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# Offshoring Production: A Simple Model of Wages, Productivity, and Growth\*

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## Abstract

We examine the relationship between offshoring and the labour market in an occupational choice model of trade and endogenous growth where workers are employed on the basis of their individual skill levels. Trade liberalization leads to offshoring and reduces employment in the manufacturing sector. Displaced workers move into the traditional and innovation sectors according to their skill levels, shaping real wages and aggregate productivity in the manufacturing sector. The paper aims to show how inter-sectoral labour market adjustments, highlighted by skill heterogeneity, could be a possible explanation for the simultaneous rise in productivity and reduction in real wages that have coincided with the sharp escalation of offshoring activities in the US manufacturing sector since 2004.

**Keywords:** F16, F23, J24.

**J.E.L. Classification:** offshoring, trade liberalization, real wages, growth, productivity, inter-sectoral labour reallocation, skill heterogeneity.

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# 1 Introduction

The theme of globalization has evolved with the changing emphasis of the debate about the costs and benefits of greater integration of the world economy. In the beginning, debate focused on free trade. Then during the 1990's significantly greater growth in foreign direct investment (FDI) over that in trade in goods made FDI, and related issues such as labour and environmental standards, the main theme of globalization. Over the last decade, the emergence of China and India has highlighted the importance of intra-industry trade and the offshoring of different stages of production. The debate on the consequences of globalization continues with offshoring as the main focus now.

Sharply differing views on offshoring have created confusion in major industrial nations about its economic consequences. Offshoring is seen chiefly as a cost-saving strategy for firms, who at times see it as their only means of survival. It has also been associated with increased profitability, enhanced productivity, and stronger long-run economic growth. Shifting the spotlight from profits to people, typically consumers should also benefit from the lower prices that follow such cost-saving strategies. Yet these same consumers, relabeled as workers, tend to be at the center of widespread public concerns associated with offshoring: loss of jobs, lower wages, and in turn, lower standards of living.

The impact of offshoring is not the same for all industries and workers in society. In particular, the skill levels of workers play a decisive role in determining who gains and who loses. Offshoring activities are often thought to exploit lower labour costs in the South, making newly employed Southern workers better off at the expense of displaced lower skilled workers in the North. This is also sometimes associated with additional downward pressure on the wages of other workers still employed in the home country. Grossman and Rossi-Hansberg (2006) have gone one step beyond traditional trade models to show how offshoring particular tasks could have a positive impact on the real wages of all workers. While they study the international trade in tasks, in a setting where skills are homogeneous within each sector, we focus on the consequences of offshoring caused by the inter-sectoral mobility of workers with heterogeneous skill levels. Indeed, the impact of this sectoral reallocation of labour and/or manufacturing activities on the fate of workers has recently

been emphasized by several articles such as Olsen (2006) and Bernard, Jensen and Schott (2004): some workers move to inferior jobs, while others are promoted to new jobs created by opportunities opened up through trade. This double dimension could reveal a number of missing links between offshoring and the labour market that are not explained by traditional trade models.

[figure 1 about here]

We construct a simple theoretical model of offshoring to explain a number of contradictory stylized facts about offshoring and the labour market in the US manufacturing sector over the last decade. Figure 1 illustrates the recent offshoring trend and, in particular, highlights the sharp escalation in the offshoring activities of US manufacturing firms since 2004. While the first panel shows total real imports of goods into the US, the second and third panels show a rise in US direct investments abroad and an increase in imports from foreign affiliates to parent firms in the US. Our model offers a possible explanation of how these trends can be associated with a series of stylized facts for the US labour market over the same period, namely a simultaneous (1) fall in employment, (2) rise in productivity, and (3) reduction of wages in the manufacturing sector.<sup>1</sup> Figure 2 summarizes these trends showing that the growth in offshoring and the fall in employment have been accompanied by an increase in productivity in this sector on the one hand and lower real wages since 2004 on the other.<sup>2</sup>

[figure 2 about here]

To study the puzzling negative relationship between labour productivity and real wages, we view this phenomenon from the occupational choice perspective pioneered by Roy (1951) and applied in an international trade context by Yeaple (2005). In addition, we incorporate an innovation sector into the model using an endogenous growth framework à la Grossman and Helpman (1991). For

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<sup>1</sup>Economists have to a large extent concentrated on the relative wages between skilled and unskilled workers in industrialized countries. For instance, Ekholm and Ulltveit-Moe (2007) build a theoretical model to explain the bell-shaped evolution of relative wages between different skill segments in the US economy over the last three decades.

<sup>2</sup>Baily and Lawrence (2004) for instance argue that the basic reason for the decline in US manufacturing employment is that although demand for the output of this sector has grown about as quickly as GDP, it has not grown fast enough to offset the productivity growth in this sector. They see the rise of trade and offshoring and this increase in productivity among the main factors explaining the loss of jobs in the manufacturing sector.

the purposes of this paper we assume that product varieties are only developed in the North, and we refer to offshoring as a shift of production to an export platform, from which finished goods are exported back to the country of origin for consumption.<sup>3</sup> The incentive for this production shift is created by a decrease in trade costs which increases the accessibility of the Northern market for manufacturing goods produced with lower labour costs in the South. Our model shows that labour market adjustments between a traditional sector that does not require skills and a manufacturing sector that employs workers with intermediate skill levels determine the real wages of workers in each sector. The shift of the lowest skilled workers to this residual sector results in lower real wages in the manufacturing sector. We also show how the impact of offshoring on productivity depends on the degrees to which the traditional and innovation sectors respectively absorb low and high skilled workers released from the manufacturing sector.

The model also provides several secondary results in accordance with the existing literature on policy issues and the future of offshoring. These are (1) stimulated innovation and enhanced growth in the North, (2) increased wage inequality in the South, and (3) increased wage inequality in the North between the skilled and the unskilled. Economists who see offshoring as an opportunity to increase productivity and growth often dismiss competition concerns that arise from free access to a large low-wage global labour pool. As put forward by Mankiw and Swagel (2006) offshoring appears to increase US employment and investment due to new jobs created both in the US and abroad. In an estimate for the year 2015, Baily and Lawrence (2004) predict that offshoring will enhance economic growth in the US.<sup>4</sup> In one of the few other empirical studies on offshoring and growth, Mann (2003, 2006) explores the effects of information hardware technology offshoring on the US economy. She finds that offshoring is linked to dynamic gains, i.e. increased real GDP. On increased wage inequality in the North, empirical findings such as Hijzen (2007) find evidence of rising wage inequality between low and high skilled workers as a result of technological change and offshoring.<sup>5</sup> Finally, our results on increased wage inequality in the South complement those of Antras, Garciano

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<sup>3</sup>Bond (2001) uses a similar concept to discuss fragmented production.

<sup>4</sup>They perform simulations using a large-scale-macro-econometric model to find that US GDP, real compensation of employees, and real profits will be higher in 2015 as a result of the lower prices of imports associated with offshoring.

<sup>5</sup>See also Feenstra and Hanson (1996, 2003).

and Rossi-Hansberg (2006), where globalization always leads to better employment matches for Southern workers.

The remainder of the paper proceeds as follows. Section 2 introduces the basic model and derives the conditions for the steady-state. Section 3 examines the results of a comparative static analysis. Concluding remarks are given in section 4. All proofs and derivations are provided in the Appendix.

## 2 The model

We consider a simple model of trade and endogenous growth with two countries, North and South, and two factors, labour and land. Labour and land are both used in the production of traditional goods ( $Y$ ), but the manufacturing ( $X$ ) and innovation ( $I$ ) sectors only employ labour. Asymmetries exist between the production structures of the North and South. While both countries produce traditional goods, only the North is capable of developing new product designs through investment in the sole innovation sector. Product designs are used to produce varieties in the manufacturing sector, but the location of this production depends on whether firms decide to produce domestically or offshore production to the South. The share of the manufacturing industry located in each country depends on this offshoring decision.

### 2.1 Preferences

The preferences of households in the North and South differ with respect to the expenditure-savings decision. A representative household in the North has the following lifetime utility function:

$$U = \int_0^{\infty} \ln [C_X(t)^\alpha C_Y(t)^{1-\alpha}] e^{-\rho t} dt,$$

where  $C_X(t)$  and  $C_Y(t)$  are the respective consumptions of a manufacturing composite and the traditional good at time  $t$ ,  $\rho$  is the discount rate, and  $0 < \alpha < 1$  is a parameter that determines the expenditure shares for each good. The manufacturing composite takes the form of a CES quantity index and is given by

$$C_X = \left[ \int_0^{n(t)} x(i, t)^{\frac{\sigma-1}{\sigma}} di + \int_0^{n(t)^*} x^*(j, t)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}, \quad (1)$$

where  $x(i, t)$  and  $x(j, t)^*$  are the consumptions of varieties  $i$  and  $j$ ,  $n(t)$  and  $n(t)^*$  are the numbers of varieties supplied by the North and South, and  $\sigma > 1$  is the elasticity of substitution between any two varieties. Intertemporal utility maximization requires that households choose an optimal expenditure path that satisfies a standard transversality condition and follows the basic Ramsey saving rule as described by the following Euler equation:

$$\frac{\dot{E}(t)}{E(t)} = R(t) - \rho, \quad (2)$$

where  $E(t)$  is expenditure,  $R(t)$  is the nominal rate of return on a risk-free asset, and a dot over a variable denotes differentiation with respect to time.

In contrast, households in the South consume only the traditional good. Furthermore, Southern households have no access to the investment market and in each period use all income for consumption. Hence, the utility function for Southern households is  $U(t)^* = C_Y(t)^*$ , where an asterisk is used to denote variables associated with the South.

In each period, households allocate fixed shares of expenditure to each sector. For the traditional sector we have

$$P_Y(t)C_Y(t) = (1 - \alpha)E(t) \quad \text{and} \quad P_Y^*(t)C_Y^*(t) = E^*(t), \quad (3)$$

where  $P_Y(t)$  and  $P_Y^*(t)$  are the prices for traditional goods in the North and South, and for the manufacturing sector we have

$$P_X(t)X(t) = \alpha E(t). \quad (4)$$

$P_X(t)$  is a CES price index associated with manufacturing varieties:

$$P_X(t) = \left[ \int_0^{n(t)} p(i, t)^{1-\sigma} di + \int_0^{n^*(t)} p^*(j, t)^{1-\sigma} dj \right]^{\frac{1}{1-\sigma}}, \quad (5)$$

where  $p(i, t)$  and  $p^*(j, t)$  are the prices paid for goods  $i$  and  $j$ , which have been produced in the North and South, respectively. Northern households allocate expenditure in the  $X$ -sector across the  $n(t) + n^*(t)$  varieties available at time  $t$ . The instantaneous demand functions are

$$x(i, t) = \alpha p(i, t)^{-\sigma} P_X(t)^{\sigma-1} E(t), \quad x^*(j, t) = \alpha p^*(j, t)^{-\sigma} P_X(t)^{\sigma-1} E(t), \quad (6)$$

for varieties that are produced domestically and those that are offshored. For the remainder of the paper we suppress time notation unless needed.

## 2.2 The Labour Market

The labour markets of the North and South have the basic characteristics of the Roy (1951) model of occupational choice. Skills are distributed continuously across populations of workers with masses  $M$  and  $M^*$  according to the time invariant, finite, and strictly increasing skill distribution functions  $G(z)$  and  $G^*(z^*)$ , both with support  $[0, 1]$ . Markets are perfectly segmented in that we assume there is no international migration. Workers are free, however, to move between sectors with negligible costs of switching employment.

The productivity of a worker depends on the type of activity undertaken. While all workers are capable of producing one unit of effective labour per period in the traditional sector, workers employed in the manufacturing and innovation sectors can produce  $\theta_i(z)$  units of effective labour,  $i \in \{X, I\}$ .  $\theta_i(z)$  is continuous, and strictly increasing in  $z$  and satisfies the following assumptions:<sup>6</sup>  $\theta_I(0) = \theta_X(0) = 1$ , and

$$\frac{\partial \theta_I(z)}{\partial z} \frac{1}{\theta_I} > \frac{\partial \theta_X(z)}{\partial z} \frac{1}{\theta_X} > 1.$$

Similar conditions exist for the South with the exception that there is no innovation sector. These assumptions ensure the existence of a comparative advantage for high-skill workers in innovation, mid-skill workers in manufacturing, and low-skill workers in traditional production. The equilibrium allocation of workers across sectors depends on the occupational choice of each worker and is illustrated in figure 3.

[figure 3 about here]

At each moment in time workers choose employment in the activity that offers the greatest wage income. This is calculated as the product of the effective, or per-unit, wage and a workers productivity in the chosen occupation. We assume a perfectly competitive labour market, and all firms in a given sector  $i$ , therefore, pay the same effective wage,  $w_i$  for  $i \in \{Y, X, I\}$ . Accordingly,

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<sup>6</sup>These assumptions parallel those made by Yeaple (2005).



the distribution of wages in the North is

$$w(z) = \begin{cases} w_Y & 0 \leq z \leq z_1 \\ w_X \theta_X(z) & z_1 \leq z \leq z_2 \\ w_I \theta_I(z) & z_2 \leq z \leq 1 \end{cases},$$

where  $z_1$  and  $z_2$  are the respective threshold skill levels for a worker who is indifferent between employment in the traditional and manufacturing sectors, and a worker who is indifferent between employment in the manufacturing and innovation sectors.

A similar wage distribution exists for the South:

$$w(z^*) = \begin{cases} w_Y^* & 0 \leq z^* \leq z_1^* \\ w_X^* \theta_X(z^*) & z_1^* \leq z^* \leq 1 \end{cases},$$

where  $z_1^*$  is the threshold skill level for a worker who can earn an equal wage from either the Southern traditional or manufacturing sectors.

The threshold skill levels determine the effective relative wages between sectors and the equilibrium labour market allocations. Specifically, from the threshold skill levels  $z_1$  and  $z_2$  we have the relative wages  $w_Y/w_X = \theta_X(z_1)$  and  $w_I/w_X = \theta_X(z_2)/\theta_I(z_2)$  in the North, and from the threshold skill level  $z_1^*$  we have the relative wage  $w_Y^*/w_X^* = \theta_X(z_1^*)$  in the South. These skill thresholds describe the equilibrium allocations of workers in both labour markets, and can be used to derive the labour market clearing conditions for the North,

$$L_Y(z_1) = M \int_0^{z_1} dG(z), \quad L_X(z_1, z_2) = M \int_{z_1}^{z_2} \theta_X dG(z), \quad L_I(z_2) = M \int_{z_2}^1 \theta_I(z) dG(z), \quad (7)$$

and the South,

$$L_Y^*(z_1^*) = M^* \int_0^{z_1^*} dG^*(z^*), \quad L_X^*(z_1^*) = M^* \int_{z_1^*}^1 \theta_X dG^*(z^*). \quad (8)$$

Changes in the threshold skill levels lead to inter-sectoral adjustments in the allocation of labour through changes in the effective relative wages and the labour market clearing conditions.

### 2.3 Traditional Sector

The traditional sectors produce goods for supply to a perfectly competitive international market that is characterized by free trade. Production requires effective labour ( $L_Y$ ) and land ( $T$ ), and identical Cobb-Douglas technologies are used in both countries:

$$Y = \left(\frac{L_Y}{\eta}\right)^\eta \left(\frac{T}{1-\eta}\right)^{1-\eta}, \quad Y^* = \left(\frac{L_Y^*}{\eta}\right)^\eta \left(\frac{T^*}{1-\eta}\right)^{1-\eta}, \quad (9)$$

where  $0 < \eta < 1$  represents the labour intensity of production. Under these assumptions the unit cost of producing traditional goods is the same in both countries:

$$P_Y = w_Y^\eta r_Y^{1-\eta} = w_Y^*{}^\eta r_Y^*{}^{1-\eta} = 1, \quad (10)$$

where  $r_Y$  and  $r_Y^*$  are the respective rents for land in North and South, and we have chosen the traditional good as the model numeraire. Profit maximization by traditional good producers requires that the per-unit value of the marginal products of land and traditional labour be equal:

$$\frac{\eta Y}{w_Y L_Y} = \frac{(1-\eta)Y}{r_Y T}, \quad \frac{\eta Y^*}{w_Y^* L_Y^*} = \frac{(1-\eta)Y^*}{r_Y^* T^*}. \quad (11)$$

These conditions can be used with (9) and (10) to derive the effective wages for traditional goods production in the North and South:

$$w_Y = \left(\frac{T}{L_Y}\right)^{1-\eta}, \quad w_Y^* = \left(\frac{T^*}{L_Y^*}\right)^{1-\eta}. \quad (12)$$

These effective wages are clearly rising in land endowments and falling in effective traditional labour supplies.

### 2.4 Manufacturing Sector

The manufacturing sector produces differentiated varieties for consumption in the North. This market is characterized by monopolistic competition and is supplied from domestic and/or offshored production.

Each firm produces a unique variety, and decides whether to locate production in the North or offshore it to the South. This decision is influenced by the trade-off between two factors: potential

cost-savings associated with lower wages for effective manufacturing labour in the South and increased trade costs incurred in the supply of goods from offshored production. Increased trade costs are modeled in the form of iceberg trade costs,  $\tau > 1$ .

Production technologies are time invariant and identical for all firms, regardless of location. These technologies are constant-returns-to-scale with unit coefficients and employ effective manufacturing labour. As is well known, monopolistically competitive firms charge a constant mark-up over unit costs. Hence, the price of domestically produced varieties is  $p = \sigma w_X / (\sigma - 1)$ , and that of offshored varieties is  $p^* = \sigma \tau w_X^* / (\sigma - 1)$ . The trade-off between effective wages and trade costs is apparent in the difference between these two prices.

Using the pricing rules in the demand functions (6) instantaneous operating profits for firms manufacturing in the North and South can be obtained as

$$\pi = \frac{\alpha}{\sigma} \left( \frac{\omega^{1-\sigma}}{n\omega^{1-\sigma} + n^*\tau^{1-\sigma}} \right), \quad \pi^* = \frac{\alpha}{\sigma} \left( \frac{\tau^{1-\sigma}}{n\omega^{1-\sigma} + n^*\tau^{1-\sigma}} \right), \quad (13)$$

where  $\omega = w_X / w_X^*$  is the relative effective manufacturing wage, and is equal to the ratio of the productivities of the lower threshold skill levels in the respective manufacturing sectors given our assumption of free trade in the traditional sector:  $\omega = \theta_X^*(z_1^*)w_Y / \theta_X(z_1)w_Y^*$ . Accordingly, adjustments in the threshold skill levels and the relative traditional wage will lead to a change in the North-South gap between effective manufacturing wages.

Given our choice of technology, the total effective labour demands are  $L_X = nx$  and  $L_X^* = n^*x^*\tau$ . Using the demand functions in (6) with the operating profits given above, the value of these effective labour demands can be obtained as

$$w_X L_X = (\sigma - 1)n\pi, \quad w_X^* L_X^* = (\sigma - 1)n^*\pi^*. \quad (14)$$

The value of effective manufacturing labour demand is closely related to the share of industry, relative effective wages, and the level of trade costs.

## 2.5 Innovation Sector

Entry into the manufacturing sector requires a new product design. All designs are developed in the perfectly competitive innovation sector of the North using knowledge capital and effective labour.<sup>7</sup>

Knowledge capital evolves according to the positive intertemporal externality, introduced by Romer (1990) and Grossman and Helpman (1991), in which a sector wide learning curve exists for product development. Each new product design adds to the existing stock of knowledge and increases the productivity of future product development. The stock of knowledge capital is proxied for using the total number of product designs that have been developed to date:  $N = n + n^*$ . The evolution of product variety, or knowledge capital, is described by

$$g = \frac{\dot{N}}{N} = L_I, \quad (15)$$

where  $g$  is the rate of growth in product variety.

The value of a product design,  $v$ , is equal to the present discounted value of the future stream of operating profits. Given the competitive nature of research and development, firms will only produce new product designs, implying a positive growth rate, when the cost of product development is equal to the value it creates

$$v = \frac{w_I}{N}, \quad (16)$$

where the RHS is the cost of developing a new design.

A positive growth rate requires that the rate of return on investment in a new product design equal that of investment in a risk-free asset. Taking the time derivative of product development costs and the price for a product design, we can derive the following no-arbitrage conditions:

$$\rho = \frac{\pi}{v} + \frac{\dot{v}}{v}, \quad \rho = \frac{\pi^*}{v} + \frac{\dot{v}}{v}. \quad (17)$$

These are the free market entry conditions for domestic and offshored manufacturing. The first term on the RHS is the dividend rate, and the second is capital gains.

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<sup>7</sup>We assume that there is no innovation sector in the South. This assumption is plausible if one supposes that the North derives a comparative advantage in innovation from a relatively large stock of knowledge capital that the South does not have access to.

## 2.6 Steady-state Equilibrium

This section provides a description of the long-run equilibrium that occurs when manufacturing shares, and therefore labour allocations, are constant.<sup>8</sup> We reduce the system to three steady-state conditions that solve implicitly for the threshold skill levels  $z_1$ ,  $z_2$ , and  $z_1^*$ . These conditions are derived from equilibrium in the market for manufactured goods, the steady-state no-arbitrage conditions, and an equalized rate of return for domestic and offshored production.

Beginning with the manufacturing sector, equilibrium requires that the product markets clear. Northern expenditure is the sum of labour and land income from the traditional and manufacturing sectors, and investment income from the domestic and offshored manufacturing industries.<sup>9</sup> Equilibrium supply and demand, therefore, require that  $\alpha E = pnx + p^*n^*x^*$ . Substituting in the pricing rules for manufacturing firms and the effective labour demands (14), and using (11), this condition can be reorganized as

$$\alpha(\sigma - 1)\omega\theta_X(z_1)L_Y = (1 - \alpha)\sigma\eta\omega L_X + (\sigma - \alpha)\eta L_X^*. \quad (18)$$

Clearly (18) is a function of all three skill thresholds.

Next, the effective labour supplies (14), product development costs (16), and the wage equations for the labour market can be substituted into the no-arbitrage conditions to obtain

$$\rho = \frac{L_X}{(\sigma - 1)s} \frac{\theta_I(z_2)}{\theta_X(z_2)} + \frac{\dot{w}_I}{w_I} - g, \quad \rho = \frac{L_X^*}{(\sigma - 1)(1 - s)\omega} \frac{\theta_I(z_2)}{\theta_X(z_2)} + \frac{\dot{w}_I}{w_I} - g, \quad (19)$$

where  $s = n/N$  is the share of varieties produced in the North, and  $\dot{w}_I = 0$  in long-run equilibrium.

These equations can be solved for the equilibrium share of domestically produced varieties:

$$s = \frac{\omega L_X}{\omega L_X + L_X^*}. \quad (20)$$

Substituting  $s$  back into either of the two conditions in (19) and combining the product market equilibrium (18), we obtain a steady-state condition that links investment and demand,

$$\rho + L_I = \frac{\alpha(\eta L_X + \theta_X(z_1)L_Y)}{(\sigma - \alpha)\eta} \frac{\theta_I(z_2)}{\theta_X(z_2)}, \quad (21)$$

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<sup>8</sup>The reduced system is composed of three control variables. Hence, it can be shown that this economy has no transition path.

<sup>9</sup>Note that labour income from innovation equals savings given the competitive nature of the innovation sector.

and is a function of the skill thresholds  $z_1$  and  $z_2$ .

Finally, we derive our third equation of the system, which equalizes the rate of return for each type of supply. A quick observation of the no-arbitrage conditions makes it clear that when both domestic and offshored production exist simultaneously the associated operating profits must be equal,  $\pi = \pi^*$ . On the other hand, if all manufacturing goods are supplied from domestic factories,  $\pi > \pi^*$ . Using the traditional wages in (12) and the operating profits in (13), these two conditions can be combined as

$$\omega = \frac{\theta_X^*(z_1^*)}{\theta_X(z_1)} \left[ \frac{T}{T^*} \frac{L_Y^*}{L_Y} \right]^{1-\eta} \leq \tau. \quad (22)$$

Accordingly, (22) will bind when a positive share of manufacturing occurs in the South. It will then determine  $z_1$  as a function of  $z_1^*$ , and vice versa. In contrast, when  $\tau > \omega$  offshoring will not be profitable and  $z_1^* = 1$ .

### 3 Implications of Offshoring: Theory and Evidence

#### 3.1 Offshoring, Employment and Growth

In this section we investigate the effects of a decline in trade costs that leads to the offshoring of production. The three steady-state conditions derived in the last section, (18), (21), and (22), will be the main focus of this investigation.

We begin by examining the effects of a change in  $\tau$  on the steady-state threshold skill levels. It is important to note here that higher profits derived through lower costs are required as an incentive to motivate firms to offshore production. This profit incentive will only exist when trade costs fall below a threshold level, and steady-state condition (22) binds. In the following we assume this to always be the case.

Accordingly, the economy can be described by the following three equation system of implicit

functions that describes the relationships between the threshold skill levels:

$$\begin{aligned}
(1 - \alpha)\sigma\eta\tau L_X + (\sigma - \alpha)\eta L_X^* - \alpha(\sigma - 1)\tau\theta_X(z_1)L_Y &= 0, \\
\frac{\alpha(\eta L_X + \theta_X(z_1)L_Y)}{(\sigma - \alpha)\eta} \frac{\theta_I(z_2)}{\theta_X(z_2)} - \rho - L_I &= 0, \\
\frac{\theta_X^*(z_1^*)}{\theta_X(z_1)} \left[ \frac{T}{T^*} \frac{L_Y^*}{L_Y} \right]^{1-\eta} - \tau &= 0.
\end{aligned}$$

Comparative statics for the effect of a change in trade costs on all three skill thresholds can be derived from this system of implicit functions. These are summarized in the following proposition.

**Proposition 1** *Trade liberalization causes an increase in employment in the Northern traditional and innovation sectors, and the Southern manufacturing sector, and causes a decrease in employment in the Northern manufacturing sector and the Southern traditional sector,*

$$\frac{dz_1}{d\tau} < 0, \quad \frac{dz_2}{d\tau} > 0, \quad \frac{dz_1^*}{d\tau} > 0.$$

**Proof.** See Appendix ■

Trade liberalization leads to adjustments in the allocation of labour in both the North and South. While Southern employment decreases for the traditional sector and increases for the manufacturing sector, in the North manufacturing employment contracts with the lowest skilled workers moving to the traditional sector and the highest skilled workers finding new employment in innovation. This result also supports the argument that increased import competition and offshoring have had a strong impact on labour composition, even if they have had little influence on aggregate employment (Coe, 2007).

As discussed above, the fall in  $z_2$  infers an increase in employment in the innovation sector, and hence a greater rate of growth in product variety. This model confirms the theoretical result that there is a positive correlation between offshoring and economic growth, obtained in Martin and Ottaviano (1999), Glass and Saggi (2001) and Gao (2005).<sup>10</sup> The mechanism through which stronger economic growth is achieved parallels that of Naghavi and Ottaviano (2008), where offshoring leads to a release of labour from manufacturing which can be reallocated to innovation activities. In this

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<sup>10</sup>As our definition of offshoring in this model is quite general, we include literature on FDI or outsourcing and growth under this category.

case, the size of increases in economic growth will diminish as the overall labour productivity of the innovation sector is pushed down by the lower than average skill levels of workers who relocate from the manufacturing sector. In other words, less productive workers are drawn from the manufacturing sector to accelerate the development of new varieties.

The discussion of the results summarized in proposition 1 implies that a decrease in trade costs leads to an increase in the share of production offshored by manufacturing firms. This can be verified by taking the total derivative of the share of domestic manufacturing (20). The result is summarized in the following proposition.

**Proposition 2** *Trade liberalization causes an increase in the share of offshored production in the manufacturing sector,*

$$\frac{ds}{d\tau} = s(1-s) \left[ \frac{1}{\tau} + \frac{L'_X(z_1)}{L_X} \frac{dz_1}{d\tau} + \frac{L'_X(z_2)}{L_X} \frac{dz_2}{d\tau} - \frac{L_X^*'}{L_X^*} \frac{dz_1^*}{d\tau} \right] > 0.$$

Trade liberalization has a negative impact on the share of Northern manufacturing. This effect is monotonic for all levels of trade costs.

### 3.2 Wages and Productivity

We address the issues of wage inequality and absolute wages in various sectors next, proceeding first with the impact of offshoring on the effective wages of the traditional sectors, as they are the base upon which all other effective wages in the same country are calculated. The impact of a change in trade costs on  $w_Y$  and  $w_Y^*$  can be examined by taking the total derivatives of the conditions given in (12). The results are summarized in the next proposition.

**Proposition 3** *Trade liberalization has a negative effect on effective wages in the Northern traditional sector and a positive effect on effective wages in the Southern traditional sector:*

$$\frac{dw_Y}{d\tau} \frac{1}{w_Y} = -(1-\eta) \frac{L_Y'}{L_Y} \frac{dz_1}{d\tau} > 0, \quad \frac{dw_Y^*}{d\tau} \frac{1}{w_Y^*} = -(1-\eta) \frac{L_Y^*'}{L_Y^*} \frac{dz_1^*}{d\tau} < 0.$$

For a given amount of land, trade liberalization results in a larger number of workers in the Northern traditional sector (proposition 1), hence reducing the marginal productivity and the real



wages of workers in that sector. The reverse argument holds for the South, where the number of workers in the traditional sector falls and they enjoy higher real wages.

With the comparative static for the changes in  $w_Y$  and  $w_Y^*$  in hand, we are now in position to examine the effects of trade liberalization on the effective wages in the Northern and Southern manufacturing sectors. These are given by  $w_X = w_Y/\theta(z_1)$  and  $w_X^* = w_Y^*/\theta_X^*(z_1^*)$ . Taking the total derivatives we obtain the following proposition.

**Proposition 4** *Trade liberalization has a negative impact on Northern manufacturing wages and a positive impact on Southern manufacturing wages:*

$$\frac{dw_X}{d\tau} \frac{1}{w_X} = \frac{dw_Y}{d\tau} \frac{1}{w_Y} - \frac{\theta'_X(z_1)}{\theta_X(z_1)} \frac{dz_1}{d\tau} > 0, \quad \frac{dw_X^*}{d\tau} \frac{1}{w_X^*} = \frac{dw_Y^*}{d\tau} \frac{1}{w_Y^*} - \frac{\theta_X^{*'}(z_1^*)}{\theta_X^*(z_1^*)} \frac{dz_1^*}{d\tau} < 0.$$

As for  $w_X$ , both the first and second terms on the RHS of the equality are positive because  $z_1$  rises when  $\tau$  is reduced (proposition 1). This implies that  $w_X$  falls by more than  $w_Y$  due to the additional effect of the second term on the RHS of the equation. This results in reduced wage inequality between manufacturing and traditional workers. Note that the fall in  $w_X$  due to an increased amount of offshored production and imports is in accordance with the stylized facts on Northern manufacturing wages illustrated in figure 1. Workers that switch to traditional employment as a result of offshoring are the least skilled in the manufacturing sector. This shift of labour therefore pulls up the average labour productivity of the manufacturing sector. These changes in the composition of the Northern labour force are consistent with the findings of Antonietti and Antonioli (2007), who find that a skill-bias effect in Italy's manufacturing labour force composition stems primarily from a fall in the employment of production workers caused by firms' offshoring activities. The basic result for Southern manufacturing real wages parallel that for  $w_X$ , but works in the opposite direction. The first term again represents the positive change in  $w_Y^*$ . There is another positive effect on  $w_X^*$ , however, as highlighted by the second term. This leads to rising wage inequality between sectors in the South.<sup>11</sup>

Finally, we investigate the impact of trade liberalization on wages in the innovation sector. The effective wage is  $w_I = w_X \frac{\theta_X(z_2)}{\theta_I(z_2)}$ . Taking the total derivative, we obtain the following proposition.

<sup>11</sup>These results reflect those obtain in Antras, Garciaano and Rossi-Hansberg (2006).

**Proposition 5** *While the effect of trade liberalization on the effective wage of the innovation sector is ambiguous, offshoring necessarily leads to increased wage inequality between skilled and unskilled labour in the North.*

$$\frac{dw_I}{d\tau} \frac{1}{w_I} = \left[ \frac{\theta_X(z_2)'}{\theta_X(z_2)} - \frac{\theta_I'(z_2)}{\theta_I(z_2)} \right] \frac{dz_2}{d\tau} + \frac{dw_X}{d\tau} \frac{1}{w_X} \gtrless 0$$

We know from proposition 4 that the second term is positive and puts downward pressure on wages in the innovation sector when trade is liberalized. The first term, however, results in an increase in innovation wages as the term in brackets is negative and  $\frac{dz_2}{d\tau} > 0$ .<sup>12</sup> This creates a positive force that results in a larger increase (or a lower fall) in  $w_I$  with respect to  $w_X$ . Wage inequality between mid-skilled manufacturing workers and high-skilled innovation workers therefore rises as a result of offshoring.<sup>13</sup> This also means that if  $w_X$  falls, then  $w_I$  could also fall, but if so it falls by less. To sum up, the fall in the average productivity of workers increases the effective innovation wage relative to that of the manufacturing sector. An examination of the Northern wage distribution reveals that this enlarges the wage premium for innovation thereby increasing the level of wage inequality between these two sectors. The two possible scenarios for the direction and degree of changes in Northern wages ( $w_Y$ ,  $w_X$ , and  $w_I$ ) are depicted in figure 4. Notice that an enhanced distribution of skill in the North, i.e. skill-biased technology adoption, magnifies the positive effect of offshoring on this wage gap as it makes it more likely for  $z_2$  to fall more than the rise in  $z_1$ .

[figure 4 about here]

As for productivity measures, the total effect of offshoring on labour productivity in the manufacturing sectors is ambiguous. The presence of an innovation sector for the highest skilled to move to makes it theoretically possible for offshoring to offset productivity improvements in the manufacturing sector brought about by the discharge of the least skilled workers.<sup>14</sup> The overall impact on average labour productivity in manufacturing will depend on which of these labour reallocations is

<sup>12</sup>Recall the comparative advantage assumptions for relatively high skilled workers in jobs that require more skills.

<sup>13</sup>Feenstra and Hanson (1996, 2003) and Hijzen (2007) are among empirical works that present evidence on offshoring-related increased wage inequality between skilled and unskilled labour.

<sup>14</sup>Several works with empirical evidence from other countries such as Goerg and Hanley (2003) and Goerg, Hanley, and Stroble (2004) on Ireland, and Calabrese and Erbetta (2004) on Italy, have found neither a significant nor a

larger. Stylized facts on the US manufacturing sector, however, do not show such a trend, implying that the growth-inducing effect of offshoring is not large enough to outweigh the shift of workers to inferior jobs with no skill requirements, thus leading to increased productivity in the manufacturing sector.<sup>15</sup> Note that this is in line with a Pareto distribution, where the population density is continuously denser as we move towards the less skilled portion of the labour market. This in turn supports the negative relationship between productivity and real wages observed from 2004 onwards.

## 4 Concluding Remarks

This paper develops a simple tractable theoretical model that supports a number of recent empirical studies and sheds light on the popular debate over the impacts of offshoring on the labour market in the home country. Using an occupational choice model with endogenous growth, we show how heterogeneity of skills across workers shapes the recomposition of the labour market that occurs as a result of offshoring. Adjustments in the labour market in turn determine the levels of offshoring, wages, productivity, and employment in the manufacturing sector. Our model can also be used to explain recent trends in the US labour market associated with offshoring, namely increased productivity that coincides with lower real wages in the manufacturing sector.

The presence of heterogeneous skills within each sector highlights results that are not attainable using traditional models of international trade. Introducing occupational choice into the existing literature on offshoring allows us to examine the impacts of the inter-sectoral recomposition of workers on real wages and productivity. These results contrast with previous theoretical models of offshoring, such as Grossman and Rossi-Hansberg (2006), where a productivity effect implies higher real wages. In addition, the results could explain recent trends in offshoring and manufacturing strictly positive relationship between offshoring and productivity.

<sup>15</sup>Our framework can be related to the empirical work of Baily and Lawrence (1994) who find that only if imports rise faster than productivity will the number of US jobs being displaced by imports rise over time. This is indeed the case in our model as offshoring not only increases  $z_1$ , but also lowers  $z_2$ . The latter effect results in a less than proportional rise in aggregate productivity in the manufacturing sector compared to the rise in imports, which could then explain the continuous fall in the employment figures of the US manufacturing sector.

wages in the US since 2004, which show a sharp rise in the offshoring of manufacturing accompanied by a fall in the real earnings of workers. We also show that wages of the most skilled in the home country can go either way depending on the degree to which skilled workers are shifted into the innovation sector. If this impact is large enough to outweigh the shift of the lowest skilled workers to the traditional sector, the most skilled workers in the North may see an improvement in their absolute real wages.

Labour market adjustments in the North also lead to aggregate productivity effects in the Northern manufacturing sector, in a similar fashion to Roy (1951). In particular, productivity could increase as the least skilled workers move to the traditional sector. This effect is counterbalanced, however, by a movement of the most skilled to the innovation sector. We prove this to indeed be the direction of change in the recomposition of the labour market and the consequence on aggregate productivity in the manufacturing sector to be ambiguous. Increased aggregate productivity figures in the US manufacturing sector, however, hint that the upgrading of labour to the innovation sector has not been significant enough to offset the flow of the least skilled to the traditional sector. Finally, we show that a larger innovation sector is always a positive side-effect of offshoring, which enhances economic growth in the North. This however is accompanied by rising wage inequality between the skilled and unskilled in the North, and between traditional and manufacturing workers in the South.

Our model clearly has its limits and cannot be used for a global welfare analysis of offshoring. In particular, we do not study in detail the consumption behavior of the Southern population, and do not take into consideration the possibility of development and innovation in the South. Neither do we consider from migration issues, which could have important implications for the wage dynamics observed in the North. We hope to tackle these issues in future work, putting more emphasis on the developing country. Other interesting lines of research would be to look at the offshoring issue in a more specific manner, namely in the context of intermediate goods, services, or R&D.

## 5 Appendix

### Derivation of the steady-state condition for product market equilibrium (16)

$$\begin{aligned}
\alpha E &= pnx + p^*n^*x^* \\
\alpha [r_Y T + w_Y L_Y + w_X L_X + n\pi + n^*\pi^*] &= \frac{\sigma}{\sigma-1} (w_X L_X + w_X^* L_X^*) \\
\alpha \left[ \frac{w_Y L_Y}{\eta} + w_X L_X + \frac{w_X L_X}{\sigma-1} + \frac{w_X^* L_X^*}{\sigma-1} \right] &= \frac{\sigma}{\sigma-1} (w_X L_X + w_X^* L_X^*) \\
\alpha(\sigma-1)w_Y L_Y &= (1-\alpha)\sigma\eta w_X L_X + (\sigma-\alpha)\eta w_X^* L_X^* \\
\alpha(\sigma-1)w_X \theta_X(z_1) L_Y &= (1-\alpha)\sigma\eta w_X L_X + (\sigma-\alpha)\eta w_X^* L_X^* \\
\alpha(\sigma-1)\omega \theta_X(z_1) L_Y &= (1-\alpha)\sigma\eta \omega L_X + (\sigma-\alpha)\eta L_X^*
\end{aligned}$$

### Derivation of the steady-state condition for investment and demand (19)

First, we rewrite the no-arbitrage condition for Northern production.

$$\begin{aligned}
\rho + g &= \frac{\pi}{v} \\
\rho + L_I &= \frac{w_X L_X}{(\sigma-1)n} \frac{N}{w_I} \\
\rho + L_I &= \frac{L_X}{(\sigma-1)s} \frac{\theta_I(z_2)}{\theta_X(z_2)} \\
\rho + L_I &= \frac{(\omega L_X + L_X^*)}{(\sigma-1)\omega} \frac{\theta_I(z_2)}{\theta_X(z_2)}
\end{aligned}$$

Next, we rearrange the product market equilibrium condition (16):

$$\frac{\omega L_X + L_X^*}{\sigma-1} = \frac{\alpha\omega[\eta L_X + \theta_X(z_1) L_Y]}{(\sigma-\alpha)\eta}.$$

Now, we substitute this condition into the steady-state no-arbitrage condition above obtain

$$\rho + L_I = \frac{\alpha(\eta L_X + \theta_X(z_1) L_Y)}{(\sigma-\alpha)\eta} \frac{\theta_I(z_2)}{\theta_X(z_2)}.$$

### Proposition 1: comparative statics for threshold skill levels

The matrix form of the totally differentiated system is

$$\begin{bmatrix} j_{11} & j_{12} & j_{13} \\ j_{21} & j_{22} & 0 \\ j_{31} & 0 & j_{33} \end{bmatrix} \begin{bmatrix} dz_1 \\ dz_2 \\ dz_1^* \end{bmatrix} = \begin{bmatrix} t_1 \\ 0 \\ 1 \end{bmatrix} d\tau,$$

where

$$\begin{aligned}
j_{11} &= (1 - \alpha)\sigma\eta\tau L'_X(z_1) - \alpha(\sigma - 1)\tau [\theta'_X(z_1)L_Y + \theta_X(z_1)L'_Y] < 0, \\
j_{12} &= (1 - \alpha)\sigma\eta\tau L'_X(z_2) > 0, \\
j_{13} &= (\sigma - \alpha)\eta L_X^{*'}(z_1^*) < 0, \\
j_{21} &= \left[ L'_X(z_1) + \frac{\theta'_X(z_1)L_Y + \theta_X(z_1)L'_Y}{\eta} \right] \frac{\theta_I(z_2)}{\theta_X(z_2)} \frac{\alpha}{(\sigma - \alpha)} > 0, \\
j_{22} &= -L'_I(z_2) + \left[ \frac{\theta'_I(z_2)}{\theta_I(z_2)} - \frac{\theta'_X(z_2)}{\theta_X(z_2)} \right] [\rho + L_I] + \frac{\theta_I(z_2)}{\theta_X(z_2)} \frac{\alpha L'_X(z_2)}{(\sigma - \alpha)} > 0, \\
j_{31} &= - \left[ \frac{\theta'_X(z_1)}{\theta_X(z_1)} + \frac{(1 - \eta)L'_Y}{L_Y} \right] \tau < 0, \\
j_{33} &= \left[ \frac{\theta_X^{*'}(z_1^*)}{\theta_X^*(z_1^*)} + \frac{(1 - \eta)L_Y^*'}{L_Y^*} \right] \tau > 0, \\
t_1 &= \frac{(\sigma - \alpha)\eta L_X^*}{\tau} > 0.
\end{aligned}$$

The determinant of the Jacobian matrix,  $J$ , is

$$|J| = j_{11}j_{22}j_{33} - j_{13}j_{22}j_{31} - j_{12}j_{21}j_{33} < 0,$$

where  $j_{11}j_{22}j_{33} < 0$ ,  $j_{13}j_{22}j_{31} > 0$ , and  $j_{12}j_{21}j_{33} > 0$ .

Now, the signs of the comparative statics given in proposition 1 can be found using Cramer's rule.

$$\begin{aligned}
\frac{dz_1}{d\tau} &= \frac{(t_1j_{33} - j_{13})j_{22}}{|J|} < 0, \\
\frac{dz_2}{d\tau} &= \frac{(j_{13} - t_1j_{33})j_{21}}{|J|} > 0, \\
\frac{dz_1^*}{d\tau} &= \frac{(j_{11} - t_1j_{31})j_{22} - j_{12}j_{21}}{|J|} \leq 0.
\end{aligned}$$

The sign of  $\frac{dz_1^*}{d\tau}$  can be shown to be positive. Given that  $|J| < 0$ , this requires showing that the numerator is negative. This will be the case if  $j_{11} - t_1j_{31} < 0$ , given that  $j_{12}j_{21} > 0$  and  $j_{22} > 0$ .

$$\begin{aligned}
j_{11} - t_1j_{31} &= \frac{\theta'_X(z_1)}{\theta_X(z_1)} [(\sigma - \alpha)\eta L_X^* - \alpha(\sigma - 1)\tau\theta_X(z_1)L_Y] + \\
&\quad \frac{L'_Y}{L_Y} [(\sigma - \alpha)\eta(1 - \eta)L_X^* - (\sigma - 1)\alpha\tau\theta_X(z_1)L_Y] - (1 - \alpha)\sigma\tau L'_X(z_1).
\end{aligned}$$

The third term is negative and can be eliminated. Next, using (18), the first and second terms can

be rewritten as

$$-\frac{\theta'_X(z_1)}{\theta_X(z_1)} [(1-\alpha)\sigma\eta\tau L_X] - \frac{L'_Y}{L_Y}\eta [(1-\alpha)\sigma\tau L_X + (\sigma-\alpha)\eta L_X^*] < 0.$$

We conclude, therefore, that  $\frac{dz_1^*}{d\tau} > 0$ .

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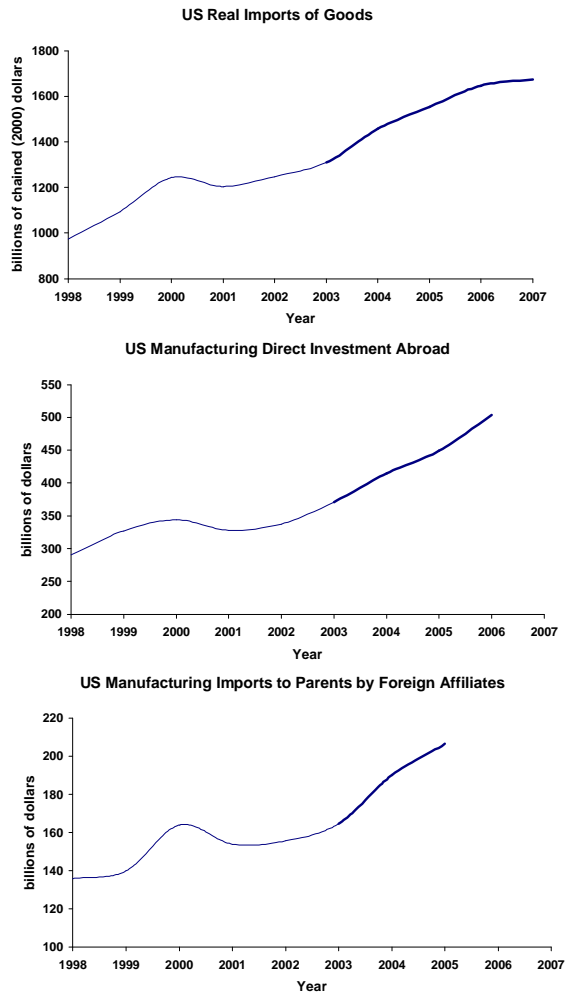
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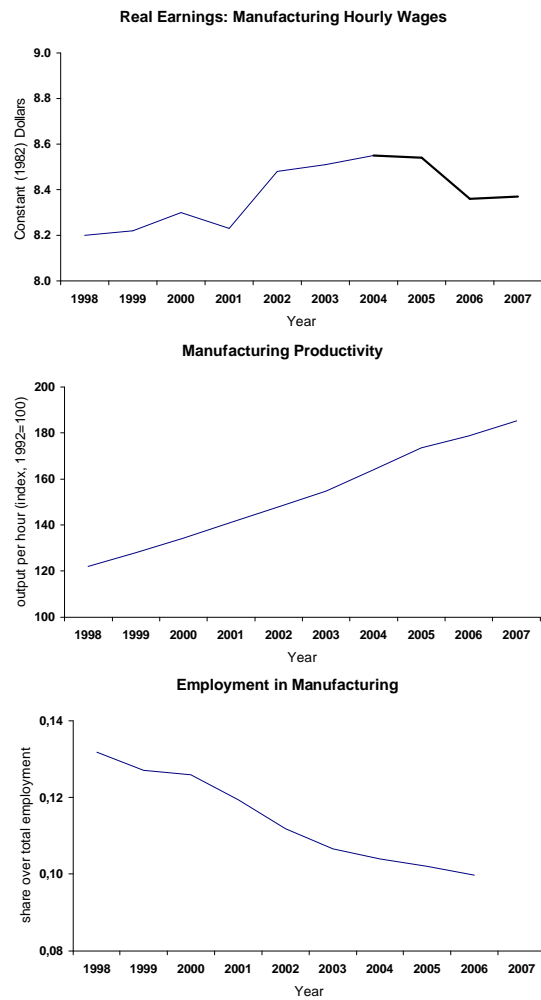
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**Figure 1: Stylized Facts on Offshoring**



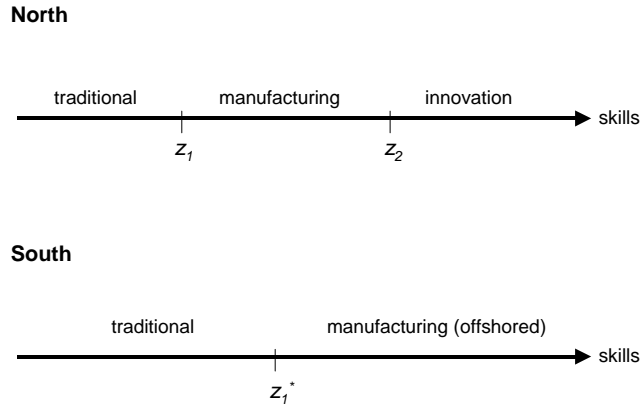
Source: Bureau of Economic Analysis

**Figure 2: Stylized Facts on US Labor Market**

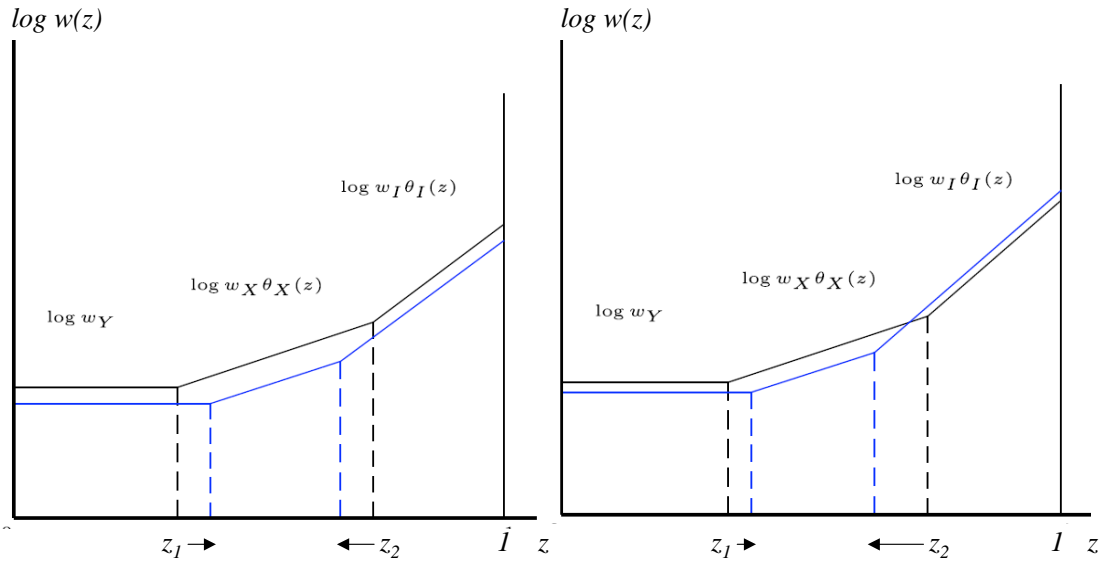


Source: Bureau of Labor Statistics, Bureau of Economic Analysis

**Figure 3: Skills and Sectoral Composition of Workers**



**Figure 4: Skills, Wage Dispersion, and Labour Reallocation**



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