Endogenous Technology Choice and the Big Push

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Abstract

We present a general equilibrium model of imperfect competition to analyze Rosenstein-Rodan's idea of the 'Big Push'. Simultaneous investment of many sectors of the economy can be profitable for everyone although no sector can break even industrializing alone. The mechanism that generates such multiple macroeconomic equilibria is a demand spillover that influences how factor saving the chosen production technologies are. Contrary to the existing 'Big Push' literature, we show that pure profit spillovers can cause multiple equilibria. Equilibria with modern technologies are preferable to others. Adoption of highly productive technologies may be the only way to get out of a 'bad' equilibrium. Technology choice crucially depends on the property rights on profits and is shown to be extremely fragile with respect to policy.

1 Introduction

In recent contributions to the development literature, Rosenstein-Rodan's (1943, 1961) famous articles on the benefits of simultaneous industrialization have received much attention: if many sectors in an economy adopt increasing returns to scale technologies simultaneously they can create income that becomes a source of demand in other sectors. Thus, they enlarge the market size for other products which makes industrialization possible. *Simultaneous* investment can be profitable for *everyone*, even if no sector can break even industrializing *alone*. This pattern is extremely important from any policymaker's point of view. Suppose there is an economy that is at the same time capable of a preindustrial state such as widespread cottage production and a modern state where the benefits of mass production can be exploited. Then, no exogenous improvement in endowments or technological knowledge is needed to move from a backward to a modern economic structure. Such an economy is capable of improving economic matters in autarchy, without any help from abroad. The way to generate this improvement is a co-ordinated action of many agents. If industrializing firms make positive profits, they create higher demand for other goods. A single firm will not take this *demand spillover* into account, thus exerting an externality on others. These externalities give rise to multiple equilibria. We associate the jump from an equilibrium with low aggregate income to a higher production outcome with the famous 'Big Push' by Rosenstein-Rodan.

The described idea of multiple equilibria induced by demand spillovers was informally discussed in the 50ies [see, e.g. Fleming (1955), Scitovsky (1954)] and taken up in the seminal paper of Murphy, Shleifer and Vishny (MSV) (1989).[1] MSV show that multiple equilibria do not appear automatically. The spillover of profits on others is not sufficient for multiplicity in their model. Starting from an equilibrium where no firm wants to adopt increasing returns to scale technologies, each investing firm would lose money, thus reducing aggregate income and making it even more unattractive for all other firms to invest. A second equilibrium with a higher level of industrialization cannot exist. MSV conclude that other mechanisms are needed for a 'Big Push' situation. They suggest alterations of demand, such as higher wages to be paid in industrializing firms, intertemporal demand shifts and an indivisible infrastructure project necessary for industrialization (railroads).

The present paper challenges this point of view. By a slight modification of their model, we show that pure profit spillovers are able to generate multiple macroeconomic equilibria. The production technology of any single firm will be optimally adjusted to the market size that the firm is facing. A huge market will make it profitable to adopt another technology than a relatively small market. Specifically, the larger the demand for a good, the more it pays to make the technology productive. Profits spilling over on other firms induce them to use even more productive processes, thus increasing their profit. These profits due to factor saving will again spill over and induce even more factor saving by other manufacturers. We show that an industrialization equilibrium where firms use modern technologies can be supported at the same time as an equilibrium where only small scale production with constant returns to scale is

[1] The basic setup is developed in Shleifer and Vishny (1988).

taking place. Thus we do not need additional structure to motivate the possibility of a 'Big Push'.

The paper is organized as follows. The next section presents our modification of the MSV (1989) model.[2] In section 3 we analyze existence and welfare properties of macro-economic equilibria. Section 4 shows the effects of policy on equilibria. In section 5 we argue how the likelihood of occurrence of equilibria is affected by policy. The last section concludes.

2 The Model

We choose a simple example of a general equilibrium model with imperfect competition. There exists a continuum of different goods indexed by *i*, $i \in [0,1]$. The representative consumer is assumed to have Dixit-Stiglitz preferences

$$u = \left[\int_0^1 x(i)^\rho \, di\right]^{1/\rho}, \quad \rho \le 0,$$

over the consumption quantities $x(i)$ of these goods. ρ is the typical CES parameter and the specification results in an elasticity of substitution of $\sigma = 1/(1-\rho) \in (0,1]$ between any two goods. σ is also the elasticity of demand for good i with respect to its price. The demands for goods will therefore be inelastic, which seems to be a good approximation for less developed countries. Goods are imperfect substitutes for each other. Note that we choose linear homogeneous preferences only to simplify calculations. Any concave functional form of the same type yields equivalent results.

Each good is produced in its own sector and may be supplied by two types of firms. Firstly, each sector has a competitive fringe that uses the constant returns to scale (CRS) technology $x^s(i) = l_i$. $x^s(i)$ is the output and l_i the labor employed in the fringe of sector *i*. We denote that kind of production system *cottage production* in the following. Secondly, the goods may also be produced by a single firm in each sector having access to an increasing returns to scale (IRS) technology with the marginal productivity of labor$\alpha, \alpha \ge 1$. Such a firm has to 'invest' *F* units of labor to set up the production process. We interpret this input as overhead cost necessary for mass production. The productivity factor α can be influenced by the effort of the owner to control the efficiency of her firm. That is, α is a function of entrepreneurial effort e_i, $\alpha = \alpha(e_i)$ with $\alpha(0) = 1$, $\alpha' > 0$, $\alpha'' < 0$. The effort improves the organizational structure of the firm, making hierarchies more efficient or monitoring the workforce to avoid shirking. A well-designed organization of the firm saves labor given any level of output.The entrepreneur in sector *i* can employ that managerial effort e_i to maximize her utility

$$v_i = \pi_i - V(e_i), \quad V' > 0, V'' \ge 0, V'(0) = 0.$$

$V(\cdot)$ is the convex disutility of effort. She gets the firm's profit

[2] The present analysis is restricted to closed economies. Although world trade has grown in the last decades, the importance of the domestic market and domestic demand is undisputed. For an elaboration on this point see MSV (1989).

$$\pi_i = x(i)\left[p_i - \frac{w}{\alpha(e_i)}\right] - wF\,,$$

where p_i denotes the price of good *i*, and *w* is the market wage rate. The term in square brackets is the difference between price and marginal cost per unit of output. Knowing that utility is linear in income, we could substitute profit in the manager's utility function.

We assume *Bertrand* price competition. The monopolist in each sector decides to set up the IRS or *industrial* technology if the revenues from high productivity production are sufficient to cover the fixed setup cost and the disutility of managerial effort.[3] Because of the inelastic demand and the competitive fringe that the entrepreneur faces, the profit maximizing price will be equal to the production cost of the fringe. Hence $p_i = w$ and in equilibrium the IRS firm captures the whole market for the product.[4] We *normalize* the market wage rate to unity. Thus $p_i = 1,\ i \in [0,1]$. Together with the above preferences this implies that constant and equal fractions of income are spent on each good in equilibrium, independent of the market structure. Due to our continuum of goods in the unit interval, this results in a demand for *each* good equal to aggregate income *Y*. The *i*th firm's profit is then

$$\pi_i = \frac{\alpha(e_i) - 1}{\alpha(e_i)} Y - F = a(e_i)Y - F,$$

where $a(\cdot) \equiv (\alpha(\cdot) - 1)/\alpha(\cdot)$ for notational convenience.

The economy is endowed with a continuum of inelastically supplied labor of mass *L*.[5] Aggregate income is the 'sum' of all profits $\Pi \equiv \int \pi_i \, di$ plus the income of the workforce,

$$Y = \Pi + L.$$

If a fraction *n* of the sectors in the economy adopts a modern technology, aggregate profits are $\Pi(n) = n[a(e)Y - F]$, where we treat all entrepreneurs' efforts to be the same *e*. This yields aggregate income as a function of the fraction of sectors adopting modern technologies and the efforts exerted in those sectors,

$$Y(n,e) = \frac{L - nF}{1 - na(e)}.$$

It is now easy to derive the impact of changes of the fraction of the economy industrializing and of the entrepreneurial efforts on national product *Y*,

$$\frac{\partial Y}{\partial n} = \frac{\pi(n)}{1 - na(e)}, \tag{1}$$

$$\frac{\partial Y}{\partial e} = \frac{na'(e)}{1 - na(e)} Y > 0.$$

$\pi(n)$ is the profit of an investing firm, given that a fraction *n* industrializes. The first equation tells us that the firm's profit is distributed via the entrepreneur's income on all sectors in the economy. If this profit is positive, it raises profits in all other modernized sectors. The sole

[3] The single monopolist in each sector that can adopt industrial structures is not just an assumption. With price competition at most one firm will enter and pay the fixed cost in equilibrium.

[4] One can imagine that the monopolist will price an ε below the fringe's production cost and then satisfies all demand for good *i*.

[5] To make investment in IRS technologies possible at all, of course $L > F$.

effect of the firm's profit is magnified by the multiplier $1/(1-na)>1$, which is increasing in the number of firms that produce with IRS and in the organizational efforts exerted in those firms. The second equation tells us about a similar effect induced by every monopolist increasing her marginal productivity in production, thus raising her own profit. In turn, she influences the profits of all other industrialized firms. An alternative interpretation of the above formulae from the supply side point of view is as follows: a firm's investment leads to a higher productivity of labor. This causes a profit exactly equal to the net labor saved. This effect is displayed by the numerator of (1). The saved labor moves into all sectors of the economy and increases output there. However, the marginal product of labor is higher in industrialized sectors. The more sectors having adopted an IRS technology and the higher labor productivity in those sectors, the stronger the resulting output effect. This is described by the denominator of (1), which gives us the average of marginal labor costs across the economy.

The entrepreneurs in each sector have two decisions to make: they decide whether to enter the market by incurring the fixed cost *F* or to stay outside. If they enter, they decide upon the technology being implemented to influence labor productivity.

3 Aggregate Outcomes and Technology Choice

We will now formally characterize the game structure. There is a continuum of players, the entrepreneurs, $i \in [0,1]$. Each player chooses a strategy, the effort, $e_i \in \Re_+ \cup \{0\}$ to select the technology $\alpha(e_i)$. $e_i = 0$ implies that in sector *i* cottage production with no fixed cost will take place. The payoff of player *i* is defined by $v_i = v_i(e_i, e_{-i})$. It is the indirect utility function consisting of the profit π_i minus the effort-cost term *V*. $e_{-i} = \{e_j | j \in [0,1] \setminus i\}$ are the actions of all other players determining aggregate income.[6] A *Nash Equilibrium* (*NE*) of the game is a continuum of strategies (e_i^*, e_{-i}^*) with $e_i \in arg\,max_{e_i}\ v(e_i, e_{-i})$ for all $i \in [0,1]$.

The decision process of agent *i* is as follows. Her optimal effort is given by

$$a'(e_i^*)Y(e_{-i}) - V'(e_i^*) = 0,^7 \tag{2}$$

if and only if

$$v_i(e_i^*, e_{-i}) = a(e_i^*)Y(e_{-i}) - F - V(e_i^*) \geq 0. \tag{3}$$

The entrepreneur takes as given aggregate income. If $v_i(\cdot) < 0$, no IRS firm is set up in sector *i*. The strategies in our game are *strategic complements* if $de_i^*/de_{-i} > 0$. If (3) holds, firm *i* earns strictly positive profits. Then, by symmetry, this holds for all investing firms, implying $dY/de_{-i} > 0$. From (2), $de_i^*/dY = -a'/(a''Y - V'') > 0$, and therefore the strategies of the investing players are strategic complements. Due to symmetry and the convexity assumptions, only symmetric *NE* can exist. If $v_i > 0$ for a single entrepreneur *i*, then $v_i > 0$ for all $i \in [0,1]$, and vice versa. Therefore, in any *NE* $n \in \{0,1\}$. We will analyze the individual's optimal effort level in both situations. If $n = 0$, aggregate income is just labor income, $Y = L$. The effort used by entrepreneur *i if* she adopts an IRS technology is given by

$$a'(e_i^*)L - V'(e_i^*) = 0. \tag{4}$$

[6] Because of the continuum of agents, entrepreneur *i* has no noticeable own influence on aggregate income.
[7] Due to $\alpha'' - 2\alpha'^2 \leq 0$ the second order condition holds.

If $n = 1$, aggregate income is $(L - F)/(1 - a(e_{-i}))$. Entrepreneur i's optimal action solves

$$a'(e_i^*)\frac{L-F}{1-a(e_{-i})} - V'(e_i^*) = 0.$$

A *NE* with everybody investing will thus implicate

$$a'(e^*)\frac{L-F}{1-a(e^*)} = V'(e^*), \tag{5}$$

where e^* is the equilibrium effort of any entrepreneur. To show the existence of such an equilibrium, (5) must have a solution *and* (3) must hold at that solution. The lhs of (5) is strictly decreasing in e^*, starting from $a'(0)(L-F) > 0$. The rhs is strictly increasing and going from zero to infinity. Hence, there is at most one *NE* with strictly positive effort levels. The entry condition (3) will be taken care of by the following proposition on the existence of *NE*.

Proposition 1 (Nash Equilibria):

a) *There exists a unique NE where nobody adopts an IRS technology, if, and only if,*

$$a(e^*)\frac{L-F}{1-a(e^*)} - F - V(e^*) \tag{6}$$

is negative, where e^* *is given by* (5).

b) *There exists a unique NE where everybody industrializes if and only if*

$$a(e^*)L - F - V(e^*) \tag{7}$$

is positive, where e^* *is given by* (4).

c) *There co-exists an equilibrium where everybody invests and an equilibrium where nobody invests, if and only if* (6) *is positive, where* e^* *is given by* (5) *and* (7) *is negative, where* e^* *is given by* (4).

Strategic complementarities can lead to multiple aggregate equilibria that display qualitatively very different features. Three situations may arise. In case a) the adoption of an IRS technology does not pay for entrepreneur i even if all other agents choose to industrialize. Aggregate income is not high enough to induce a market size for firm i's produce that is able to cover the fixed setup costs by operative profits. In this case, v_i is negative at the optimal e_i^* as calculated above, and the resulting effort of the manager-entrepreneur will be naught. If this behavior is optimal for entrepreneur i, it will be so for all the others. No IRS technology will be adopted. Situation b) is the opposite: assume everyone produces with the basic technology. Then the resulting market size is $Y = L$. If the optimization problem of a single firm results in an e_i^* such that $v_i(e_i^*, 0) \geq 0$, the firm will invest. Therefore, this is efficient for any firm, and the whole economy is adopting a modern technology. Case c) is most interesting from a theorist's as well as from a policymaker's point of view: it would not pay for a single firm to invest, because aggregate income just from wages is not sufficient to justify modern production. On the other hand, if a generic set of firms invest, market demand will be pushed enough such that utility and profits for investing entrepreneurs are positive. We then have multiple equilibria. An interesting feature of the model is that there *does not exist an unstable equilibrium* where a fraction $n^* \in (0,1)$ of the economy industrializes. When the payoff $v_i(\cdot)$

of a single entrepreneur is zero and she is therefore indifferent between setting up an IRS firm or staying with cottage production, she will already make strictly positive profits. Those profits increase the market size for any other firm. Hence, the next entrepreneur thinking about industrializing will have better conditions and therefore invests.

Contrary to MSV (1989) in our setting *pure profit spillovers are able to generate multiple outcomes*. No exogenous mechanisms like higher wages or the usage of a time structure are necessary to have a 'Big Push' situation. This result is due to our avoiding the polar assumptions MSV make on the available technologies. In their model the entrepreneur is only given the choice between traditional production and an IRS process with fixed α. In contrast, in our model additional economic insight is won by analyzing *which* IRS technology is picked. Moreover, it is more realistic to assume that monopolists adjust production technologies depending on the market conditions they face. However, there is a technical similarity with MSV. They argue that a necessary condition for multiple equilibria in their model is that the link between profits of a single firm and the induced spillovers must be broken. Then, even when a single firm makes losses, a positive spillover can take place. An equivalent effect is present in our model. The objective of an individual entrepreneur is not just to maximize the monetary profit. The disutility from controlling labor productivity plays a role. Hence the profits of a firm may already be positive when it does not pay to industrialize. This is the split between the individual's objective and the aggregate effects for which MSV (1989) need additional structural assumptions.

To show that multiple equilibria are generic and more than a theoretical curiosity, we provide a simple example.

Example 1: Suppose $\alpha = 1 + e$, $V = \vartheta e$. Then $e_i^* = -1 + \sqrt{Y/\vartheta}$ from the first-order-condition. If $n = 0$, $Y = L$. If $n = 1$, $Y = (1 + e_{-i}^*)(L - F)$. In the industrialized structure, from (5) we have $e^* = (L - F - \vartheta)/\vartheta$. Choose the parameters $L = 10$, $F = 4$, $\vartheta = 5/2$. In slight abuse of notation, the argument of the following functions is the fraction of firms that adopt IRS technologies. Then $e_i^*(0) = 1$ and $v_i^*(0) = 5 - 4 - 5/2 = -1/2$, hence no adoption of IRS is an equilibrium. In that case $Y(0) = 10$. But $e^*(1) = 7/2$, $v_i^*(1) = 42/5 - 4 - 7/2 = 9/10$ and $Y(1) = 72/5$. This gives us a second *NE*. Of course, the parameter values can be changed in ways to destroy one or the other equilibrium. With respect to small changes, however, the example is robust. Totally different parametrizations to yield qualitatively the same outcomes are easily found.

The huge differences in output values of our example suggest that the resulting equilibria also have different welfare properties. It is easily seen that we can exclude the workforce from our considerations: prices are unity in any equilibrium and the workers' income is always *L*, hence their utilities stay the same. Let $e_i^{**} \in \arg\max_{e_i} v_i(e_i, e_{-i})$ be the best response of entrepreneur *i* on e_{-i}. The optimal payoff of the entrepreneur is $v_i(e_i^{**}(e_{-i}), e_{-i}) = a(e_i^{**}(e_{-i}))Y(e_{-i}) - F - V(e_i^{**}(e_{-i}))$. By the envelope theorem,

$$\frac{dv_i(e_i^{**}(e_{-i}), e_{-i})}{de_{-i}} = a(e_i^{**}(e_{-i}))\frac{dY}{de_{-i}},$$

which is positive if the other firms' investments yield positive profits. From this follows

Proposition 2 (Pareto-ranking of multiple equilibria): If there exist multiple NE, they can be Pareto-ranked in order of the effort levels. Higher effort level equilibria Pareto-dominate lower effort level equilibria.

Note that Proposition 2 is valid for multiple equilibria with positive effort levels, independent of symmetry. If we had a distribution over different fixed costs $F(i)$, $i \in [0,1]$, we might have more than one equilibrium where not all firms, but some fractions of firms with the lowest costs, enter.

From the preceding discussion we have seen that there is an externality of a single firm's investment on others. We will now show that due to this effect, *NE* are not Pareto-efficient. Taking the market structure of imperfect competition as given, a benevolent dictator would solve $\max_e \; a(e)Y(e) - F - V(e)$. This results in a first order condition of an interior solution[8]

$$a'(e^{po})Y(e^{po}) + a(e^{po})\frac{dY(e^{po})}{de} = V'(e^{po}). \tag{8}$$

e^{po} denotes the Pareto-optimal effort of any entrepreneur.[9] From the envelope theorem the resulting value function $v_i(e^{po}, e^{po})$ at least *weakly* exceeds $v_i(e^*, e^*)$ for any *i*. By comparison of (8) with (5) we know that $e^{po} \neq e_i^*$. From the proof of Proposition 2, it follows $e^{po} > e_i^*$. We conclude that the utilities of the players are strictly larger under the benevolent dictator's regime, if adoption of IRS pays at all. We therefore formulate

Proposition 3 (inefficiency of NE): Any NE with positive effort levels is not Pareto-efficient. The efficient efforts are higher than the equilibrium efforts.

Note that a unique *NE* with nobody adopting IRS technologies may be efficient. In such a case, even if the technology is chosen by the social optimizer, the market size is not large enough to justify spending the fixed setup costs.

4 The Effects of Policy on Equilibria

In a situation where multiple aggregate outcomes with different output and welfare properties are possible, the influence of policy is of great importance. As a benchmark we will first analyze how an optimal policy can implement the Pareto-optimal allocation as described by (8). Any entrepreneur's effort is positively related to the profit she can obtain. To internalize the externality, we know from Proposition 3 that the entrepreneurial incentives to use high productivity technologies have to be increased. An appropriate profit subsidy rate $s > 0$ will do the job. The objective of an entrepreneur becomes $\max_{e_i} \; (1+s)(a(e_i)Y - F) - V(e_i)$ and results in a first order condition $a'(e_i^*)Y + sa'(e_i^*)Y - V'(e_i^*) = 0$. For this expression to match

[8] The social planner's objective function need not to be concave. We assume an interior solution to exist.

[9] Due to the symmetry, there is no aggregate inefficiency induced by imperfect competition. Thus, the solution of the social planner's second best problem is a first best.

(8), $sa'Y = a\,dY/de$. Remembering that in a high output equilibrium $dY/de = a'Y/(1-a)$, we conclude

Proposition 4 (decentralization of Pareto-optimal allocation): The Pareto-optimal allocation can be decentralized in a high output equilibrium by a profit subsidy of rate $s^* = a(e^{po})/(1-a(e^{po}))$, where e^{po} is given through (8).[10]

For a positive analysis the above result is unsuited for several reasons. Firstly, for a balanced budget to reach the subsidy rule, we need lump sum taxation. This device is not available in practice. Secondly, the only people who benefit from such a policy are the entrepreneurs who receive higher profits and utilities. Workers get the same as before. We thus turn to the evaluation of more realistic policy measures. Governments all over the world rely on profit taxation as a way of raising funds. Firms are often more easily to observe than individuals and thus taxes can be taken from them more cheaply. Moreover, profit taxation is held to be favorable for distributional reasons. In many societies productive capital is in the hands of a small class of relatively wealthy individuals. From a politico-economic point of view profit taxation does not harm the majority of voters and may hence be easily imposed.

Assume the government taxes profits at rate t. If the government has the same preferences as the population or tax revenues are redistributed, the funds are spent according to the preferences of the representative consumer and demand remains the same, *ceteris paribus*. The maximization problem of an entrepreneur becomes $\max_{e_i}\,(1-t)(a(e_i)Y-F) - V(e_i)$. It is solved by the optimal effort under taxation e_i^{*t} given by

$$(1-t)a'(e_i^{*t})Y - V'(e_i^{*t}) = 0, \tag{9}$$

if industrializing pays. Applying the implicit-function theorem on (9), we obtain

$$\frac{de_i^{*,t}}{dt} = \frac{a'Y}{(1-t)a''Y - V''} < 0.$$

The productivity under taxation is lower. The condition that industrialization results at all, $(1-t)(aY-F) - V \geq 0$, is also harder to fulfill, as follows from the envelope theorem. Thus, we have two detrimental effects on the adoption of new technologies. From the discussion in the preceding section we saw that high output equilibria need the adoption of relatively productive technologies. We therefore formulate

Proposition 5 (aggregate effect of profit taxation): The higher the tax rate on profits, the smaller is the parameter space that allows for high output equilibria. Any high output equilibrium is characterized by lower output than in the corresponding regime without taxation. High output equilibria vanish at all if t is sufficiently large.

Due to the qualitative differences between industrialization and cottage production equilibria, the effect just described may have immense impact on output and welfare. The existence of *macroeconomic* high output equilibria is extremely fragile with respect to the *microeconomic*

[10] Proposition 4 does not imply that by such a profit subsidy the good equilibrium is necessarily implemented.

incentives. Profit taxation has negative incentive effects. To show how sensible equilibria are with respect taxation, we extend our example.

Example 2: We take preferences, technology and parameter values as in Example 1. Then, for $t > .077$, the high output equilibrium vanishes. Hence, even relatively low rates of taxation can have large aggregate impact. For $t = .05$, the industrialization equilibrium implies owners' efforts of $e^{*} = 1.28$. Utilities from profits are .296 for the entrepreneurs and .184 for the government (or the individuals who receive the tax revenues). The output is $Y = 13.68$. Thus a relative output loss of 36.8 percent may be incurred by a change of the tax rate of 3 percentage points.

The *aggregate* impact of microeconomic disincentive effects can be dramatic. If the 'good' high output equilibrium is destroyed by policy measures, the economy falls (or is held) back in a 'poverty trap'. Note that it is easy to generalize the result of Proposition 5 to other policies. For example, a share *t* of workers in the profits of the firm is formally identical to taxation. In many countries such devices are installed. Our result indicates that serious problems may be caused. More generally, *any mechanism influencing the technology choice of single firms may have strong influence on macroeconomic outcomes*. The simultaneous installation of high productivity technologies in large fractions of the economy may be the only way to escape a poverty trap. A main influence on the choice of production technologies are property rights on profits. The distribution of profit claims in single firms can thus be very important for aggregate measures. The example we presented gives us an idea how fragile equilibria are with respect to policy. Slight changes in the government's instruments may cause large differences in national income due to the critical mass effect causing discrete jumps in the outcome of the market process.

5 A Note on Equilibrium Choice

In Proposition 5 we argued that the parameter space that allows for 'good' equilibria shrinks when some policy is applied. If a 'good' equilibrium is destroyed by policy, we might argue that such a policy has adverse welfare effects. However, we often remain with a 'bad' low productivity trap with, at the same time, a good outcome. In such a case, what are the normative implications that a parameter space allowing for the good outcome is larger or smaller? If we do not determine which equilibrium is chosen and why, what is the influence of the parameter space?

Obviously the resulting equilibrium is a matter of the agents' expectations of the other agents' actions. Since the other agents' actions are dependent on their expectations what everybody else does, expectations about other expectations have to be formed. This problem has not yet been resolved fully satisfactorily by the theoretic literature. In macroeconomic models related to the one we present, the equilibria are of the 'sunspot' type [Gans (1994)]. That is, expectations may be influenced by any imaginable mechanism, independent of its economic content. In this sense, the parameter space may have nothing to do with the question of which equilibrium is picked. To see that this interpretation is superficial from an economist's point of view, consider the following polar examples where in each case we have two *NE*.

Assume we have one hundred branches in the economy. In the first case, the parameters and the policy of the model are such that it pays for entrepreneur *i* to invest only if all 99 other firms also invest. If only one sector stays with cottage production, every industrializer loses money. The second case is the opposite: if only one firm invests and the rest stays out, the one firm loses money. But if two firms make the investment, the market is large enough and both make positive profits. To argue that the parameter space has no implication on what equilibrium is chosen would mean arguing that both situations are qualitatively the same. This is somehow puzzling, and several refinement mechanisms have been suggested to solve the problem. We briefly discuss two of them which may be applied to our setup. The first one relates to Selten's (1975) 'trembling hand' argument. Suppose that 10 percent of the entrepreneurs make errors when deciding whether to invest or not. Thus, even if the high output equilibrium is expected to occur in the first case of our example, 10 firms will not invest. But then investment does not pay for anybody, because the parameter space which supports the high output equilibrium is so small. In the second case, even if the low output expectation is adopted, 10 firms invest erroneously, but knowing that, everyone (who does not make mistakes) chooses to industrialize. If we accept that kind of reasoning, the parameter space clearly matters. The second approach is to allow for mixed strategies. Then, by any given priors about other agents' expectations, the *NE* probabilities of investment will depend on the parameter space. If the probability to choose 'investment' is 10 percent for any player, in the first case the low output equilibrium will (almost certainly) result. Thus, the probability of 10 percent could not have been an optimal strategy. By reasoning that the optimal randomizing strategy must put even less weight on investment, the high output equilibrium is (almost certainly) erased. The second case works the other way round, supporting the high output equilibrium.

We do, therefore, think that parameter spaces matter in any real world application of the theory. Any policy should be concerned about not only which equilibria may turn out, but also on how it influences the conditions that support those equilibria.

6 Conclusion

We have analyzed conditions under which a less developed economy is capable of making a 'Big Push' into industrialization. The coordination of investments across sectors can lead to a Pareto-dominant state of larger output. This sort of jump into a 'good' state of matters is possible because any industrialized firm captures only a fraction of its contribution to economywide demand and profits. Even if a single firm's investment in productivity increasing technologies is not beneficial for the entrepreneur alone, it can help to foster industrialization in other sectors. Generalizing the MSV (1989) framework we show that profit spillovers alone can generate this pattern.

Allowing for a continuous choice of technologies, we were able to focus on an important point not yet extensively discussed in the development literature: the *macro-economic effects of property rights*. Industrialization may only be possible if entrepreneurs receive extensive claims on the profits generated by their actions. Small changes in the property rights such as profit taxation may have an enormous influence on aggregate outcomes. Even low tax rates can destroy industrialization equilibria, and slight changes in the policy regime can dramatically change industrial structure and income of an economy. This is due to multipliers and critical mass effects, that lead to huge reactions in the aggregate. The critical mass effect is already described by MSV. The multiplier due to the optimal technology choice that we present adds additional economic insights: which *type of industrialization* is chosen is certainly an important question for many less developed countries. A 'Big Push' may be only possible if extremely modern, highly productive ways of manufacturing are implemented. The question thus is not only *whether* to industrialize, but *how*. Our model can be interpreted as favoring the immediate jump into the most productive technology available. Several sequential steps of technology adoption might not work and the economy gets stuck in a poverty trap.

The usual disclaimer applies: one should be extremely cautious when applying our model for economic policy advice. We provide a very simple *example* to focus on economic effects of simultaneous investments. Situations which are present in a model not necessarily occur in practice. However, any policymaker should take into account the possibility of the existence of those effects. If they exist, the impact of policy can be dramatic.

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