Did Government Intervention Target Technological Externalities?

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Abstract

After the Second World War, Japan experienced one of the most spectacular episodes of economic growth in history. At the same time, the government of Japan implemented an active industrial policy. What was the effect of industrial policy on economic growth in postwar Japan? In theory, industrial policy can accelerate economic growth by favoring industries with stronger technological externalities. Was the government of Japan able to do so in practice? I attempt to answer this question in two steps. First, I estimate the magnitude of technological externalities in the form of (static) economies of scale and (dynamic) learning by doing for each major manufacturing industry. The identification strategy takes advantage of exogenous shocks to foreign supply and demand conditions, which affect the size and experience of Japanese industries through international trade flows, but are otherwise not related to domestic supply conditions. I find evidence of external economies of scale and external learning by doing, which are relatively large and significantly different across manufacturing industries. Second, I evaluate the industrial policy of postwar Japan by comparing estimates of technological externalities to measures of government intervention across industries and over time. I use quantitative and qualitative measures of government intervention to obtain a more complete picture of industrial policy in postwar Japan. I find evidence that industrial policy favored industries with stronger external economies of scale but weaker external learning by doing.

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1 Introduction

In 1940, Japan was a very poor country; income per capita ($2,874) was lower than in 2010 India ($3,372) and much lower than in 2010 China ($8,032). Between the Second World War and the First Oil Shock, Japan managed to catch up with the West, as shown in Figure 1. By 2000, Japan had become a very rich country; income per capita ($20,481) was similar to that of Germany ($18,944) or the United Kingdom ($21,046). While Japan experienced fast economic growth, the government of Japan implemented an active industrial policy. National economic plans coordinated investment and production. Administrative guidance influenced business decisions. Policy and culture favored domestic over foreign producers. Most controversially, the government of Japan openly favored some industries over others through the provision of directed credit, import protection, and tax incentives, among other forms of government intervention.

This paper investigates the relationship between industrial policy and economic growth in postwar Japan. In theory, industrial policy can accelerate economic growth by targeting industries with stronger technological externalities. Was the government of Japan able to do so in practice? I attempt to answer this question in two steps. First, I estimate the magnitude of technological externalities in the form of (static) economies of scale and (dynamic) learning by doing for each major manufacturing industry. I use detailed, firm-level data from 1964 to 1983 to estimate industry-specific production functions and uncover the causal effect of industry size and industry experience on firm productivity. The identification strategy takes advantage of exogenous shocks to foreign supply and demand conditions, which affect the size and experience of Japanese industries through international trade flows, but are otherwise not related to domestic supply conditions. I find evidence of external economies of scale and external learning by doing, which are relatively large and significantly different across manufacturing industries. Second, I evaluate industrial policy by comparing the severity of technological externalities to the intensity of government intervention across industries and over time. Quantitative evidence of government intervention measuring more salient policies (such as directed credit, import protection, and tax incentives) is combined with qualitative evidence measuring less salient policies (such as national economic planning, “buy Japanese” practices, and administrative guidance). It is important to combine quantitative with qualitative evidence of government intervention because industrial policy was implemented with many tools (not all of which can be measured) and formulated with many goals (not all of which were economic growth). I find evidence that industrial policy favored industries with stronger external economies of scale but weaker external learning by doing.

1 Data on income per capita are from the Maddison Project (2013), measured in 1990 USD and adjusted for PPP.
2 Income per capita in Japan grew at 1.9% in 1900-1944, 8.0% in 1945-1973, and 2.4% in 1974-2000. From 1900 to 1940, income per capita grew at 1.36% in the United States and 1.06% in the United Kingdom. Starting in 1940 and ignoring the massive war destruction of 1945, it would have taken Japan approximately 250 years to reach the income level of the United Kingdom at its prewar growth rate.
3 Throughout the paper, I use the term “active industrial policy” to mean a deliberate effort by the government to change the allocation of resources across industries. Implementing an active industrial policy may therefore involve many forms of government intervention, including fiscal policy, monetary policy, trade policy, and tax policy.
4 The theoretical framework section presents a model in which technological externalities (such as economies of scale and learning by doing) lead to suboptimal levels of investment and production across industries. These market failures have level and growth effects on income per capita, and may be corrected by government intervention.
5 Throughout the paper, the effect of industry size on firm productivity will be referred to as “external economies of scale” and the effect of industry experience on firm productivity will be referred to as “external learning by doing.”
Figure 1: Real income per capita in the United Kingdom, Japan, and China (1900-2000).

The closest contribution to this paper is Beason and Weinstein (1996). Richard Beason and David Weinstein collected industry-level data on directed credit, import protection, and tax incentives given by the government to each major manufacturing industry in Japan between 1955 and 1990. With these data, Beason and Weinstein investigate whether the government of Japan favored industries with higher growth of gross output, higher growth of total factor productivity, or stronger economies of scale. Of these three sets of correlations, only the correlation between government intervention and economies of scale can be used to evaluate the effect of industrial policy on economic growth. Unfortunately, the industry-level nature of their data do not allow Beason and Weinstein to obtain precise estimates of economies of scale. Using their point estimates, the authors show a negative correlation between economies of scale and most of their measures of government intervention, and conclude that industrial policy favored industries with weaker economies of scale, and probably had a negative effect on economic growth.

Another close contribution to this paper is Vestal (1993). James Vestal took a very similar approach to the one used in this paper and in Beason and Weinstein (1996), evaluating industrial policy by comparing market failures to government interventions across industries. Vestal (1993) discusses the likelihood that certain industries suffered from market failures caused by natural monopolies, linkage effects, and technological externalities, and comments on the role played by government intervention in those industries.

I am very thankful to Richard Beason and David Weinstein for sharing their data, which are used in this paper. The fact that some industries have higher growth of gross output or total factor productivity than others does not constitute a market failure, and attempting to equalize these growth rates across industries will generally decrease economic efficiency. Instead, government intervention correcting market failures, such as (external) economies of scale, may increase economic efficiency (Rodrik 1994, pp. 32).

Their estimates are not able to reject the hypothesis of constant returns to scale in every manufacturing industry.
This paper expands previous work on industrial policy and economic growth in postwar Japan. First, the paper makes an explicit distinction between internal (firm-level) and external (industry-level) sources of productivity. This distinction is possible thanks to the availability of detailed firm-level data, and is important because external economies of scale and learning by doing provide a theoretically-grounded economic justification for industrial policy. Second, the paper considers the effects of external economies of scale as well as external learning by doing on firm productivity. These two technological externalities give rise to similar market failures involving too little investment and production in some industries, and should therefore be considered simultaneously to evaluate industrial policy. Third, the paper uses quantitative and qualitative evidence on government intervention in postwar Japan. Quantitative evidence is more precise but less complete than qualitative evidence, which is why a combination of the two gives a more adequate description of the general direction of industrial policy. Fourth, the paper evaluates industrial policy based on its ability to correct market failures caused by technological externalities. Previous work has focused on the ability of government intervention to target industries with higher growth of gross output, higher growth of total factor productivity, or other economic variables that are not clearly associated with a theoretically-grounded economic justification for industrial policy.

Several features make the economic history of postwar Japan particularly interesting to students of economic growth. Japan was the first non-Western country to achieve high levels of income per capita. Before the rise of Japan in the second half of the 20th century, all high-income countries were of European origin (Patrick 1997). Other countries in East Asia have followed a similar industrialization strategy, combining market forces with government intervention, and achieving fast and sustained economic growth. This has been the case for South Korea and Taiwan since the 1960s, and China since the 1980s. Perhaps other countries will be able to follow Japan’s path. After all, prewar Japan was a densely populated, mostly agricultural, and relatively isolated country; characteristics shared with many poor countries today. Even from a purely academic point of view, Japan offers interesting insights. The relationship between industrial policy and economic growth is a research topic for which the knowledge gap between theoretical possibilities and practical implications is very large; making even small empirical contributions very valuable. A better understanding of the economic history of postwar Japan may lead us to a better understanding of economic growth elsewhere.

This paper is organized as follows. Section 2 discusses four strands of literature which are closely related to this paper. Section 3 summarizes the main facts about economic growth and industrial policy in postwar Japan. Section 4 presents a simple model to formalize the relationship between industrial policy and economic growth. Section 5 explains the main variables that will be used, their sources, and their limitations. Section 6 contains the empirical analysis, estimating technological externalities and evaluating industrial policy in postwar Japan. Section 7 offers an interpretation of

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10 Internal economies of scale and learning by doing generate another kind of market failure (the rise of natural monopolies), but they do not provide a theoretically-grounded economic justification for industrial policy.

11 For example, Krueger and Tuncer (1982) consider the correlation between import protection and growth of total factor productivity, and Lee (1996) considers the correlation between import protection and growth of labor productivity and total factor productivity.

12 For the case of South Korea see Amsden (1989), for Taiwan see Wade (1990), and for China see Naughton (2007). As is the case for Japan, the relationship between industrial policy and economic growth in these countries is not clear.
the main findings and proposes possibilities for future research.

## 2 Related Literature

Economists and historians have long been interested in explaining the unprecedented fast and sustained economic growth that characterized Japan between the Second World War and the First Oil Shock. Several explanations have been proposed to explain Japan’s sudden catch up with the West. Human capital, as measured by literacy and numeracy rates, was relatively high in Japan and might have facilitated the adoption of more advanced, foreign technology. Japan’s labor force, usually described as hard-working and obedient, could have been particularly suited for manufacturing and facilitated the movement of workers from farm to factory. The savings and investment rates, which were exceptionally high in postwar Japan, caused the rapid accumulation of physical capital and may have been the main source of economic growth. Fiscal and monetary policy provided good macroeconomic conditions, such as low inflation rates, unemployment rates, and public deficits, which might explain Japan’s economic growth (Tsuruta 1988, pp. 49). Relatively low levels of income and wealth inequality, the result of numerous reforms both before and after the Second World War, may also have contributed to economic growth (Rodrik 1994, pp. 16). By far the most controversial explanation of all is the use of an active industrial policy by the government of Japan. While the idea that Japan had an active industrial policy is usually not disputed, the idea that such an industrial policy accelerated economic growth is often debated. On the one hand there are those who argue that industrial policy corrected inefficient market allocations, speeding up economic growth. According to this view, the government of Japan was able to identify industries with severe market failures, and target policies to correct these market failures while resisting political capture by special interest groups. On the other hand there are those who argue that industrial policy distorted efficient market allocations, slowing down economic growth. According to this view, the government of Japan was either not capable of identifying industries with severe market failures, or not capable of targeting policies to correct these market failures because of political capture by special interest groups.

From an economic point of view, the main justification for an active industrial policy is the presence of technological externalities (Rodrik 1994). Arguments in favor of an active industrial policy to accelerate economic growth by correcting technological externalities are very old. Alexander Hamilton (1791) argued that the presence of industry-level economies of scale and learning by doing in the manufacturing sector justified the implementation of an industrial policy to accelerate economic growth in the United States. Friedrich List (1841) used similar arguments to justify an industrial policy for Germany. Since then, economists have formalized the idea of technological externalities. John Stuart

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16 There are other economic justifications for an active industrial policy, such as pecuniary externalities (Murphy, Shleifer, and Vishny 1989) or financial frictions (Itskhoki and Moll 2015).
Mill (1848, pp. 839-840) acknowledged the potential usefulness of import protection for backward countries in the presence of industry-level learning by doing. Alfred Marshall (1890) identified the main sources of industry-level economies of scale and discussed their implications for the location of economic activity. More recently, economists following the pioneering work of Kenneth Arrow (1962) and Paul Romer (1986) have explored the role of technological externalities in generating endogenous economic growth. A central finding of this literature is that technological externalities generally lead the competitive equilibrium to a lower level and slower growth of income per capita compared to the social optimum. While theoretical work has made significant progress in formalizing the relationship between industrial policy and economic growth, there has been little empirical work on the ability of real-world governments to accelerate economic growth by implementing an active industrial policy (Harrison & Rodríguez-Clare 2010).

Technological externalities are central to many economic situations, and numerous attempts have been made at measuring them. In macroeconomics, technological externalities have been studied as a source of short-run business cycles (Hall 1988; Caballero & Lyons 1989, 1990, 1992; Bartelsman, Caballero, & Lyons 1994) as well as long-run economic growth (Chan, Chen, & Cheung 1995). In international economics, technological externalities have been considered as a source of comparative advantage and an explanation for international trade and specialization patterns (Backus, Kehoe, & Kehoe 1992; Irwin & Klenow 1994; Gruber 1998). In economic geography, technological externalities and other agglomeration forces have been used to explain the uneven location of economic activity (Henderson 2003, Rosenthal & Strange 2004, Drucker & Feser 2012). Despite the considerable effort that economists have made to measure them, technological externalities remain elusive.

This paper joins a small body of work attempting to evaluate the effects of industrial policy on economic growth. This strand of literature is fundamentally different from papers studying the effects of a particular policy on a particular industry. Evaluating the effects of industrial policy on economic growth requires considering all relevant policies and industries at the same time. To my knowledge, the first attempt at evaluating the effects of an industrial policy on economic growth is Krueger & Tuncer (1982). Anne Krueger and Baran Tuncer studied the industrial policy of Turkey between 1963 and 1976, concluding that import protection was correlated with slower growth of total factor productivity at the industry level. However, Robert Lucas (1984) pointed out that this correlation is not enough to conclude that industrial policy slowed down economic growth, and Ann Harrison (1994) showed that the correlation between import protection and growth of total factor productivity was in fact positive. Noland (1993) is probably the first attempt at evaluating the industrial policy of postwar Japan. Marcus Noland argued that industrial policy changed Japan’s trade pattern, and concluded that it most likely had a negative effect on national welfare. Beason and Weinstein (1996), discussed above, also concludes that industrial policy did not contribute to economic growth in postwar Japan.

18 Other work involving the estimation of technological externalities which do not fall into the categories described above includes Foster & Rosenzweig (1995), Branstetter (2001), and Thornton & Thompson (2001), among others.
19 Such as Jacobsson (1993), Head (1994), Luzio & Greenstein (1995), and Irwin (2000), among others.
20 Focusing on a particular policy does not take into account that incentives provided by one policy may be offset by another. Focusing on a particular industry does not take into account that benefits to one industry may be costs to another.
21 The authors use import protection as a proxy for the general direction of industrial policy in Turkey.
A similar exercise is conducted in Lee (1996) for South Korea, where measures of import protection are compared to estimates of labor productivity and total factor productivity across manufacturing industries between 1963 and 1983. Jong-Wha Lee concludes that industrial policy decreased labor productivity and total factor productivity in South Korea, slowing down economic growth. More recently, Lane (2017) studies the role of industrial policy in moving South Korea from labor-intensive to capital-intensive industries. Nathan Lane argues that political and economic shocks in 1973 and 1979 provide exogenous changes in the industrial policy of South Korea, and concludes that temporary government intervention caused a persistent transition towards capital-intensive industries. Finally, Liu (2017) studies how industrial policy in China has been used to correct pecuniary externalities arising from financial frictions caused by credit constraints. Ernest Liu finds that different measures of government intervention in China and other Asian countries are correlated with estimates of financial frictions, and concludes that industrial policy probably increased economic efficiency in these countries.

3 Historical Context

This section offers a brief summary of the main facts regarding economic growth and industrial policy in postwar Japan. The first half of the section describes the performance of the Japanese economy in modern times, before and after the Second World War. The second half of the section explains the role of the Japanese government in the economy, focusing on the formulation and implementation of industrial policy.

3.1 Economic Growth

During the Tokugawa period (1603-1868), Japan’s economy was based on agriculture and therefore poor, ruled by a hereditary aristocracy that perpetuated high levels of inequality and feudal traditions that obstructed economic growth. Foreign trade was banned, as was foreign travel. The arrival of Commodore Perry in 1853 set in motion the industrialization of Japan, causing a revolution that transformed its economy and society. During the Meiji period (1868-1912), a new government committed Japan to industrialization, seeking economic growth to secure military power and ultimately catch up with the West.22 The government of Japan protected and promoted the manufacturing sector, with particular emphasis on light industries (such as textiles) earlier, and heavy industries (such as chemicals) later. At the same time, the government modernized the army and the navy, established a meritocratic bureaucracy, expanded mass schooling, allowed foreign trade and foreign travel, facilitated the adoption of foreign technology, and improved communication and transportation with the adoption of telegraphs and railroads (Huber 1981). Despite these modernization efforts and the achievement of fast structural transformation, economic growth was relatively slow. Income per capita, which had

Economic growth accelerated in the Taisho period (1912-1926) and the Showa period (1926-1945), when income per capita grew at 2.7% per year, but even then Japan was lagging behind the West. It was not until after the Second World War that Japan began to catch up, as shown in Figure 2.

Figure 2: Growth rate of real income per capita in Japan (1900-2000).

In 1945, the United States occupied Japan and used the existing government bureaucracy to rule the country. During the first two years of occupation, the economy was in complete disarray. War destruction had cut income per capita in half. The war effort had displaced millions of people who were now returning to the labor force, finding employment mostly in a backward agricultural sector. Food shortages caused by bad crops and the disruption of trade were accompanied by energy shortages caused by the loss Japanese mining colonies in Korea and China. Inflation was high due to the payment of war reparations and the disbursement of war compensations. Initially, the US policy towards Japan consisted of dismantling the army and the navy, restricting production in war-related industries, and providing little assistance for economic recovery. The United States provided immediate relief to avoid mass starvation (Nester 1991, pp. 9). The US occupation authorities carried out a land reform that redistributed farmland from large to small owners, an industrial reform that fragmented several large corporations (the zaibatsu), and a labor reform that promoted the establishment and

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23In the United States, income per capita grew at 0.5% per year during the Tokugawa period and 1.7% per year during the Meiji period; in Great Britain, income per capita grew at 0.4% and 1.0% per year, respectively.


There was fast economic growth during the Occupation period (1945-1952), with income per capita growing at 8.2% per year. This growth was mostly the result of very fast accumulation of physical capital, given that approximately a third of Japan’s stock of physical capital had been destroyed in the Second World War.\textsuperscript{28} When tensions between the United States and the Soviet Union spiked in 1949, the US policy towards Japan began to shift.\textsuperscript{29} The United States eased the payment of war reparations and the restrictions on the economy, and allowed foreign trade under direct government control (Nakamura 1981, pp. 35, 36). Also in 1949, the US occupation authorities began the implementation of the Dodge line, a set of fiscal and monetary policies that ensured balanced national budgets, maintained price stability, and established a fixed exchange rate of 360 Yen per Dollar.\textsuperscript{30} The outbreak of the Korean War (1950-1951) benefited several industries in Japan due to extensive US military procurements.\textsuperscript{31} Many of the policies used by the US occupation authorities to control the economy were maintained after independence and used by the government of Japan to implement industrial policy.\textsuperscript{32} The United States ended the occupation of Japan in 1952. Defeat in the Second World War forced Japan to abandon its military ambitions, but not its economic ones.\textsuperscript{33} After regaining independence, the government of Japan embarked in a renewed effort to catch up with the West. The government supported basic industries such as coal mining and power generation, as well as other manufacturing industries such as basic metals and shipbuilding.\textsuperscript{34} Throughout the 1950s, there was a steady increase in the domestic savings rate, which was mirrored by an increase in the domestic investment given that international capital flows were severely restricted.\textsuperscript{35} At the same time, Japan gradually adopted foreign technology, which was generally more advanced than domestic technology due to wartime isolation. Technology adoption was facilitated by the government of Japan through the preferential allocation of foreign exchange.\textsuperscript{36} In 1960, the government issued the National Income Doubling Plan, which embodied a new national consensus for the conscious pursuit of economic growth. The plan set expectations for fast and sustained economic growth, and committed the government of Japan to that end.\textsuperscript{37} After the publication of the plan, private sector investment rates increased, as was true after the publication of subsequent national economic plans.\textsuperscript{38} During the 1950s and early 1960s, the government of Japan implemented extensive import protection through controls on foreign exchange

\textsuperscript{29}Morishima (1982, pp. 162), Kosai (1997, pp. 166).
\textsuperscript{36}Nakamura (1994, pp. 185), Kosai (1997, pp. 185).
\textsuperscript{37}Before the National Income Doubling Plan, the Japanese people were not very optimistic about the possibility of economic growth beyond war recovery (The Economist 1963, pp. 60; Johnson 1982, pp. 4; Kosai 1997, pp. 189; O’Bryan 2009, pp. 6, 11).
and foreign investment, and the use of tariffs and quotas. In the early 1960s, Japan began the liberalization of international trade and capital flows after receiving foreign pressure, particularly from the United States. Economic growth was high during this recovery period (1952-1964), with income per capita growing at 7.7% per year.

By 1964, Japan had reattained its prewar trend of income per capita, marking the beginning of economic growth beyond war recovery. In 1964, Japan became an Article 8 member of the International Monetary Fund and joined the OECD, committing itself to the full liberalization of international trade and capital flows. The government of Japan undertook a gradual and selective liberalization process throughout the late 1960s. Import protection was relaxed, particularly after strategic domestic industries had become internationally competitive. More salient measures of import protection, such as tariffs and quotas, were substituted by less salient ones, such as quality standards. In 1971 the Yen to Dollar fixed exchange rate was devaluated after repeated trade surpluses, and in 1973 Japan adopted a floating exchange rate. By 1973, Japan had fully liberalized its international trade and capital flows, at least in theory (Tanaka 1973, pp. 34). Despite the policy limitations imposed by this liberalization process, the government of Japan was still committed to the pursuit of economic growth (Patrick & Rosovsky 1976, pp. 12). During this period, Japan moved from light to heavy manufacturing industries, partly as a result of an industrial policy favoring the chemical and the iron and steel industries, which made Japan extremely dependent on foreign oil. Japan managed to maintain fast and sustained economic growth throughout this expansion period (1964-1973), in which income per capita grew at 8.1% per year. Explaining how Japan managed to expand beyond recovery, and determining the role played by the government of Japan in this catch-up process, is still a controversial research topic.

The First Oil Shock of 1973 broke Japan’s national consensus for economic growth. The government was pressed to tackle many issues besides economic growth, such as keeping inflation and unemployment rates low, or improving housing and environmental conditions. The government responded to the First Oil Shock with aggressive anti-inflationary policies that led to a recession. The quadrupling of oil prices made Japan’s dependence on foreign resources highly salient. The Japanese people began questioning the usefulness of an industrial policy that had been pushing Japan towards energy-intensive industries, such as chemicals and basic metals, which were extremely dependent on foreign resources. After 1973, the goal of industrial policy was to move Japan towards knowledge-intensive industries, such as machinery and electronics, which would be less vulnerable to foreign shocks and would allow Japan

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41The specific year in which Japan reattained its prewar trend of income per capita depends on the measure of income used. Data from the Maddison Project (2013) imply that if income per capita in Japan had grown at the same rate as in 1900-1940 and avoided war destruction in 1945, Japan would have reattained that prewar trend in 1962.
to reach the technological frontier.\textsuperscript{49} Economic growth slowed down considerably in this adjustment period (1973-1990), with income per capita growing at 3.0\% per year, but it was fast enough to keep Japan among the most advanced economies in the world.\textsuperscript{50}

3.2 Industrial Policy

The Ministry of International Trade and Industry (MITI) was the main actor in the formulation of industrial policy in postwar Japan. Nearly all manufacturing industries were under the jurisdiction of the MITI, except for transportation, communications, pharmaceuticals, and shipbuilding, which had their own specialized ministries. The Ministry of Finance (MoF) also had an important role in the formulation of industrial policy through the approval of national budgets and the control of the Bank of Japan and other public financial institutions. Besides the MITI and the MoF, the most important government agency involved in formulating industrial policy was the Economic Planning Agency (EPA), which issued several national economic plans covering periods of about five years, and provided industry-level guidelines for government policies as well as business decisions. The formulation of industrial policy in postwar Japan was the result of a continuous deliberation process between the government, business, and academia. This deliberation process ensured that the major economic players were informed of the general direction of industrial policy, and could coordinate to minimize implementation costs (Morishima 1982, pp. 188).

The industrial policy of postwar Japan had at least two goals.\textsuperscript{51} On the one hand, industrial policy aimed at establishing production in new “sunrise” industries which would contribute to economic growth. To that end, the government of Japan protected and promoted industries with high capital intensity, high income elasticity, and strong pecuniary and technological externalities; these industries were viewed by the Japanese as being characteristic of more advanced countries, such as the United States and West Germany.\textsuperscript{52} On the other hand, industrial policy aimed at maintaining production in old “sunset” industries which would contribute to economic security. To that end, the government took measures to ensure the orderly decline of shrinking industries, closing inefficient plants, retraining workers to minimize unemployment, and preventing whole industries from disappearing (Patrick and Rosovsky 1976, pp. 46).

Industrial policy was implemented largely by the MITI and the MoF, although virtually every ministry was involved to some degree. Industrial policy was implemented largely through markets and not through government ownership.\textsuperscript{53} The MoF channelled funds to targeted industries through commercial banks, which depended on the Bank of Japan, and through public financial institutions funded through national budgets.

\textsuperscript{50} In 1990, Japan’s income per capita ($18,789) was 81\% that of the United States ($23,201) and 112\% that of Western Europe ($16,793). Western Europe is defined in Maddison (2013) as Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.
by the Fiscal Investment and Loan Program. During the 1950s and early 1960s, the MITI controlled foreign exchange and foreign investment, as well as the system of tariffs and quotas. Afterwards, these measures of import protection were gradually substituted by domestic public procurements, delayed import permits, stringent quality standards, and “buy Japanese” practices. The MoF provided tax incentives to certain industries through numerous exemptions, allowances, and subsidies. In a form of capital rationing known as “window guidance,” the channeled funds to targeted industries. National economic plans of the EPA were an effective tool to coordinate private investment. Through a practice known as administrative guidance, government officials made recommendations to the businesses with the understanding that the government may act to enforce them.

4 Theoretical Framework

This section presents a simple model describing the allocation of resources across industries and the role of industrial policy in the presence of technological externalities.

4.1 Baseline Model

Consider a small open economy with two industries, \( i = \{1, 2\} \). International prices \( P_1 \) and \( P_2 \) are taken as given. Firms produce according to a Cobb-Douglas technology, \( Y_{fit} = A_{it} K_{fit}^{\beta_{K,i}} L_{fit}^{\beta_{L,i}} \), where \( Y_{fit} \) is the value added by firm \( f \) in industry \( i \) at time \( t \), \( A_{it} \) is the total factor productivity of firms in industry \( i \) at time \( t \), \( K_{fit} \) and \( L_{fit} \) are the capital and labor inputs of firm \( f \) in industry \( i \) at time \( t \), and \( \beta_{K,i} \) and \( \beta_{L,i} \) are the output elasticities with respect to capital and labor in industry \( i \).

In the competitive equilibrium, the marginal product of capital and labor will be equated across industries, so as to maximize national income:

\[
P_{1t} A_{1t} \beta_{K,1} K_{1t}^{\beta_{K,1}-1} L_{1t}^{\beta_{L,1}} = P_{2t} A_{2t} \beta_{K,2} K_{2t}^{\beta_{K,2}-1} L_{2t}^{\beta_{L,2}}
\]

Without technological externalities or other market failures, the allocation of resources across industries in the competitive equilibrium given by Equation (1) is the same as in the social optimum, and there is no scope for welfare-enhancing industrial policy.

58The model describes an economy with two industries but the result regarding optimal industrial policy applies to economies with more than two industries.
59The following conditions for the allocation of resources in the competitive equilibrium and the social optimum are derived from the capital market; equivalent conditions can be derived from the labor market.
4.2 Economies of Scale

Consider the possibility of external (industry-level) economies of scale, which are perceived by individual firms as an exogenous component of their total factor productivity. External economies of scale are usually modeled as a function of current industry-level production $Y_{it}$; for simplicity, assume that external economies of scale enter the production function of individual firms as $A_{it} = Y_{it}^{\gamma_i}$. External economies of scale are caused by threshold effects and indivisibilities, such as the establishment of new input markets or the construction of infrastructure, which cause firm productivity to increase with industry size.

Let $\tau_{it}$ be a measure of government intervention in industry $i$, where $\tau_{it} > 0$ represents a subsidy and $\tau_{it} < 0$ represents a tax. For simplicity, assume that the measure of government intervention is multiplied with the free-market price, so that the effective price is given by $\tau_{it} P_{it}$. The competitive equilibrium allocation of resources across industries with external economies of scale is given by:

$$\tau_{1t} P_{1t} \beta_{K_1} K_{1t}^{\frac{1}{1-\gamma_1}} L_{1t}^{\frac{\gamma_1-1}{1-\gamma_1}} = \tau_{2t} P_{2t} \beta_{K_2} K_{2t}^{\frac{1}{1-\gamma_2}} L_{2t}^{\frac{\gamma_2-1}{1-\gamma_2}} \quad (2)$$

However, the social optimum allocation of resources across industries, which takes into account external economies of scale, is given by:

$$P_{1t} \beta_{K_1} K_{1t}^{\frac{1}{1-\gamma_1}} L_{1t}^{\frac{\gamma_1-1}{1-\gamma_1}} = P_{2t} \beta_{K_2} K_{2t}^{\frac{1}{1-\gamma_2}} L_{2t}^{\frac{\gamma_2-1}{1-\gamma_2}} \quad (3)$$

Equation (2) and Equation (3) imply that the government can lead the competitive equilibrium to the social optimum by setting $\tau_{1t}$ and $\tau_{2t}$ such that:

$$\tau_{1t} (1 - \gamma_1) = \tau_{2t} (1 - \gamma_2) \quad (4)$$

All else equal, the optimal industrial policy given by Equation (4) favors industries with stronger external economies of scale (higher $\gamma_i$) over industries with weaker external economies of scale (lower $\gamma_i$).

4.3 Learning by Doing

Next, consider the possibility of external (industry-level) learning by doing, which is also perceived by individual firms as an exogenous component of their total factor productivity. External learning by
doing is usually modeled as a function of cumulative industry-level production \( \sum_{s=0}^{t-1} Y_{ts} \); for simplicity, assume that external learning by doing enters the production function of individual firms as \( A_t = \left( \sum_{s=0}^{t-1} \delta^{t-s} Y_{ts} \right)^{\theta_i} \), where \( \delta \) represents forgetting or obsolescence of knowledge. External learning by doing is caused by the diffusion of tacit knowledge, which causes firm productivity to increase with industry experience.

Let \( \tau_i \) be a measure of government intervention in industry \( i \) and assume that it is added to the free-market price, so that the effective price is given by \( \tau_i + P_i \). The competitive equilibrium allocation of resources across industries with external learning by doing is given by:

\[
\tau_{1t} + P_{1t} \left( \sum_{s=0}^{t-1} \delta^{t-s} Y_{1s} \right)^{\theta_1} \beta_{K,1} K_{1t}^{\beta_{K,1}-1} L_{1t}^{\beta_{L,1}} = \tau_{2t} + P_{2t} \left( \sum_{s=0}^{t-1} \delta^{t-s} Y_{2s} \right)^{\theta_2} \beta_{K,2} K_{2t}^{\beta_{K,2}-1} L_{2t}^{\beta_{L,2}} \tag{5}
\]

However, the social optimum allocation of resources across industries, which takes into account external learning by doing represented by the shadow value of future productivity increases \( \lambda(\cdot|\theta_i) \), is given by:

\[
\lambda(\cdot|\theta_1) + P_{1t} \left( \sum_{s=0}^{t-1} \delta^{t-s} Y_{1s} \right)^{\theta_1} \beta_{K,1} K_{1t}^{\beta_{K,1}-1} L_{1t}^{\beta_{L,1}} = \lambda(\cdot|\theta_2) + P_{2t} \left( \sum_{s=0}^{t-1} \delta^{t-s} Y_{2s} \right)^{\theta_2} \beta_{K,2} K_{2t}^{\beta_{K,2}-1} L_{2t}^{\beta_{L,2}} \tag{6}
\]

Equations (5) and (6) imply that the government can lead the competitive equilibrium to the social optimum by setting \( \tau_{1t} \) and \( \tau_{2t} \) such that:

\[
\lambda(Y_{1,t},\theta_1) - \tau_{1t} = \lambda(Y_{2,t},\theta_2) - \tau_{2t} \tag{7}
\]

All else equal, the optimal industrial policy given by Equation (7) favors industries with stronger external learning by doing (higher \( \theta_{it} \)) over industries with weaker external learning by doing (lower \( \theta_{it} \)).

5 Data

5.1 Firm-level Variables

Firm-level data on value added, capital inputs, and labor inputs come from the balance sheets and income statements of all publicly-traded firms in Japan between 1964 and 1990.\(^{61}\) The original vari-
ables are measured in nominal terms (current Japanese Yen) and are converted to real terms using industry-level price indices provided by the Statistics Bureau of Japan, described below. The data set contains 16,522 observations, corresponding to 1,052 firms over 27 years. Firms are divided into 88 subindustries, which are grouped into 17 industries roughly corresponding to 2-digits standard industrial classification codes.

Output is measured as value added (in millions of current Yen, deflated with industry-level price indices) as reported in the income statement of firms. Measuring output as nominal value added implies that measures of total factor productivity will capture changes in the firm’s market power as well as changes in technical efficiency. Capital input is measured as the book value of fixed assets (in millions of current Yen, deflated with an economy-wide price index) as reported in the balance sheet of firms. Measuring capital input as the book value of fixed assets assumes that the capital stock is a good measure of the flow of capital services derived from it, and that all firms in an industry have the same depreciation rate. Labor input is measured as the wage bill (in millions of current Yen, deflated using an economy-wide price index) as reported in the income statement of firms. Measuring labor input as the wage bill provides a quality-adjusted measure of the labor input to the extent that wages are tied to the marginal product of labor.

Given that there is a significant drop in the number of observations after 1983, the empirical analysis will be restricted to the years between 1964 and 1983, divided into two periods of equal length. Coincidentally, 1973-1974 is a natural breaking point for the period under study because the First Oil Shock of 1973 caused a change in the rate of economic growth and a change in the goals of industrial policy. The data set will be further restricted to a balanced panel of firms for each of the periods to avoid issues related to the entry and exit of firms. The balanced panel for the decade between 1964 and 1973 has 455 firms (4,550 observations) and the balanced panel for the decade between 1974 and 1983 has 613 firms (6,130 observations), as shown in Figure 1.

5.2 Industry-level Variables

All price indices have been obtained from the Statistics Bureau of Japan, and have been normalized using 1990 as the base year. The price index for value added is the GDP deflator for manufacturing.

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62 The original data set contains 41,734 observations. Keeping one observation per firm per year, and restricting the sample to firms in the manufacturing sector with data on output and inputs (dropping negative values), the number of observations becomes 16,546.

63 These are (1) processed foodstuffs, (2) textile products, (3) pulp and paper products, (4) chemical products, (5) drugs, (6) petroleum and coal products, (7) rubber and leather products, (8) stone, clay, and glass products, (9) iron and steel products, (10) fabricated metal products, (11) general machinery, (12) electric machinery, (13) shipbuilding and repairing, (14) motor vehicles and parts, (15) other transportation equipment, (16) precision instruments, and (17) other manufacturing products.

64 Value added is the difference between revenue and intermediate costs. It includes the cost of labor, the cost of capital (rent, depreciation, royalties, interest, dividends, etc.), gross profits, and taxes.

65 In other words, measures of total factor productivity will be revenue-based \( TFP_R \) and not quantity-based \( TFP_Q \).

66 Fixed assets are composed of property, plant, and equipment.

67 If there are large differences in capacity utilization across firms or across time, the capital stock will not be a good measure of capital input and measures of total factor productivity will capture changes in capacity utilization as well as changes in technical efficiency.
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Precision Instruments</td>
<td>17</td>
<td>14</td>
</tr>
</tbody>
</table>

| Total                            | 455       | 613       |

Table 1: Number of firms in each balanced panel.

Output data before 1970, and the industry-specific GDP deflator for output after 1970. The price index for capital input is the GDP deflator for private sector fixed capital formation in machinery, plant, and equipment, which is common across all industries. The price index for labor input is the general consumer price index excluding imputed house rent, which is also common across industries.

Industry-level output data (value added and gross sales) has been obtained from the Statistics Bureau of Japan, and industry-level trade data (value of imports and value of exports) has been obtained from the United Nations Comtrade Database. Output data is measured in current Japanese Yen and given at the 2-digit industry level. Trade data is measured in current US dollars and converted to constant Japanese Yen using the nominal exchange rate and the GDP deflators for output provided by the Statistics Bureau of Japan. Trade data is reorganized into 2-digit industries to match the level of aggregation of output data.

6 Empirical Analysis

The first part of this section estimates technological externalities across manufacturing industries in postwar Japan, and the second part of this section evaluates industrial policy according to different measures of government intervention.

6.1 Estimation of Technological Externalities

From the point of view of an individual firm, technological externalities (such as external economies of scale and external learning by doing) are part of their total factor productivity (TFP).\(^{68}\) In a Cobb-Douglas production function, TFP is given by\(^ {69}\)

\[
Y_{fit} = TFP_{fit} K_{fit}^{\beta_{K,it}} L_{fit}^{\beta_{L,it}}
\]

(8)

where \(Y_{fit}\) is the output of firm \(f\) in industry \(i\) at time \(t\), \(TFP_{fit}\) is its total factor productivity, \(K_{fit}\) is its capital input, and \(L_{fit}\) is its labor input; \(\beta_{K,it}\) and \(\beta_{L,it}\) are the output elasticities of capital and labor in industry \(i\) at time \(t\).\(^ {70}\) Taking natural logarithms gives the linear estimation equation

\[
\log(Y_{fit}) = \log(TFP_{fit}) + \beta_{K,it} \log(K_{fit}) + \beta_{L,it} \log(L_{fit})
\]

(9)

or, equivalently

\[
y_{fit} = tfp_{fit} + \beta_{K,it}k_{fit} + \beta_{L,it}l_{fit}
\]

(10)

We are interested in measuring two components of TFP: external economies of scale and external learning by doing. To do so, decompose TFP into a vector of controls, the effect of industry size on firm productivity, the effect of industry experience on firm productivity, and all other determinants of firm productivity:

\[
y_{fit} = \beta_{x}x_{fit} + \beta_{K,i}k_{fit} + \beta_{L,i}l_{fit} + \gamma_{i}(size)_{it} + \theta_{i}(experience)_{it} + u_{fit}
\]

(11)

In the equation above, \(x_{fit}\) is a vector of controls containing a constant, a linear time trend, and the age of the firm; \((size)_{it}\) is the logarithm of current industry sales in industry \(i\) at time \(t\); \((experience)_{it}\) is the logarithm of current industry sales in industry \(i\) at time \(t\).\(^{68}\) TFP measures the efficiency with which inputs are transformed into output; changes in output that are not accounted for by changes in inputs are attributed to changes in TFP.\(^ {69}\) The Cobb-Douglas production function is a first-order approximation to a generic production function.\(^ {70}\) Throughout the paper, it will be assumed that all firms in an industry share the same output-elasticities at any given point in time. Therefore, estimates of industry-level output elasticities which are computed for 10-years periods will capture an average output elasticity in that period.
is the logarithm of cumulative industry sales in industry $i$ at time $t$, depreciated at rate $\delta$; and $u_{fit}$ is a residual containing all other determinants of firm productivity.\(^71\) The goal of this estimation equation is to measure technological externalities generated by the size and experience of an industry on its firms. There may be other sources of technological externalities (across industries or across countries) which will not be captured by this specification.\(^72\)

The main challenge with the estimation of production functions is that firms make their input choices knowing their TFP. Since we are not able to observe TFP or output elasticities, input choices will generally be correlated with the residual term, making them endogenous. Similarly, industry size and experience may be correlated with unobserved determinants of firm productivity. This section first presents the conditional correlation between firm productivity and industry size and experience given by an Ordinary Least Squares (OLS) estimator, and then turns to the causal estimation of external economies of scale ($\gamma_{it}$) and external learning by doing ($\theta_{it}$) given by a combination of First Order Conditions (FOC) and Instrumental Variables (IV) estimators.\(^73\)

### 6.1.1 Ordinary Least Squares

Given the endogeneity problem described above, OLS estimates of the parameters of interest, $\gamma_i$ and $\theta_i$ will generally be biased and inconsistent. However, OLS estimates provide a useful benchmark for the subsequent analysis.\(^74\)

$$y_{fit} = \beta_0 + \beta_K k_{fit} + \beta_L l_{fit} + \gamma_i(size)_{it} + \theta_i(experience)_{it} + \psi_i(year)_{it} + \phi_i(age)_{fit} + v_{fit} \quad (12)$$

OLS estimates of external economies of scale, shown in Figure 3, are statistically distinguishable from zero in 12 out of 15 industries in each period, all of them positive. Point estimates are on the neighborhood of $\gamma = 1$, implying that a 1% increase in the size (measured as current sales) of an industry is associated with an increase of 1% in the total factor productivity of firms in that industry.\(^75\)

---

\(^71\)The variable $(experience)_{it}$ is constructed as the cumulative sum of the variable $(size)_{it}$, using a discount factor of 10%. All results are robust to alternative discount factors of 5% and 15%. The discount factor is necessary to account for the possibility that knowledge can be forgotten or become obsolete. The variable $(size)_{it}$ includes all firms in the industry. Ideally, one would subtract the sales of each firm from the sales of the industry to measure production that is external to the firm. However, doing so would imply constructing a $(size)_{fit}$ variable for each firm, complicating the computation process. For most industries, there is no difference between the practical measure $(size)_{it}$ and the ideal measure $(size)_{fit}$ of industry size because each firm represents a very small fraction (<10%) of its own industry. This is true for all industries and periods except for Electric Machinery in 1964-1973 (21%), Rubber and Leather in 1964-1973 and 1974-1983 (19%), Iron and Steel in 1964-1973 and 1974-1983 (17%), and Transportation Equipment in 1974-1983 (10%).

\(^72\)Own-industry technological externalities are generally found to be stronger than other technological externalities, and should therefore be easier to measure (Jaffe et al. 1993; World Bank 1993, pp. 93, 326; Henriksen et al. 2001; Branstetter 2001).

\(^73\)I present estimates from OLS and IV regressions given concerns that neither method is clearly better than the other (Young 2017). The second part of the empirical analysis evaluates industrial policy based on the IV estimates.

\(^74\)Griliches and Mairesse (1997, brackets added) note that “simple OLS regressions yield plausible parameter estimates [of output elasticities], in line with evidence from factor [cost] shares and generally consistent with constant returns to scale [at the firm level]."
External Economies of Scale, 1964-1973

- Precision Instruments
- Other Transp. Equipment
- Motor Vehicles & Parts
- Shipbuilding & Repairing
- Electric Machinery
- General Machinery
- Fabricated Metal Products
- Iron and Steel Products
- Stone; Clay; Glass Pr.
- Rubber and Leather Pr.
- Petroleum and Coal Pr.
- Drugs
- Chemical Products
- Pulp and Paper Products
- Textile Products
- Processed Foodstuffs

(1) Grey Band: 95% Confidence Interval.
(2) Estimation Method: Ordinary Least Squares.
(3) Control Variables: Constant, Firm Age, Year.
(4) Petroleum and Coal Pr: Dropped, few observations. This industry represented 1% of manufacturing value added in 1970, 2% in 1980.

External Economies of Scale, 1974-1983

- Precision Instruments
- Other Transp. Equipment
- Motor Vehicles & Parts
- Shipbuilding & Repairing
- Electric Machinery
- General Machinery
- Fabricated Metal Products
- Iron and Steel Products
- Stone; Clay; Glass Pr.
- Rubber and Leather Pr.
- Petroleum and Coal Pr.
- Drugs
- Chemical Products
- Pulp and Paper Products
- Textile Products
- Processed Foodstuffs

(1) Grey Band: 95% Confidence Interval.
(2) Estimation Method: Ordinary Least Squares.
(3) Control Variables: Constant, Firm Age, Year.
(4) Petroleum and Coal Pr: Dropped, few observations. This industry represented 1% of manufacturing value added in 1970, 2% in 1980.

Figure 3: OLS estimates of external economies of scale ($\gamma_i$).
Figure 4: OLS estimates of external learning by doing ($\theta_i$).
Most importantly for the purposes of this paper, there are notable differences across industries in the magnitude of these effects. In the 1964-1973 period, external economies of scale are stronger in Chemical Products and Drugs, and weaker in Fabricated Metal Products. In the 1974-1983 period, external economies of scale are stronger in Electric Machinery and weaker in Pulp and Paper Products.

OLS estimates of external learning by doing, shown in Figure 4, are statistically distinguishable from zero in only 2 out of 15 industries in each period. In the 1964-1973 period, estimates of external learning by doing are larger in Chemical Products & Drugs and weaker in Fabricated Metal Products, while in the 1974-1983 period these effects are stronger in the Fabricated Metal Products (not statistically distinguishable from zero) and weaker in Iron and Steel Products. In the Iron and Steel Products, the coefficient is negative and significant in 1974-1983, suggesting forgetting or obsolescence of tacit knowledge in that industry, which was in decline. Differences across industries in the magnitude of external learning by doing are also notable.

6.1.2 First Order Conditions

The optimal behavior of profit-maximizing competitive firms with constant returns to scale has observable theoretical implications in their cost shares. In particular, firms operating under these three conditions will optimally set their cost shares of capital and labor equal to the output elasticities of capital and labor, respectively. Assuming a Cobb-Douglas production function such as

$$Y_t = A_t K_t^\beta K L_t^\beta L$$

(where $Y_t$ is value added at time $t$, $A_t$ is total factor productivity, $K_t$ is the capital input, and $L_t$ is the labor input), firms will optimally rent capital and hire labor until

$$K_t = \left(\frac{rK_t}{rK_t + wL_t}\right)$$

and

$$L_t = \left(\frac{wL_t}{rK_t + wL_t}\right).$$

These first order conditions can be used as estimates of output elasticities, under the assumptions of (1) profit maximization, (2) perfect competition, and (3) constant returns to scale at the firm level. These assumptions will not be satisfied if (1) there are frictions preventing firms from maximizing profits at all times, (2) some firms have market power, (3) firms operate under increasing or decreasing returns to scale.

6.1.3 Instrumental Variables

To obtain estimates of the causal relationship between industry size and firm productivity, or industry experience and firm productivity, we need to measure movements of industry size and experience that are otherwise independent of firm productivity. In general, industry size and industry experience may be correlated with unobserved firm productivity, making OLS estimates biased and inconsistent. This section presents estimates based on an instrumental variable approach that takes advantage of exogenous shocks to foreign supply and demand conditions, which affect the relative size of Japanese industries through international trade flows, but are otherwise not related to domestic supply conditions.

75These assumptions will not be satisfied if (1) there are frictions preventing firms from maximizing profits at all times, (2) some firms have market power, (3) firms operate under increasing or decreasing returns to scale.
The instrumental variables are constructed as follows. For each manufacturing industry, divide all countries in the World into three groups: Japan, Japan’s main trading partners, and the rest of the World. Here, “Japan’s main trading partners” are the 10 countries with the largest volume of net exports with Japan in a given industry, and all other countries except Japan are in “the rest of the World”. The basic idea of this identification strategy is to use net exports between Japan’s main trading partners and the rest of the World as an instrumental variable for the size of industries in Japan.\footnote{This instrumental variable approach is very similar to the one used in Autor, Dorn, and Hanson (2013), where the authors “instrument for the growth in US imports from China using Chinese import growth in other high-income markets.” This identification strategy is closely related to the widely-used Bartik (1991) instrumental variable approach.}

Define $NX_{it}$ as the value of net exports from Japan to Japan’s main trading partners in industry $i$ at time $t$, and define $NX_{it}^\ast$ as the value of net exports from the rest of the World to Japan’s main trading partners in industry $i$ at time $t$. The size of a given industry in Japan ($Y_{it}$) depends on domestic supply and demand conditions ($S_{JP}^{FP}, D_{JP}^{FP}$), foreign supply and demand conditions in Japan’s main trading partners ($S_{TP}^{FP}, D_{TP}^{FP}$), and foreign supply and demand conditions in the rest of the World ($S_{RW}^{FP}, D_{RW}^{FP}$). A valid instrumental variable for the size of a Japanese industry should include some of these components (inclusion restriction) but not include domestic supply conditions (exclusion restriction). Such an instrumental variable would capture movements in the size of a Japanese industry which are not driven by movements in domestic supply conditions, allowing the identification of supply parameters such as $\gamma_i$ and $\theta_i$ in Equation 12.

First, consider using $NX_{it}$ as an instrumental variable for the size of an industry in Japan ($Y_{it}$). Since $NX_{it}$ depends crucially on domestic supply conditions ($S_{JP}^{FP}$), it violates the exclusion restriction. Next, consider using $NX_{it}^\ast$ as an instrumental variable for the size of an industry in Japan. $NX_{it}^\ast$ is mostly determined by foreign supply and demand conditions in Japan’s main trading partners and in the rest of the World. As can be seen in Figure 6, net exports from Japan’s main trading partners to the rest of the world are a good predictor of the size of Japanese industries.\footnote{The F-statistic of all first-stage regressions for industry size are very large; the lowest F-statistic is 23, corresponding to Iron and Steel in 1973-1984. Similarly, the F-statistic of all first-stage regressions for industry experience are very large; the lowest F-statistic is 48, corresponding to Fabricated Metal Products in 1973-1984. All other industries have F-statistics above 100, and often above 1,000.}

The validity of the exclusion restriction also depends on the correlation between foreign countries in the “Japan’s main trading partners” group, so that $NX_{it}$ represents a very small fraction of $NX_{it}^\ast$.\footnote{For each industry and period, domestic net exports $NX_{it}$ represents less than 5% of foreign net exports $NX_{it}^\ast$ except for Rubber and Leather Products (47% in 1973-1984), Electric Machinery (15% in 1964-1973), and Other Transportation Equipment (6% in 1964-1973, 16% in 1974-1983).}
supply conditions and domestic supply conditions. Given that there are several countries in each of
the groups, only aggregate shocks affecting supply conditions worldwide would pose a threat to the
identification strategy.

IV estimates of external economies of scale are statistically distinguishable from zero in 10 out of 15
industries in each period, all of them positive. External economies of scale are stronger in Chemical
Products and weaker in Textile Products in 1964-1973. In 1974-1983, these effects are stronger in Gen-
eral Machinery and weaker in Shipbuilding and Repairing. As with the OLS estimates, IV estimates of
external economies of scale are notably different across industries, suggesting an economic justification
for industrial policy.

IV estimates of external learning by doing are statistically distinguishable from zero in only 3 out of
15 industries in 1964-1973, and 6 out of 15 industries in 1974-1983, all of which are positive except for
Chemical Products in 1964-1973. In the 1964-1973 period, Textile Products has the strongest external
learning by doing effects, while Chemical Products has the weakest. In the 1973-1983 period, Textile
Products again has the strongest external learning by doing effects, while Other Transportation Equip-
ment has the weakest (but not statistically distinguishable from zero). Again, there are considerable
differences in IV estimates of external learning by doing across industries, suggesting an economic
justification for industrial policy.

6.2 Evaluation of Industrial Policy

Ideally, the effect of industrial policy on economic growth can be evaluated by comparing (1) actual
productivity levels under government intervention with (2) counterfactual productivity levels under no
government intervention. However, this approach is not feasible because counterfactual productivity
levels are not observable. Instead, I rely on standard predictions of economic theory (summarized
in the theoretical framework section) and compare the severity of technological externalities with the
intensity of government intervention across manufacturing industries.

I use two kinds of evidence of government intervention in postwar Japan. First, I use five quantitative
measures related to directed credit, import protection, and tax incentives. Second, I use qualitative
evidence from historical accounts on the general direction of industrial policy. It is important to
combine quantitative and qualitative evidence of government intervention because industrial policy
was formulated with many goals (not all of which were economic growth) and implemented with many
tools (not all of which can be easily measured).

6.2.1 Quantitative Evidence

Beason & Weinstein (1996) provides comprehensive and systematic quantitative evidence on industrial
policy in postwar Japan. Their data set contains five quantitative measures of government intervention
Figure 6: OLS regressions of domestic production ($Y_{it}$) on foreign net exports ($NX_{it}^*$).
Figure 7: IV estimates of external economies of scale ($\gamma_h$).
Figure 8: IV estimates of external learning by doing ($\theta_i$).
for each manufacturing industry over the period 1955-1990.

The first quantitative measure of government intervention is the fraction of loans provided by the Japan Development Bank, which is a measure of directed credit. The Japan Development Bank was the largest public financial institution providing low-interest loans to the manufacturing sector. Figure 9 shows the fraction of loans provided by the Japan Development Bank to each major manufacturing industry between 1964 and 1983. Although public loans represent a small fraction of total loans, they were often followed by private loans from commercial banks who interpreted government support as a sign of creditworthiness.79 The government of Japan implemented directed credit by other means as well. For example, the Bank of Japan encouraged commercial banks to provide loans to targeted industries in a practice known as window guidance.80 Directed credit is considered one of the main tools used by the government of Japan to implement industrial policy. Japanese firms relied heavily on loans (as opposed to equity) to finance their operations, making directed credit a very effective policy tool.81 Lowering the cost of capital, directed credit presumably stimulated investment and production in targeted industries.

The second quantitative measure of government intervention is the tariff rate as measured by the effec-

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80The Bank of Japan is controlled by the Ministry of Finance, and the Ministry of Finance consulted the Ministry of International Trade and Industry regarding which industries to target.
tive rate of protection, which is a measure of import protection. The effective rate of protection, taken from Shouda (1983), measures the effect of the whole tariff schedule on each manufacturing industry, taking into account forward and backward linkages between industries.\textsuperscript{82} Despite Japan's liberalization process during the 1960s, effective rates of protection were relatively high throughout the period, ranging from 30\% to 40\%.\textsuperscript{83} Unfortunately, effective rates of protection were not very different across manufacturing industries, which reduces their value as a proxy for the general direction of industrial policy.\textsuperscript{84} The third measure of government intervention is the quota coverage as measured by the fraction of items under quota restriction, which is also a measure of import protection. Quota coverage is significantly different across manufacturing industries, particularly before 1973. Presumably, both measures of import protection raised domestic prices for targeted industries, leading to more investment and production in those industries. Figure 10 shows the effective rate of protection between and quota coverage of each major manufacturing industry in Japan between 1964 and 1983.

The fourth measure of government intervention is the effective rate of indirect taxation, given by net indirect taxes over gross output, which is a measure of tax incentives. The government of Japan gave preferential tax treatment to targeted industries, providing them with more generous tax exemptions, allowances and subsidies, lowering their effective indirect tax rate. The fifth and last measure of government intervention is the effective rate of corporate taxation, given by corporate taxes over taxable profits, which is also a measure of tax incentives. The government gave allowed favorable tax exemptions and depreciation schemes to targeted industries, lowering their effective corporate tax rate. Presumably, both measures of tax incentives made targeted industries more profitable, leading to more investment and production in those industries. Figure 11 shows the effective rates of indirect and corporate taxation for each major manufacturing industry in Japan between 1964 and 1983.

Table 2 summarizes the statistical relationship between the estimates of technological externalities obtained in the previous section, and the measures of government intervention described in this section. The table shows the slope coefficients and their standard errors obtained from OLS regressions of estimated technological externalities on measured government interventions. The coefficients in Table 2 suggest that industrial policy in postwar Japan, as measured by these government interventions, systematically targeted industries with stronger external economies of scale but weaker external learning by doing. In fact, there seems to be an inherent tension between targeting industries with stronger external economies of scale and targeting industries with stronger external learning by doing, as these industries are often different. The coefficients in Table 2 also suggests that industrial policy targeting was not systematically worse after 1973, as is commonly believed.

In 1964-1973, industries with stronger external economies of scale were favored by directed credit but not by import protection or tax incentives. In the same period, directed credit and tax incentives (corporate taxation) favored industries with weaker external learning by doing. In 1974-1983, industries with stronger external economies of scale were targeted by tax incentives (corporate taxation),

\textsuperscript{82}An industry will have a high effective rate of protection if that industry has high tariff rates or if industries selling its inputs or buying its output have high tariff rates.

\textsuperscript{83}The government of Japan might have used tariffs to protect the manufacturing sector as a whole, with little distinction across manufacturing industries.

\textsuperscript{84}Effective rates of protection are particularly similar across manufacturing industries after 1973, as noted by Magaziner and Hout (1980, pp. 40).
Figure 10: Effective rate of protection (above) and quota coverage (below) in Japan.
Figure 11: Effective rate of indirect (above) and corporate (below) taxation in Japan.
Table 2: OLS regressions of estimated technological externalities on measured government interventions.

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<tr>
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<th>JDB Loans</th>
<th>Tariff Rate</th>
<th>Quota Coverage</th>
<th>Indirect Taxation</th>
<th>Corporate Taxation</th>
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<td>(0.097)</td>
<td>(0.008)</td>
<td>(0.028)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Learning by Doing, $\theta_i$</td>
<td>-0.708 ***</td>
<td>0.049</td>
<td>-0.002</td>
<td>-0.011</td>
<td>-0.026 ***</td>
</tr>
<tr>
<td></td>
<td>(0.092)</td>
<td>(0.101)</td>
<td>(0.009)</td>
<td>(0.029)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Economies of Scale, $\gamma_i$</td>
<td>-0.003</td>
<td>0.059 *</td>
<td>-0.003</td>
<td>0.010</td>
<td>0.006 ***</td>
</tr>
<tr>
<td>1974-1983</td>
<td>(0.022)</td>
<td>(0.032)</td>
<td>(0.008)</td>
<td>(0.018)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Learning by Doing, $\theta_i$</td>
<td>0.069</td>
<td>-0.137 **</td>
<td>-0.091 ***</td>
<td>0.117 ***</td>
<td>-0.006</td>
</tr>
<tr>
<td></td>
<td>(0.045)</td>
<td>(0.066)</td>
<td>(0.015)</td>
<td>(0.035)</td>
<td>(0.004)</td>
</tr>
</tbody>
</table>

while industries with stronger external learning by doing were encouraged by tax incentives (indirect taxation) but discouraged by import protection. Table 2 suggests a more nuanced role of industrial policy than is often portrayed.

It is possible, however, that these five quantitative measures of government intervention do not provide a complete picture of the general direction of industrial policy. In the next section, I consider quantitative evidence that allows a comparison between targeted and non-targeted industries, as described in historical accounts of postwar Japan.

6.2.2 Qualitative Evidence

Not all forms of government intervention used to implement Japan’s industrial policy can be easily measured, but this does not mean they were not important. While directed credit, import protection, and tax incentives surely affected the industrial structure of Japan, so did national economic plans, administrative guidance, or “buy Japanese” practices. Numerous historical accounts of postwar Japan provide an indication of the general direction of industrial policy in different periods of postwar Japan. In this section, I consider two ways to aggregate these historical accounts.

Economists and historians of postwar Japan agree that the First Oil Shock of 1973 caused a shift in industrial policy. Before 1973, industrial policy favored energy-intensive (materials) industries such as Chemicals Products, Iron and Steel, and Fabricated Metal Products. After 1973, industrial policy

---

<table>
<thead>
<tr>
<th></th>
<th>Targeted Industries</th>
<th>Non-Targeted Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economies of Scale</strong></td>
<td>3.026 (3.211)</td>
<td>0.712 (0.840)</td>
</tr>
<tr>
<td><strong>Learning by Doing</strong></td>
<td>-2.723 (3.099)</td>
<td>-0.074 (0.927)</td>
</tr>
</tbody>
</table>

### Table 3: Average technological externalities in targeted and non-targeted industries.

The distinction between targeted and non-targeted industries, while fairly consistent across students of postwar Japan, is not as clean cut as a binary choice might suggest. To allow a more nuanced vision of industrial policy, consider the following exercise. Take fairly large number of historical accounts. Count the number of authors that mention a certain industry to be targeted by industrial policy. Use this count as a measure of the intensity of government intervention encouraging that industry. Compare this measure of government intervention with estimates of technological externalities.

The results of the exercise described above are shown in Table 4, which presents mean estimates of external economies of scale ($\gamma_i$) and external learning by doing ($\theta_i$), weighted by the value added of each industry, as a function of the number of historical accounts mentioning that industry as targeted.

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Table 4: Average technological externalities in less and more targeted “sunrise” industries.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economies of Scale</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.475</td>
<td>0.944</td>
<td>2.283</td>
</tr>
<tr>
<td>(1.030)</td>
<td>(0.174)</td>
<td>(2.572)</td>
</tr>
<tr>
<td><strong>Learning by Doing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.279</td>
<td>-0.774</td>
<td>-1.936</td>
</tr>
<tr>
<td>(0.983)</td>
<td>(0.554)</td>
<td>(2.529)</td>
</tr>
<tr>
<td><strong>Economies of Scale</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.663</td>
<td>1.188</td>
<td>[no obs.]</td>
</tr>
<tr>
<td>(0.628)</td>
<td>(0.358)</td>
<td>[no obs.]</td>
</tr>
<tr>
<td><strong>Learning by Doing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.572</td>
<td>-0.605</td>
<td>-1.334</td>
</tr>
<tr>
<td>(1.184)</td>
<td>(1.406)</td>
<td>[no obs.]</td>
</tr>
</tbody>
</table>

The estimates in Table 4 confirms the findings of Table 3 and Table 2. Government intervention targeted industries with stronger external economies of scale, and the intensity of government intervention seems positively correlated with the magnitude of external economies of scale. Likewise, government intervention targeted industries with weaker external learning by doing, and the intensity of government intervention seems negatively correlated with the magnitude of external learning by doing.

A consistent picture emerges from the comparison of estimates of technological externalities and measures of government intervention in this section. Quantitative and qualitative measures of government intervention in postwar Japan systematically targeted industries in which external economies of scale were stronger, but external learning by doing were weaker. This is true before and after 1973. Moreover, I find no evidence supporting the common claim that industrial policy targeting was better before than after the First Oil Shock.

## 7 Conclusions

I estimate technological externalities generated by external economies of scale and learning by doing across major manufacturing industries in postwar Japan. Both OLS and IV estimates suggest that external economies of scale and learning by doing were relatively large and significantly different across manufacturing industries, providing a theoretically-grounded economic justification for industrial policy. Assuming that prices in the competitive equilibrium do not take into account the effects of technological externalities, there is room for government intervention to accelerate economic growth. An industrial policy that targets industries with stronger technological externalities, giving incentives
for further investment and production in those industries, can increase economic growth in principle. My estimates suggest that industries with stronger economies of scale do not always have stronger learning by doing and vice versa, which would make the implementation of an industrial policy very difficult in practice.

I evaluate industrial policy in postwar Japan by comparing quantitative and qualitative measures of government intervention to estimates of technological externalities. Industrial policy in postwar Japan was not very consistent, as different policies favored different sets of industries. At the same time, some policies targeted industries with stronger external economies of scale and others targeted industries with stronger external learning by doing. Quantitative measures of government intervention, which attempt to encapsulate the effects of all government interventions, show that in 1964-1973 industries with stronger economies of scale were not systematically favored, while industries with weaker learning by doing were; in 1974-1983, government intervention encouraged industries with stronger economies of scale and discouraged industries with stronger learning by doing. A similar picture emerges from qualitative measures of government intervention, showing that industrial policy favored industries with stronger economies of scale and weaker learning by doing in both periods.

What must not be forgotten, however, is that an effort to learn from the experiences of Japan can be rewarded not with a detailed map to follow but only with a diary describing how a determined traveler managed, with hardship and sacrifice, to complete his journey successfully.

Kozo Yamamura (1995, pp. 132)

There are many possibilities for future research regarding the causes of economic growth in postwar Japan. Industrial policy may have accelerated economic growth in postwar Japan by favoring manufacturing over agriculture, accelerating structural transformation. High saving and investment rates probably explain a large fraction of economic growth in postwar Japan, but it is not clear the extent to which these high saving and investment rates were the result of policy. The role of national economic planning is not well understood, as projected growth rates may or may not have had a direct effect on actual growth rates through a change in expectations. It is also possible that fiscal policy and monetary policy were enough to create conditions leading to economic growth, while industrial policy had no significant effect. Even in industrial policy contributed to economic growth, it is possible that the government of Japan was targeting the right industries (market failures such as technological externalities) for the wrong reasons (high income elasticity, high capital intensity, etc.). Yet another possibility is that international trade allowed the decoupling of consumption and production, providing the opportunities for Japan to move into economic activities that were more favorable to economic growth, as in Lucas (1993). The causes of economic growth in postwar Japan may be found in the prewar Japan, when the government implemented an active industrial policy to establish domestic production in new manufacturing industries, allowing Japan to reach the technological frontier. Lastly,

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87 This possibility has been suggested by Nakamura (1981, pp. 49, 81), Francks (1992, pp. 279), the World Bank (1993) and Harrison & Rodriguez-Clare (2010, pp. 4069) among others, while the opposite has been suggested by Patrick & Rosovsky (1976, pp. 46) and Trezise & Suzuki (1976, pp. 773, 800, 809) among others.

economic growth in postwar Japan may have been the result of economies of scale and learning by doing that would have been realized with or without industrial policy, as Japan enjoyed the advantages of economic backwardness.\cite{89}

\footnote{\textit{Economies of scale, learning by doing, and other advantages of economic backwardness, have been suggested as explanations for Japan’s economic growth by Tanaka (1973, pp. 28), Patrick & Rosovsky (1976, pp. 46), Denison & Chang (1976, pp. 46-47, 51), Nakamura (1981, pp. 77), Carliner (1986, pp. 151-152), Okimoto (1989, pp. 25, 27), and others.}}
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The Economist. 1963. *Consider Japan*. Billing and Sons Ltd.


