Productivity-Based Theory of Manufacturing Employment Declines: A Global Perspective

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1. Introduction.

We live in the global economy where countries are interdependent with one another. Yet, most studies on structural change develop a closed economy model, apply it to each country, and use the cross-country data to test the model. Effectively, they treat each country in autarky, as if countries were still independent fiefdoms in the Middle Ages or were located on different planets. In this note, we will present a simple example demonstrating how misleading this common practice can be in the context of productivity-based theory of manufacturing employment decline.

In many developed countries, manufacturing employment has been declining over time. A common explanation attributes it to the faster productivity growth in manufacturing. With productivity growth, few workers are needed to produce a higher volume of manufacturers. Unless productivity gains also lead to an equally higher growth in demand for manufacturers, some workers in the manufacturing sectors will have to switch jobs to satisfy the higher demand in other sectors.

When one looks at the cross-section data, however, you do not find clear evidence that countries experiencing higher productivity growth in manufacturing are not experience faster decline in their manufacturing employments. See, e.g., Figure 4.7 of Obstfeld and Rogoff (1996), which show that countries like Germany and Japan experience slower (if any) declines in their manufacturing employments than countries like U.S. and U.K.

One might be tempted to read such cross-country evidence as a rejection of the productivity-based theories of manufacturing employment decline. Such a reading of the cross-country evidence, however, would be unwarranted, as it is implicitly making the assumption that each country is a closed economy, and offers an independent observation. The false assumption of closed economies makes a simple cross-country comparison misleading. The productivity-based theory argues that, when Japan experiences high productivity growth in manufacturing, some manufacturing workers will have to move to other sectors, so that the employment share of

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manufacturing in the world economy, the only closed economy that we know of, must decline. The productivity-based theory does not say that Japanese manufacturing workers will have to switch jobs; they may be American or British. Indeed, faster productivity growth in Japan implies a shift in Japan's comparative advantage toward manufacturing, so that the net effect on its national employment share is ambiguous.

2. A Ricardian Model of the World Economy.

The world consists of two economies, Home and Foreign. There are three goods, the numeraire *(O)*, the manufacturing good *(M)*, and the services *(S)*. The first two, *O* and *M*, can be traded costlessly, while *S* is nontraded. There is no production of the numeraire good; both economies are endowed with y units of the numeraire good. The economies are also endowed with one unit of labor, which can be converted to *M* or *S* by constant returns to scale technologies. Let A_M (A_M^*) and A_S (A_S^*) denote the labor productivity in the two sectors. (As usual, the asterisk denotes Foreign variables.) Let P_M be the international price of *M*, and W (W^*), and P_S (P_S^*) be the wage rate and the price of *S* at Home (Foreign). Perfect competition implies that

$$(1) \qquad P_M = \frac{W}{A_M} = \frac{W^*}{A_M^*}, \qquad P_S = \frac{W}{A_S}, \qquad P_S^* = \frac{W^*}{A_S^*},$$

if both economies produce *M* and *S*. For the moment, we proceed under the assumption that this condition holds. Later, we will show the parameter restrictions that ensure that this is indeed the case in equilibrium.

Each economy is populated by the representative consumer. Their preferences are given by

$$U(C_O, C_M, C_S) = \begin{cases} (C_O)^\alpha \left[\beta_M (C_M - \gamma)^\theta + \beta_S (C_S)^\theta\right]^{\frac{1-\alpha}{\theta}} & \text{for } \theta < 1, \theta \neq 0, \\ (C_O)^\alpha (C_M - \gamma)^{\beta_M(1-\alpha)} (C_S)^{\beta_S(1-\alpha)} & \text{for } \theta = 0, \end{cases}$$

at Home and

$$U(C_O^*, C_M^*, C_S^*) = \begin{cases} (C_O^*)^\alpha \left[\beta_M (C_M^* - \gamma)^\theta + \beta_S (C_S^*)^\theta\right]^{\frac{1-\alpha}{\theta}} & \text{for } \theta < 1, \theta \neq 0, \\ (C_O^*)^\alpha (C_M^* - \gamma)^{\beta_M(1-\alpha)} (C_S^*)^{\beta_S(1-\alpha)} & \text{for } \theta = 0, \end{cases}$$

at Foreign. We assume, for simplicity, that both Home and Foreign representative consumers share the same preferences. The two countries differ only in labor productivity of *M* and *S*. If $\gamma > 0$, the income elasticity of demand for the manufacturing good is less than one. If $\theta < 0$, the direct partial elasticity of substitution between *M* and *S*, $\sigma = 1/(1-\theta)$, is less than one, which means that an increase in the supply of *M* would cause a more-than-proportionate decline in the relative price of *M* over *S*.

The Home consumer maximizes utility subject to the budget constraint,

$$C_O + P_M C_M + P_S C_S \leq y + W ,$$

which yields the Home demand schedules for *O* and *S*:

$$(2) \qquad C_O = \alpha(y + W - \gamma P_M), \qquad C_S = \frac{(\beta_S)^\sigma (P_S)^{-\sigma}(1-\alpha)(y + W - \gamma P_M)}{(\beta_M)^\sigma (P_M)^{1-\sigma} + (\beta_S)^\sigma (P_S)^{1-\sigma}}$$

Likewise, the Foreign demand schedules for *O* and *S* are

$$(3) \qquad C_O^* = \alpha(y + W^* - \gamma P_M), \qquad C_S^* = \frac{(\beta_S)^\sigma (P_S^*)^{-\sigma}(1-\alpha)(y + W^* - \gamma P_M)}{(\beta_M)^\sigma (P_M)^{1-\sigma} + (\beta_S)^\sigma (P_S^*)^{1-\sigma}} .$$

The market clearing conditions in the numeraire good and in the nontraded services in each economy are given by

$$(4) \qquad C_O + C_O^* = 2y, \qquad C_S = A_S(1 - L_M), \qquad C_S^* = A_S^*(1 - L_M^*),$$

where L_M and L_M^* are the manufacturing share of employment at Home and Abroad.

Equations (1)-(4) can be combined to solve for the equilibrium value of the shares of manufacturing in employment, as follows:

$$(5) \qquad L_M = \frac{\frac{\alpha}{2}\left(1 - \frac{A_M^*}{A_M}\right) + \frac{\gamma}{A_M} + \left(\frac{\beta_M}{\beta_S}\right)^\sigma \left(\frac{A_S}{A_M}\right)^{1-\sigma}}{1 + \left(\frac{\beta_M}{\beta_S}\right)^\sigma \left(\frac{A_S}{A_M}\right)^{1-\sigma}}, \quad L_M^* = \frac{\frac{\alpha}{2}\left(1 - \frac{A_M}{A_M^*}\right) + \frac{\gamma}{A_M^*} + \left(\frac{\beta_M}{\beta_S}\right)^\sigma \left(\frac{A_S^*}{A_M^*}\right)^{1-\sigma}}{1 + \left(\frac{\beta_M}{\beta_S}\right)^\sigma \left(\frac{A_S^*}{A_M^*}\right)^{1-\sigma}},$$

Each of these expressions must take a value between zero and one in order for both economies to produce *M* and *S*. We shall thus impose the following parameter restrictions:

$$-\left(\frac{\beta_M}{\beta_S}\right)^{\sigma}\left(\frac{A_S}{A_M}\right)^{1-\sigma} < \frac{\alpha}{2}\left(1-\frac{A_M^*}{A_M}\right)+\frac{\gamma}{A_M} < 1; \quad -\left(\frac{\beta_M}{\beta_S}\right)^{\sigma}\left(\frac{A_S^*}{A_M^*}\right)^{1-\sigma} < \frac{\alpha}{2}\left(1-\frac{A_M}{A_M^*}\right)+\frac{\gamma}{A_M^*} < 1.$$

3. Comparative Statics

Let us now examine the effects of productivity changes in manufacturing. We will focus on two cases that capture the productivity-based theory of manufacturing declines in its essentials.

***Case I:* σ = 1 (θ = 0) and γ > 0.** In this case, equation (5) is simplified to

(6) $$L_M = \frac{\alpha(1-\beta)}{2}\left(1-\frac{A_M^*}{A_M}\right)+\frac{\gamma}{A_M}+\beta; \quad L_M^* = \frac{\alpha(1-\beta)}{2}\left(1-\frac{A_M}{A_M^*}\right)+\frac{\gamma}{A_M^*}+\beta,$$

where $\beta \equiv \beta_M/(\beta_M+\beta_S)$. It is easy to verify that

$$\frac{\Delta A_M}{A_M} = \frac{\Delta A_M^*}{A_M^*} > 0 \quad \rightarrow \quad \Delta L_M < 0,\ \Delta L_M^* < 0.$$

The condition, γ > 0, implies that the income elasticity of demand for M is less than one, which means that, with constant prices, an increase in demand for *M* due to the higher income does not keep up with an increase in the supply. The manufacturing employment thus declines because of the productivity gains in that sector.[2]

This condition does not ensure, however, that faster productivity in one country leads to a larger decline in the manufacturing employment in that economy. It is easy to verify that

$$\frac{\Delta A_M}{A_M} > 0 = \frac{\Delta A_M^*}{A_M^*} \rightarrow \quad \operatorname{sgn}\Delta L_M = \operatorname{sgn}\left[\frac{\alpha(1-\beta)}{2}-\frac{\gamma}{A_M^*}\right], \qquad \Delta L_M^* < 0.$$

Note that an increase in A_M affects the manufacturing employment at home, L_M, through two distinctive channels. The first is the income effect. If γ > 0 and hence the demand for *M* does not grow as fast as the national income, the income effect implies that productivity growth at home leads to a decline in manufacturing employment at home. The second is the trade effect. To the extent that productivity gains at home is larger than abroad, a shift in comparative advantage leads

[2] A large number of studies use similar non-homothetic preferences to explain structural change. See Matsuyama (forthcoming) for the reference.

to an increase in manufacturing employment at home. The combined effect of Home productivity growth in manufacturing on Home manufacturing employment is ambiguous. Its effect on Foreign manufacturing employment is unambiguously negative, because there is no income effect. Hence, if one regress the national share of manufacturing in employment on the national manufacturing productivity growth in the cross-country data, the effect would be positive. This does not constitute any evidence against the productivity-based theory of manufacturing employment decline.

Case II: γ = 0 and σ < 1 (θ < 0). In this case, equation (5) becomes:

$$(7) \qquad L_M = \frac{\frac{\alpha}{2}\left(1-\frac{A_M^*}{A_M}\right)+\left(\frac{\beta_M}{\beta_S}\right)^{\sigma}\left(\frac{A_S}{A_M}\right)^{1-\sigma}}{1+\left(\frac{\beta_M}{\beta_S}\right)^{\sigma}\left(\frac{A_S}{A_M}\right)^{1-\sigma}}; \qquad L_M^* = \frac{\frac{\alpha}{2}\left(1-\frac{A_M}{A_M^*}\right)+\left(\frac{\beta_M}{\beta_S}\right)^{\sigma}\left(\frac{A_S^*}{A_M^*}\right)^{1-\sigma}}{1+\left(\frac{\beta_M}{\beta_S}\right)^{\sigma}\left(\frac{A_S^*}{A_M^*}\right)^{1-\sigma}}$$

Again, it is easy to verify that

$$\frac{\Delta A_M}{A_M} = \frac{\Delta A_M^*}{A_M^*} > 0 \qquad \rightarrow \qquad \Delta L_M < 0,\ \Delta L_M^* < 0.$$

The condition, σ < 1 (θ < 0), implies that *M* is not very substitutable with *S*. As *M* becomes more productive, *S* becomes scarcer. An increase in the supply of *M* would thus bring down the relative price of M (and drive up the relative price of *S*) fast enough to shift labor away from the "progressive" *M* sector towards the "stagnant" *S* sector. Through its relative supply effect, the *M* sector experiences a decline in its employment because of its own productivity gains.[3]

As in Case I, however, the condition, σ < 1 (θ < 0), does not ensure that faster productivity in one country leads to a larger decline in the manufacturing employment in that economy. Again, this is because an increase in A_M affects the manufacturing employment at home, L_M, through two distinctive channels. The first is the relative supply effect, which works to reduce the employment in the Home manufacturing. The second is the trade effect, which works in the opposite direction. The combined effect of Home productivity growth in manufacturing on Home manufacturing

[3] The classical contribution for this mechanism is Baumol (1967).

employment is ambiguous. Its effect on Foreign manufacturing employment is unambiguously negative, as there is no relative supply effect. Again, if one regress the national share of manufacturing in employment on the national manufacturing productivity growth in the cross-country data, the effect would be positive, which does not constitute any evidence against the productivity-based theory of manufacturing employment decline.

4. Concluding Remarks.

Interpreting the cross-country evidence under the false assumption that each country in the date were in autarky and offered an independent observation can be highly misleading. Clearly, this note is not the first to make this point. See, for example, Matsuyama (1992), and more recently, Ventura (2005). Nevertheless, the vast majority of studies in macroeconomic growth and development continue to develop a closed-economy model and use the cross-country data to test the model under the false assumption.[4] It is time to start taking the simple truth; the only closed economy is our planet, the world economy.

References:

Baumol, W. J. "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis," American Economic Review, 57, June 1967, 415-426.

Matsuyama, K., "Agricultural Productivity, Comparative Advantage, and Economic Growth," Journal of Economic Theory 58, December 1992, 317-334.

Matsuyama, K, "Structural Change," in The New Palgrave Dictionary in Economics, 2nd Edition, edited by Lawrence Blume and Steven N. Durlauf, McMillan, forthcoming.

Obstfeld, M., and K. Rogoff, Foundations of International Macroeconomics, Cambridge, Masss, MIT Press, 1996.

Ventura, J., "Global View of Economic Growth," Chapter 22 in Handbook of Economic Growth. Vol, IB, edited by Philippe Aghion and Steven N. Durlauf, Amsterdam, Elsevier BV, 2005.

[4] This practice is common not only in macroeconomics but also in other fields. For example, many studies on national innovation policies on their effectiveness on encouraging the R&D activities look at the cross-country evidence without paying much attention to the fact that the US or European patent policies affect the incentive for innovation for exporting firms throughout the world.