Industrialization and the Big Push

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This paper explores Rosenstein-Rodan's idea that simultaneous industrialization of many sectors of the economy can be profitable for them all even when no sector can break even industrializing alone. We analyze this idea in the context of an imperfectly competitive economy with aggregate demand spillovers and interpret the big push into industrialization as a move from a bad to a good equilibrium. We present three mechanisms for generating a big push and discuss their relevance for less developed countries.

I. Introduction

Virtually 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. Yet despite the evident gains from industrialization and the success of many countries in achieving it, numerous other countries remain unindustrialized and poor. What is it that allows some but not other countries to industrialize? And can government intervention accelerate the process?

Of the many causes of lack of growth of underdeveloped countries, a particularly important and frequently discussed constraint on industrialization is the small size of the domestic market. When domestic markets are small and world trade is not free and costless, firms may not be able to generate enough sales to make adoption of increasing returns technologies profitable, and hence industrialization is

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stalled. In this paper, we present some models of economies with small domestic markets and discuss how these markets can expand so that a country can get out of the no-industrialization trap. In particular, we focus on the contribution of industrialization of one sector to enlarging the size of the market in other sectors. Such spillovers give rise to the possibility that coordination of investments across sectors—which the government can promote—is essential for industrialization. This idea of coordinated investment is the basis of the concept of the "big push," introduced by Rosenstein-Rodan (1943) and discussed by many others.

According to Rosenstein-Rodan, if various sectors of the economy adopted increasing returns technologies simultaneously, they could each create income that becomes a source of demand for goods in other sectors, and so enlarge their markets and make industrialization profitable. In fact, simultaneous industrialization of many sectors can be self-sustaining even if *no* sector could break even industrializing alone. This insight has been developed by Nurkse (1953), Scitovsky (1954), and Fleming (1955) into a doctrine of balanced growth or the big push, with two important elements. First, the same economy must be capable of both the backward preindustrial and the modern industrialized state. No exogenous improvement in endowments or technological opportunities is needed to move to industrialization, only the simultaneous investment by all the sectors using the available technology. Second, industrialization is associated with a better state of affairs. The population of a country benefits from its leap into the industrial state.

In this paper, we attempt to understand the importance of demand spillovers between sectors by looking at simple stylized models of a less developed economy in which these spillovers are strong enough to generate a big push. In doing so, we chiefly associate the big push with multiple equilibria of the economy and interpret it as a switch from the cottage production equilibrium to industrial equilibrium. The main question we address is, What does it take for such multiple equilibria to exist? In addition, we ask when the equilibrium in which various sectors of the economy "industrialize" is Pareto-preferred to the equilibrium in which they do not. We thus make precise the sense in which industrialization benefits an economy with fixed preferences, endowments, and technological opportunities.

In all the models described in this paper, the source of multiplicity of equilibria is pecuniary externalities generated by imperfect competition with large fixed costs.[1] Yet such multiplicity is not automatic: in

[1] The pecuniary externalities analyzed in this paper should be contrasted with technological externalities that can also give rise to interesting growth paths (Romer 1986*a*;

Section III we show that even where pecuniary externalities are important, equilibrium can be unique. The idea behind the uniqueness result is that if a firm contributes to the demand for other firms' goods *only* by distributing its profits and raising aggregate income, then unprofitable investments must *reduce* income and therefore the size of other firms' markets. Starting from the equilibrium in which no firm wants to adopt increasing returns, each investing firm would then lose money and therefore make it even less attractive for other firms to invest. As a result, the second equilibrium with a higher level of industrialization cannot exist. When profits are the only channel of spillovers, the industrialized equilibrium cannot coexist with the unindustrialized one.

In contrast, multiple equilibria arise naturally if an industrializing firm *raises* the size of other firms' markets even when it itself loses money. This occurs when firms raise the profit of other industrial firms through channels other than their own profits. In the models we present, industrialization in one sector can increase spending in other manufacturing sectors by altering the composition of demand. In the model of Section IV, industrialization raises the demand for manufactures because workers are paid higher wages to entice them to work in industrial plants. Hence, even a firm losing money can benefit firms in other sectors because it raises labor income and hence demand for their products.

The model of Section V focuses on the intertemporal aspect of industrialization. In that model, industrialization has the effect of giving up current income for future income because the benefits of current investment in cost reduction are realized over a long period of time. The more sectors industrialize, the higher is the level of future spending. But this means that the profitability of investment depends on there being enough other sectors to industrialize so that high future spending justifies putting down a large-scale plant today. Since an investing firm generates a positive cash flow in the future, it raises the demand for the output in other sectors even if its own investment has a negative net present value. In the models of both Sections IV and V, coordinated investment across sectors leads to the expansion of markets for all industrial goods and can thus be self-sustaining even when no firm can break even investing alone.

The effect of a firm's investment on the size of the markets for

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Lucas 1988). Romer and Lucas also look at increasing returns, except in their models increasing returns are external to the firm. Earlier attempts outside the development literature to model pecuniary externalities in the growth context include important work of Young (1928) and Kaldor (1966) and recent work of Romer (1986*b*) and Shleifer (1986). Also related is some work in macroeconomics, e.g., Hart (1982), Weitzman (1982), and Kiyotaki (1988).

output in other sectors is not the only relevant pecuniary externality. An important component of industrialization for which pecuniary externalities can be crucial is investment in jointly used intermediate goods, for example, infrastructure such as railroads and training facilities. To the extent that the cost of an infrastructure is largely fixed, each industrializing firm that uses it helps defray this fixed cost and so brings the building of the infrastructure closer to profitability. In this way, each user indirectly helps other users and hence makes their industrialization more likely. As a result, infrastructure develops only when many sectors industrialize and become its users. In Section VI we associate the big push with the economy making large investments in a shared infrastructure. This approach has the advantage of being important even in a completely open economy.

The emphasis of this paper on the efficiency of industrialization warrants some explanation. All the deviations from the first-best are ultimately driven by imperfect competition and the resulting divergence of the price of output from marginal cost. But inefficiency manifests itself in two distinct ways. First, at any positive level of industrialization, there is a static monopoly pricing inefficiency in that industrial goods are overpriced relative to cottage-produced goods. Second, given monopoly pricing in industrial sectors, the level of industrialization can be too low from a second-best welfare point of view. In particular, welfare is lower in the nonindustrialized equilibrium than in the fully industrialized equilibrium. In our discussion of government policy, we take monopoly pricing in industrial sectors as given and always focus on second-best policies that bring about a Pareto-preferred, higher level of industrialization. We stress, however, that because all our models are highly stylized and capture what we can only hope to be one aspect of reality, policies suggested by these models should be interpreted with caution.[2]

II. The Importance of Domestic Markets

Except for the example of infrastructure (Sec. VI), our analysis relies crucially on the importance of domestic markets for industrialization. Such analysis runs into an obvious objection. If world trade is free and costless, then an industry faces a world market, the size of which cannot plausibly constrain adoption of increasing returns technologies. Yet despite this theoretical objection, there is now considerable empirical evidence pointing to the importance of the domestic market as an outlet for sales of domestic industry.

The best evidence comes from the work of Chenery and Syrquin

[2] Farrell and Saloner (1985) suggest that multiplicity of equilibria is not a problem if one redefines the game to be sequential. We believe that for the problem we address the multiple equilibrium model we present captures the essential aspects of reality.

(1975) and Chenery, Robinson, and Syrquin (1986). Using a sample of rapidly growing economies over the period from the early 1950s to the early 1970s, Chenery et al. look at a change in domestic industrial output over that period in each country and divide it between a change in domestic demand and a change in exports. Because some outputs are also used as intermediate goods and the structure of production as measured by the input-output matrix is changing, Chenery et al. correct their results for changes in technology. By far the most important sources of growth in output, however, are growth in domestic demand and growth in exports.

The findings of Chenery et al. point to a dominant share of domestic demand in growth of domestic industrial output. In countries with populations over 20 million, expansion of domestic demand accounts for 72–74 percent of the increase in domestic industrial output (1986, p. 156).[3] In such countries, when per capita income is between 200 and 800 1964 U.S. dollars, the share of industry in gross national product is five to six percentage points higher than in countries with populations under 20 million, with the difference concentrated in industries with important economies of scale, such as basic metals, paper, chemicals, and rubber products (Chenery and Syrquin 1975, p. 78). In small primary goods–oriented countries with populations under 20 million, a rise in domestic sales accounts for 70–72 percent of the increase in the domestic industrial output (Chenery et al. 1986, p. 156). Even in small manufacturing-oriented countries with populations under 20 million, expansion of domestic demand accounts for about 50–60 percent of industrial output expansion (p. 156). In Korea—the paragon of an open, export-oriented economy—domestic demand expansion accounted for 53 percent of growth of industrial output between 1955 and 1973 (p. 158) and a much larger fraction if one abstracts from export-intensive sectors such as textiles. Moreover, the intensive export of manufactures began only after the industry became established in the domestic market (Chenery and Syrquin 1975, p. 101). Whether the causes of limited trade are natural, such as transport costs or taste differences across countries, or man-made, such as tariffs, the bottom line is the overwhelming importance of domestic demand for most of domestic industry.

III. A Simple Aggregate Demand Spillovers Model with a Unique Equilibrium

The existence of multiple, Pareto-ranked equilibria of the type envisioned in the big push literature requires that the economy be capable of sustaining two alternative levels of industrialization. This means

[3] Our own calculations are based on table 6.3 in Chenery et al. (1986).

that industrialization must be individually unprofitable at a low aggregate level of industrialization but individually profitable as long as a sufficient number of other sectors industrialize. Put another way, even individually unprofitable industrialization must have spillover effects on other sectors that make industrialization in other sectors more profitable.

In this section, we discuss a simple model in which profit spillovers across sectors are present, but they are still not sufficient to generate the conditions for the big push. The firm in this model has a positive spillover on the demands (profits) of other sectors if and only if it makes a positive profit itself. Hence, even though the firm does not internalize the effect of its dividends on the profits in other sectors, it still makes a (second-best) efficient investment decision and has a positive spillover on other firms only to the extent that its own industrialization decision is individually profitable. We start with this model in order to illustrate the fact that the conditions for individually unprofitable investments to raise the profitability of investment in other sectors are more stringent than those loosely expressed in much of the big push literature of the 1940s and 1950s (see, e.g., Rosenstein-Rodan 1943).

Consider a one-period economy with a representative consumer, with Cobb-Douglas utility function $\int_0^1 \ln x(q)dq$ defined over a unit interval of goods indexed by q.[4] All goods have the same expenditure shares. Thus when his income is y, the consumer can be thought of as spending y on every good $x(q)$. The consumer is endowed with L units of labor, which he supplies inelastically, and he owns all the profits of this economy. If his wage is taken as numeraire, his budget constraint is given by

$$y = \Pi + L, \tag{1}$$

where Π is aggregate profits.

Each good is produced in its own sector, and each sector consists of two types of firms. First, each sector has a competitive fringe of firms that convert one unit of labor input into one unit of output with a constant returns to scale (cottage production) technology. Second, each sector has a unique firm with access to an increasing returns (mass production) technology. This firm is alone in having access to that technology in its sector and hence will be referred to as a monopolist (even though, as we specify below, it does not always operate). Industrialization requires the input of F units of labor and allows each additional unit of labor to produce $\alpha > 1$ units of output.

The monopolist in each sector decides whether to industrialize or to

[4] The discussion that follows partly draws on Shleifer and Vishny (1988).

abstain from production altogether. We assume that the monopolist maximizes his profit taking the demand curve as given.[5] He industrializes ("invests") only if he can earn a profit at the price he charges. That price equals one since the monopolist loses all his sales to the fringe if he charges more, and he would not want to charge less when facing a unit elastic demand curve. When income is y, the profit of a monopolist who spends F to industrialize is

$$\pi = \frac{\alpha - 1}{\alpha} y - F \equiv ay - F, \tag{2}$$

where a is the difference between price and marginal cost, or markup.

When a fraction n of the sectors in the economy industrialize, aggregate profits are

$$\Pi(n) = n(ay - F). \tag{3}$$

Substituting (3) into (1) yields aggregate income as a function of the fraction of sectors industrializing:

$$y(n) = \frac{L - nF}{1 - na}. \tag{4}$$

The numerator of (4) is the amount of labor used in the economy for actual production of output, after investment outlays. One over the denominator is the multiplier showing that an increase in effective labor raises income by more than one for one since expansion of low-cost sectors also raises profits. To see this more explicitly, note that

$$\frac{dy(n)}{dn} = \frac{\pi(n)}{1 - an}, \tag{5}$$

where $\pi(n)$ is the profit of the last firm to invest. When the last firm earns this profit, it distributes it to shareholders, who in turn spend it on all goods and thus raise profits in all industrial firms in the economy. The effect of this firm's profit is therefore enhanced by the increases in profits of all industrial firms resulting from increased spending. Since there are a fraction n of such firms, the multiplier is increasing in the number of firms that benefit from the spillover of the marginal firm. The more firms invest, the greater is the cumulative increase in profits and therefore income resulting from a positive net present value investment by the last firm.

For an alternative interpretation of (5), notice that since the price of labor is unity, the profit of the last firm, $\pi(n)$, is exactly equal to the

[5] The assumption that each monopolist maximizes profits rather than the welfare of his shareholders is what allows pecuniary externalities to matter. Shleifer (1986) justifies this assumption in some detail.

net labor saved from its investment in cost reduction. The numerator of (5) is therefore the increase in labor available to the economy as a result of the investment by the last firm. In equilibrium, this freed-up labor moves into all sectors. However, its marginal product is higher in industrialized sectors than in nonindustrialized sectors. The more sectors industrialize (i.e., the higher is n), the greater is the increase in total output resulting from the inflow of freed-up labor into these sectors. In fact, the denominator of (5) is just the average of marginal labor costs across sectors, which is clearly a decreasing function of n. This interpretation connects (5) to (4), which explicitly states that income is a multiple of productive labor and that the multiplier is increasing in n.

Despite the fact that the firm ignores the profit spillover from its investment, it is easy to see that there is a unique Nash equilibrium in which either all firms industrialize or none of them do (i.e., there is no big push). In order for there to be a no-industrialization equilibrium, it must be the case that when aggregate income is equal to L, a single firm loses money from industrializing. But if no firm can break even from investing when income is L, then there cannot be an equilibrium in which any firms invest. For suppose that a single firm decides to invest. Since it loses money, it only reduces aggregate income, making the profit from industrialization in any other sectors even lower. Hence if it is unprofitable for a single firm to invest, it is even less profitable for more firms to do so, making the existence of the second equilibrium impossible. As is clear from (5), a firm's spillover is positive if and only if its own profits are positive. The multiplier changes only the magnitude of the effect of a firm's investment on income, and not the sign.

The remainder of the paper presents three modifications of this model in which a firm engaging in unprofitable investment can still benefit other sectors and make it more likely that they will find it profitable to invest. By doing so, we get away from the uniqueness result of this section and generate a big push.

IV. A Model with a Factory Wage Premium

The first model of the big push we present comes closest in its spirit to Rosenstein-Rodan's (1943) paper. According to this theory, to bring farm laborers to work in a factory, a firm has to pay them a wage premium. But unless the firm can generate enough sales to people other than its own workers, it will not be able to afford to pay higher wages. If this firm is the only one to start production, its sales might be too low for it to break even. In contrast, if firms producing different products all invest and expand production together, they can all sell their output to each other's workers and so can afford to pay a wage premium and still break even. In this section, we construct a model along these lines.[6]

We assume that higher wages are paid in the factory to compensate workers for disutility of such work. Accordingly, we take utility to be $\exp[\int_0^1 \ln x(q)dq]$ if a person is employed in cottage production and $\exp[\int_0^1 \ln x(q)dq] - v$ if he or she is employed in a factory using increasing returns. Although factory workers earn higher wages, they have the same unit elastic demand curves for manufactures as cottage production workers, and so we can calculate demands based on the aggregate income, y.[7] Specifically, when the total profit and labor income is y, we can think of it as expenditure y on each good. Workers engage in either constant returns to scale (CRS) cottage production of manufactures or in factory work in which increasing returns to scale (IRS) technologies are used.[8] Cottage production wage is set to one as numeraire, and total labor supply is fixed at L.

As before, the cottage technology for each good yields one unit of output for each unit of labor input. Cottage producers who use this technology are competitive. In contrast, the IRS technology requires a fixed cost of F units of labor to set up a factory but then yields $\alpha > 1$ units of output for one unit of labor input. We assume that access to the IRS technology is restricted to a separate monopolist in each sector.

The monopolist will choose to operate his technology only if he expects to make a profit taking the demand curve as given. If he does operate, he could not raise his price above one without losing the business to the fringe. But he also would not want to cut the price since demand is unit elastic.

Since all prices are always kept at unity, it is easy to calculate the competitive factory wage, w. Each monopolist must pay a wage that makes a worker indifferent between factory and cottage production employment:

$$w = 1 + v > 1. \tag{6}$$

In this pure compensating differentials model, factory employees get the minimum wage necessary to get them out of cottage production

[6] Factory employment is usually associated with working in a city. Lewis (1967) and many others confirm the empirical validity of the assumption that higher real wages are paid in cities.

[7] All the models we study assume unit elastic demand. Historically, however, price-elastic demand for manufactures has played an important role in growth of industry (Deane 1979). Price-elastic demand leads to price cuts by a monopolist and the increase in consumer surplus, which is an additional reason for a big push.

[8] For simplicity, there is no agricultural sector, although one could be added (see Murphy, Shleifer, and Vishny 1989).

and hence get no surplus from industrialization except as profit owners.

When aggregate income is y, the monopolist's profit is given by

$$\pi = y\left(1 - \frac{1 + v}{\alpha}\right) - F(1 + v), \tag{7}$$

where 1 is the price he gets and $(1 + v)/\alpha$ is his unit variable cost. The monopolist will incur $F(1 + v)$ only if he expects income to be high enough for this investment to make money.

As is clear from (7), for this model to be at all interesting, the productivity gain from using the IRS technology must exceed the compensating differential that must be paid to a worker, that is,

$$\alpha - 1 > v. \tag{8}$$

If this condition does not hold, the factory will not be able to afford any labor even if it surrenders to it all the efficiency gain over the cottage technology. As a result, the factory could not possibly break even, whatever the level of income.

Under the conditions discussed below, this model can have two equilibria, one with and one without industrialization. In the first equilibrium, no firm incurs the fixed cost for fear of not being able to break even, and the population stays in cottage production. Income is equal to L, the wage bill of the cottage labor, since no profits are earned. For this to be an equilibrium, it must be the case that in no sector would a monopolist want to set up a factory if he has to pay the required factory wage. That is, for no industrialization to take place, we must have

$$L\left(1 - \frac{1 + v}{\alpha}\right) - F(1 + v) < 0. \tag{9}$$

In a second equilibrium, all sectors industrialize. By symmetry, the quantity of output produced in each sector is $\alpha(L - F)$, which at unit prices is also the value of output. Since the only input is labor, total factor payments are wages, which are equal to $L(1 + v)$. For this to be an equilibrium, profits must be positive:

$$\pi = \alpha(L - F) - L(1 + v) > 0. \tag{10}$$

When (10) holds, all firms expect a high level of income and sales resulting from simultaneous labor-saving industrialization of many sectors and are consequently happy to incur the fixed cost $F(1 + v)$ to set up a factory. This of course makes the expectation of industrialization self-fulfilling.

An examination of (9) and (10) suggests that there always exist some values of F for which both equilibria exist, provided (8) holds.

For these values of F, the economy is capable of a big push, whereby it moves from the unindustrialized equilibrium to one with industrialization when all its sectors coordinate investments. The reason for the multiplicity of equilibria is that a link between a firm's profit and its contribution to demand for products of other sectors is now broken. Because a firm that sets up a factory pays a wage premium, it increases the size of the market for producers of other manufactures, even if its investment loses money. Consequently, the firm's profit in this model is not an adequate measure of its contribution to the aggregate demand for manufactures since a second component of this contribution—the extra wages it pays—is not captured by the profits.

In this model, the Pareto superiority of the equilibrium with industrialization is apparent. Since prices do not change, workers are equally well off as wage earners in the second equilibrium, but they also get some profits. They have higher income at the same prices and hence must be better off. Firms making investment decisions in the no-industrialization equilibrium ignore the fact that, even when they lose money, the higher factory wages they pay generate profits in other industrializing sectors by increasing the demand for manufactures. As a result, these firms underinvest in the no-industrialization equilibrium, and an inefficiency results. As is commonly supposed in the discussion of industrialization, it indeed creates wealth and represents a better outcome.

The big push resulting from higher factory wages could also be obtained using a different but related model of industrialization. Instead of focusing on a compensating differential, we could assume that cottage production is located on the farm and factories are located in the cities, and that city dwellers' demand is more concentrated on manufactures. For example, living in a city might require consumption of processed food if fresh food is expensive to transport from the farm. Urbanization also leads to increased consumption of other manufactures, such as textiles, leather goods, and furniture (Reynolds 1983). If these changes in demand are important, then urbanization in the process of industrialization leads to an increase in the demand for manufactures. In this way industrialization can be self-sustaining even if there is no compensating wage differential for factory work, but only a shift in the consumption bundle toward manufactures.

V. A Dynamic Model of Investment

This section presents a second example in which an investment that loses money nonetheless raises aggregate income. A firm that uses resources to invest at one point in time, but generates the labor savings from this investment at a later point, decreases aggregate demand today and raises it tomorrow. This shift in the composition of demand away from today's goods and toward tomorrow's goods can also give rise to multiple equilibria and inefficient underinvestment, unless the government coordinates investment or entrepreneurs are spontaneously "bullish."

One historical account (Sawyer [1954]; quoted in Cole [1959]) motivates this model in the context of nineteenth-century American economic growth. According to Sawyer, even when a cold economic calculation dictated otherwise, irrationally bullish and overoptimistic American entrepreneurs insisted on investing. But with enough people making this mistake, optimistic projections became self-fulfilling (cf. Keynes's [1936] account of entrepreneurial optimism):

> To the extent that it worked in an economic sense—that an over-anticipation of prospects in fact paid off in either a private or social balance sheet, we find ourselves on the perilous edge of an "economics of euphoria"—a dizzy world in which if enough people make parallel errors of over-estimation, and their resulting investment decisions fall in reasonable approximation to the course of growth, they may collectively generate the conditions of realizing their original vision. It suggests, historically, a sort of self-fulfilling prophecy, in which the generalized belief in growth operated to shift the marginal efficiency of capital schedule to the right, and in which the multiple centers of initiative, acting in terms of exaggerated prospects of growth, pulled capital and labor from home and from the available reservoirs abroad, and so acted as to create the conditions on which their initial decisions were predicated. [Sawyer 1954, pt. C, p. 3]

Our model shows that Sawyer's ideas about self-fulfilling expectations of growth do not really rely on assuming entrepreneurial irrationality.

A two-period model suffices to illustrate the big push in a dynamic context. Consider a representative consumer with preferences defined over the same unit interval of goods in both the first and the second periods. If we denote by $x_1(q)$ and $x_2(q)$, with q between zero and one, his consumption of good q in periods 1 and 2, respectively, the consumer's utility is given by

$$U = \left[\int_0^1 x_1^\gamma(q)dq\right]^{\theta/\gamma} + \beta\left[\int_0^1 x_2^\gamma(q)dq\right]^{\theta/\gamma}. \tag{11}$$

In this expression, $1/(1 - \theta)$ is the intertemporal elasticity of substitution, and $1/(1 - \gamma)$ is the elasticity of substitution between different goods within a period. For example, in the special case in which $\gamma = 0$ and $\theta = 1$, to which we return below, the consumer has unit elastic demand for each good q and is indifferent about when to consume his income. The representative consumer is endowed with L units of labor each period that he supplies inelastically, and he owns all the profits. Without loss of generality, each period's wage is set equal to one.

Each good q in the first period must be produced using a CRS technology converting one unit of labor into one unit of output. The same technology is also available in the second period. The CRS technology is used by a competitive fringe of firms. In addition to this CRS technology, each sector q has a potential monopolist who can invest F units of labor in the *first* period and then produce $\alpha > 1$ units of output per unit of labor in the *second* period. Each monopolist in this model thus has an intertemporal investment decision since the benefits of the IRS technology obtain only with a lag. His decision whether or not to invest depends both on the equilibrium interest rate and on income in period 2.

To analyze the decision of a monopolist in a representative sector, denote his profits by π, equilibrium discount factor by β^*,[9] and periods 1 and 2 aggregate incomes by y_1 and y_2, respectively. As before, the price the monopolist can charge in the second period if he invests is bounded above by one, the price of the competitive fringe. We assume that

$$\alpha < \frac{1}{\gamma}. \tag{12}$$

The demand curve in each sector is sufficiently inelastic that the monopolist does not want to cut the price below one. If we denote by $a = 1 - (1/\alpha)$ the marginal profit rate of the monopolist per dollar of sales, his profits can now be written as

$$\pi = \beta^* a y_2 - F. \tag{13}$$

The monopolist will incur the fixed cost F in the first period whenever the net present value of his profits given by (13) is positive.

For some parameter values, this model has two equilibria. In the first equilibrium, no sector incurs the fixed cost F in period 1, and no industrialization takes place. Income each period is equal to wage income:

$$y_1 = y_2 = L. \tag{14}$$

[9] If r is the equilibrium interest rate, then $\beta^* = 1/(1 + r)$.

Furthermore, the equilibrium discount factor at which the consumers are willing to accept the constant expenditure L on consumption in both periods is equal to β. For this to be an equilibrium, it must not pay a monopolist in a representative sector to incur F in the first period if he expects income in the second period to be L and if the discount factor is β. By (13), the monopolist will not invest if

$$\pi = \beta aL - F < 0. \tag{15}$$

When this condition holds, the demand that firms expect to obtain in the second period is too low for them to break even on their investments. Since they do not invest, the realized level of income is indeed low, and the no-industrialization equilibrium is sustained.

An important feature of this model is that, whereas what matters for a firm is the present value of its profits, what matters for its contribution to aggregate demand in the second period is its second-period cash flow. Thus even if an investing firm loses money, it still raises second-period income. Put differently, even an unprofitable investment transfers income from the first to the second period and thereby makes investment for other firms, which sell only in the second period, more attractive, ceteris paribus. Of course, this shift of income across periods resulting from investment is in part offset by an increase in the interest rate. Nonetheless, the income effect is in many cases more important than the interest rate effect, and, as a result, simultaneous investment by many firms can become profitable even when each loses money investing in isolation. This gives rise to a second equilibrium, in which the economy makes the "big push."

In this equilibrium with industrialization, each sector incurs the fixed cost F in the first period, and as a result the first-period income is

$$y_1 = L - F. \tag{16}$$

The second-period income is higher because of higher profits:

$$y_2 = L + \pi = L + ay_2 = \alpha L. \tag{17}$$

One way to think about these equations for income is that, in the first period, there are no markups charged, and hence the multiplier is one, while in the second period the multiplier is α because each sector marks up the price over cost.

For the consumer to accept a higher level of consumption in period 2 than in period 1, the discount factor in this equilibrium must be

$$\beta^* = \beta\left(\frac{\alpha L}{L - F}\right)^{\theta - 1}. \tag{18}$$

The interest rate rises in equilibrium to prevent the consumer from wanting to smooth his consumption. The higher θ is, the less averse the consumer is to intertemporal substitution, and hence the lower is the interest rate needed to equilibrate the loan market at zero. In the limiting case in which $\theta = 1$ and the consumer is perfectly happy to substitute consumption across time, the equilibrium discount rate is simply his rate of time preference β.

For the proposed allocation to be an equilibrium, it must pay the firm expecting income y_2 from (17) and faced with a discount rate from (18) to invest in the first period. This will be the case provided

$$(a\alpha L)\beta\left(\frac{\alpha L}{L - F}\right)^{\theta - 1} - F > 0. \tag{19}$$

When condition (19) holds, the interest rate does not rise too much when consumption is growing. As a result, there exists an equilibrium in which firms expect other firms to invest and income to rise, and all firms in fact invest in anticipation of profiting from the higher income. Our interpretation of the possibility of the big push is the coexistence of both equilibria for the same parameter values. In that case, firms invest if they expect other firms to do the same and income to grow, and they do not invest if they expect the economy to remain stationary.

The key to the coexistence of the two equilibria is the fact that a firm's profits are not an adequate measure of its contribution to demand for manufactures. An investing firm, even if it loses money, reduces period 1 income and raises period 2 income. Aside from the effect of this investment on the rate of interest, the main consequence of this action by the firm is to reduce the demand for manufactures in the first period—which is irrelevant for investment—and to raise the demand for manufactures of other firms in the second period—which is key to their investment decisions. As a result, the investment by a firm makes investment by other firms more attractive. All that is needed for this to be the case is that the second-period cash flow of the firm be positive. Then the whole cash flow contributes to the second-period demand for manufactures and raises the profitability of investment of all other firms in the economy (as long as the interest rate does not rise too much). The result of the investment, then, is to shift the composition of demand across periods in a way that makes the investment by other firms more attractive. This shift of income makes the big push possible, even if the net present value of a firm investing alone in the economy is negative. As before, the possibility of the big push turns on the divergence between the firm's profits and its contribution to the demand for manufactures of other investing firms.

In this model, the equilibrium with industrialization is Pareto-preferred to that without industrialization. This can be most easily seen from the fact that spot prices of manufacturing goods are the same in the two equilibria in both periods, but that the present value of income is higher in the second equilibrium even though the interest rate has risen. The reason for the Pareto ranking has to do with the difference in multipliers across the two periods. An investing firm uses up labor in the first period, when the contribution of labor to income is exactly equal to its wage. The same firm saves labor in the second period, which goes on to generate *both* wages and profits in other sectors. Hence the firm undervalues the labor it saves in the second period when making its investment decision. This is equivalent to saying that a dollar of a firm's positive cash flow in the second period generates more than a dollar in income since the dividends the firm pays become a source of demand and hence of profits in other sectors. In contrast, a dollar of negative cash flow in the first period reduces income by only a dollar. Both the labor market version of the story and the demand generation version explain why a dollar of the firm's profit in the second period raises income by $\$\alpha$, that is, has a multiplier associated with it. Because the firm ignores this multiplier in making its investment decision, it will in general underinvest in the no-industrialization equilibrium. The variation of multipliers across periods thus explains the Pareto ranking of the two equilibria.

We stress that the reasons for multiplicity of equilibria and for their Pareto ranking are not the same. To see this, suppose that the first-period technologies are also used by monopolists in the various sectors, who mark up the price over cost but get imitated by the competitive fringe in the second period. As before, monopolists can also further reduce costs and stay ahead of competition in the second period if they invest F in the first period. If the markup in the first period is larger, the multiplier in the first period will be larger than the multiplier in the second period, even if monopolists invest to cut second-period costs below the competitive price. In this case, we might still have two equilibria. In the first, firms do not invest because they expect too few others to invest and raise second-period income. In the second equilibrium, firms invest and shift income from period 1 to period 2 and thus create high enough period 2 cash flows for other firms to justify their investments. In this case, however, the high investment equilibrium might be less efficient since firms are using up labor to build plants in the first period, when markups elsewhere in the economy are high, and saving labor in the second period, when the wage is closer to its contribution to income.[10] The point is that multiplicity is affected by gross cash flows in the two periods, whereas the relative efficiency of equilibria is determined by the difference in the multipliers.

[10] An example demonstrating this possibility is available from the authors.

At least at the initial stages of industrialization, it is plausible to think of the economy as moving from the use of competitive CRS backstop technologies to the use of less competitive IRS technologies. In this case, our model yields both a positive and a normative result concerning the big push. First, the big push indeed might take the form of simultaneous industrialization of many sectors, each generating future income that helps the profitability of other sectors. The mutual reinforcement of sectors is thus a key property of this big push. Second, the big push, or simultaneous industrialization, is good in this economy because it uses up labor when it is least productive (i.e., when it is stuck in backstop) and frees up labor when it is most productive (i.e., when industrialization has occurred).

The inefficiency of unindustrialized equilibrium raises the possibility of a government role either in encouraging agents to invest or, alternatively, in discouraging current consumption. In our model, persuasion and encouragement of investment alone might be an effective enough tool since these steps might coordinate agents' plans on a better equilibrium. Alternatively, the government can use investment subsidies as long as they are widely enough spread to bring about a critical mass of investment needed to sustain a big push.[11]

VI. A Model of Investment in Infrastructure

For a large infrastructure project, such as a railroad, the size of the market can be particularly important since most of the costs are fixed. As a result, the building of a railroad often depends on the demand from potential users. These users, in turn, can access much larger markets if they can cheaply transport their goods using a railroad. It is not surprising in this context that infrastructure in general and railroads in particular have been commonly credited with being an important component of the big push (Rostow 1960; Rosenstein-Rodan 1961), although there is some debate on whether they have been absolutely pivotal (Fogel 1964; Fishlow 1965).

In our context, building a railroad is especially important because it interacts so closely with industrialization. In particular, since many sectors share in paying for the railroad and the railroad brings down effective production costs, an industrializing sector essentially has the effect of reducing the total production costs of the other sectors.

[11] Policies coordinating private investment across sectors appear in Rosenstein-Rodan's (1943) proposal for the East European Investment Trust. According to that proposal, foreign lenders and donors should insist that the money they lend to the economy be spent on investment and not on consumption. This is entirely consistent with their concern for the welfare of aid recipients as well as with a concern for getting their money back.

These external effects of an investment are not captured by the firm making it, and hence we again have room for multiple equilibria. The railroad might not get built and industrialization might not take place unless there are enough potential industrial customers.

There are two separate reasons why a railroad might not get built even when it is socially efficient to build it. First, if a railroad is unable to price-discriminate between its users, it can extract only part of the social surplus that it generates. This reflects just the usual reason why a monopolist underinvests in a new technology. If the railroad could extract from each firm all the profits obtained through the use of its services, this inefficiency would not result. In addition, a railroad might not get built if, once it is built, there still remains extrinsic uncertainty about whether the economy industrializes. As in the model of the previous section, if it pays a sector to build a factory only when other sectors do the same even after the railroad is built, then there is always a chance of the bad equilibrium with no industrialization. If the railroad builder is sufficiently averse to this outcome, in which he gets no customers, the railroad will not be built.

We illustrate these results using a modified version of the intertemporal investment model from the previous section. First, we use the same utility function (11) as before, but since we do not care about the interest rate effects, we assume that $\theta = 1$ and $\gamma = 0$. The representative consumer is indifferent about when he consumes his income and spends equal shares of his income in each period on all goods. We also assume that the consumers' time discount factor β is equal to one, so that the equilibrium interest rate is always zero.

It is natural to suppose that the CRS cottage technologies can be set up in all locations and hence do not require the use of a railroad. In contrast, IRS technologies are operated in only one location, and hence each unit of output produced with these technologies must be transported to get sold. We assume that industrialization cannot take place in the absence of the railroad. We also assume for simplicity that the transportation input is the same for all units manufactured using IRS.

In addition, we assume that there are now two types of IRS technologies. A fraction n of sectors (1-firms) requires the fixed cost F_1 to be incurred in the first period to build a factory, whereas the fraction $1 - n$ (2-firms) requires the fixed cost $F_2 > F_1$. In the second period, all fixed-cost firms have labor productivity α. We introduce the two types of sectors in order to address the case in which the railroad fails to extract all the surplus it generates. We also assume that it takes a fixed cost of R units of labor in the first period to build the railroad and that the marginal cost of using it is zero. The latter assumption is used only for simplicity.

To address the question of surplus extraction by the railroad, we note that if the railroad does not observe the fixed cost of each firm, all firms look the same in the first period. As a result, the railroad cannot price-discriminate between them. A further issue is that to the extent that costs F_i are sunk in the first period, a railroad that extracts all the period 2 cash flows from the investing firms will make all their investments money-losing. Accordingly, we assume that the railroad can commit itself to a price it will charge in the second period before the potential industrial firms make their investments.

Throughout this section we also assume that there is no way that low-fixed-cost firms, even if they could profitably industrialize alone, would generate enough surplus to pay for the railroad; both types must industrialize to pay for it. This assumption amounts to

$$n\left(\frac{aL}{1 - an} - F_1\right) < R, \tag{20}$$

which is essentially an upper bound on the profits 1-firms can generate. Note that (20) is also an efficiency condition for 1-firms industrializing alone since we are assuming that the railroad extracts all the surplus.

Under our assumptions, the price the railroad charges enables it to extract all the profits from high- but not low-fixed-cost firms. This seems to us to be the easiest way to model the realistic notion that the railroad owners do not capture all the social benefits of the investment.

A necessary and sufficient condition for there to exist an equilibrium in which a railroad is built and all sectors industrialize is

$$a\alpha L - F_2 > R. \tag{21}$$

Condition (21) implies that the railroad can cover its costs when it charges each firm the amount equal to the profit of a 2-firm. Since the railroad cannot price-discriminate, each high-fixed-cost firm will then earn a zero profit, and each low-fixed-cost firm will earn a profit of $F_2 - F_1$. Condition (21) also implies that the high-fixed-cost firms can break even since period 2 income is αL. It is easy to see, then, that (21) guarantees both that all firms are prepared to invest when the railroad is built and other firms invest, and that the railroad can be paid for by tariffs charged to investing firms.

In some circumstances, building of the railroad and industrialization of all sectors will not take place even if this outcome is efficient. Building the railroad is efficient whenever the surplus from industrialization is positive, which happens if

$$a\alpha L - nF_1 - (1 - n)F_2 > R. \tag{22}$$

Since (22) is less stringent than (21), the railroad sometimes is not built even when it is efficient. This happens precisely because the railroad can charge each firm only the amount equal to the profits of 2-firms, which are smaller than the profits of 1-firms. At the same time, it would be efficient to build the railroad if it can break even extracting both the surplus of 1-firms and that of 2-firms. The impossibility of price discrimination gives rise to the outcome in which the railroad is not built and industrialization does not take place even when efficiency dictates otherwise.

This is a very simple reason for a failure of an efficient industrialization. When (22) holds but (21) fails, the market for railroad services is too small in the sense that some users do not end up paying as much as the services are worth to them, even if all firms would industrialize with a railroad. If the railroad could price-discriminate better, the efficient outcome would be achieved and there would be a large increase in income due to the large amount of producer and consumer surplus created by the railroad. As it is, there is a unique equilibrium in which the railroad is not built because it is privately unprofitable, even though it is socially very desirable.

The discussion thus far leaves open the question whether (21) suffices for the railroad to be built. In other words, will the railroad be built for sure if once it is built industrialization is a feasible equilibrium? The answer of course is no since industrialization need not be the only equilibrium that can occur once the railroad is built. What would keep the railroad from being built is the extrinsic uncertainty over whether or not the potential users of the railroad do in fact make their fixed-cost investments and thus become actual users. This uncertainty thus concerns the selection of equilibrium between sectors. If the railroad must be built without a prior knowledge of the actions of manufacturing sectors, its organizers might refuse to accept the uncertainty about the future demand, in which case the railroad is not built and industrialization does not occur.

For both equilibria to exist after the railroad is built, it suffices to look at parameter values for which (21) holds, and it also does not pay a 1-firm to invest when expected income is L, that is,

$$aL - F_1 < 0. \tag{23}$$

For these parameter values, the railroad will make money on its first-period investment if the economy industrializes but will incur a large loss if no industrialization takes place and there are no consumers of its services. The investment R might then not be made because the proprietors of the railroad are averse to the possibility that the bad equilibrium obtains. We then have a standoff in which the railroad is not built for fear that an insufficient number of sectors will industrialize, and this in turn ensures that firms do not make the large-scale investments needed to industrialize.

This discussion reveals two ways in which investment by a sector benefits other sectors in a way that is not captured by profits. First, just as in the previous section, an investing firm raises the demand in the second period and hence helps other firms make money. Second, by using railroad services, an investing firm helps pay for the fixed cost of the railroad. The railroad, in turn, reduces the production costs of other sectors. Indirectly, then, an investing firm contributes to the reduction of total costs of the other industrializing sectors. These effects give rise to the possibility that a firm actually benefits other firms even if it loses money, and so to big push type results. Furthermore, for reasons identical to those in the previous section, the equilibrium with industrialization is Pareto-preferred.

The failures of an efficient railroad to be built suggest some clear functions for the government in this model. Subsidizing the railroad might be helpful but not sufficient. What is also needed is a coordination of investments by enough private users of the railroad to get to the equilibrium with industrialization. Without industrialization by such users, the railroad can become a classic "white elephant" project that is not needed when it is built. This problem can of course be ameliorated if railroad users are sufficiently optimistic that they are eager to invest: this might be the description of America's nineteenth-century experience. The problem can also be solved if one large sector of the economy demands enough railroad services to cover the fixed cost: Colombia's coffee boom in the 1880s is a case in point. In the absence of such favorable circumstances, however, government intervention in support of the railroad might be essential.

The railroad is one of a number of examples of infrastructure projects that require substantial demand by industry (or by other customers) to break even and that might need public subsidies if built ahead of demand. Other examples include power stations, roads, airports, and perhaps, most important, training facilities (Rosenstein-Rodan 1961). One reason for underinvestment in such facilities is the inability of firms to prevent workers they train from moving to other firms and so appropriating the returns from training. A second important reason why a country with little industry will have too few training facilities concerns the ignorance of untrained workers about what they are good at. Some education is necessary to discover one's comparative advantage. A worker will invest in such education only if a broad range of different industries offer employment, so that he can take advantage of his skills. But a broad range of industries is less likely to develop in the first place if the labor force is uneducated.

In the context of market size models, infrastructure can be a particularly appealing area for state intervention. First, coordination issues are especially important since the infrastructure serves many sectors simultaneously. Second, the projects tend to be large and time-consuming, so that capital market constraints and substantial uncertainty can deter private participation. Third, projects are fairly standard, and hence "local knowledge" (Hayek 1945), which is perhaps the main advantage of private entrepreneurs over government, is not as essential as in other activities. It is not surprising then that most governments support infrastructure, and the most successful ones—such as Korea—coordinate that support with general industrial development.

VII. Conclusion

The analysis of this paper has established some, though by no means all, conditions under which a backward economy can make a big push into industrialization by coordinating investments across sectors. The principal idea is that the big push is possible in economies in which industrialized firms capture in their profits only a fraction of the total contribution of their investment to the profits of other industrializing firms. In our examples, a firm adopting increasing returns must be shifting demand toward manufactured goods, redistributing demand toward the periods in which other firms sell, or paying part of the cost of the essential infrastructure, such as a railroad. In these cases, the firm can help foster a mutually profitable big push even when it would lose money industrializing alone. All our models have the common feature that complementarities between industrializing sectors work through market size effects. In the first two models, industrialization of one sector raises the demand for other manufactures directly and so makes large-scale production in other sectors more attractive. In the railroad model, industrialization in one sector increases the size of the market for railroad services used by other sectors and so renders the provision of these services more viable.

The analysis may also have some implications for the role of government in the development process. First, a program that encourages industrialization in many sectors simultaneously can substantially boost income and welfare even when investment in any one sector appears unprofitable. This is especially true for a country whose access to foreign markets is limited by high transportation costs or trade restrictions. The net payoff from a program of simultaneous industrialization can also be high when all markets are open, but a shared infrastructure—such as a railroad or a stock of managers—is necessary to operate profitably in any given sector. In the latter case, simultaneous development of many export sectors may be necessary to sustain any one of them.

Our analysis also suggests that countries such as South Korea that have implemented a coordinated investment program can achieve industrialization of each sector at a lower explicit cost in terms of temporary tariffs and subsidies than a country that industrializes piecemeal. The reason is that potentially large implicit subsidies flow across sectors under a program of simultaneous industrialization. Any cost-benefit analysis of subsidies or of temporary protection should reflect both the lower direct costs and the higher net benefit of a program that is coordinated across sectors.

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