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Public Infrastructures, Production Organizations, and Economic Development

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Abstract

We develop a political economy model of growth to examine economic development led by the interactions between an economic decision concerning a firm's production technology (CRS vs IRS technology) and a political decision concerning public infrastructures. We show that multiple equilibrium growth paths occur due to differences in expectations regarding the quality of public infrastructures. These multiple paths illustrate why economies with poor initial conditions can catch up to and, furthermore, overtake economies with better initial conditions. Our result could explain the experiences of some East Asian countries where co-evolutions of public infrastructures and industrial transformations spurred economic development.

JEL classification numbers: H5, O1, O4

Keywords: Public Infrastructure, Political Economy, Production Organization, Overlapping Generations Model

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1 Introduction

Over the past five decades, several East Asian countries, including Japan, South Korea, and Taiwan, have experienced rapid growth because of the drastic industrial transformation of production organizations from engaging in obsolete, inefficient small-scale production to developing modern, efficient large-scale production. However, many other countries have struggled with poverty because they have continued to engage in inefficient small-scale production.[1] The adoption of large-scale production is one of the significant driving forces behind economic development (Rosenstein-Rodan, 1943; Nurkse, 1953). Murphy et al. (1989 in p1003) states that "[V]irtually every country that experienced rapid growth of productivity and living standards over the last 200 years has done so by industrializing. Countries that have successfully industrialized – turned to production of manufactures taking advantage of scale economies – are the ones that grew rich, be they eighteenth-century Britain or twentieth-century Korea and Japan."

Increasing the efficiency of large-scale production requires sufficient aggregate demand and high-quality infrastructures. In particular, the roles of public infrastructures (e.g., power plants, transportation, telecommunication, property rights of institutions) are essential. For example, Tybou's (2000) survey of empirical studies of manufacturing sectors argues that the high proportion of very small firms in developing countries partly stems from their weak transportation systems, uncertainty about policies, poor rule of law, and corruption. Kumar et al. (2005) and Leaven and Woodruff (2007) also provide empirical evidence of a positive relationship between firm size and the quality of legal institutions. Moreover, World Bank (1994) provides convincing evidence that public infrastructures have played crucial roles in drastic industrial transformations in East Asian countries. Table 1 shows GDP and infrastructure stock at their 1995 levels as multiples of their 1975 levels, which is calculated by Straub et al. (2008). East Asia's economic growth and accumulation of infrastructure stocks has outpaced those of other regions. Co-evolutions of infrastructure and industrial transformation induced economic development in these countries.

Note that large-scale production firms come to rely more heavily on public infrastructures. For example, they require more reliable power grids for their advanced equipment and more developed transportation systems for their commodity distributions. Thus, as the number of firms that adopt large-scale production increases, large expenditures for public infrastructures are more likely to gain political support. This hypothesis is in line with Wagner's (1893) law that the transformation from a

[1] For example, see Evans (1995) for an illustration of the industrial transformation of Japan, South Korea, and Taiwan.

traditional society to an industrialized society is accompanied by a surge in demand for public services such as education, health care, and infrastructure. In fact, Randolph et al. (1996) and Sturm (2001) show that the per capita expenditures for public infrastructures strongly respond to changes in the per capita income and that the estimated income elasticity of the per capita expenditures exceeds unity.

The purpose of this paper is to examine how interactions between political decisions for public infrastructures and economic decisions for production organizations affect the long-run process of economic development. We show that multiple growth paths occur due to interactions between political and economic decisions. In our model, self-fulfilling properties of voting can occur and lead to multiple equilibria. The intuition is as follows. If people rationally anticipate large expenditures for public infrastructures as a political outcome, they will begin to employ large-scale production even when potential aggregate demand is still small. Once this is accomplished, it is indeed optimal for them to agree to large expenditures for public infrastructures in relatively early stages of economic development. In contrast, if people rationally anticipate small expenditures for public infrastructures, they will continue to employ small-scale production until the economy's aggregate demand becomes sufficiently large. Once this is accomplished, it is indeed optimal for them to agree to small expenditures for public infrastructures in relatively early stages of economic development. Hence, even for economies with equivalent initial conditions, the difference between their expectations of political outcomes concerning public infrastructures leads to different processes of evolution concerning public infrastructures, firms' production organizations, and per capita income.[2]

This "multiple growth paths" result could explain why relatively backward economies with relatively poor initial conditions can catch up to and, furthermore, overtake more advanced economies with better initial conditions. Suppose the former adopts efficient large-scale production earlier than the latter due to success in the coordination of decisions on production organizations and the corresponding high level of political supports for public infrastructures. Then, an equilibrium outcome is the result of an economy with relatively poor initial conditions rapidly catching up to and overtaking the economy with better initial conditions. This result helps us to understand how such rapid transformations are related to differences in the evolution of public infrastructures and production organizations across countries

[2]It is well known that agents' expectations about future policy may be self-fulfilling when public policy is endogenous. In particular, Saint-Paul and Verdier (1997) derive a similar multiplicity result in a voting model regarding the interaction between capital income tax and saving decisions. As we will explain later, what is important for the occurrence of multiplicity in our model is that each firm makes its irreversible decision on production organization prior to the determination of public policy. Once the firm employs the large-scale production organization, it is usually difficult to instantly return to the small-scale production organization. Thus, the production organization decision is one of the most irreversible decisions for any firm. The possibility that the feedback mechanism between economic and political decisions generates multiple equilibria has been noted in various contexts (e.g., Glomm and Ravikumar, 1996; Hessler et al., 2003).

(Gerschekron, 1962; Rodrik, 2005). In particular, our result is partly consistent with the experiences of some East Asian countries where co-evolutions of public infrastructures and industrial transformations spurred economic development.

In addition, this paper notes the critical role of efficiency in public service production. Efficiency is determined by the quality of bureaucratic and legal procedures. If efficiency is high, production organization changes monotonically from small-scale to large-scale production. Along with this change, people are more willing to support increases in public infrastructure expenditures. Due to these co-evolutions of production organization and public infrastructures, the economy eventually converges to the steady state equilibrium characterized by "high quality infrastructures, large-scale production, and high per-capita income." However, if efficiency is low, the economy is trapped in the steady state equilibrium characterized by "low quality infrastructures, small-scale production, and low per-capita income." Moreover, if efficiency is at an intermediate value, multiple steady state equilibria exist. Under some parameter regions, even economies with equivalent initial conditions may converge to different steady state equilibria due to differential expectations about the quality of public infrastructures. This "multiple steady state equilibria" result suggests that small differences in the efficiency of public service production can account for large differences in the per capita income across countries (La Porta et al., 2008; Chakraborty and Dabla-Norris, 2011).

This paper is related to the literature on public infrastructures and economic growth (e.g., Barro, 1990; Agénor, 2010; Chakraborty and Dabla-Norris, 2011). These studies show that public infrastructures have growth-promoting effects through various channels (e.g., productivity of private inputs, complementarity effects on private investment, and the production of health and education services).[3] However, as noted by Agénor (2010), the effect of public infrastructure on economic growth through its impact on a firm's choice of technology has not been yet rigorously examined, although this channel is critical. We examine this issue. The present paper is also related to theoretical studies of big-push arguments (e.g., Murphy et al., 1989; Matsuyama, 1992; Rodrik, 1996; Wang and Xie, 2004). For example, a pioneering study by Murphy et al. (1989) proposes an intuitive model of multiple equilibria arising from aggregate demand externality. In their model, each sector's adoption of large-scale production increases the demand for the other sectors' products through the rise in income induced by the adoption of large-scale production. These interactions between private firms' choices of technology and their market size lead to multiple equilibria: a large-scale production equilibrium and a small-scale production equilibrium. Although we

[3]See, for example, Agénor and Moreno-Dodson (2006) for survey.

share a common framework and interests with these studies, we focus on the multiple equilibria arising from the interactions between political decisions concerning public infrastructures and economic decisions concerning technology choices. This paper adds new insights to the literature by considering the political decision concerning public infrastructure explicitly.

This paper is organized as follows. Section 2 sets up the basic model. Section 3 describes firms' economic decisions on production organization and political decisions on expenditures for public infrastructures. Section 3 characterizes a rational-expectation equilibrium and shows that multiple equilibria occur under some parameter conditions. Section 5 characterizes the dynamic properties of the economy and discusses the effect of the efficiency of government service production. Section 6 concludes the paper.

2 The Model

Consider an overlapping-generations economy in which activity extends over infinitely discrete time. There are two types of goods in this economy: a unique final good and a variety of intermediate goods indexed by $i \in [0, 1]$. The final good is produced by competitive firms using a variety of intermediate goods, capital, and labor as inputs, while each intermediate good i is produced by one monopoly firm using the final good as input. Capital depreciates completely after one period of use in production.

2.1 Individuals

In each period t, a generation containing a continuum of identical individuals of measure one joins the economy. Individuals, each of whom lives for two periods (young and old age), obtain utility from their second-period consumption. The young individuals supply one unit of labor and save all wage income w_t. The old individuals do not supply any labor, but earn accrued interest $\rho_{t+1}w_t$. Additionally, the old individuals are endowed with the property rights on the production sites of intermediate goods. Each of them becomes an owner of intermediate-good firm i and earns monopoly profits $\pi_{t+1}(i)$. Because lump-sum tax τ_{t+1} is levied on each old individual, each old individual's after-tax income is given by $\rho_{t+1}w_t + \pi_{t+1}(i) - \tau_{t+1}$.

2.2 Final Good Sector

The output produced in the final good sector in period t, Y_t, is governed by a Cobb-Douglas, constant-returns-to-scale production technology such that

$$Y_t = K_t^{1-\epsilon-\delta} L_t^{\epsilon} \int_0^1 x_t(i)^{\delta} di, \quad \epsilon > 0,\ \delta > 0,\ \epsilon + \delta < 1, \tag{1}$$

where K_t is the amount of capital employed in the final good sector, L_t is the amount of labor, and $x_t(i)$ is the amount of intermediate good $i \in [0,1]$ used as input. For clarity, we rewrite (1) as

$$Y_t = A_t^{1-\delta} \int_0^1 x_t(i)^\delta di$$

where $A_t \equiv (K_t^{1-\epsilon-\delta} L_t^\epsilon)^{\frac{1}{1-\delta}}$. Furthermore, to avoid unnecessary lexicographic explanations, we focus our analysis on the case where $\delta \leq \frac{1}{2}$.

Let $p_t(i)$, w_t, and ρ_t represent the price of intermediate good i, the wage of workers, and the rental rate of capital in period t, respectively. The conditions for profit maximization in the competitive final good sector are consistent with the following conditions in factor markets:

$$p_t(i) = \delta A_t^{1-\delta} x_t(i)^{\delta-1}, \tag{2}$$

$$w_t = \epsilon \frac{A_t^{1-\delta} \int_0^1 x_t(i)^\delta di}{L_t}, \tag{3}$$

$$\rho_t = (1-\epsilon-\delta) \frac{A_t^{1-\delta} \int_0^1 x_t(i)^\delta di}{K_t}. \tag{4}$$

As explained above, only young individuals supply labor as waged workers who are only employed in the final good sector. Thus, in equilibrium, we obtain $L_t = 1$, and $A_t = K_t^{\frac{1-\epsilon-\delta}{1-\delta}}$.

2.3 Intermediate Good Sector

Each intermediate good i is produced by one monopoly firm owned by an old individual. Recalling the fact that the variety of intermediate goods is normalized to one, each old individual possesses one monopoly firm producing a specific intermediate good i. Each intermediate-good firm can access two types of technologies: the "old technology" and the "new technology." A production function of intermediate good i is given as follows.

$$x_t(i) = \lambda_t^j z_t s_t(i), \tag{5}$$

where

$$\lambda_t^j = \begin{cases} 1 & \text{with old technology } (j = O), \\ \lambda > 1 & \text{with new technology } (j = N). \end{cases}$$

$s_t(i)$ denotes the final-good input devoted to producing intermediate good i. $\lambda_t^j z_t$ denotes the firm's effective productivity level given technology j, which depends on both the technology specific term λ_t^j and the quality of public infrastructures z_t, such as economic infrastructures in the form of power plant, transport, telecommunication and legal infrastructures in the form of court and law enforcement institutions.[4]

Because $\lambda > 1$, the new technology's marginal cost of production of intermediate goods is smaller than that of the old technology's (i.e., $1/(\lambda z_t) < 1/z_t$). However, old individuals need to make an investment in employing the new technology, which costs F in terms of final goods. The fixed cost of production of intermediate goods is expressed as

$$F^j = \begin{cases} 0 & \text{with old technology } (j = O), \\ F & \text{with new technology } (j = N). \end{cases}$$

Our specification of choice between old technology and new technology follows Murphy et al.'s (1989) specification of the choice between production technology with constant returns to scale (CRS) and one with increasing returns to scale (IRS). The firm with new technology (i.e., IRS) requires a fixed cost of F but then yields output more efficiently than the firm with old technology (i.e., CRS) because $\lambda > 1$. With respect to production organization, following Thesmar and Theong (2000), we interpret the firm's transition from old technology to new technology as the transition from "small-scale production organization" to "large-scale production organization."

Given technology j, each old individual maximizes profit

$$\begin{aligned} \pi_t^j(i) &= p_t(i)x_t(i) - [\frac{x_t(i)}{\lambda_t^j z_t} + F^j] \\ &= \delta A_t^{1-\delta} x_t(i)^\delta - [\frac{x_t(i)}{\lambda_t^j z_t} + F^j]. \end{aligned} \tag{6}$$

The optimal choice of $x_t(i)$ is $x_t(i) = \delta^{\frac{2}{1-\delta}} (\lambda_t^j z_t)^{\frac{1}{1-\delta}} A_t = \delta^{\frac{2}{1-\delta}} (\lambda_t^j z_t)^{\frac{1}{1-\delta}} K_t^{\frac{1-\epsilon-\delta}{1-\delta}}$, for all $i \in [0, 1]$. Then, the equilibrium price is $p_t(i) = \frac{1}{\delta \lambda_t^j z_t}$, for all $i \in [0, 1]$, and the equilibrium gross profit given technology j is

$$\pi_t^j(i) = \bar{\pi} (\lambda_t^j z_t)^{\frac{\delta}{1-\delta}} K_t^{\frac{1-\epsilon-\delta}{1-\delta}} - F^j, \ \forall i \in [0, 1], \tag{7}$$

where $\bar{\pi} \equiv (1 - \delta)\delta^{\frac{1+\delta}{1-\delta}}$. Hence, given technology j, each old individual sells the same amount of intermediate goods, charges the same price, and obtains the same amount of profits.

2.4 Public Infrastructures and Productivity

The specification in (5) that the firm's effective productivity level is positively related with the quality of public infrastructures z_t has been widely used in theoretical analyses (e.g., Barro, 1990 and Acemoglu and Robinson, 2006) and is empirically supported at the macro and micro levels (e.g., Cohen and Paul,

[4]In the next subsection, we will discuss the reason why we suppose the firm's effective productivity level depends also on z_t.

2004 and Hulten et al., 2006).[5] For example, adequate transport facilities lower transportation costs, and reliable supplies of electricity lower energy costs. These cost savings lead to higher levels of productivity for intermediate-good firms.

Before going forward, it will help to keep in mind how the profit $\pi_t^j(i)$ in (7) depends upon the quality of public infrastructures z_t. From (7), we can easily confirm that $\frac{\partial \pi_t^N(i)}{\partial z_t} > \frac{\partial \pi_t^O(i)}{\partial z_t} > 0$ for all i hold because $\lambda > 1$. This result indicates that new technology firms can obtain larger profit gains from per-unit improvements in public infrastructures than old technology firms. In this sense, the quality of public infrastructures is more relevant for new technology firms than old technology firms. This is derived from the complementary relationship between the technology-specific term, λ_t^j, and the quality of public infrastructures, z_t, specified in (5).

This specification in (5) is justified by the following arguments. New technology's lower marginal cost of production relative to old technology is achieved by building a new factory or introducing new equipment for a large-scale production. To pay off fixed costs for these investments and make a profit, sufficiently large amounts of production are necessary for firms. To do exercise these large-scale investments and productions, new technology firms rely more heavily on public infrastructures in the form of power plants, transportation, and telecommunication than old technology firms.[6] Furthermore, new technology firms depend more heavily on public legal institutions than old technology firms because large-scale investment and production require more market-based complex economic transactions for which the formal enforceability of contracts by public institutions plays an important role.[7] Thus, the new technology's effective productivity becomes more relevant to the quality of public infrastructures than the old technology's effective productivity. The complementary relationship between λ_t^j and z_t in (5) captures these facts in a reduced-form way.[8]

[5] For instance, Hulten et al. (2006) using data from Indian states find a substantial externality effect from states' infrastructures to manufacturing productivity. For the period from 1972-1992, they find that the growth of road and electricity-generating capacity accounted for nearly half of the growth of the productivity residual of India's registered manufacturing.

[6] The amount of fixed cost, F, might be negatively related to the quality of public infrastructures, z_t. Such an extension does not alter main arguments, but it requires unnecessary lexicographic explanations.

[7] Informal bilateral arrangements are only feasible if there is no information asymmetry, which requires certain conditions such as geographic proximity and no alternative trading partner. Information asymmetries increase as markets grow in size and geography. Therefore, the role of formal legal institutions becomes more critical to governing transactions between strangers.

[8] Penrose (1959) and Chandler (1962) argue that decentralization was essential to the emergence of large firms. When firm owners are constrained over the number of decisions they can make, managers, who typically have better information than firm owners, can complete the task more efficiently than the owners. If this is the case, decentralization by delegating decision-making authorities form owners to managers is effective. Public legal institutions are essential to the proper functioning of decentralization. In our model, the new technology's lower marginal cost of production relative to the old technology can be interpreted as the result of more decentralized decision-making inside of firms due to the introduction of a new labor management system. Firm owners will be willing to delegate their authorities when the judicial systems works effectively such that the owners do not fear theft by their managers. Thus, even under this interpretation, the new technology's effective productivity becomes more relevant to the quality of public infrastructures than the old technology's

2.5 Government Budget

The quality of public infrastructures, z_t, is positively related to the level of public expenditure on maintaining and improving these infrastructures, G_t. We suppose that z_t is increasing and a strictly concave function of public expenditure, G_t, and we specify its functional form as

$$z_t = \mu\Gamma(G_t), \quad \mu > 0, \tag{8}$$

where $\Gamma_G(\cdot) > 0$, $\Gamma_{GG}(\cdot) < 0$, $\Gamma(0) = \underline{z} > 0$, $\lim_{G_t\to\infty}\Gamma(G_t) = \bar{z} < \infty$. The parameter μ captures the efficiency of public service production. The larger value of μ indicates the higher efficiency of public service production.[9]

In our model, the beneficiaries of public infrastructures are only old individuals who own intermediate-good firms. Therefore, we simply assume that the public expenditure in period t is financed by a lump-sum tax τ_t on old individuals, which satisfies $\tau_t = G_t$. From (8), the inverse function of $z_t = \mu\Gamma(G_t)$ can be described as

$$G_t = \Gamma^{-1}(\frac{z_t}{\mu}) \equiv C(z_t; \mu), \tag{9}$$

where $C_z(\cdot) > 0$, $C_{zz}(\cdot) > 0$, $\lim_{z_t\to\mu\underline{z}} C(z_t; \mu) = 0$, $\lim_{z_t\to\mu\bar{z}} C(z_t; \mu) = \infty$, $C_\mu(\cdot) < 0$, $\lim_{\mu\to 0} C_z(z_t; \mu) = \infty$, and $\lim_{\mu\to\infty} C_z(z_t; \mu) = 0$. In addition, we assume $C_z(\mu\underline{z}; \mu) = 0$ for simplicity. Hence, the lump-sum tax τ_t on old individuals is given by

$$\tau_t = G_t = C(z_t; \mu). \tag{10}$$

3 Technology Choice and Political Decision

3.1 Timing of Events

Now, we describe the political decision concerning public infrastructures. Because old individuals are the direct beneficiaries of public infrastructures and taxpayers in period t, we demonstrate that public expenditures in period t, G_t, is decided by a vote among old individuals. We can replace the political decision problem of G_t with the political decision problem of the quality of public infrastructures, z_t, because the value of G_t corresponds to z_t in a one-to-one manner from (10). Following Lindbeck and Weibul (1987), we employ a probabilistic voting framework where a political platform in period t simply maximizes a weighted utility of voters (i.e., old individuals) in period t.

effective productivity.

[9] In the last paragraph of 5.3, we will discuss some elements that influence μ as introducing empirical findings.

We focus our analysis on the situation where a government cannot commit to its policies on public infrastructures ex ante.[10] To describe this situation in the simplest way, following Saint-Paul and Verdier (1997), we assume that political decision G_t (or z_t) is made after the old individuals' choice of technology. Thus, the timing of the events is summarized as follows.

1. At the beginning of each period t, each old individual decides her or his type of technology. This decision is irreversible. In making this decision, each old individual treats the technology choices of other individuals as given and has perfect foresight regarding the outcome of the future voting process over expenditures for public infrastructures.

2. After making their technology choices, all old individuals vote on a policy concerning expenditures for public infrastructures, and a political platform in period t determines the level of G_t (or z_t) to maximize a weighted utility of old individuals in period t.

We should comment on a few critical issues regarding to timing. First, a production organization decision is one of the most irreversible decisions for any firms simply because once firms employ the large-scale production organization, it is usually difficult for them to instantly return back to a small-scale production organization. Second, firms decide their production organizations based upon their expectation of the outcome of future political process. As stressed by Acemoglu et al. (2005), there is an inherent commitment problem in politics. Politicians who care about their future elections may not necessarily try to keep past promises. Thus, it is important for firms to expect the outcome of future political processes when they need to make a crucial managerial decision such as a determination on their production organizations. Finally, related to above two issues, old individuals' preferences for public expenditures are directly affected by whether they adopted new technology beforehand. This timing of voting is critical for our following main arguments.

3.2 Technology Choice

We consider the old individual's technology choice problem. Suppose old individuals adopt new technology, $\pi_t^N(i) > \pi_t^O(i)$. From (7), $\pi_t^N(i) > \pi_t^O(i)$ holds if and only if,

$$z_t^e > \hat{F} K_t^{-\frac{1-\epsilon-\delta}{\delta}} \equiv \hat{z}(K_t), \tag{11}$$

[10] This non-commitment assumption may not be realistic, but the perfect commitment assumption is also unrealistic. The truth may lie between these two extreme cases. In this paper, we focus on the non-commitment case to clarify the main implication of our work.

where $\hat{F} \equiv [\frac{F}{\bar{\pi}(\lambda^{\frac{\delta}{1-\delta}}-1)}]^{\frac{1-\delta}{\delta}}$. The quality of public infrastructures, z_t, is determined in the second-stage voting process. This implies that in the first stage, old individuals decide their type of technology based on their expectation about z_t, which is represented by z_t^e in (11). The optimal technology choice can be illustrated in Figure 1. Suppose $z_t^e > \hat{z}(K_t)$ (resp. $z_t^e < \hat{z}(K_t)$), all individuals choose new technology (resp. old technology), suppose $z_t^e = \hat{z}(K_t)$. Then, each old individual is indifferent regarding whether to choose new technology or old technology. Hence, new technology and old technology firms may coexist only when $z_t^e = \hat{z}(K_t)$.

Figure 1 implies that old individuals prefer new technology to old technology when the level of capital, K_t, is high or when the expected quality of public infrastructures, z_t^e, is high. The advantage of the new technology relative to the old technology is its lower marginal cost of production. The marginal benefit of this advantage becomes more critical as the size of demand for intermediate goods (henceforth, the market size) becomes larger. From (2) and $A_t = K_t^{\frac{1-\epsilon-\delta}{1-\delta}}$, the higher K_t leads to the larger market size, and old individuals are more likely to choose new technology. Moreover, the higher z_t^e leads to the higher productivity rise in the new technology relative to the old technology. Consequently, old individuals are more likely to choose new technology.

Let $d_t \in [0,1]$ be the share of old individuals who choose new technology in period t. From (11) and Figure 1, we obtain following results.

$$d_t = \begin{cases} 0 & \text{if } z_t^e < \hat{z}(K_t), \\ 1 & \text{if } z_t^e > \hat{z}(K_t), \end{cases} \text{ and } d_t \in [0,1] \text{ if } z_t^e = \hat{z}(K_t). \tag{12}$$

This result that the higher quality of public infrastructures leads to the larger production organization is consistent with empirical findings. For example, Tybou (2000) argues that the high proportion of very small firms in developing countries partly stems from their weak transportation system, uncertainty about policies, poor rule of law, and corruption. Kumar et al. (2005) find a positive relationship between firm size and the quality of legal institutions using data from thirteen Europeans countries. Leaven and Woodruff (2007) also document a similar positive relationship in Mexico and provide evidence that this link is causal using the instrumental variable approach.

3.3 Probabilistic Voting

We consider the political decision problem concerning the quality of public infrastructures, z_t. The political decision of z_t is determined within a probabilistic voting framework. In our model, as individuals obtain utility from their second-period consumption, the political platform in period t simply maximizes a weighted after-tax income level of old individuals in period t.

Recall that an old individual's after-tax income in period t is given by $\rho_t w_{t-1} + \pi_t(i) - \tau_t$. From (7) and (10), the political objective function is given by

$$W_t = d_t v^N(z_t; K_t) + (1 - d_t) v^O(z_t; K_t) - C(z_t; \mu), \tag{13}$$

where

$$v^N(z_t; K_t) \equiv \rho_t w_{t-1} + \bar{\pi}(\lambda z_t)^{\frac{\delta}{1-\delta}} K_t^{\frac{1-\epsilon-\delta}{1-\delta}} - F,$$

$$v^O(z_t; K_t) \equiv \rho_t w_{t-1} + \bar{\pi}(z_t)^{\frac{\delta}{1-\delta}} K_t^{\frac{1-\epsilon-\delta}{1-\delta}}.$$

$v^N(z_t; K_t)$ (resp. $v^O(z_t; K_t)$) represents the pre-tax income level of old individuals who choose new technology (resp. old technology) in period t. Note that d_t is already determined in the first stage (i.e., the old individual's technology choice stage). Thus, the policy maker's first order condition with respect to z_t given ρ_t is

$$d_t v_z^N(z_t; K_t) + (1 - d_t) v_z^O(z_t; K_t) = C_z(z_t; \mu), \tag{14}$$

where

$$v_z^N(z_t; K_t) \equiv \frac{\delta}{1-\delta} \lambda^{\frac{\delta}{1-\delta}} \bar{\pi}(z_t)^{\frac{\delta}{1-\delta}-1} K_t^{\frac{1-\epsilon-\delta}{1-\delta}},$$

$$v_z^O(z_t; K_t) \equiv \frac{\delta}{1-\delta} \bar{\pi}(z_t)^{\frac{\delta}{1-\delta}-1} K_t^{\frac{1-\epsilon-\delta}{1-\delta}}.$$

Because $\lambda > 1$, $v_z^N(z_t; K_t) > v_z^O(z_t; K_t)$ holds for all $z_t > 0$. As shown in Figure 2, $\frac{\delta}{1-\delta} \leq 1$ results in the policy maker's optimal value of z_t being determined uniquely as a function of d_t, K_t and μ as follows.[11]

$$z_t^p \equiv z^p(d_t, K_t; \mu) = \begin{cases} z^O(K_t; \mu) & \text{if } d_t = 0, \\ d_t z^N(K_t; \mu) + (1 - d_t) z^O(K_t; \mu) & \text{if } d_t \in [0, 1], \\ z^N(K_t; \mu) & \text{if } d_t = 1, \end{cases} \tag{15}$$

where

$$z^O(K_t; \mu) \equiv \{z_t \mid v_z^O(z_t; K_t) = C_z(z_t; \mu)\},$$

$$z^N(K_t; \mu) \equiv \{z_t \mid v_z^N(z_t; K_t) = C_z(z_t; \mu)\}.$$

$z^O(K_t; \mu)$ (resp. $z^N(K_t; \mu)$) represents the politically determined value of z_t when all old individuals choose old technology (resp. new technology). Because $v_z^N(z_t; K_t) > v_z^O(z_t; K_t)$ and $d_t \in [0, 1]$, $z^N(K_t; \mu) \geq d_t z^N(K_t; \mu) + (1 - d_t) z^O(K_t; \mu) \geq z^O(K_t; \mu)$ holds for all $K_t > 0$. Moreover, as shown in

[11] Note that we assume $\delta \leq \frac{1}{2}$.

Appendix A, we find (i) $z_d^p(\cdot) > 0$, $z_K^j(\cdot) > 0$, and $z_\mu^j(\cdot) > 0$ for $j = O, N$ and (ii) $\lim_{K_t \to 0} z^j(K_t; \mu) = \mu \underline{z}$, $\lim_{K_t \to \infty} z^j(K_t; \mu) = \mu \bar{z}$, $\lim_{\mu \to 0} z^j(K_t; \mu) = 0$, and $\lim_{\mu \to \infty} z^j(K_t; \mu) = \infty$ for $j = P, O, N$.

Our results imply that the politically determined quality of public infrastructures, z_t^p, is increasing both in the share of old individuals who choose new technology, d_t, and in the level of capital, K_t. The firm with new technology can obtain larger profits from per-unit improvements in public infrastructures than that with old technology because the quality of public infrastructures is more relevant for the former than the latter. Thus, d_t has a positive effect on z_t^p. Moreover, the higher K_t leads to larger market size, which increases all old individuals' marginal profit from per-unit improvements in public infrastructures. Thus, K_t also has a positive effect on z_t^p.

In summary, large expenditures on public infrastructures are more likely to be politically supported both when many firms employ large-scale production and when the market size is large. This result is consistent with the predictions of Wagner's law (1893), which claims that the transformation from a traditional society to an industrialized society is accompanied by a surge in demand for public infrastructures. For example, Randolph et al. (1996) show that income elasticity of expenditures on public infrastructures exceeds unity by using pooled cross-sectional time-series data from 1980-1986 for 27 less-developed countries. Sturm (2001) also examines panel data for 123 less-developed countries from 1970-1998 and finds a similar high income elasticity of public capital spending.

4 Perfect Foresight Equilibrium

4.1 Rational Expectation Equilibrium

This section characterizes rational-expectation equilibria of the quality of public infrastructures, z_t. In the first stage (i.e., the technology-choice stage), old individuals decide their type of technology based on their expectation about z_t in the second stage (i.e., the voting stage). Rational expectation requires that old individuals' expectations about z_t (i.e., z_t^e) in the first stage be consistent with the politically determined quality of z_t in the second stage (i.e., z_t^p). Let z_t^* be a rational-expectation equilibrium of z_t. From (12) and (15), z_t^* satisfies the following conditions.

$$z_t^* = z^*(K_t; \mu) = \begin{cases} z^O(K_t; \mu) & \text{if } z_t^* < \hat{z}(K_t), \\ d^*(K_t; \mu) z^N(K_t; \mu) + [1 - d^*(K_t; \mu)] z^O(K_t; \mu) & \text{if } z_t^* = \hat{z}(K_t), \\ z^N(K_t; \mu) & \text{if } z_t^* > \hat{z}(K_t), \end{cases} \tag{16}$$

where

$$d^*(K_t; \mu) \equiv \{ d_t \mid d_t z^N(K_t; \mu) + (1 - d_t) z^O(K_t; \mu) = \hat{z}(K_t) \}.$$

On the one hand, from (15), both $z^N(K_t;\mu)$ and $z^O(K_t;\mu)$ are increasing in K_t and satisfy $\lim_{K_t\to 0} z^j(K_t;\mu) = \mu\underline{z}$ and $\lim_{K_t\to\infty} z^j(K_t;\mu) = \mu\bar{z}$ for $j = O, N$. On the other hand, from (11), $\hat{z}(K_t)$ is decreasing in K_t and satisfies $\lim_{K_t\to 0}\hat{z}(K_t) = \infty$ and $\lim_{K_t\to\infty}\hat{z}(K_t) = 0$. Thus, $z^N(K_t;\mu)$ (resp. $z^O(K_t;\mu)$) intersects with $\hat{z}(K_t)$ only once at $K_t = \underline{K}(\mu)$ (resp. $K_t = \bar{K}(\mu)$) where

$$\underline{K}(\mu) \equiv \{K_t \mid \hat{z}(K_t) = z^N(K_t;\mu)\},$$

$$\bar{K}(\mu) \equiv \{K_t \mid \hat{z}(K_t) = z^O(K_t;\mu)\}. \tag{17}$$

Because $z^N(K_t;\mu) > z^O(K_t;\mu)$ for all $K_t > 0$, $\underline{K}(\mu) < \bar{K}(\mu)$ holds. Moreover, as described in Appendix B, $\bar{K}_\mu(\cdot) < 0$, $\underline{K}_\mu(\cdot) < 0$, $\lim_{\mu\to 0}\bar{K}(\mu) = \infty$, $\lim_{\mu\to\infty}\bar{K}(\mu) = 0$, $\lim_{\mu\to 0}\underline{K}(\mu) = \infty$, and $\lim_{\mu\to\infty}\underline{K}(\mu) = 0$ hold. Thus, using $\underline{K}(\mu)$ and $\bar{K}(\mu)$, we can rewrite (16) as follows:

$$z_t^* = z^*(K_t;\mu) = \begin{cases} z^O(K_t;\mu) & \text{if } K_t < \bar{K}(\mu), \\ \hat{z}(K_t) & \text{if } K_t \in [\underline{K}(\mu), \bar{K}(\mu)], \\ z^N(K_t;\mu) & \text{if } K_t > \underline{K}(\mu). \end{cases} \tag{18}$$

The bold line in Figure 3 represents the results. The results are summarized as the following proposition.

Proposition 1. *1. If $K_t < \underline{K}(\mu)$, then $z_t^* = z^O(K_t;\mu)$ is a unique rational-expectation equilibrium of z_t.*

2. If $K_t > \bar{K}(\mu)$, then $z_t^* = z^N(K_t;\mu)$ is a unique rational-expectation equilibrium of z_t.

3. If $\underline{K}(\mu) \leq K_t \leq \bar{K}(\mu)$, then the following three rational-expectation equilibria of z_t exist:

$$z_t^* = z^*(K_t;\mu) = \begin{cases} z^O(K_t;\mu), \\ \hat{z}(K_t), \\ z^N(K_t;\mu). \end{cases}$$

The proof of Proposition 1 is given in Appendix C. In the following analysis, we label the equilibrium in which all old individuals choose new technology (i.e., $d_t = 1$) and the politically determined quality of public infrastructures satisfies $z_t^* = z^N(K_t;\mu)$ as the "N-equilibrium." Similarly, we label the equilibrium in which $d_t = 0$ and $z_t^* = z^O(K_t;\mu)$ as the "O-equilibrium." We also label the equilibrium in which $d_t \in (0,1)$ and $z_t^* = \hat{z}(K_t)$ as the "mixed equilibrium." In the region (a) of Figure 3, where $K_t < \underline{K}(\mu)$, the O-equilibrium is realized as a unique rational-expectation equilibrium. In the region (c) of Figure 3 where $K_t > \bar{K}(\mu)$, the N-equilibrium is realized as a unique rational-expectation equilibrium. For $K_t \in [\underline{K}(\mu), \bar{K}(\mu)]$, which corresponds to the region (b) of Figure 3, there are three rational-expectation equilibria.

In the region of $K_t \in [\underline{K}(\mu), \bar{K}(\mu)]$, which equilibrium is realized depends on each old individual's expectation about z_t. First, suppose that each old individual expects that all other old individuals will choose the new technology. In this case, $d_t = 1$ holds in the voting stage. From (15), a high-quality public infrastructures (i.e., $z^N(K_t;\mu)$) is expected to be realized. Under this expectation, all old individuals are willing to choose the new technology because $z^N(K_t;\mu) > \hat{z}(K_t)$; thus, the N-equilibrium is realized as a self-fulfilling equilibrium. Second, suppose that each old individual expects that all other old individuals will choose the old technology. In this case, the O-equilibrium is realized as a self-fulfilling equilibrium in a similar manner but through an inverse feedback effect in the case of realizing the N-equilibrium. Finally, suppose that each old individual expects that a fraction $d^*(K_t;\mu) \in (0,1)$ of old individuals will choose the new technology. In this case, the expectation about z_t adjusts to satisfy $z_t^* = \hat{z}(K_t)$. Each old individual will be indifferent between choosing the new technology and the old technology, and the mixed equilibrium will be realized as a self-fulfilling equilibrium.

4.2 Multiple Equilibria and Their Selections

We can provide an informal explanation for the stability of the equilibria we derived above. Suppose the economy is in the mixed equilibrium at E_M in Figure 3 and that old individuals' expectations about z_t (i.e., z_t^e) has decreased (resp. increased) slightly from $\hat{z}(K_t)$ for an exogenous reason. This circumstance means that $z_t^e < \hat{z}(K_t)$ (resp. $z_t^e > \hat{z}(K_t)$) holds. Then, from (12), all old individuals have strict incentives to choose the old technology (resp. the new technology), and the economy instantly deviates from the mixed equilibrium at E_M to reach the O-equilibrium at E_O (resp. the N-equilibrium at E_N). Therefore, the mixed equilibrium at E_M in Figure 3 is unstable in that the economy cannot be returned to the original equilibrium once it deviates from it. In contrast, both the O-equilibrium at E_O and the N-equilibrium at E_N are stable. In the following analysis, as in Chakraborty and Dabla-Norris (2011), we focus our analysis on these stable equilibria.[12] Henceforth, we can rewrite (18) as follows:

$$z_t^* = z^*(K_t;\mu) = \begin{cases} z^O(K_t;\mu) & \text{if } K_t \leq \bar{K}(\mu), \\ z^N(K_t;\mu) & \text{if } K_t \geq \underline{K}(\mu). \end{cases} \tag{19}$$

[12]Explicit consideration of mixed equilibrium does not alter our main arguments, but it requires unnecessary lexicographic explanations.

5 Dynamic Properties

5.1 Steady State Equilibrium

In this section, we examine the dynamic properties of the economy. The equilibrium condition in the capital market is given by $K_{t+1} = w_t$. By substituting $L_t = 1$, , $x_t(i) = \delta^{\frac{2}{1-\delta}}(z_t^j)^{\frac{1}{1-\delta}}A_t$, $A_t = K_t^{\frac{1-\epsilon-\delta}{1-\delta}}$, (3) and (19) into $K_{t+1} = w_t$, we obtain

$$K_{t+1} = \begin{cases} \Omega[z^O(K_t;\mu)]^{\frac{\delta}{1-\delta}} K_t^{\frac{1-\epsilon-\delta}{1-\delta}} \equiv \Phi^O(K_t;\mu), & \text{if } K_t \leq \bar{K}(\mu), \\ \Omega[\lambda z^N(K_t;\mu)]^{\frac{\delta}{1-\delta}} K_t^{\frac{1-\epsilon-\delta}{1-\delta}} \equiv \Phi^N(K_t;\mu), & \text{if } K_t \geq \underline{K}(\mu), \end{cases} \tag{20}$$

where $\Omega \equiv \epsilon\delta^{\frac{2\delta}{1-\delta}}$. Because $z^N(K_t;\mu) > z^O(K_t;\mu)$ and $\lambda > 1$, $\Phi^N(K_t;\mu) > \Phi^O(K_t;\mu)$ holds. Furthermore, as shown in Appendix D, $\Phi^j_\mu(\cdot) > 0$, $\lim_{\mu\to 0}\Phi^j(K_t;\mu) = 0$, and $\lim_{\mu\to\infty}\Phi^j(K_t;\mu) = \infty$ for $j = O, N$ hold. Because $\underline{K}(\mu) < \bar{K}(\mu)$, there exist multiple equilibria in the region of $K_t \in (\underline{K}(\mu), \bar{K}(\mu))$, where both the O-equilibrium and the N-equilibrium are realized as rational-expectation equilibria.

Figures 4 to 8 show several patterns of equilibrium dynamics. As shown in Figures 4 and 5, there may exist two non-trivial steady state equilibria. We denote the point at which the 45 degree line intersects with the graph of $\Phi^O(K_t;\mu)$ (resp. $\Phi^N(K_t;\mu)$) as E_O (resp. E_N) and define the level of K_t at E_O (resp. E_N) as $K^O(\mu)$ (resp. $K^N(\mu)$) where

$$K^O(\mu) \equiv \{K_t \mid K_t = \Phi^O(K_t;\mu)\},$$

$$K^N(\mu) \equiv \{K_t \mid K_t = \Phi^N(K_t;\mu)\}. \tag{21}$$

$K^N(\mu) > K^O(\mu)$ holds because $\Phi^N(K_t;\mu) > \Phi^O(K_t;\mu)$. Moreover, as shown in Appendix D, $K^j_\mu(\cdot) > 0$, $\lim_{\mu\to 0} K^j(\mu) = 0$ and $\lim_{\mu\to\infty} K^j(\mu) = \infty$ for $j = O, N$ hold. From the argument in subsection 4.2, in Figures 4 and 5, E_O is the stable steady state equilibrium characterized by the O-equilibrium with "old technology, low-quality public infrastructures and low capital per worker," while E_N is the stable steady state equilibrium characterized by the N-equilibrium with "new technology, high-quality public infrastructures and high capital per worker."

5.2 Equilibrium Dynamics

Now, the magnitude relationships among $K^N(\mu)$, $K^O(\mu)$, $\bar{K}(\mu)$, and $\underline{K}(\mu)$ lead us to several patterns of equilibrium dynamics summarized in Figures 4 to 8. To avoid lexicographic explanations, we focus on several interesting cases where intuitive results are obtained.[13]

[13]If we ignore trivial cases where equality holds among them, we have the following 6 patterns of the magnitude relationships among $K^N(\mu)$, $K^O(\mu)$, $\bar{K}(\mu)$ and $\underline{K}(\mu)$; (1) $\underline{K}(\mu) < K^O(\mu) < \bar{K}(\mu) < K^N(\mu)$ (i.e., Figure 4), (2)

Note the following properties: $K^N(\mu) > K^O(\mu)$, $\bar{K}(\mu) > \underline{K}(\mu)$, and $K^j_\mu(\cdot) > 0$ for $j = O, N$, $\bar{K}_\mu(\cdot) < 0$ and $\underline{K}_\mu(\cdot) < 0$. When the efficiency of public service production μ is sufficiently high to satisfy $\bar{K}(\mu) < K^O(\mu)$, we obtain the following proposition.

Proposition 2. *Suppose the efficiency of public service production μ is sufficiently high to satisfy $\bar{K}(\mu) < K^O(\mu)$, then the economy eventually converges to the steady state equilibrium E_N.*

Figure 6 shows the case where $\underline{K}(\mu) < \bar{K}(\mu) < K^O(\mu) < K^N(\mu)$ holds. The economy with any initial capital K_0 eventually converges to the steady state equilibrium E_N (i.e., the N-equilibrium steady state). When the economy lies in the region where $K_t < \underline{K}(\mu)$, all old individuals choose old technology because market size is still small and they expect the realization of low-quality public infrastructures. Thus, the O-equilibrium is realized in the early stage of economic development. However, as the economy develops and its capital level exceeds the threshold level of $\underline{K}(\mu)$ (i.e., $K_t > \underline{K}(\mu)$), old individuals may begin to employ new technology because the market size becomes large and they may expect political support for high-quality public infrastructures. Moreover, when $K_t > \bar{K}(\mu)$, all old individuals are convinced of the realization of high-quality public infrastructures and have strict incentives to employ the new technology. Then, the N-equilibrium is realized.[14] This co-evolution among public infrastructures, the production organizations of firms, and the per capita income is widely observed in the process of economic development. While public infrastructures may affect income through a firm's organizational decision and its productivity, economic growth can also shape the demand for public infrastructures and the political support for them. Note here that the co-evolution generates a positive feedback mechanism. Better public infrastructures are associated with efficient production organization and higher productivity. These factors raise the per capita income, accelerate capital accumulation, and increase the size of the market for intermediate goods. This market size expansion boosts the demand for public infrastructures and increases the political support for them.

In addition, there exist multiple equilibria in the region of $K_t \in (\underline{K}(\mu), \bar{K}(\mu))$. The multiple equilibria in this region could help us to understand why some relatively backward economies that were initially lagging behind can catch up to and, moreover, overtake economies that were initially ahead. In Figure 7, we depict two different economies that have different initial conditions K_0 and K_0', where $K_0' > K_0$. The dashed arrow displays the equilibrium path of the economy with better initial condition K_0', while the

$K^O(\mu) < \underline{K}(\mu) < \bar{K}(\mu) < K^N(\mu)$ (i.e., Figure 5), (3) $\underline{K}(\mu) < \bar{K}(\mu) < K^O(\mu) < K^N(\mu)$ (i.e., Figure 6, 7), (4) $K^O(\mu) < K^N(\mu) < \underline{K}(\mu) < \bar{K}(\mu)$ (i.e., Figure 8), (5) $\underline{K}(\mu) < K^O(\mu) < K^N(\mu) < \bar{K}(\mu)$, and (6) $K^O(\mu) < \underline{K}(\mu) < K^N(\mu) < \bar{K}(\mu)$. Although we do not discuss cases (5) and (6) explicitly, the main implication obtained from case (5) (resp. case (6)) is analogous to case (1) (resp. case (2)).

[14] In this paper, we implicitly assume that the transition from the old technology to the new technology occurs only once.

straight arrow displays that with inferior initial condition K_0. In the early stage of economic development, the economy with better initial condition K_0' is ahead of the economy with inferior initial condition K_0. However, as the level of capital rises, the backward economy can catch up to and eventually overtake the initially advanced economy if the former can successfully adopt the new technology earlier than the latter due to firm-level coordination of technology choices and the corresponding high levels of political support for public infrastructures. This finding implies that the timing of the transition from the O-equilibrium to the N-equilibrium is crucial for the emergence of rapid catch up and overtaking results.

Our result is partly consistent with experiences in some East Asian countries, such as Japan, South Korea, and Taiwan, where co-evolutions of public infrastructures and industrial transformations spurred economic growth. Note that it is still highly controversial whether governmental industrial policies influenced these events. On the one hand, Okazaki (1996) and Rodrik (1996) provide some convincing anecdotal evidence that governmental industrial policies in some East Asian countries played critical roles in coordinating private firms' investment activities. On the other hand, some studies stress the importance of private initiatives. For example, Matsuyama (1996) states, "[E]ven if one can establish, as convincingly as Okazaki's study (1996) on the Post WWII Japan and Rodrik (1996)'s study on Korea and Taiwan, that government policies sometimes appear to have succeeded in coordination in intended way, it does not follow that government was essential in achieving coordination in such instances. The private initiative could have achieved the same or, even better, results." Matsuyama (1996) also notes, "[O]kazaki's study (1996) stresses the role of government councils in facilitating coordination between shipbuilding and steel industries. But, one can also point out a story of Eiichi Shibusawa, a private entrepreneur, who achieved to coordinate between cotton textile and ocean shipping industries in Meiji Japan."

With respect to the government's role in coordinating private sector activities, this paper provides inherently skeptical views due to our assumption that government cannot commit to their policies ex ante. In our model, as in other models of coordination failures, if private firms can coordinate their technology choices, the economy can shift from the O-equilibrium to the N-equilibrium. However, in our political decision framework, government policies (public infrastructures) only reflect the results of private sector technology decisions. Therefore, the prevalence of coordination failures in private sectors leads to insufficient supplies of public infrastructures, which in turn sustains the prevalence of coordination failures in private sectors. In this sense, a government cannot play any active role in coordinating private sector activities. Although this result is obvious from our political decision assumption, it may shed light on one of the inherent difficulties of governmental coordination policies.[15]

5.3 Stagnation

The previous subsection focuses on the one extreme case where the efficiency of public service production, μ, is sufficiently high to satisfy $\bar{K}(\mu) < K^O(\mu)$. This subsection examines the opposite extreme case where μ is sufficiently low to satisfy $K^N(\mu) < \underline{K}(\mu)$, as shown in Figure 8. In this case, we obtain the following proposition.

Proposition 3. *Suppose the efficiency of public service production μ is sufficiently low to satisfy $K^N(\mu) < \underline{K}(\mu)$; then, the economy eventually converges to the steady state equilibrium E_O.*

Figure 8 shows the case where the magnitude relationships $K^O(\mu) < K^N(\mu) < \underline{K}(\mu) < \bar{K}(\mu)$. In this case, the economy with any initial capital K_0 eventually converges to the steady state equilibrium E_O (i.e., the O-equilibrium steady state). Because the efficiency of public service production, μ, is sufficiently low, the lowest threshold level of capital $\underline{K}(\mu)$ where old individuals may potentially start to choose new technology exceeds the highest steady state level of capital where the economy can potentially achieve $K^N(\mu)$. Consequently, all old individuals are convinced of the realization of low-quality public infrastructures and have no incentives to employ new technology. The O-equilibrium is realized in the steady state equilibrium. These results imply that the economy is trapped in the low-development steady state equilibrium characterized by "old technology, low quality of public infrastructures, and low capital per worker."

The results from Figures 6 to 8 suggest the critical impact of public service production efficiency, μ, on long-run economic development. μ is affected by several region-specific and historical factors, such as the quality of bureaucrats, the origins of legal institutions, and the types of organic private-order institutions.[16] First, Chakraborty and Dabla-Norris (2011) show that a higher tendency of bureaucratic corruption lowers the efficiency of public service production and argue that the quality differences in public capital can potentially explain a large fraction of the income gap between rich and poor nations. Second, the legal tradition adopted by countries (e.g., common law vs. civil law) has a long lasting impact on the efficiency of bureaucratic and legal procedures. Djankov et al. (2003) show that the flexibility and adaptability of legal institutions vary across legal traditions. While French Civil Code systems rely more on formalistic procedures and judgments based narrowly on statutory law, the common law tradition

[15] See, for example, Matsuyama (1995, 1996) for a summary of the policy implications of coordination failures.

[16] Beck (2010) shows that certain types of organic private-order institutions, which are based on reputation and informal relationships, complement the function of public legal institutions.

embraces case law and judicial discretion. Beck et al. (2003, 2005) demonstrate that this difference in the adaptability of legal systems explains differences in financial sector development and economic growth.[17] Therefore, our theoretical results are partly consistent with these empirical findings.

5.4 Multiple Equilibrium Paths and Multiple Steady State Equilibria

This subsection examines the cases where the efficiency of public service, μ, has intermediate values in the sense that both $K^N(\mu) < \underline{K}(\mu)$ and $\bar{K}(\mu) < K^O(\mu)$ do not hold.

Figure 4 shows the case where the magnitude relationships $\underline{K}(\mu) < K^O(\mu) < \bar{K}(\mu) < K^N(\mu)$ hold. In this case, even for the economies with equivalent initial capital K_0, the economies in which different expectations are formed in region where $\underline{K}(\mu) < K_t < \bar{K}(\mu)$ may converge to different steady state equilibria. As shown in Figure 4, on one equilibrium path, the economy succeeds in switching from the O-equilibrium to the N-equilibrium and eventually converges to steady state equilibrium E_N, while on the other path, the economy remains at the O-equilibrium and converges to the steady state equilibrium E_O. However, note that E_O lies in the region where $\underline{K}(\mu) < K_t < \bar{K}(\mu)$ in Figure 4. This result implies that even once the economy converges to E_O, the economy can shift from the O-equilibrium to the N-equilibrium and may possibly converge to E_N if all individuals' technology choice are well coordinated.

Figure 5 shows the case where the magnitude relationships $K^O(\mu) < \underline{K}(\mu) < \bar{K}(\mu) < K^N(\mu)$ hold. In this case, suppose that the initial capital satisfies $K_0 > \bar{K}(\mu)$ (resp. $K_0 < \underline{K}(\mu)$); then, the economy eventually converges to E_N (resp. E_O). Moreover, suppose that the initial capital level lies in region $K_0 \in [\underline{K}(\mu), \bar{K}(\mu)]$; then, we have multiple equilibrium paths. Even for the economies with equivalent initial capital $K_0 \in [\underline{K}(\mu), \bar{K}(\mu)]$, the economies in which different expectations are formed may ultimately converge to different steady state equilibria, some of which converge to E_N, while others converge to E_O. Note that E_O lies in the region where $K_t < \underline{K}(\mu)$ in Figure 5. In this case, once the economy converges to E_O, it cannot escape from E_O without exogenous parametric or policy changes.

Both Figures 4 and 5 show the case where there exists two non-trivial steady state equilibria E_O and E_N. By comparing the steady state welfare level (the after-tax income level of old individuals) at E_O and E_N, we obtain the following proposition.

Proposition 4. *Suppose the efficiency of public service production μ is sufficiently high to satisfy $K^N(\mu) > \bar{K}(\mu)$; then, the steady state welfare level at E_N is higher than that at E_O.*

[17] Esfahani and Ramirez (2003) show that the growth effect via infrastructure depends on the strength of a country's institutions, such as bureaucratic efficiency and contract enforcement.

The proof of Proposition 4 is given in Appendix E. When $K^N(\mu) > \bar{K}(\mu)$ holds, as in both Figures 4 and 5, the steady state welfare level at E_N is higher than that at E_O. Therefore, the economy converges to the low-welfare steady state equilibrium if its initial capital is less than $\underline{K}(\mu)$ in Figure 5 or if individuals' technology choices are not well coordinated in the region where $\underline{K}(\mu) < K_t < \bar{K}(\mu)$ in Figures 4 and 5.[18]

Multiple steady state equilibria results shown in Figures 4 and 5 suggest that small differences in the efficiency of public service production can account for large differences in the per capita income across countries. This suggestion implies, again, that the efficiency of public service production matters. The higher efficiency of public service production enhances expectations for the realization of high-quality infrastructures, induces the adoption of new technologies, and lowers the risk of the inferior steady state equilibrium. Our model straightforwardly suggests that policies should aim to improve the quality of monitoring and bureaucratic oversight and raise the flexibility and adoptability of court procedures. However, as mentioned above, the efficiency of public service is affected by region-specific or historical factors. Thus, the reform of these institutions must be observed in the context of the legal and historical traditions of the economy.

6 Concluding Remarks

We have developed a political economic model of growth to examine how a firm's economic decision regarding production organization is affected by the quality of public infrastructures and economic development and how a firm's economic decision affects political decisions concerning public infrastructures and economic development. We showed that multiple-equilibrium growth paths occur due to these interactions between economic and political decisions. Even economies with equivalent initial conditions may follow different development paths if they have different expectations about the quality of public infrastructures. These multiple growth paths could explain why backward economies with relatively poor initial conditions can catch up to and, furthermore, overtake more advanced economies with relatively better initial conditions. Our result is consistent with the experiences of some East Asian countries where co-evolutions of public infrastructures and industrial transformations spurred economic development.

Appendix A

- $z_d^P(\cdot) > 0$, $z_K^j(\cdot) > 0$, $z_\mu^j(\cdot) > 0$ for $j = O, N$:

[18] As discussed in Appendix E, the condition $K^N(\mu) > \bar{K}(\mu)$ is the sufficient condition for which the steady state welfare level at E_N is higher than that at E_O. Even if the condition $K^N(\mu) > \bar{K}(\mu)$ does not hold, there exists a range of parameter regions for which the steady state welfare level at E_N is higher than that at E_O. In particular, ceteris paribus, when the new technology's fixed F is smaller or the effective productivity is higher, this parameter region becomes larger.

By totally differentiating (14), because $v_z^N(\cdot) > v_z^O(\cdot)$, $v_{zK}^j(\cdot) > 0$ for $j = O, N$, $c_{zz}(\cdot) > 0$ and $c_{z\mu}(\cdot) < 0$, we obtain

$$z_d^P(\cdot) = \frac{v_z^N(\cdot) - v_z^O(\cdot)}{c_{zz}(\cdot)} > 0,$$

$$z_K^P(\cdot) = \frac{d_t v_{zK}^N(\cdot) + (1 - d_t) v_{zK}^O(\cdot)}{c_{zz}(\cdot)} > 0,$$

$$z_\mu^P(\cdot) = -\frac{c_{z\mu}(\cdot)}{c_{zz}(\cdot)} > 0.$$

Noting $z^P(1, K_t; \mu) = z^N(K_t; \mu)$ and $z^P(0, K_t; \mu) = z^O(K_t; \mu)$, we also confirm that the relations $z_K^j(\cdot) > 0$, $z_\mu^j(\cdot) > 0$ for $j = O, N$ hold.

- $\lim_{K_t \to 0} z^j(K_t; \mu) = \mu \underline{z}$, $\lim_{K_t \to \infty} z^j(K_t; \mu) = \mu \bar{z}$ for $j = P, O, N$:

  From (14), because $\lim_{K_t \to 0} v_z^N(z_t, K_t) = 0$, $\lim_{K_t \to 0} v_z^O(z_t, K_t) = 0$ and $\lim_{z_t \to \mu \underline{z}} c_z(z_t; \mu) = 0$, we obtain $\lim_{K_t \to 0} z^j(K_t; \mu) = \mu \underline{z}$ for $j = P, O, N$. Similarly, from (14), because $\lim_{K_t \to \infty} v_z^N(z_t, K_t) = \infty$, $\lim_{K_t \to \infty} v_z^O(z_t, K_t) = \infty$ and $\lim_{z_t \to \mu \bar{z}} c_z(z_t; \mu) = \infty$, we obtain $\lim_{K_t \to \infty} z^j(K_t; \mu) = \mu \bar{z}$ for $j = P, O, N$.

- $\lim_{\mu \to 0} z^j(K_t; \mu) = 0$, $\lim_{\mu \to \infty} z^j(K_t; \mu) = \infty$ for $j = P, O, N$:

  From (14), because $\lim_{\mu \to 0} c_z(z_t; \mu) = \infty$, $\lim_{z_t \to 0} v_z^N(z_t, K_t) = \infty$, $\lim_{z_t \to 0} v_z^O(z_t, K_t) = \infty$, we obtain $\lim_{\mu \to 0} z^j(K_t; \mu) = 0$ for $j = P, O, N$. Similarly, from (14), because $\lim_{\mu \to \infty} c_z(z_t; \mu) = 0$, $\lim_{z_t \to \infty} v_z^N(z_t, K_t) = 0$, $\lim_{z_t \to \infty} v_z^O(z_t, K_t) = 0$, we obtain $\lim_{\mu \to \infty} z^j(K_t; \mu) = \infty$ for $j = P, O, N$

Appendix B

- $\bar{K}_\mu(\cdot) < 0$, $\underline{K}_\mu(\cdot) < 0$:

  By totally differentiating (17), because $z_\mu^j(\cdot) > 0$, $z_K^j(\cdot) > 0$ for $j = N, O$ and $\hat{z}_K(\cdot) < 0$, we obtain

$$\underline{K}_\mu(\cdot) = \frac{z_\mu^N(\cdot)}{\hat{z}_K(\cdot) - z_K^N(\cdot)} < 0,$$

$$\bar{K}_\mu(\cdot) = \frac{z_\mu^O(\cdot)}{\hat{z}_K(\cdot) - z_K^O(\cdot)} < 0,$$

- $\lim_{\mu \to 0} \bar{K}(\mu) = \infty$, $\lim_{\mu \to \infty} \bar{K}(\mu) = 0$:

  From (14), because $\lim_{\mu \to 0} z^N(K_t; \mu) = 0$, $\lim_{K_t \to \infty} \hat{z}(K_t) = 0$, we obtain $\lim_{\mu \to 0} \bar{K}(\mu) = \infty$. Moreover, because $\lim_{\mu \to \infty} z^N(K_t; \mu) = \infty$, $\lim_{K_t \to 0} \hat{z}(K_t) = \infty$, we obtain $\lim_{\mu \to \infty} \bar{K}(\mu) = 0$. The proof of $\lim_{\mu \to 0} \underline{K}(\mu) = \infty$ and $\lim_{\mu \to \infty} \underline{K}(\mu) = 0$ can be provided in a similar way.

Appendix C

This Appendix only proves Propositions 1-1 and 1-3. The proof of Proposition 1-2 can be provided in a similar way to Propositions 1-1 and 1-3.

Proof of Proposition 1-1

First, given $K_t < \underline{K}(\mu)$, suppose that all individuals expected the value of z_t that satisfies $z_t^e > \hat{z}(K_t)$. From (12), all old individuals choose the new technology (i.e., $d_t = 1$) because $z_t^e > \hat{z}(K_t)$. Because $d_t = 1$, from (15), $z_t^p = z^N(K_t;\mu)$ is realized in the voting stage. In an equilibrium, rational expectation requires that $z_t^e = z_t^p \Rightarrow \hat{z}(K_t) < z^N(K_t;\mu)$. However, $z^N(K_t;\mu) < \hat{z}(K_t)$ when $K_t < \underline{K}(\mu)$, which is a contradiction.

Second, suppose that all individuals expected the value of z_t that satisfies $z_t^e = \hat{z}(K_t)$. From (12), each old individual is indifferent regarding whether to choose the new technology or the old technology (i.e., $d_t \in (0,1)$) because $z_t^e = \hat{z}(K_t)$. Because $d_t \in (0,1)$, from (15), $z_t^p = d_t z^N(K_t;\mu) + (1-d_t)z^O(K_t;\mu)$ is realized in the voting stage. In an equilibrium, rational expectation requires that $z_t^e = z_t^p \Rightarrow \hat{z}(K_t) = d_t z^N(K_t;\mu) + (1-d_t)z^O(K_t;\mu)$. However, $d_t z^N(K_t;\mu) + (1-d_t)z^O(K_t;\mu) < \hat{z}(K_t)$ because $z^O(K_t;\mu) < z^N(K_t;\mu) < \hat{z}(K_t)$ when $K_t < \underline{K}(\mu)$, which is a contradiction.

Finally, suppose that all individuals expected the value of z_t that satisfies $z_t^e < \hat{z}(K_t)$. From (12), all old individuals choose the old technology (i.e., $d_t = 0$) because $z_t^e < \hat{z}(K_t)$. Because $d_t = 0$, from (15), $z_t^p = z^O(K_t;\mu)$ is realized in the voting stage. In an equilibrium, rational expectation requires that $z_t^e = z_t^p \Rightarrow \hat{z}(K_t) > z^O(K_t;\mu)$. This condition is satisfied when $K_t < \underline{K}(\mu)$. Thus, $z_t^* = z^O(K_t;\mu)$ could be a rational-expectation equilibrium value of z_t.

As a result, any expectations except for $z_t^e = z^O(K_t;\mu)$ result in a contradiction. Thus, when $K_t < \underline{K}(\mu)$, $z_t^* = z^O(K_t;\mu)$ is an unique rational-expectation equilibrium value of z_t.

Proof of Proposition 1-3

First, given $\underline{K}(\mu) \leq K_t \leq \bar{K}(\mu)$, suppose that all individuals expected the value of z_t that satisfies $z_t^e > \hat{z}(K_t)$. From (12), all old individuals choose new technology (i.e., $d_t = 1$) because $z_t^e > \hat{z}(K_t)$. Because $d_t = 1$, from (15), $z_t^p = z^N(K_t;\mu)$ is realized in the voting stage. In an equilibrium, rational expectation requires that $z_t^e = z_t^p \Rightarrow \hat{z}(K_t) < z^N(K_t;\mu)$. This condition is satisfied when $\underline{K}(\mu) \leq K_t \leq \bar{K}(\mu)$. Thus, $z_t^* = z^N(K_t;\mu)$ could be a rational-expectation equilibrium value of z_t.

Second, suppose that all individuals expected the value of z_t that satisfies $z_t^e = \hat{z}(K_t)$. From (12), each old individual is indifferent regarding whether to choose the new technology or the old technology (i.e., $d_t \in (0,1)$) because $z_t^e = \hat{z}(K_t)$. Because $d_t \in (0,1)$, from (15), $z_t^p = d_t z^N(K_t;\mu) + (1-d_t) z^O(K_t;\mu)$ is realized in the voting stage. In an equilibrium, rational expectation requires that $z_t^e = z_t^p \Rightarrow \hat{z}(K_t) = d_t z^N(K_t;\mu) + (1-d_t) z^O(K_t;\mu)$. Note that there exists $d_t \in [0,1]$ that satisfies this condition because $z^O(K_t;\mu) \le \hat{z}(K_t) \le z^N(K_t;\mu)$ when $\underline{K}(\mu) \le K_t \le \bar{K}(\mu)$. Thus, $z_t^* = \hat{z}(K_t;\mu)$ could be a rational-expectation equilibrium value of z_t.

Finally, suppose that all individuals expected the value of z_t that satisfies $z_t^e < \hat{z}(K_t)$. From (12), all old individuals choose the old technology (i.e., $d_t = 0$) because $z_t^e < \hat{z}(K_t)$. Because $d_t = 0$, from (15), $z_t^p = z^O(K_t;\mu)$ is realized in the voting stage. In an equilibrium, rational expectation requires that $z_t^e = z_t^p \Rightarrow \hat{z}(K_t) > z^O(K_t;\mu)$. This condition is satisfied when $K_t < \underline{K}(\mu)$. Thus, $z_t^* = z^O(K_t;\mu)$ could be a rational-expectation equilibrium value of z_t.

Appendix D

- $\Phi_\mu^j(\cdot) > 0$, $\lim_{\mu\to 0} \Phi^j(K_t;\mu) = 0$ and $\lim_{\mu\to\infty} \Phi^j(K_t;\mu) = \infty$ for j=O,N

  From (20), because $z_\mu^j(\cdot) > 0$ for $j = O,N$, the relation $\Phi_\mu^j(\cdot) > 0$. In addition, because $\lim_{\mu\to 0} z^j(K_t;\mu) = 0$, $\lim_{\mu\to\infty} z^j(K_t;\mu) = \infty$, we obtain $\lim_{\mu\to 0} \Phi^j(K_t;\mu) = 0$ and $\lim_{\mu\to\infty} \Phi^j(K_t;\mu) = \infty$ for j=O,N.

- $K_\mu^j(\cdot) > 0$, $\lim_{\mu\to 0} K^j(\mu) = 0$, $\lim_{\mu\to\infty} K^j(\mu) = \infty$ for $j = O,N$

  By totally differentiating (21), because $\Phi_\mu^j(\cdot) > 0$ for $j = O,N$, $\Phi_K^j(\cdot) < 1$, we obtain

  $$K_\mu^j(\cdot) = \frac{\Phi_\mu^j(\cdot)}{1 - \Phi_K^j(\cdot)} > 0 \quad for\ j = O,N.$$

  Furthermore, from (21), because $\lim_{\mu\to 0} \Phi^j(K_t;\mu) = 0$ and $\lim_{\mu\to\infty} \Phi^j(K_t;\mu) = \infty$ for $j = O,N$, we obtain $\lim_{\mu\to 0} K^j(\mu) = 0$, $\lim_{\mu\to\infty} K^j(\mu) = \infty$ for $j = O,N$.

Appendix E

We denote the steady state welfare level, which is represented by the after-tax income level of old individuals at E_O (resp. E_N), as $W^O(z^O(K^O), K^O)$ (resp. $W^N(z^N(K^N), K^N)$). Here, K^O (resp. K^N) is the steady state capital level at E_O (resp. E_N), and $z^O(K^O)$ (resp. $z^N(K^N)$) is the steady state quality of public infrastructures at E_O (resp. E_N). Here, we show that $W^N(z^N(K^N), K^N) > W^O(z^O(K^O), K^O)$ holds when $K^N > \bar{K}(\mu)$.

By substituting (4), $K_t = w_{t-1}$, $x_t(i) = \delta^{\frac{2}{1-\delta}} (\lambda_t^j z_t)^{\frac{1}{1-\delta}} K_t^{\frac{1-\epsilon-\delta}{1-\delta}}$, (15) and (21) into $v^N(z_t; K_t) - C(z_t; \mu)$ (resp. $v^O(z_t; K_t) - C(z_t; \mu)$) in (13), $W^O(z^O(K^O), K^O)$ (resp. $W^N(z^N(K^N), K^N)$) is given by

$$W^O(z^O(K^O), K^O) = [(1-\epsilon-\delta) + (1-\delta)\delta] Y^O(z^O(K^O), K^O) - C(z^O(K^O)),$$

$$W^N(z^N(K^N), K^N) = [(1-\epsilon-\delta) + (1-\delta)\delta] Y^N(z^N(K^N), K^N) - C(z^N(K^N)) - F.$$

where

$$Y^O(z^O(K^O), K^O) \equiv \delta^{\frac{2\delta}{1-\delta}} [z^O(K^O)]^{\frac{\delta}{1-\delta}} (K^O)^{\frac{1-\epsilon-\delta}{1-\delta}},$$

$$Y^N(z^N(K^N), K^N) \equiv \delta^{\frac{2\delta}{1-\delta}} [\lambda z^N(K^N)]^{\frac{\delta}{1-\delta}} (K^N)^{\frac{1-\epsilon-\delta}{1-\delta}}.$$

$Y^O(z^O(K^O), K^O)$ (resp. $Y^N(z^N(K^N), K^N)$) is the steady state final output at E_O (resp. E_N), and $C(z^O(K^O))$ (resp. $C(z^N(K^N))$) is the steady state lump-sum tax at E_O (resp. E_N). Moreover, the term $(1-\epsilon-\delta)Y^O(z^O(K^O), K^O)$ (resp. $(1-\epsilon-\delta)Y^N(z^N(K^N), K^N)$) expresses the steady state income through capital holdings (i.e., $\rho_t w_{t-1}$) at E_O (resp. E_N), while the term $(1-\delta)\delta Y^O(z^O(K^O), K^O)$ (resp. $(1-\delta)\delta Y^N(z^N(K^N), K^N)$) expresses the steady state income through intermediate good firm holdings (i.e., $\pi_t(i)$) at E_O (resp. E_N). Note that $(1-\delta)\delta Y^O(z^O(K^O), K^O)$ ($(1-\delta)\delta Y^N(z^N(K^N), K^N)$) is rewritten as $\bar{\pi}[z^O(K^O)]^{\frac{\delta}{1-\delta}} (K^O)^{\frac{1-\epsilon-\delta}{1-\delta}}$ (resp. $\bar{\pi}[\lambda z^N(K^N)]^{\frac{\delta}{1-\delta}} (K^N)^{\frac{1-\epsilon-\delta}{1-\delta}}$).

Because $\lambda > 1$ and $z^N(K^N) > z^O(K^O)$, we can easily confirm that

$$(1-\epsilon-\delta)Y^N(z^N(K^N), K^N) > (1-\epsilon-\delta)Y^O(z^O(K^O), K^O)$$

holds. The steady state income through capital holdings at E_N is always larger than that at E_O. Therefore, the sufficient condition for $W^N(z^N(K^N), K^N) > W^O(z^O(K^O), K^O)$ is expressed as follows:

$$\bar{\pi}[\lambda z^N(K^N)]^{\frac{\delta}{1-\delta}} (K^N)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^N(K^N)) - F > \bar{\pi}[z^O(K^O)]^{\frac{\delta}{1-\delta}} (K^O)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^O(K^O)).$$

Because the first term in the right-hand side, $\bar{\pi}[z^O(K)]^{\frac{\delta}{1-\delta}} (K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^O(K))$, is an increasing function of K and $K^N > K^O$, the above inequality always holds if

$$\bar{\pi}[\lambda z^N(K^N)]^{\frac{\delta}{1-\delta}} (K^N)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^N(K^N)) - F > \bar{\pi}[z^O(K^N)]^{\frac{\delta}{1-\delta}} (K^N)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^O(K^N)). \tag{22}$$

As a result, (22) expresses the sufficient condition for $W^N(z^N(K^N), K^N) > W^O(z^O(K^O), K^O)$.

From the definition of $\hat{z}(K)$ in (11),

$$\bar{\pi}(\lambda z)^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z) - F > \bar{\pi}(z)^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z)$$

holds for $z > \hat{z}(K)$. Furthermore, from the definition of $\bar{K}(\mu)$ in (17), the inequality $z^O(K) > \hat{z}(K)$ holds for all $K > \bar{K}(\mu)$. Then, for all $K > \bar{K}(\mu)$,

$$\bar{\pi}[\lambda z^O(K)]^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^O(K)) - F > \bar{\pi}[z^O(K)]^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^O(K)).$$

From the definition of $z^N(K)$ in (19), we can easily confirm that the $\bar{\pi}[\lambda z^N(K)]^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^N(K)) - F > \bar{\pi}[\lambda z^O(K)]^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^O(K)) - F$. Then, for all $K > \bar{K}(\mu)$,

$$\bar{\pi}[\lambda z^N(K)]^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^N(K)) - F > \bar{\pi}[z^O(K)]^{\frac{\delta}{1-\delta}}(K)^{\frac{1-\epsilon-\delta}{1-\delta}} - C(z^O(K)).$$

holds.

As a result, suppose that $K^N > \bar{K}(\mu)$. We can confirm that equation (22) holds and that the sufficient condition for $W^N(z^N(K^N), K^N) > W^O(z^O(K^O), K^O)$ is satisfied.

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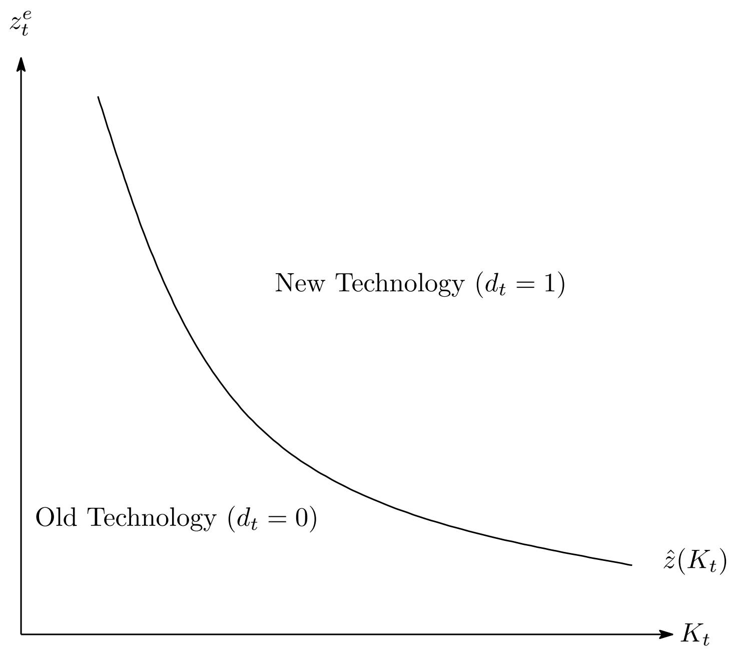

Figure 1: The Optimal Technology Choice

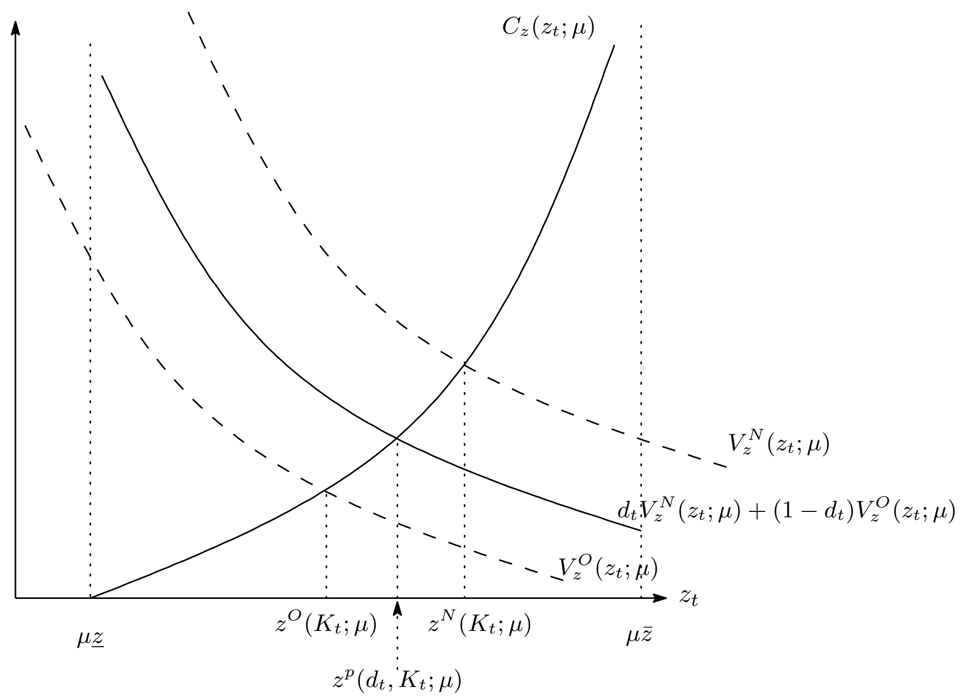

Figure 2: The Policy Maker's Optimal Value of z_t

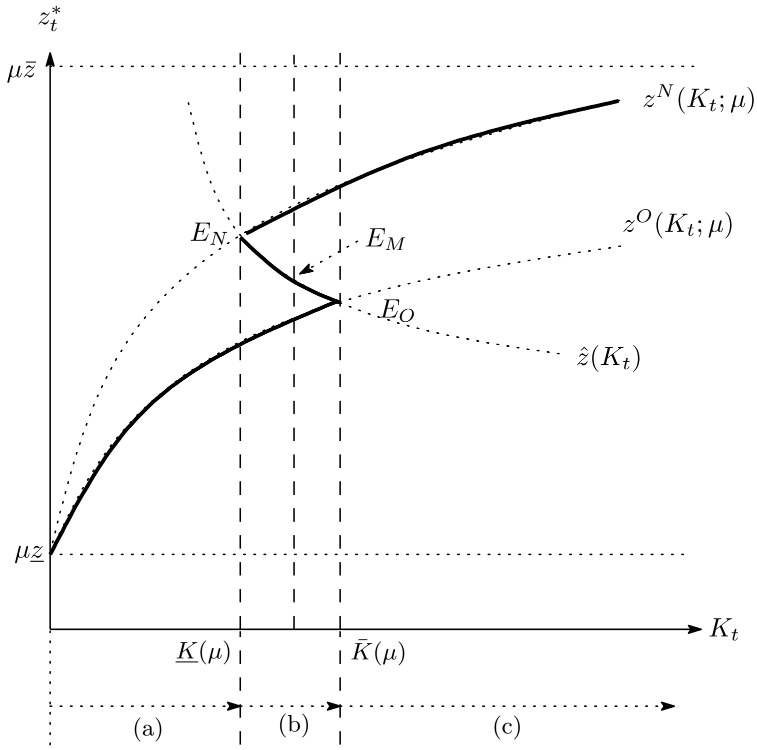

Figure 3: Rational Expectation Equilibria

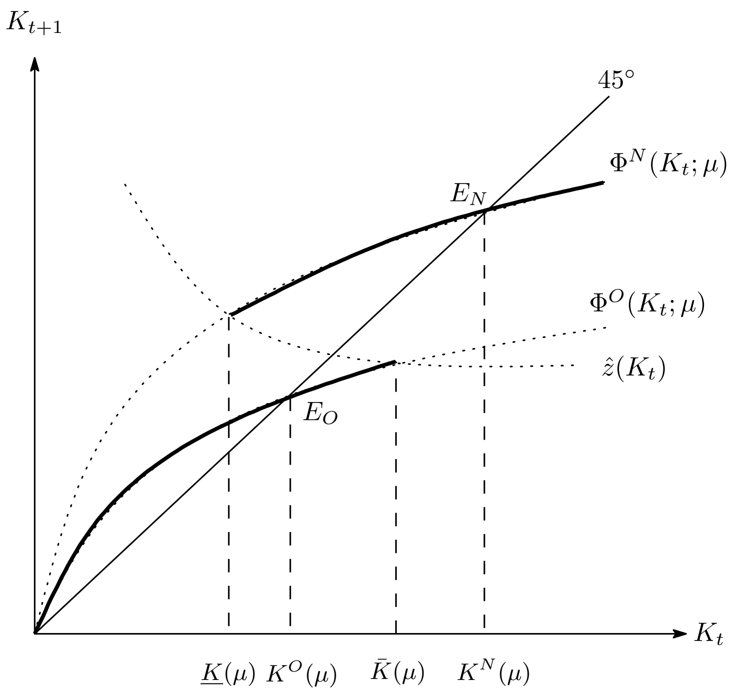

Figure 4: The Case Where $\underline{K}(\mu) < K^O(\mu) < \bar{K}(\mu) < K^N(\mu)$

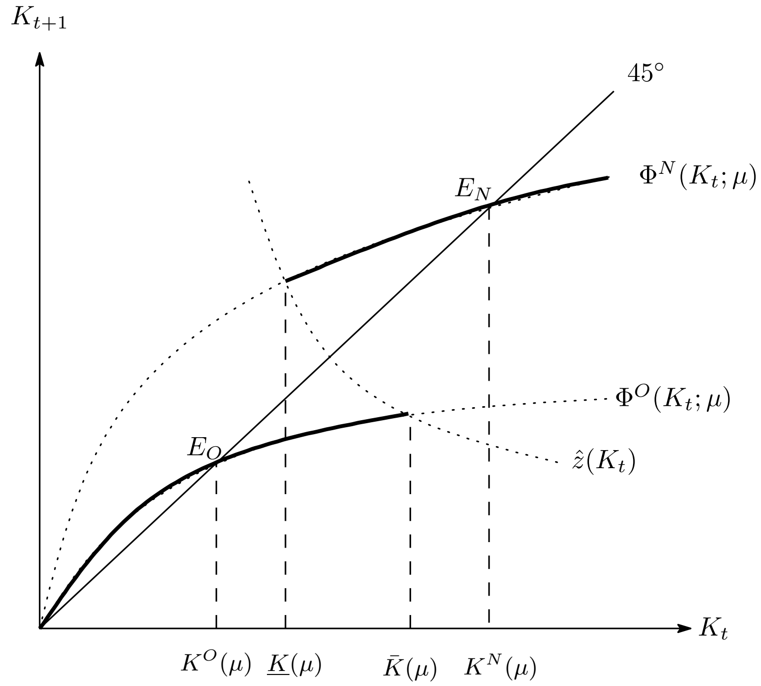

Figure 5: The Case Where $K^O(\mu) < \underline{K}(\mu) < \bar{K}(\mu) < K^N(\mu)$

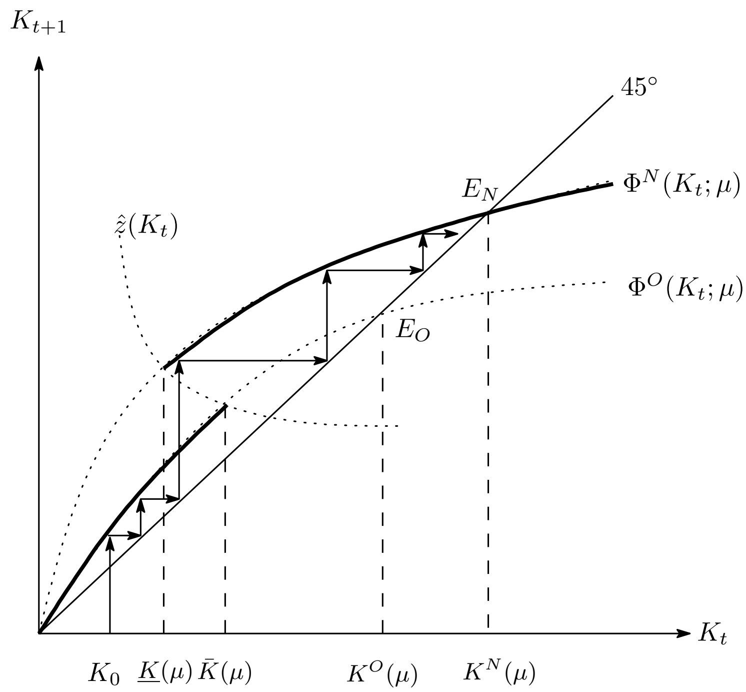

Figure 6: Monotone Convergence to E_N

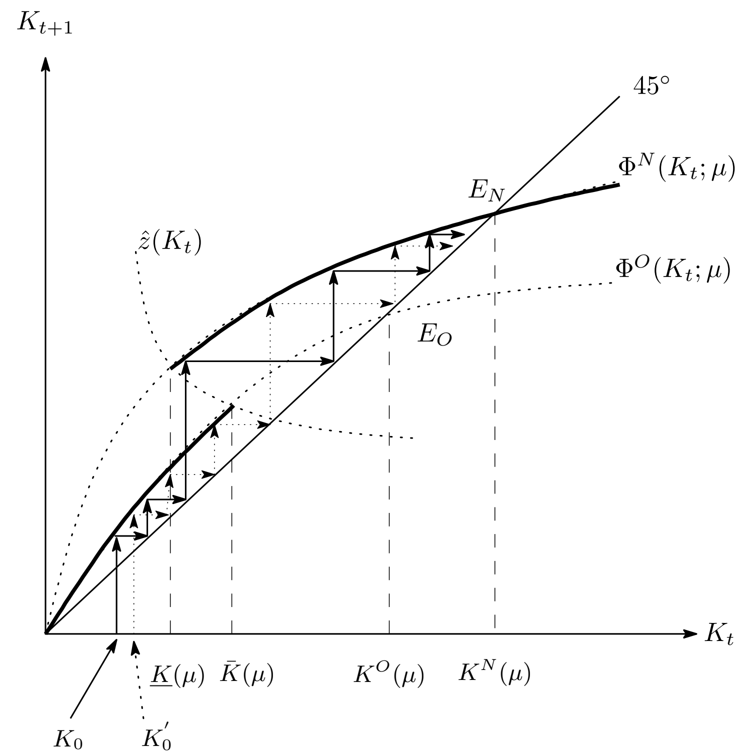

Figure 7: Overtaking

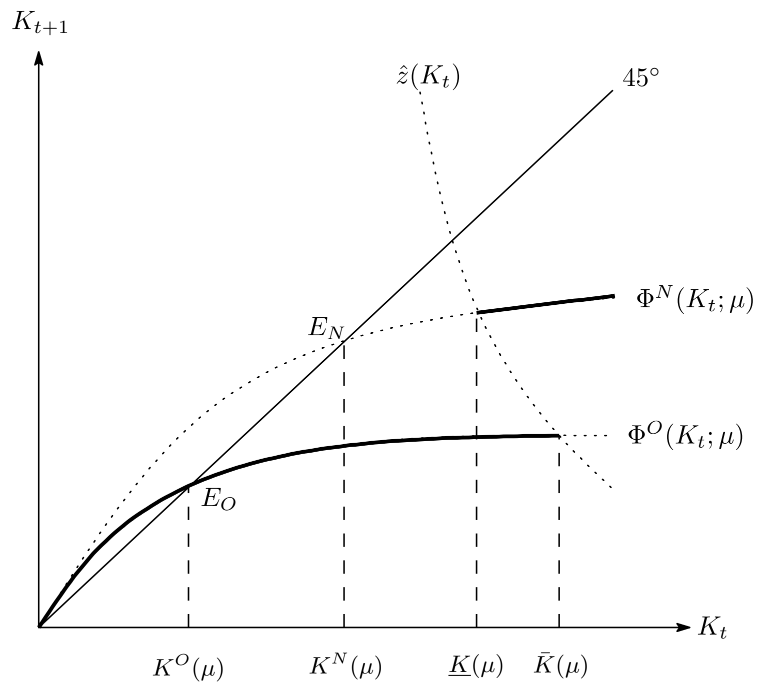

Figure 8: Monotone Convergence to E_O

Table 1: Growth of GDP and Infrastructure

Stocks 1995 levels as multiples of 1975 levels

	GDP	Electricity	Roads	Telecoms
East Asia	4.8	5.9	2.9	15.5
South Asia	2.6	4.4	2.5	8.2
Middle East & North Africa	1.8	6.1	2.1	7.2
Latin America & Caribbean	1.8	3.0	1.9	5.1
OECD	1.8	1.6	1.4	2.2
Pacific	1.7	2.0		4.3
Sub-Saharan Africa	1.4	2.6	1.7	3.9
Eastern Europe	1.0	1.6	1.2	6.9

GDP; PPP constant 2000 international $; Electricity-MW of generating capacity;
Roads-km of paved road; Telecoms-number of main lines.
Sources: Straub et al. (2008) in p2, table1