STRUCTURAL CHANGE IN AN INTERDEPENDENT WORLD: A GLOBAL VIEW OF MANUFACTURING DECLINE

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Abstract

This paper presents a simple model of the world economy, in which productivity gains in manufacturing are responsible for the global trend of manufacturing decline, and yet, in cross-section of countries, faster productivity gains in manufacturing do not necessarily imply faster declines in manufacturing. In doing so, it aims to draw attention to the common pitfall of using the cross-country evidence to test a closed economy model, and argues for a global perspective; in order to understand cross-country patterns of structural change, one needs a world economy model in which the interdependence across countries is explicitly spelled out.

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1. Introduction

We live in the global economy where countries are interdependent with one another. Yet, most empirical studies of structural change write down a closed economy model, apply it to each country, and use the cross-country data to test the model. Effectively, they treat each country as an autarky as if these countries were still isolated fiefdoms in the Middle Ages or were located on different planets. This paper presents a simple example demonstrating how misleading this common practice can be in the context of productivity-based theory of manufacturing employment decline.[2]

In many countries, manufacturing employment has been declining over time. A common explanation for this general trend attributes it to productivity gains in manufacturing. With the rise in productivity, fewer workers are needed to produce a higher volume of manufacturing goods. Unless productivity gains also lead to an equally higher growth in demand for manufacturing goods, some workers in the manufacturing sectors will have to switch jobs to satisfy the higher demand in other sectors, such as services.

In cross-section of countries, however, it is difficult to find any evidence that a country with higher productivity growth in manufacturing experiences a faster decline in its manufacturing employment. See, e.g., Figure 4.7 of Obstfeld and Rogoff (1996), which shows that countries like Germany and Japan experience slower (if any) declines in their manufacturing employments than countries like U.S. and U.K. And some countries in the Pacific Rim countries, such as South Korea, Hong Kong, Taiwan, Vietnam, and Indonesia, have not shown a decline in their manufacturing employment shares.

One might be tempted to read such cross-country evidence as a rejection of the productivity-based theories of manufacturing employment decline.[3] Such a reading, however, is unwarranted, as it implicitly assumes that each country is a closed economy and offers an independent observation. The productivity-based

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[2]Although the first draft of this paper was originally written in February 1998, and circulated under the title, "Productivity-Based Theory of Manufacturing Employment Decline: A Global Perspective," I did not continue working on it afterwards. Only recently have I decided to resusticate it in view of the recent growing interest on the topic, as evident from Acemoglu and Guerrieri (2008), Buera and Kaboski (2006, 2007), and Ngai and Pissarides (2007), and others.

[3] For example, after pointing out that Japan's manufacturing employment share "has been roughly level since the mid-1970s," Obstfeld and Rogoff (1996, p.225) argued that, "Considering that Japan has had exceptionally high productivity growth in manufacturing relative to services, its experience is especially hard to square with productivity-based theories of manufacturing employment decline."

theory argues that, when South Korea experiences high productivity growth in manufacturing, manufacturing workers will have to move to other sectors *somewhere in the world*, thereby accelerating the global trend of the manufacturing employment decline. The productivity-based theory does *not* say that South Korean manufacturing workers would have to switch jobs; they could be instead, American, British, or Japanese. Indeed, to the extent that productivity gains in the South Korean manufacturing cause a shift in its comparative advantage toward manufacturing, we should expect the net effect on its national employment share to be ambiguous or even positive.

2. A Ricardian Model of the World Economy

The main message of this paper can be conveyed by many different models. The following Ricardian model of the world economy is chosen mostly because of its simplicity.

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 nontradeable. 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 asterisks denote Foreign variables.) To keep it simple, let us assume that the two countries may differ only in labor productivity in M and S.

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

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

if both economies produce M and S. For the moment, let us proceed under the assumption that this condition holds. Later, the necessary parameter restrictions will be imposed to ensure that this is indeed the case in equilibrium.

The Home representative consumer has the following form of Stone-Geary preferences:[4]

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[4] As I have argued elsewhere, the Stone-Geary specification of non-homothetic preferences used here is restrictive in many ways. First, the marginal property to consume each good is independent of income levels, so that aggregate demand is not affected by income distribution. Second, it is asymptotically homothetic; that

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

If $\gamma > 0$, M has a smaller income elasticity of demand than S.[5] If $\theta < 0$, the direct partial elasticity of substitution between M and S, $\sigma \equiv 1/(1-\theta)$, 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 representative consumer maximizes utility subject to the budget constraint, $C_O + P_M C_M + P_S C_S \leq y + W$. This yields the Home demand schedules for O and S:

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

Likewise, the Foreign demand schedules for O and S are

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

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is, the non-homotheticity disappears as the income level goes to infinity. This would pose a problem when one tries to fit the long run data, covering a wide range of income levels, as pointed out by Buera and Kaboski (2008). Third, it cannot be easily applied to a model with many consumption goods. Although there are alternative specifications that are not subject to these restrictions, such as the hierarchical demand system used by Matsuyama (2000, 2002), Buera and Kaboski (2006, 2007), and Foellmi and Zweimüller (2006, 2008, forthcoming), I believe that the Stone-Geary specification is adequate for the purpose of this paper, and use it for its simplicity.

[5] In contrast, no assumption will be made on the sign of γ_O. In earlier versions, it was assumed $\gamma_O = 0$, which might have given the false impression that it would be important for M to have a smaller income elasticity of demand than O. This would be awkward if O is interpreted as agriculture or mining, as pointed out by the referee. By allowing for $\gamma_O \neq 0$, this extension helps to show that the income elasticity of O itself plays no role in the analysis.

The market clearing conditions for the tradeable O in the world economy and for the nontradeable S in each economy are given by

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

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

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

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

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

Both L_M and L_M^* must take a value strictly between zero and one in order for both economies to produce M and S. This is ensured under the following parameter restrictions:

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

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

which is assumed to hold when conducting comparative static exercises.

Remark: Several readers have asked me why I have chosen a model with three goods, two tradable goods and one nontradable good. In particular, what is the role of the numeraire good, O, in the analysis? Just to show that productivity gains in the tradable sector, M, may cause labor to move from the tradable sector

M to the nontradable sector S, it would suffice to have a simpler model with two goods, M and S. However, in order for such processes of structural change from the tradable M to the nontradable S to become interdependent across countries, the presence of a second tradable sector is necessary.[6] Note that, as can easily be seen in (5), productivity changes in M in one country can have effects on the other country only when $\alpha > 0$. The assumption that O is not produced with labor and instead endowed is not essential; it is made solely to keep the algebra simple for a wide range of preference specification over M and S. Note that (5) is independent of y and γ_O. This simplicity is due to the two assumptions: non-production of O, and the Cobb-Douglas preferences between O and the other two goods, M and S.

3. Comparative Statics: Structural Change in an Interdependent World

To examine the effects of productivity gains in manufacturing, let us focus on two cases that capture the productivity-based theory of manufacturing declines in its essentials. The first case relies on income-elasticity differentials across sectors M and S. The second case relies on productivity differentials across sectors M and S.[7]

3.1. *Income-Elasticity Differentials across M & S*

Suppose $\sigma = 1$ ($\theta = 0$) and $\gamma > 0$. Then, equation (5) is simplified to

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

[6] One possible interpretation of O is agriculture or mining. Or it could be interpreted as tradeable services. Or it could be future goods or some sorts of financial claims.

[7] These two cases roughly correspond to what Acemoglu and Guerrieri (2008) call "demand-side" and "supply-side" explanations and what Ngai and Pissarides (2007) call "utility-based" and "technological" explanations. I view both cases as the "productivity-based" theory, because, in each case, productivity gains in manufacturing cause a decline in manufacturing employment. Needless to say, this is merely a matter of semantics, and nothing of importance hinges on these choices of terminology.

where $\beta \equiv \beta_M / (\beta_M + \beta_S)$. Note that, with $\sigma = 1$ ($\theta = 0$), these expressions are independent of A_S and A_S^*.

It is easy to verify that

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

The condition, $\gamma > 0$, implies that M has a smaller income elasticity of demand than S, which means that, with constant prices, an increase in the 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.[8]

This condition does not ensure, however, that a country with faster productivity gains in manufacturing experiences a larger decline in its manufacturing employment. It is easy to verify that

$$\frac{\Delta A_M}{A_M} > 0 = \frac{\Delta A_M^*}{A_M^*} \quad \Rightarrow \quad \operatorname{sgn} \Delta L_M \;=\; \operatorname{sgn}\left[\frac{\alpha}{2} - \frac{\gamma}{A_M^*}\right], \quad \Delta L_M^* < 0\,.$$

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 $\gamma > 0$ 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 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

[8] A large number of studies use non-homothetic preferences to introduce income-elasticity differentials across sectors as the main driving force behind structural change. For the reference, see Matsuyama (2008). Most of these studies use Stone-Geary preferences to explain the decline of agriculture and the rise of manufacturing in the context of early industrialization. The exceptions include Matsuyama (2002) and Foellmi and Zweimüller (forthcoming), which use hierarchical preferences to explain sequential birth and growth of new industries, and Buera and Kaboski (2006, 2007), which uses hierarchical preferences to explain the decline of manufacturing and the rise of services.

unambiguously negative, because there is no income effect. Hence, if one regresses the national share of manufacturing in employment on the national manufacturing productivity growth in the cross-country data, the effect could be positive. Such cross-country evidence hence cannot be interpreted against the productivity-based theory of manufacturing employment decline.

3.2. *Productivity Growth Differentials across M & S*

Suppose now that $\gamma = 0$ and $\sigma < 1$ ($\theta < 0$). Then, equation (5) becomes:

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

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

It is easy to verify that:

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

The condition, $\sigma < 1$ ($\theta < 0$), 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.[9]

As in the previous case, however, the condition, $\sigma < 1$ ($\theta < 0$), does not ensure that a country whose manufacturing productivity grows faster relative to services experiences a larger decline in its manufacturing employment. Again, this is because an increase in A_M/A_S affects the manufacturing employment at

[9] The classical contribution for this mechanism is Baumol (1967). This mechanism also plays an important role in Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008).

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 employment is ambiguous. Its effect on Foreign manufacturing employment is unambiguously negative, as the first effect is absent there. Again, if one regresses the national share of manufacturing in employment on the national manufacturing productivity growth in the cross-country data, the effect could be positive, which does not constitute any evidence against the productivity-based theory of manufacturing employment decline.

4. Concluding Remarks

Broadly stated, the productivity-based theory of manufacturing employment declines argues that productivity gains in manufacturing are responsible for the global trend for manufacturing employment declines in time series, observed in many countries. For the purpose of delivering this message, a closed economy model is quite adequate. However, it is wrong to test the predictions of such a closed economy model based on the cross-country evidence, under the false assumption that each country in the data were in autarky and offered an independent observation. Such a closed economy model is not designed to explain cross-country variations of manufacturing employment shares. If one is interested in explaining cross-country variations, one needs to adopt a global perspective. That is to say, one must write down a world economy model, where the interdependence among countries is explicitly spelled out.

Clearly, this paper is not the first to point out the common pitfall of using the cross-country evidence. For example, Matsuyama (1992) pointed it out in the context of reading the historical evidence of regional patterns of early industrialization. As many historians believe, the Industrial Revolution might not have been possible without the Agricultural Revolution that had preceded it. This statement is consistent with the evidence that countries and regions with less productive agricultural sectors were among the first to industrialize. Acemoglu and Ventura (2002) built an endogenous growth model of the world economy, which generates unbounded growth of the world economy *and* convergence of the growth rates across countries, thereby demonstrating that cross-country growth convergence should not be interpreted as the evidence against endogenous growth models; see Ventura (1997, 2005) for more on this issue. In these models, cross-country implications differ from time-series implications because countries interact with each other through international trade.

Once stated, the point made above should be quite intuitive. Yet, in my view, it has not attracted the attention it deserves. And the vast majority of empirical studies in macroeconomic growth and development continue to test a closed-economy model, using the cross-country data under the false assumption that each country offers an independent observation.[10] By drawing attention to the common pitfall that even good economists have stumbled over, this paper aimed to highlight the need for a global perspective. To guard against such pitfalls, we need to keep reminding ourselves of the simple truth; we live in an interdependent global economy and our planet, the world economy, is the only closed economy we know of.[11]

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[10] This practice is common not only among macroeconomists but also among economists in other fields. For example, many researchers have examined the effectiveness of different national innovation policies on encouraging the R&D activities by looking at the cross-country evidence. In doing so, they pay little (if any) attention to the possibility that the US or European patent policies affect the incentive for innovation for exporting firms throughout the world.

[11] One might expect that trade economists have already addressed these questions of how international trade affects the patterns of structural change or the effectiveness of national innovation policies. Unfortunately, and perhaps surprisingly to the outsider, very little has been done in the trade literature, either, because they are primarily concerned with explaining the patterns and volume of trade flows, taking the structural differences across countries as given. What is needed is a greater collaboration and exchange of ideas between international trade and other fields.

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