Endowment Structure and Role of State in Industrialization*

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Abstract

Why do some economies fail to industrialize, some only reach incomplete industrialization, while others manage to achieve complete industrialization? Why is the industrialization in China much more successful than that in Russia during their market-oriented economic reforms? To answer these questions, we develop a dynamic general-equilibrium model of industrialization to illustrate the critical roles played both by the state and the factor markets. We show that due to the pecuniary externality, industrial policies consistent with a country's time-varying endowment structure are the key to successful industrialization. We show that starting from the same initial endowment structure with abundant labor and scarce capital, (i) a Laissez-faire development policy could render a country stuck in the insufficient industrialization due to the coordination failure; (ii) a big-push development strategy, when violating the comparative advantage governed by the endowment structure, could only result in short-lived industrialization or even a fatal collapse of the entire economy; (iii) a "market-led-and-state-facilitated" approach that is consistent with the time-varying endowment structure would enable an economy to achieve complete industrialization or more successful market-oriented reforms, because the state could not only avoid premature big push by fully taking into account the factor market prices but also fix the coordination failure which impedes industrialization. Our model also shows that the role of state is crucial in economic reforms when a country tries to rectify its mistake of pre-mature big push.

Keywords: industrialization, endowment structure, the role of state

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1 Introduction

For all less developed economies, how to catch up with the developed ones is a central and long-lasting aspiration. Unfortunately, however, the past eighty years witness only a few successes. People's living standard in most developing countries fails to converge to that in rich countries (Acemoglu and Ventura, 2002; World Bank, 2008). More specifically, we make three comparisons in the following figures. Figure 1 shows that, in the 1950s, the average real income level of a Chinese citizen is almost as low as that of the African countries, but these low-income countries experience dramatically different growth paths afterward: China grows fast, converging to the US, especially after its market-oriented reforms start in 1978, while the African countries grow much more slowly, further diverging from the US with income levels mostly below 5% of the US level. Figure 2 shows the industrialization levels of China and some African countries. The pattern is similar to figure 1, the industrialization level of China grows fast, while the industrialization levels of those African countries remain at a very low level.

[insert figure 1 here]

[insert figure 2 here]

Figure 3 contrasts the relative economic performance of seven Latin American middle-income economies and five East Asian economies that are all initially in low-income or middle-income status, using US as the benchmark. It shows that the initial living standards in these Latin American economies are generally higher than their counterparts in East Asia, but those Latin American economies fail to close their gap with the US, whereas those East Asian economies all significantly converge to or even surpass the US in real per capita income. Figure 4 shows the industrialization levels of the same economies as Figure 3. The industrialization levels of Singapore and Korea grow fast and the industrialization levels of Hong Kong and Japan remain at a high level since their data are available, while the industrialization levels of those Latin American countries grow slowly.

[insert figure 3 here]

[insert figure 4 here]

Figure 5 shows the GDP per capita relative to the U.S. of former Soviet Union, China, Vietnam and other five former socialist economies. It shows that the former Soviet Union was converging rapidly toward the U.S. income level before the mid-1970s, but the convergence stopped and was followed by a sharp divergence afterward. In fact, the other five former socialist countries followed the same suit of the former Soviet Union after WWII by adopting central planning to speed up industrialization. Some of them were able to rapidly industrialize for a period of time through state-backed massive "big push". However, such an ambitious development strategy created only short-lived industrialization and temporary catch-up with the western European countries. Eventually, these economies ran out of steam and started to decline in their living standard relative to the U.S., calling for serious economic and political reforms to stop the declining process.

[insert figure 5 here]

Three questions arise naturally: Why do developing countries with similar initial income levels follow such dramatically different paths of development? Why do some countries succeed in escaping the poverty trap or middle-income trap but others are stuck in such traps and fail to converge to the living standard of the high-income countries? Why did economic reforms fail in Russia but succeeded in China?

The primary goal of this paper is to shed light on these important questions. We argue that the laissez-faire neoliberalism strategy for industrialization and reforms could not deliver desirable economic outcomes, because it undermines the important role of state in overcoming market failures. Industrialization could not jump start if the state provides no facilitation (due to either unwillingness or incapability of the state to intervene) in the presence of market failure, as observed in those low-income African economies in Figure 1 and Figure 2. We also contend that the big-push development strategy does not work either if the targeted sectors defy the comparative advantage determined by the factor endowment structure. Industrialization might get triggered or even start early when the state tries to prematurely support capital-intensive industries, but such overly ambitious big-push strategies would either result in immediate stagnation and incomplete industrialization (as observed in China before 1978 in Figure 1 and in Latin American countries from the 1950s up to the late 1970s in Figure 3) or lead to a period of temporary vigorous growth and short-lived industrialization followed by economic collapse (as observed in Russia from the 1950s till the late 1980s in Figure 5). It is because the targeted industries are too capital-intensive for the endowment structure in those economies, so firms are not viable in those sectors due to incompatibility between the factor used in their production technologies and relative factor prices. Government regulations and various kinds of distortions emerge endogenously as a result of the comparative-advantage-defying (CAD henceforth) big-push strategies.

It becomes clear by the late 1970s that the big-push development strategy has failed widely across the globe, so deregulations and market-oriented reforms become the fashionable trend. Both the Latin American countries and Russia embrace the neo-liberalism reform approach by radically reverting to extreme Laissez-faire policies. As the role of state is missing, coordination failure becomes rampant, resulting in either continual economic stagnation (as in those Latin American countries since the 1980s in Figure 3) or a cliff dive in GDP per capita accompanied by serious deindustrialization (as Russia since the late 1990s in Figure 5). In contrast, China adopts a different approach when its reform starts in 1978: the state continues to play a coordinating role while the CAD development strategy (including import-substitution policies) is abandoned. It turns out that this approach is much more successful in boosting economic growth and enhancing industrialization, see Figure 1.

We emphasize that appropriate government facilitation based on the endowment structure is the key to success, as observed in China after 1978 in Figure 1, and the Asian economies in Figure 3. We also explain why a few Asian economies could manage to catch up with rich countries by escaping both the poverty trap and the middle-income trap, because they relied on industrial policies based on their comparative advantages determined by their respective endowment structure by first developing labor-intensive industries and then adopting more capital-intensive technologies when capital became sufficiently abundant. The big-push strategy proposed by Rosenstein-Rodan (1943) failed in reality mainly because it ignored the importance of endowment structure and the fundamental role of market prices in determining resource allocation (Lin, 2003, 2009).

To illustrate our ideas, we develop a simple dynamic general equilibrium model to highlight the central issues involved in technology choice and industrial upgrading. In our model, fixed costs in adopting new technologies or switching from labor-intensive technologies to capital-intensive technologies serve as the key source of market failures and obstacles to hinder industrialization or development under laissez-faire. Our model yields the following predictions for an economy starting in poverty or a low level of capital stock: (1) When the government chooses a laissez-faire approach, the economy either gets stuck in the poverty trap or converges to a steady-state with a low degree of industrialization. (2) When the government chooses a big-push strategy that defies the comparative advantage determined by the economy's endowment structure, the economy is able to jump-start industrialization despite a very low level of capital-labor ratio; however, this CAD strategy renders industrialization un-sustainable and can lead to an eventual economic collapse, resulting in a social welfare level even lower than the laissez-faire approach. (3) When the government facilitates industrialization by designing industrial policies consistent with the economy's evolving endowment structure, the economy is able to escape both the poverty trap and the middle-income trap and eventually converges to a high-income steady-state with complete industrialization and a welfare level much higher than those under the first two approaches.

Literature Review

Rosenstein-Rodan's influential idea of big push was first mathematically formalized in Murphy, Shleifer and Vishny (1989). We refer to their model as the MSV model thereafter. This model has largely failed in practice because, we argue, it does not take *endowment structure* (capital to labor ratio) into account, as labor is assumed to be the only production factor in the MSV model. To highlight the crucial role of endowment structure and to make the comparison easier, we tighten our hands by seeking the minimum deviation from the setting of the MSV model. We introduce physical capital as a second production factor into the MSV model. It is empirically natural to assume that modern technologies are more capital-intensive than traditional technologies. Such deviations in model settings might seem trivial, but it turns out that both the conclusions and underlying mechanisms become drastically different. Most importantly, when the fixed cost is sufficiently small, the MSV model implies that big push is *always* socially desirable. In contrast, our model shows that big push is desirable only when the endowment structure is sufficiently capital abundant. If, instead, big push is exercised when the endowment structure is still sufficiently labor abundant, then it would defy the comparative advantage, causing both output and welfare to be even worse than the laissez-faire level. Moreover, we show that premature big push may expedite industrialization initially, but eventually make it unsustainable.

Same as the MSV model, there may exist imperfect competition and increasing returns to scale technologies, so the laissez-faire market equilibrium might not be socially optimal. In this sense, our model concurs with the MSV model on the necessity of state facilitation in industrialization. Nevertheless, there still exist important differences. Firstly, never is there any interior (laissez-faire) market equilibrium in the MSV model: either no industrialization at all or complete industrialization, or both, whereas our model could have an interior equilibrium with incomplete industrialization, which enables us to explain a richer set of real-world facts such as growth performances of middle-income economies. Because, in the MSV model, the strategic complementarity across sectors is not affected by factor prices, whereas in our model, the rental price of capital is pushed up when more sectors industrialize because modern technologies are more capital-intensive, so the relative factor price effect tends to discourage the remaining unindustrialized sectors from industrializing, weakening the force of supermodularity and hence making an interior solution possible. It also explains why our model always has a unique equilibrium, but the MSV model may exhibit multiple equilibria. Secondly, without introducing a somewhat *ad hoc* wage premium, positive cross-sector demand spillover exists only when profits of industrialized sectors are strictly positive in the (static) MSV model, whereas in our model positive demand spillover may still exist even when industrialized firms incur negative profits because the total household income could still increase with the number of industrialized sectors, if the increase in rental income of capital more than compensates the profit loss. Thirdly, the full industrialization equilibrium is still Pareto inferior to the first best, even if it is Pareto superior to the no industrialization equilibrium. The analytical focus of the MSV model is on how the state could help by (coordinating to) selecting the better laissez-faire market equilibrium, whereas our model goes a step further to explore how the state could improve upon the laissez-faire market equilibrium with a given set of fiscal instruments. In particular, we show that the state should encourage more sectors to industrialize when the capital endowment is relatively small but should do the opposite when the capital endowment is relatively large, because the state is resource-constrained by the endowment structure and has to balance the tradeoff between fixing the cross-sector pecuniary externality (extensive margin) and fixing the undersupply of monopolist firms within industrialized sectors (intensive margin). Finally, the MSV model is essentially static, silent about the dynamics of industrialization such as the optimal timing, speed or duration of industrialization, whereas our dynamic model shows that, in the laissez-faire market equilibrium, industrialization would start too late because of pecuniary externality and industrialization would be incomplete because capital accumulation is negatively affected by inefficient industrialization. We also explicitly characterize the optimal dynamic policies. All these differences between the MSV model and ours unanimously point to the importance of endowment structure, because the resulting relative factor prices would significantly affect equilibrium outcomes and policy implications, no matter in static or dynamic settings. Such effects are important in reality, but they are absent in the one-factor MSV model.

Another highly related paper is Buera et al. (2021). This paper built a quantitative model that features complementarity in firms' technology adoption choices and calibrated it with micro-level data from the US and India. It is a one-factor static model and the quantitative result shows that the income gap between the US and India is mainly due to the higher adoption costs and degrees of idiosyncratic distortions in India. While in our model, the income gap between developing countries and developed countries is driven by endowment structure and developing countries can catch developed countries by facilitating industrialization and accumulating capital. There are also some empirical works on multiple equilibria and coordination failures (Davis and Weinstein, 2002, 2008; Redding et al., 2011; Kline and Moretti, 2014; Lane, 2019; Crouzet et al., 2020).

Broadly speaking, our paper revisits one of the oldest yet most fundamental questions in economics: Why do some poor countries manage to become rich but others do not? (Lucas, 1988; Hall and Jones, 1999). Lin (2003, 2009) argues that the key to economic success is to follow the comparative advantage determined by endowment structure, for which we need both efficient market and facilitating state. In particular, he argues that a core common reason behind many development failures after WWII is that the state plays inappropriate roles: either too passive to overcome market failures that prevent comparative advantage from being fully utilized (*i.e.*, laissez-faire), or too hasty to promote overly capital-intensive industries and technologies that are incongruent with factor endowment structure (*i.e.*, big push). In this paper, we attempt to mathematically formalize this idea. Therefore, our paper contributes to the vast literature on the role of state in growth and development, especially on development policies and industrial policies for developing countries (For surveys and collective essays, see, *e.g.*, Rodrik (1996, 2005, 2008); Harrison and Rodriguez-Clare (2010); Bardhan (2012); Stiglitz and Lin (2013). The past decade has witnessed revived academic interest in this topic (Aghion et al, 2015; Itskhoki and Moll, 2019; Liu, 2019). Unlike the existing pertinent literature, which mostly argues for why state intervention is needed (and how it should be conducted), we go beyond by showing why such well-intended policies, for precisely the reasons argued by the literature, could make things even worse if endowment structure is not carefully taken into account. Put more technically, the most appropriate technologies are stage-independent in single-factor models, whereas they could be stage-dependent if technologies are heterogeneous in factor intensities (Basu and Weil, 1998; Ju, Lin and Wang, 2015). It implies that introducing endowment structure into the models would help avoid "one-size-fits-all" types of policy recommendations, and factor markets could be of pivotal help in formulating and adjusting policies in accordance with the evolving comparative advantages determined by endowment structure (Ju, Lin and Wang, 2011). In this sense, our model advocates a "market-led-and-state-facilitated" approach instead of trying to peddle a universal recipe.

The modeling strategy in this paper is simple: The key actors in the model are heterogeneous firms that decide which type of technology—labor-intensive vs. capital-intensive technologies—to adopt, taking the government industrial policies and factor prices as given. We define the degree of "industrialization" as the fraction of production sectors that adopt modern capital-intensive technologies in our model. Using this definition we demonstrate the notions of poverty trap and non-convergence of middle-income countries in terms of the degree of industrialization and study how the degree of industrialization depends on the endowment structure and industrial policies.

The rest of the paper is structured as follows: In Section 2, a static model is developed, in which factor endowment structure is exogenously given. In Section 3, the static model is extended to a dynamic setting, in which the endowment structure changes endogenously. Section 4 concludes.

2 Static Model

We start with a static model, in which both capital stock and labor are exogenously given, to compare laissez-faire market equilibrium outcome and the first best allocation, and draw key implications of industrial policies. In the next section, we make the model dynamic by letting the aggregate capital stock change endogenously via optimal saving decisions, and we explore the general-equilibrium effects of various types of industrial policies.

2.1 Model Environment

Households and Endowment Structure. There is a unit-measured continuum of identical households, each endowed with K units of physical capital and L units of labor. The vector of aggregate production factors (K, L) is referred to as the endowment structure of the economy. The absoluate level of each factor and their relative abundance (say capital-to-labor ratio $\frac{K}{L}$) both matter. Households are the owner of all firms and they rent out capital to firms at market rate r, inelastically supply labor to firms at wage rate w, and collect total profits Π. The utility function of a household is $U(C)$, where $U'(C) > 0$ and C is the final-good consumption. Let X denote the total output of final good and P denote its price. A representative household maximizes $U(C)$ subject to the following budget constraint:

$$PC \leq wL + rK + \Pi. \tag{1}$$

Firms. There are two types of goods: a final good X and a continuum of intermediate goods $x(i)$ with

$i \in [0, 1]$. The final good X is produced by competitive final-good firms with the following technology:

$$X = \left[\int_0^1 x(i)^{\sigma} di\right]^{\frac{1}{\sigma}}, \sigma \in (0, 1)$$

where $x(i)$ is intermediate input produced in industry $i \in [0, 1]$.

Each intermediate good $x(i)$ can be produced by two alternative technologies: a traditional labor-intensive technology (called technology A)

$$F^A(k, l) = A\frac{k^{\alpha} l^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}, \tag{2}$$

or a capital-intensive technology (called technology B)

$$F^B(k, l) = B\frac{k^{\beta} l^{1-\beta}}{\beta^{\beta}(1-\beta)^{1-\beta}}, \tag{3}$$

where k denotes firm-level capital, l denotes firm-level labor, A and B denote the total factor productivity of technology A and technology B, respectively. Without loss of generality, we assume technology B is more capital intensive: $0 < \alpha < \beta < 1$. Firms using technology A are called type-A firms and those adopting technology B are called type-B firms. If technology B is adopted in an intermediate-good sector, we call this sector industrialized, otherwise we call it a traditional or unindustrialized sector.

Technology A is freely accessible and entails no fixed cost, so type-A firms are perfectly competitive; but to operate technology B, a firm has to first pay a fixed cost $z > 0$, which is paid in terms of physical capital. It captures all fixed amounts of costs involved in structural investment in equipment and buildings, R&D investment, payments for transportation or market transaction, learning, training, financing, or other types of operations and infrastructure costs (such as electricity). In principle the fixed cost can be sector-specific, but for our purpose in this paper it suffices to assume it identical across sectors. The fixed cost creates a critical source of market failures and a source of increasing returns to scale, so that the market size is important for technology upgrading. Following Murphy et al (1989), we assume that there exists only one type-B firm in each intermediate-good sector. However, since technology A and technology B produce identical goods, the type-B firm chooses to actively produce only when capital is cheap enough and the market size is large enough to reduce the average costs of production (*a la* Adam Smith). Hence, the economy's endowment structure—which simultaneously determines both the relative factor prices and the size of the market—will dictate the equilibrium level of industrialization (*i.e.*, the number of industrialized sectors).

Market Structure. As mentioned before, the final-good market is perfectly competitive, but the market structure of an intermediate good endogenously depends on whether it is produced by type-A or type-B firms, or both. If intermediate good i is all produced by type-A firms, the market structure is perfect competition. If it is solely produced by a monopolist type-B firm, the market structure is monopolistic (recall there is only one type-B firm in each sector). There is a third possibility: both technology B and technology A are used in sector i, which we rule out for simplicity by imposing the following condition[1]:

$$\frac{B}{A} > \frac{1}{\sigma}\left[\frac{(1-\sigma)\,L}{\sigma(1-\beta)z}\right]^{\beta-\alpha}. \tag{4}$$

This condition ensures that the full markup price charged by the monopolist type-B firm is lower than the marginal cost of type-A firms if the type-B firm is willing to operate, because the TFP of technology B is sufficiently larger than that of technology A. Consequently, type-A firms will never co-produce with the type-B firm in the same sector i.

Let $n \in [0,1]$ denote the number of sectors that are industrialized; we will show how aggregate factor endowment and the problem of technology choice, as well as industrial policies, jointly determine the equilibrium value of n, or the degree of industrialization.

We analyze three different economies. Economy I is a laissez-faire economy with the degree of industrialization n determined solely by market mechanisms. Economy II is a (first-best) planned economy with the degree of industrialization chosen by a benevolent artificial social planner; so that economy II provides the benchmark of efficiency to evaluate the efficacy and effects of industrial policies in other types of economies. Economy III is a market economy where different industrial policies and government interventions are also implemented. In particular, we use economy III to explore the optimal Ramsey allocation where the government has a limited set of policy tools, and we also use it to characterize the allocation under a comparative-advantage-defying (CAD) development strategy—where the state prematurely promotes capital-intensive industries even when the endowment structure is labor abundant.

2.2 Laissez-faire Market Equilibrium

Since unindustrialized sectors are perfectly competitive and industrialized sectors are monopolies, we have the following pricing rules opted by type-A and type-B firms: $p_A = \frac{w^{1-\alpha}r^{\alpha}}{A}$ is the price charged by type-A firms and $p_B = \frac{1}{\sigma}\frac{w^{1-\beta}r^{\beta}}{B}$ is the price charged by type B firms. The final good price is therefore given by

$$P = \left[(1-n)p_A{}^{\frac{\sigma}{\sigma-1}} + np_B{}^{\frac{\sigma}{\sigma-1}}\right]^{\frac{\sigma-1}{\sigma}}. \tag{5}$$

In each unindustrialized sector the output is given by $x_A = (\frac{P}{p_A})^{\frac{1}{1-\sigma}}X$, and in each industrialized sector the demand function faced by the type-B firm is given by $x_B = (\frac{P}{p_B})^{\frac{1}{1-\sigma}}X$. The final-good output is

[1] See the appendix for detailed discussions about what happens if this condition is violated.

obtained by aggregating all intermediate inputs:

$$X = [(1-n)\cdot {x_A}^{\sigma} + n \cdot {x_B}^{\sigma}]^{\frac{1}{\sigma}}. \tag{6}$$

The profit of an unindustrialized sector is zero and the profit in an industrialized sector is given by

$$\pi = (1-\sigma)\,(\frac{w^{1-\beta} r^{\beta}}{\sigma B})^{\frac{\sigma}{\sigma-1}} P^{\frac{1}{1-\sigma}} X - rz, \tag{7}$$

Let $\{L_A, K_A\}$ and $\{L_B, K_B\}$ denote, respectively, labor and capital used in an unindustrialized sector and an industrialized sector. The market-clearing conditions for capital, labor, final good, and intermediate goods are given, respectively, by:

$$K = (1-n)\,K_A + nK_B + nz, \tag{8}$$

$$L = (1-n)\,L_A + nL_B, \tag{9}$$

$$X = (C =)\frac{wL + rK + n\cdot\pi}{P}, \tag{10}$$

$$A\frac{{K_A}^{\alpha}{L_A}^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}} = x_A; B\frac{{K_B}^{\beta}{L_B}^{1-\beta}}{\beta^{\beta}(1-\beta)^{1-\beta}} = x_B, \tag{11}$$

where the left-hand side of each equation is supply and the right-hand side is demand. Solving the above system of five equations yields the equilibrium allocation of production factors $\{K_A, K_B, L_A, L_B\}$ and the degree of industrialization—the equilibrium value of n, as characterized in the following proposition:

Proposition 1 *In the Laissez-faire economy, there is a unique equilibrium, in which the degree of industrialization n is determined as follows:*

$$n = \begin{cases} 0, & \textit{if} \quad K \leq K_b^{LF} \\ n^* \in (0,1), & \textit{if} \quad K_b^{LF} < K < K_f^{LF} \\ 1, & \textit{if} \quad K \geq K_f^{LF} \end{cases},$$

where

$$K_b^{LF} \equiv \alpha(\frac{A}{\sigma B})^{\frac{\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}(\frac{z}{1-\sigma})^{\frac{1-\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}(\frac{L}{1-\alpha})^{\frac{\beta\sigma-\alpha\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}, \tag{12}$$

and

$$K_f^{LF} \equiv \frac{1-\sigma+\beta\sigma}{1-\sigma} z, \tag{13}$$

and the interior value n^* increases with the TFP of capital-intensive technology B and the capital endowment K, and it decreases with the TFP of labor-intensive technology A, the labor endowment L, and the fixed cost z.

Proof. Please see the appendix. ■

The above proposition is graphically illustrated by the blue line (line LF) in Figure 6. It shows that no industrialization occurs when the capital endowment is sufficiently low ($K \leq K_b^{LF}$), because capital is too expensive to make it profitable for firm B to operate. Equation (12) implies that the threshold capital K_b^{LF} required for a take-off in industrialization strictly increases with fixed cost z, the relative productivity of the traditional technology (TFP ratio $\frac{A}{B}$), and labor endowment L; it is because increases in these parameters make labor-intensive technology A more attractive than the capital-intensive technology B. Hence, the economy stays in a poverty trap when the endowment structure is sufficiently capital scarce or when fixed cost z is sufficiently large, *ceteris paribus.*

[insert figure 6 here]

However, when capital endowment K is high enough to fall into the intermediate range (K_b^{LF}, K_f^{LF}), the degree of industrialization $n = n^*$ becomes strictly positive; and it increases with K because a higher capital endowment not only makes capital cheaper but also the market size bigger, and hence more sectors find it profitable to adopt the capital-intensive technology B. When the capital endowment is sufficiently abundant ($K \geq K_f^{LF}$), the economy achieves full industrialization with $n = 1$.

Observe that the MSV model is just a special case of our model without capital.[2] Their single-factor model has no *endowment structure* but our model does, which leads to different, sometimes even opposite, conclusions. One such difference is that in the MSV model n can take only a binary value of either 0 or 1 in equilibrium, whereas in our model n can take continuum of values on the interval $[0, 1]$. Hence, the MSV model implies either no industrialization or complete industrialization, whereas our model has the potential to explain why economies might reach continuously different degrees of industrialization, which is important in helping us understand a much wider array of differentiated economic performances such as stagnation of middle-income countries. The reason behind the difference is the following: the MSV model has labor as the only production factor and changes in wage have a neutral impact on technology choice, resulting in the "bang-bang" outcome because of positive pecuniary externality due to the demand spillover across sectors. Our model preserves the feature of pecuniary externality, but when more sectors adopt the capital-intensive technology, the increase in demand for capital drives up the rental price of capital relative to the wage rate, which discourages other unindustrialized sectors to industrialize. This counterforce through the relative factor prices weakens the degree of supermodularity among type-B firms and thus leads to an equilibrium with interior $n \in (0, 1)$ for any given endowment level $K \in (K_b^{LF}, K_f^{LF})$. It implies that, with the endowment structure at presence, relative factor-price signals can play an important

[2] More precisely, when $\alpha = \beta = 0, \sigma = 0, A = \alpha^\alpha (1-\alpha)^{1-\alpha}, B > \beta^\beta (1-\beta)^{1-\beta}$ hold simultaneously and the fixed cost is paid in terms of labor, the model developed here exactly degenerates to the MSV model. Condition (4) is irrelevant for Murphy et al (1989) as long as $z > 0$. Notice that labor is the only input in MSV model, which can be relabelled as capital without changing anything.

coordinating role for firms in the decentralized market economy in their technology choices, whereas the factor price has no coordinating effect at all in the one-factor model.

Another important difference is that in the MSV model, when labor endowment L is large enough, full industrialization always emerges in a laissez-faire market equilibrium because the market size strictly increases with labor income. In contrast, poverty trap with no industrialization will be the laissez-faire market equilibrium in our model when L is large enough, because an increase in L entails both an income effect and a substitution effect, which work in opposite directions: the income effect favors adoption of the capital-intensive (or increasing-returns-to-scale) technology B as the market size becomes larger, but the substitution effect discourages adoption of capital-intensive technology B because capital becomes more expensive relative to labor. Therefore, an economy with a large population L does not necessarily mean that industrialization is more likely to take place due to cheaper labor; it is the endowment structure that matters.

2.3 Social-Planner Allocation

The existence of fixed cost and pecuniary externality imply market failures such that the first welfare theorem no longer applies. In this subsection, we characterize the socially optimal allocation or the optimal degree of industrialization by solving a benevolent social planner's problem. Observe that maximizing the welfare of a representative household is equivalent to maximizing the total real GDP (X) in the current static setting. Substituting (11) into (6), we obtain the following optimization problem for the social planner:

$$\max_{n,L_A,L_B,K_A,K_B}[(1-n)\cdot(A\frac{K_A^{\alpha}L_A^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}})^{\sigma}+n\cdot(B\frac{K_B^{\beta}L_B^{1-\beta}}{\beta^{\beta}(1-\beta)^{1-\beta}})^{\sigma}]^{\frac{1}{\sigma}}, \tag{14}$$

subject to the feasibility constraints (8) and (9).

Let K_b^{SP} denotes the cutoff value of capital endowment at which the social planner opts to start industrialization, and K_f^{SP} denotes the cutoff value at which the social planner opts to finish industrialization. The first-best choice in the degree of industrialization is characterized in the following proposition:

Proposition 2 *The socially optimal pattern of industrialization is given by*

$$n=\begin{cases} 0, & \text{if} \quad K\leq K_b^{SP} \\ n^{**}, & \text{if} \quad K\in(K_b^{SP},K_f^{SP}) \\ 1, & \text{if} \quad K\geq K_f^{SP} \end{cases},$$

where the lower cutoff K_b^{SP} for triggering industrialization is uniquely determined by the implicit function:

$$(\frac{B}{A})^{\frac{1}{\beta-\alpha}}\frac{1-\alpha}{\alpha}(\frac{\sigma\alpha z}{(1-\sigma)K_b^{SP}}+1)^{\frac{\sigma-1}{(\beta-\alpha)\sigma}}K_b^{SP}=L,$$

and the higher cutoff K_f^{SP} for completing industrialization is uniquely determined by the implicit function:

$$\frac{1-\beta}{\beta}(K_f^{SP}-z)(\frac{B}{A})^{\frac{1}{\beta-\alpha}}(\frac{(1-\sigma)(K_f^{SP}-z)}{(1-\sigma)K_f^{SP}-(1-\sigma+\beta\sigma)z})^{\frac{\sigma-1}{(\beta-\alpha)\sigma}}=L,$$

and the interior range n^{**} increases with the TFP of capital-intensive technology B and capital endowment K, and it decreases with the TFP of labor-intensive technology A, labor endowment L, and fixed cost z. Moreover, compared with the Laissez-faire economy we have $K_b^{SP} < K_b^{LF}$ and $K_f^{SP} > K_f^{LF}$.

Proof. Please see the appendix. ■

The first-best allocation is represented by the orange dashed line (line SP) in figure 6. Note that the first-best allocation is to jump-start industrialization at a lower level of capital endowment than in the laissez-faire market equilibrium ($K_b^{SP} < K_b^{LF}$), but to finish industrialization at a higher capital level ($K_f^{SP} > K_f^{LF}$).

The reason for a lower take-off capital stock ($K_b^{SP} < K_b^{LF}$) is that the social planner internalizes the benefits of industrialization (positive pecuniary externalities) generated from the industrialized sectors to the society, thus opts to jump-start industrialization "earlier" and push more sectors to industrialize even when the aggregate capital stock is relatively low: $K \in (K_b^{SP}, K_b^{LF}]$. On the other hand, the reason for $K_f^{SP} > K_f^{LF}$ is that the social planner rectifies the undersupply of monopolist firms in industrialized sectors by discouraging more sectors from industrializing but inducing each industrialized sector to produce more with the existing production factors when the degree of industrialization is already relatively large, so as to avoid too much fixed costs of upgrading; consequently, the first-best degree of industrialization ends at a higher level of capital endowment. In other words, the social planner makes use of the extensive margin (n) when K is relatively small and then makes use of the intensive margin (x_B) when K is sufficiently large.

The difference in efficiency or welfare gains between the social planner's approach and the laissez-faire equilibrium is illustrated in Figure 7. It shows that social planner achieves a much higher level of efficiency than the laissez-faire approach for any given capital endowment $K \in (K_b^{SP}, K_f^{SP})$, as measured by the percentage increase in final output relative to the laissez-faire market equilibrium. But when K is outside this interval, the social planner and laissez-faire market equilibrium would achieve the same level of efficiency. In particular, when the capital endowment is sufficiently large ($K \geq K_f^{SP}$), laissez-faire market equilibrium achieves the same level of welfare (equivalent to the same level of GDP) as the first-best allocation despite the monopolistic market structure across sectors, because, in general equilibrium, the monopoly profits are owned by households as part of their income, so households' induced demand for each intermediate good goes up due to the income effect, which exactly cancels out the negative effect on households' demand due to monopolistic markup pricing.

[insert figure 7 here]

Remember that in the static model, the capital stock changes exogenously in the comparative static analysis when we determine the equilibrium degree of industrialization in different scenarios. We will show later in general equilibrium analyses when the capital stock changes endogenously through household saving, the laissez-faire economy may never be able to accumulate enough capital to jump-start industrialization or reach full industrialization if the initial capital endowment is too low or the fixed cost is too high. But such a poverty-trap equilibrium can nonetheless be avoided by the social planner, suggesting the existence of welfare-enhancing industrial policies to escape the poverty trap. But before we conduct the general equilibrium analysis, it is beneficial to consider some policy experiments within the static framework.

2.4 The Effects of Industrial Policies

In this subsection, we study the role of state in facilitating industrialization by examining how the objective function of a state and the policy instruments available would affect the pattern of industrialization and the associated welfare levels. It turns out that the following Ramsey planner problem provides a useful benchmark for our policy analysis.

2.4.1 Ramsey Outcome

Consider the following Ramsey planner problem: the Ramsey planner maximizes the welfare of a representative household by choosing the degree of industrialization n (*i.e.*, how many sectors to industrialize), while the prices and quantities of all sectors are fully determined by firms based on market mechanisms. That is, the Ramsey planner can "order" more firms to adopt capital-intensive technology, but the "chosen" firms will determine their level of production and factor demand based on market prices even if doing so implies negative profits. In other words, if a firm in a sector is ordered by the Ramsey planner to operate technology B, this firm has to pay fixed cost z and then decide its output and price to maximize its profit, even though it may incur negative net profits. However, since the fixed cost z is a must-pay sunk cost, the profit-maximizing output must be strictly positive even if the net profit is negative. On the other hand, if a type-B firm receives no permission to operate, it cannot operate even if it can earn strictly positive profits. How the value of n changes with capital endowment K under the Ramsey planner problem is shown by the yellow dot line (line RP) in Figure 6. Please refer to the appendix for details about how optimal n is determined.

It shows that the Ramsey planner starts industrialization at a level of capital lower than that in Laissez-faire market equilibrium but higher than that in the first best (that is, $K_b^{SP} < K_b^{RP} < K_b^{LF}$), and completes industrialization at a level of capital lower than that under social planner but equal to that in Laissez-faire economy (that is, $K_f^{SP} > K_f^{RP} = K_f^{LF}$). Let $\widehat{K}$ denote the level of capital at which the number of industrialized sectors is the same for Laissez-faire equilibrium and Ramsey outcome, the optimal value of n under the Ramsey planner is larger than that under laissez faire when $K \in (K_b^{RP}, \widehat{K})$, but smaller than that under laissez faire when $K \in (\widehat{K}, K_f^{RP})$. Observe that all industrialized sectors under the Ramsey planner earn negative profits when $K \in (K_b^{RP}, \widehat{K})$ but enjoy strictly positive profits when $K \in (\widehat{K}, K_f^{RP})$.

To understand why negative profits are optimal for the Ramsey planner, we compare the real return to capital under these different scenarios because the pecuniary externalities mainly come from demand spillover (see Figure 8). When $K \in (K_b^{RP}, \widehat{K})$, the real return to capital in the Ramsey outcome is higher than that in the Laissez-faire equilibrium, because a higher n drives up the demand for capital, so the capital income is higher in the Ramsey outcome even though Π is negative. Labor income wL in the Ramsey outcome is lower than that in the Laissez-faire equilibrium, because relative demand for labor decreases with n, as industrialized sectors adopt more capital-intensive technologies. It turns out that the increase in capital income dominates. So the Ramsey planner (partly) internalizes the positive externality from industrialized sectors by encouraging more sectors than laissez-faire to industrialize when $K \in (K_b^{RP}, \widehat{K})$.

[insert figure 8 here]

When $K \in (\widehat{K}, K_f^{RP})$, the undersupply of monopolist type-B firms in industrialized sectors becomes the major source of inefficiency, so the Ramsey planner (partly) rectifies the market distortion by lowering n (that is, discouraging premature industrialization), which helps increase the output of all industrialized sectors because each industrialized sector now has more capital available for production. Note that, when $K \in (\widehat{K}, K_f^{RP})$, the real return to capital is lower under Ramsey planner than the laissez-faire, although industrialized sectors earn strictly positive profits in the former case while their counterparts earn zero profit in the latter case. It is because changes in total capital return are dominated by changes in rental income of capital instead of profits. Note that the rental income of capital increases more if one additional unit of capital is used as fixed cost for newly industrialized sectors (extensive margin) than if it is used to increase the output of incumbent industrialized sectors (intensive margin), because the latter is more subject to diminishing returns. The reason for $K_f^{RP} = K_f^{LF}$ is that the Ramsey planner's tool to improve efficiency is very limited. He can only achieve that by changing the number of industrialized sectors. When $K = K_f^{LF}$, all the sectors are industrialized in laissez-faire, all capital is used in production by industrialized firms except those used to pay for fixed costs. So there is no undersupply in industrialized sectors and the Ramsey planner would not like to change the number of industrialized sectors ($K_f^{RP} = K_f^{LF}$). The Ramsey planner cannot achieve the first best (for example, $K_b^{SP} < K_b^{RP}$ and $K_f^{SP} > K_f^{RP}$), because it is still subject to private incentives of households and firms in the market.

The efficiency comparison between the Ramsey planner and the laissez-faire is shown in Figure 9. The efficiency gain of the Ramsey planner over laissez-faire has two peaks. The first local maximum is reached at K_b^{LF} and the second local maximum is reached between $\widehat{K}$ and K_f^{RP}, because the difference between the number of industrialized sectors chosen by Ramsey planner and the number of industrialized sectors in laissez-faire reaches peaks at these two points.

[insert figure 9 here]

It suggests that, from the social welfare point of view, the negative profit of a firm does not necessarily justify its shut down and positive profit does not necessarily justify its operation. In other words, depriving type-B firms of their rights to voluntarily choose whether to produce could enhance social welfare when there exists pecuniary externality. Keeping these findings in mind, we are ready to study the effects of industrial policies below.

2.4.2 Industrial Policies

In this subsection, we discuss various types of industrial policies and compare their effects with the scenarios under the Ramsey planner regime, the laissez-faire regime and the social planner regime.

Industrial Policy I Suppose the government subsidizes each type-B firm by covering F units of fixed cost, and the government expenditure is financed by a lump-sum income tax (T). The government budget is balanced: $T = n \cdot r \cdot F$. The after-tax income of a representative household now becomes $rK + wL + \Pi - T$. The government chooses subsidy level F to maximize the welfare of a representative household in the decentralized market equilibrium. Notice that when $F < 0$, it means a tax on type-B firms in industrialized sectors, and consequently the income tax becomes subsidies to the household. We obtain the following result.

Proposition 3 *The optimal industrial policy I stipulated by $\{F, T\}$ achieves the same market outcome (in both quantities and prices) and welfare level as in the Ramsey planner's problem, except that now all firms earn zero profit under Policy I when $K \in [K_b^{RP}, K_f^{RP}]$.*

Proof. Please see the appendix. ■

The intuition for this result is as follows: optimal industry policy I affects only the fixed cost paid by type-B firms in industrialized sectors without changing their output decisions, and it does not distort households' marginal consumption decisions because the income tax is lump-sum. The main effect of this industrial policy is to restore zero profit for all industrialized sectors by lump-sum taxes/subsidies in the decentralized market.

The optimal value of F is shown in Figure 10. It is positive when $K \in (K_b^{RP}, \widehat{K})$, because type-B firms in industrialized sectors would incur negative profits in Ramsey planner problem so they need subsidies to break even. The subsidized amount F decreases with K because the profit loss of each type-B firm in industrialized sectors decreases with K due to the accompanied increase in pecuniary externality. F turns negative when $K > \widehat{K}$, because the Ramsey government wants to reduce n to fix the undersupply problem of monopoly in industrialized sectors. When $K = K_f^{RP}$, the government chooses optimal industrial policy I to maximize the same objective function as the Ramsey planner, and it happens that all type-B firms earn exactly zero profits, so there is no need to intervene, that is, optimal F is zero in the decentralized market equilibrium.

[insert figure 10 here]

Industrial Policy II We have just shown that Industrial Policy I can achieve the same welfare level as in the Ramsey planner problem. But this allocation is not the first best and has room to be improved. To get closer to the first-best allocation, we need more policy instruments. Consider Industrial Policy II, which consists of a subsidy rate τ for the fixed cost paid by type-B firms and a subsidy rate s_k for capital used by type-B firms in production. The first instrument τ is equivalent to Industrial Policy I ($\tau = \frac{F}{z}$), and the newly added policy instrument s_k is mainly aimed at adjusting the output of industrialized sectors. To balance the budget, the government still imposes a lump-sum tax T on household income:

$$T = n \cdot s_k \cdot r \cdot K_B + n \cdot \tau \cdot r \cdot z.$$

In equilibrium, the number of industrialized sectors under the optimal Industrial Policy II is the purple dash-dot line (line n_{PII}) in Figure 11. It shows that, not surprisingly, the equilibrium number of industrialized sectors with industry policy II is closer to that in the first-best allocation than Policy I because more policy instruments are available. Figure 12 shows that the welfare gain of policy II is larger than policy I.

[insert figure 11 here]
[insert figure 12 here]

Industrial Policy III Industrial policy II only considers subsidies on capital. Now we expand the policy space by adding a subsidy rate s_l for labor used in production by industrialized firms to adjust output. We reserve the subsidy rate τ for fixed costs paid by industrialized firms to adjust decisions on industrialization. As before, the government levies a lump-sum tax T on household income and we impose a balanced government budget:

$$T = n \cdot s_l \cdot w \cdot L_B + n \cdot \tau \cdot r \cdot z.$$

The number of industrialized sectors under the optimal industrial policies is shown in Figure 11. The welfare comparison is shown in Figure 12. Not surprisingly, industrial policy III is better than policy II.

2.4.3 Premature Big Push

Now we explore what happens if the state "naively" applies the policy of big push implied by the MSV model, without taking into account the role of endowment structure. We model the big-push ideology by assuming that the government's objective (social welfare) function includes not only aggregate consumption (GDP) but also the share of output produced by capital-intensive technology in GDP, so as to capture the government's desire for rapid industrialization by favoring heavy industries.

Let τ_L, τ_K, τ_z denote the subsidy rate for labor, capital used in production, fixed cost in the industrialized sectors, respectively. Let τ_A denote the tax rate on the revenue of unindustrialized sectors and T denote the lump-sum tax on household income. The balanced budget of the state is therefore given by

$$\tau_A(1-n)\widetilde{P}_A\widetilde{x}_A + T = n \cdot \widetilde{r}(\tau_K\widetilde{K}_B + \tau_z z) + \tau_L \cdot n \cdot \widetilde{w}\widetilde{L}_B, \tag{15}$$

where all variables with tilde denote the corresponding variables for the big-push case. The state maximizes the weighted average of real GDP ($\widetilde{X}$) and share of industrialized output value in total GDP ($\frac{n\widetilde{P}_B\widetilde{x}_B}{\widetilde{P}\widetilde{X}}$):

$$\max_{\tau_L,\tau_K,\tau_A,\tau_z} (1-\phi)\widetilde{X} + \phi\frac{n\widetilde{P}_B\widetilde{x}_B}{\widetilde{P}\widetilde{X}}, \tag{16}$$

where the shared parameter in the objective function $\phi \in [0,1]$ captures how strong the desire for big push is. A larger ϕ implies a stronger preference for industrialization *per se*. When $\phi = 0$, the government has no obsession for industrialization *per se*.

Taking $\tau_L, \tau_K, \tau_A, \tau_z$ as given, all firms maximize profits and all households maximize utility subject to the following budget constraint:

$$\widetilde{P}\widetilde{C} \leq \widetilde{w}L + \widetilde{r}K + n\widetilde{\pi} - T, \tag{17}$$

where $\widetilde{\pi}$ is the profit of an industrialized sector, given by

$$\widetilde{\pi} = \left(\frac{1}{\sigma} - 1\right)\left(\frac{[(1-\tau_L)\widetilde{w}]^{1-\beta}\left((1-\tau_K)\widetilde{r}\right)^{\beta}}{B}\right)^{\frac{\sigma}{\sigma-1}}\widetilde{P}^{\frac{1}{1-\sigma}}\widetilde{X} - (1-\tau_z)\widetilde{r}z, \tag{18}$$

and all markets clear. The state solves (16) subject to the government budget constraint (15) in the decentralized market equilibrium.

The equilibrium number of industrialized sectors under optimal industrial policy vector $(\tau_L, \tau_K, \tau_A, \tau_z)$ is shown in Figure 13. When $\phi = 0$, the optimal fiscal policy can achieve close to the first-best number of industrialized sectors. When the government has a stronger desire for big push (ϕ increases), in equilibrium industrialization starts at a lower level of capital endowment and the corresponding n also increases for any given capital endowment.

[insert figure 13 here]

The efficiency levels for all these different cases are shown in Figure 14. When $\phi = 0$, the optimal policies can achieve a level of welfare close to the first best (because there is one more policy instrument than Industrial Policy III). As ϕ increases, the speed of industrialization increases but the welfare level decreases, because big push results in comparative-advantage-defying industrialization. When the capital endowment is small, $\phi > 0$ might lead to premature industrialization and even lower welfare than in the laissez-faire case. It helps explain why the Great Leap Forward Movement in China resulted in poor economic performance in the period of 1958-1962 and why Latin America failed to converge to the US income level from the 1950s to 1970s, during which period those countries mistakenly followed the "big push" strategy implied by the MSV model.[3]

[insert figure 14 here]

3 Dynamic General Equilibrium

In the static model, the endowment structure is exogenously given, suggesting answers to the underlying question of what would happen to the degree of industrialization if a particular economy can obtain the desired level of the capital stock or endowment structure. However, it is clear that different development policies would lead to dramatically different levels of the capital stock or endowment structure, hence resulting in very different degrees of industrialization. Therefore, in this section we extend the static model to a dynamic setting with endogenous capital accumulation, so as to explain the three stylized facts mentioned in the introduction of the paper; namely, the poverty trap, the middle-income trap, and the different paths of industrialization under industrial policies observed in Africa, Latin America, East Europe, East Asia including China.

3.1 Model Setting

In any period t there is a representative household who lives for only one period and is replaced by her offspring next period. A generation-t household owns K_t units of capital and L units of labor with the following utility function:

$$u(C_t, H_t) = lnC_t + \gamma lnH_t,$$

[3] Figure 14 also shows that, when capital stock is in some high range, big push with $\phi > 0$ may achieve higher welfare than Laissez-faire. It is because government preference for big push *per se* may partly internalize the pecuniary externality as an unintended consequence. However, in reality, it is mainly less developed countries (with relatively small K) that pursue comparative-advantage-defying big-push development strategies, so empirically relevant cases are those when K is small.

where C_t is consumption, H_t is bequest, and γ is a positive parameter measuring the degree of altruism. The total income (in terms of final good) X_t can be divided between consumption and bequest. The household's optimization implies $H_t = \frac{\gamma}{1+\gamma} X_t$, which is then invested by the young generation to augment firms' capital stock; so the aggregate capital stock accumulates endogenously according to the following law of motion:

$$K_{t+1} = \frac{\gamma}{1+\gamma} X_t + (1-\delta) K_t, \tag{19}$$

where δ is the depreciation rate of capital. Note that the saving rate is endogenously given by a constant, $\frac{\gamma}{1+\gamma}$. For simplicity without loss of generality, we assume that a type-B firm also lives for one period and is replaced by an identical one in each corresponding sector.

The structure of the production sector is identical to that in the static model. Namely, there is a representative final-good firm and a continuum of intermediate-good firms. Each intermediate-good i can be produced by two alternative technologies: labor-intensive and capital-intensive technologies. A firm must pay a fixed cost $z > 0$ to adopt capital-intensive technology. Hence, given the aggregate capital stock K_t in any period t, firms' decisions are the same as in the static model characterized in Section 2. The key difference now is that the aggregate capital stock K_t evolves endogenously. Note that maximizing the welfare of a representative household in period t is still equivalent to maximizing the total real output X_t in that period.

3.2 Laissez faire Economy

Figure 15 shows how the steady-state of the laissez-faire market equilibrium is determined. Let M denote the level of final output at which capital investment is equal to capital depreciation, $M = \frac{1+\gamma}{\gamma}\delta K$. When the final output (denoted by X_{LF}) exceeds M, investment exceeds depreciation, so capital accumulates and the economy grows; on the other hand, if investment falls short of depreciation, the aggregate capital stock decreases. A steady-state exists at the crossing point of the two curves. There are two crossing points between the curve $M = \frac{1+\gamma}{\gamma}\delta K$ and the curve $X = X_{LF}(K)$ in figure 15, corresponding to two distinct steady states.[4] Obviously, the left one is stable, and the right one is unstable—a slight perturbation will push the economy toward the lower steady-state. There is another stable steady-state which is not drawn in figure 15 as the marginal productivity of capital would decrease after full industrialization. Given the fixed cost z, when the economy starts at a sufficiently low capital endowment, it eventually reaches the lower steady-state in the laissez-faire economy, which means that the economy's industrialization will be incomplete and the steady-state GDP level is relatively low.

[insert figure 15 here]

[4] Krugman (1991) and Matsuyama (1991) both study industrial policies when there exist multiple steady states in the presence of increasing returns to scale. Here, we mainly focus on the stable steady state, although there may also exist multiple steady states in our dynamic model.

When the fixed cost z increases such that the market size is too small to make the capital-intensive technology profitable, the curve $X = X_{LF}(K)$ shifts downward to $X = X_{LF2}(K)$, which implies that the two steady states are pushed further apart such that the lower (stable) steady-state becomes even lower and the higher (unstable) steady-state even higher. Moreover, the cutoff level of aggregate capital required to trigger industrialization becomes higher (that is, $K_b^{LF} < K_b^{LF2}$); this is also true for the cutoff capital required to finish industrialization (that is, $K_f^{LF} < K_f^{LF2}$). When z is sufficiently large, as shown in figure 15, the lower steady-state features no industrialization ($n = 0$), because the steady-state capital level is lower than K_b^{LF2}. The difference between those two stable steady-states generated by different fixed cost z may explain why those Latin American countries in figure 3 are caught in a middle-income trap while those African countries in figure 1 are caught in a poverty trap.

3.3 Social Planner Economy

When considering the social planner economy in the dynamic model, we assume that the social planner can not influence the household's investment choice. That is to say, the law of motion of capital is also (19). The social planner's goal is to maximize GDP (X_t) subject to the feasible constraints (8) and (9). So given K_t, the social planner behaves exactly the same as in the static model characterized earlier. In this case, the difference between the social planner economy and laissez-faire is only that the social planner can improve GDP in each period. If we relax the assumption and let the social planner to influence the household's investment choice, the social planner economy will begin and finish industrialization sooner. A comparison between the first best and the laissez-faire market equilibrium is shown in Figure 16, where the blue line (line LF) denotes the laissez-faire market equilibrium and the orange dashed line (line SP) denotes the first best industrialization process.

[insert figure 16 here]

As we can see, starting with the same initial capital endowment, the social planner opts to jump-start industrialization earlier in time than the Laissez-faire dynamic equilibrium (that is, $t_b^{SP} < t_b^{LF}$), and more importantly, in the long run, the social planner manages to achieve full industrialization whereas the Laissez-faire economy only achieves partial industrialization ($n < 1$) and is stuck in a poverty trap or middle-income trap, depending on the initial capital endowment and the implied long-run general-equilibrium value of n.

The time path of GDP under laissez-faire and social planner is shown by the blue line (line LF) and the orange dashed line (line SP) in figure 17, respectively. We can see that, after industrialization starts, GDP grows faster under social planner than under laissez-faire. It is not only because that the aggregate output is much higher in the first-best allocation, but also because capital accumulates faster under social planner. The slope of GDP becomes flatter later, especially after full industrialization is achieved, because of the force of diminishing returns to capital. The growth rate of GDP eventually decreases to zero, approaching the steady-state. In the long run steady-state, the laissez-faire approach achieves very little GDP.

[insert figure 17 here]

3.4 Optimal Industrial Policies

In this subsection, we explore the industrial policies that the state could adopt to improve the laissez-faire equilibrium and enhance social welfare in a market economy. To simplify the analysis, we focus our attention on the same set of policy instruments as specified in industrial policy III in the static model except that these policies are now state-dependent and hence can change over time. For each period t, the government maximizes the welfare of a period$-t$ representative household by choosing a subsidy rate s_{lt} for labor employed by type-B firms, a subsidy rate τ_t for the fixed cost in industrialized sectors, and a lump-sum tax T_t on household income. The government budget is balanced for each period. We also assume that the government can not influence the household's investment choice, so the law of motion of capital is still (19). The government's goal is to maximize GDP (X_t) subject to its budget constraint $T_t = n_t \cdot s_{lt} \cdot w_t \cdot L_{Bt} + n_t \cdot \tau_t \cdot r_t \cdot z$ in each period. The equilibrium industrialization process is shown by the yellow dot line (line FP) in Figure 16.

It shows that under optimal dynamic policies the economy jump-starts industrialization earlier than the laissez-faire equilibrium, although still later than the first-best scenario ($t_b^{SP} < t_b^{FP} < t_b^{LF}$). In addition, the economy can reach full industrialization, although it is achieved later than the first best ($t_f^{SP} < t_f^{FP}$), so the state enables the economy to escape the poverty trap or middle-income trap with incomplete industrialization, reaching a steady-state with a much higher level of GDP and social welfare than the laissez-faire market equilibrium. See Figure 17 for the time path of GDP.

This experiment explains why and how some East Asian economies were able to successfully catch up and converge to the U.S. income level shown in Figure 3. Their governments used industrial policies to fix the market-failure problems that impeded industrialization and the policies followed the economy's comparative advantage determined by their factor endowment structure (see, e.g., Lin 2003, 2009).

3.5 Comparative-Advantage-Defying(CAD) Strategy

We now study an economy where the government adopts a comparative-advantage-defying (CAD) strategy by ignoring the endowment structure and prematurely jump-starting and speeding up industrialization. We show that such a development strategy can achieve a certain degree of industrialization in the beginning but will eventually result in economic collapse. More concretely, imagine that the state chooses n by following an *ad hoc* linear rule of industrialization: $n(t) = \theta_0 + \theta_1 \cdot t$, where positive parameter θ_1 measures the speed of industrialization, reflecting how eager the state is to push industrialization. Effectively, each type-B firm receives an order from the government whether it should enter the business or not. All type-B firms have to strictly follow the order but they can decide the output and price to maximize profits, which could be negative, just as in the Ramsey planner problem discussed earlier. This is analogous to the State-Owned Enterprises in a planned economy where they may incur negative profits to uphold industrialization. All resource allocation is determined by the market except that the number of industrialized sectors (n) is chosen by the state. Again, the law of motion of capital is (19).

The time paths of capital K_t and GDP X_t under such CAD strategies are plotted in Figure 18. It shows that GDP grows fast right after the CAD strategy is implemented, but later the growth becomes unsustainable and the GDP level starts to decrease because type-B firms are not viable when capital is too scarce, so these firms suffer negative profits and aggregate output is also low due to resource misallocation, and capital stock also declines as the investment eventually falls short of capital depreciation, eventually leaving firms with no capital for production.

[insert figure 18 here]

The above analysis assumes an *ad hoc* rule of industrialization. An alternative way to model the CAD strategy is that the government maximizes (16) under normal fiscal policies but keeps a high ϕ. Now n becomes endogenous, and the corresponding time paths for different ϕ are shown in Figure 19. When ϕ equals 0, the government's goal is the same as the social planner. Given so many policy tools, the government can achieve the industrialization process very close to the social planner problem. When ϕ equals 0.8, industrialization begins earlier but ends later than the social planner problem, as capital accumulation is slower when the CAD strategy is followed. When ϕ equals 0.95, industrialization begins earlier but stagnates in a middle-income trap. It means that, when the government values heavy industries in the social welfare function and is thus too eager to industrialize by promoting a "big push" strategy, it will lead to incomplete industrialization or even economic collapse in the end.

As we can see in figure 20, when $\phi = 0.95$, the GDP reaches a steady-state level lower than the laissez-faire case though the steady-state industrialization level is higher. When ϕ gradually increases from 0.2 to 0.95, the GDP achieves a higher level than the laissez-faire case first, then it falls down to a lower level than the laissez-faire case as the government's desire to industrialize increases.

[insert figure 19 here]

[insert figure 20 here]

The above two types of CAD strategies can both generate an inverted U-shaped economic performance, the GDP level is always lower than laissez-faire when the first type of CAD strategy is adopted by the government, while the GDP level might be higher than laissez-faire when the second type of CAD strategy is adopted. These experiments may help us understand why industrialization failed in all the planned economies that adopted the CAD strategies (examples include Eastern European countries before the economic reform, such as the former Soviet Union before the late 1980s in Figure 5, China before the year 1978 in Figure 1, Latin America during 1950s-1970s in Figure 3), even though it may appear quite successful when the strategies were initially implemented (such as Russia before mid-1970s).

3.6 Economic Reforms

This subsection discusses different approaches to economic reform when a country realizes that its CAD strategy is not working. We assume that the reform starts at the time when the CAD strategy becomes economically infeasible. One approach to reform is to switch immediately to a laissez-faire policy right after abandoning the CAD strategy. We show that under this "shock-therapy" approach, the economy would experience a lengthy period of deindustrialization (i.e., n decreases rapidly) before bouncing back and eventually converging to the same steady-state as the laissez-faire equilibrium (both in terms of the number of industrialized sectors and GDP). The paths of industrialization under CAD first and "shock-therapy" reform second and the corresponding GDP level are presented by the CAD-LF curve in purple in figure 21 and figure 22, respectively. This experiment may explain what happened in Russia before and after its economic reform in the late 1980s as well as and in Latin America after its radical deregulation in the 1980s.

[insert figure 21 here]

[insert figure 22 here]

An alternative approach to economic reform is for the government to continue to play an active role during the entire reform and post-reform periods, but its industrial policies are switched from the CAD strategy to the social planner's strategy—which is based on and consistent with the economy's endowment structure and comparative advantage. We show that the economy under this alternative approach would experience only a very mild deindustrialization when more resources being reallocated to labor-intensive industries congruent with the factor endowment structure. But this comparative-advantage-following strategy enables the economy to grow fast in terms of GDP level as soon as the reform starts and eventually converges to the first-best steady-state with full industrialization. The path of industrialization and the corresponding GDP level are shown in Figure 21 and Figure 22 by the CAD-SP curve in green, respectively. This experiment is reminiscent of the path of economic reform followed by China since 1978.

4 Conclusion

Why do some economies fail to industrialize and stuck in poverty trap, some end up with incomplete industrialization and incapable of becoming high-income economies after reaching the middle-income status, while a few other economies manage to escape both the poverty trap and the middle-income trap, achieving complete industrialization? Why do laissez-faire approach and big-push approach both largely fail in the real world? To shed light on these important questions, we develop a simple dynamic model of technology choice constrained by the economy's endowment structure to study the role of state in industrialization. We show that: 1. Laissez-faire policies would lead to poverty trap or low-level of industrialization due to market coordination failures; 2. When the state tries to prematurely adopt the "big push" strategy by promoting capital-intensive technologies that are inconsistent with the comparative advantage governed by the factor endowment structure, it would result in short-lived, incomplete industrialization and unsustainable development, even if such comparative-advantage-defying (CAD) development strategies could overcome coordination failure; 3. The "market-led-and-state-facilitated" approach that designs industrial policies consistent with the evolving endowment structure would enable a developing economy to achieve complete industrialization and successfully catch up with the high-income countries. Moreover, when CAD strategies are followed, the resulting premature industrialization could be even worse than the laissez-faire market equilibrium in terms of welfare; 4. Government facilitation is also needed in reforms after abandoning the CAD strategies, and shock therapy or Laissez-faire reform approach would cause too much deindustrialization, too slow recovery and too low long-run steady-state of GDP and welfare.

References

[1] Acemoglu, D., & Ventura, J. (2002). The world income distribution. The Quarterly Journal of Economics, 117(2), 659-694.

[2] Aghion, P., Cai, J., Dewatripont, M., Du, L., Harrison, A., & Legros, P. (2015). Industrial policy and competition. American Economic Journal: Macroeconomics, 7(4), 1-32.

[3] Bardhan, P. (2012). Awakening giants, feet of clay. In Awakening Giants, Feet of Clay. Princeton University Press.

[4] Basu, S., & Weil, D. N. (1998). Appropriate technology and growth. The Quarterly Journal of Economics, 113(4), 1025-1054.

[5] Buera, F. J., Hopenhayn, H., Shin, Y., & Trachter, N. (2021). Big Push in Distorted Economies (No. w28561). National Bureau of Economic Research.

[6] Crouzet, N., Gupta, A., & Mezzanotti, F. (2019). Shocks and technology adoption: Evidence from electronic payment systems. Techn. rep., Northwestern University Working Paper.

[7] Davis, D. R. and Weinstein, D. E. (2002). Bones, bombs, and break points: The geography of economic activity. American Economic Review, 92(5): 1269-1289.

[8] Davis, D. R. and Weinstein, D. E. (2008). A search for multiple equilibria in urban industrial structure. Journal of Regional Science, 48(1): 29-65.

[9] Hall, R., Jones, C.I. (1999). "Why do some countries produce so much more output per worker than others?".Quarterly Journal of Economics 114 (1), 83–116.

[10] Harrison, A., & Rodriguez-Clare, A. (2010). Trade, foreign investment, and industrial policy for developing countries. Handbook of development economics, 5, 4039-4214.

[11] Itskhoki, O., & Moll, B. (2019). Optimal development policies with financial frictions. Econometrica, 87(1), 139-173.

[12] Ju, J., Lin, J. Y., & Wang, Y. (2015). Endowment structures, industrial dynamics, and economic growth. Journal of Monetary Economics, 76, 244-263.

[13] ____, (2011). Marshallian externality, industrial upgrading, and industrial policies. World Bank Policy Research Working Paper, (5796).

[14] Krugman, P. (1991). History Versus Expectations, Quarterly Journal of Economics 106(2): 651-667.

[15] Kline, P. and Moretti, E. (2014). Local economic development, agglomeration economies, and the big push: 100 years of evidence from the Tennessee Valley Authority. The Quarterly Journal of Economics, 129(1): 275-331.

[16] Lane, N. (2019). Manufacturing revolutions: Industrial policy and industrialization in South Korea. Technical report, Monash University.

[17] Lin, J. Y. (2003). Development strategy, viability, and economic convergence. Economic Development and Cultural Change, 51(2), 277-308.

[18] ____ (2009). Marshall Lectures: Economic development and transition: thought, strategy, and viability. Cambridge university press.

[19] Liu, E. (2019). Industrial policies in production networks. The Quarterly Journal of Economics, 134(4), 1883-1948.

[20] Lucas Jr, R. E. (1988). On the mechanics of economic development. Journal of monetary economics, 22(1), 3-42.

[21] Matsuyama, K. (1991). Increasing Returns, Industrialization, and Indeterminacy of Equilibrium. Quarterly Journal of Economics 106(2): 617-650.

[22] Murphy, K. M., Shleifer, A., & Vishny, R. W. (1989). Industrialization and the big push. Journal of political economy, 97(5), 1003-1026.

[23] Redding, S. J., Sturm, D. M., and Wolf, N. (2011). History and industry location: Evidence from German airports. The Review of Economics and Statistics, 93(3):814-831.

[24] Rodrik, D. (1996). Coordination failures and government policy: A model with applications to East Asia and Eastern Europe. Journal of international economics, 40(1-2), 1-22.

[25] _ _ _ _ (2005). Growth strategies. Handbook of economic growth, 1, 967-1014.

[26] —— (2008). *Normalizing Industrial Policies*, Washington, DC. World Bank Press .

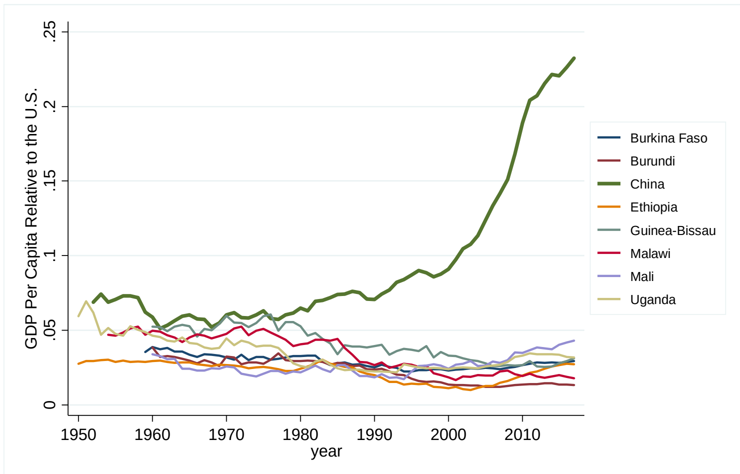
[27] Rosenstein-Rodan, P. N. (1943). Problems of industrialisation of eastern and south-eastern Europe. The economic journal, 53(210/211), 202-211.

[28] Stiglitz, J.E. & Lin, J. Y. (2013). The Industrial Policy Revolution I: The Role of Government Beyond Ideology. Palgrave Macmillan.

[29] World Bank. (2008). The growth report: Strategies for sustained growth and inclusive development.

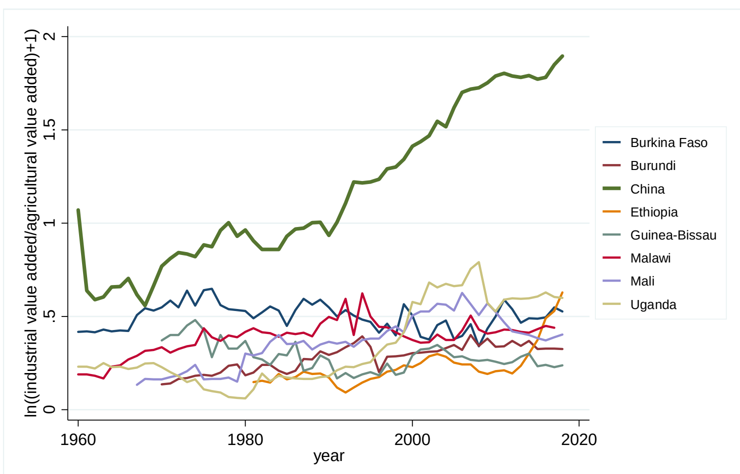
Figures

Figure 1: Economic Performances (Group 1)



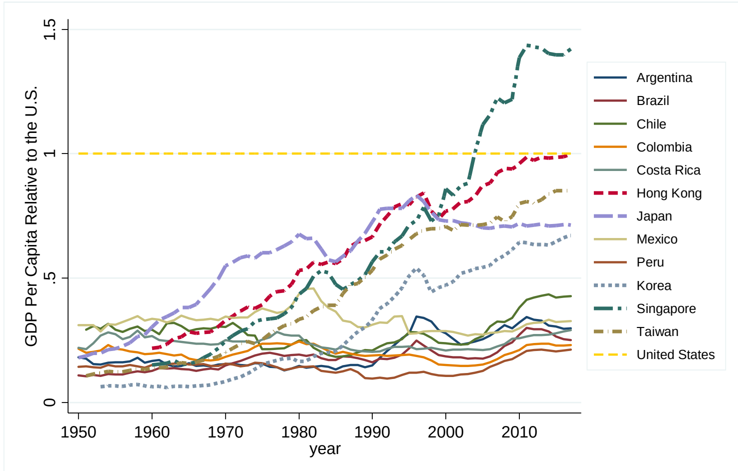
Notes. This figure shows the economic performances of China and Some African Countries. These data are calculated by the expenditure-side real GDP at chained PPPs and the population from Penn World Table.

Figure 2: Industrialization Levels (Group 1)



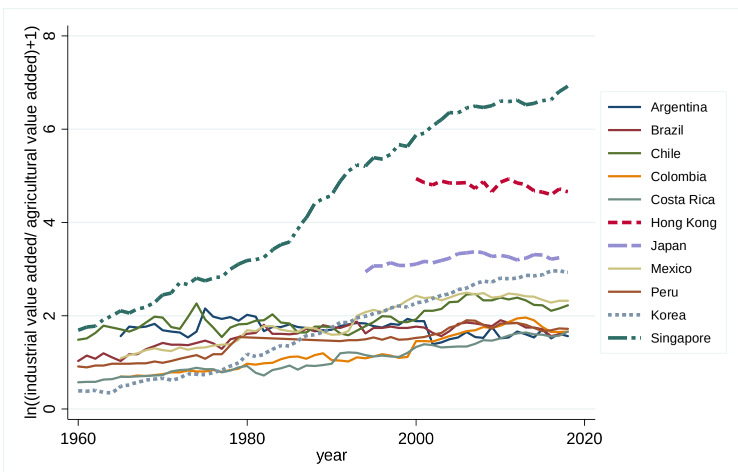
Notes. This figure shows the industrialization levels of China and some African countries. These data are calculated by the value added of agriculture, forestry and fishing and the value added of industry from WDI.

Figure 3: Economic Performances (Group 2)



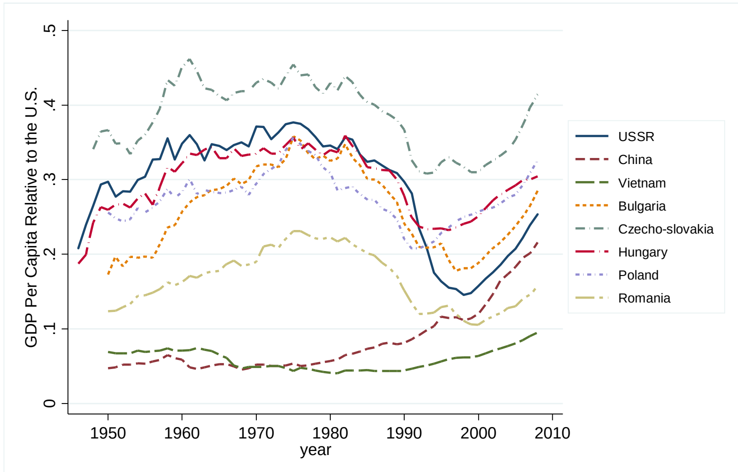
Notes. This figure shows the economic performances of Some East-Asian economies and some Latin American countries. These data are also calculated by the expenditure-side real GDP at chained PPPs and the population from Penn World Table.

Figure 4: Industrialization Levels (Group 2)



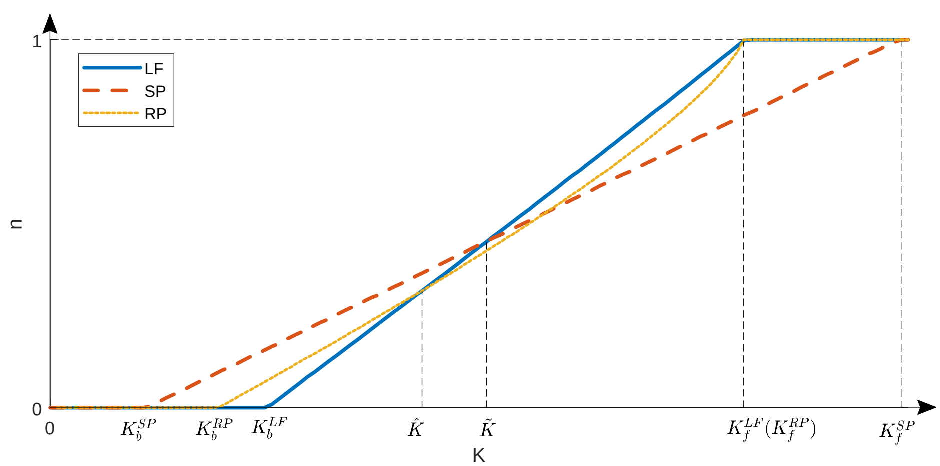
Notes. This figure shows the industrialization levels of Some East-Asian economies and some Latin American countries. These data are calculated by the value added of agriculture, forestry and fishing and the value added of industry from WDI.

Figure 5: Econmic Performances (Group 3)



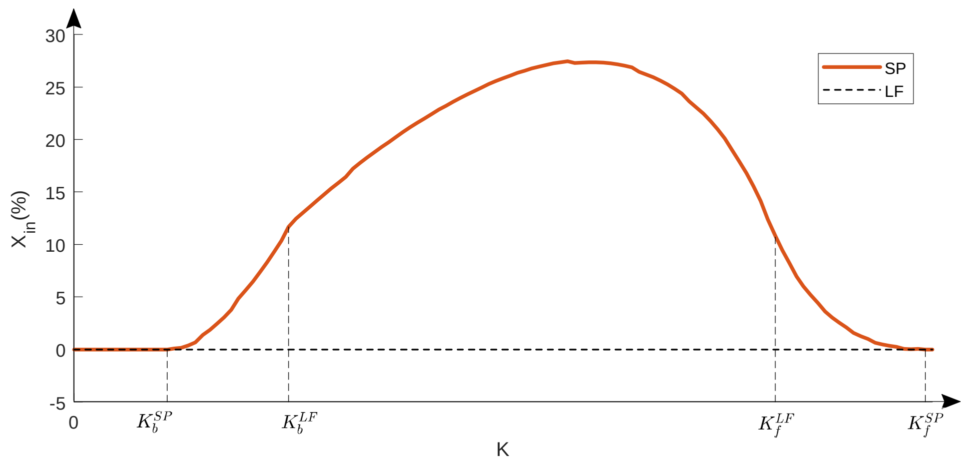
Notes. This figure shows the economic performances of Soviet Union, Vietnam and other fomer socialist economies. The data source is Maddison(2003).

Figure 6: The Number of Industrialized Sectors



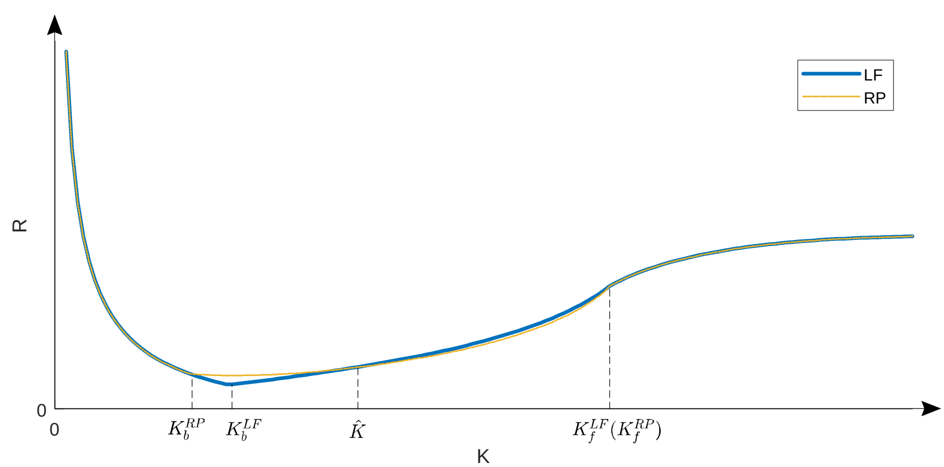
Notes. The blue line denotes the number of industrialized sectors in the Laissez-faire economy. The orange dashed line denotes the number of industrialized sectors in the social planner problem. The yellow dotted line denotes the number of industrialized sectors chosen by the Ramsey planner.

Figure 7: The Efficiency Comparison between Social Planner and Laissez-faire



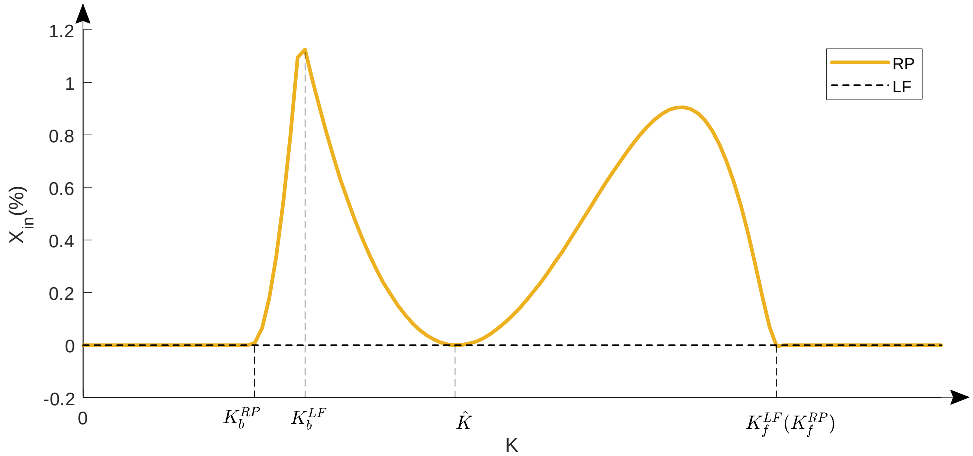
Notes. Line SP denotes the percentage increase in final goods in the social planner problem compared to the laissez-faire economy.

Figure 8: The Real Return to Capital



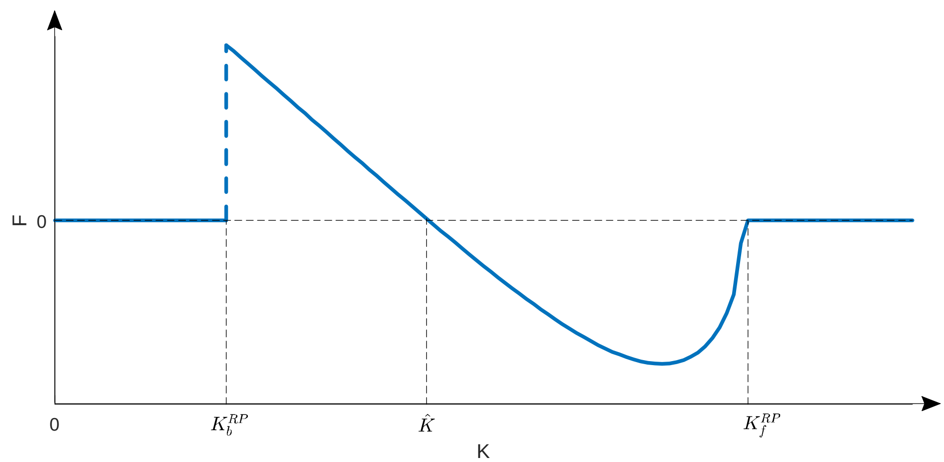
Notes. The real return to capital contains the rental revenue of capital as well as the profit. The blue line denotes the real return to capital in the laissez-faire economy. The yellow line denotes the real return to capital in the Ramsey planner problem.

Figure 9: The Efficiency Comparison Between Ramsey Planner and Laissez-faire



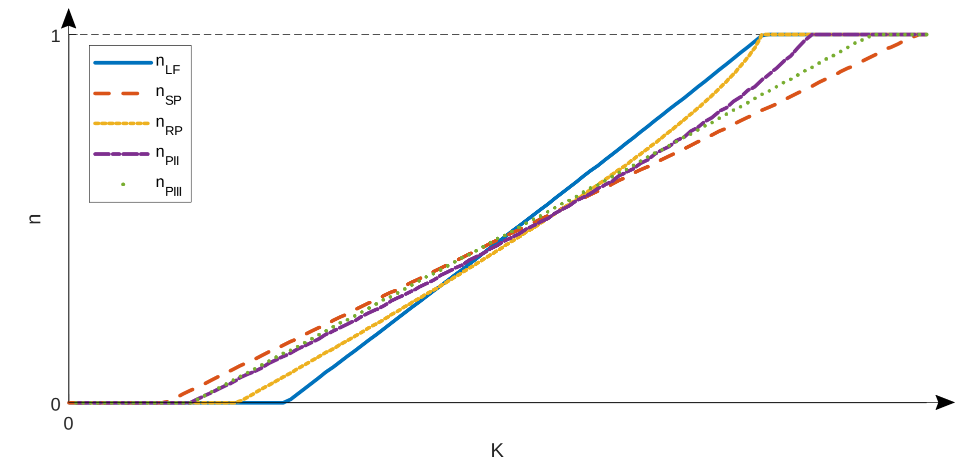
Notes. Line RP denotes the percentage increase in final goods in the Ramsey planner problem compared to the laissez-faire economy.

Figure 10: How F Changes with K



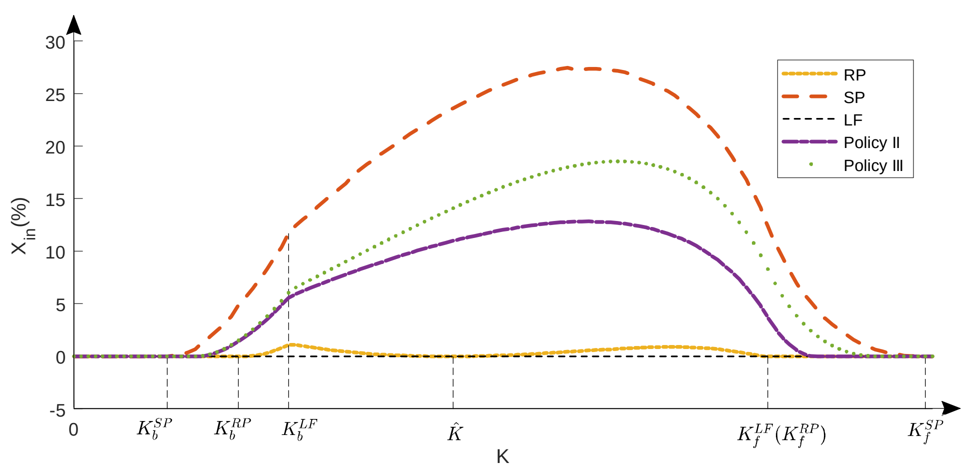
Notes. This figure shows how the optimal subsidy F changes with capital endowment K. When $K \in (K_b^{RP}, \hat{K})$, it is positive because the government wants more sectors to be industrialized. When $K \in (\hat{K}, K_f^{RP})$, it is negative because the government wants fewer sectors to be industrialized and industrialized sectors to produce more goods.

Figure 11: The Number of Industrialized Sectors under Different Policies



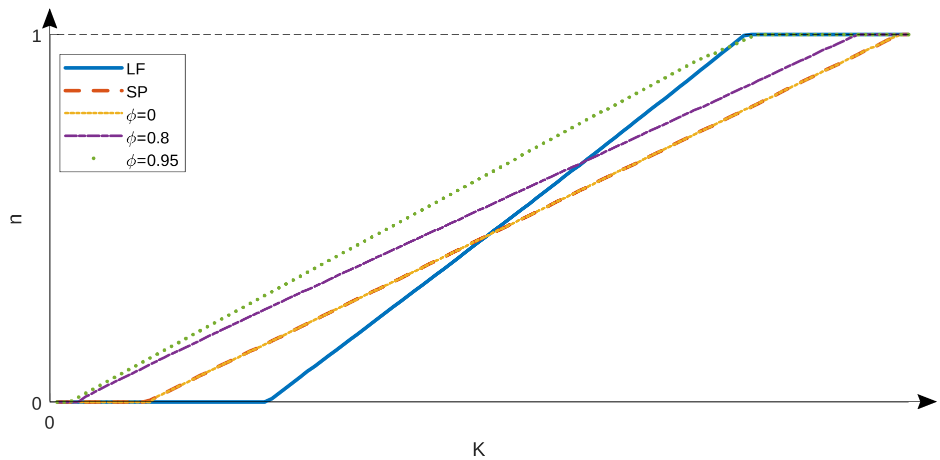
Notes. The number of industrialized sectors under industry policy I is the same as that in the Ramsey planner problem. Line n_{LF}, line n_{SP} and line n_{RP} denote the number of industrialized sectors in the laissez-faire economy, the social planner problem and the Ramsey planner problem, respectively. Line n_{PII} and line n_{PIII} denote the number of industrialized sectors under industry policy II and industry policy III, respectively.

Figure 12: The Efficiency Comparison between Different Policies



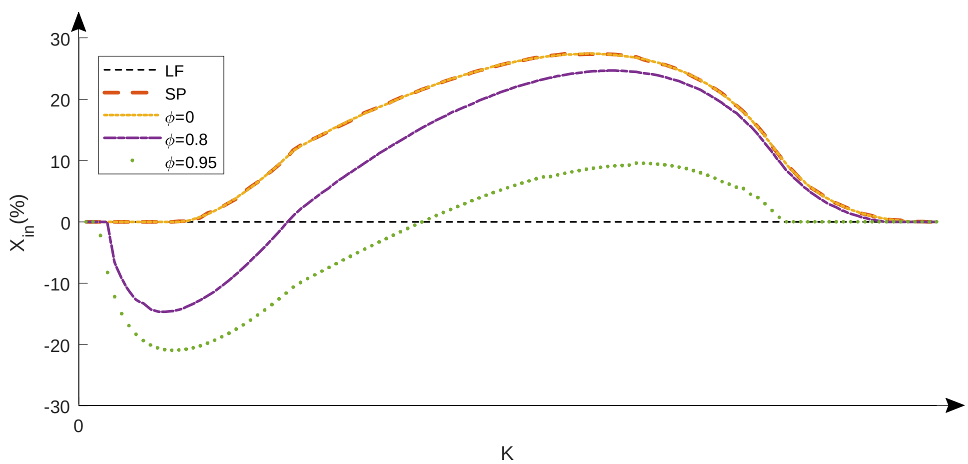
Notes. Line RP and Line SP denote the percentage increase in final goods in the Ramsey planner problem and the social planner problem, respectively. The percentage increase in final goods under industrial policy I is the same as that in the Ramsey planner problem.

Figure 13: The Number of Industrialized Sectors under Different ϕ



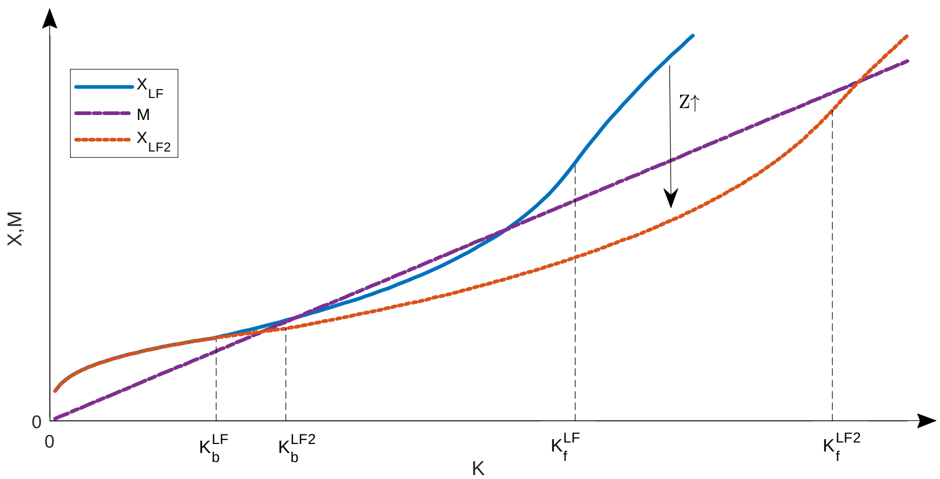
Notes. ϕ captures the state's desire for big push. When $\phi = 0$, the state's objective function is the same as the social planner, given those fiscal policy tools, the number of industrialized sectors is very close to that in the social planner problem.

Figure 14: The Efficiency Comparison between Different ϕ



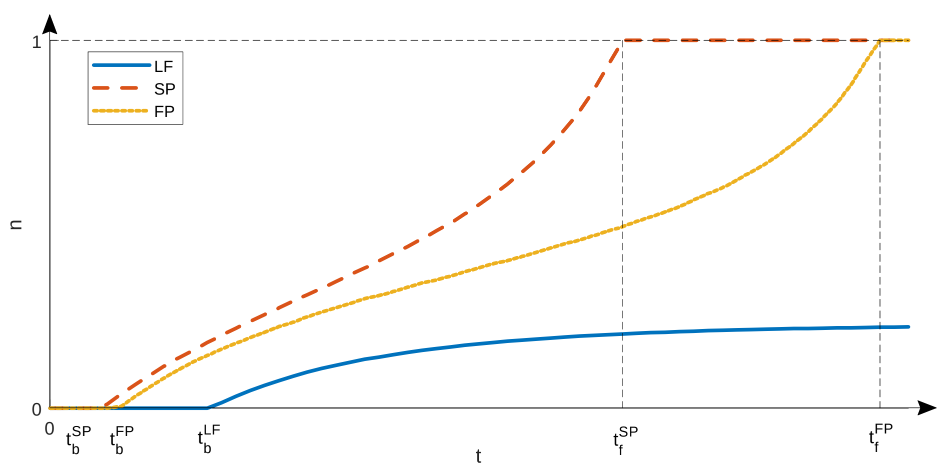
Notes. ϕ captures the state's desire for big push. When $\phi = 0$, the state's objective function is the same as the social planner, given those fiscal policy tools, the percentage increase in final goods is very close to that in the social planner problem.

Figure 15: Incomplete Industrialization in Laissez-faire Steady-state



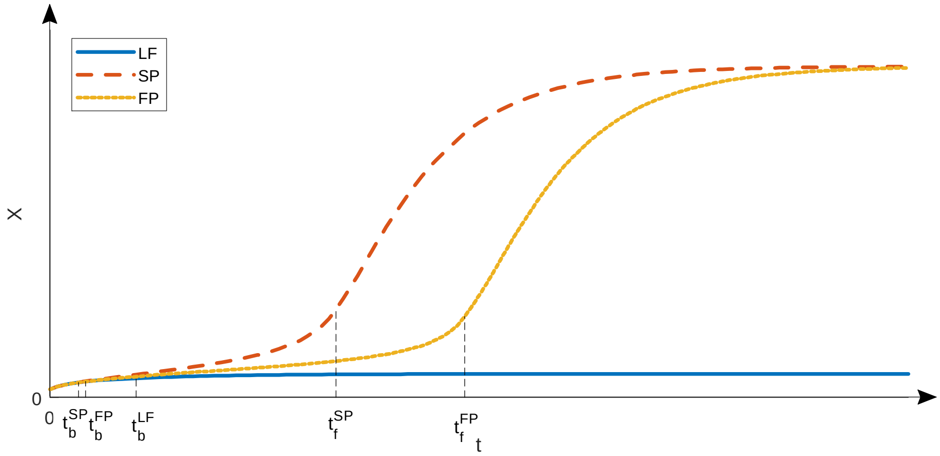
Notes. Line X_{LF} denotes the level of final output given capital endowment in the laissez-faire economy. Line M denotes the level of final output which makes capital investment and capital depreciation equal. Line X_{LF2} denotes the level of final output when fixed cost Z increases in the laissez-faire economy.

Figure 16: Industrialization Processes



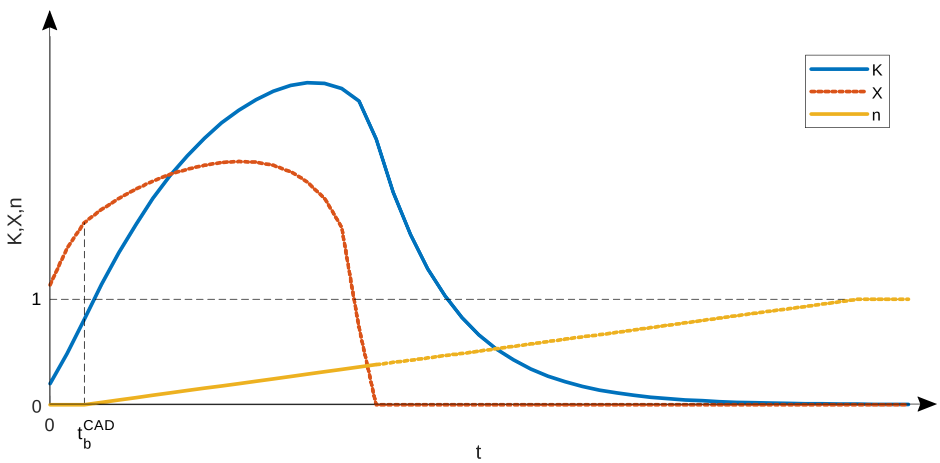
Notes. Line LF, line SP and line FP denote how the number of industrialized sectors changes over time in the laissez-faire economy, in the social planner problem, and under industrial policy III, respectively.

Figure 17: Time Paths of GDP



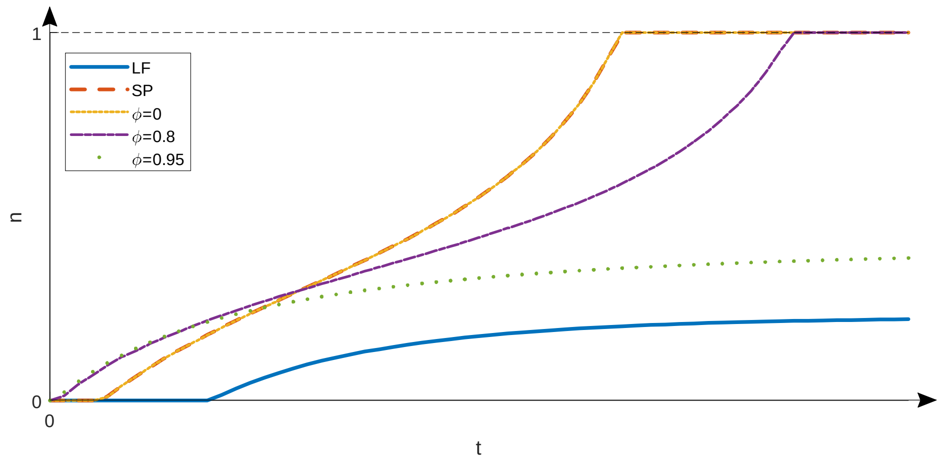
Notes. Line LF, line SP and line FP denote how the final output changes over time in the laissez-faire economy, in the social planner problem, and under industrial policy III, respectively.

Figure 18: Time Paths of K, X and n under CAD strategy



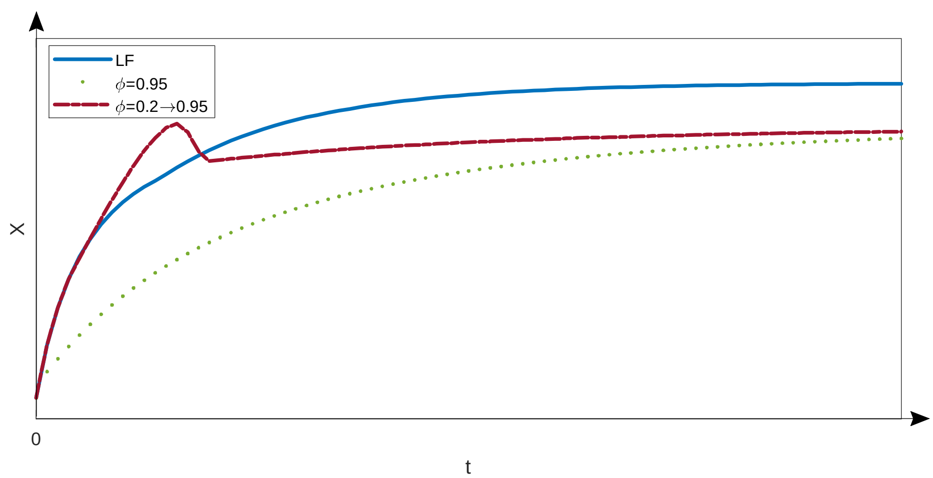
Notes. This figure shows the time paths of capital and final output when the state chooses n by following a linear rule of industrialization. They first increase and then decrease. The final output decreases to zero when all the capital is used to pay fixed costs.

Figure 19: Industrialization Processes for Different ϕ



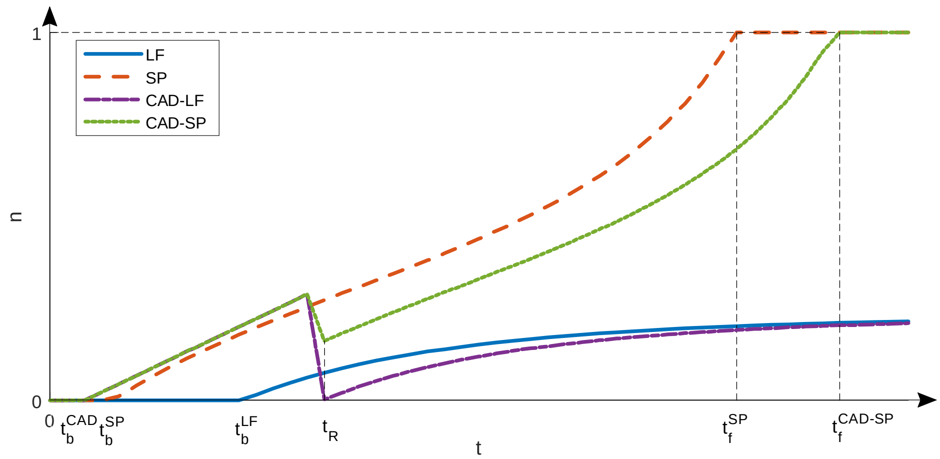
Notes. ϕ captures the state's desire for big push. When $\phi = 0$, the state's objective function is the same as the social planner, given those fiscal policy tools, the number of industrialized sectors is very close to that in the social planner problem.

Figure 20: The Time Paths of GDP



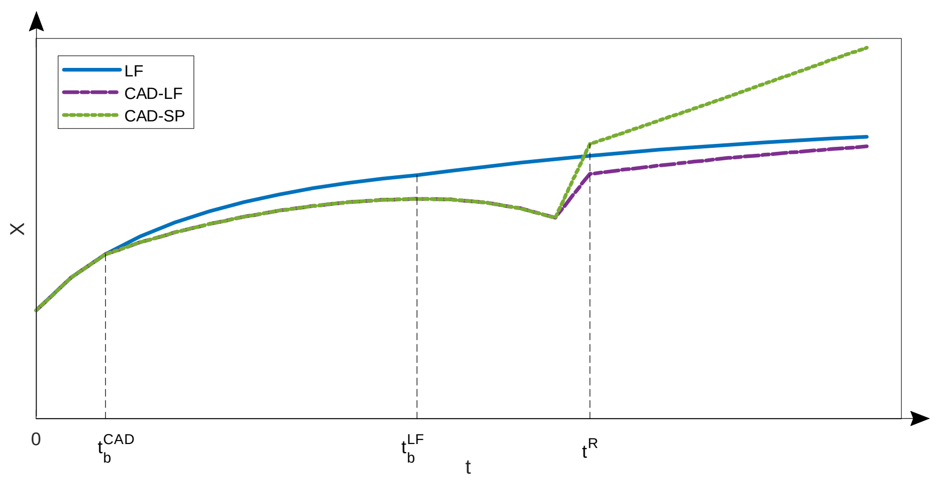
Notes. ϕ captures the state's desire for big push. When $\phi = 0.95$, the GDP is even lower than that in the laissez-faire equilibrium. When ϕ gradually increases from 0.2 to 0.95, the GDP exceeds that in the laissez-faire equilibrium first, then drops to a level lower than that in the laissez-faire equilibrium as the state is too eager to industrialize.

Figure 21: Industrialization Processes under Different Reform Approaches



Notes. Line CAD-LF denotes the number of industrialized sectors if the government switches to laissez-faire after the CAD strategy. Line CAD-SP denotes the number of industrialized sectors if the government continues to play an active role after the CAD strategy.

Figure 22: The Time Paths of GDP under Different Reform Approaches



Notes. Line CAD-LF denotes the time path of GDP if the government switches to laissez-faire after the CAD strategy. Line CAD-SP denotes the time path of GDP if the government continues to play an active role after the CAD strategy.

Appendix

A.1 Proof of Proposition 1

There are two cases to consider: (1) $p_B < p_A$ and (2) $p_B \geq p_A$.

A.1.1 Case 1: $p_B < p_A$.

In this case, during the transition phase ($0 < n < 1$) the endowment structure and the structural parameters are such that the equilibrium price of intermediate goods in industrialized sectors is $p(i) = p_B < p_A$ and that less than 100% of sectors are industrialized ($n < 1$). The price index of the final good is then given by

$$P = \left[n(\frac{w^{1-\beta}r^{\beta}}{\sigma B})^{\frac{\sigma}{\sigma-1}} + (1-n)(\frac{w^{1-\alpha}r^{\alpha}}{A})^{\frac{\sigma}{\sigma-1}} \right]^{\frac{\sigma-1}{\sigma}}. \tag{20}$$

The demand function for intermediate goods in the unindustrialized sectors is given by

$$x_A = \frac{(\frac{w^{1-\alpha}r^{\alpha}}{A})^{\frac{1}{\sigma-1}}}{P^{\frac{1}{\sigma-1}}} X$$

and that in the industrialized sectors is given by

$$x_B = \frac{(\frac{w^{1-\beta}r^{\beta}}{\sigma B})^{\frac{1}{\sigma-1}}}{P^{\frac{1}{\sigma-1}}} X,$$

so the aggregate demand of intermediate goods satisfies

$$(1-n)\, x_A + n x_B = \left[(1-n)\, (\frac{w^{1-\alpha}r^{\alpha}}{A})^{\frac{1}{\sigma-1}} + n(\frac{w^{1-\beta}r^{\beta}}{\sigma B})^{\frac{1}{\sigma-1}} \right] \frac{X}{P^{\frac{1}{\sigma-1}}}.$$

Labor Market. Combining the demand function and the production function of intermediate goods in the unindustrialized sectors yields the labor demand in the unindustrialized sectors:

$$L_A = (1-\alpha)\frac{(w^{1-\alpha\sigma}r^{\alpha\sigma})^{\frac{1}{\sigma-1}}}{A^{\frac{\sigma}{\sigma-1}} P^{\frac{1}{\sigma-1}}} X.$$

Similarly, the labor demand in the industrialized sectors is given by

$$L_B = (1-\beta)\frac{(w^{1-\beta\sigma}r^{\beta\sigma})^{\frac{1}{\sigma-1}}}{B^{\frac{\sigma}{\sigma-1}} \sigma^{\frac{1}{\sigma-1}} P^{\frac{1}{\sigma-1}}} X.$$

The labor market-clearing condition then implies

$$L = (1-n)L_A + nL_B = \left[(1-n)(1-\alpha)\frac{(w^{1-\alpha\sigma}r^{\alpha\sigma})^{\frac{1}{\sigma-1}}}{A^{\frac{\sigma}{\sigma-1}}} + n(1-\beta)\frac{(w^{1-\beta\sigma}r^{\beta\sigma})^{\frac{1}{\sigma-1}}}{B^{\frac{\sigma}{\sigma-1}} \sigma^{\frac{1}{\sigma-1}}} \right] \frac{X}{P^{\frac{1}{\sigma-1}}}. \tag{21}$$

Capital Market. The demand for capital in the unindustrialized sectors is

$$K_A = \frac{\alpha w}{(1-\alpha)r} L_A = \alpha \frac{(w^{\sigma-\alpha\sigma} r^{1-\sigma+\alpha\sigma})^{\frac{1}{\sigma-1}}}{A^{\frac{\sigma}{\sigma-1}} P^{\frac{1}{\sigma-1}}} X,$$

and the demand for capital in industrialized sectors is

$$K_B = \frac{\beta w}{(1-\beta)r} L_B = \beta \frac{(w^{\sigma-\beta\sigma} r^{1-\sigma+\beta\sigma})^{\frac{1}{\sigma-1}}}{B^{\frac{\sigma}{\sigma-1}} \sigma^{\frac{1}{\sigma-1}} P^{\frac{1}{\sigma-1}}} X.$$

The capital market-clearing condition implies

$$K = (1-n)K_A + nK_B + nz = \left[(1-n)\alpha \frac{(w^{\sigma-\alpha\sigma} r^{1-\sigma+\alpha\sigma})^{\frac{1}{\sigma-1}}}{A^{\frac{\sigma}{\sigma-1}}} + n\beta \frac{(w^{\sigma-\beta\sigma} r^{1-\sigma+\beta\sigma})^{\frac{1}{\sigma-1}}}{B^{\frac{\sigma}{\sigma-1}} \sigma^{\frac{1}{\sigma-1}}} \right] \frac{X}{P^{\frac{1}{\sigma-1}}} + nz. \quad (22)$$

Profit Condition. Since unindustrialized sectors are perfectly competitive, all firms in these sectors earn zero profit: $\pi_A = 0$. However, since in equilibrium $n < 1$, a firm's profit in the industrialized sectors must also be zero, otherwise firms in the unindustrialized sectors have incentives to adopt capital-intensive technology B (to become industrialized) to further increase n. That is, for n to be an equilibrium, the following zero-profit condition must hold for the industrialized sectors:

$$\pi_B = (1-\sigma) \frac{(w^{1-\beta} r^{\beta})^{\frac{\sigma}{\sigma-1}}}{(\sigma B)^{\frac{\sigma}{\sigma-1}} P^{\frac{1}{\sigma-1}}} X - rz = 0. \quad (23)$$

The aggregate profit is then

$$\Pi = (1-n)\pi_A + n\pi_B = 0.$$

The household budget constraint is given by

$$wL + rK + \Pi\,(=0) = PX.$$

We normalize $P = 1$. Then equation (20), (21), (22) and (23) become

$$n(p_B)^{\frac{\sigma}{\sigma-1}} + (1-n)(p_A)^{\frac{\sigma}{\sigma-1}} = 1 \quad (24)$$

$$(1-n)(1-\alpha)\frac{(p_A)^{\frac{\sigma}{\sigma-1}}}{w} X + n(1-\beta)\sigma \frac{(p_B)^{\frac{\sigma}{\sigma-1}}}{w} X = L \quad (25)$$

$$(1-n)\alpha \frac{(p_A)^{\frac{\sigma}{\sigma-1}}}{r} X + n\beta\sigma \frac{(p_B)^{\frac{\sigma}{\sigma-1}}}{r} X + nz = K \quad (26)$$

$$(1-\sigma)(p_B)^{\frac{\sigma}{\sigma-1}} X = rz \quad (27)$$

Substitute (24) and (27) into (25), we have

$$(1-\alpha)\frac{rz}{(1-\sigma)w}\frac{1-n(p_B)^{\frac{\sigma}{\sigma-1}}}{(p_B)^{\frac{\sigma}{\sigma-1}}}+n(1-\beta)\sigma\frac{rz}{(1-\sigma)w}=L. \tag{28}$$

Substitute (24) and (27) into (26), we have

$$\alpha\frac{1-n(p_B)^{\frac{\sigma}{\sigma-1}}}{(p_B)^{\frac{\sigma}{\sigma-1}}}\frac{z}{1-\sigma}+n\beta\sigma\frac{z}{1-\sigma}+nz=K.$$

By the definition of p_A and p_B , we have

$$\frac{r}{w}=[\frac{A}{\sigma B}(\frac{1-n(p_B)^{\frac{\sigma}{\sigma-1}}}{(1-n)(p_B)^{\frac{\sigma}{\sigma-1}}})^{\frac{\sigma-1}{\sigma}}]^{\frac{1}{\alpha-\beta}} \tag{29}$$

Substitute (29) into (28), we have

$$[\frac{(1-\beta)\sigma-(1-\alpha)}{1-\sigma}n+\frac{1-\alpha}{(1-\sigma)(p_B)^{\frac{\sigma}{\sigma-1}}}][\frac{A}{\sigma B}(\frac{1-n(p_B)^{\frac{\sigma}{\sigma-1}}}{(1-n)(p_B)^{\frac{\sigma}{\sigma-1}}})^{\frac{\sigma-1}{\sigma}}]^{\frac{1}{\alpha-\beta}}z=L$$

We define

$$G(n,p_B)=[n\beta\sigma+\frac{\alpha}{(p_B)^{\frac{\sigma}{\sigma-1}}}-\alpha n+n(1-\sigma)]\frac{z}{1-\sigma}-K$$

and

$$H(n,p_B)=[\frac{(1-\beta)\sigma-(1-\alpha)}{1-\sigma}n+\frac{1-\alpha}{(1-\sigma)(p_B)^{\frac{\sigma}{\sigma-1}}}][\frac{A}{\sigma B}(\frac{1-n(p_B)^{\frac{\sigma}{\sigma-1}}}{(1-n)(p_B)^{\frac{\sigma}{\sigma-1}}})^{\frac{\sigma-1}{\sigma}}]^{\frac{1}{\alpha-\beta}}z-L.$$

So the equilibrium is the pair $\{n^*,p_B^*\}$ which satisfies $G(n^*,p_B^*)=0$, $H(n^*,p_B^*)=0$, $p_B^*<p_A^*$, and $n^*\in(0,1)$ under Case 1. Notice that $G(n,p_B)=0$ describes the capital market-clearing equilibrium locus and that $H(n,p_B)=0$ describes labor market-clearing equilibrium locus. The coefficient of n is positive in the G curve and negative in the H curve. So the $G=0$ locus is downward sloping and the $H=0$ locus is upward sloping in the (n,p_B) space, and a higher capital endowment will shift the curve $G\,(n,p_B)$ up and outward and will not affect the curve $H\,(n,p_B)$. The two curves are drawn in Figure A1.

To ensure $n^*>0$, we need capital endowment to be large enough so that at $n=0$ the $G(n,p_B)=0$ locus lines above the $H(n,p_B)=0$ locus, which implies a cutoff K_1 such that

$$K>K_1\equiv\alpha(\frac{A}{\sigma B})^{\frac{\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}(\frac{z}{1-\sigma})^{\frac{1-\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}(\frac{L}{1-\alpha})^{\frac{\beta\sigma-\alpha\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}.$$

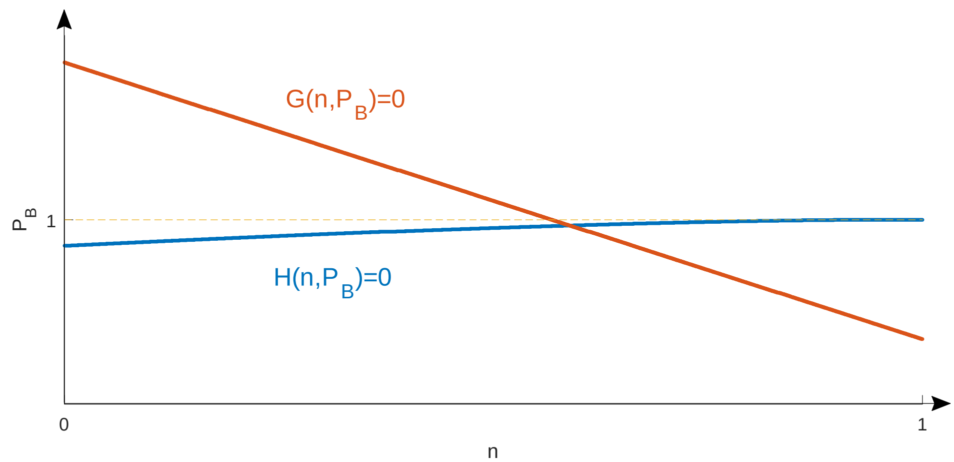
In other words, if $K\leq K_1$, then $n^*=0$ and no firms have adopted the capital-intensive technology in any sectors yet. So $K>K_1$ implies $n^*>0$ for a given level of L.

Since P is normalized to 1, then $p_B=1$ implies $p_A=1$. To ensure that $p_B^*<p_A^*$, we need $p_B^*<1$ or the intersection of $G(n,p_B)=0$ and $H(n,p_B)=0$ to be lower than the dashed line $p_B=1$, which implies a cutoff K_2 such that

$$K < K_2 \equiv \frac{z}{1-\sigma} - (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L.$$

In other words, to ensure that $p_B < p_A$, we need $K < K_2$.

Figure A1: Equilibrium Solution (Case 1)



Notes. This figure shows how n^* is determined by the intersection between $G(n^*, p_B^*) = 0$ locus and $H(n^*, p_B^*) = 0$ locus. The dashed line denotes the reference point where $p_B = 1$.

Notice that when $K = K_2$, we have $n^* = \frac{(1-\alpha)z-(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}(1-\sigma)L}{(\beta\sigma-\alpha+1-\sigma)z}$. To ensure that $n^* < 1$, we also need another cutoff for the capital stock: namely, we need the curve $G(n, P_B) = 0$ lies below the curve $H(n, P_B) = 0$ at $n = 1$, which implies a cutoff K_3 such that

$$K < K_3 \equiv \frac{1-\sigma+\beta\sigma}{1-\sigma} z. \tag{30}$$

On the other hand, if industrialization is finished, then $n = 1$, and all sectors are industrialized with $x_A = 0$, $x_B = X$, and in this case we have $p(i) = p_B = 1$ for all $i \in [0, 1]$. Since there are no more firms using the labor-intensive technology, firms in all the industrialized sectors now have positive profits despite the fact that $p_B < p_A$. In this case, the labor market clearing implies

$$L = L_B = \frac{1-\beta}{B} (\frac{r}{w})^{\beta} X \tag{31}$$

and capital market clearing implies

$$K = K_B + z = \frac{\beta}{B} (\frac{r}{w})^{\beta-1} X + z. \tag{32}$$

Under the normalization $P = 1$, we have

$$1 = [n(\frac{w^{1-\beta} r^{\beta}}{\sigma B})^{\frac{\sigma}{\sigma-1}} + (1-n)(\frac{w^{1-\alpha} r^{\alpha}}{A})^{\frac{\sigma}{\sigma-1}}]^{\frac{\sigma-1}{\sigma}} = \frac{w^{1-\beta} r^{\beta}}{\sigma B},$$

which also implies that $p_B = 1$ or $\sigma B = w^{1-\beta} r^{\beta}$. Substituting $\frac{w^{1-\beta} r^{\beta}}{\sigma B} = 1$ into (31) and (32) gives

$$X = B \frac{(K-z)^{\beta} L^{1-\beta}}{(1-\beta)^{1-\beta} \beta^{\beta}},$$

$$r = \sigma\beta \frac{X}{K-z} = \sigma B (\frac{\beta L}{(K-z)(1-\beta)})^{1-\beta}, \tag{33}$$

$$w = \sigma (1-\beta) \frac{X}{L} = \sigma B (\frac{(K-z)(1-\beta)}{\beta L})^{\beta}. \tag{34}$$

The aggregate profit is then

$$\Pi = (1-\sigma) P_B X - rz = \frac{(1-\sigma) BL (K-z) - \sigma\beta BLz}{\beta^{\beta} (1-\beta)^{1-\beta} L^{\beta} (K-z)^{1-\beta}}.$$

When $n^* = 1$, the profit of industrialized firms must be nonnegative, which implies the cutoff K_3 such that

$$K \geq K_3 \equiv \frac{1-\sigma+\beta\sigma}{1-\sigma} z,$$

which is obviously identical to the cutoff in equation (30).

To ensure $P_B < P_A$ at $n = 1$, we also need the condition

$$\frac{w^{1-\alpha} r^{\alpha}}{A} > 1. \tag{35}$$

Substitute (33) and (34) into (35), we have

$$K > z + \frac{\beta}{1-\beta} (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L \equiv K_4,$$

which defines the 4th cutoff K_4.

In conclusion, during the transitional phase, for any given level of L, when the capital endowment is in the interval $K \in (K_1, \min\{K_2, K_3\})$, we have $p_B < p_A$ and $0 < n^* < 1$. In this interval, if K increases, then n^* increases. Obviously, holding K constant, if L increases, then n^* decreases. On the other hand, if $K \geq \min\{K_3, K_4\}$, all of the intermediate-goods sectors are industrialized ($n = 1$) and the firms will set their price at $p_B = P = 1$. Within this interval, if K increases, the price of capital r decreases because the marginal product of capital declines, but the wage rate w increases because the marginal product of labor increases; the aggregate output X and aggregate profit Π also increase with K.

A.1.2 Case 2: $p_B \geq p_A$.

When $p_B \geq p_A$, during the transition ($0 < n < 1$) the optimal monopoly price in the industrialized sectors is to set $p(i) = p_A$, otherwise type-B firm will not be able to capture demand if it sets $p(i) = p_B$. So the price of the final good $P = p_A$. Since $P = 1$ and both types of firms charge the same price, equation (6) implies that the demand from both unindustrialized sectors and industrialized sectors are also the same: $x_A = x_B = X$.

The labor demand of the firms using the labor-intensive technology can be solved from combining the goods demand function and the production function to obtain

$$L_A = \frac{1-\alpha}{A}(\frac{r}{w})^{\alpha} X.$$

Similarly, the labor demand in the industrialized sectors is given by

$$L_B = \frac{1-\beta}{B}(\frac{r}{w})^{\beta} X.$$

Labor market clearing implies

$$L = (1-n)L_A + nL_B = \left[(1-n)\frac{1-\alpha}{A}(\frac{r}{w})^{\alpha} + n\frac{1-\beta}{B}(\frac{r}{w})^{\beta}\right] X. \tag{36}$$

Analogously, the capital demand in the unindustrialized sectors is given by

$$K_A = \frac{\alpha w}{(1-\alpha)r} L_A = \frac{\alpha}{A}(\frac{r}{w})^{\alpha-1} X,$$

and the capital demand in the industrialized sectors is given by

$$K_B = \frac{\beta w}{(1-\beta)r} L_B = \frac{\beta}{B}(\frac{r}{w})^{\beta-1} X.$$

Capital market clearing implies

$$K = (1-n)K_A + nK_B + nz = \left[(1-n)\frac{\alpha}{A}(\frac{r}{w})^{\alpha-1} + n\frac{\beta}{B}(\frac{r}{w})^{\beta-1}\right] X + nz. \tag{37}$$

As firms in the unindustrialized sectors are perfectly competitive, their profit $\pi_A = 0$. And when $n < 1$, firms' profit in the industrialized sectors are also zero, otherwise unindustrialized sectors have incentive to industrialize, which would change n. Hence, given the zero profit condition

$$\pi_B = \left(\frac{w^{1-\alpha} r^{\alpha}}{A} - \frac{w^{1-\beta} r^{\beta}}{B}\right) X - rz = 0. \tag{38}$$

Substitute (38) into (36) and (37) and normalize $w = 1$, we have

$$\left[n\frac{\beta-1}{B} r^{\beta-1} + \frac{\alpha(1-n)+n}{A} r^{\alpha-1}\right] \frac{z}{\frac{r^{\alpha-1}}{A} - \frac{r^{\beta-1}}{B}} = K$$

and

$$\left[n\frac{1-\beta}{B}r^{\beta}+\frac{(1-n)(1-\alpha)}{A}r^{\alpha}\right]\frac{z}{\frac{r^{\alpha-1}}{A}-\frac{r^{\beta-1}}{B}}=L.$$

We define

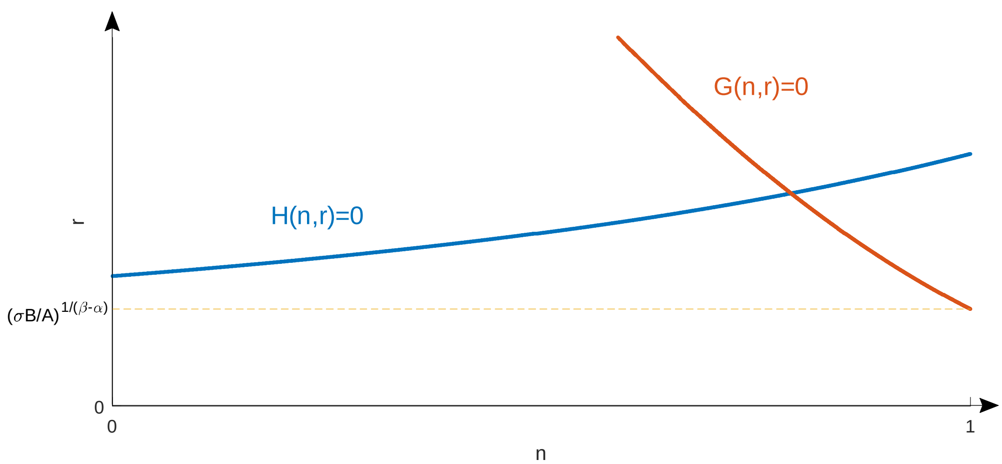
$$G(n,r)\equiv\left[n\frac{\beta-1}{B}r^{\beta-1}+\frac{\alpha(1-n)+n}{A}r^{\alpha-1}\right]z-\left(\frac{r^{\alpha-1}}{A}-\frac{r^{\beta-1}}{B}\right)K$$

and

$$H(n,r)\equiv\left[n\frac{1-\beta}{B}r^{\beta}+\frac{(1-n)(1-\alpha)}{A}r^{\alpha}\right]z-\left(\frac{r^{\alpha-1}}{A}-\frac{r^{\beta-1}}{B}\right)L.$$

The intersection of these two curves will pin down the equilibrium values of (n^*, r^*), as shown in Figure A2.

Figure A2: Equilibrium Solution (Case 2)



Notes. This figure shows that the equilibrium point (n^*, r^*) is determined by the intersection of the $G(n,r)=0$ locus and the $H(n,r)=0$ locus. The dashed line denotes the reference locus $r=(\frac{\sigma B}{A})^{\frac{1}{\beta-\alpha}}$.

To ensure $n^*>0$, we need capital endowments to be large enough. This means that at $n=0$ we need the position of the $G(n,r)=0$ locus to lie above the $H(n,r)=0$ locus, which implies a cutoff K_5 such that

$$\frac{1-\alpha}{\alpha}K_5-(\frac{A}{B})^{\frac{1}{\beta-\alpha}}(\frac{K_5-\alpha z}{K_5})^{\frac{-1}{\beta-\alpha}}L=0.$$

To ensure $p_B\geq p_A$, which means $r\geq(\frac{\boldsymbol{\sigma}B}{A})^{\frac{1}{\beta-\alpha}}$, we need the intersection of $G(n,r)=0$ and $H(n,r)=0$ to lie above the reference line $r=(\frac{\boldsymbol{\sigma}B}{A})^{\frac{1}{\beta-\alpha}}$. This implies a cutoff K_2 for capital such that

$$K\geq K_2\equiv\frac{z}{1-\sigma}-(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L.$$

This threshold K_2 is the same as that in Case 1, because it is the same threshold that ensures $p_B<p_A$.

To ensure $n^*<1$, we also need the capital endowment not to be too large, otherwise $G(n,r)=0$ and

$H(n,r) = 0$ will not intersect at $n^* < 1$. This implies

$$(\frac{\beta L}{1-\beta})^{\beta-\alpha} A[K - (1-\beta)z] - B(K-z)^{1+\beta-\alpha} > 0,$$

or a cutoff of capital K_6 such that

$$(\frac{\beta L}{1-\beta})^{\beta-\alpha} A[K_6 - (1-\beta)z] - B(K_6-z)^{1+\beta-\alpha} = 0.$$

On the other hand, if $n = 1$ and $p_B \geq p_A$, then $P = p_A = 1$, $x_B = X$, $x_A = 0$. Labor market clearing implies

$$L = L_B = \frac{1-\beta}{B}(\frac{r}{w})^{\beta} X, \tag{39}$$

and capital market clearing implies

$$K = z + K_B = \frac{\beta}{B}(\frac{r}{w})^{\beta-1} X + z. \tag{40}$$

Substitute $\frac{w^{1-\alpha} r^{\alpha}}{A} = 1$ into (39) and (40), we have

$$X = \frac{BL}{1-\beta}(\frac{(1-\beta)(K-z)}{\beta L})^{\beta},$$

$$r = A(\frac{(1-\beta)(K-z)}{\beta L})^{\alpha-1}, \tag{41}$$

$$w = A(\frac{(1-\beta)(K-z)}{\beta L})^{\alpha}. \tag{42}$$

The aggregate profit is

$$\Pi = \pi_B = \frac{BL}{1-\beta}(\frac{(1-\beta)(K-z)}{\beta L})^{\beta} - \frac{AL}{1-\beta}(\frac{(1-\beta)(K-z)}{\beta L})^{\alpha} - A(\frac{(1-\beta)(K-z)}{\beta L})^{\alpha-1} z.$$

When $n = 1$, the profit of industrialized firms must be nonnegative, which implies a cutoff K_6 such that

$$B(K_6 - z)^{1+\beta-\alpha} - (\frac{\beta L}{1-\beta})^{\beta-\alpha} A[K_6 - (1-\beta)z] = 0.$$

To ensure $P_B \geq P_A$, on the other hand, we need

$$\frac{w^{1-\beta} r^{\beta}}{\sigma B} \geq 1. \tag{43}$$

Substitute (41) and (42) into (43), we have

$$K \leq z + \frac{\beta}{1-\beta}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L \equiv K_4.$$

This threshold K_4 is the same as that in Case 1, because it is the threshold which separates $p_B < p_A$ and $p_B \geq p_A$ when $n = 1$ under Case 1 and Case 2.

In conclusion, during the transition phase ($0 \leq n < 1$), if capital is in the interval $\max\{K_2, K_5\} \leq K < K_6$, then as K increases, n increases, r increases. If L increases, n decreases, r increases. When $K \geq K_4$, the industrialization is complete and we have $n = 1$, $P = p_B$, and all sectors are industrialized. But when $K_6 \leq K < K_4$, all the sectors will industrialize and the industrialized firms will set their price at $p(i) = p_A$. If K increases, r decreases as marginal return of capital declines, w increases as marginal productivity of labor increases, X and Π also increase.

A.1.3 Summary

As the above analyses show, there are six possible thresholds of capital (endowment structure) in the determination of industrialization:

1. $K_1 = \alpha(\frac{A}{\sigma B})^{\frac{\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}(\frac{z}{1-\sigma})^{\frac{1-\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}(\frac{L}{1-\alpha})^{\frac{\beta\sigma-\alpha\sigma}{1-\sigma+\beta\sigma-\alpha\sigma}}$ is the threshold where some sectors begin to industrialize $n > 0$ under the condition $p_B < p_A$;

2. $K_2 = \frac{z}{1-\sigma} - (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L$ is the threshold where industrialization is incomplete ($n < 1$) under the condition $p_B = p_A$;

3. $K_3 = \frac{1-\sigma+\beta\sigma}{1-\sigma} z$ is the threshold where all the sectors finish industrialization ($n = 1$) under the condition $p_B < p_A$;

4. $K_4 = z + \frac{\beta}{1-\beta}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L$ is the threshold where all the sectors finish industrialization ($n = 1$) under the condition $p_B = p_A$;

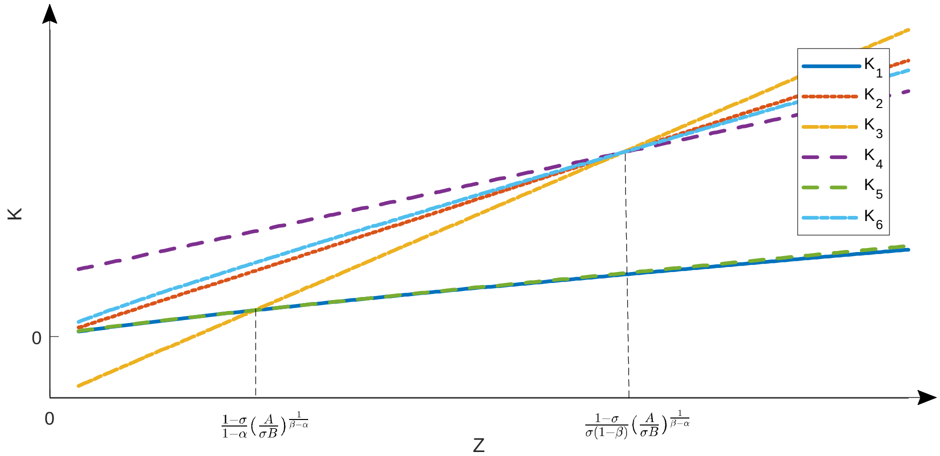
5. K_5 satisfying $\frac{1-\alpha}{\alpha} K_5 - (\frac{A}{B})^{\frac{1}{\beta-\alpha}}(\frac{K_5-\alpha z}{K_5})^{\frac{-1}{\beta-\alpha}} L = 0$ is the threshold where sectors begin to industrialize ($n > 0$) under the condition $p_B > p_A$;

6. K_6 satisfying $(\frac{\beta L}{1-\beta})^{\beta-\alpha} A[K_6 - (1-\beta)z] - B(K_6 - z)^{1+\beta-\alpha} = 0$ is the threshold where all the sectors finish industrialization ($n = 1$) under the condition $p_B > p_A$.

These six thresholds obviously depend on structural parameters such as z. Their relationships with z are drawn in Figure A3.

As shown in figure A3, the size relationship of the six thresholds can be divided into three cases. When $0 \leq z \leq \frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L$, $K_2 \leq K_1 \leq K_5 < K_3 < K_6 < K_4$; when $\frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L < z \leq \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L$, $K_1 < K_5 < K_2 \leq K_3 \leq K_6 \leq K_4$; when $z > \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L$, $K_1 < K_5 < K_4 < K_6 < K_3 < K_2$. So when $z > \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} L$, the beginning cutoff $K_b^{LF} = K_1$ and the finishing cutoff $K_f^{LF} = K_3$.

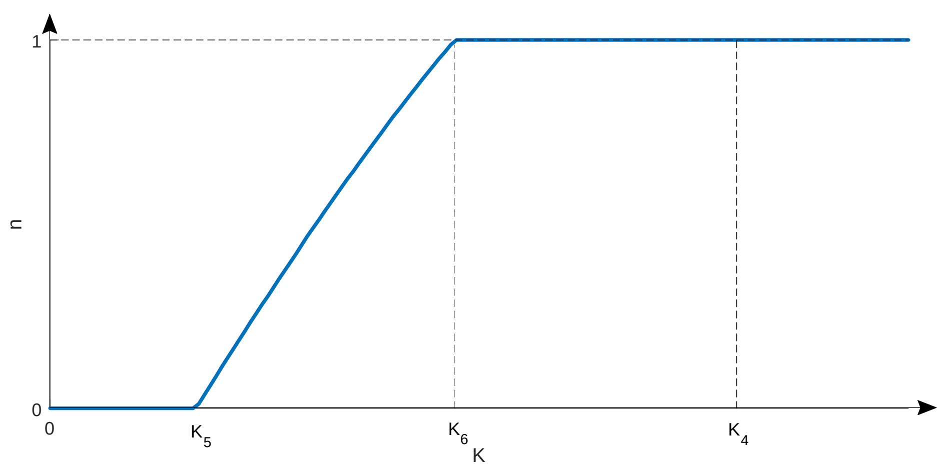
Figure A3: Relationship between the Six Thresholds



A.2 The Other Two Cases of Laissez-faire Market Equilibrium

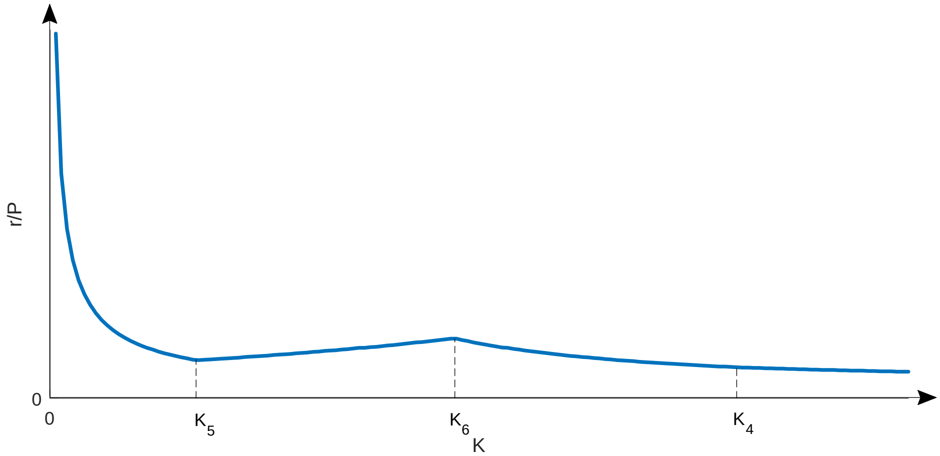
When $0 \leq z \leq \frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$, $K_2 \leq K_1 \leq K_5 < K_3 < K_6 < K_4$. How n and $\frac{r}{P}$ changes with K are drawn in figure A4 and A5, respectively. As K increases from 0 to K_5 , no sectors will industrialize and $P = p_A$, $\frac{r}{P} = A(\frac{\alpha L}{(1-\alpha)K})^{1-\alpha}$ decreases. As K increases from K_5 to K_6 , n increases and $P = p_A$, $\frac{r}{P}$ increases. When $K_6 \leq K \leq K_4$, all sectors will industrialize and $P = p_A$, $\frac{r}{P} = A(\frac{(1-\beta)(K-z)}{\beta L})^{\alpha-1}$ decreases as K increase. When $K > K_4$, all sectors will industrialize and $P = p_B$, $\frac{r}{P} = \sigma B(\frac{(1-\beta)(K-z)}{\beta L})^{\beta-1}$ decreases as K increases.

Figure A4: The Number of Industrialized Sectors



Notes. This figure shows how n changes with K when $0 \leq z \leq \frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$. In this case, $K_2 \leq K_1 \leq K_5$, so $p_B \geq p_A$ in the process of industrialization. Only when $K > K_4$. p_B becomes smaller than p_A. So $P = p_A$ if $K \leq K_4$, $P = p_B$ if $K > K_4$.

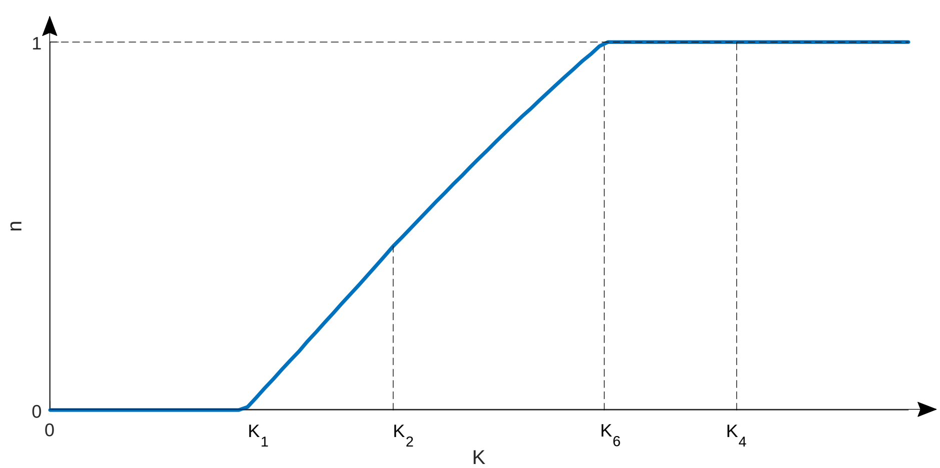
Figure A5: The Rental Price of Capital



Notes. This figure shows how $\frac{r}{P}$ changes with K when $0 \leq z \leq \frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$. $\frac{r}{P}$ decreases as K increases except in the process of industrialization.

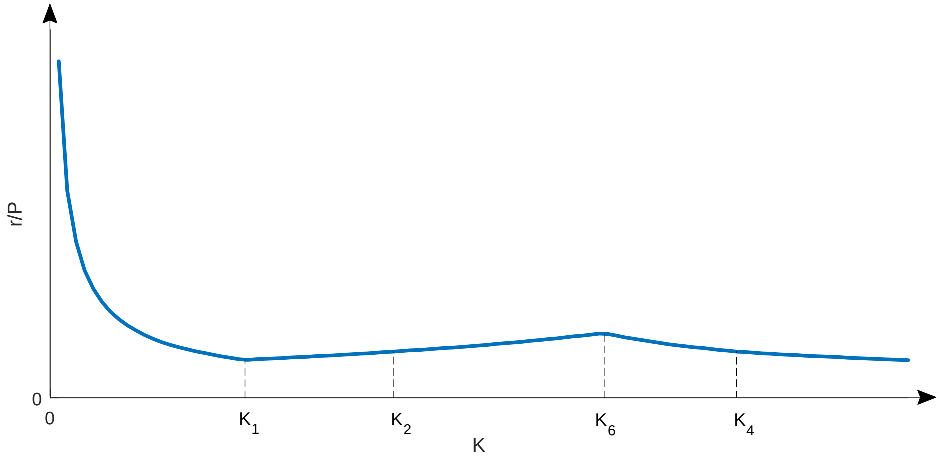
When $\frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L < z \leq \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$, $K_1 < K_5 < K_2 \leq K_3 \leq K_6 \leq K_4$. How n and $\frac{r}{P}$ changes with K are drawn in figure A6 and A7, respectively. As K increases from 0 to K_1 , no sector will industrialize and $P = p_A$, $\frac{r}{P} = A(\frac{\alpha L}{(1-\alpha)K})^{1-\alpha}$ decreases. As K increases from K_1 to K_2 , n increases and the monopolists will set their prices at p_B , $\frac{r}{P}$ increases. As K increases from K_2 to K_6 , n increases and $P = p_A$, $\frac{r}{P}$ increases. As K increases from K_6 to K_4 , all the sectors will industrialize and $P = p_A$, $\frac{r}{P} = A(\frac{(1-\beta)(K-z)}{\beta L})^{\alpha-1}$ decreases. When $K > K_4$, all sectors will industrialize and $P = p_B$, $\frac{r}{P} = \sigma B(\frac{(1-\beta)(K-z)}{\beta L})^{\beta-1}$ decreases as K increases.

Figure A6: The Number of Industrialized Sectors



Notes. This figure shows how n changes with K when $\frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L < z \leq \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$. When $K_1 < K \leq K_2$, the industrialized monopolists will set their prices at p_B. When $K_2 < K \leq K_4$, $P = p_A$. When $K > K_4$, $P = p_B$.

Figure A7: The Rental Price of Capital



Notes. This figure shows how $\frac{r}{P}$ changes with K when $\frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L < Z \leq \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$. $\frac{r}{P}$ decreases as K increases except in the process of industrialization.

A.3 The Proof of Proposition 2

The social planner problem is:

$$maxX = [\int_0^n (B\frac{K_B^\beta L_B^{1-\beta}}{\beta^\beta(1-\beta)^{1-\beta}})^\sigma di + \int_n^1 (A\frac{K_A^\alpha L_A^{1-\alpha}}{\alpha^\alpha(1-\alpha)^{1-\alpha}})^\sigma di]^{\frac{1}{\sigma}}$$

$$s.t. nK_B + (1-n)K_A + nz = K, nL_B + (1-n)L_A = L.$$

From the F.O.C of K_A, K_B, L_A, L_B,n, we have

$$\begin{gathered} \frac{\beta K_A}{\alpha K_B} = \frac{(1-\beta)L_A}{(1-\alpha)L_B}, \\ (A\frac{K_A^\alpha L_A^{1-\alpha}}{\alpha^\alpha(1-\alpha)^{1-\alpha}})^\sigma \frac{\alpha}{K_A} = (B\frac{K_B^\beta L_B^{1-\beta}}{\beta^\beta(1-\beta)^{1-\beta}})^\sigma \frac{\beta}{K_B} \end{gathered} \tag{44}$$

and

$$K_B = \frac{\sigma}{1-\sigma}\beta z + \frac{\beta}{\alpha}K_A.$$

We also have the capital market clearing condition

$$nK_B + (1-n)K_A + nz = K$$

and labor market clearing condition

$$nL_B + (1-n)L_A = L.$$

Then we can get two equations to pin down the resource allocations

$$(1-n+\frac{\beta}{\alpha}n)K_A + nz + n\frac{\sigma}{1-\sigma}\beta z = K$$

and

$$[n\frac{\alpha(1-\beta)\sigma}{(1-\alpha)(1-\sigma)}\frac{z}{K_A} + n\frac{1-\beta}{1-\alpha} + 1 - n](\frac{B}{A})^{\frac{1}{\beta-\alpha}}\frac{1-\alpha}{\alpha}(\frac{\sigma\alpha z}{(1-\sigma)K_A}+1)^{\frac{\sigma-1}{(\beta-\alpha)\sigma}}K_A = L.$$

Similarly, we have two thresholds to make sure $0 < n < 1$. When n=0, $K = K_b^{SP}$ satisfies

$$(\frac{B}{A})^{\frac{1}{\beta-\alpha}}\frac{1-\alpha}{\alpha}(\frac{\sigma\alpha z}{(1-\sigma)K}+1)^{\frac{\sigma-1}{(\beta-\alpha)\sigma}}K = L.$$

When n=1, $K = K_f^{SP}$ satisfies

$$\frac{1-\beta}{\beta}(K-z)(\frac{B}{A})^{\frac{1}{\beta-\alpha}}(\frac{(1-\sigma)(K-z)}{(1-\sigma)K-(1-\sigma+\beta\sigma)z})^{\frac{\sigma-1}{(\beta-\alpha)\sigma}} = L. \tag{45}$$

If $K_1 > K_b^{SP}$, then $(\frac{B}{A})^{\frac{1}{\beta-\alpha}}\frac{1-\alpha}{\alpha}(\frac{\sigma\alpha z}{(1-\sigma)K_1}+1)^{\frac{\sigma-1}{(\beta-\alpha)\sigma}}K_1 > L$, this implies $z > (\sigma^{\frac{\sigma}{\sigma-1}}-\sigma)^{\frac{1-\sigma+\beta\sigma-\alpha\sigma}{(\alpha-\beta)\sigma}} * \frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$. Let $g(\sigma) = (1-\sigma)ln(1+\sigma)+\sigma ln\sigma$. $\lim_{\sigma\to 0} g(\sigma) = 0$, $g(1) = 0$, $g'(\sigma) = ln\sigma - ln(1+\sigma) + \frac{2}{1+\sigma}$, $g''(\sigma) = \frac{1-\sigma}{\sigma(1+\sigma)^2} > 0$, $g'(0) = -\infty$, $g'(1) = 1 - ln2$. So $g(\sigma)$ first decreases and then increases, $g(\sigma) < 0$, $\forall\sigma \in (0,1)$. This implies $\sigma^{\frac{\sigma}{\sigma-1}} - \sigma > 1$, so $(\sigma^{\frac{\sigma}{\sigma-1}}-\sigma)^{\frac{1-\sigma+\beta\sigma-\alpha\sigma}{(\alpha-\beta)\sigma}} * \frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L < \frac{1-\sigma}{1-\alpha}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L < \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$.

Take K_3 into the left hand side of equation (45), it equals zero. Because the left hand side of equation (45) is positively correlated with K, K_f^{SP} must be bigger than K_3 to ensure the equation is satisfied.

In conclusion, when $z > \frac{1-\sigma}{\sigma(1-\beta)}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L$, $K_b^{SP} < K_1$, $K_f^{SP} > K_3$, which means the social planner will begin industrialization with less capital endowment and finish industrialization with more capital endowment.

A.4 The Solution of Ramsey Planner Problem

- If $n = 0$, all sectors use technology 1, $X = A\frac{K^\alpha L^{1-\alpha}}{\alpha^\alpha(1-\alpha)^{1-\alpha}}$.
- If $n = 1$, all sectors use technology 2, $X = B\frac{K^\beta L^{1-\beta}}{\beta^\beta(1-\beta)^{1-\beta}}$.
- If $0 < n < 1$, $p_B < p_A$, $P = [(1-n)(\frac{w^{1-\alpha}r^\alpha}{A})^{\frac{\sigma}{\sigma-1}} + n(\frac{w^{1-\beta}r^\beta}{\sigma B})^{\frac{\sigma}{\sigma-1}}]^{\frac{\sigma-1}{\sigma}}$. As prices and quantities of goods are determined by market, the labor market clearing condition and the capital market clearing condition are the same as in market equilibrium.

$$\frac{(1-n)(1-\alpha)}{A}(\frac{r}{w})^\alpha(\frac{w^{1-\alpha}r^\alpha}{A})^{\frac{1}{\sigma-1}}X/P^{\frac{1}{\sigma-1}} + \frac{n(1-\beta)}{B}(\frac{r}{w})^\beta(\frac{w^{1-\beta}r^\beta}{\sigma B})^{\frac{1}{\sigma-1}}X/P^{\frac{1}{\sigma-1}} = L$$

$$\frac{(1-n)\alpha}{A}(\frac{w}{r})^{1-\alpha}(\frac{w^{1-\alpha}r^{\alpha}}{A})^{\frac{1}{\sigma-1}}X/P^{\frac{1}{\sigma-1}}+\frac{n\beta}{B}(\frac{w}{r})^{1-\beta}(\frac{w^{1-\beta}r^{\beta}}{\sigma B})^{\frac{1}{\sigma-1}}X/P^{\frac{1}{\sigma-1}}+nz=K$$

We normalize $P=1$, then for any given n, X can be solved.

- If $0<n<1$, $p_B \geq p_A$, $P=\frac{w^{1-\alpha}r^{\alpha}}{A}$. Similarly, as prices and quantities of goods are determined by market, the labor market clearing condition and the capital market clearing condition are the same as in market equilibrium.

$$\frac{(1-n)(1-\alpha)}{A}(\frac{r}{w})^{\alpha}X+\frac{n(1-\beta)}{B}(\frac{r}{w})^{\beta}X=L$$

$$\frac{(1-n)\alpha}{A}(\frac{w}{r})^{1-\alpha}X+\frac{n\beta}{B}(\frac{w}{r})^{1-\beta}X+nz=K$$

We normalize $w=1$, then for any given n, X can be solved. Then we can find out the optimal n to maximize X.

A.5 The Proof of Proposition 3

First, we show that the optimal fixed cost subsidy can not achieve higher household's utility than the Ramsey planner. The Ramsey planner maximizes household's utility subject to the profit maximization of firms, the labor market clearing condition and the capital market condition, while the government imposing fixed cost subsidy faces one more condition:

$$\pi=(p(i)-\frac{w^{1-\beta}r^{\beta}}{B})p(i)^{\frac{1}{\sigma-1}}P^{\frac{1}{1-\sigma}}X-r(z-F)=0. \tag{46}$$

So with one more condition, the maximized utility can not be higher than which achieved by Ramsey planner. Then we show that the Ramsey planner's choice can be achieved by optimal fixed cost subsidy. When $\frac{w^{1-\beta}r^{\beta}}{B}>\frac{w^{1-\alpha}r^{\alpha}}{A}$, the marginal cost of technology B is bigger than the marginal cost of technology A, the Ramsey planner would not want to industrialize. So when he chooses to industrialize, the marginal costs must satisfy $\frac{w^{1-\beta}r^{\beta}}{B}\leq\frac{w^{1-\alpha}r^{\alpha}}{A}$. We also have $p(i)=\min\{\frac{w^{1-\beta}r^{\beta}}{\sigma B},\frac{w^{1-\alpha}r^{\alpha}}{A}\}$. So $(p(i)-\frac{w^{1-\beta}r^{\beta}}{B})p(i)^{\frac{1}{\sigma-1}}P^{\frac{1}{1-\sigma}}X\geq 0$. The government must choose F to satisfy (46) and make the market equilibrium the same as Ramsey planner problem. Then $r(Z-F)\geq 0$, $T=nrF\leq nrz\leq wL+rK+\Pi$. So the F which makes the market equilibrium the same as the Ramsey planner problem is feasible. In conclusion, the optimal fixed cost subsidy achieves the same market equilibrium as the Ramsey planner problem.

A.6 Cutoffs of Industrial Policies

A.6.1 Industrial Policy I

Similar to the laissez-faire market equilibrium, we can solve this problem by discussing it in two cases and get six thresholds.

$$K_1^F = \alpha(\frac{A}{\sigma B})^{\frac{\sigma}{1-\sigma+(\beta-\alpha)\sigma}}(\frac{z-F}{1-\sigma})^{\frac{1-\sigma}{1-\sigma+(\beta-\alpha)\sigma}}(\frac{L}{1-\alpha})^{\frac{(\beta-\alpha)\sigma}{1-\sigma+(\beta-\alpha)\sigma}};$$

$$K_2^F = \frac{z-F}{1-\sigma} - (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L + F\frac{(1-\alpha)\frac{z-F}{1-\sigma} - (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L}{\frac{z-F}{1-\sigma}[(1-\alpha)-(1-\beta)\sigma]};$$

$$K_3^F = \frac{1-\sigma+\beta\sigma}{1-\sigma}z - \frac{\beta\sigma}{1-\sigma}F;$$

$$K_4^F = z + \frac{\beta}{1-\beta}(\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}L;$$

K_5^F satisfies

$$\frac{B}{A}[K_5^F - \alpha(z-F)](K_5^F)^{\beta-\alpha-1} - [\frac{\alpha}{1-\alpha}(z-F)L]^{\beta-\alpha} = 0;$$

K_6^F satisfies

$$(\frac{\beta L}{1-\beta})^{\beta-\alpha}A[K_6^F - (1-\beta)z - \beta F] - B(K_6^F - z)^{1+\beta-\alpha} = 0.$$

Given F, K_1^F is the amount of capital where sectors begin to industrialize when $p_B < p_A$; K_2^F is the amount of capital where $p_A = p_B$ when $n < 1$; K_3^F is the amount of capital where all sectors choose to industrialize when $p_B < p_A$; K_4^F is the amount of capital where $p_A = p_B$ when $n = 1$; K_5^F is the amount of capital where sectors begin to industrialize when $p_B > p_A$; K_6^F is the amount of capital where all sectors choose to industrialize when $p_B > p_A$.

A.6.2 Industrial Policy II

Similar to the laissez-faire market equilibrium, we can solve this problem by discussing it in two cases and get six thresholds.

$$K_1^{\tau sk} = \alpha(\frac{A}{\sigma B})^{\frac{\sigma}{1-\sigma+\sigma(\beta-\alpha)}}(1-s_k)^{\frac{\sigma\beta}{1-\sigma+\sigma(\beta-\alpha)}}(\frac{1-\tau}{1-\sigma}z)^{\frac{1-\sigma}{1-\sigma+\sigma(\beta-\alpha)}}(\frac{L}{1-\alpha})^{\frac{\sigma(\beta-\alpha)}{1-\sigma+\sigma(\beta-\alpha)}};$$

$$K_2^{\tau sk} = \alpha\frac{1-\tau}{1-\sigma}z + \frac{\frac{\beta\sigma}{1-s_k} - \alpha + \frac{1-\sigma}{1-\tau}}{1-\alpha-\sigma+\beta\sigma}[\frac{1-\tau}{1-\sigma}(1-\alpha)z - (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}(1-s_k)^{\frac{\beta}{\beta-\alpha}}L];$$

$$K_3^{\tau sk} = \frac{\beta\sigma\frac{1-\tau}{1-s_k} + 1 - \sigma}{1-\sigma} z,$$

$$K_4^{\tau sk} = (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}} (1-s_k)^{\frac{\alpha}{\beta-\alpha}} \frac{\beta L}{1-\beta} + z,$$

$K_5^{\tau sk}$ satisfies

$$B[K - \alpha z(1-\tau)]K^{\beta-\alpha-1} - A(1-s_k)^{\beta}(\frac{\alpha L}{1-\alpha})^{\beta-\alpha} = 0.$$

$K_6^{\tau sk}$ satisfies

$$A(1-s_k)^{\beta}(K - z + \beta z\frac{1-\tau}{1-s_k})(\frac{\beta L}{(1-\beta)(1-s_k)})^{\beta-\alpha} - B(K-z)^{\beta-\alpha+1} = 0.$$

Given the subsidy rates, $K_1^{\tau sk}$ is the amount of capital where sectors begin to industrialize when $p_B < p_A$; $K_2^{\tau sk}$ is the amount of capital where $p_A = p_B$ when $n < 1$; $K_3^{\tau sk}$ is the amount of capital where all sectors choose to industrialize when $p_B < p_A$; $K_4^{\tau sk}$ is the amount of capital where $p_A = p_B$ when $n = 1$; $K_5^{\tau sk}$ is the amount of capital where sectors begin to industrialize when $p_B > p_A$; $K_6^{\tau sk}$ is the amount of capital where all sectors choose to industrialize when $p_B > p_A$.

A.6.3 Industrial Policy III

Similar to the laissez-faire market equilibrium, we can solve this problem by discussing it in two cases and get six thresholds.

$$K_1^{\tau sl} = \alpha(\frac{A}{\sigma B})^{\frac{\sigma}{1-\sigma+(\beta-\alpha)\sigma}} (1-s_l)^{\frac{(1-\beta)\sigma}{1-\sigma+(\beta-\alpha)\sigma}} (\frac{(1-\tau)z}{1-\sigma})^{\frac{1-\sigma}{1-\sigma+(\beta-\alpha)\sigma}} (\frac{L}{1-\alpha})^{\frac{(\beta-\alpha)\sigma}{1-\sigma+(\beta-\alpha)\sigma}};$$

$$K_2^{\tau sl} = \alpha\frac{1-\tau}{1-\sigma}z + \frac{\beta\sigma - \alpha + \frac{1-\sigma}{1-\tau}}{1-\alpha-\frac{(1-\beta)\sigma}{1-s_l}}[\frac{(1-\alpha)(1-\tau)}{1-\sigma}z - (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}(1-s_l)^{\frac{1-\beta}{\beta-\alpha}}L];$$

$$K_3^{\tau sl} = \frac{\beta\sigma(1-\tau) + 1 - \sigma}{1-\sigma} z;$$

$$K_4^{\tau sl} = z + (\frac{A}{\sigma B})^{\frac{1}{\beta-\alpha}}(1-s_l)^{\frac{1-\alpha}{\beta-\alpha}}\frac{\beta L}{1-\beta};$$

$K_5^{\tau sl}$ satisfies

$$B[K - \alpha z(1-\tau)]K^{\beta-\alpha-1} - A(1-s_l)^{1-\beta}(\frac{\alpha L}{1-\alpha})^{\beta-\alpha} = 0;$$

$K_6^{\tau sl}$ satisfies

$$A(1-s_l)^{1-\alpha}(\frac{\beta L}{1-\beta})^{\beta-\alpha}[K-z+\beta z(1-\tau)]-B(K-z)^{1+\beta-\alpha}=0.$$

Given the subsidy rates, $K_1^{\tau sl}$ is the amount of capital where sectors begin to industrialize when $p_B < p_A$; $K_2^{\tau sl}$ is the amount of capital where $p_A = p_B$ when $n < 1$; $K_3^{\tau sl}$ is the amount of capital where all sectors choose to industrialize when $p_B < p_A$; $K_4^{\tau sl}$ is the amount of capital where $p_A = p_B$ when $n = 1$; $K_5^{\tau sl}$ is the amount of capital where sectors begin to industrialize when $p_B > p_A$; $K_6^{\tau sl}$ is the amount of capital where all sectors choose to industrialize when $p_B > p_A$.

A.6.4 Premature Big Push

We suppose that the government is able to use all the fiscal policy tools we mentioned before with constraints $0 \leq \tau_A \leq 0.6$, $0 \leq \tau_K \leq 0.6$, $0 \leq \tau_L \leq 0.6$ and $-0.6 \leq \tau_Z \leq 0.6$. τ_A, τ_K, τ_L are supposed to be positive, because the government would always want to encourage industrialized sectors to produce more. τ_Z can be negative because sometimes the government wants fewer sectors to be industrialized as shown in the social planner problem. When all these fiscal policies are imposed, we can also solve this problem by discussing it in two cases and get six thresholds.

$$\widetilde{K}_1=\alpha(1-\tau_A)[\frac{A(1-\tau_A)(1-\tau_L)^{1-\beta}(1-\tau_K)^{\beta}}{\sigma B}]^{\frac{\sigma}{(\beta-\alpha)\sigma+1-\sigma}}(\frac{z(1-\tau_Z)}{1-\sigma})^{\frac{1-\sigma}{(\beta-\alpha)\sigma+1-\sigma}}(\frac{L}{(1-\alpha)(1-\tau_A)})^{\frac{(\beta-\alpha)\sigma}{(\beta-\alpha)\sigma+1-\sigma}};$$

$$\begin{aligned}\widetilde{K}_2 \quad = \quad & \frac{\frac{(1-\alpha)\beta\sigma}{1-\tau_K}+\frac{(1-\alpha)(1-\sigma)}{1-\tau_Z}-\frac{\alpha(1-\beta)\sigma}{1-\tau_L}}{(1-\alpha)(1-\tau_A)-\frac{(1-\beta)\sigma}{1-\tau_L}}\frac{z(1-\tau_A)(1-\tau_Z)}{1-\sigma} \\ & -\frac{\frac{\beta\sigma}{1-\tau_K}+\frac{1-\sigma}{1-\tau_Z}-\alpha(1-\tau_A)}{(1-\alpha)(1-\tau_A)-\frac{(1-\beta)\sigma}{1-\tau_L}}[\frac{A(1-\tau_A)(1-\tau_L)^{1-\beta}(1-\tau_K)^{\beta}}{\sigma B}]^{\frac{1}{\beta-\alpha}}L;\end{aligned}$$

$$\widetilde{K}_3=\frac{1-\sigma+\beta\sigma\frac{1-\tau_Z}{1-\tau_K}}{1-\sigma}z;$$

$$\widetilde{K}_4=z+[\frac{A(1-\tau_A)}{\sigma B}(1-\tau_L)^{1-\alpha}(1-\tau_K)^{\alpha}]^{\frac{1}{\beta-\alpha}}\frac{\beta}{1-\beta}L;$$

$\widetilde{K}_5$ satisfies

$$\frac{1-\alpha}{\alpha}K-(\frac{A(1-\tau_A)}{B})^{\frac{1}{\beta-\alpha}}(\frac{(1-\tau_L)^{1-\beta}(1-\tau_K)^{\beta}K}{K-\alpha(1-\tau_Z)(1-\tau_A)z})^{\frac{1}{\beta-\alpha}}L=0;$$

$\widetilde{K}_6$ satisfies

$$B(1-\tau_K)(K-z)^{\beta-\alpha+1} = A(1-\tau_A)(\frac{\beta(1-\tau_L)L}{(1-\beta)(1-\tau_K)})^{\beta-\alpha}[\beta(1-\tau_K)^{\beta}(1-\tau_L)^{1-\beta}(1-\tau_Z)z+(1-\tau_L)^{1-\beta}(1-\tau_K)^{\beta+1}(K-z)].$$

Given the subsidy rates, $\widetilde{K}_1$ is the amount of capital where sectors begin to industrialize when $p_B < p_A$; $\widetilde{K}_2$ is the amount of capital where $p_A = p_B$ when $n < 1$; $\widetilde{K}_3$ is the amount of capital where all sectors choose to industrialize when $p_B < p_A$; $\widetilde{K}_4$ is the amount of capital where $p_A = p_B$ when $n = 1$; $\widetilde{K}_5$ is the amount of capital where sectors begin to industrialize when $p_B > p_A$; $\widetilde{K}_6$ is the amount of capital where all sectors choose to industrialize when $p_B > p_A$.