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Functional Distribution, Land Ownership and Industrial Takeoff

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Abstract - This paper investigates how the distribution of land property rights affects industrial take-off and aggregate income through the demand side. We study a stylized two sectors economy where the manufacturing sector is assumed to be constituted by a continuum of small markets producing distinct commodities. Following Murphy et al. [24] we model industrialization as the introduction of an increasing returns technology in place of a constant returns one. However, we depart from their framework by assuming income to be distributed according to functional groups' membership (landowners, capitalists, workers). We carry out an equilibrium analysis for different levels of land ownership concentration proving that, under the specified conditions, there is a non-monotonic relation between the distribution of land property rights and both industrialization and income. We clarify that non-monotonicity arises because of the way land ownership concentration affects the level and the distribution of profits among capitalists. Our results suggest that i) both a too concentrated and a too diffused distribution of land property rights can be detrimental to industrialization, ii) landownership affects the economic performance of an industrializing country by determining industrial profits and iii) in terms of optimal land distribution there may be a tradeoff between income and industrialization.

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I. Introduction

1. An Interesting Case: South Korea and Philippines in '60-'80

Some years ago Lucas [23] raised an intriguing issue about the different economic performances of South Korea and Philippines.[1] In the early 1960's the two countries were similar under many respects showing almost the same GDP per capita, schooling levels, population and urbanization. Philippines had a slightly higher share of manufactures in total GDP, but both exported a similar proportion of primary goods and manufactures. In other words, at the beginning of the '60s South Korea and Philippines were in very similar macroeconomic *initial* conditions. Nevertheless, during the following twenty-five years the former experienced sustained growth – about 6% – fully undertaking the industrialization process, while the latter grew at a speed of about one third – less than 2% – remaining mainly an agricultural economy. Lucas classified the case of Korea as a sort of *productivity miracle*.[2]

Interestingly, moving the attention to the distribution of income and land ownership, one finds no such similarities. Indeed, the two countries were sensibly different from a distributional point of view: South Korea had a much more equal distribution of both land property rights and income than Philippines. Remarkably, the ratio between income of the top 20% population and that of the bottom 20% – or even 40% – was nearly twice bigger in Philippines. The Gini coefficient for land ownership was 38.7 in Korea in 1961 and 53.4 in Philippines in 1960.[3]

These distributive differences contribute explaining the best economic performance of Korea over Philippines, particularly in the early years of industrialization. A more equal distribution of income and land ownership granted Korea a greater

[1] See Bénabou [6] for more comments on this economic puzzle.

[2] See Lucas [23].

[3] This latter difference is the effect of the land reform undertaken by the Government of South Korea in 1949 which took the name of Agricultural Land Reform Amendment Act. It consisted mostly of the redistribution of land previously owned by Japanese people but it was sufficient to reduce the number of tenants to nearly zero in a couple of years (see Jeon and Kim [19]).

and more stable domestic demand of basic manufactures which made investments in mass production technologies more profitable. Labour division increased productivity and generated a greater surplus that, due to a more equal distribution, transformed into a higher income for a vast majority of the population. Higher income further raised domestic demand sustaining early growth. Our intuition is that, before becoming leading exporters of basic manufactures, Korea's *chaebols* have been crucially relying on domestic demand.

Clearly, this is only part of the story about the Korean industrial success and it has to be cautiously interpreted. There are other crucial factors like good international relationships, access to credit, effectiveness of political choices and foreign investments which have been relevant as well. However, our point is rather simple and applies in conjunction with other explanations: when an industrial technology with increasing returns is available and domestic demand of basic manufactures is affected by the distribution of income, the actual distribution of land property rights matters for both income growth and industrialization.[4]

2. Related literature

The process of industrial development has always been an object of inquiry in economics.[5] Following Adam Smith, early economists interpreted industrialization as a substantial increase in labour productivity due to the increase of labour division and specialization.[6] For quite a long time, the conquest of new markets has been

[4]Chenery and Syrquin [11], Chenery, Robinson and Syrquin [10] provide further empirical evidence of the relevance of domestic demand for industrialization. Using a sample of rapidly growing economies they show that the expansion of domestic demand accounts for a large part of the increase of domestic income. For the biggest countries in their sample, domestic demand explains more than 70 percent of the increase of domestic income, while in small countries (under 20 million people) the percentage diminishes until a minimum of 50 percent. See also Murphy *et al.* [25] section II.

[5]For a short survey of the view points of classical economists on this topic see Fiaschi and Signorino [12], and also Rosenberg [28] and Brewer [9].

[6]Early economists emphasized the role of demand. As they assimilated industrialization to labour specialization – or, as a modern economist would say, to the adoption of increasing return

considered the best way to sustain industrialization and growth. Needless to say, an industrial takeoff requires more than a proper level of demand. It is a rather complex phenomenon and it is affected by a quantity of economic, social and cultural factors. Here we briefly review some attempts to model and explain the industrialization process, focusing in particular on those which investigate the role of income and land ownership distribution.

During the 1940s and 1950s, several contributions analysed the effects of export booms and agricultural productivity improvements (see for instance Rosenstein-Rodan [29], Lewis [20] [21] and Fleming [13]). This literature has mainly focused on exogenous shocks and their persistent effects, with scarce reference to distributional issues. In the late 1980s, Murphy *et al.* [24] proposed a model of early industrialization where the takeoff is sustained by domestic demand and the extent of industrialization is determined by the distribution of income. They studied the relationship between income distribution and the size of domestic demand when several manufactures are available. Assuming that a fraction of the labour force receives profits and rents they investigated how the distribution of shares influences the extent of industrialization by modifying the profitability of mass production. We replicate some results provided by Murphy *et al.* [24] under different distributional assumptions, which allow us to analyse in greater detail how the distribution of land property rights affects the distribution of profits and, in turn, income and industrialization.

More recently, the relationships between distribution, growth and industrialization have been analyzed from a variety of perspectives. A first group of contributions links inequality and growth arguing that, whenever there are imperfections in assets' markets, people without the necessary collateral may be prevented from undertaking the efficient level of investment (see Loury [22], Galor and Zeira [15], Aghion and Bolton [3]). A second group looks at the interaction of income distribution and the

technologies – the expansion of manufactured goods was considered to be a necessary condition for industrial development and growth.

political system finding that, under a democratic regime, inequality is detrimental to growth because it pushes towards higher taxation and lower incentives for investments (see Bertola [8], Alesina and Rodrik [4], Persson and Tabellini [27]). A third group focuses on institutional issues claiming that greater inequality increases social conflict and reduces the enforcement of property rights, negatively affecting investment (see Grossman [16] [17], Acemoglu [1], Benhabib and Rustichini [7]). A fourth group, taking again an institutional perspective, emphasizes the importance of the conflict between interest groups in presence of technological choices (see Parente and Prescott [26], Acemoglu and Robinson [2]). Differently from these contributions we take a more traditional perspective and focus on the demand side. We do this to emphasize that land ownership distribution matters not only because of market imperfections or institutional complementarities but also because it directly shapes production incentives.

A work much closer to ours is the study by Galor, Moav and Vollrath [14] which analyzes how the distribution of land property rights affects growth via education. They argue that the more unequal is the distribution of land ownership the later educational reforms are introduced, with a strong negative impact on human capital.[7] This is a sort of indirect effect of land ownership distribution on growth as it relies on the power of landowners to influence political institutions and therefore the implementation of educational reforms. In this paper we point out that there is a more direct relation going through the demand side, which has to do with the composition of manufactures' demand that effects the profitability of increasing returns technologies.

3. An overview of the paper

The basic structure of our model is very close to that of Murphy *et al.* [24] but we believe that, in the study of the relationship between distribution and early

[7] They provide empirical evidence from US in the period 1880-1920.

industrialization, it is better to assume a functional sharp division of income between members of distinct classes for two main reasons. Firstly, it is more reasonable: a widespread ownership of firms' shares is typical of economies in advanced stages of industrialization and it is not an appropriate picture for countries which are about their takeoff. Secondly, it allows to investigate the effects of intra-group distribution of income and inter-groups distributional relationships. Hence, we assume that each entrepreneur retains the profits made by the firms she manages, being also the capitalist.[8] Moreover, we sharply distinguish among landowners, entrepreneurs and workers making their number explicit.

The economy we describe is composed of two sectors: agriculture, which provides food, and manufacturing, constituted by a continuum of markets each providing a different commodity. Consumption is assumed to be incremental in the sense that the higher is the income the greater the variety of goods consumed. In particular, all individuals have the same tastes and demand goods according to the same schedule of priorities. Their first priority is the amount of food necessary to survive, the second is a unit of the most necessary manufacture, the third is the second most necessary manufacture and so on and so forth. Industrialization is conceived as the substitution of a traditional technology – showing constant returns to scale – with an industrial one – showing increasing returns to scale. In each market of manufactures, artisans exploiting traditional technologies compete with each other driving profits to zero. However, a single artisan per market has access to the industrial technology. Provided demand is high enough, she can become an entrepreneur and monopolize the market making positive profits.

We first analyze economies where industrialization does not take place. Three different kinds can be distinguished: a) subsistence economies, where only food is produced and consumed and there are only landowners and land workers; b) small economies, where a manufacturing sector exists but the population is too small to

[8]For this reason we use the terms entrepreneur and capitalist interchangeably.

make entrepreneurship and mass production profitable; c) traditional economies, where wages are at subsistence level but there is a manufacturing sector producing only for landowners. We take traditional economies as the non-industrialization standard case, exemplifying a typical situation for many non-industrial countries. Then, by comparing states induced by different distributions of land property rights we show that, *ceteris paribus*, the relation between land ownership concentration and income and between land ownership concentration and industrialization are both non-monotonic.[9]

Not surprisingly, different degrees of land ownership concentration produce quite different patterns of industrialization and income in equilibrium. We use two measures of the degree of industrialization: the number of markets which adopt the industrial technology, say the *extent of industrialization*, and the number of workers hired by firms operating the industrial technology, that is *industrial employment*. The maximum extent of industrialization is reached for an intermediate level of land ownership concentration. In particular, the variety of goods produced with the industrial technology is maximal when each operating market is industrialized, and demand in all markets is just sufficient to cover start-up costs and grant profits equal to the opportunity cost of labour wage. Instead, the maximum income is generally obtained for a lower extent of industrialization, hence for a broader distribution of land property rights. The reason is that the increasing returns are better exploited when the demand is concentrated in less commodities, producing higher profits.

We also show that a too equal distribution of land property rights can be detrimental to industrialization and income. This is due to the fact that many not-so-rich landowners would demand only few very basic manufactures, concentrating the benefits of industrialization into the hands of very few entrepreneurs. This would induce a very unequal distribution between capitalists and everyone else with the conse-

[9] In this model there is no direct spillover accruing from industrialization. Indeed, only one equilibrium is determined for any given set of parameters and there is no coordination problem. In that we differ from Rosenstein-Rodan's [29].

quence that the demand of manufactures produced with the industrial technology would be rather low and mass production would not be properly exploited.

For what concerns maximum industrial employment, we find that it is obtained for a level of land ownership concentration which is in-between the level associated to the maximum industrial extent and that associated to maximum income, possibly coinciding with either of them. This result arises, on one side, from the fact that a more intensive exploitation of the increasing returns technology is often possible only at the cost of reducing the range of industrialized markets and, on the other, from the nature of industrial employment which increases with the intensity of exploitation – like income – but decreases with the number of industrialized markets – like industrial extent. So, more industrial employment need not coincide with more income or more industrialized markets. We describe in detail, both in Section IV and in the Appendix, a variety of cases which depend on parameters' specification.

Most of these results are consistent with the main findings of Murphy *et al.* [24]. Our specific contribution is the analysis of the model given a sharp distinction between land and firm ownership. Indeed, by assuming functional distribution of income we are able to go into greater detail and show how the distribution of land affects the distribution of profits and how this impacts on income and industrialization through the demand side.

The paper is organized as follows: section II presents the basic model; section III characterizes the equilibrium of the model; section IV compares equilibria with different distribution of land property rights; section V explores some extensions of the model; section VI contains concluding remarks.

II. The Model

In this section we illustrate the basic features of the model. Our assumptions yield a unique equilibrium showing some novel features with respect to Murphy *et al.* [24].

1. Commodities and Consumption Patterns

There is a single homogeneous divisible agricultural good. For simplicity we label it *food* and use it as numeraire. Moreover, there is a continuum of manufactured goods represented by the open interval $[0, \infty) \in \Re$. Each good is denoted by its distance q from the origin. The consumption pattern – or tastes, if one prefers – is assumed to be the same for each individual. There is a subsistence level of food consumption $\bar{\omega}$. After that, any unit of income is spent to buy the manufactured goods following their order in the interval. This is intended to represent in a simple way the fact that there is a common ranking of necessities, i.e. people first need to buy what is necessary to survive, then basic manufactures and durables which allow better life standards and, only after that, they buy luxuries. For simplicity, we assume that only one unit is bought of any manufactured good. In other terms, any individual with income $\omega \geq \bar{\omega}$ uses her first $\bar{\omega}$ of income to purchase food needed to survive and $(\omega - \bar{\omega})$ to purchase the manufactured goods, one of each kind following her necessity ranking. Any individual with $\omega < \bar{\omega}$ starves.

It is worth pointing out the intuitive consequences of our assumptions. First, individuals are almost identical for what concerns consumption decisions and they only differ in terms of income. Thus, a landowner and her servants would consume the same if given the same income. Second, any increase of income results in an increase of consumption variety. In particular, richer people buy the same bundle of poorer people plus some other commodities.

2. The Agricultural Sector

In order to produce food it is necessary to use land and labour. However, we abstract from land and assume it is always fully utilized in production. For the sake of simplicity, we also assume all workers have the same skills – labour is homogenous – and perfect competition in the output side – no profits are earned.

Technology and Incomes. Given the amount of land utilized, labour has decreasing marginal productivity. Total production is determined by the function $F(L_f)$ where L_f is the number of workers employed in agriculture. It is assumed $F' > 0$, $F'' < 0$. Agricultural wage w_f is a function of agricultural employment with $w'_f(L_F) < 0$. This formalization is consistent with the case in which labour is paid its marginal product. Since profits are nil, income generated in agriculture is exhausted by land workers' wages and landowners' rents. Denoting with R the total amount of rents earned, we have the account equation

$$R = F(L_f) - w_f L_f \tag{1}$$

Land Ownership. Differently from Murphy *et al.* [24], we assume property rights of the land stock to be equally distributed among M landowners. We also assume income of each landowner to be equal to R/M and, hence, to be negatively related to their number. This is intended to represent in a simple way the fact that, on average, the greater is the number of landowners the smaller is the area of land they posses and, therefore, the smaller the rent they earn. We know that in the real world a non-uniform distribution of land property rights is the norm in many countries. However, we emphasize that our simplification works well as long as the the average concentration of land property is the relevant feature. In this sense, M should be interpreted as a rough index of land property concentration. In addition, this assumption allows us to investigate in greater detail the relationship between land ownership concentration and profits distribution. Finally, we abstract from the issue of productivity change due to variations in the extent of land ownership, such as that described in Banerjee *et al.* [5].[10]

[10]The qualitative results of our model can be obtained also by allowing for an increase in productivity due to the reduced dimension of land property. However, the analysis would become more complicated and would somehow obscure the mechanism we want to highlight.

3. The Manufacturing Sector

Each good q identifies a distinct market of the manufacturing sector. Hence, there is a continuum of markets which are significantly small with respect to the entire economy. The number of workers employed in the manufacturing sector as a whole is denoted by L_m while the ruling wage by w_m.

Technology and Markets. It is assumed that the production of each commodity q has the same cost structure. In particular, in any of the manufacturing markets two technologies are available. The first, labelled *traditional technology* or TT, requires α units of labour in order to produce a unit of output. This represents the case in which commodities are produced by artisans who at the same time organize production and work as other wage-paid labourers. For this reason, the number of workers in the TT markets includes also artisans. The second, labelled *industrial technology* or IT, requires a fixed amount k of labour plus β units of labour per unit of output produced, with $0 < \beta < \alpha$. This represents the case where a former artisan becomes an entrepreneur exploiting the benefits of mass production. Furthermore, we assume $(k+1) > (\alpha - \beta)$ which simply means that the amount $(\alpha - \beta)$ of labour saved producing one output unit using IT is less than the fixed amount k needed to introduce the IT plus the unit of labour provided by the artisan who knows it. Clearly, this is the only interesting case because if $(k + 1) \leq (\alpha - \beta)$ the IT would never require more units of labour with respect to the TT and, hence, it would be always preferred by artisans. Lastly, we denote by E the number of entrepreneurs.

We stress the fact that the TT has constant returns to scale while the IT has increasing returns to scale. The difference between these two technologies represents the economic advantage of industrialization.

Competition and Income. A group of competing artisans is assumed to operate in each market q of the economy. Given a wage w_m, any amount of commodities can be produced and sold at the unit price αw_m. No profits are earned by artisans. Besides, it is assumed that in each market q there exists one and only one artisan who knows the IT. She has the choice to become an entrepreneur introducing the IT or to hold on with her current business as an artisan. If she decides to be an entrepreneur she can become a monopolist by slightly undercutting the price αw_m, so that nobody would buy the good from the traditional sector. In this case her profits would be

$$\pi(q) = (p_q - \beta w_m)D_q - kw_m \tag{2}$$

where p_q is the price she sets and D_q is the demand of market q.

4. Population and Labour Market .

Agricultural employment determines the ruling wage w_f. Workers of the manufacturing sector are not paid the marginal product but instead their wage depends on customs, necessities, pressure generated by the agricultural wage and on mobility of labour between the two sectors. As we will not carry out an analysis for different wage levels and differentials among sectors, we assume perfect mobility of labour which, in equilibrium, implies $w_f = w_m = w$.

The active population is denoted by L and each worker either supplies inelastically one unit of labour or becomes an entrepreneur. The total supply of labour is hence equal to $L - E$. Finally, the population is assumed to be fixed and equal to $N = L + M$ where $L = L_f + L_m + E$.

III. Equilibrium

In this section we characterize the equilibrium of the described economy as a function of the number of landowners M, the wage level w, the available labour force L

and technology, denoted by F for agriculture and by the vector $\tau \equiv (\alpha, \beta, k)$ for manufactures. In the next section we illustrate how these parameters affect the extent of industrialization.

Since we want the economy to effectively produce commodities, we assume the ruling wage w to be not less than the subsistence level $\bar{\omega}$, otherwise no worker would supply labour.[11] For obvious reasons, we also assume the rent of a single landowner R/M to be not lower than w. The same holds for profits as artisans who know the IT would decide to become entrepreneurs if and only if by doing so they earn an income which is greater than what they would earn as workers.[12]

The demand of food is given by

$$D_f = (L_f + L_m + E + M)\,\bar{\omega} = \bar{\omega}N \tag{3}$$

while the supply of food is

$$S_f = F(L_f) \tag{4}$$

Regarding the manufacturing sector, we have to take into account how prices influence both aggregate demand and supply. The price of commodities produced with TT is, as mentioned above, αw as a consequence of competition among artisans. The price of commodities produced with IT is set by entrepreneurs in order to maximize profits. Since consumers buy manufactured goods following a well specified order and at most one of each kind, in any market the elasticity of demand with

[11]Clearly it is possible that agricultural productivity is so low that w_f is less than $\bar{\omega}$. To rule out this case we apply a standard Malthusian argument, that is, when $w < \bar{\omega}$ population reduces and the agricultural sector employs less and less workers until labour productivity is high enough to sustain a wage level equal to $\bar{\omega}$. So in equilibrium $w \geq \bar{\omega}$. Of course, the Malthusian argument does not apply when $w > \bar{\omega}$, because the remaining wage above $\bar{\omega}$ is spent in the manufacturing sector.

[12]It could be objected that we do not consider the possibility of people having a preference for being an entrepreneur or a landowner (because of the social status granted, the disutility of effort, etc). Indeed, we have not explicitly taken into account this issues in the model because, although reasonable, it would add very little to our results.

respect to the price is 0.[13] Hence, entrepreneurs find convenient to rise prices as much as possible. However, the level αw constitutes an upper bound because, for any price greater than that, some artisans would get the entire demand. Therefore, each entrepreneur will set the price $p_q = \alpha w$, which implies the price of each manufactured commodity is αw independently of how many markets industrialize.

Besides, it takes only one's moment reflection to realize that the demand faced by each manufacturing market is non-increasing in q. Since poorer people simply consumes a bundle of commodities which is a subset of richer ones, it cannot happen that for two markets q' and q'' such that $q' < q''$ it is $D_{q'} < D_{q''}$. Moreover, entrepreneurs face the same cost structure, so in each sector they find convenient to start their business at the same level of D_q. The last two observations imply that there is a separating market Q^* such that in any $0 \leq q \leq Q^*$ the IT is implemented – i.e. the market q industrializes – and in any $q > Q^*$ the TT is applied or the demand is 0. So, we have that the aggregate demand of the manufacturing sector is

$$D_m = \frac{1}{\alpha w}\left[(R - \bar{\omega}M) + (L_f + L_m)(w - \bar{\omega}) + \int_0^{Q^*} (\pi(q, \tau, w) - \bar{\omega})\mathrm{d}q\right] \tag{5}$$

The aggregate supply is

$$S_m = \int_0^{\bar{Q}} S_q \mathrm{d}q \tag{6}$$

where $\bar{Q}$ denotes the extent of the manufacturing sector and S_q the supply of the market q. Finally, the demand of labour is

$$D_l = L_f + L_m \tag{7}$$

and, as anticipated, the supply is

[13] Notice that being the manufacturing sector a continuum of markets, the consumers' income is always entirely spent.

$$S_l = L - Q^* \tag{8}$$

since the number of entrepreneurs is $E = Q^*$.

In equilibrium it must simultaneously hold that $D_f = S_f$, $D_m = S_m$ and $D_l = S_l$. We assume that the economy can sustain the whole population $N = (L + M)$, that is $F(L) \geq \bar{\omega}N$. From $D_f = S_f$, we get the equilibrium value of employment in agriculture

$$L_f^* = F^{-1}\big(\bar{\omega}N\big) \tag{9}$$

which is fully determined as $F(L_f)$ is invertible with respect to L_f and the parameters N and $\bar{\omega}$ are given. In particular the equilibrium levels of wage, employment and output in the agricultural sector are independent of the equilibrium of the manufacturing sector since the aggregate demand of food is $\bar{\omega}N$ in any case. From $D_l = S_l$ and L_f^* we get the equilibrium value $(L - L_f^*)$ of people with a job in the manufacturing sector (workers, artisans or entrepreneurs). From L_f^* we obtain $w(L_f^*)$ which is assumed to be not less than $\bar{\omega}$. Then M, F and τ are sufficient to determine the extent of the manufacturing sector $\bar{Q}$. We are left with only two unknowns, namely Q^* and L_m^*. Exploiting equilibrium conditions, equation (5) can be written as

$$\begin{aligned} D_m &= \frac{1}{\alpha w}\left[R^* + (L_f^* + L_m)w + \int_0^{Q^*} \pi(q,\tau,w)\mathrm{d}q - (L_f^* + L_m + Q^* + M)\bar{\omega}\right] = \\ &= \frac{1}{\alpha w}\left[F(T, L_f^*) + L_m w + \int_0^{Q^*} \pi(q,\tau,w)\mathrm{d}q - (L + M)\bar{\omega}\right] = \\ &= \frac{1}{\alpha w}\left[L_m w + \int_0^{Q^*} \pi(q,\tau,w)\mathrm{d}q\right] \end{aligned} \tag{10}$$

where R^* is the equilibrium level of aggregate rents. Now, exploiting $D_m = S_m$, equation (2) and $D_q = S_q$ – holding for each q in $(0, \bar{Q})$ – we can equate the righthand sides of equations (6) and (10) to obtain

$$\begin{aligned} L_m^* &= \alpha \int_0^{\bar{Q}} S_q \mathrm{d}q - \int_0^{Q^*} \big((\alpha - \beta) D_q - k\big) \mathrm{d}q \\ &= \alpha \int_{Q^*}^{\bar{Q}} D_q \mathrm{d}q + \beta \int_0^{Q^*} D_q \mathrm{d}q + kQ^* \end{aligned} \tag{11}$$

where the first term of equation (11) represents the labour employed in markets using the TT, and the sum of the second and the third terms represents the labour employed in the industrialized markets.

Since any entrepreneur in q starts her business depending on the value of D_q, the extent of industrialization Q^* is univocally determined by the continuum of demands in $(0, \bar{Q})$. Although we have not yet provided an expression for any of those demand functions, in the Appendix we illustrate the mechanism of profits formation and industrialization, showing that for each q the demand D_q is univocally determined by population, land ownership distribution and technology. So, the only real unknown variable is L_m^*, and equation (11) leaves no degree of freedom, identifying the equilibrium.

Land Ownership, Profits and Industrialization. In order to give the intuition of the relation between income distribution and industrialization we focus on equilibrium outcomes for different land ownership concentrations. Consider the economy we have described so far and assume the agricultural sector is already in equilibrium. Denote with Ω_m the total expenditure in manufactures and with ω_i the income of individual i. Since every consumer who has already bought $\bar{\omega}$ units of food spends her remaining income to get a unit of each manufacture in the specified order, the demand D_q faced by a generic market q is determined by the number of individuals who earn enough income to buy at least commodity q, namely individuals satisfying $(\omega_i - \bar{\omega})/\alpha w > q$. Assume workers are poor and consume only food since

$w = \bar{\omega}$. Then, the distribution of land property rights shapes the demand for manufactures by determining the income of individuals who buy manufactures. For instance, if there are only few landowners they will be very rich and the extent of the manufacturing sector will be quite large, although the demand faced by each market will be relatively small. On the contrary, if there is a large number of landowners the extent of the manufacturing sector will be smaller but the demand faced by each operating market will be greater. Land property rights distribution also affects the absolute level of Ω_m. The higher is land ownership concentration the higher is Ω_m because total rents are unchanged but there are less landowners, hence less income is spent in food and the fraction of rents spent in manufactures is higher.

Since the IT is introduced only if demand goes over a certain profitability threshold, a too concentrated ownership of land will prevent the takeoff even if Ω_m is great. On the contrary, if land ownership is distributed so that the threshold is met, some markets will industrialize and the running entrepreneurs will make positive profits. This will start a multiplicative process of demand sustained by entrepreneurs' earnings. The interesting thing is that this extra demand can well offset the negative effect of a lower aggregate demand by landowners with the result that a broader distribution of land is even more income enhancing. The multiplicative effect arises because the extra demand can increase aggregate profits inducing a further increase in Ω_m.[14] Such a process can go on for several steps – profits, new demand, new profits – but in each step the amount of new profits must decrease because the new demand partially goes to cover production costs which are constituted by wages spent in food. In particular, the process ends when new generated profits fail to industrialize new markets or to generate extra demand for markets already industrialized.

Summing up, different distributions of land property rights determine, in equilibrium, different scenarios of industrialization and income. In our view, this provides

[14] The precise outcome depends on how profits are distributed among entrepreneurs. We investigate this issue in the following sections and in the Appendix.

an insight of why land ownership distribution may be relevant to industrialization and income growth. In what follows we explore in detail such a relationship by first providing a description of the conditions which prevent industrialization and then going through industrialization equilibria associated to different concentrations of land.

IV. Analysis

1. Non-industrial Economies

We start illustrating those conditions which may prevent a country from industrializing. In order for any market q to operate, the IT profits π_q must be not less than the ruling wage w, otherwise artisans would find convenient to keep using the TT. Since, as mentioned above, the technology τ is the same in each market and $q' < q''$ implies $D_{q'} \geq D_{q''}$, a necessary and sufficient condition for no industrialization is $\pi_0 < w$. From equation (2) we get

$$\pi_0 < w \iff D_0 < \rho \tag{12}$$

where $\rho \equiv (k + 1)/(\alpha - \beta)$. Equation (12) simply states that in equilibrium no market industrializes if and only if the demand faced by the first market is less than the value which allows to cover start-up costs plus the opportunity cost of quitting the previous job. Neglecting profits – which however are nil in a no industrialization equilibrium – demand D_0 is given by

$$D_0 = \begin{cases} 0 & if \;\; w = \bar{\omega}, \; R/M = \bar{\omega} \\ M & if \;\; w = \bar{\omega}, \; R/M > \bar{\omega} \\ L + M & if \;\; w > \bar{\omega}, \; R/M > \bar{\omega} \end{cases} \tag{13}$$

Any consumer who earns more than $\bar{\omega}$ demands at least the 0-commodity which implies that for $R/M > \bar{\omega}$ demand D_0 is at least M and for $R/M \geq w > \bar{\omega}$ it is $M + L$. So, the no industrialization condition of equation (12) can be satisfied by a variety of triples (L, M, τ). In the next paragraphs we group them in three classes of interest.

Subsistence economy. In a subsistence economy only food is produced and consumed and there is no manufacturing sector. This is the case when the ruling wage is $w = \bar{\omega}$ and L, $F(L_f)$ and M are such that $M + L = F(L)/\bar{\omega}$. Substituting M in equation (9) we easily obtain $L_f^* = L$ which implies that all the labour force of the economy is employed in agriculture. From equations (7) and (8) we get $L_m^* = 0$, $E = Q^* = 0$.

For that level of agricultural productivity, the number of landowners with respect to population is too high to allow for industrialization. The excessive dispersion of land property rights makes landowners' individual rents R/M as low as $\bar{\omega}$, fully offsetting the benefits accruing from a wage equal the subsistence level. As a consequence, no one demands manufactured goods and there is no manufacturing sector.

Traditional economy. In a traditional economy workers earn just what is needed to keep population stable while few landowners are rich enough to demand manufactures. There exists a manufacturing sector but mass production is still not profitable and commodities are all produced with the traditional technology. This is the case when $w = \bar{\omega}$ and L, $F(L_f)$ and M are such that $M + L < F(L)/\bar{\omega}$ and $M < \rho$. From equation (9) we get $L_f^* < L$ and $R/M > \bar{\omega}$.[15] Landowners spend $(R/M - \bar{\omega})$ in manufactures whose price is αw. So they consume commodities in $[0, Q_R]$ where

[15]Since $L_f^* < L$, in equilibrium we have

$$M < L + M - L_f^* \iff \bar{\omega} < \frac{(L+M)\bar{\omega} - L_f^*\bar{\omega}}{M} \iff \bar{\omega} < \frac{F(L_f^*) - L_f^*\bar{\omega}}{M} = \frac{R}{M}$$

$Q_R = (R - \bar{\omega}M)/\alpha\bar{\omega}M$. Since each operating market faces a demand $D_q = M < \rho$, none industrializes. Hence, the extent of the manufacturing sector coincides with the extent of landowners demand, $\bar{Q} = Q_R$, as shown in Figure 1. From equations (7) and (8) we also get $L_m^* = L - L_f^*$ implying $E = Q^* = 0$.

In this economy land concentration prevents industrialization because, although landowners are rich enough to demand manufactures, their number is not sufficient to make the introduction of IT profitable for entrepreneurs.

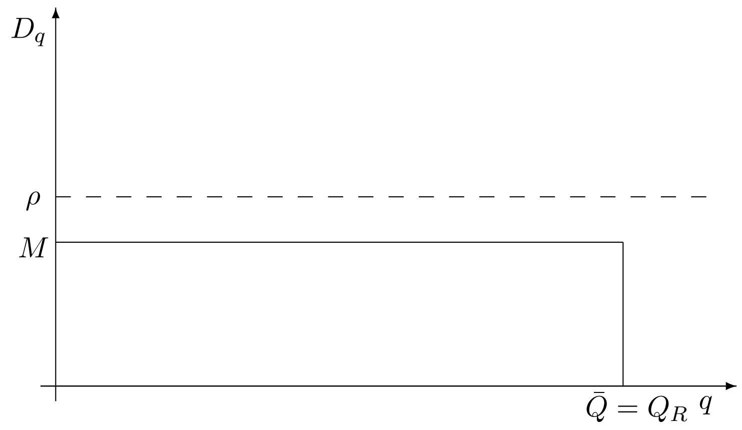

Figure 1. Traditional economy

Small economy. In a small economy both workers and landowners are rich enough to demand manufactures but population is so small that the industrial technology is still not profitable. This is the case when $R/M \geq w > \bar{\omega}$ and $M + L < \rho$. As before, from equation (9) we get $L_f^* < L$. Notice that there is an upper bound for w constituted by the level of wages which reduces the rent of each landowner to $\bar{\omega}$, namely $L\bar{\omega}/L_f^*$.[16] So, for $w < L\bar{\omega}/L_f^*$ both workers and landowners demand manufactures. Let $Q_L = (w - \bar{\omega})/\alpha w$ be the extent of workers' demand and Q_R be, as before, the extent of landowners demand. In a small economy markets in $[0, Q_L]$ face a demand equal to $D_q = (L + M) < \rho$ while markets in $(Q_L, Q_R]$ get a demand equal to $M < \rho$, as shown in Figure 2. Hence, no market industrializes and the extent of the manufacturing sector is $\bar{Q} = Q_R$. Exploiting equation (7) and (8) we obtain $L_m^* = L - L_f^*$ and $E = Q^* = 0$.[17]

In this economy, industrialization is prevented by the small size of population and not by distribution. Indeed, even if agricultural productivity was high enough to grant both workers and landowners a very high income, their small number would make mass production unprofitable. This represents the typical case where the manufacturing sector can flourish and produce manufactures of great quality and value, but no artisan tries to become an entrepreneur and implement mass production.

2. Industrialization Driven by Landowners Demand

Workers of countries in an early stage of industrialization frequently experience low wages and spend most of their income for subsistence. Therefore we assume that productivity is such that wages are equal to $\bar{\omega}$. Such a simplification allows us to investigate the role of landownership distribution in greater detail. For the sake of completeness, in the next section we sketch what happens for higher wages, although we leave full analysis of this case to further research.

For every level of land ownership concentration we compare the equilibrium

[16] From (1) and imposing $R/M > \bar{\omega}$ we obtain

$$\frac{R}{M} = \frac{F(L_f^*) - wL_f^*}{M} = \frac{\bar{\omega}(M + L) - wL_f^*}{M} > \bar{\omega} \Longleftrightarrow \bar{\omega}L - wL_f^* > 0$$

[17] For completeness notice that by assuming $R/M \geq w$ we have also ruled out the case of $\bar{\omega} < w = L\bar{\omega}/L_f^*$ where only workers demand manufactures. This would imply $D_q = L$ for any q in $[0, Q_L]$ and an extent of the manufacturing sector equal to $\bar{Q} = Q_L$.

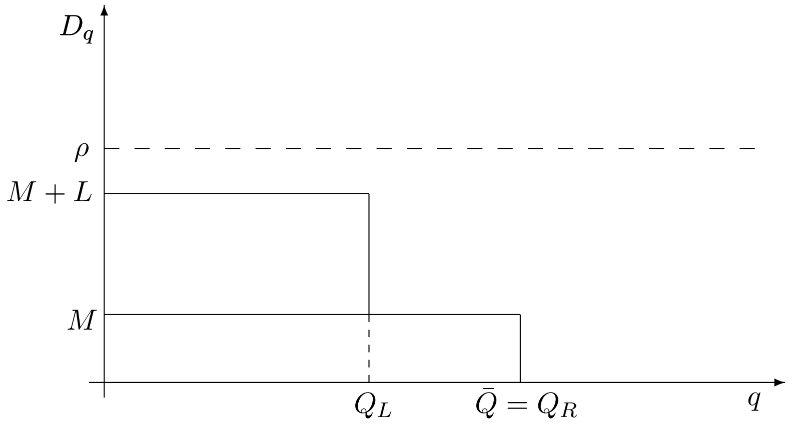

Figure 2. Small economy ($Q_R > Q_L$)

values of aggregate income, industrial extent and industrial employment. Aggregate income is obtained by the sum of rents, profits and wages; extent of industrialization is the length of the interval of industrialized markets; industrial employment is the sum of all workers employed in direct production and start-up tasks. We will show that all three variables have a non-monotonic relation with land concentration and, in the great majority of cases, their maximal values are not obtained for the same distribution of land property rights.[18]

As we have pointed out for traditional economies, as long as $M < \rho$ no artisan introduces the IT. Hence, both industrial extent and employment are nil. In this case, the income of the economy is equal to

$$Y^* = R^* + \bar{\omega}(L_f^* + L_m^*) = R^* + \bar{\omega}N - \bar{\omega}M$$

As N and R^* are constant, Y^* decreases as the number of landowners increases. The reason is that aggregate demand of manufactures Ω_m decreases in M and this

[18]Since calculations are not particularly enlightening and are rather long we collect them in the Appendix, providing here only results and their interpretation.

happens because the quota of rents spent on food increases.

When M equals ρ those artisans operating in markets $[0, Q_R]$ who know the IT can become entrepreneurs and earn an income equal to $\bar{\omega}$. Assuming for simplicity that IT is introduced whenever it is not disadvantageous to do it, we have that industrial extent jumps to $Q^* = Q_R = \bar{Q}$ and no commodity is produced with the TT. Similarly, industrial employment jumps to

$$L^*_{IT} = \beta M Q_R + k Q_R$$

where the first term accounts for workers in direct production and the second one for those involved in start-up tasks. Instead, income does not increase, indeed it is equal to

$$Y^* = R^* + \Pi^* + \bar{\omega} N - \bar{\omega}\left(M + Q_R\right) = R^* + \bar{\omega} N - \bar{\omega} M$$

as if no industrialization had taken place. The reason is that increasing returns are exploited just enough to grant entrepreneurs an income of $\bar{\omega}$ which implies $\Pi^* = \bar{\omega} Q_R$.

For $M > \rho$, some entrepreneurs spend part of their profits in manufactures generating new demand and triggering the multiplicative mechanism described in the previous section. Recalling that entrepreneurs – differently from landowners – do not have equalitarian intra-class income distribution, we shall distinguish the case of landowners being the richest in society from that of some entrepreneurs being the richest. In particular, there exists a level of M, denoted by μ, such that for $M < \mu$ landowners are the richest and for $M > \mu$ entrepreneurs in $[0, Q_R]$ are richer than landowners. When $M = \mu$, entrepreneurs and landowners are equally rich and, hence, buy exactly the same bundle of goods.[19]

[19] In the Appendix we show that

$$\mu = \frac{\alpha(k+1) - \beta + \sqrt{(\alpha(k+1) - \beta)^2 + 4\ \alpha\beta(\alpha - \beta)\frac{R}{\bar{w}}}}{2(\alpha - \beta)\alpha}$$

For $M \leq \mu$ the extent of industrialization Q^* decreases in the number of landowners M. This happens because landowners are the richest consumers, hence the extent of industrialization coincides with the extent of landowners demand Q_R, which decreases in M. Since no one demands commodities beyond Q_R, no good is produced with the TT and Q^* is also the extent of the manufacturing sector, i.e. $Q^* = Q_R = \bar{Q}$. For what concerns industrial employment, in equilibrium we have

$$L_{IT}^* = \frac{R^*}{\bar{\omega}} - (M + Q_R) \tag{14}$$

Industrial employment is equal to the number of people who are not employed as agricultural workers, $R^*/\bar{\omega} = (N - L_f^*)$, minus the sum of landowners and entrepreneurs $(M + Q_R)$. Since equilibrium rents are constant in M, it follows that the greater is the number of landowners the lower is their individual income but also the smaller is their marginal income reduction. Therefore, as M increases, the extent of landowners demand Q_R diminishes at a decreasing rate, and from equation (14) industrial employment can increase, decrease, or first increase and then decrease. Also aggregate income may not be monotonic in M. In particular, it can either increase or first increase and then decrease. For the range under consideration

$$Y^* = R^* + \bar{\omega}N + \Pi^* - \bar{\omega}(M + Q_R) \tag{15}$$

where the expression for Π^* is given in the Appendix. The actual behaviour depends on how the term $\Pi^* - \bar{\omega}(M + Q_R)$ behaves. As we pointed out in the previous section, two opposite effects are at work when M increases: the concentration of landowners demand in fewer markets – which allows a better exploitation of increasing returns – and a higher quota of rents spent in subsistence – which reduces aggregate landowners demand of manufactures. Whether the first or the second effect prevails, determining whether Y^* increases or decreases, depends on the response of aggregate profits. Indeed, the number of entrepreneurs declines but, on average, they become richer so that the total effect on Y^* is ambiguous.

For $M > \mu$ entrepreneurs in Q_R are richer than landowners, hence they demand commodities beyond Q_R. If their number is high enough, namely $Q_R \geq \rho$, markets beyond Q_R facing their demand industrialize. Entrepreneurs of these last markets earn profits sufficient to demand some basic manufactures, increasing the earnings of those entrepreneurs who produce such goods. These ones are the richest group within their class since their products are demanded by all those who buy manufactures. Hence, they earn additional profits and demand commodities in a new interval of markets. If this richest group is large enough, also markets in this last interval will adopt the IT, and the process may go on for several steps. We will refer to the number of such intervals as the number of *steps* and will denote it by i^*, which is a non-increasing step function of M. Notice that a greater i^* does not imply a more extended industrialization. The extent of industrialization Q^* is determined by the richest group of entrepreneurs large enough to induce some artisans to introduce the IT, and can be written as

$$Q^* = (M - \rho) \sum_{j=1}^{i^*} \left(\frac{\alpha - \beta}{\alpha} \right)^j + Q_R \left(\frac{\alpha - \beta}{\alpha} \right)^{i^*} \tag{16}$$

The first term accounts for the positive effect produced on Q^*, as M increases, by landowners demand concentration in basic manufactures, which allows the richest entrepreneurs to extend their demand. The magnitude of this effect increases, *ceteris paribus*, in the number of steps because more steps imply more groups of entrepreneurs demanding to the richest group. The second term accounts for the negative effect produced by the decreasing extent of landowners demand as M increases, which reduces the amount of profits earned by the richest group of entrepreneurs. The magnitude of this negative effect decreases in the number of steps because it is partially compensated by more groups of entrepreneurs demanding to the richest group.[20] Combining the two effects, the extent of industrialization can both increase

[20]Since i^* is a non-increasing step function of M, after a certain level of M, $i^* = 0$. In this case no market beyond Q_R industrializes, and $Q^* = Q_R$ as for $M < \mu$, but there will be commodities

and/or decrease in M, possibly showing discontinuous variations when M reaches values which imply a change in i^*. In the great majority of cases, the extent of the manufacturing sector $\bar{Q}$, which is determined by the extent of demand of the richest group of entrepreneurs, is greater than Q^* and there are commodities produced with the TT.[21] Moreover, industrial employment is equal to

$$L_{IT}^* = \frac{R^*}{\bar{\omega}} - (M + Q^*) - L_{TT}^* \tag{17}$$

where L_{TT}^* is the equilibrium number of workers producing with TT. For any i^* and for the associated range of M, L_{TT}^* may increase in M but sooner or later it must decrease since the number of entrepreneurs demanding commodities produced with the TT strictly diminishes in M. So, taking into account the behaviour of Q^* we have that also L_{IT}^* can increase and/or decrease in M and possibly show discontinuities in coincidence with the reduction of the number of steps. Finally, aggregate income is given by

$$Y^* = R^* + \bar{\omega}N + \Pi^* - \bar{\omega}(M + Q^*) \tag{18}$$

where the expression for Π^* is provided in the Appendix. As for the case where $M < \mu$, Y^* may change in M in two ways. In particular, it can either decrease or first increase and then decrease. The main intuition for this is the same given for the previous case but here we have an additional reason for income to be decreasing in the number of landowners. Indeed, as long as there is industrialization and landowners are the richest group in society, i.e. $M < \mu$, no one demands commodities produced with TT and, except what is spent in subsistence, all profits are

produced with TT and the extent of the manufacturing sector $\bar{Q}$ will be equal to the extent of entrepreneurs demand. Besides, all entrepreneurs will earn the same profits.

[21] In particular, $\bar{Q}$ is determined by the extent of demand of the richest group of entrepreneurs which is composed by those receiving the demand of entrepreneurs in the last interval of industrialized markets. We have that $\bar{Q} = Q^*$ when the latter earn just $\bar{\omega}$ and do not demand manufactures. In such a case the group of entrepreneurs which demand at least until Q^* does not have any member which demands beyond it and therefore production with the TT does not take place. Notice that this only happens for single isolated values of M which mark a change in the number of steps.

transformed in extra demand for industrial goods. On the contrary, when some entrepreneurs are the richest in society, i.e. $M > \mu$, it will often happen that they demand commodities produced traditionally so partially foregoing the possibility to generate additional profits and consequently extra income.

3. Maxima: Aggregate Income, Industrial Extent and Employment

A natural question to ask is for which degree of land concentration the maximal levels of aggregate income, industrial extent and industrial employment are obtained. Interestingly, our analysis shows that in general these three possible policy targets are not achieved for the same distribution of land ownership. Putting it differently, this model suggests that the distribution of land property rights can affect the overall economic performance of a country in a way which produces a tradeoff between income and industrialization.

The maximum extent of industrialization $\widehat{Q}^*$ is obtained for $M = \rho$. In order to have an intuition of why it is so, consider the following remarks. For $M < \rho$ it is straightforward to see that no market industrializes. When $M = \rho$ all workers of the manufacturing sector work with the IT and their number is the minimum which allows to industrialize until $\widehat{Q}^*$. Since the maximum number of people employable as industrial workers is $(N - L_f^* - M - Q^*)$, for $M > \rho$ it is impossible to have $Q^* \geq \widehat{Q^*}$ because there are not enough employable workers. As one expects, higher start-up costs increase the maximizing M because they require landowners to be in greater number for their demand to make the IT profitable. For the same reason, a higher $(\alpha - \beta)$ has an opposite effect. In any case, the maximum extent of industrialization is always obtained for the distribution of land which produces a demand of manufactures just sufficient to industrialize markets in $[0, Q_R]$, making entrepreneurs earn as much as workers and landowners the richest in society.

On the contrary, the overall distributional structure associated to the M which gives the maximum aggregate income $\widehat{Y}^*$ depends on τ and F. It may happen, for instance, that Y^* is maximal when land is quite concentrated and landowners are the richest in society as well as when land is more equally distributed and the richest are some entrepreneurs. It may also obtain when landowners and entrepreneurs earn exactly the same. In any case, maximum income is achieved for a intermediate level of M which is always greater than that associated with the maximum extent of industrialization. The reason is that for $M = \rho$ increasing returns are not exploited at all – indeed, income is even lower than in the traditional economy case. A more equal distribution of land can enhance income because, by inducing a greater concentration of demand in basic manufactures, it allows a better exploitation of increasing returns. However, a too wide diffusion of land property rights can be detrimental to aggregate income because it concentrates most of the surplus into the hands of few entrepreneurs who spend a consistent part of their earnings in manufactures produced with TT. Whether optimal land concentration is greater, equal or lower than μ – that is, how surplus is optimally distributed among landowners and entrepreneurs – depends on agricultural and manufacturing technology. Intuitively, both higher start-up costs rents and higher rents increase the optimal M. A higher α reduces the optimal M because it increases the relative price of manufactures, having the same effect on landowners demand as a reduction of rents. A higher β may or may not have an effect – depending on whether entrepreneurs or landowners are the richest – but always increases μ because reduces the profit earned for each unit sold and hence increases the range of M for which landowners are the richest. The reason of such a twofold influence is that, as long as $M < \mu$, β only affects the way profits accruing from landowners demand are increased by the multiplicative process. So, β can affect the absolute value of $\widehat{Y}^*$ but not the optimal M. In the case that the optimal $M > \mu$ a higher β reduces it since the direct cost of industrial production also determines the demand received by markets beyond Q_R.

Finally, maximum industrial employment $\widehat{L}^*_{IT}$ is obtained for a distribution of landownership between ρ and μ. The exact value depends, again, on τ and F.

To see why maximum employment cannot be obtained for $M > \mu$ recall that L^*_{IT} always decreases in $(M + Q^*)$ and that for $M = \mu$ we have $L^*_{TT} = 0$. Hence, a necessary condition to have the maximum industrial employment when $M > \mu$ is $M + Q^*(M) \leq \mu + Q^*(\mu)$. However, this turns out to be impossible because $M + Q^*(M) \leq \mu + Q^*(\mu)$ would imply that i) the richest entrepreneurs earn as much or less than in $M = \mu$ and ii) there are less industrialized markets than in $M = \mu$. So, total demand faced by the industrial sector cannot be greater than for $M = \mu$ and employment in start-up tasks is certainly lower. More precisely, the M associated to $\widehat{L}^*_{IT}$ is included between that maximizing the extent of industrialization and the one maximizing aggregate income, possibly coinciding with either of them. When a greater number of landowners always induces a shrinking of the interval of industrialized markets which never frees enough labour force to compensate the increased M, then we obviously have no tradeoff between industrial extent and employment: $\widehat{L}^*_{IT}$ is obtained for $M = \rho$. If, on the contrary, the reduction of Q_R always compensates for the increased M in the interval $[\rho, \mu]$, then the maximum industrial employment is obtained for $M = \mu$ and may or may not coincide with the distribution of land maximizing aggregate income. In all other cases $(M + Q_R)$ has its minimum in the interior of $[\rho, \mu]$ and the distribution of landownership which maximizes industrial employment is strictly comprised between that maximizing industrial extent and the one maximizing income. Indeed, industrial employment is partly similar to industrial extent because it increases in the number of people working in start-up tasks and partly similar to aggregate income because it grows in the level of profits – which represents how intense is industrial production in every manufacturing sector. Since, in the general case, there is a tradeoff between the number of workers employed in start-up tasks and the level of profits, it is not surprising to have such a result.

In order to give the reader a flavour of these findings we depict an example in Figure 3. The case exemplifies the non-monotonic relation between land distribution

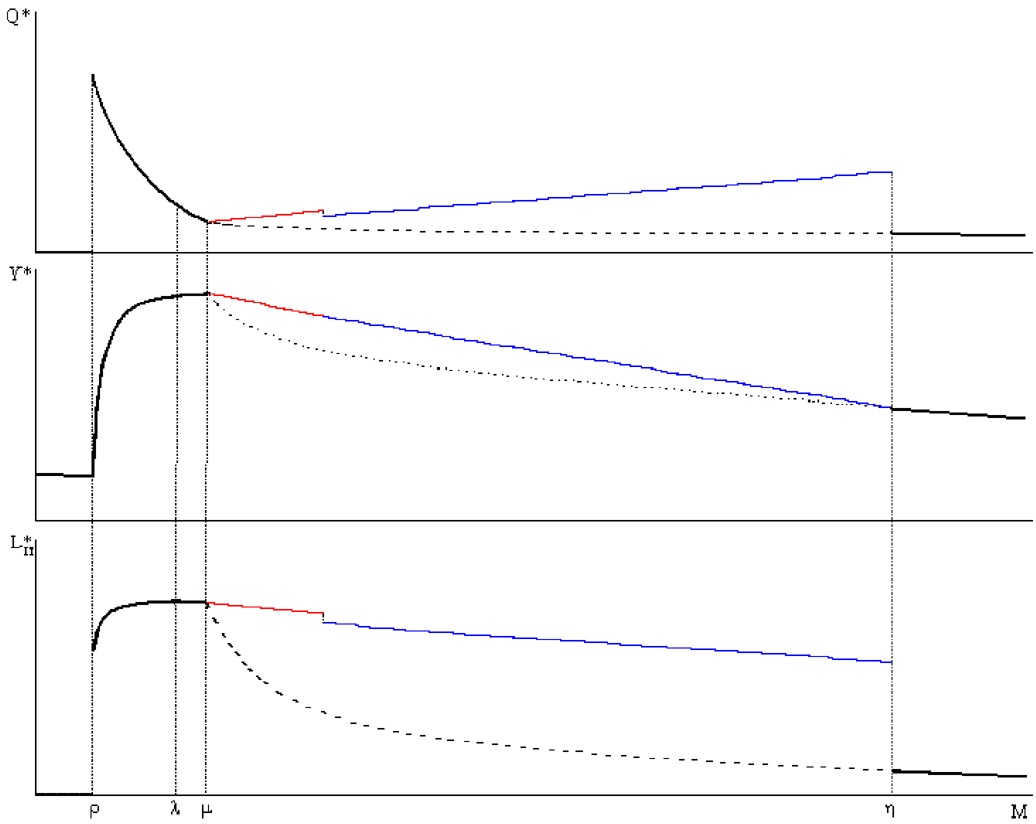

Figure 3. An example with $i^* = 2$.

and industrialization/income as well as the fact that maximal income, industrial extent and employment are not obtained, in general, for the same distribution of land property rights. As M increases in the range $[\rho, \mu]$ there is a substantial tradeoff between industrialization and income. More precisely, until λ the tradeoff is between industrial extent on one side and industrial employment and income on the other. In this range, a more equal distribution of land concentrates landowners demand in such a way that the new workers needed for direct production are more than those who were previously needed for the start-up tasks of markets that no

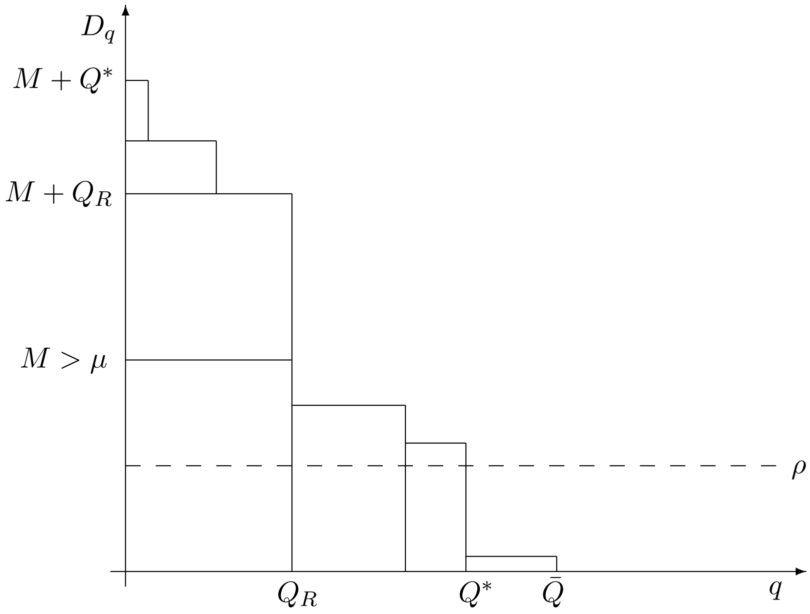

Figure 4. Two more intervals of markets industrialize.

longer industrialize. So, income and industrial employment go the same way. On the contrary, beyond λ a tradeoff exists between income and both industrial extent and employment. In this range, income increases despite the decrease in industrial employment because the total number of workers employed in direct production is still rising and industrial surplus grows. Indeed, industrial employment decreases just because the reduction of workers hired for start-up tasks is greater than the number of new hirings for direct production. So, a better exploitation of increasing returns does not coincide anymore with a greater number of industrial workers.

When land is distributed so widely that some entrepreneurs are richer than landowners, i.e. M in $[\mu, \eta]$, the tradeoff – apart from discontinuity points – occurs again between industrial extent on one side and industrial employment and income on the other but with the opposite sign. The multiplicative mechanism of profits induces two new intervals of markets to industrialize creating five different earning groups of entrepreneurs (as depicted in Figure 4). In particular, we have two intervals until the first discontinuity and only one afterwards.

Finally, for M greater than η land ownership is so dispersed – and consequently landowners demand so concentrated – that there are only few and very rich entrepreneurs. Their number is so small that their demand is divided in many manufacturing sectors but no new market receives enough demand to industrialize. In this range there is no longer tradeoff among income, industrial employment and industrial extent as they all decrease in M.

V. Extensions

In this section we explore some possible extensions of the model providing an intuitive sketch of the results. Their full development is left for further research.

1. *Agricultural Productivity and Wages*

The analysis confirms the common wisdom that technical improvements in the agricultural sector can lead to industrialization. A slightly modified version of the model shows how greater agricultural productivity can push the economy to a new equilibrium with more extensive industrialization and higher income level. Suppose $F = F(L_f, \gamma)$ where γ is a productivity parameter. Assume $\mathrm{d}L_f^*(\gamma)/\mathrm{d}\gamma < 0$ meaning that the equilibrium employment in agriculture decreases as a consequence of higher agricultural productivity. This also implies wages increase with productivity, that is $\mathrm{d}w(\gamma)/\mathrm{d}\gamma > 0$. The increase of agricultural productivity has two effects. The first one constitutes no novelty being the well known and exhaustively analyzed process of freed workers from agriculture increasing the labour supply of the industrial sector. Indeed, the reduction of L_f^* allows both a greater number of entrepreneurs Q^*

and a greater industrial employment L_{IT}^*. The second, on the contrary, is less recognized and to some extent surprising. A higher agricultural productivity traduces in higher workers wages implying higher production costs and commodities prices. So, a higher γ can damage both traditional and industrial markets because, although it may increase profits of some entrepreneurs who benefit from higher prices, it reduces the extent of consumers demand. However, a higher w may greatly benefit the manufacturing sector thanks to extra workers demand: richer workers demand more manufactures as $(w - \bar{\omega})/\alpha w$ increases in w. Instead, the impact of a higher γ on landowners demand is ambiguous as R may be affected in either ways. Hence, assuming workers outnumber landowners, it can easily happen that several markets face higher demand and, due to the multiplicative process, both industrial extent and employment will be greater.

Interestingly, this brief digression highlights the relevance of *how* the benefits accruing from a high agricultural productivity are shared between workers and landowners. Suppose agricultural productivity is very high and only few workers are employed in the agricultural sector. In this case there would be potential for a quite large industrial sector. However, if land is concentrated in the hands of few landowners and w is close to the subsistence level $\bar{\omega}$ for some technical, cultural, political or institutional reasons, then in equilibrium no substantial industrialization takes place. The reason is that few landowners are taking for themselves most of the benefits of the increased agricultural productivity. In this case, the manufacturing sector would be significantly large but only very few markets, if any, would industrialize.

2. Exports

The model we have described so far provides some insights about whether or not export booms foster industrialization. Indeed, there are cases where domestic demand is not the unique source of potential purchases, even in traditional economies. Positive shocks on either international price or demand of tradables may induce export booms at the country level and help the industrialization process. Such positive effects, however, are not guaranteed. The case of Colombia reported by Harbison [18] is illuminating. During the years between 1850 and 1870 Colombia experienced a strong increase in revenues accruing from tobacco exports. Unfortunately, this did not result in any significant increase of domestic demand of manufactures and the small industrial sector of the country did not benefit from it. A second export boom took place in Colombia between 1880 and 1915 but this time it was coffee-driven. Interestingly, it was beneficial not only to the coffee-related businesses but to the colombian industry as a whole. Harbison's explanation of the different impact of the two booms points to the fact that tobacco was produced in huge land estates while coffee was mainly cultivated in small or medium fields. Since the first boom increased the income of few landlords, it had no substantial effect on the domestic demand of basic manufactures, mostly resulting in demand for luxuries and imports. This did not happen in the second boom because it rewarded a larger and poorer fraction of the population, increasing the aggregate demand of basic manufactures.

We shall distinguish between two types of export booms. The first one affects the manufacturing sector directly and takes place when there is an increase of international demand of those manufactures which are produced with the TT at the country level. In this case, the distribution of land property rights affects the equilibrium outcome by determining the extra demand needed to make profitable mass production. Consider a traditional economy and assume that technology τ is competitive in the sense that it allows producers to export with standard profits.[22] The volume of exports needed to industrialize any markets of this country is $(\rho - M)$. So, a greater M makes smaller shocks capable of inducing industrialization in those markets which already produce with the TT.[23] However, the extent of the manu-

[22]In this brief discussion it is assumed that all necessary conditions for producing tradables are met and that imports play no significant role. Moreover, we abstract from the extra labour force which may be needed to meet demand.

[23]For simplicity, we leave aside markets with no initial demand.

facturing sector often decreases in M, reducing the number of markets which can benefit from the export boom. Which effect is more important may be not simple to establish analytically as it requires some kind of measure of expected industrialization benefits.[24]

The second type of export boom affects manufacturing markets indirectly and takes places when there is an increase of the revenues accruing from agricultural products sold abroad. Consider an economy exporting a certain amount of food denoted by I. Assume food is the only tradable good of the economy and local prices are unaffected by international prices. The demand of food is then $(I + \bar{\omega}N)$ and the equilibrium aggregate rents are $R^* = Ip_f + \bar{\omega}N - L_f^*\bar{\omega}$, where p_f represents the international price of food. For the sake of exposition, we shall focus on two extreme cases: the boom driven only by an increase in prices and the one driven only by an increase of quantity demanded.

If p_f increases with no substantial change in the volume of production then R^* increases leaving wage and agricultural employment unchanged. Such an increase expands the extent of landowners demand accordingly. If land is not too concentrated – i.e. $M \geq \rho$ – then the increase in revenues from exports induces a sensible growth of the industrial sector. On the contrary, if property is quite concentrated – i.e. $M < \rho$ – nothing happens but an expansion of traditional production. These two stylized cases well represent Harbisons's basic argument for the two opposite outcomes of the colombian export booms.

If the amount of food exported I increases with no substantial effects on p_f, then several things can happen. If wages are both at the subsistence level and equal to marginal productivity, production cannot increase and the boom fails to take place. This is due to the fact that to produce more food more workers are needed but a greater L_f^* would imply $w < \bar{\omega}$. If agricultural employment can

[24] For instance, applying a very simple measure as the area between the line identified by ρ and the segment representing landowner demand (see Figure 1) would not work because it would not take into account the effects of the new demand generated by the profits of the industrialized markets.

increase to some extent without lowering wages, say leaving them constant, then R increases as for the case of an increase in p_f. Finally, if $w > \bar{\omega}$ we have that the export boom surely increases both R^* and L_f^*. Again, if w is unaffected only R increases. On the contrary, if w decreases it may well happen that the export boom is detrimental to industrialization. The intuition is the following. Since $w > \bar{\omega}$, it must be that workers are demanding manufactures. With their wages reduced the extent of their demand shrinks accordingly even if manufactures prices decrease. If workers demand of manufactures is driven to zero and landowners do not provide a sufficient demand – i.e. ($M < \rho$) – the industrial sector disappears while the manufacturing sector as a whole expands dramatically. If w is not reduced to the subsistence level but landowners demand alone is not sufficient to sustain mass production, then the industrial sector shrinks to the markets facing workers demand while the manufacturing sector as a whole expands. Finally, if landowners demand alone can sustain industrialization then the industrial sector may or may not expand depending on technology and actual distribution of profits and the same is true for the manufacturing sector as a whole.

VI. Discussion

In this paper we have analyzed how the distribution of land ownership affects income and industrialization through the demand side. In order to do this we have applied a modified version of the model of Murphy *et al.* [24] where the main novelty is that we assume a functional distribution of income. The motivation for this choice is two-fold: on one side, we find that it is a better representation of an early industrializing country and, on the other, it allows us to investigate in greater detail the impact of land property rights distribution on income and industrialization. Consistently with the general results about income distribution found in Murphy *et al.* [24], we have shown that the degree of land ownership concentration is in a non-monotonic relation with both income and industrialization. We have also proved that, under quite general conditions, there may be a tradeoff between aggregate income and early industrialization. Indeed, their maximal values occur at different degrees of land concentration and, in particular, we found that maximal income is associated with a more diffuse distribution of land ownership than maximal industrialization.

More important, we have shown that a high concentration of land ownership – a typical situation in many countries on the door of industrialization – can prevent the industrial takeoff. The reason is that it induces a very unequal distribution of income with the result that only few commodities of each kind are demanded and mass production is unprofitable. Moreover, a very diffuse distribution of land may be detrimental to income and industrialization. This result derives from our assumption of functional distribution of income. Indeed, a widespread ownership of land allows the exploitation of scale economies in some markets of basic manufactures but their number is likely to be quite small due to the low income of landowners. As a consequence, since profits are not shared but each entrepreneur takes all earnings of the firm she manages, a very diffuse distribution of land would concentrate profits into the hands of very few capitalists. So, very diffused distribution of land property rights induces a very unequal distribution of income between capitalist and everyone else with the result that the demand of manufactures produced with the industrial technology is low and mass production is not exploited properly. Besides, the analysis shows that the degree of land concentration determines the distribution of profits because it determines the earnings of each entrepreneur in the first place, that is before the multiplicative process takes place. In our opinion these findings underline the relevance of *how* surplus is shared among the different social groups.

Few remarks about the nature of our results are worth doing. In our analysis there is no dynamics and all results come from a comparative statics exercise. Therefore, this study does not offer any reliable prediction about the impact of *changes* in land ownership distribution. For this reason, although we recognize that land redistribution is a major source of the distributional conditions we are analyzing, it has not been an explicit issue here. Indeed, a policy of land redistribution would trigger a number of economic and social mechanisms which are not captured by the model and clearly require a dynamical analysis. In this sense, the present study can provide only weak policy suggestions. Nevertheless, the comparative statics we have carried out tells us something important. If a country is about the industrial takeoff we expect that, *ceteris paribus*, countries with a very concentrated land ownership perform worse than countries with a mild concentration. Going back to the example about South Korea and Philippines mentioned in the introduction, we understand that South Korea's more equal distribution of land has helped its industrial takeoff by providing a domestic demand of basic manufactures since the very beginning of its development. In other words, we expect those countries that have successfully carried out some kind of land reform to be in a better position for staring their industrialization process. Finally, since the analysis abstracts from the effects of industrialization in the long run our findings must be intended as restricted only to countries in their early phase of industrialization.

Further research should provide a detailed analysis of the role of agricultural productivity and non-subsistence wages, taking into account the issue of unemployment. Lastly, this framework may well fit the analysis of the impact of distribution of property rights over natural resources, both exhaustible and renewable.

A. Appendix

1. *Derivation of μ*

In order to obtain the expression for μ provided in footnote 19 we must impose the condition that entrepreneurs and landowners in equilibrium have the same income. For any $M > \rho$, the Q_R entrepreneurs who receive the demand of landowners will demand manufactures in the interval $[0, Q_1]$ where $Q_1 = (M - \rho)(\alpha - \beta)/\alpha$. Assuming that $Q_1 < Q_R$, entrepreneurs in $[0, Q_1]$ face additional demand and their profits will be equal to $[(M + Q_R)(\alpha - \beta) - k]\bar{\omega}$. Equalizing the latter expression to the income of each landowner R/M we obtain

$$
\begin{aligned}
&[(M+Q_R)(\alpha-\beta)-k]\bar{\omega}=\frac{R}{M}\\
&\alpha(\alpha-\beta)M^2-[\alpha(k+1)-\beta]M-\beta\frac{R}{\bar{\omega}}=0
\end{aligned} \tag{19}
$$

where the solutions to equation (19) are

$$
\frac{\alpha(k+1)-\beta \pm \sqrt{(\alpha(k+1)-\beta)^2+4\ \alpha\beta(\alpha-\beta)\frac{R}{\bar{\omega}}}}{2(\alpha-\beta)\alpha} \tag{20}
$$

Notice that $(\alpha(k+1)-\beta)$ is positive and greater than one by assumptions about technology, so we have one strictly positive and one strictly negative solution. We name μ the positive one.

2. Equilibria: $M \leq \mu$

Define Q_2 the extent of demand of the group of entrepreneurs in $[0, Q_1]$. Then, $M \leq \mu$ implies $Q_2 \leq Q_R$. Since entrepreneurs in $[0, Q_1]$ face the highest demand, and hence earn the highest profits, no entrepreneur demands manufactures beyond Q_R. Moreover, in equilibrium entrepreneurs in $[0, Q_1]$ receive the demand of every entrepreneur, including themselves, so their total demand is $(Q_R + M)$. Hence, entrepreneurs in $(Q_1, Q_2]$ earn additional profits and demand manufactures until $Q_3 = (M + Q_2)(\alpha - \beta)/\alpha$. By iterating this mechanism, we can calculate the equilibrium demand and profits of each market.

Points Q_1,Q_3,Q_5,... and Q_2,Q_4,Q_6,... can be written as follows

$$
\begin{aligned}
Q_1 &= (M-\rho)\left(\frac{\alpha-\beta}{\alpha}\right)\\
Q_2 &= (M-\rho)\left(\frac{\alpha-\beta}{\alpha}\right)+Q_R\left(\frac{\alpha-\beta}{\alpha}\right)\\
Q_3 &= (M-\rho)\left[\frac{\alpha-\beta}{\alpha}+\left(\frac{\alpha-\beta}{\alpha}\right)^2\right]\\
Q_4 &= (M-\rho)\left[\frac{\alpha-\beta}{\alpha}+\left(\frac{\alpha-\beta}{\alpha}\right)^2\right]+Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^2\\
Q_5 &= (M-\rho)\left[\frac{\alpha-\beta}{\alpha}+\left(\frac{\alpha-\beta}{\alpha}\right)^2+\left(\frac{\alpha-\beta}{\alpha}\right)^3\right]\\
Q_6 &= (M-\rho)\left[\frac{\alpha-\beta}{\alpha}+\left(\frac{\alpha-\beta}{\alpha}\right)^2+\left(\frac{\alpha-\beta}{\alpha}\right)^3\right]+Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^3\\
\ldots &= \ldots
\end{aligned}
$$

Hence, the expressions for a generic Q_{2i} (even index) and Q_{2i+1} (odd index) are

$$
\begin{aligned}
Q_{2i} &= (M-\rho)\sum_{j=1}^{i}\left(\frac{\alpha-\beta}{\alpha}\right)^{j} + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^{i} \\
&= (M-\rho)\sum_{j=0}^{i}\left(\frac{\alpha-\beta}{\alpha}\right)^{j} + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^{i} - M^{k} \qquad (21) \\
Q_{2i+1} &= (M-\rho)\sum_{j=1}^{i+1}\left(\frac{\alpha-\beta}{\alpha}\right)^{j} = (M-\rho)\sum_{j=0}^{i+1}\left(\frac{\alpha-\beta}{\alpha}\right)^{j} - (M-\rho) \qquad (22)
\end{aligned}
$$

where $Q_0 \equiv Q_R$. As i goes to ∞ expressions (21) and (22) converge to the same value from above and below, respectively

$$
\begin{aligned}
\lim_{i\to\infty} Q_{2i} &= \lim_{i\to\infty}(M-\rho)\sum_{j=0}^{i}\left(\frac{\alpha-\beta}{\alpha}\right)^{j} + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^{i} - (M-\rho) = (M-\rho)\left(\frac{\alpha-\beta}{\beta}\right) \\
\lim_{i\to\infty} Q_{2i+1} &= \lim_{i\to\infty}(M-\rho)\sum_{j=0}^{i+1}\left(\frac{\alpha-\beta}{\alpha}\right)^{j} - (M-\rho) = (M-\rho)\left(\frac{\alpha-\beta}{\beta}\right)
\end{aligned}
$$

Therefore, for any value of $M \leq \mu$ the equilibrium demand of each market is uniquely determined and the calculation of the equilibrium profits of each entrepreneur is straightforward. In the case $M = \mu$ we get $Q_R = Q_2 i$ for every $i \geq 1$.

Figure 5 and Figure 6 give a graphical representation of industrialization for $M < \mu$ and for $M = \mu$ respectively.

3. $M \leq \mu$: Industrial Extent, Industrial Employment and Aggregate Income

Since no entrepreneur demands beyond market Q_R the extent of industrialization either zero, if $M < \rho$, or $Q^* = Q_R$, if otherwise.

Industrial employment is given by

$$L_{IT} = N - L_f - L_{TT} - E - M$$

In an equilibrium with positive industrialization, since i) $L^*_{TT} = 0$ and ii) $E = Q^* = Q_R$, we have

$$L^*_{IT} = N - L^*_f - Q_R - M \qquad (23)$$

Taking into account equation (1) and the fact that $F(L^*_f) = \bar{\omega}N$ we obtain

$$N - L^*_f = \frac{R}{\bar{\omega}} \qquad (24)$$

From equations (23) and (24) we get equation (14).

Aggregate income is given by the sum of of rents, profits and wages

$$Y = R + \Pi + w(L_f + L_m)$$

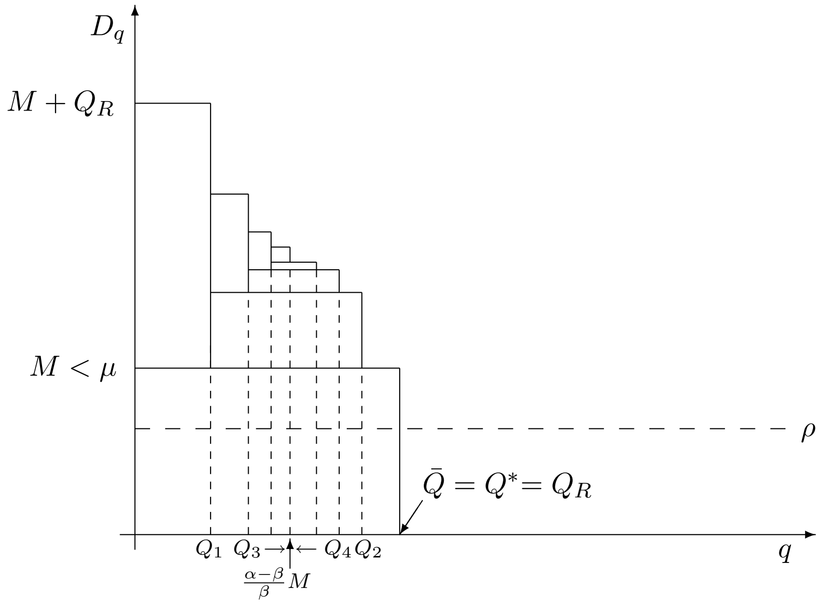

Figure 5. $M<\mu$

Since $(L_f + L_m) = N - E - M$, in equilibrium we obtain equation (15). The expression for Π^* is derived by adding the profits of each entrepreneur, calculated on the basis of the demand she faces in equilibrium. In order to calculate aggregate demand, we first derive the length of the generic intervals

$$Q_{2i} - Q_{2i+2} = (M-\rho)\left(\frac{\alpha-\beta}{\alpha}\right)^i + Q_R\frac{\beta}{\alpha}\left(\frac{\alpha-\beta}{\alpha}\right)^i \tag{25}$$

$$Q_{2i+1} - Q_{2i-1} = (M-\rho)\left(\frac{\alpha-\beta}{\alpha}\right)^{i+1} \tag{26}$$

where $Q_{-1} \equiv 0$. Multiplying the length of each interval of markets by the demand exceeding ρ that they face, we get the aggregate demand which generates profits exceeding subsistence. The demand faced by each interval of markets is

$$\begin{aligned} D_{q\in(Q_{2i-1},Q_{2i+1}]} &= M + Q_{2i} \\ D_{q\in(Q_{2i+2},Q_{2i}]} &= M + Q_{2i-1} \end{aligned}$$

So aggregate demand is

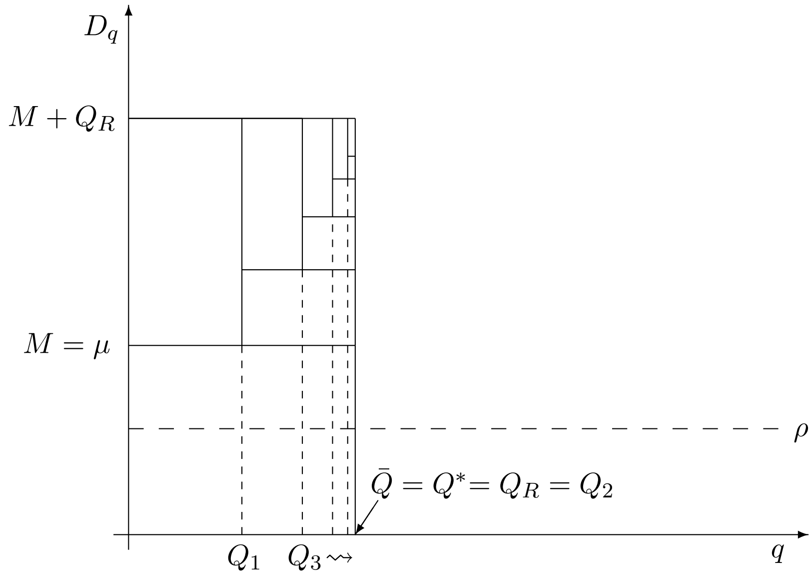

Figure 6. $M=\mu$

$$D^{\pi}(M\leq\mu)=\sum_{i=0}^{\infty}\left[(Q_{2i+1}-Q_{2i-1})((M-\rho)+Q_{2i})+(Q_{2i}-Q_{2i+2})((M-\rho)+Q_{2i-1})\right] \quad (27)$$

Defining $x\equiv(\alpha-\beta)/(\alpha)$ and plugging (21), (22), (25) and (26) into expression (27), we can rewrite the latter as

$$\begin{aligned}
&\sum_{i=0}^{\infty}\left[(M-\rho)x^{i+1}\left((M-\rho)\sum_{j=0}^{i}x^{j}+Q_Rx^{i}\right)+(M-\rho)\sum_{j=0}^{i}x^{j}\left(Q_R\frac{\beta}{\alpha}x^{i}-(M-\rho)x^{i+1}\right)\right]=\\
&=\ (M^{k})^{2}\sum_{i=0}^{\infty}\left(x^{i+1}\sum_{j=0}^{i}x^{j}-x^{i+1}\sum_{j=0}^{i}x^{j}\right)+(M-\rho)Q_R\sum_{i=0}^{\infty}\left[x^{2i+1}+\frac{\beta}{\alpha}x^{i}\sum_{j=0}^{i}x^{j}\right]=\\
&=\ (M-\rho)Q_Rx\left[\frac{1}{1-x^{2}}+\frac{\beta}{\alpha}\sum_{i=0}^{\infty}\left(x^{i}\sum_{j=0}^{i}x^{j}\right)\right] \qquad (28)
\end{aligned}$$

In order to solve the remaining series in (28) notice that

$$
\begin{aligned}
\sum_{i=0}^{\infty}\left(x^i\sum_{j=0}^{i}x^j\right) &= 1+(x+x^2)+(x^2+x^3+x^4)+\ldots = \\
&= 1+x+2x^2+2x^3+3x^4+3x^5+4x^6+4x^7+\ldots = \\
&= (1+x)(1+2x^2+3x^4+4x^6+5x^8+\ldots) = \\
&= (1+x)\sum_{i=0}^{\infty}(i+1)x^{2i} = (1+x)\left(\frac{1}{1-x^2}+\sum_{i=0}^{\infty}ix^{2i}\right)
\end{aligned}
$$

where

$$
\begin{aligned}
\sum_{i=0}^{\infty}ix^{2i} &= 0+x^2+2x^4+3x^6+4x^8+\ldots = \\
&= (0+x^4+2x^6+3x^8+\ldots)+(x^2+x^4+x^6+x^8+\ldots) = \\
&= x^2\sum_{i=0}^{\infty}ix^{2i}+\left(\sum_{i=0}^{\infty}x^{2i}-1\right)
\end{aligned}
$$

Hence, we have

$$
\sum_{i=0}^{\infty}ix^{2i} = \frac{\sum_{i=0}^{\infty}x^{2i}-1}{1-x^2} = \left(\frac{x}{1-x^2}\right)^2
$$

that in turn gives

$$
\sum_{i=0}^{\infty}\left(x^i\sum_{j=0}^{i}x^j\right) = (1+x)\left[\frac{1}{1-x^2}+\left(\frac{x}{1-x^2}\right)^2\right] = \frac{1+x}{(1-x^2)^2} \tag{29}
$$

From (29) and (28), making some rearrangements, we get

$$
D^{\pi}(M\leq\mu) = (M-\rho)Q_R\left(\frac{\alpha(\alpha-\beta)}{\beta(2\alpha-\beta)}+\frac{\alpha^2}{\beta(2\alpha-\beta)}\right) = (M-\rho)Q_R\frac{\alpha}{\beta}
$$

Finally, taking into account entrepreneurs expenditure in food, we obtain the aggregate profits Π^* of equation (15), that is

$$
\Pi^* = (\alpha-\beta)\frac{\alpha}{\beta}\,(M-\rho)\,\bar{w}Q_R+\bar{w}Q_R
$$

Notice that profits are equal to the units of manufactures demanded beyond those needed to introduce IT, i.e. $(M-\rho)Q_R$, times the profit earned for each unit sold, i.e. $(\alpha-\beta)\bar{\omega}$, times α/β which accounts for the multiplicative process we have described.

4. Equilibria: $M > \mu$

For $M > \mu$ we have $Q_2 > Q_R$. As before, markets in $[0, Q_R]$ industrialize. In order to determine whether or not other markets introduce the IT, we must compare the demand they face with the threshold value ρ.

The sequence of Q_{2i+1} is formally as in 22 but stops beyond Q_R. The sequence of Q_{2i} is constant and equal to

$$Q_{2i} = Q_2 = (M-\rho)\left(\frac{\alpha-\beta}{\alpha}\right) + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)$$

and it stops as soon as Q_{2i+1} stops. So far, each market in $[0, Q_R]$ faces the same demand (Q_R+M) and each entrepreneur in $[0, Q_R]$ earns the same profits. In order to take into account the multiplicative process triggered by industrialization beyond Q_R, let us simplify notation and preserve the intuition about the sequence of Qs. Both Q_1 and Q_0 are set equal to Q_R, and Q_2 denotes the extent of demand of the richest entrepreneurs, no matter where the "Q_1" defined for the previous case falls. So, $(Q_R, Q_2]$ is the first interval to receive only entrepreneurs demand, which industrializes if and only if $Q_R > \rho$. If this happens, we call Q_3 the extent of demand of entrepreneurs in $(Q_R, Q_2]$. Similarly, Q_4 indicate the new extent of demand of entrepreneurs in $[0, Q_3]$, and so on. Therefore, points Q_1,Q_3,Q_5,... and Q_2,Q_4,Q_6,... are given by

$$\begin{aligned}
Q_1 &= Q_R \\
Q_2 &= (M-\rho)\left(\frac{\alpha-\beta}{\alpha}\right) + Q_R\left(\frac{\alpha-\beta}{\alpha}\right) \\
Q_3 &= Q_R\left(\frac{\alpha-\beta}{\alpha}\right) - \rho\left(\frac{\alpha-\beta}{\alpha}\right) \\
Q_4 &= (M-\rho)\left[\frac{\alpha-\beta}{\alpha} + \left(\frac{\alpha-\beta}{\alpha}\right)^2\right] + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^2 \\
Q_5 &= Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^2 - \rho\left[\frac{\alpha-\beta}{\alpha} + \left(\frac{\alpha-\beta}{\alpha}\right)^2\right] \\
\ldots &= \ldots
\end{aligned}$$

from which we get the expressions for the generic Q_{2i} and Q_{2i+1}

$$Q_{2i} = (M-\rho)\sum_{j=1}^{i}\left(\frac{\alpha-\beta}{\alpha}\right)^j + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^i \tag{30}$$

$$Q_{2i+1} = Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^i - \rho\sum_{j=1}^{i}\left(\frac{\alpha-\beta}{\alpha}\right)^j \tag{31}$$

As previously mentioned, markets in $(Q_R, Q_2]$ industrialize if and only if

$$Q_R \geq \rho\left(1 + \frac{\alpha}{\alpha-\beta}\right) \tag{32}$$

If (32) holds with strict inequality, new demand is generated and entrepreneurs in $[0, Q_3]$ earn new profits and extend their demand of manufactures beyond Q_2 until Q_4. Then, markets in $(Q_2, Q_4]$ industrialize if and only if

$$\begin{aligned} Q_3 &\geq \rho\left(1+\frac{\alpha}{\alpha-\beta}\right) \Leftrightarrow \\ \Leftrightarrow \left(\frac{\alpha-\beta}{\alpha}\right)(Q_R-\rho) &\geq \rho\left(1+\frac{\alpha}{\alpha-\beta}\right) \Leftrightarrow \\ \Leftrightarrow Q_R &\geq \rho\left[1+\frac{\alpha}{\alpha-\beta}+\left(\frac{\alpha-\beta}{\alpha}\right)^2\right] \end{aligned}$$

By iteration, we get that the number of steps – that is the number of new industrialized intervals of markets – is given by the minimum value of i, denoted by i^*, such that

$$Q_R < \rho \sum_{j=0}^{i}\left(\frac{\alpha}{\alpha-\beta}\right)^j \tag{33}$$

Since $\alpha/(\alpha-\beta)$ is greater than 1 there always exists a finite value of i such that inequality (33) is satisfied. Figure 7 shows the case of $i^* = 1$ while Figure 4 in the main body refers to the case of two steps. Moreover, since Q_R is a decreasing function of M, i^* takes its maximum value for M infinitesimally greater than μ and is non-increasing step function afterwards.

5. $M > \mu$: Industrial Extent, Industrial Employment and Aggregate Income

Given i^* the extent of industrialization is

$$Q^* = Q_{2i^*} = (M-\rho)\sum_{j=1}^{i^*}\left(\frac{\alpha-\beta}{\alpha}\right)^j + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^{i^*} \tag{34}$$

Similarly the extent of the manufacturing sector is

$$\bar{Q} = Q_{2(i^*+1)} = (M-\rho)\sum_{j=1}^{i^*+1}\left(\frac{\alpha-\beta}{\alpha}\right)^j + Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^{i^*+1} \tag{35}$$

and the last group of markets which receive only the demand of the richest entrepreneurs employs the TT. However, if the last group of entrepreneurs who industrialize faces a demand equal to ρ, then the extent of the manufacturing sector coincides with the extent of industrialization and traditional production disappears.

The equilibrium level of L^*_{TT} is equal to the number of units produced with TT multiplied by the labour coefficient α, that is

$$\begin{aligned} L^*_{TT} &= \alpha(\bar{Q}-Q^*)Q_{2i^*+1} \\ &= \left(\frac{\alpha-\beta}{\alpha}\right)^{i^*}[(M-\rho)(\alpha-\beta)-\beta Q_R]\left[Q_R\left(\frac{\alpha-\beta}{\alpha}\right)^{i^*} - \rho\sum_{j=1}^{i^*}\left(\frac{\alpha-\beta}{\alpha}\right)^j\right] \end{aligned} \tag{36}$$

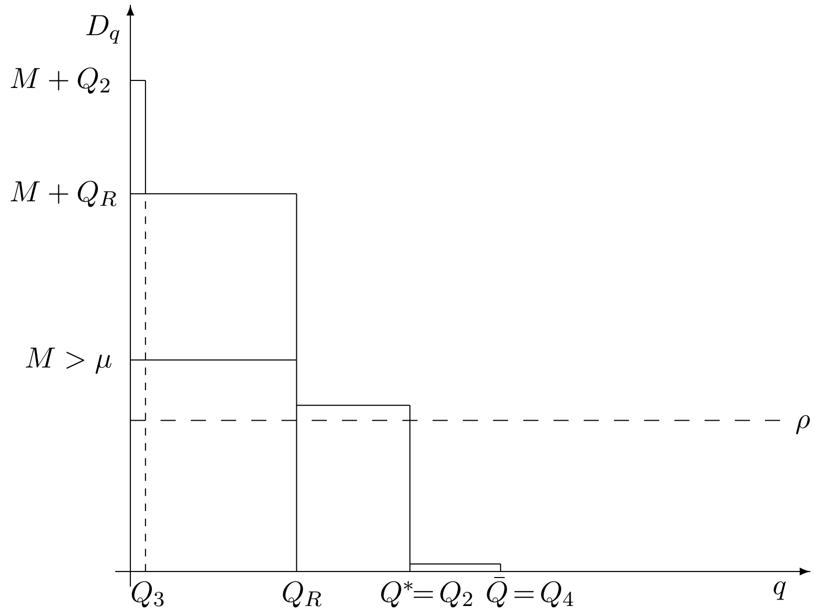

Figure 7. Scenario 2, Sub-case II: $Q^{*} = Q_2$, $\bar{Q} = Q_4$, $i^{*} = 1$

where $(\bar{Q} - Q^{*})Q_{2i^{*}+1}$ is the number of traditional manufactures demanded. By plugging equation (36) into (17) we get L^{*}_{IT}.

For any i^{*}, aggregate profits are obtained by summing the profits earned by each entrepreneur. If there is no step the net total demand is

$$D_0^{\pi} = Q_R(M + Q_R - \rho) \tag{37}$$

where π is used to denote the fact that we are referring only to demand generating new profits – labelled net demand, hereafter. When there is one step net demand is

$$\begin{aligned} D_1^{\pi} &= D_0^{\pi} + (Q_2 - Q_R)(Q_R - \rho) + (Q_R - \rho)(Q_2 - Q_R)x \\ &= D_0^{\pi} + (Q_2 - Q_R)\left[Q_R(1 + x) - \rho(1 + x)\right] \end{aligned} \tag{38}$$

where, as before $x = (\alpha - \beta)/\alpha$. Looking at the first line, the second term accounts for net demand of new entrepreneurs beyond Q_R: $(Q_2 - Q_R)$ is the number of markets while $(Q_R - \rho)$ is the net demand for each of them. The third term accounts for the additional demand received by the first group of entrepreneurs: $(Q_R - \rho)x = Q_3$ is the number of markets and $(Q_2 - Q_R)$ is their additional demand. With two steps, the new markets receiving the demand of the richest entrepreneurs introduce the IT. Their net demand grants entrepreneurs in $[0, Q_5]$ additional profits, where $Q_5 < Q_3$. The aggregate net demand generated with two steps is

$$\begin{aligned}
D_2^\pi &= D_1^\pi + (Q_2 - Q_R)x\left[(Q_R - \rho)x - \rho\right] + (Q_2 - Q_R)x^2\left[(Q_R - \rho)x - \rho\right] \\
&= D_0^\pi + (Q_2 - Q_R)\left[Q_R\left(1 + x + x^2 + x^3\right) - \rho(1 + 2x + 2x^2 + x^3)\right] \\
&= D_0^\pi + (Q_2 - Q_R)\left[Q_R\left(1 + x + x^2 + x^3\right) - \rho(1 + x)(1 + x + x^2)\right]
\end{aligned}$$

In the case of three steps we have

$$\begin{aligned}
D_3^\pi &= D_2^\pi + (Q_2 - Q_R)x^2\{[(Q_R - \rho)x - \rho]x - \rho\} + (Q_2 - Q_R)x^3\{[(Q_R - \rho)x - \rho]x - \rho\} \\
&= D_0^\pi + (Q_2 - Q_R)\left[Q_R\left(1 + x + x^2 + x^3 + x^4 + x^5\right) - \rho(1 + 2x + 3x^2 + 3x^3 + 2x^4 + x^5)\right] \\
&= D_0^\pi + (Q_2 - Q_R)\left[Q_R\left(\sum_{j=0}^{5} x^j\right) - \rho(1 + x + x^2)(1 + x + x^2 + x^3)\right]
\end{aligned}$$

Hence, for a generic i^* we get the following expression

$$D_{i^*}^\pi = Q_R(M + Q_R - \rho) + (Q_2 - Q_R)\left(Q_R\sum_{j=0}^{2i^*-1} x^j - \rho\sum_{j=0}^{i^*-1} x^j \sum_{j=0}^{i^*} x^j\right) \tag{39}$$

Therefore, Π^* of equation (18) is

$$\Pi^* = (\alpha - \beta)\left[Q_R(M + Q_R - \rho) + (Q_2 - Q_R)\left(Q_R\sum_{j=0}^{2i^*-1} x^j - \rho\sum_{j=0}^{i^*-1} x^j \sum_{j=0}^{i^*} x^j\right)\right]\bar{\omega} + \bar{\omega}Q^* \tag{40}$$

6. Maxima

As we proved in the main body of the article, the maximum extent of industrialization obtained for $M = \rho$ is

$$\widehat{Q}^* = \frac{R - \bar{\omega}\rho}{\alpha\bar{\omega}\rho} = \frac{1}{\alpha}\left(\frac{R}{\bar{\omega}}\frac{\alpha - \beta}{k + 1} - 1\right) \tag{41}$$

Since we have two different functions for aggregate income depending on the relation between M and μ, we must calculate maximum income in both cases. Taking into account equations (15) and (30) for $M < \mu$ we have

$$\begin{aligned}
Y^* &= R + \bar{\omega}N + (\alpha - \beta)(M - \rho)\frac{R - \bar{\omega}M}{\beta M} - \bar{\omega}M \\
&= \frac{\alpha}{\beta}R + \bar{\omega}N - \frac{\alpha}{\beta}\bar{\omega}M - \frac{k + 1}{\beta}\frac{R}{M} + \frac{k + 1}{\beta}\bar{\omega}
\end{aligned} \tag{42}$$

In order to maximize (42) with respect to M we calculate the first order condition.

$$\begin{aligned}\frac{\partial Y^*}{\partial M} &= \frac{k+1}{\beta}\frac{R}{M^2} - \frac{\alpha}{\beta}\bar{\omega} = 0 \\ &\iff M^2 = \frac{k+1}{\alpha}\frac{R}{\bar{\omega}} \end{aligned} \tag{43}$$

The only positive solution is

$$M = \sqrt{\frac{k+1}{\alpha}\frac{R}{\bar{\omega}}} \tag{44}$$

If $\mu > \sqrt{(k+1)R/\alpha\bar{\omega}}$ the maximum income is obtained for a concentration of land property rights such that landowners are richer than entrepreneurs. In this case from equations (42) and (44) we get the expression $\widehat{Y}^*$

$$\begin{aligned}\widehat{Y}^* &= \frac{\alpha}{\beta}R + \bar{\omega}N + \frac{k+1}{\beta}\bar{\omega} - 2\frac{\sqrt{\alpha\bar{\omega}(k+1)R}}{\beta} \\ &= \bar{\omega}N + \left(\sqrt{\frac{\alpha}{\beta}R} - \sqrt{\frac{k+1}{\beta}\bar{\omega}}\right)^2 \end{aligned} \tag{45}$$

If instead $\mu \leq \sqrt{(k+1)R/\alpha\bar{\omega}}$ the maximum income is reached for a $M \geq \mu$. In this case, the value of M which maximizes aggregate income must be calculated numerically since the function changes depending on the number of steps.

As we pointed out in the main body, maximum industrial employment $\widehat{L}^*_{IT}$ is obtained for M in $[\rho, \mu]$. *Ab absurdo* consider that there is a distribution of land ownership such that $\widehat{L}^*_{IT}$ is obtained for $M > \mu$. A necessary condition for M to maximize L^*_{IT} when $M > \mu$ is that $(M + Q^*)$ does not increase in M, since i) $L^*_{IT} = N - L^*_f - L^*_{TT} - (M + Q^*)$, ii) $L^*_{TT} = 0$ for $M \leq \mu$ and iii) $L^*_{TT} \geq 0$ for $M > \mu$. For $M = \mu$ industrial labour amounts to the units of labour necessary to produce the demanded units of industrial goods, hence

$$L^*_{IT}(\mu) = \beta Q^*_\mu (Q^*_\mu + \mu) + kQ^*_\mu \tag{46}$$

where $Q^*_\mu(Q^*_\mu + \mu)$ is aggregate demand of manufactures. When $M > \mu$ the richest group of entrepreneurs receives demand by $(M + Q^*_M)$ individuals, but other industrialized markets will receive less. However we overestimate the aggregate industrial demand and, as before, we write industrial labour as

$$L^*_{IT}(M) = \beta Q^*_M (Q^*_M + M) + kQ^*_M \tag{47}$$

We can say with certainty that (46) is greater then (47) since as M increases $(M + Q^*)$ does not increase and Q^* decreases. Therefore, $Q^*_\mu > Q^*_M$ for $M > \mu$ implying that it is impossible that $\widehat{L}^*_{IT}$ is obtained for $M > \mu$.

In the interval $[\rho, \mu]$ there is no market operating with the TT, therefore industrial employment is given by equation (14). In order to maximize (14) with respect to M we derive the first order condition

$$\frac{\partial L_{IT}^*}{\partial M} = 0 \Longleftrightarrow M = \sqrt{\frac{R}{\alpha\bar{\omega}}}$$

If $\sqrt{R/(\alpha\bar{\omega})} \leq \rho$, then maximal industrial employment is obtained for $M = \rho$ also maximizing the extent of industrialization. If $\sqrt{R/(\alpha\bar{\omega})} \geq \mu$, then $\widehat{L}_{IT}^*$ is obtained for $M = \mu$ which may also maximize aggregate income. Finally if $\rho < \sqrt{R/(\alpha\bar{\omega})} < \mu$ the maximum industrial employment is obtained for a level of M strictly lower than that which maximizes aggregate income, that is $\sqrt{(k+1)R/\alpha\bar{\omega}}$. In this last case

$$\widehat{L}_{IT}^* = \left(\sqrt{\frac{R}{\bar{\omega}}} - \sqrt{\frac{1}{\alpha}}\right)^2 \tag{48}$$

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