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JEL Classification: O11, O14, O33

Keywords: structural change, premature deindustrialization, sectoral productivity growth rate differences, adoption lags, technology gap

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A Technology-Gap Model of Premature Deindustrialization*

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Abstract

This paper presents a simple model of what Rodrik (2016) called "premature deindustrialization," the tendency that late industrializers reach their peaks of industrialization at lower levels of per capita income with the lower peak shares of manufacturing, compared to early industrializers. In this model, the hump-shaped path of the manufacturing share in each country is driven by the frontier technology whose productivity growth rate differs across the sectors. The countries are heterogenous in their "technology gaps," their capacity to adopt the frontier technology, which might affect adoption lags across sectors differently. In this setup, we show that premature deindustrialization occurs, for example, if adoption takes longer in the service sector, and yet the productivity growth rate in the service sector is sufficiently smaller such that cross-country productivity differences are smaller in the service sector.

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1. Introduction

In most countries, the share of manufacturing (measured in employment or value-added) followed an inverted U-shaped or hump-shaped path over the course of development, as well-documented by Herrendorf, Rogerson, and Valentinyi (2014). Recently, Rodrik (2016) presented the finding that recent industrializers entered the stage of deindustrialization at lower income levels with lower peak manufacturing shares, compared to more advanced economies that had industrialized earlier. See, in particular, Rodrik (2016, Figure 5). Rodrik called this finding "premature deindustrialization."

In this paper, we present a simple model of premature deindustrialization. The model has three sectors: agriculture, manufacturing, and services, which produce the consumption goods that are gross complements. As the frontier technology improves over time, productivity grows at an exogenously constant rate in each sector, which is the highest in agriculture, the lowest in services, with the manufacturing in the middle. This generates a hump-shaped path of the manufacturing in each country, as in Ngai and Pissarides (2007). The countries differ in their ability to adopt the frontier technology, which we call "technology gap," following Krugman (1985). Unlike Krugman, however, we allow for the possibility that the extent to which the country's technology gap affects its adoption lags varies across the sectors. Within this setup, we study under what conditions the model generates premature deindustrialization.

For example, suppose that the technology gap of a country affects its adoption lags in all sectors uniformly, so that adoption lags are the same in all sectors in each country. Then, poorer countries, which suffer from larger technology gaps, reach their peaks later than richer countries, but they reach the same peak shares of the manufacturing at the same level of the real per capita income. Instead, suppose that, for any given level of technology gap, technology adoption takes longer in the service sector than in agriculture and manufacturing, capturing the inherent difficulty of adoption in the service sector due to the intangible nature of its technology, and a larger technology gap magnifies the difference in the adoption lags across sectors. Yet, in spite of the longer adoption lag in the service sector, the productivity growth rate is sufficiently smaller in the service sector, so that productivity differences are smaller in services across countries, as observed empirically.[1] Then, we obtain premature deindustrialization, as poorer countries that suffer from larger technology gaps, reach the peak later and at the lower level of per capita income with the lower peak share of manufacturing, compared to richer countries with smaller technology gaps, which industrialized earlier.

In Section 2, we set up the three-sector model and solve for the equilibrium sectoral shares as functions of sectoral productivities. In Section 3, we introduce the frontier technology and adoption lags in each sector to obtain the hump-shaped pattern of manufacturing. In Section 4, we finally introduce technology gap differences across countries, and show under what conditions premature deindustrialization occurs. We conclude in Section 5.

2. The Model

Consider an economy with three competitive sectors, indexed by $j = 1,2,3$. Each sector produces a single consumption good, also indexed by $j = 1,2,3$. We interpret sector-1 as agriculture, sector-2 as manufacturing and sector-3 as services.

2.1 Households

The economy is populated by L identical households. Each household supplies one unit of labor, which is perfectly mobile across sectors, at the wage rate w and κ_j units of the factor specific to sector-j at the rental price, ρ_j, to earn income, $w + \sum_{j=1}^{3} \rho_j \kappa_j$. It spends its income to consume c_j units of good-j, purchased at the price, p_j, subject to the budget constraint,

$$\sum_{j=1}^{3} p_j c_j \leq E = w + \sum_{j=1}^{3} \rho_j \kappa_j, \tag{1}$$

to maximize its CES utility

$$U = \left[\sum_{j=1}^{3} (\beta_j)^{\frac{1}{\sigma}} (c_j)^{1-\frac{1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

[1] For example, Kravis, Heston and Summers (1982, p.8) wrote that "services are much cheaper in the relative price structure of a typical poor country than in that of a rich country." This finding has been confirmed by many subsequent studies.

where E denotes the per capita income (and expenditure) and $\beta_j > 0$ and $0 < \sigma < 1$, so that the three goods are gross complements. Maximizing eq.(2) subject to eq.(1) yields the household's expenditure shares,

$$\frac{p_j c_j}{E} = \frac{\beta_j \left(p_j\right)^{1-\sigma}}{\sum_{k=1}^{3} \beta_k (p_k)^{1-\sigma}} = \beta_j \left(\frac{p_j}{P}\right)^{1-\sigma} = \beta_j \left(\frac{E/p_j}{U}\right)^{\sigma-1}, \tag{3}$$

where

$$P = \left[\sum\nolimits_{k=1}^{3} \beta_k (p_k)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

is the cost-of-living index and

$$U = \frac{E}{P} = \frac{E}{\left[\sum_{k=1}^{3} \beta_k (p_k)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}} = \left[\sum\nolimits_{k=1}^{3} \beta_k \left(\frac{E}{p_k}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}}$$

is the real per capita income (and expenditure).

2.2. Production

Sector-j produces good-j, with its specific factor and labor as the inputs, by using the following Cobb-Douglas Technology:

$$Y_j = A_j \left(\kappa_j L\right)^{\alpha} \left(L_j\right)^{1-\alpha}, \tag{4}$$

where $A_j > 0$ is the TFP of sector-j; $\kappa_j L$ is the total supply of specific factor-j; and L_j is the labor employed in sector-j, with $\alpha \in [0,1)$ being the share of specific factor. Labor employed in the three sectors are subject to the labor supply constraint:

$$\sum\nolimits_{j=1}^{3} L_j = L. \tag{5}$$

From eq.(4), output per worker and output per capita in sector-j can be expressed as:

$$\frac{Y_j}{L_j} = \tilde{A}_j \left(s_j\right)^{-\alpha}; \qquad \frac{Y_j}{L} = \tilde{A}_j \left(s_j\right)^{1-\alpha} \tag{6}$$

where $\tilde{A}_j \equiv A_j \left(\kappa_j\right)^{\alpha}$ and $s_j \equiv L_j / L$ is the employment share of sector-j with

$$\sum\nolimits_{j=1}^{3} s_j = 1. \tag{7}$$

Firms in each sector chooses the inputs to minimize their cost of production, while taking the wage rate w and the rental price ρ_j given. Under the Cobb-Douglas technology, eq.(4), this leads to:

$$wL_j = (1-\alpha)p_jY_j; \qquad \rho_j\kappa_jL = \alpha p_jY_j$$

Thus, the shares of labor and of the specific factor in the value-added of each sector are $1-\alpha$ and α respectively, which are common across all sectors. Using the household budget constraint, eq.(1), this implies the aggregate budget constraint, $EL = \sum_{j=1}^{3} p_jY_j$. Furthermore, using the labor supply constraint, eq.(5), the sectoral shares measured in labor employment are equal to those measured in value-added.

$$s_j \equiv \frac{L_j}{L} = \frac{p_jY_j}{\sum_{k=1}^{3} p_kY_k} = \frac{p_jY_j}{EL}. \tag{8}$$

2.3 Equilibrium

From eq.(6) and eq.(8), we obtain

$$\frac{E}{p_j} = \frac{Y_j}{L_j} = \tilde{A}_j(s_j)^{-\alpha}. \tag{9}$$

By inserting this expression in eq.(3), the expenditure shares can now be expressed as:

$$\frac{p_jc_j}{E} = \beta_j\left(\frac{\tilde{A}_j(s_j)^{-\alpha}}{U}\right)^{\sigma-1}.$$

Since the expenditure shares are equal to the value-added (and employment) shares,

$$s_j = \frac{p_jY_j}{\sum_{k=1}^{3} p_kY_k} = \frac{p_jY_j}{EL} = \frac{p_jc_j}{E} = \beta_j\left(\frac{\tilde{A}_j(s_j)^{-\alpha}}{U}\right)^{\sigma-1}.$$

Solving this equation for s_j yields

$$s_j = \frac{\left[\beta_j^{\frac{1}{\sigma-1}}\tilde{A}_j\right]^{-a}}{U^{-a}},$$

where

$$a \equiv \frac{1-\sigma}{1-\alpha(1-\sigma)} > 0.$$

Then, by using the adding up constraint, eq.(7), this implies

$$s_j = \frac{\left[\beta_j^{\frac{1}{\sigma-1}}\tilde{A}_j\right]^{-a}}{\sum_{k=1}^{3}\left[\beta_k^{\frac{1}{\sigma-1}}\tilde{A}_k\right]^{-a}} \tag{10}$$

$$U = \left\{\sum_{k=1}^{3}\left[\beta_k^{\frac{1}{\sigma-1}}\tilde{A}_k\right]^{-a}\right\}^{-\frac{1}{a}} \tag{11}$$

Eq.(10) and eq.(11) show the equilibrium values of the sectoral shares (measured in employment, value-added, and expenditure) and of the real per capita income, as functions of the sectoral productivities, $\{\tilde{A}_j\}_{j=1}^{3}$.

3. Productivity Growth Rates, Adoption Lags and Structural Change

Let us now see how the sectoral shares respond to the sectoral productivities change over time.[2] Suppose that $\{\tilde{A}_j(t)\}_{j=1}^{3}$ change according to:

$$\tilde{A}_j(t) = \bar{A}_j(t-\lambda_j) = \bar{A}_j(0)e^{g_j(t-\lambda_j)} = \bar{A}_j(0)e^{-\lambda_j g_j}e^{g_j t}, \tag{12}$$

with $g_j > 0.$ and $\lambda_j \geq 0$, while the other parameters stay constant.[3] Here, $\bar{A}_j(t) = \bar{A}_j(0)e^{g_j t}$ is the frontier technology in sector-j at time t, which grows at a constant rate $g_j > 0$. With $\tilde{A}_j(t) = \bar{A}_j(t-\lambda_j)$, λ_j represents the adoption lag in sector-j. Note that both the growth rates and the adoption lags are sector-specific. Note also that the adoption lag in each sector does not affect the productivity growth rate of that sector. However, the "level" effect of the adoption lags, $e^{-\lambda_j g_j}$, depends on the growth rate. A large adoption lag would not matter much in a sector with slow productivity growth, but even a small adoption lag would matter a lot in a sector with fast productivity growth, a feature that plays a crucial role later. For the moment, "the base year," $t = 0$, is chosen arbitrarily, but we will later set the calendar time to ease the notation.

Inserting eq.(12) into eq.(11) yields the time path of the real per capita income:

$$U(t) = \left\{\sum_{k=1}^{3}\left[(\beta_k)^{\frac{1}{\sigma-1}}\bar{A}_k(0)e^{g_k(t-\lambda_k)}\right]^{-a}\right\}^{-\frac{1}{a}} \tag{13}$$

Clearly, larger adoption lags would shift down the time path of $U(t)$.

To understand the patterns of structural change, let us first take the ratio of the shares of two sectors, j and $k \neq j$, given in eq.(10) and using eq.(12), to obtain:

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[2] Without any means to save, the equilibrium path of this economy can be viewed as a sequence of the static equilibrium.

[3] Since $\tilde{A}_j \equiv A_j(\kappa_j)^{\alpha}$, g_j includes both the growth rate of A_j and the growth rate of κ_j.

$$\frac{s_j(t)}{s_k(t)} = \left[\left(\frac{\beta_j}{\beta_k}\right)^{\frac{1}{\sigma-1}}\left(\frac{\tilde{A}_j(t)}{\tilde{A}_k(t)}\right)\right]^{-a} = \left[\left(\frac{\beta_j}{\beta_k}\right)^{\frac{1}{\sigma-1}}\left(\frac{\bar{A}_j(t-\lambda_j)}{\bar{A}_j(t-\lambda_k)}\right)\right]^{-a} \tag{14}$$

$$= \left(\frac{\tilde{\beta}_j}{\tilde{\beta}_k}\right) e^{a(\lambda_j g_j - \lambda_k g_k)} e^{-a(g_j - g_k)t}$$

where

$$\tilde{\beta}_j \equiv \left(\beta_j^{\frac{1}{\sigma-1}} \bar{A}_j(0)\right)^{-a} > 0.$$

Eq.(14) shows that, with the two sectors producing gross complements ($a > 0$ because $\sigma < 1$), $s_j(t)/s_k(t)$ is decreasing over time if $g_j > g_k$, and increasing over time if $g_j < g_k$. That is, the sectoral shares shift from sectors with faster productivity growth to those with slower productivity growth over time. In contrast, the adoption lags have no effect on the direction of the sector changes *over time*, but they shifts the time path, with a higher $\lambda_j g_j - \lambda_k g_k$ raising $s_j(t)/s_k(t)$ at any point in time.

Likewise, using eq.(9) and eq.(14), the relative price can be expressed as:

$$\frac{p_j(t)}{p_k(t)} = \left(\left(\frac{\beta_j}{\beta_k}\right)^{\alpha}\left(\frac{\bar{A}_k(0)}{\bar{A}_j(0)}\right)\right)^{\frac{a}{1-\sigma}} e^{\frac{a(g_k - g_j)t}{1-\sigma}} e^{\frac{a(\lambda_j g_j - \lambda_k g_k)}{1-\sigma}} \tag{15}$$

Eq.(15) shows that $p_j(t)/p_k(t)$ is decreasing over time if $g_j > g_k$, and increasing over time if $g_j < g_k$, so that slower productivity growth causes its relative price to go up over time. In contrast, the adoption lags shift the time path, with a higher $\lambda_j g_j - \lambda_k g_k$ raising $p_j(t)/p_k(t)$ at any point in time.

In what follows, we restrict ourselves to the case of $g_1 > g_2 > g_3 > 0$, to generate the patterns of structural change, well documented, for example, by Herrendorf, Rogerson, Valentinyi (2014), based on the mechanism put forward by Ngai and Pissarides (2007). That is, the share of agriculture, $s_1(t)$, is decreasing over time because

$$\frac{1}{s_1(t)} = \frac{s_1(t) + s_2(t) + s_3(t)}{s_1(t)} = 1 + \frac{s_2(t)}{s_1(t)} + \frac{s_3(t)}{s_1(t)},$$

with both the 2nd and 3rd terms increasing; the share of services, $s_3(t)$, is increasing over time, because

$$\frac{1}{s_3(t)} = \frac{s_1(t) + s_2(t) + s_3(t)}{s_3(t)} = \frac{s_1(t)}{s_3(t)} + \frac{s_2(t)}{s_3(t)} + 1,$$

with both the 1st and 2nd terms decreasing; and the share of manufacturing; $s_2(t)$, is hump-shaped, because

$$\frac{1}{s_2(t)} = \frac{s_1(t) + s_2(t) + s_3(t)}{s_2(t)} = \frac{s_1(t)}{s_2(t)} + 1 + \frac{s_3(t)}{s_2(t)} \tag{16}$$

$$= \left[\frac{\tilde{\beta}_1}{\tilde{\beta}_2} e^{a(\lambda_1 g_1 - \lambda_2 g_2)}\right] e^{-a(g_1 - g_2)t} + 1 + \left[\frac{\tilde{\beta}_3}{\tilde{\beta}_2} e^{a(\lambda_3 g_3 - \lambda_2 g_2)}\right] e^{a(g_2 - g_3)t},$$

with the 1st term exponentially decreasing and the 3rd term exponentially increasing.

Differentiating eq.(16) with respect to t yields the peak time of the manufacturing share as:

$$\hat{t} = \frac{\lambda_1 g_1 - \lambda_3 g_3}{g_1 - g_3} + \hat{t}_0,$$

where

$$\hat{t}_0 \equiv \frac{1}{a(g_1 - g_3)} \ln\left(\frac{g_1 - g_2}{g_2 - g_3}\right)\left(\frac{\tilde{\beta}_1}{\tilde{\beta}_3}\right).$$

Using $\tilde{\beta}_j \equiv \left(\beta_j^{\frac{1}{\sigma-1}} \bar{A}_j(0)\right)^{-a} > 0$, this can be rewritten as

$$\left(\frac{\beta_1}{\beta_3}\right)^{\frac{1}{\sigma-1}} \frac{\bar{A}_1(\hat{t}_0)}{\bar{A}_3(\hat{t}_0)} = \left(\frac{g_1 - g_2}{g_2 - g_3}\right)^{\frac{1}{a}}.$$

In what follows, we reset the calendar time to simplify the notation, such that $\hat{t}_0 = 0$ and

$$\hat{t} = \frac{\lambda_1 g_1 - \lambda_3 g_3}{g_1 - g_3}. \tag{17}$$

This choice of the calendar time also implies that, if an economy could use the frontier technology without any adoption lag, the share of the manufacturing sector would peak at $\hat{t} = \hat{t}_0 = 0$, so that eq.(17) shows how adoption lags affect the peak time. Notice that a larger λ_1, which makes the relative productivity of the agriculture sector lower and hence agriculture relatively more expensive, causes a further delay in the manufacturing peak, while a larger λ_3, which makes the relative productivity of the service sector lower and hence services relatively more expensive, reduces a delay in the manufacturing peak.

From eq.(17), simple algebra can verify:

$$g_1(\hat{t}-\lambda_1) = g_3(\hat{t}-\lambda_3) = \left(\frac{\lambda_1-\lambda_3}{g_1-g_3}\right) g_1 g_3;$$

$$g_2(\hat{t}-\lambda_2) = \frac{(\lambda_1-\lambda_2)g_1g_2 + (\lambda_2-\lambda_3)g_2g_3}{g_1-g_3}.$$

Using these expressions, the peak manufacturing share, $\widehat{s_2} \equiv s_2(\hat{t})$, can be derived as:

$$\frac{1}{\widehat{s_2}} = 1 + \left(\frac{\tilde{\beta}_1+\tilde{\beta}_3}{\tilde{\beta}_2}\right) e^{\frac{a[(\lambda_1-\lambda_2)g_1g_2 + (\lambda_2-\lambda_3)g_2g_3 + (\lambda_3-\lambda_1)g_3g_1]}{g_1-g_3}} \tag{18}$$

and the real per capita income at the peak, $\widehat{U} \equiv U(\hat{t})$, as:

$$\widehat{U} = \left\{(\tilde{\beta}_1+\tilde{\beta}_3)e^{-a\left(\frac{\lambda_1-\lambda_3}{g_1-g_3}\right)g_1g_3} + \tilde{\beta}_2 e^{-a\frac{(\lambda_1-\lambda_2)g_1g_2+(\lambda_2-\lambda_3)g_2g_3}{g_1-g_3}}\right\}^{-\frac{1}{a}}. \tag{19}$$

4. Technology Gaps and Premature Deindustrialization

Now imagine that there are many countries, whose adoption lags are given by $(\lambda_1, \lambda_2, \lambda_3) = (\theta_1, \theta_2, 1)\lambda$, with λ varying across countries. The countries are otherwise identical, including $\theta_1 > 0$ and $\theta_2 > 0$. Thus, the countries differ in one dimension, λ. The idea is that each country tries to adopt the frontier technologies, which keep improving at exogenously constant growth rates, but the countries differ in their ability to adopt, indexed by the country-specific parameter, λ, which we shall call "technology gap," following Krugman (1985). Unlike Krugman (1985), who assumed $\lambda_j = \lambda$ in all sectors, we allow for the possibility that the extent to which technology gap affects the adoption lag varies across sectors. That is, θ_1 and θ_2 are sector-specific parameters, common across countries, capturing the inherent difficulty of adoption in the agriculture and manufacturing sectors, relative to the service sector.

First, consider the case where $\theta_1 = \theta_2 = 1$, so that $\lambda_1 = \lambda_2 = \lambda_3 = \lambda > 0$, as in Krugman (1985). Then, from eqs.(17)-(19),

$$\hat{t} = \lambda; \quad \frac{1}{\widehat{s_2}} = 1 + \left(\frac{\tilde{\beta}_1+\tilde{\beta}_3}{\tilde{\beta}_2}\right); \quad \widehat{U} = \left(\tilde{\beta}_1+\tilde{\beta}_2+\tilde{\beta}_3\right)^{-\frac{1}{a}}.$$

Thus, if technology gaps affect the adoption lags in all the sectors uniformly, they cause a delay in the peak time by $\lambda > 0$, but they do not affect the peak manufacturing share and the real per capita income at the time of the peak. This means that poorer countries that suffer from larger technology gaps are late industrializers, with a larger $\hat{t} = \lambda$, but they reach the same peak manufacturing share at the same level of the real per capita income as earlier industrializers with a smaller $\hat{t} = \lambda$.

Now, consider the case where $\theta_1 = \theta_2 = \theta$ with $g_3/g_2 < \theta < 1$. The condition, $\theta < 1$, implies

$$\lambda_1 = \lambda_2 < \lambda_3.$$

This means that technology adoption takes longer in the service sector than in the agriculture and manufacturing sector, capturing the inherent difficulty of adoption in the service sector due to the intangible nature of its technology. The condition, $\theta > g_3/g_2$, ensures $\theta g_1, \theta g_2 > g_3$ and hence,

$$\lambda_1 g_1, \lambda_2 g_2 > \lambda_3 g_3.$$

From eq.(15), this implies that, in spite of the longer adoption lag in the service sector, the productivity growth rate is sufficiently smaller in the service sector, so that cross-country productivity differences are smaller in services, and equivalently that the services are relatively cheaper in poorer countries, as observed empirically by Kravis, Heston and Summers (1982) and many others.

Then, from eqs.(17)-(19),

$$\hat{t} = \left(\frac{\theta g_1 - g_3}{g_1 - g_3}\right)\lambda.$$

$$\frac{1}{\widehat{s_2}} = 1 + \left(\frac{\tilde{\beta}_1 + \tilde{\beta}_3}{\tilde{\beta}_2}\right) e^{\frac{a(g_1 - g_2)g_3}{g_1 - g_3}(1-\theta)\lambda}$$

$$\widehat{U} = \left\{\left(\tilde{\beta}_1 + \tilde{\beta}_3\right) e^{\frac{a g_1 g_3}{g_1 - g_3}(1-\theta)\lambda} + \tilde{\beta}_2 e^{\frac{a g_2 g_3}{g_1 - g_3}(1-\theta)\lambda}\right\}^{-\frac{1}{a}}.$$

This case thus generates premature deindustrialization. Poorer countries that suffer from bigger technology gaps, λ, are late industrializers in the sense that they reach their peaks later ($\hat{t}$ is larger), have smaller peak manufacturing shares, $\widehat{s_2}$, and reach their peaks at the lower levels of the per capita income, $\widehat{U}$, compared to richer, early industrializers with smaller technology gaps, λ.

Figure 1 illustrates this case with $g_1 = .10 > g_2 = .06 > g_3 = .02$, $\theta = .35$, $\alpha = 1/3$, and $\sigma = 0.6$ (hence $a = 6/13$). The other parameters are chosen such that $\ln \widehat{U} = 0$ and $\hat{t} = 0$ for $\lambda = 0$.[4] The hump-shaped curves, each capturing the rise and fall of the

[4]They are $\beta_j = 1$, $\bar{A}_j(0) = 3^{1/a} = 3^{13/6} = 10.8\ldots$, so that $\tilde{\beta}_j = 1/3$ for $j = 1,2,3$.

manufacturing sector, are plotted for $\lambda = 0$, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, using eq.(13) and eq.(16). The left panel shows the time paths of $s_2(t)$, which shows that a higher λ causes a delay in the timing of the peak. The right panel traces the movement of $\left(\ln U(t), s_2(t)\right)$, which shows that a bigger technology gap λ shifts the curve down and to the left, with the upward-sloping line connecting the peaks, which captures premature deindustrialization.

More generally, what are the conditions for premature deindustrialization? From eq.(17), the condition for $\hat{t}$ increasing in λ is given by $\theta_1 > g_3/g_1$, whose boundary is depicted by the vertical line, $\theta_1 = g_3/g_1$, in Figure 2. From eq.(18), the condition for $\widehat{s_2}$ decreasing in λ is:

$$\left(\frac{g_2}{g_3} - 1\right)\left(\theta_1 \frac{g_1}{g_3} - 1\right) > \left(\frac{g_1}{g_3} - 1\right)\left(\theta_2 \frac{g_2}{g_3} - 1\right),$$

whose boundary is depicted by the line connecting $(\theta_1, \theta_2) = (g_3/g_1, g_3/g_2)$ and $(\theta_1, \theta_2) = (1,1)$, in Figure 2. From eq.(19), the condition for $\widehat{U}$ decreasing in λ is:

$$\left(\frac{g_1}{g_3} - 1\right)\theta_2 > \left(\theta_1 \frac{g_1}{g_3} - 1\right),$$

whose boundary is depicted by the line connecting $(\theta_1, \theta_2) = (g_3/g_1, 0)$ and $(\theta_1, \theta_2) = (1,1)$, in Figure 2. Thus, when (θ_1, θ_2) belongs to the triangle area in Figure 2, poorer countries with bigger technology gaps λ reach their peaks of the manufacturing share later at lower levels of the real per capita income with lower peak shares of the manufacturing sectors.

5. Concluding Remarks

In this paper, we developed a simple model of Rodrik's (2016) premature deindustrialization. We have done so by combining the mechanism of structural change due to the exogenous productivity growth rate differences across sectors, as in Ngai and Pissarides (2007), with heterogeneity across countries due to the technology gap, as in Krugman (1985), with an additional element, which allows the technology gap of a country to have disproportionate impacts on its adoption lags across sectors.

Needless to say, we are not claiming that the countries differ only in their capacity to adopt the frontier technology. Nor do we argue that our mechanism is the sole cause for premature deindustrialization. After all, differential productivity growth rate across sectors is not the only mechanism capable of generating a hump-shaped path of the manufacturing sector. As pointed out by Herrendorf, Rogerson and Valentinyi (2014) in their survey article, another well-known mechanism is income elasticity differentials across sectors. See also Comin, Lashkari, and Mestieri (forthcoming) and Matsuyama (2019) for recent examples. It would be interesting to see what types of country heterogeneity could explain premature deindustrialization in models of structural change based on income elasticity differentials.

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Figure 1: Premature Deindustrialization

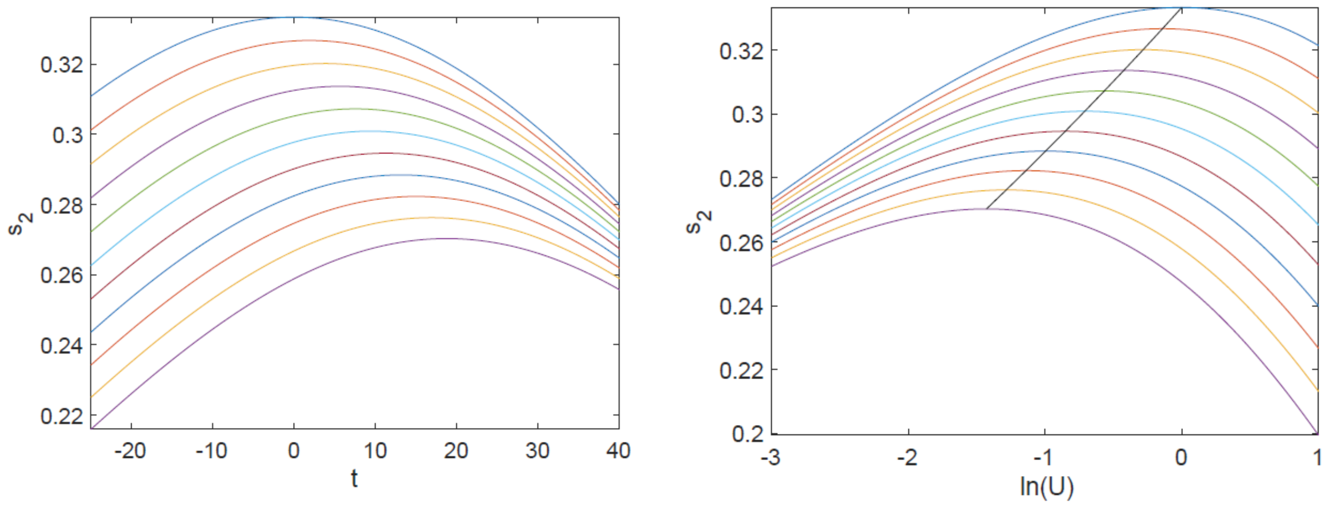

Figure 2: Conditions for Premature Deindustrialization