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A THEORETICAL MODEL OF INDUSTRIAL POLICIES, WAGE LADDER AND TRADE BALANCE [5]

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1. Introduction

Increasing globalization with its technological spillovers among countries, accelerating technological progress, recent scientific and technical advancements in production and services, such as computerization and information technologies, have clearly showed that the world is facing new advancing Industrial Revolutions. Similarly with the first Industrial Revolution of 18th century, these waves of new technological innovations are reshaping economies of not only developing but of developed countries as well. This justly leads to the nowadays' revived interest to all economic aspects of industrialization and introduction of new technologies, especially in the framework of overall macroeconomic domestic and foreign trade balances.

In this paper, we deal with industrialization of a small open economy with a dual structure. We construct a real 2-sector Ricardian model, with agriculture and manufacturing, and describe an adoption of modern technology with increasing returns to scale and macroeconomic consequences of this process. Manufacturing itself consists of production of intermediate inputs and assembly of final goods as in Ethier (1982). The intermediate inputs are produced with traditional constant returns-to-scale technology; the modern technology is a more efficient increasing returns-to-scale modern technology with fixed costs in the Murphy, Schleifer and Vishny (1989a) and Sachs and Warner (1999) spirit. Exogenous terms of trade

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determine initial structure of the economy and allocation of labor among sectors.

There are some new features of this paper. First, we investigate an impact of technology's adoption on wages in a trading economy framework. The former effect on wages is often neglected in related literature, which is due to assumptions of market structure in these models. In aforementioned models of Murphy, Schleifer and Vishny (1989) and Sachs and Warner (1999) an existence of the competitive fringe of cottage industries is assumed. This fringe of cottage industries utilizes CRS technology, while monopolies (one in each sub-sector) decide whether to enter with increasing returns to scale technologies. Irrelevant of their entry, the continuous existence of the competitive fringe fixes wages before and *after* the adoption of modern technology, since the competitive fringe remains to compete with unchanged technology after the entrance of monopolies. On the other hand, in the economic geography approach, wages are essentially fixed by the assumption of CRS production function in agriculture and exogenous prices on agricultural goods. Krugman allows for flexible wages in manufacturing (Krugman, 1991) by assuming that manufacturing labor and labor in agriculture are different production factors.

Second, we pay special attention to the problem of trade balance and the changes in trade balance, *resulting* from the transition to new technology. Since the economy is a small open one, we assume unchanging terms of trade. In Ricardian spirit, these exogenous terms of trade determine the initial allocation of resources. Nonetheless, we show that even under unchanged terms of trade the adoption of modern technology can completely change not only the country's sectoral macroeconomic structure, but also the structure of its trade balance.

Third, in existing literature the transition to modern technology tends to be caused by exogenous changes in demand. These total demand changes result from exogenous demand shocks (export booms in Sachs and Warner, 1999), demand spillovers of actions of entrepreneurs as in Murphy, Schleifer and Vishny (1989), optimistic expectations (Dei, 1999, Rodriguez-Clare, 1996). Therefore, the transitions to new technology take place being caused solely by demand side. In this paper, we show that a government's industrial policy (market concentration policies) or *supply side* policies can cause this transition without exogenous demand shocks.

Structure of the paper is organized as follows. Section 2 introduces the basic model. Sections 3 and 4 describe the equilibrium

with traditional technology. Section 5 describes the thresholds of new technology adoption and industrial policies, promoting technological advancement. Section 6 introduces industrial policies. Sections 7 and 8 depict the impact of this introduction of new technology on the macroeconomic level and a new resulting equilibrium. Section 9 concludes.

1.1 Related Literature

This paper belongs to the research on introduction of new technologies, development, and changes in the macroeconomic structure and concentrates on development of a small *open* economy. Since ultimately trade shapes formation of any open economy, we view terms of trade and foreign trade as essential in determining the structure of economy, at least on initial stages of development. Since international trade defines the macroeconomic structure, any industrialization process may face constraints or barriers, as well as advantages, resulting from the openness. Adoption of new technologies and development must take place under conditions, dictated by world markets, which may not be favorable from the beginning. This adds a new dimension to the issue of industrialization.

Recent studies in this field belong to a remarkably wide area of economic research. The problem has attracted increasing attention of development and international trade economists, as well as researchers, specializing in game theory, industrial organization and macroeconomics. Since it is infeasible to outline all directions of research in this short paper, we shall highlight in the review of related literature major topics and articles relevant to macroeconomic aspects of new technology adoptions. Although these topics can be organized in many ways, we choose the macroeconomic aspects of the industrialization process to be the criteria of classification. From this point of view, two major approaches to industrialization within recent theoretical literature can be distinguished.

The first approach can be defined generally as a "closed economy" approach to industrialization. The second one belongs to a sphere of international trade and imperfect competition, and sometimes is defined as the "economic geography" approach to industrialization.

The first one can be characterized as studying macroeconomic constraints of industrialization in terms of absolute capacity of *domestic* markets, both from demand and supply points of view.

For a closed economy one of the first efforts to formalize the adoption of modern technology was done in the aforementioned paper of Murphy, Schleifer and Vishny (1989b). More specifically, they suppose that domestic market is too small to support industrialization, requiring large production volumes to justify introduction of new technologies (with fixed costs). The market capacity would expand if all sectors adopt new technologies, which induce demand spillovers and increase as a result the domestic market's demand for manufactures. If the actions of entrepreneurs in various sectors could be coordinated or prompted by self-fulfilling expectations, the domestic market could expand as a gross result of their actions.

Coordination failure or pessimistic expectations in this setting result in lagging development, according to studies on coordination games and coordination failures of industrialization (Cooper, 1999, Rodrik, 1999), demand spillovers and adoption of new technologies (Murphy, Schleifer and Vishny, 1989a, 1989b). Demand spillovers may also come from "superior" or "fairer" income distribution (Murphy, Schleifer and Vishny, 1989a) or from export booms (Sachs and Warner, 1999). Since only domestic market spillovers matter, foreign trade does not influence industrialization processes. Sachs and Warner (1999) extend this setting to deal with trading economy, which experiences export boom.

McDermott and Goodfriend (1996) used one-sector model to describe adoption of a modern IRS technology in a closed economy, dividing development in stages. Azariadis and Drazen (1990) have refined the determination of thresholds of the economic development stages as multiple equilibria, explaining them by increasing returns in human capital, augmenting productivity.

Another approach is concerned with finer division of labor in the domestic market or higher specialization and increasing (external) returns to scale (based on Ethier, 1982, and represented by Rodriguez-Clare, 1996, Dei, 1999). In this case too, a size of domestic market can be a constraint for industrialization, since a smaller market supports fewer varieties of intermediate inputs, than a larger one. Increasing returns to scale bring about multiple equilibria with high (low) specialization and large (small) number of intermediate inputs. Successful industrialization is viewed as a "good" equilibrium with higher specialization and large external economies of scale. This view of higher specialization is analogous to the "demand spillovers" theories in the sense that successful coordination or optimistic expectations could result in more entry by firms and thus higher specialization. Similarly, this research is dominantly concerned with only domestic market, since the intermediate inputs are thought to be

non-tradable; trade balance issues are not investigated.

The international trade approach, sometimes defined as economic geography approach to industrialization, views industrialization process as a concentration of industries, being an outcome of trade or the "home market effect" hypothesis (Krugman, 1980). This approach is based on the spatial choice of industries and transportation costs. Firms are free to move among markets, regions or countries. Industrialization or development is regarded as a concentration of industries in one separate region or country and thus is close to agglomeration in its implied meaning. Due to presence of transportation costs, firms prefer to locate in *relatively* larger markets. The model structure can incorporate vertically integrated firms with backward or forward linkages, tariffs and industrialization (Gros, 1987), agglomeration of industries and development (Krugman, Venables, 1995)[i]. Recent studies (Fujita, Krugman, Venables, 1999) include transportation costs or external economies of scale from agglomeration as centripetal forces and higher labor cost from concentration as a centrifugal force.

2. The Basic Model

The economy has 2 sectors: agriculture and manufacturing, although depending on exogenous terms of trade, a possibility of complete specialization in one good in this Ricardian framework can not be rejected. We assume that exogenous terms of trade allow the economy to produce both goods[ii]. This will not, however, alter the analysis and results do not depend on this assumption.

Development is divided into stages in the model. These development stages in the model, as we believe, adequately correspond to actual historic stages in development and industrialization. In each of these stages three types of goods are assumed to exist: agricultural goods Z, intermediate inputs x and manufactured final goods X, assembled from the intermediate inputs.

The stages differ in technology, employed to produce intermediate inputs and we make a simplification assuming that throughout the stages other goods, agricultural and final goods, are produced with unchanging technology. Although simplifying, this enables us to measure more specifically the impact of new technology's adoption on macroeconomic allocation of resources and particularly on wages.

The stages[iii] in the model are defined as:

- A traditional economy stage, where traditional constant returns-to-scale technology is utilized in production of intermediate inputs.
- A stage of adoption of modern, more productive technology with

fixed costs in production of intermediate inputs, identified as an industrial revolution stage in the Murphy-Schleifer-Vishny spirit.

- The final stage of more efficient production of goods, with a new macroeconomic equilibrium and new trade balance structure.

To some extent, these stages constitute an essential cycle of any new technology's adoption, be it steam locomotives instead of horses or supercomputers instead of mainframe computers[iv].

2.1 Agriculture

The formal description of agriculture essentially follows Murphy, Schleifer and Vishny (1989b) and Matsuyama (1992). The small open economy is endowed with L number of households, each inelastically supplying 1 unit of labor. Total labor stock is distributed between agricultural sector Z and industrial sector X:

$$L_Z + L_X = L \quad 1$$

The agricultural market is perfectly competitive. Agriculture produces freely tradable agricultural good Z and we assume that its price pz is given exogenously on the world market. The agricultural good Z is chosen to be numeraire and by selection of units its price is equal to 1. In agricultural sector, a representative farm employs labor Lz at the economy-wide wage rate w, produces the agricultural good Z and sells at world market-determined price pz. The agricultural good Z is produced with hired labor Lz with diminishing returns to scale:

$$Z = f(L_Z),\ f'(L_Z) > 0,\ f''(L_Z) < 0 \quad 2$$

where Z is total output. For clarity, we assume a particular form of the function f,

$$Z = Lz^{\lambda},\ 0 < \lambda < 1 \quad 3$$

which exhibits diminishing returns to scale. Farmers solve a following profit maximization problem with πz being profit or rent in agriculture:

$$\pi_Z = p_Z L_Z^{\lambda} - wL_Z \quad 4$$

Since pz is determined on the world market and by choice of units is equal to 1, the profit maximization procedure results in wages in agriculture, equal to value of labor's marginal product:

$$w = \lambda L_Z^{\lambda - 1} \quad 5$$

This equation is showed on the Figure 1 by the curve AA. The domestic labor market is perfectly inter-sectorally mobile, so the equation (5) describes an upward-sloping supply for labor in the industrial sector.

Notice that at this wage the farm has positive profit or land rent. From the equations 4-5 and using the definition of the

agricultural production function, we can determine rents of a farm as:

$$\pi_Z = L_Z^{\lambda} - \lambda L_Z^{\lambda} = (1-\lambda)L_Z^{\lambda},\ 0 < \lambda < 1 \quad 6$$

If the economy were completely specializing in agriculture, this would ensure lower wages than without manufacturing, since manufacturing competes for labor with agriculture.

Concerning income distribution, clearly, the farm profit is higher, when wages are lower. Consider a case, where unfavorable for manufacturing terms of trade ensure that the country is dominated by agriculture. Although manufacturing may exist, prevalence of agriculture implies low wages in both agriculture and manufacturing. By (6), we see that in that case profits of farms are higher than in a case with large manufacturing sector. In terms of income distribution, we can see a picture, characteristic for a developing country: dominance of agriculture, low wages and a small manufacturing sector.

2.2 Manufacturing

The final good X is freely tradable on the world market and its world market price Px is given exogenously. The small open economy is behaving as a price-taker one and the world market is sufficiently large to absorb exports or to supply imports of good X at price Px without oversupply or shortage problems. The assembly production of final goods X is assumed to be perfectly competitive. Under perfect competition and free entry in the production of the final good X firms in the assembly sector assumed to have zero profits.

The manufactured goods are assembled from the intermediate inputs or parts. There are N varieties of intermediate inputs, indexed by i, $i=1,..,N$. The number of intermediate inputs N is exogenously given by history, as in Sachs and Warner (1999). The intermediate inputs for the X good are differentiated, and they are imperfect substitutes to each other. The larger is N, the more varieties of inputs are utilized for production of the final good, so N can be thought of as an indicator of technological complexity of the final good.

Formally, manufacturing sector consists of production of final consumer goods, assembled from the intermediate inputs, which we call parts, with a CES production function as in Ethier (1982):

$$X = \left(\sum_{i=1}^{N} x_i^{\lambda}\right)^{\frac{1}{\lambda}},\ 0 < \lambda < 1 \quad 7,$$

where $1/1\text{-}\lambda=\varepsilon$, representing the constant elasticity of substitution between inputs.

Given the world price Px and technical requirements N of the final consumer good, assemblers procure parts at home market; these parts are non-tradable, following Rodriguez-Clare (1996), who includes in intermediate inputs services such as banking and insurance. Price of intermediate input with index i is p_i. Assemblers of the final good purchase intermediate inputs and minimize production costs, according to the technological constraint (7). Demand for intermediate inputs can be expressed as

$$x_i = \frac{(p_i)^{\frac{1}{\lambda-1}}}{\left(\sum_{i=1}^{N} p_i^{\frac{\lambda}{\lambda-1}}\right)^{\frac{1}{\lambda}}} X \qquad \mathbf{8}$$

where $\varepsilon = 1/1-\lambda$ is constant price elasticity of demand for intermediate input i. Cost minimization by firms, which assemble the final good, leads to the unit cost cx of X good, expressed as:

$$c_X = \left(\sum_{i=1}^{N} p_i^{\frac{\lambda}{\lambda-1}}\right)^{\frac{\lambda-1}{\lambda}} \qquad \mathbf{9}$$

Finally, unit cost cx of the final good X is equal to its world price Px, exogenously given on the world market:

$$P_X = c_X \qquad \mathbf{10}$$

3. Structure of the market for intermediate inputs

We construct a stylized system of production of intermediate inputs, which nevertheless can capture the essential concept.

The history of economic development shows that producers tried to keep access to production technology closed and attempted to monopolize markets for their goods. "The central feature of pre-industrial production was that technological knowledge took the form of craft skills and those who possessed it, controlled production processes" (Bruland, 1989). For traditional economy, particular well-known examples are apprenticeship systems and guild systems of medieval Europe.

Each master taught necessary skills only to his apprentices; the apprenticeship could last decades and only after rigorous examinations the apprentices were allowed to work. The guild system also resembles apprenticeship in a sense, that the guilds or groups of skilled craftsmen were limiting entry in their market by requiring newcomers to join it.

Therefore, we assume that in manufacturing the traditional technology or skills are monopolized. Intermediate inputs can be produced with two kinds of technologies: traditional one with constant returns to scale (handicraft may be appropriate analogy) and modern

one with increasing returns to scale.

On the pre-industrial stage of development, all inputs are produced with traditional constant returns to scale technology without fixed costs, with constant average and marginal costs. Firms limit entry in each marketplace by making access to traditional technology closed and produce all intermediate inputs. Hence, from the beginning the industries are monopolized, albeit utilizing traditional technologies.

Notice that this set-up is radically different from settings in Murphy, Schleifer and Vishny (1992), Sachs and Warner (1999). In these papers traditional technology is assumed to be freely available to a competitive fringe of cottage industries, which compete with monopolistic enterprises, having access to modern technologies. This leads to a result of wages being fixed by existence of the competitive fringe irrelevant of entry of monopolistic enterprises. For that reason, we assume away the competitive fringe of cottage industries, thus allowing wages to be flexible.

Every industry requires its specific traditional technology, although we make a simplification by assuming that *cost* structure is identical for each producer and inputs enter the final good's production function symmetrically. This allows treating all inputs symmetrically and dropping the subscripts. The demand for input x now becomes

$$x = \left(\frac{p}{P_X}\right)^{\frac{1}{\lambda-1}} X \qquad \mathbf{11}$$

The production function (7) can be simplified due to symmetry between inputs to

$$X = N^{\frac{1}{\lambda}} x \qquad \mathbf{12}$$

Notice that contrary to a closed economy, X good's domestic production is determined by the stock of available domestic intermediate inputs. This point is important.

If the economy is closed, domestic production of X good must be determined by demand for final good. With demand-determined production of final goods, demand for intermediate inputs would be derived from the production of final goods. However, in trading economy with exogenously given terms of trade, whether or not intermediate inputs x are produced under given conditions depends on profitability of their production for firms. We shall now define the conditions of domestic production of intermediate inputs.

The overall structure of the market for differentiated inputs is following: there are N sub-markets for intermediate inputs, at which assemblers of the final good X procure the inputs. Only one firm produces a differentiated input. The firm, producing intermediate input, will supply volume x of intermediate input at price p or won't supply at all if their production costs c exceed the purchasing price p:

$$x = \begin{cases} o, & for\ c > p \\ XN^{-1/\lambda}, & for\ c \le p \end{cases} \quad \mathbf{13}$$

Formally, on the traditional technology stage, production of intermediate input incurs total labor requirement l:

$$l = bx \quad \mathbf{14}$$

where x is total output of intermediate input, and b is positive constant, an inverse of the labor productivity coefficient of the traditional technology. Higher coefficient b means that technology requires more labor per unit of output of x and thus is less productive, while smaller b implies higher productivity of labor.

Each monopoly, a maker of differentiated input, faces the downward sloping demand curve with constant price elasticity of demand as given in(11) and maximizes their profits given as:

$$\pi = px - wl \quad \mathbf{15}$$

The profit maximization procedure results in familiar marginal cost = marginal revenue condition:

$$p\left(1 - \frac{1}{\varepsilon}\right) = bw, \quad \mathbf{16}$$

where ε is elasticity of price demand and is equal to *1/1-λ*. This results in a monopolistic mark-up over costs:

$$p = \frac{bw}{\lambda} \quad \mathbf{17}$$

The unit labor costs bw are lower than price p with the positive mark-up, since λ<1; hence makers of intermediate inputs are gaining profit. Contrary to the usual monopolistic competition, since free entry in intermediate inputs sector is not possible and N is fixed, these profits remain positive.

Notice that wages in manufacturing, at which firms hire labor, are related with the productivity of traditional technology. The Eq.17 implies that wages in manufacturing are given by p and the productivity parameter b:

$$w = \frac{\lambda p}{b} \quad \mathbf{18}$$

Larger b, or more labor-costly and ineffective technology, implies lower wages in production of intermediate inputs by.

By substituting for p using (11) and (12), we can explicitly express manufacturing wages w in terms of world prices for final

goods P_X, number of utilized inputs N and labor productivity b:

$$w = \frac{\lambda N^{\frac{1-\lambda}{\lambda}} P_X}{b} \quad \mathbf{19.}$$

Note that higher prices of final consumer goods P_X lead to higher domestic wages in manufacturing. It is evident that if economy produces high-priced manufacturing goods, then manufacturing wages in that country tend to be higher. Second, less productive technology (large b shows a high degree of labor requirement per unit of output) tends to lower wages.

The manufacturing wage expression (19) can be interpreted as follows: exogenous terms of trade P_X determine domestic wages in manufacturing together with industrial structure (parameter N) and technological structure (parameter b).

4. Macroeconomic equilibrium with traditional technology

On the macroeconomic labor market, agriculture competes with manufacturing for labor. With perfect mobility, labor should earn equal rewards in both sectors and we assume that labor mobility is high enough to always ensure the equality of wages across sectors. With constant returns to scale and without fixed costs in traditional technology regime, amount of production of each sector is determined in the following way.

Equilibrium in domestic labor market is achieved at the intersection point E (Figure 1), where perfect mobility of labor ensures equal wages in agriculture and manufacturing. Wages in manufacturing are given by world prices (illustrated by the *MM* line on the Figure 1), and equal to wages in agriculture, so agricultural employment and labor allocation, associated with this wage level, can be found. Since at the point E wages in agriculture and in manufacturing are equal, we can combine wage equations (5) and (19),

$$\lambda L_Z^{\lambda-1} = \frac{\lambda N^{\frac{1-\lambda}{\lambda}} P_X}{b} \quad \mathbf{20}$$

and derive labor L_Z, employed in agriculture, determined as

$$L_Z = \left(N^{\frac{1-\lambda}{\lambda}} P_X / b\right)^{\frac{1}{\lambda-1}} \quad \mathbf{21}$$

Exogenous terms of trade, industrial structure and technology jointly determine domestic wage in manufacturing, and decide the allocation of labor among sectors through manufacturing wages in (19-21).

Insert Figure 4.1. **Labor market equilibrium**

Terms of trade define size of the labor pool available for manufacturing by determining exact agricultural employment at given terms of trade in (21). Using the labor market clearance condition (1), total labor, devoted to manufacturing L_X is then explicitly stated as a remaining part of total labor endowment:

$$L_X = \bar{L} - \left(N^{\frac{1-\lambda}{\lambda}} P_X / b\right)^{\frac{1}{\lambda-1}} \quad \mathbf{22}$$

This pool of available labor for manufacturing is symmetrically divided between all subsectors N of intermediate inputs. Total labor, employed in the intermediate inputs sector, can be expressed as:

$$L_X = Nl = Nbx \quad \mathbf{23}$$

Therefore, expressing x as a L_X / Nb and given parameters b and N, we can substitute the Eq.22 for L_X and derive the precise amount[v] of production of each intermediate input x:

$$x = \frac{\bar{L} - \left(N^{\frac{1-\lambda}{\lambda}} P_X / b\right)^{\frac{1}{\lambda-1}}}{bN} \quad \mathbf{24}$$

Output of X good is determined by volume of available intermediate inputs, which depend on pool of available labor. Knowing output of intermediate inputs x from (24), consequently by using production function of final good X it is possible to find total output of the final assembled good X:

$$X = \left(\bar{L} - \left(N^{\frac{1-\lambda}{\lambda}} P_X / b\right)^{\frac{1}{\lambda-1}}\right) b^{-1} N^{\frac{1-\lambda}{\lambda}} \quad \mathbf{25}$$

Total output of X good is larger, if economy has larger endowment of labor L; more effective output of intermediate inputs (smaller b) also will result in larger output of the final good. The manufacturing productivity parameter b is crucial in determining allocation of labor and wage level, as we can see.

Description of the macroeconomic allocation of resources is completed with determination of agricultural output, using Eqs.3 and 21:

$$Z = N^{-1}\left(\frac{P_X}{b}\right)^{\frac{\lambda}{\lambda-1}} \quad \mathbf{26}$$

Notice that agricultural output is inversely related to price of the final manufactured good or terms of trade. Thus terms of trade indirectly

determinate allocation of resources and the macroeconomic structure of output in the small open economy.

4.1 Demand

Consumers in the small country use agricultural good Z and final good X for consumption. Consumers inelastically supply labor at wage w, own all firms and farms, receive profits π (if there are profits) and π_Z, maximizing their utility according to a following Cobb-Douglas utility function:

$$U = C_Z^{1-\mu} C_X^{\mu}, \; 0<\mu<1 \quad \mathbf{27}$$

where C_Z and C_X stand for consumption of Z and X goods, μ is share of manufactured goods in total consumption. Total expenditure E thus consists of wages, profits π of N firms, producing intermediate inputs, and p_Z, profits of agricultural farms.

$$E = wL + \pi N + \pi_Z \quad \mathbf{28}$$

Maximization of the utility function subject to the income constraint allows writing domestic demand for X as

$$C_X = \mu E \quad \mathbf{29a}$$

where E stands for total expenditure of consumers and μ is the share allocated to final manufactured goods, and domestic demand for agricultural good:

$$C_Z = (1-\mu)E \quad \mathbf{29b}$$

Specification of foreign trade balance of the economy finishes the description of the economy on the traditional stage of development. $P_X X^T$ and Z^T accordingly denote values of total traded output of manufacturing and total value of traded agricultural goods Z (recall that p_Z is equal to 1). Domestic markets for both X and Z goods clear

$$\mu E = P_X X^T + P_X X$$

$$(1-\mu)E = Z^T + Z$$

Turning to the structure of trade balance, foreign trade is balanced:

$$\mu E - P_X X - P_X X^T + (1-\mu)E - Z - Z^T = 0 \quad \mathbf{30}$$

From these expressions for market clearance conditions it is possible to write down an expression for trade balance:

$$P_X X^T = -Z^T \quad \mathbf{31}$$

This expression states that under exogenous terms of trade whatever good, the economy produces in quantity exceeding domestic demand for it, is exported and exchanged for a good, which under the given allocation of labor, is insufficiently produced.

4.2 Wage Ladder and Output Structure

Allocation of labor among sectors depends on the wage level, which indirectly is given by terms of trade. Sufficiently high or low wages (or corresponding terms of trade) lead to complete specialization in manufacturing or agriculture. We assume that terms of trade are in a range such that the economy does not completely specialize in production of either good and both goods are produced.

In a case of incomplete specialization, output of each sector depends on how much labor is released from agriculture at the current wage level, indirectly given by terms of trade, p_z and P_X. Under unfavorable terms of trade for manufacturing, the economy would be dominated by agriculture, and manufacturing will employ only a small fraction of labor force. This fact implies small volumes of manufacturing output.

The structure of trade balance depends crucially on wage level (at constant expenditure shares of domestic consumers, which is guaranteed by Cobb-Douglas utility function). Low wages imply that labor is employed dominantly in agriculture and the country produces largely agricultural good, surplus of which is exported to import manufactured goods. High wages on the contrary lead to labor being employed mainly in manufacturing and exports of manufacturing goods.

From the wage equation in agriculture (5) and agricultural production function (3), we can express (see Appendix for derivation details) the relation between wages and agricultural output:

$$Z = Z(w), Z'(w) < 0 \quad \textbf{32a}$$

Manufacturing output can be also expressed as an increasing function of wage w:

$$X = X(w), X'(w) > 0 \quad \textbf{32b}$$

Let us then define the structure of the economy's output. Define by s the share of manufacturing product in total production as function of wages w:

$$s = \frac{P_X X(w)}{P_X X(w) + Z(w)}, \; s \in [0,1] \qquad \textbf{33}$$

Denominator shows total output. Since sectoral outputs depend on wage level, this relation between s and wages w is shown on the Figure 2:

Insert Figure 4.2. Wage Ladder and Structure of Trade Balance

On other hand, the structure of domestic demand is determined by parameter μ[vi]. There is unique wage level w\` such that structure of domestic demand for manufacturing and agricultural good exactly matches domestic structure of output of both goods. Since the country is open economy, it is possible to overlap both structures to derive the structure of trade balance.

For low wages, such as $w<w$\`, economy produces mainly agricultural goods, which output exceeds its share of domestic $(1-\mu)$ of

domestic demand. Therefore, its surplus is exported in exchange for manufacturing goods, which domestic production is short of domestic demand $(s<\mu)$. As wages increase (which is possible with unchanging productivity of labor in agriculture only if productivity increases in manufacturing), increasingly labor moves to manufacturing, and the share of manufacturing output increases. At $w>w$\`, manufacturing becomes a dominant sector in terms of employed labor. Manufactures also become main export items.

At initial exogenous terms of trade on the traditional stage of development the country is assumed to be predominantly agricultural country, with wages $w<w$\`. Therefore, under the terms of trade the economy exports agricultural goods and utilizes traditional technology in manufacturing.

The country can become an exporter of manufactured goods and an importer of agricultural goods at unchanged terms of trade only if wages in manufacturing increase[vii]. By the equation (17) this can happen only if productivity of labor increases. However, how productivity of labor in manufacturing can increase if under the *given* conditions entrepreneurs do not have incentives to adopt more effective technology?

5. The threshold of modern technology's adoption

In the pre-industrialization equilibrium producers of inputs have positive profits and have no incentive to introduce modern technology. The modern technology available for producers of intermediate inputs is described by labor requirement:

$$l = F + \beta x \qquad \textbf{34}$$

Although it requires setting up fixed labor costs (overhead costs), it is more productive traditional one. If we compare equation 34 with the Equation 14, the increase in productivity is shown by $b>\beta$. An installation of overhead labor input improves productivity, such that each unit of x requires only β/b of old technology's variable cost.

However, the fixed cost of modern technology implies that there must a minimal volume of output or a threshold, which makes the adoption of modern technology profitable.

We can find the threshold, which the makes adopting of modern technology profitable for a firm, producer of intermediate inputs. Calculations show that producers will not be interested in adoption of modern technology if output of x is lower than the threshold level x\`, which we assume is the case under consideration.

The threshold x\`, which the makes adopting of modern technology profitable for a producer of intermediate inputs, is:

$$x` = \frac{F}{b-\beta} \quad 35$$

Increasing returns to scale technology can be afforded only at sufficiently high volumes of output. Large fixed cost F raises the threshold level. Higher productivity of new technology (small β) or a high degree of obsoleteness of old technology (too large b) can lower the threshold level.

Notice the role of the fixed cost F in determining the thresholds or minimal acceptable output levels for firms. It implies that adoption of modern technologies is more difficult task for industries that require large fixed costs for operation of modern technologies, and scale of output becomes more important with larger fixed costs.

The only feasible explanation of available technology not being adopted is that at existing production volumes traditional technology is more profitable and output has not exceeded the threshold. Otherwise, rational firms must already introduce the modern technology. It means that current production volume is at level such that $x < x`$.

This volume of output per firm, too low for adoption of modern technology, is a consequence of exogenously given terms of trade and thus can not be changed by actions of individual firms. Terms of trade, as we saw above, decide wage and labor resources, available for manufacturing. With number of firms, determined by history, labor resource is divided symmetrically among all firms. For available labor resource, each maker of intermediate inputs thus can not introduce modern technology, because producers of intermediate input are too small and possess too small individual shares of the total market for intermediate inputs. It is clear that under the traditional technology regime economy can not employ modern technologies and modernize.

6. Industrial concentration policies

Suppose the country wants to modernize[viii]. Adoption of modern technologies in these conditions can take place only if volume of output of each firm exceeds the threshold level.

Labor resource for manufacturing in open economy is limited and exogenously determined by terms of trade. Hence, the feasible way for increasing the share of labor resources and output for each firm is to limit the number of inputs, which are produced domestically, and concentrate the available labor resources in remaining industries.

Consider an analogy with a car: there is a minimal number of inputs, without which an automobile would not be one: engine,

chassis, wheels and etc. On the other hand it may have non-essential parts as silver ornaments or leather seats. The idea is that the country concentrates on production of essential inputs, since it now aims at a mass scale production of them rather than (small-scale) production of all possible inputs or industries.

It means that a selection of firms or industries must take place and the rest must be merged with selected industries, consolidated or simply shut down. This concentration can be achieved through various ways, such as limiting free entry into selected industries, preferential bank credit and long-term financing, promotion of mergers and consolidations of domestic producers, or administrative "guidance" measures.

We assume that government policies thus are aimed at promoting market concentration and mass-scale production in selected industries to advance adoption of modern technology. In our model, we represent the government's policies as an exogenous reduction of the number of produced intermediate inputs from N to N^*. Since wages are unchanged at this stage, labor resources available for manufacturing is same as in traditional economy; however, now *unchanged* manufacturing labor resources are divided between *fewer* firms, increasing output of each firm.

Despite the simplicity of the industrial policies in the model, they can describe two essential industrialization policies: one is *selection* of few key industries for industrialization, and another is promotion of *concentration* in selected industries. It adequately captures the core of actual industrialization policies, undertaken in the beginning of the First Industrial Revolution in Europe, during industrialization and rapid development of Japan in 19-20 centuries, and South Korea's development after the World War II.

First, a historical example from the British industrial revolution (usually dated 1760-1850) can illustrate the basic idea. In XVIII century Britain, British Parliament promoted mass scale production in cotton: "Parliament not only encouraged the dyeing and printing of textiles... to mature, its legislative enactment in 1736-1774 helped to transform fustian (cotton fabric) into a mechanized cotton industry". The reason of cotton becoming a leading industry, applying modern technologies, was that the cotton industry in Britain "concentrated on ... textile and -other- markets for which the new, mass production methods could be applied" (Crouzet, 1996). As a result, "the cotton industry presented most dramatic example of rapid transition from a traditional...system of production, dependent on hand-tool technology, to a centrally managed...factory system, using large-scale machinery" (Deane, 1996).

Industrialization of Japan presents another classic example of both types of industrial policies. Cases of administrative guidance of industries and government-led industrialization are well known. For example, in early years of industrialization during in XIX century, Japanese government promoted development of certain *selected* industries, which ultimately formed the backbone of Japan's industrial complex, simultaneously contributing to extremely high concentration in Japanese industry through "zaibatsu" conglomerates before WWII. In a period after World War II, government policies to *consolidate* domestic producers to gain economies of scale and eradicate unnecessary domestic competition were consequently undertaken in car industry (1955, 1961) (Kosai and Ogino, 1984), steel, chemistry, oil (1955) (Oppenheim, 1992). After 1945, the general policy of Japan's Ministry of Trade and Industry was aimed at "concentrating resources in …internationally competitive areas". At the same time it was "organizing capacity cuts" and assisting "prompt and effective closing down of capacity" in other industries, which MITI perceived as lacking such future, e.g. textiles (contributed to Abegglen, Oppenheim, 1992).

In South Korea, inspired by successful Japanese industrial policies, "by the late 1960's the government began selecting "strategic" industries…including electronics, shipbuilding and automobiles. The support measures were gradually strengthened." However, in South Korea as in Japan the most important point was not only the selection itself, but rather the willingness to cut off "undesirable" industries to channel resources into supported selected industries. In South Korea too "an industry could even be sacrificed if need be" (Woronoff, 1983). While not completely successful or accepted, undertaken intentionally or spontaneously, these industrial policies nevertheless reached their results[ix].

7. The stage of industrial concentration

In this simplified setting distinguishing between symmetrical industries is impossible, therefore it does not matter in the model *which* industries are selected for output promotion as far as the target levels of concentration and output in them is achieved.

The industrialization policy in the model, assumed to change industrial structure in order to enable introduction of modern technologies in manufacturing, has an impact on both prices and wages before the modern technology itself is adopted.

It was shown that exogenous terms of trade P_X determine domestic wages and consequently the labor resources available for

manufacturing through 2 parameters: industrial structure N and technological parameter of productivity b (for traditional technology), defining domestic price of intermediate input.

The selection of concentrated industries must ensure high enough degree of concentration of production resources, such that mass-scale production in selected industries exceeds threshold level.

Suppose that government undertakes concentration policies, reducing number of intermediate input producers from N to N^*, where $N^*<N$ (asterisk * denotes the policy stage). It changes the impact of terms of trade P_X on domestic price of intermediate inputs as follows.

Using (11) and (12), prices of intermediate inputs p can be determined as

$$p = N^{\frac{1-\lambda}{\lambda}} P_X \qquad 36$$

Government policies reduce N to N^*, this results in new price of intermediate inputs p*, which is lower than pre-reform price without industrial concentration measures:

$$p^* = N^{*\frac{1-\lambda}{\lambda}} P_X \qquad 37$$

Lower prices of intermediate inputs p^* result through of mark-up pricing in temporary lower wages, which we denote w^*:

$$p^* = \frac{bw^*}{\lambda} \qquad 38$$

Labor stock is now given by new labor equilibrium:

$$L^*_X = \bar{L} - \left(N^{*\frac{1-\lambda}{\lambda}} P_X / b\right)^{\frac{1}{\lambda-1}} \qquad 39$$

Lower wages lead to smaller manufacturing labor stock, because $N^*<N$.

However, since this labor resource is divided between fewer firms, output of each firm may *increase*. The manufacturing labor resource L^*_X is given by Eq.39. The policy-determined number of intermediate input produces N^* (number of selected industries) must be chosen such that $x>x`$ (the threshold level). Output per firm can be expre

The threshold level of industrial concentration for output of a firm to exceed x` is N^*, such that

$$\frac{\bar{L} - (N^* P_X / b)^{\frac{1}{\lambda-1}}}{bN^*} = \frac{F}{b-\beta} \qquad 40$$

We see that the concentration threshold N^* can be written as depending on technological parameters and terms of trade (remember that smaller N^* implies higher concentration and opposite).

$$N^* = N^*(F, P_X, b-\beta), N^*_F < 0, N^*_{P_X} > 0, N^*_{b-\beta} > 0$$

Large F (fixed costs of modern technology) require higher degree of concentration (smaller N^*), favorable terms of trade P_X work against high concentration, and difference in productivity between old and modern technology $(b-\beta)$ has similar effect, requiring less concentration for larger jumps in productivity.

8. Macroeconomic Equilibrium with Modern Technology

The government selects N^* industries, such as production in them exceeds x`. Now with new technology the cost requirements of firms change to:

$$l = F + \beta x \qquad \mathbf{41}$$

Total costs of a firm, producing inputs with new technology become

$$c = w^*(F + \beta x) \qquad \mathbf{42}$$

At production levels, $x > x$`, for firms total average costs with modern technology will be lower than with traditional technology

$$\frac{F}{x} + \beta < b \text{ for } x > x` \qquad 43$$

Adoption of modern technology will be profitable for remaining operating firms. The firms adopt new technology. Total profits of each producer of intermediate input increases with new technology and cost structure:

$$p^*x - w^*(F + \beta x) > p^*x - w^*bx, \text{ for } x > x` \qquad 44$$

However, introduction of new technology changes wages level, because now labor is more productive.

Profit maximization results in a new marginal revenue = marginal cost condition, where we denote by $\tilde{w}$ wages in modern technology equilibrium

$$p^*\left(1 - \frac{1}{\varepsilon}\right) = \beta\tilde{w}, \qquad 45$$

where ε is elasticity of price demand and is equal to $1/1\text{-}\lambda$.

This results in a new technology-determined monopolistic mark-up over costs:

$$p^* = \frac{\beta\tilde{w}}{\lambda} \qquad \mathbf{46}$$

Compared to the previous mark-up rate (38) $p^* = bw^*/\lambda$, price of intermediate input p^* does not change.

But the introduction of more effective new technology increases wages in a following ratio:

$$\frac{\tilde{w}}{w^*} = \frac{b}{\beta} \qquad 47$$

Wages in manufacturing rise with introduction of more efficient technology.

Insert Figure 4.1. Switch to modern technology and increase in wages

Because of raised wages in manufacturing, labor will flow to manufacturing from agriculture, therefore increasing output of intermediate inputs. This inflow of labor will continue until agricultural wages will match wages in manufacturing, and with high wage level, it is possible that economy will specialize in manufacturing. Complete or incomplete character of specialization depends on range of wage increase.

Because of labor inflow, the manufacturing labor (tilde over variable shows that it describes modern technology stage) increases:

$$L_X = \bar{L} - \left(N^{*\frac{1-\lambda}{\lambda}} P_X/\beta\right)^{\frac{1}{\lambda-1}} \qquad \mathbf{48}$$

Since $\beta<b$, $L_X < \tilde{L}_X$. This increase in manufacturing employment results in increased amount of production of intermediate inputs.

Each intermediate input's output increases to $\tilde{x}$ (tilde over x shows that it is output produced with modern technology)

$$\tilde{x} = \frac{\bar{L} - \left(N^{*\frac{1-\lambda}{\lambda}} P_X/\beta\right)^{\frac{1}{\lambda-1}} - N^*F}{\beta N^*} \qquad \mathbf{49}$$

Total output of X now increases, because more of each intermediate input is available, and becomes equal to

$$\tilde{X} = \frac{\left[\bar{L} - \left(N^{*\frac{1-\lambda}{\lambda}} P_X/\beta\right)^{\frac{1}{1-\lambda}} - N^*F\right] N^{*\frac{1-\lambda}{\lambda}}}{\beta} \qquad \mathbf{50}$$

Therefore, the development policies, aimed at concentration of production and larger market share of each producer, enable mass scale production with subsequent adoption of modern technologies. Sufficient increases in productivity thus result in drastic structural changes in economy.

First, through the relation (47) wages will increase in ratio equal with increase in productivity of labor. This will result in inflow of labor (and increase in manufacturing output), that will continue until agricultural wages match wages in manufacturing. With sufficiently high labor productivity and wage levels, it is possible that economy will completely specialize in manufacturing. The economy moves to the high-wage equilibrium with high-volume output of intermediate inputs and increased output of final industrial goods. On the wage ladder, economy will move up from point E to $E`$, and economy's structure will change from agriculture-dominated to manufacturing-dominated one.

Domestic demand structure is unchanged, but the country now produces more of final good X. The increase in output of final goods will lead to excess supply of final manufactured goods, which will become the export good. These results are summed in the Result 1 below.

RESULT 1. Adoption of more productive technologies in manufacturing leads to economy-wide increase in wages, a transition to manufacturing-dominated macroeconomic structure of output, and a prevalence of manufactured goods in export composition.

9. Concluding remarks

Recent papers on industrialization have studied multiple aspects of industrialization. However, some aspects have been often left out of research area: in our opinion, the aspects, which require more attention, are determination of wages and changes in trade balance structure, brought by the adoption of modern technologies.

These simplifications result from some quite widely used assumptions, applied to simplify model structures. For example, to create possibility of multiple equilibria during "Big-Push" industrialization, Murphy, Schleifer and Vishny (1989) introduced wage premium, or a higher wage in manufacturing compared to wage in agriculture as a method of inducing labor inflow in manufacturing. This assumption was later criticized for being too artificial. Wages (in agriculture) in the "economic geography" approach are necessarily fixed by CRS production functions in agriculture and assumption of traded agricultural goods, since (Davis, 1999) any possible inequality of wages between trading countries ruins "the home market" effect or the industrial agglomeration. Therefore, in both research fields of "Big Push" and "economic geography", wages are essentially exogenously fixed.

Concerning the trade balance determination, obviously since the original formulation of Murphy, Schleifer and Vishny of the "Big Push" industrialization was generally reached for a closed economy, this left aside the trade balance issues. Rodriguez-Clare (1996) assumes small open economy with exogenous terms of trade,

Goodfriend and McDermott (1996) use one-sector models but either abstain from intersectoral or foreign trade issues. Dei (1999) applies the small open economy assumption for a 2-sector model, but does not specify foreign trade balance for the country itself.

However, these simplifications lead to omission in the analysis of a number of important issues, which could provide answers to key questions, concerning development, industrialization and macroeconomic structure determination. For example, higher productivity would logically imply higher wages, and it is the main reason why most technologically developed countries have also highest wages, but such facts could not be explained under the original "Big Push" framework.

In our paper, the development policies, aimed at concentration of production and a larger market share of each producer, enable mass scale production with subsequent adoption of modern technologies. This in turn increases wages, and the economy moves to the high-wage equilibrium with increased output of industrial goods (both intermediate inputs and final goods). Despite its simplicity, the model in this paper is able to provide a number of insights on aforementioned and other issues. In our opinion, wages represent the key, which leads to macroeconomic allocation of resources (there is no capital in our model). In determining the precise macroeconomic structure, we do not utilize wage premiums to explain intersectoral labor flows. The macroeconomic structure determination allows exact defining of developments in foreign trade.

Summarizing, the main clarified points are: (1) The impact of industrial policies on adoption of modern technologies; (2) an effect of new technology on wage level, (3) the effect of modern technology on factor allocation, (4) changes in foreign trade structure, caused by industrialization.

These clarified points bear striking resemblance to actual industrialization cases and explain well macroeconomic changes in industrializing countries. Consider the cases of Britain, Japan and South Korea, to name just most dynamic examples of development and industrialization. Industrial revolutions in these in countries in different ages universally led to higher wages, a formation of industry as main export sector and to manufacturing-dominated macroeconomic structure of the countries, just as our model predicts.

Of course, this paper can present explanations only for a limited number of issues; we hope to extend the model to incorporate shifts in agricultural productivity as well. Aspects of industrialization, left for future research, are the role of agriculture and the role of agricultural entrepreneurs in development, as has been initially proposed by Matsuyama (1992). This direction will be studied in detail in the companion paper.

Appendix

Agricultural output is expressed as a function of wages:

$$Z = \left[\frac{w}{\lambda}\right]^{\frac{\lambda}{\lambda-1}} \quad \textbf{A1}$$

Since λ is smaller than 1, agricultural output Z is decreasing in wages. In similar way, industrial output is expressed as

$$X = \frac{\left[\overline{L} - (w/b)^{\frac{1}{\lambda-1}}\right]}{b} N^{\frac{1-\lambda}{\lambda}} \quad \textbf{A2}$$

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АЖ ҮЙЛДВЭРЖИЛТИЙН БОДЛОГО, ЦАЛИНГИЙН ТӨВШИН БА ГАДААД ХУДАЛДААНЫ БАЛАНСЫН ОНОЛЫН ЗАГВАР

Абстракт

Аж үйлдвэржилт, орчин үеийн технологийг нэвтрүүлж хөгжих үйл явцын макроэдийн засгийн үр дагаварыг анх 1989 онд Мерфи, Шлайфер, Вишни онолын талаас загварчлан судалсан ба 1999 онд Жеффри Сакс болон Уорнер нар тус асуудлыг өөр загварын хүрээнд нэмж судалсан. Тус нийтлэлийн шинэлэг санаа гэвэл Мерфи, Шлайфер, Вишни болон Сакс-Уорнерийн загварт өөрчлөлтгүй үлдсэн цалин, орлогын өсөлтийн түвшин, хангалттай судлагдаагүй гадаад худалдааны балансыг судалж, аж үйлдвэрийн бодлогоор дамжуулан зэрэг гадаад худалдааны баланс, өндөр орлоготой болох боломж байгааг загвар дээр харуулсан. Үүний тулд тус нийтлэлд 2 салбартаи, жижиг нээлттэй эдийн засгийн монопольт өрсөлдөөний Рикардогийн загварыг боловсруулж, гадаад худалдааны баланс, цалин орлогын түвшний өөрчлөлтийг шууд илэрхийлэн гаргасан юм. Аж үйлдвэржилтийн оновчтой бодлого нь хувийн компаниудыг үйл ажиллагааны цар хүрээ, хэмжээг томсгоход орших естой ба тэгснээр компаниудад орчин үеийн технологийг өргөнөөр нэвтрүүлэх ашигтай боломжийг олгоно.