Bigg\} \\
& + \sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^j_k\frac{\sigma-1}{\sigma}X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^j_k X_{k2}\Bigg] + \pi_{fj2}EX_{j2}, \quad \forall f, j.
\end{aligned}
$$

In the data, these conditions are unlikely to hold. Therefore, following Costinot and Rodríguez-Clare (2014) and di Giovanni et al. (2024), we introduce sector-specific wedge $\{\iota_{jt}\}$ that makes the above market clearing condition to hold exactly, that is,

$$
\begin{aligned}
X_{fj1} = \pi_{fj1}(1-\pi^F_{j1})\Bigg[\alpha^j \Bigg\{ & \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^{\mathcal{L}}_k\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j X_{k1}}_{w_1\mathcal{L}_1} \\
& + \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\left(1-\kappa_{fk1}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\right)X_{fk1}}_{=\Pi_1} + \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_j}(\kappa_{fk1}-1)\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)X_{fk1}}_{=T_1}\Bigg\} \\
& + \sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^j_k\left(\frac{\lambda_{j1}}{\kappa_{fj1}}\right)^{\frac{1}{\sigma}}\frac{\sigma-1}{\sigma}X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^j_k X_{k1}\Bigg] + \pi_{fj1}EX_{j1} + \pi_{fj1}\iota_{j1}, \quad \forall f, j,
\end{aligned}
$$

and

$$
\begin{aligned}
X_{fj2} = \pi_{fj2}(1-\pi^F_{j2})\Bigg[\alpha^j \Bigg\{ & \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^{\mathcal{L}}_k\left(\frac{\sigma-1}{\sigma}\right)X_{fk2} + \sum_{k\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j X_{k2}}_{w_2\mathcal{L}_2} + \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\frac{1}{\sigma}X_{fk2}}_{=\Pi_2}\Bigg\} \\
& + \sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^j_k\frac{\sigma-1}{\sigma}X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^j_k X_{k2}\Bigg] + \pi_{fj2}EX_{j2} + \pi_{fj2}\iota_{j2}, \quad \forall f, j.
\end{aligned}
$$

Then we apply the hat algebra and then feed the shocks $\hat{\iota}^S_{jt} = 0, \forall j, t$ that eliminate the wedges.

Other shocks are held constant. We obtain $\{\hat{X}^S_{fjt}\}$ and $\{\hat{X}^S_{jt}\}$ by solving

$$
\begin{aligned}
\hat{X}^S_{fj1}X_{fj1} = \hat{\pi}^S_{fj1}\pi_{fj1} \\
\times (1-\hat{\pi}^{F,S}_{j1}\pi^F_{j1})\Bigg[\alpha^j\Bigg\{ \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^{\mathcal{L}}_k\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\hat{X}^S_{fk1}X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j\hat{X}^S_{k1}X_{k1}}_{\hat{w}^S_1 w_1\mathcal{L}_1} \\
+ \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\left(1-\kappa_{fk1}\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\right)\hat{X}^S_{fk1}X_{fk1}}_{=\hat{\Pi}^S_1\Pi_1} \\
+ \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}(\kappa_{fk1}-1)\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\left(\frac{\sigma-1}{\sigma}\right)\hat{X}^S_{fk1}X_{fk1}\Bigg\}}_{=\hat{T}^S_1 T_1} \\
+ \sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^j_k\left(\frac{\lambda_{k1}}{\kappa_{fk1}}\right)^{\frac{1}{\sigma}}\frac{\sigma-1}{\sigma}\hat{X}^S_{fk1}X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^j_k\hat{X}^S_{k1}X_{k1}\Bigg] \\
+ \hat{\pi}^S_{fj1}\pi_{fj1}\hat{EX}^S_{j1}EX_{j1} + \hat{\pi}^S_{fj1}\pi_{fj1}\hat{\iota}^S_{j1}\iota_{j1}, \quad \forall f, j,
\end{aligned}
$$

and

$$
\begin{aligned}
\hat{X}^S_{fj2}X_{fj2} = \hat{\pi}^S_{fj2}\pi_{fj2}(1-\hat{\pi}^{F,S}_{j2}\pi^F_{j2})\Bigg[\alpha^j\Bigg\{ \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^{\mathcal{L}}_k\left(\frac{\sigma-1}{\sigma}\right)\hat{X}^S_{fk2}X_{fk2} + \sum_{k\in\mathcal{J}_{NM}}\gamma^{\mathcal{L}}_j\hat{X}^S_{k2}X_{k2}}_{\hat{w}^S_2 w_2\mathcal{L}_2} \\
+ \underbrace{\sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\frac{1}{\sigma}\hat{X}^S_{fk2}X_{fk2}}_{=\hat{\Pi}^S_2\Pi_2}\Bigg\} + \sum_{k\in\mathcal{J}_M}\sum_{f\in\mathcal{F}_k}\gamma^j_k\frac{\sigma-1}{\sigma}\hat{X}^S_{fk1}X_{fk1} + \sum_{k\in\mathcal{J}_{NM}}\gamma^j_k\hat{X}^S_{k2}X_{k2}\Bigg] \\
+ \hat{\pi}^S_{fj2}\pi_{fj2}\hat{EX}^S_{j2}EX_{j2} + \hat{\pi}^S_{fj2}\pi_{fj2}\hat{\iota}^S_{j2}\iota_{j2}, \quad \forall f, j.
\end{aligned}
$$

After solving for $\{\hat{X}^S_{fjt}\}$, $\{\hat{X}^S_{jt}\}$, $\{\hat{EX}^S_{jt}\}$, and $\{\hat{\pi}^{F,S}_{j1}\}$, we obtain the new $\{X^S_{fjt}\}$, $\{X^S_{jt}\}$, $\{EX^S_{jt}\}$, and $\{\pi^{F,S}_{j1}\}$ that satisfy the market clearing conditions. We use the new set of $\{X^S_{fjt}\}$, $\{X^S_{jt}\}$, $\{EX^S_{jt}\}$, and $\{\pi^{F,S}_{j1}\}$ as our main data for the counterfactual analysis.

C.9 Statistical Uncertainty

We quantify a range of the welfare effects due to statistical uncertainty of the short- and long-run estimates. We obtain a joint distribution of estimates using block-bootstrapping. For each a set of the short- and long-run estimates, we calculate the implied subsidy level of the model using equation (5.6) and the learning-by-doing parameter implied from equation (5.10). The number of bootstraps is 500. Because the samples are block-bootstrapped at the regional level, the estimates account for correlations of residuals within these regions. Additionally, by using a draw of regions for estimating both short- and long-run estimates, we capture the underlying statistical relationship between these estimates.

Specifically, we proceed by the following steps.

- Step 1. Randomly draw a set of 55 regions, where 55 represents the number of clusters in the short-run regression.
- Step 2. Construct a sample of firms located in the randomly drawn regions and use this sample to estimate equation (3.1), obtaining short- and long-run IV estimates.
- Step 3. Repeat the above two steps 500 times to obtain a joint distribution of the short- and long-run estimates.
- Step 4. Discard estimates where the first-stage F-statistics are below 5 in either the short- or long-run regression.
- Step 5. Calculate the percentile p of the largest negative estimate value. Truncate estimates below this percentile p to remove estimates with negative values. Similarly, truncate estimates symmetrically above $1 - p$ to prevent upward bias from truncating the negative values.
- Step 6. Using the truncated distribution of estimates, calculate a distribution of the welfare effects.

C.10 Distortionary Taxation

The baseline model assumes that households supply labor inelastically and subsidies are financed through lump-sum taxation. Therefore, subsidies are not distortionary, which may affect the welfare consequences of the subsidies. As a sensitivity check, this appendix introduces upward-sloping labor supply and labor taxes τ_t^h that finance the subsidies. Labor taxes introduce distortions in households' labor supply decisions.

The consumption-leisure tradeoff is GHH (Greenwood et al., 1988). The household solves:

$$\max \sum_{t=1,2} \beta^{t-1} \ln\left(\prod_j C_{jt}^{\alpha^j} - \frac{\varphi_t}{1+1/\psi}\mathcal{L}_t^{1+1/\psi}\right)$$

subject to the budget constraint:

$$\sum_j P_{jt}C_{jt} = (1-\tau_t^h)W_t\mathcal{L}_t + \Pi_t,$$

where Π_t is still the total profits, and φ_t is a preference shock to the disutility of labor. Households' maximization implies that

$$\mathcal{L}_t^{1/\psi} = \frac{1-\tau_t^h}{\varphi_t}\frac{W_t}{P_t}$$

and

$$\hat{\mathcal{L}}_t^{1/\psi} = \frac{1}{\hat{\varphi}}\frac{1-\tau_{c,t}^h}{1-\tau_t^h}\frac{\hat{W}_t}{\hat{P}_t}$$

in changes. Goods market clearing conditions are:

$$X_{c,jt} = (1-\pi_{c,jt}^F)\left[\alpha^j(1-\tau_{c,t}^h)\hat{w}_t\hat{\mathcal{L}}_t w_t\mathcal{L}_t + \sum_k \gamma_k^j c_{kt}m_{kt}\right] + EX_{c,jt}.$$

The other equilibrium conditions are the same as those in Section C.4.

We have to calibrate two additional parameters: ψ and φ_t. We set ψ to be 0.5 following Chetty et al. (2011). For the short-run hat algebra, we set $\hat{\varphi}_t^S = 1$. For the long run, we calibrate $\hat{\varphi}_t^L$ by matching changes in total hours worked by employees between 1982 and 2010. We obtain these changes in hours worked from the OECD Stan database. Similar to the baseline counterfactual without distortionary taxation, we report changes in discounted real consumption. Table C2 reports the results, which are discussed in the main text.

C.11 Cross-Firm Spillovers

Model. The model is identical to the baseline with the exception of $t = 2$ productivity. When there are spillovers, firm f's productivity at $t = 2$ is:

$$A_{fj2} = \phi_{fj2}(q_{fj1})^{\xi}(Q^{A,\mathrm{H}}_{fj1})^{\zeta^{\mathrm{H}}}(Q^{A,\mathrm{U}}_{fj1})^{\zeta^{\mathrm{U}}}(Q^{A,\mathrm{D}}_{fj1})^{\zeta^{\mathrm{D}}}. \tag{C.15}$$

The second period productivity is increasing in the first period quantity produced with elasticity ξ and before, and now in addition it increases in the first period weighted averages of quantities produced by other firms with elasticities ζ^{H}, ζ^{U}, and ζ^{D}. These weighted averages are defined as

$$Q^{A,\mathrm{H}}_{fj1} = \left(\sum_{g\in\mathcal{F}_{(-f)j}} d_{fg} q_{gj1}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \qquad Q^{A,\mathrm{U}}_{fj1} = \left(\sum_{k\neq j}\sum_{g\in\mathcal{F}_{(-f)k}} d_{fg}\gamma^{j}_{k} q_{gk1}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}},$$

$$Q^{A,\mathrm{D}}_{fj1} = \left(\prod_{k\neq j}\sum_{g\in\mathcal{F}_{(-f)k}} d_{fg} q_{gk1}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}\gamma^{j}_{k}},$$

where $\mathcal{F}_{(-f)j}$ is the set of sector j firms other than f. Because of different weights d_{fg} and the exclusion of own quantity, $Q^{A,\mathrm{H}}_{fj1}$, $Q^{A,\mathrm{U}}_{fj1}$, and $Q^{A,\mathrm{D}}_{fj1}$ vary across firms within sectors. The functional forms for Q^{A}_{fj1} are theoretical counterparts of the empirical exposure measures (B.1) (B.3), and (B.5). The weight d_{fg} governs the decay rate of external LBD effects between firms. This functional form is similar to the external LBD formulations in Melitz (2005) and Allen and Donaldson (2022), but takes into account the matrix of bilateral geographical frictions between firms and the direction of input links. Analogous to the empirical exposure measures, in the quantification we will parameterize d_{fg} as a function of geographic distance between two firms $d_{fg} \equiv \mathrm{Dist}^{-\chi}_{fg}$ and set $\chi = 1.1$.

Note that the model has roundabout production, and thus a supply chain of infinite length. Thus, a subsidy shock at $t = 1$, or an LBD-induced productivity change at $t = 2$ propagate through first-, second-, third-, etc., round production linkages. By contrast, the external spillover (C.15) is a function of the quantities produced by the directly linked firms. This is by necessity, as we specify this functional form to map the model objects tightly to the empirical results, and we do not have enough statistical power to estimate higher-round spillover terms in our data. The posited LBD function (C.15) is a reduced-form assumption that ties future productivity to present quantities. Once the $t = 2$ productivity is set, the $t = 2$ equilibrium can be computed.

Calibration. After log-approximating $Q^{A,\mathrm{H}}_{fj1}$, $Q^{A,\mathrm{U}}_{fj1}$, and $Q^{A,\mathrm{D}}_{fj1}$ second period firm sales can be written as:

$$\begin{aligned}\ln X_{fj2} &= (\sigma-1)\xi\ln\kappa_{fj1} + (\sigma-1)\zeta^{\mathrm{H}}\Big(\sum_{g\in\mathcal{F}_{(-f)k}}\omega^{f,\mathrm{H}}_{gk1}\ln\kappa_{gk1}\Big)\\ &+ (\sigma-1)\zeta^{\mathrm{U}}\Big(\sum_{k\neq j}\sum_{g\in\mathcal{F}_{(-f)k}}\omega^{f,\mathrm{U}}_{gk1}\ln\kappa_{gk1}\Big) + (\sigma-1)\zeta^{\mathrm{D}}\Big(\sum_{k\neq j}\gamma^{j}_{k}\sum_{g\in\mathcal{F}_{(-f)k}}\omega^{f,\mathrm{D}}_{gk1}\ln\kappa_{gk1}\Big) + \delta_{n2} + \delta_{j2} + u_{fj2},\end{aligned} \tag{C.16}$$

where $\omega_{gk1}^{f,\mathrm{H}}$, $\omega_{gk1}^{f,\mathrm{U}}$, and $\omega_{gk1}^{f,\mathrm{D}}$ are given by the theoretical counterpart of (B.2), (B.4), and (B.6). δ_{n2} and δ_{j2} are region and industry common components, and u_{fj2} is the error term that is a function of own and other firms' exogenous productivity.[48]

Substituting (5.6) into (C.16) yields the following estimable regression model:

$$\begin{aligned}\ln X_{fj2} = & \underbrace{\beta_1^L}_{=(\sigma-1)\xi\eta} \times \mathrm{asinh}(Credit_{fj1}) + \underbrace{\beta_2^{L,\mathrm{H}}}_{=(\sigma-1)\zeta^{\mathrm{H}}\eta} \times \mathrm{Horizontal}_{fj1} \\ & + \underbrace{\beta_3^{L,\mathrm{U}}}_{=(\sigma-1)\zeta^{\mathrm{U}}\eta} \times \mathrm{Upstream}_{fj1} + \underbrace{\beta_4^{L,\mathrm{D}}}_{=(\sigma-1)\zeta^{\mathrm{D}}\eta} \times \mathrm{Downstream}_{fj1} + \delta_{n2} + \delta_{j2} + u_{fj2}, \quad \text{(C.17)}\end{aligned}$$

where region and sector fixed effects capture similar objects as in equation (5.7). Subtracting initial period sales from both sides yields the long-run regression specification (3.1). Since firm sales are proportional to firm productivity, initial sales also control for the initial productivity $\ln \phi_{fj1}$ in u_{fj2}. Combining the short-run and long-run estimates from (5.7) and (C.17) and a value of σ, we can obtain values of ξ, ζ^{H}, ζ^{U}, and ζ^{D} as follows:

$$\sigma\xi = \frac{\beta_1^L}{\beta_1^S}, \qquad \sigma\zeta^{\mathrm{H}} = \frac{\beta_2^{L,\mathrm{H}}}{\beta_1^S}, \qquad \sigma\zeta^{\mathrm{U}} = \frac{\beta_3^{L,\mathrm{U}}}{\beta_1^S}, \qquad \sigma\zeta^{\mathrm{D}} = \frac{\beta_4^{L,\mathrm{D}}}{\beta_1^S}.$$

Thus, as in the baseline model, we can use the regression coefficients on the spillover terms to pin down the strength of the LBD coming from each type of spillover. The values of the regression coefficients $\beta_2^{L,\mathrm{H}}$, $\beta_3^{L,\mathrm{U}}$, and $\beta_4^{L,\mathrm{D}}$ come from column 7 of Table B5. In this column, the spillover terms (B.1) (B.3), and (B.5) are used as regressors of interest, and instrumented with (B.7), (B.8), and (B.9). Table C3 reports the welfare results.

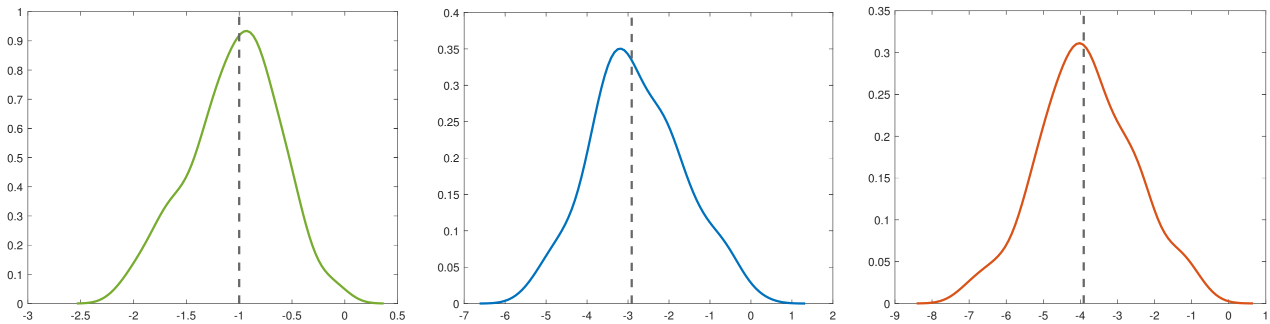
[48]Specifically, δ_{j2} is proportional to

$$\prod_{h=0}^{1}\left[\left(\frac{\sigma}{(\sigma-1)}c_{j,2-h}\right)^{(1-\sigma)(\sigma\xi)^h} \times ((P_{j,2-h}^H)^{\sigma-1}X_{j,2-h})^{(\xi(\sigma-1))^h}\right],$$

and

$$\begin{aligned}u_{fj2} = {} & \sigma\xi(\sigma-1)\ln\phi_{fj1} + (\sigma-1)\ln\phi_{fj2} + \sigma\zeta^{\mathrm{H}}(\sigma-1)\sum_{g\in\mathcal{F}_{(-f)j}} \omega_{gk1}^{f,\mathrm{H}} \ln\phi_{gj1} \\ & + \sigma\zeta^{\mathrm{U}}(\sigma-1)\sum_{k\neq j}\sum_{g\in\mathcal{F}_{(-f)k}} \omega_{gk1}^{f,\mathrm{U}}\ln\phi_{gk1} + \sigma\zeta^{\mathrm{D}}(\sigma-1)\sum_{k\neq j}\sum_{f\in\mathcal{F}_{(-f)k}} \omega_{gk1}^{f,\mathrm{D}}\ln\phi_{gk1}.\end{aligned}$$

Figure C1: The Distribution of the Welfare Effects



Notes. Panels A, B and C present distributions of the short-run, long-run and total welfare effects under the counterfactual in which the Korean government did not conduct the industrial policy, with the dashed vertical lines corresponding to the baseline counterfactual effects in Table 6.

Table C1: Robustness. Financial Constraints. Counterfactual: No Subsidy

Welfare change (%):	(1) Short-run	(2) Long-run	(3) Total
Productivity change:			
Permanent (β = 1.62)	−1.0	−2.86	−3.86
Temporary (β = 0.90)	−1.0	−1.59	−2.59

Notes. The table reports the welfare effects under the counterfactual in which the Korean government did not conduct the industrial policy. Financial constraints parameters in the second period have the same values to those in the first period.

Table C2: Robustness: Distortionary Taxation. Counterfactual: No Subsidy

Welfare change (%):	(1) Short-run	(2) Long-run	(3) Total
Productivity change:			
Permanent (β = 1.62)	−0.37	−3.10	−3.47
Temporary (β = 0.90)	−0.37	−1.72	−2.09

Notes. The table reports the welfare effects under the counterfactual in which the Korean government did not conduct the industrial policy, in the model with distortionary taxation and upward-sloping labor supply.

Table C3: Robustness. Spillovers. Counterfactual: No Subsidy

Welfare change (%):	(1) Short-run	(2) Long-run	(3) Total
Productivity change:			
Permanent (β = 1.62)	−0.74	−9.26	−10.0
Temporary (β = 0.90)	−0.74	−5.15	−5.89

Notes. The table reports the welfare effects under the counterfactual in which the Korean government did not conduct the industrial policy. This scenario models cross-firm spillovers as described in Section C.11. The values of η, ξ, ζ^{H}, ζ^{U}, and ζ^{D} are calibrated based on the estimates from columns 1 and 7 of Table B5.

Table C4: Robustness. Elasticities of Substitution. Counterfactual: No Subsidy

ρ \ σ	2	3	4	5	6	7	8	9
2	−12.88	−3.91	−1.77	−0.86	−0.58	−0.39	−0.26	−0.17
3		−4.75	−2.19	−1.16	−0.71	−0.44	−0.30	−0.22
4			−2.46	−1.33	−0.83	−0.51	−0.35	−0.25
5				−1.48	−0.90	−0.57	−0.40	−0.29
6					−0.98	−0.64	−0.44	−0.32
7						−0.68	−0.49	−0.33
8							−0.52	−0.38
9								−0.39

Notes. This table reports the total welfare effects under different values of σ and ρ. β = 1.62.

Table C5: Welfare Multiplier across Sectors

Sector	Short-run (%)	Long-run (%)	Total (%)	Share of Credit (%)
Pharmaceuticals and Medicine Chemicals	0.12	0.07	0.19	0.03
Textiles, Apparel, Leather	0.13	0.27	0.40	8.34
Food, Beverages, and Tobacco	0.14	0.32	0.46	1.58
Other Non-Metallic Mineral Products	0.16	0.61	0.77	7.36
Wood, Paper, Printing, and Furniture	0.23	0.70	0.93	1.48
Electrical Equipment*	0.19	0.98	1.17	2.99
Chemicals, Petrochemicals, and Rubber and Plastic Products*	0.36	1.16	1.52	38.45
Machinery and Transport Equipment*	0.23	1.74	1.97	14.33
Basic and Fabricated Metals*	0.42	2.54	2.96	25.43

Notes. The table reports the welfare changes from subsidizing each sector in the amount of 1% of initial GDP. The last column reports the share of the aggregate HCI drive credit received by each sector in the data. Superscript * denotes the HCI sectors.