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Service Links and Wage Inequality

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Abstract: In our general equilibrium model, the variety of specialized service links affects international production fragmentation in manufacturing. Decreases in cost of education or fixed cost of service links raise the relative supply of skilled workers, increase service specialization, and decrease the price of aggregate services. Consequently, the market for service- and skill-intensive component manufacturing enlarges, raising relative demand for skilled workers. Empirically, endogenous change in international outsourcing rather than skill-biased technological progress is the main reason for a modest decline in wage gap despite the rapid rise in relative supply of skilled workers in Singapore from 1978 to 2000.

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1. Introduction

How does one reconcile an increased supply of skill with a rise in the skill premium? A very interesting answer proposed recently by Acemoglu is that the rightward shift of the relative supply of skilled labor by itself leads to an induced rightward shift of the relative demand for skilled labor (see Acemoglu [2002] for a treatment of this idea). Consequently, the wage gap or skill premium is kept from falling by as much, and, if the induced demand shift is sufficiently strong, we could actually observe rising wage inequality accompanying the increase in the supply of skill. The propounded theory sees a market size effect associated with an increase in the supply of skilled workers in the conduct of R&D activities, which makes skill-complementary innovation more profitable. The result is an endogenous skill-biased technological progress spurred by abundant skill supply.

Such a theory can throw some light on the huge rise in wage inequality observed in several advanced industrial economies in the past two to three decades but it would seem to have limited applicability to other countries that have also undertaken rapid human capital accumulation but that do very little basic R&D. The overwhelming share of world R&D activities is concentrated in only a small handful of OECD countries—the G7 countries, in particular. Our interest in trying to identify other sources of induced demand shifts brought about by rapid increases in skill supply was piqued by the experience of Singapore, which, although it started from a low base, engaged in very rapid human capital accumulation in the past two decades or more. Yet, this is a country that has performed very little basic R&D. Its historical development as a trading and service economy supporting an industrial sector whose production activities are dominated by multinational enterprises led us to explore both theoretically as well as empirically the relationship between service links and wage inequality.

Our story is roughly as follows. The increase in the supply of skilled labor and a comparative advantage held by Singapore in providing the activities constituting service links, especially as they can be provided by firms separately from those involved in the production blocks, served to encourage the outsourcing of production activities by parent firms in the advanced industrial economies. With services being skilled labor intensive,

there is, with worldwide increases in fragmentation, an increase in demand for skilled labor that roughly matches the increase in supply, without having to rely on skill biased technological progress as in studies of more advanced economies.[1]

Singapore's economic growth since her independence in 1965 has been phenomenal. Per capita GDP has increased from US$512 in 1965 to US$20,732 in 2001 at current market prices. Using the period from November 1997 to October 1998 as the base year, real per capita GDP were S$4,120 and S$36,381 respectively in 1965 and 2001, generating an average real per capita annual growth rate of 6 percent.[2] The rapid rise in incomes has been accompanied by a modest decline in the wage gap compared to a sharply rising supply of skilled workers relative to unskilled workers. In 1978 when the earliest data on relative wages are available, the ratios of the average monthly earnings of managerial and professional workers (defined as skilled workers) to the average monthly earnings of production and manual workers (defined as unskilled workers) in the manufacturing sector and the entire economy were 4.96 and 3.62 respectively. The corresponding ratios have both dropped to 2.37 in 2000. Such a decline in the wage gap is, however, not comparable to the very sharp increase in the supply of skilled workers relative to unskilled workers. We normalize the ratios of the supply of skilled workers to unskilled workers (both by education and occupation) and the ratios of skilled wage to unskilled wage to 1 in 1978 and trace the time trends from 1978 to 2000 in Figure 1.

[Figure 1: Wage gap and relative supply of skilled labor, 1978 to 2000]

Figure 1 depicts the trends of 3 measures of the supply of skilled relative to unskilled labor: (a) the ratio of the supply of workers with post-secondary, polytechnic, and tertiary education to the supply of workers with educational attainment below the former in the entire economy, (b) the ratio of the supply of managerial and professional workers to the supply of production and manual workers in the entire economy, and (c) the ratio of the supply of managerial and professional workers to the supply of production

[1] We are very grateful to Professor Ronald Jones for this interpretation of our paper, given during his visit to Singapore.
[2] The computations are based on data collected from the website of the Singapore Department of Statistics http://www.singstat.gov.sg.

and manual workers in the manufacturing sector. All three series increased to more than 4 times the original levels from 1978 to 2000. A simple demand-supply framework suggests that an outward shift of the relative supply curve of such a big magnitude would have caused a huge decline in the relative wage rate, holding the relative demand curve unchanged.[3] However, the relatively modest decline in the wage gaps to about half of the original levels from 1978 to 2000 would suggest that the relative demand curve must have shifted out.

What are the possible causes of the outward shift in the relative demand for skilled workers in Singapore? Before answering this question, we first review the experiences of other countries. Studies of the United States showed that increases in the relative supply of non-production workers to production workers coincided with the increase in the wage of non-production workers relative to production workers since the middle of 1980s (Katz and Murphy, 1992; Katz and Autor, 1999). Machin (1996) showed that wage inequality increased very dramatically in the United Kingdom since the late 1970s. Similar to the case of the United States, the United Kingdom also experienced an increase in the relative share of skilled workers. Cragg and Epelbaum (1996) documented a rise in wage dispersion in Mexico since the mid-1980s, coinciding with the economy becoming more skill-abundant. One interpretation of the experiences of these countries is that the demand curve could have shifted out by more than the outward shift of the supply curve, bringing about an increase in the wage gap associated with an increase in the relative supply of skilled workers.

Several researchers have advocated that technology is the main cause of increasing wage inequality. In particular, mainly based on U.S. data, Acemoglu (2002) argued that the rapid increase in the supply of skilled workers has induced the

[3] In the case of a small open economy with the two-factor (skilled and unskilled labor), two-good Heckscher-Ohlin structure, it is possible that an increase in the relative supply of skilled labor leads to a change in the relative supply of the two goods (according to the Rybczynski theorem) without any change in the relative wage so that the relative demand curve is, in effect, horizontal. This would, however, be the case only if the economy's relative factor supply stays within the cone of diversification. From the perspective of the Singapore experience, which motivates this paper, the industrial restructuring that has accompanied the rapid pace of human capital accumulation, with the destruction of unskilled labor intensive industries and creation of more and more skill-intensive industries over the past two to three decades, suggests that the economy has constantly moved into new cones correspondingly to more skill-intensive industries. The implication is that the effective relative demand schedule facing this small open economy is downward sloping, made up of adjoining flat portions.

development of skill-complementary technologies. Technological developments may have further impact on the organization of the labor market, and hence on the structure of wages. Berman, Bound and Machin (1998) argued that pervasive skill-biased technological change (SBTC), rather than increased trade with developing countries, is the main reason for the drastic decrease in demand for less skilled workers in the U.S. and other developed countries. Without rigorous testing, they suggested that the same force is operating in less developed countries, which have been expanding their manufacturing sectors and upgrading the skills of their workforce: increased proportion of skilled labor and relatively stable wages of non-production workers. However, using their Figure A1 and Figure A2, we see that in the 1980s, there were more developing countries which experienced increased proportion of non-production workers and declining relative wage: Korea, Venezuela, Panama, Ethiopia, and Guatemala. Using (currently discontinued) industrial data from United Nations General Industrial Statistics, and employing a method similar to Katz and Murphy (1992), Berman and Machin (2000a, 2000b) decomposed changes in the wage share of skilled workers into within and between industries and found that within-industry changes are more important in high-income countries as well as middle-income countries but not low-income countries, implying SBTC for the first two groups of countries. They also found positive correlations of within-industry changes in non-production wage bill shares between U.S. and 11 out of 12 middle-income countries in the sample, suggesting diffusion of skill-biased technological change from developed to developing countries.

We argue that induced skill-biased technological progress is not the main driving force in Singapore for the following reasons. First, compared to the G-7 countries, Singapore does not have a large pool of skilled workers, especially R&D personnel, despite the rapid increase in the share of skilled workers in the economy. The skill level of Singaporean workers is still relatively low compared to that of advanced countries and hence, the R&D conducted in Singapore is more of an applied nature, rather than basic research. In fact, we document empirically that, in so far as there has been any induced technological progress through the applied R&D activities, it has been unskilled-biased rather than skill-biased. Second, Singapore is a small open economy, relying on the world market and the operations of multinational corporations in Singapore. Way before her

independence, Singapore had been a free port, engaged in entrepôt trade, linking the region to the world. Since her independence, foreign investors have been actively sought after. As Singapore moved up the value-chain of the international production ladder, multinational corporations have also increased the skill and technology intensities of their investments in Singapore. More recently, Singapore has sought to be the regional business center, providing support services such as management, logistics, finance, and telecommunications to multinational corporations in their operations in the region. As argued by Feenstra (1998), by allowing trade in intermediate inputs, globalization has an impact on employment and wages that are observationally equivalent to changes caused by technological innovations. Hence, within-industry shifts in labor demand are not just restricted to factor-biased technological progress, but could be caused by trade in intermediate products within the same industry as well as international outsourcing. Feenstra and Hanson (1999) found that international outsourcing explains 20 percent of the shift in relative demand toward non-production workers in U.S. manufacturing during 1979—1990 and that the increased use of computers and other high-technology equipment explains 30 percent of the shift.

Most of the existing literature has examined the pattern of the wage gap for advanced countries. None has compared the influences of technology and global production sharing on the evolution of the wage gap for small open economies such as Singapore. In this paper, using appropriate measures, we will separate out the influences of technology and international production fragmentation and empirically test their impact on the wage gap. The case of Singapore is interesting and apt for testing new mechanisms explaining relative wage movements within a world of international outsourcing since it has a long history of economic development based upon reliance on attracting parent firms in advanced economies to place production blocks within its shores with strong support from service links. Our empirical results show that Singapore has experienced a technological progress biased toward unskilled workers. Despite the rapid increase in the relative supply of skilled workers and the technological progress biased toward unskilled workers, the wage gap was prevented from falling drastically by the process of international production fragmentation.

Theoretically, our paper makes a contribution to the literature by developing a model of international production fragmentation for a small open economy in which service links are important for specialization in manufacture parts and components across national borders. The model enables us to study how an increase in the supply of skilled workers in a small open economy will attract international production fragmentation into activities which are more skill-intensive, or, in particular, requiring more aggregate services. In other words, the spectrum of international production fragmentation is changed as the relative supply of skilled workers increases. The increase in the supply of skilled workers has a direct downward pressure on the wage gap; however, the participation in global production sharing will increase the demand for skilled workers, and hence exert an upward pressure on the wage gap. This endogenous shift in the demand for skilled workers will at least partially offset the downward movement of the wage gap. We argue that international outsourcing as a demand shifter provides more explanatory power than skill-biased technical progress for small and open economies where fundamental R&D is basically absent.

The remainder of the paper is organized as follows: section 2 provides intuition on service links and the model of international outsourcing to be developed. Section 3 sets up the structure of the closed economy version of the model while section 4 examines its general equilibrium solution. Section 5 investigates the impact of changes in costs and supply of skilled workers on service specialization and the wage gap. An extension to a small open economy endogenizing the extent of international outsourcing is provided in section 6. Section 7 further endogenizes the process of human capital accumulation. Section 8 presents the empirical study on the Singapore economy and section 9 concludes.

2. The conceptual model

Service links are essential in connecting production blocks and the costs of establishing these service links are primarily viewed as fixed costs in Jones and Kierzkowski (1990, 2001). The slicing up of an integrated production structure into different production blocks so as to take advantage of a lower marginal cost of production

has to be balanced off with the fixed cost of providing service links to coordinate the various production blocks. In their framework, the extent of the market limits the degree of production fragmentation. However, the characteristics and the provision of service links and the interaction with the fragmentation of manufacturing are not modeled formally in their papers. Existing models of production fragmentation in the literature are not satisfactory: they neither endogenize the extent of production fragmentation nor use a general equilibrium framework to study the impact on the skilled-unskilled wage gap. Human capital accumulation, central to economic development, is also not modeled in these papers on production fragmentation.[4] We attempt to develop a model which enables us to examine how the specialization of service links is linked to the production fragmentation in manufacturing, how the fixed and variable costs of service providers will affect the degree of international outsourcing in component production in manufacturing, and the implications for the skilled-unskilled wage gap.

Before proceeding to develop a formal model of production fragmentation, it is essential to understand better the characteristics of service links which facilitate the disintegration process of production. First of all, many services such as telecommunications, freighting, warehousing, distribution, marketing, accounting, banking, and legal consultation are all required for outsourcing to occur. These services do not occur in vertical stages but are bundled together in a horizontal fashion as a service link. Furthermore, fragmentation of these services into a greater variety of specialized services occurs in a horizontal fashion. Secondly, the provision of specialized services is skill-intensive,[5] especially in the initial setting up of these operations. Setup

[4] Burda and Dhulosh (2000) modeled "fragmentation" as roundabout-ness in the production process giving rise to increasing returns but not as different production blocks producing parts and components. De Groot (2001) modeled the outsourcing of support services but not the slicing of the value chain. Using contract theory, Grossman and Helpman (2002) focused on the search for an intermediate input provider. Long, Riezman, and Soubeyran (2001) formalized the idea that component production in manufacturing is facilitated by aggregate services. However, the number of specialized service providers is exogenous in their model. They are concerned with trade in components and services. Building on their basic setup of the service sector and link to manufacturing, we incorporate skilled and unskilled workers, endogenize the entry and exit of specialized service providers, and determine the extent of international component outsourcing in a general equilibrium model of a small open economy as in Hoon and Ho (2001). Hoon and Ho (2001), however, did not have skilled versus unskilled workers, nor an explicit modeling of service links.

[5] For example, the share of managerial and professional workers in total employment in financial and business services for Singapore in 2000 was 63.9%, much higher than 34.7%, the corresponding share for

costs include costs of gathering and analysis of information, costs of networking and coordination with other service providers, and possibly costs of product differentiation, which are likely to involve skilled workers instead of unskilled workers. Once these setup costs are incurred, the marginal costs of providing services are primarily wage costs of unskilled workers. Thirdly and lastly, the non-tradability of services suggests that the providers of service links and the component manufacturers utilizing these services are located in the same place. With technological progress and liberalization, however, it is possible that services become more tradable.[6]

Given the above observations on services, and service links in particular, we propose that each specialized service is like a differentiated product and its provision requires a setup cost involving skilled workers and a marginal cost involving unskilled workers. Each specialized service provider operates in a monopolistically competitive environment. Free entry and exit of specialized service providers will drive profits to zero, and determine the equilibrium number of specialized services, which is also the extent of variety of specialized services available. All the available specialized services form a bundle of aggregate service, which is the service link required by component manufacturers in the process of production fragmentation. The extent of variety of specialized services may be viewed as the extent of fragmentation of the aggregate service. This horizontal fragmentation of aggregate service is limited by the available pool of skilled workers.

The aggregate service in the form of a service link is purchased by a component manufacturer, together with the hiring of unskilled workers. More aggregate services are required for a component manufacturer who is producing a more sophisticated component, which is more skill-intensive effectively. Each component manufacturer operates in a perfectly competitive environment. All the components produced are assembled, in a sense linked by the aggregate service, to form a final manufacture product. In other words, the vertical fragmentation of manufacturing is facilitated by the

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manufacturing in 2000. In 1974, the figures were 21.1% and 10.3% for financial and business services, and manufacturing respectively.

[6] Other characteristics of services include intangibility, non-storability, and network effect. These features may be incorporated in future research. Being intangible, markets for services may be incomplete. The non-storability of services suggests that the speed of delivery of services is crucial in the operations of service links. Finally, the network or clustering effect of services may bring about increasing returns to scale.

aggregate service link. In a closed economy, the total number of manufacture components required for the final manufacture product is exogenous. When a small open economy framework is used, the range of manufacture components produced in the small open economy versus the rest of the world is made endogenous. In particular, a larger supply of skilled workers or a reduction in the set-up cost of specialized services will lower the endogenous price of aggregate services and encourage production fragmentation in the manufacturing sector, extending the range of manufacture components produced in the small open economy and moving up the value chain of international production sharing. An increase in the supply of skilled workers or a decrease in the set-up cost of specialized services may be viewed as an increase in the effective size of the local market of services, which in turn induces an enlargement of the small open economy's share of the international market of manufacture components.

In the model economy, apart from the manufacture product which entails components, there is another final good which is consumed. The production of this final good requires only unskilled workers. Unskilled workers may be hired by this final good producer, by component manufacturers, or by specialized service providers. Skilled workers, however, can only be hired by specialized service providers in the model, for simplicity.[7]

An increase in the supply of skilled workers, or a reduction in the set-up cost of specialized services, will directly depress the skilled-unskilled wage ratio in a closed economy, akin to an outward shift in the relative supply curve. However, in a small open economy engaged in production fragmentation, the endogenous decline in aggregate services attracts foreign investors outsourcing a larger spectrum of manufacture components. This larger spectrum of manufacture components requires more aggregate services and hence is effectively more skill intensive. Consequently, an induced increase in the relative demand for skilled workers will exert an upward pressure on the skilled-unskilled wage ratio, offsetting the initial downward impact on the wage gap. Whether the induced effect is larger than the direct effect depends on whether the response of the extent of manufacture fragmentation is sufficiently elastic with respect to the increase in

[7] This assumption can be relaxed but the qualitative results of the model will remain intact.

the supply of skilled workers. It can be shown that, in a small open economy, the real consumption wage of unskilled workers will also unambiguously increase.

As human capital deepens in developing countries in the process of growth, the wage gap may drop as the supply of skilled workers is increased. The fall in the wage gap acts to dampen the incentive to acquire skill. However, as implied by our model, participating in international outsourcing provides a channel through which the incentive to acquire skill is retained: the wage gap is prevented from falling drastically despite a rapid increase in the supply of skilled workers. Heckman, Lochner and Taber (1998, 1999) stressed that evaluations on schooling and impacts on wages using partial equilibrium "treatment" models are misleading. Our general equilibrium approach thus provides a correct framework to study the evolution of wages and supply of skilled workers in small open economies.

3. Structure of the closed-economy model

3.1. The service sector

The aggregate service S is a horizontal bundle of specialized services m_i, for i = 1...n, and takes the CES functional form:

$$S = \left[\sum_{i=1}^{n} m_i^{a} \right]^{\frac{1}{a}} \tag{1}$$

where $0 < a < 1$. Taking the price of specialized service p_i as given and solving the cost minimization problem

$$Ps = \left[\min_{m_i} \sum_{i=1}^{n} p_i m_i \right] \tag{2}$$

subject to (1) and setting $S = 1$, where P_S is the price of the aggregate service, we have

$$m_i = ASp_i^{\frac{1}{a-1}} \tag{3}$$

where $A = \left[\sum_{j=1}^{n} p_j^{\frac{a}{a-1}} \right]^{\frac{-1}{a}}$ is a price index, taken as exogenous by individual specialized service providers. Using the inverse demand function implied by (3), the marginal revenue of a specialized service provider is

$$MR_i = ap_i . \tag{4}$$

To provide specialized service, a setup cost of fw^H and a variable cost of $cw^L m_i$ are incurred, where w^H and w^L are the skilled and unskilled wage rates respectively, f is the fixed number of skilled workers required for setting up the operation, and c is the number of unskilled workers required to produce one unit of specialized service. Equating marginal revenue to marginal cost of specialized service gives

$$p_i = \frac{cw^L}{a} \tag{5}$$

where $1/a$ is interpreted as the markup. Assuming free entry and exit of specialized service providers, each specialized service provider earns zero profits:

$$p_i = \frac{fw^H}{m_i} + cw^L . \tag{6}$$

Combining (5) and (6), we have $\frac{fw^H}{m_i} = (1-a)p_i$, meaning that a fraction of the price is used to pay for the setup cost. Assuming symmetric equilibrium for the specialized service providers, we have

$$m = n^{\frac{-1}{a}} S , \tag{7}$$

$$P_S = n^{\frac{a-1}{a}} p . \tag{8}$$

Substituting (5) and (7) into (6) gives

$$n = \left(\frac{1-a}{a} \right)^a \left(\frac{fw^H}{cw^L} \right)^{-a} S^a . \tag{9}$$

From (9), we see that, the extent of horizontal fragmentation is limited by the size of the market S, and the fixed number of skilled workers required for startup. Of course, we will endogenize S later on.

3.2. The goods sector

There are two final goods in the economy: X and Y. The production of X requires parts and components while that of Y merely requires unskilled labor. To produce one unit of Y, a_Y units of unskilled workers are required. Under perfect competition, the representative firm in Y earns zero profits and the price of Y is given by

$$P_Y = a_Y w^L . \tag{10}$$

In the production of X, a component manufacturer produces a component j in the interval $[0, k]$, where k is the exogenously given number of stages or number of components required in the closed economy. To produce one unit of X, one unit of component j is required for each j in the interval $[0, k]$. To produce one unit of j, one unskilled worker and bj units of aggregate services are required, where $b > 0$. Hence, components of higher stages (bigger j) require more support from the service link, and effectively are more skill-intensive, or service-intensive. Assuming that each component manufacturer operates in a perfectly competitive environment, the price charged by the component manufacturer j is

$$p_j = w^L + bjP_S . \tag{11}$$

Assembly of the manufacture components is assumed to be costless and competitive. Zero profits imply that the price of X is

$$P_X = \int_0^k \left(w^L + bjP_S \right) dj . \tag{12}$$

Note that the total demand for aggregate service is given by $X \int_0^k bjdj = \frac{bk^2}{2} X$. In equilibrium, demand equals supply, giving

$$S = \frac{bk^2}{2} X . \tag{13}$$

Substituting (13) into (9), and in turn into (7) and (8), we have

$$m = \left(\frac{a}{1-a} \right) \left(\frac{fw^H}{cw^L} \right), \tag{14}$$

$$P_S = \frac{1}{1-a} \left(\frac{1-a}{a} \right)^a \left(\frac{fw^H}{X} \right)^{1-a} \left(\frac{2}{bk^2} \right)^{1-a} \left(cw^L \right)^a , \tag{15}$$

$$n = \left(\frac{1-a}{a}\right)^a \left(\frac{w^L cbk^2}{2fw^H} X\right)^a . \tag{16}$$

We see that P_S is decreasing in X as the fixed cost of service link is spread thin by a larger X. Again, n is increasing in X as the extent of the market limits the degree of specialization. Substituting (15) into (12) gives

$$P_X = kw^L + \frac{1}{1-a}\left(\frac{1-a}{a}\right)^a \left(\frac{fw^H}{X}\right)^{1-a} \left(\frac{cbk^2 w^L}{2}\right)^a . \tag{17}$$

3.3. The consumer

The representative consumer has a utility function given by

$$U(X,Y) = X^b Y^{1-b} \tag{18}$$

where $0 < \beta < 1$. The budget constraint faced by the representative consumer is

$$P_X X + P_Y Y = w^L L + w^H H \tag{19}$$

where L and H are the endowments of unskilled labor and skilled labor respectively in the economy. The demand functions for X and Y are respectively

$$X = \frac{b}{P_X}\left(w^L L + w^H H\right), \tag{20}$$

$$Y = \frac{(1-b)}{P_Y}\left(w^L L + w^H H\right). \tag{21}$$

4. General equilibrium of the closed-economy model

The market clearing conditions for the unskilled and skilled workers are respectively

$$L = kX + ncm + a_Y Y , \tag{22}$$

$$H = nf . \tag{23}$$

From (23), we have

$$n = \frac{H}{f} \tag{24}$$

which implies that the degree of horizontal fragmentation in aggregate services is limited by the endowment of skilled labor and the setup cost. Substituting (14) and (16) into (22) and (23) gives

$$L = kX + \left(\frac{1-a}{a}\right)^{a-1}\left(\frac{w^L}{fw^H}\right)^{a-1}\left(\frac{cbk^2X}{2}\right)^{a} + a_Y Y, \tag{25}$$

$$H = \left(\frac{1-a}{a}\right)^{a}\left(\frac{w^L cbk^2 X}{2w^H}\right)^{a}(f)^{1-a}. \tag{26}$$

Hence, we have a system of six equations, namely (10), (17), (20), (21), (25) and (26), in six unknowns: P_Y, P_X, w^L, w^H, X and Y. We are able to solve for the quantities, the relative price, and the relative wage. The solutions are

$$X = \frac{bL}{k + \frac{1}{a}\left(\frac{f}{H}\right)^{\frac{1-a}{a}}\left(\frac{cbk^2}{2}\right)[1-b(1-a)]} = X(\overset{+}{L},\overset{+}{H},\overset{-}{c},\overset{-}{b},\overset{-}{k},\overset{-}{f}), \tag{27}$$

$$Y = \frac{bL(1-b)\left(\frac{1-a}{a}\right)}{a_Y\left\{\left(\frac{2}{cbk}\right)\left(\frac{H}{f}\right)^{\frac{1-a}{a}} + \frac{1}{a}[1-b(1-a)]\right\}} = Y(\overset{+}{L},\overset{-}{H},\overset{+}{c},\overset{+}{b},\overset{+}{k},\overset{+}{f}), \tag{28}$$

$$\frac{w^H}{w^L} = \frac{bL\left(\frac{1-a}{a}\right)}{H\left\{\left(\frac{2}{cbk}\right)\left(\frac{H}{f}\right)^{\frac{1-a}{a}} + \frac{1}{a}[1-b(1-a)]\right\}} = w(\overset{+}{L},\overset{-}{H},\overset{+}{c},\overset{+}{b},\overset{+}{k},\overset{+}{f}), \tag{29}$$

$$\frac{P_X}{P_Y} = \frac{1}{a_Y}\left[k + \left(\frac{1}{a}\right)\left(\frac{f}{H}\right)^{\frac{1-a}{a}}\left(\frac{cbk^2}{2}\right)\right] = q(\overset{-}{H},\overset{+}{c},\overset{+}{b},\overset{+}{k},\overset{+}{f}). \tag{30}$$

Substituting (27) and (29) into (15) gives

$$\frac{P_S}{w^L} = \frac{1}{a}\left(\frac{f}{H}\right)^{\frac{1-a}{a}} c. \tag{31}$$

Substituting (29) into (14) gives

$$m = \frac{bL}{\left(\frac{2}{bk}\right)\left(\frac{H}{f}\right)^{\frac{1}{a}} + \left(\frac{c}{a}\right)\left(\frac{H}{f}\right)[1 - b(1-a)]} = m\left(\overset{+}{L}, \overset{-}{H}, \overset{-}{c}, \overset{+}{b}, \overset{+}{k}, \overset{+}{f}\right). \quad (32)$$

Note that substituting (27) and (29) into (16) gives $n = H/f$, which is (24).

5. Impact on service specialization and wage gap

5.1. Exogenous increase in k

As the required number of components increases exogenously, the demand for aggregate services linking and supporting component manufacturing increases, shifting up the demand for skilled workers, and resulting in a higher skilled-unskilled wage gap. Requiring more manufacture components translates into a higher price P_X of the final manufacture product relative to P_Y, price of good *Y*. Consequently, *X* decreases, and *Y* increases.

5.2. Decrease in fixed cost f

A decrease in *f* will decrease the price of aggregate services relative to unskilled wage rate, increase the number of specialized service providers, and decrease the quantity of services supplied by each provider. The new equilibrium quantity of the final manufacture good will become larger. The skilled-unskilled wage gap will be reduced. Relative price P_X/P_Y is also reduced.

5.3. Decrease in marginal cost c

Unlike a decrease in fixed cost, a decrease in marginal cost will raise the quantity of services supplied by each specialized service provider. The number of specialized service providers is not affected by a decrease in the marginal cost. The impact on other variables and ratios are similar to those corresponding to a decrease in the fixed cost.

5.4. Increase in skilled labor H

An increase in the supply of skilled labor is equivalent to a decrease in the fixed cost, bringing a greater extent of horizontal fragmentation in aggregate services. In particular, the wage gap will be narrowed. Opening up of the economy to foreign talent or a liberalization of the service sector such that the provision of service link is not limited by the local pool of skilled workers is theoretically captured by an increase in H in the model.

Note that, in a closed economy set-up, either a decrease in f or an increase in H would raise the number of specialized service providers, reduce the price of aggregate services relative to the unskilled wage rate, and depress the skilled-unskilled wage gap. However, when we open the economy to international outsourcing in component manufacturing, there will be an additional and induced effect on the relative demand for skilled workers, which may offset the initial downward pressure on the wage gap. Such a general equilibrium extension to a small open economy is presented in the next section.

6. Extension to a small open economy

As in Hoon and Ho (2001), an MNC places skill-intensive component manufacturing in the US and labor-intensive component manufacturing in Singapore, the small open economy: activities in the interval $[k, 1]$ take place in the US while those in $[0, k]$ take place in Singapore. Producing manufacture parts and components in the US is similar to doing so in Singapore except that the wages and price of aggregate services are different across the two countries. Since the total supply of skilled workers is far larger in the US than in Singapore, (31) would imply that P_S^*/ w^{L*} is less than P_S/ w^L, where we use an asterisk to denote a US variable. The MNC takes the price of X, P_X, as given. The zero profit condition for the production of X is

$$\mathrm{P_X} = \int_0^k \left(w^L + bjP_S\right)\, dj + \int_k^1 \left(w^{L*} + bjP_S^{\,*}\right)\, dj\,. \tag{33}$$

The unit cost of producing the marginal component is equal in both countries:

$$w^L + bkP_S = w^{L*} + bkP_S^{\,*}\,. \tag{34}$$

Using (24), (31), (33), and (34), we are able to derive a quadratic expression for k:

$$b\left(aP_S^{*}n^{\frac{1-a}{a}}-cw^{L^*}\right)k^2+2bc\left(w^{L^*}+0.5bP_S^{*}-\mathrm{P_X}\right)k+2an^{\frac{1-a}{a}}\left(w^{L^*}+0.5bP_S^{*}-\mathrm{P_X}\right)=0. \tag{35}$$

To simplify notations, we re-write (35) as

$$\Omega_1 k^2+\Omega_2 k+\Omega_3=0$$

where $\Omega_1 < 0$, $\Omega_2 > 0$, and $\Omega_3 > 0$. We may solve for k and obtain

$$k=\frac{-\Omega_2-\sqrt{\Omega_2^2-4\Omega_1\Omega_3}}{2\Omega_1}=k(\overset{+}{n},\overset{-}{c},\overset{+}{b},\overset{+}{w^{L^*}},\overset{+}{P_S^{*}})>0. \tag{36}$$

In the extension to a small open economy, (24) (the limit to specialization in services), (29) (the relative wage rate of skilled to unskilled), and (31) (price of aggregate services relative to the wage rate of unskilled workers) remain the same as before.

6.1. Increase in w^{L^*} or P_S^*

An exogenous increase in the cost of either w^{L^*} or P_S^* would shift up the cost of the existing range of manufacture components produced in the United States. Hence, it is optimal to outsource a wider range of manufacture components to be produced in Singapore, resulting in an increase in k. Consequently, from (29), the relative demand for skilled workers rises and the wage gap goes up.

6.2. Decrease in marginal cost c

A decrease in the marginal cost of specialized services reduces the price of aggregate services relative to unskilled wage rate. This induces a larger range of manufacture components outsourced to Singapore. A decrease in c directly reduces the wage gap. However, the induced effect via a larger k would suggest an upward pressure on the wage gap. The combined effect is ambiguous, depending on the extent of adjustment of fragmentation.

6.3. Increase in H or decrease in fixed cost f

An increase in n, the extent of specialization in services, driven by either an increase in H or a decrease in f, reduces the price of aggregate services and hence attracts a wider range of manufacture components outsourced to Singapore. Hence, service specialization correlates with production fragmentation in manufacturing. The endogenous increase in k would exert an upward pressure on the wage gap, countering the initial downward impact on the wage gap caused by an increase in H or a decrease in f. In particular, if

$$\frac{dk}{dn^{\frac{1-a}{a}}} > 1,$$

that is, the adjustment in the extent of production fragmentation in manufacturing is sufficiently more responsive than the adjustment in the extent of horizontal fragmentation or specialization in services, then the induced outward shift in the relative demand for skilled workers will overwhelm, resulting in a rise in the wage gap.

Based on (29) and (36), we argue that the direct negative impact on the wage gap due to a decrease in f is likely to be smaller in magnitude compared to an increase in H. Hence, compared to an increase in H, the induced outward shift in relative demand due to a decrease in f is more likely to dominate and bring about a rise in the wage gap.

6.4. Exogenous increase in b

As b increases, the amount of required aggregate services for higher-end components increases more than that for lower-end components, increasing the cost of component manufacturing in the United States relative to Singapore. Since unskilled workers are also required in component manufacturing, it is then optimal to outsource a wider range of component manufacturing to Singapore in order to take advantage of the lower cost of unskilled workers. Hence k increases. Both the increases in b and k will increase the relative demand for skilled workers in Singapore, pushing the wage gap up. An increase in b is akin to an exogenous skill-biased structural change.

7. Incorporating endogenous human capital accumulation

One of the important insights coming out of our general-equilibrium analysis is that the induced demand shift brought about by the increase in the supply of skill should act to sustain the incentive to acquire skill. To formalize this idea, we now set out to endogenize an individual's decision to acquire skill, and place it in the context of our general-equilibrium setup. Suppose the ability to learn ε is uniformly distributed in the open-interval (0, 1) in the economy:

$$e \sim U(0,1).$$

The direct cost of acquiring education faced by a worker is given by

$$\frac{kw^L}{e},$$

where $k > 0$, a cost parameter which may be influenced by government policy or subsidy on education. The indirect opportunity cost is the forgone unskilled wage rate. Upon completion of the education, the worker will become a skilled worker, attaining the skilled wage rate. Hence, a worker will choose to acquire education if $w^H - \frac{kw^L}{e} > w^L$. Therefore, the threshold level of ability above which an individual will be skilled, and below which he will choose to be unskilled is given by

$$\hat{e} = \frac{k}{\frac{w^H}{w^L} - 1}. \tag{37}$$

The supply of skilled workers in the economy is then given by $H = (1-\hat{e})(H+L)$. Rearranging, we have

$$\frac{H}{L} = \frac{1}{\hat{e}} - 1, \text{ or}$$

$$\frac{H}{L} = \frac{\frac{w^H}{w^L} - 1}{k} - 1, \tag{38}$$

which is increasing in the wage gap and decreasing in the cost parameter k. Suppose $H + L = \overline{N}$, a fixed population size. Then, we are able to derive an expression for H and substitute into $n = H/f$, which is (24), to get

$$n = \frac{\overline{N}}{f}\left(1 - \frac{k}{\frac{w^H}{w^L} - 1}\right). \tag{39}$$

From (38) and (39), we see that a higher wage gap provides an incentive to get education and enhances the extent of service specialization. A reduction in the cost of education, driven by a decrease in k, possibly brought about by an increase in education subsidy or government expenditure per student, will increase the relative supply of skilled workers and the extent of specialization in services at any level of wage gap.

Substituting (38) and (39) into (29) gives:

$$\frac{w^H}{w^L} = \frac{b\left(\frac{k}{\frac{w^H}{w^L} - 1 - k}\right)\left(\frac{1-a}{a}\right)}{\left\{\left(\frac{2}{cbk}\right)\left(\frac{\overline{N}}{f}\frac{\left\{\frac{w^H}{w^L} - 1 - k\right\}}{\left\{\frac{w^H}{w^L} - 1\right\}}\right)^{\frac{1-a}{a}} + \frac{1}{a}\left[1 - b\left(1-a\right)\right]\right\}}, \tag{40}$$

where the endogenous k is given by (36).

Plotting the left-hand side of (40) against (w^H/w^L) gives an upward slopping curve while plotting the right-hand side of (40) gives a downward sloping curve. To determine the impact on the wage gap given a decrease in k at a level of k, we consider the shifts in the left-hand side and right-hand side of (40) as in Figure 2. By inspection, a decrease in k will shift the right-hand side curve down, due to an increase in the relative supply of the skilled workers and an increase in the degree of service specialization. However, k, the extent of production fragmentation, is an increasing function of the degree of service specialization. As k increases, the right-hand side curve will shift up, offsetting the initial downward shift of the right-hand side curve. The extent of offsetting depends on how responsive is the change in k.

[Figure 2: Decrease in κ]

From the analysis above, we see that an increase in education subsidy, represented by a decrease in k, will dampen the incentive to acquire education through a declining wage gap via an increase in the relative supply of skilled workers. However, a more efficient bundle of service links, denoted by an increase in n, attracts international outsourcing into Singapore, raising the relative demand for the skilled workers, and preventing the wage gap and hence incentive to acquire education to drop drastically.[8]

A concern for policy-makers is whether the increases in n and k are beneficial to the unskilled workers. To address this question, we use as a measure of the welfare of the unskilled worker her real consumption wage. Since the utility function is Cobb Douglas, it can be shown that the consumer price index is given by $P_X^b P_Y^{1-b}$ and the real consumption wage for the unskilled worker will be given by

$$\frac{w^L}{P_X^b P_Y^{1-b}},$$

which is the same as, using (10),

$$\frac{(w^L)^b}{P_X^b a_Y^{1-b}}.$$

Hence, an increase in w^L will indicate an increase in the welfare of unskilled workers since P_X is fixed in a small open economy. Assuming the structure of service specialization is similar in both the US and the small open economy, the counterpart of (31), using (24), for the US is

$$\frac{P_S^*}{w^{L*}} = \frac{c}{a n^{*\frac{1-a}{a}}}, \qquad (41)$$

where we have argued earlier that since the total supply of skilled workers is far larger in the US than in Singapore, we have that $n^* > n$, and so $\frac{P_S^*}{w^{L*}} < \frac{P_S}{w^L}$. Substituting (41) into (34) gives

[8] Compared to a decrease in k, a decrease in f, the setup cost of specialized services, is more likely to increase the wage gap because the impact of an increase in the relative supply of skilled workers is absent.

$$w^L = \left\{ \frac{1 + \frac{bkc}{an^{*\frac{1-a}{a}}}}{1 + \frac{bkc}{an^{\frac{1-a}{a}}}} \right\} w^{L*}. \qquad (42)$$

It can be shown that holding k constant, an increase in n will raise w^L, and that holding n constant, an increase in k will raise w^L. Since k is increasing in n, a decrease in k or f will raise n, k, and w^L. In other words, the real consumption wage of unskilled workers improves as the small open economy engages in a wider spectrum of component manufacturing supported by a greater extent of service specialization.[9]

8. An empirical study using Singapore data

In this section, we will estimate the reduced form of the equilibrium relative wage equation using Singapore data. The relative wage is measured by either the ratio of the average monthly earnings of managerial and professional workers (defined as skilled workers) to the average monthly earnings of production and manual workers (defined as unskilled workers) in the manufacturing sector (WGAP_M), or the ratio in the entire economy (WGAP_ALL). Relative wage is a function of the various demand shifters as well as supply shifters. In particular, the demand shifters are (a) gross expenditure in R&D as a proportion of GDP (GERD), (b) ratio of foreign direct investment to local equity investment in manufacturing (FDI_LEI_M), and (c) per capita international calls, with 2 periods' lag (CALLS2, in thousands), while the supply shifters are (d) real government recurrent expenditure per tertiary student, with 2 periods' lag (EXP_ED2, S$ at 1997 prices), and (e) ratio of workers aged 15 and above with post-secondary, polytechnic and tertiary education to those without, with 4 periods' lag (SD_EDUC4).[10] Other lags of different order are dropped because they are statistically insignificant. The

[9] If the equilibrium wage gap does not decline drastically, then it is probable that the real consumption wage of *skilled* workers will also increase. If the wage gap increases, then the welfare of skilled workers will surely improve.

[10] The values for the variables are computed based on data collected from various issues of *Yearbook of Statistics*, *Foreign Equity Investment in Singapore*, *Report on Wages in Singapore*, and the *National Survey of R&D in Singapore*. Since 1978 is the earliest year when data on GERD and wage gap in manufacturing are available, our estimations use 1978 as the starting date.

expected signs of the coefficients of the variables in the regressions on the wage gap are given in Table 1 with further explanations following it:

[Table 1: Expected signs]

Following Machin and Reenen (1998), we use GERD as a directly observed measure of technical change, rather than TFP which is indirectly measured. Machin and Reenen (1998) argued that R&D input is a good measure of the innovative process and uncovered evidence of a strong association of technical change and the relative demand for skilled workers for seven OECD countries. If the technological progress is biased toward skilled workers, we will expect a positive coefficient for GERD. On the other hand, a technical change biased toward unskilled workers will produce a negative coefficient, as implied by a downward shift in the relative demand curve.

FDI_LEI_M is used as a proxy for the extent of international production fragmentation in the manufacturing sector of Singapore. This important measure is akin to k in the model in which an increase will raise the demand for skilled workers relative to unskilled, pushing the wage gap up. Omitting this measure of international outsourcing as an explanatory variable will make the equation to be estimated mis-specified. Its absence will also render the estimated coefficient of SD_EDUC4 biased and misleading as the direct and indirect effects (via k) of an increase in the relative supply of skilled are mixed up. Later, we will present regressions without FDI_LEI_M so as to highlight the problem of mis-specification.

CALLS2 is a pre-determined variable representing telecommunications as a service link. An increase in CALLS2 is a proxy for a decrease in f in the model, implying a probable rise in the wage gap given an upward shift of the relative demand curve. Hence, the coefficient is expected to be positive.

EXP_ED2 is pre-determined and represents a shifter in the relative supply of skilled workers. As real expenditure per tertiary student increases, we expect the skill level of the work force to be enhanced and hence an outward shift in the relative supply of skilled will bring about a decrease in the wage gap: a negative coefficient. An increase in EXP_ED2 is a proxy for a decrease in k in the model.

SD_EDUC4 is another pre-determined supply shifter. An increase in SD_EDUC4 means that more workers have higher educational attainment, and hence higher skill, implying an outward shift in the relative supply of skilled and a direct decrease in the wage gap: a negative coefficient.

Before proceeding with the OLS regressions, we first test for unit roots and cointegration of the variables as in Johansen (1988). The results are available upon request. Indeed, there are unit roots in the time series and both trace and max-eigenvalue tests indicate that they are cointegrated at 1% level of significance. Hence, running an OLS regression on the levels of the variables (without differencing) will yield consistent estimates. We perform two OLS regressions with EVIEW: first using WGAP_M as the dependent variable, and then WGAP_ALL. The explanatory variables are the same for both estimations. Table 2 shows the results.

[Table 2: Results with FDI_LEI_M]

From Regression 1, GERD has a negative coefficient and is significant at 10% level of significance, suggesting a technological progress biased toward the unskilled workers in Singapore. Compared to the United States, the relative pool of skilled workers is much smaller in Singapore and the R&D done is more applied rather than basic, and hence the endogenous technical progress may not be biased toward skilled workers. All other coefficients are statistically significant at 1% level of significance and have the correct signs as predicted by the model. The high adjusted R^2 suggests a good fit while the Durbin-Watson statistics, being close to 2, suggests no mis-specification of the model. A LM test on the residuals suggests no problem of serial correlation.

From Regression 2, although GERD is not significant at 10% level of significance, its negative coefficient suggests that technological progress, if any, is not likely to be skill-biased. All other variables are statistically significant at 5% level of significance. Their estimated coefficients have the correct signs as predicted by the model. A high adjusted R^2 and a Durbin-Watson statistics close to 2 suggest a good fit as well as no error of model mis-specification. A LM test on the residuals shows no problem of serial correlation.

Our regression results suggest that both technology and international outsourcing are at work in influencing the wage gap of Singapore, a small open economy. Katz and Murphy (1992) found substantial shifts in relative demand and suggested that they may be caused by factor-biased technological change and international outsourcing without testing the causes. Feenstra and Hanson (1999) estimated the relative contributions of international outsourcing and use of high-technology equipment to the shift in relative demand for the United States. To our knowledge, our empirical study is the first to examine both technology and international outsourcing for the case of a small open economy. Furthermore, a measure of service links has been included in the empirics and is found to have a positive impact on the wage gap. The direct effect of a predetermined increase in the supply of skilled would directly decrease the wage gap but would indirectly increase the wage gap via an increase in the extent of international outsourcing.

Regressions 3 and 4 re-do the regression analysis without using FDI_LEI_M. Table 3 shows the results. The error in mis-specifying the model is obvious, as evidenced by the Durbin-Watson statistics. Also, the coefficients for SD_EDUC4 become statistically insignificant and much smaller in magnitude compared to those in Regressions 1 and 2. Therefore, it is important to consider the induced effect on the relative demand curve given an increase in the relative supply curve. Without an indicator of the degree of international production fragmentation such as FDI_LEI_M, the estimated coefficients will be biased and misleading.

[Table 3: Results without FDI_LEI_M]

How do we link the regression results to Figure 1? We look at the coefficients of SD_EDUC4, which represent the effect of an increase in the relative supply of skilled workers on the wage gap. The coefficients from Regressions 3 and 4, which ignored the endogenous increase in the range of manufacture component fragmentation, hence mis-specified, give negative values but are insignificant statistically. See Table 4. The slightly negative and insignificant coefficients in Regressions 3 and 4 correspond to the modest declines in wage gaps shown in Figure 1 despite a rapid increase in the relative supply of skilled workers. Figure 1 actually has an endogenous change in production fragmentation

hidden in it. When we incorporate a measure of production fragmentation in component manufacturing, FDI_LEI_M, in Regressions 1 and 2, hence correctly specifying the model, we see that the coefficients for SD_EDUC4 are much more negative and statistically significant. They represent a direct impact on wage gap. The endogenous outward shift in the relative demand for skilled workers is represented by the coefficients of FDI_LEI_M. They are positive at 1% level of statistical significance. See Table 4. In other words, the endogenous outward shift in the relative demand curve due to the endogenous extent of fragmentation in component manufactures is an important explanation for the evolution of the wage gap in Singapore. International outsourcing hence has prevented the wage gap from falling drastically despite a rapid increase in the relative supply of skilled workers.

[Table 4: Importance of international outsourcing]

In summary, our empirical results show the importance of an induced shift of the relative demand curve given an outward shift in the relative supply curve. The induced effect is not an endogenous skill-biased technological progress as argued by Acemoglu (2002) for the United States. Instead, changes in the relative supply of skilled workers have interacted with the structure of production in a small open economy like Singapore. In particular, the spectrum of international production fragmentation is changed as the relative supply of skilled workers increases. The rise in international outsourcing would then have an impact on wage inequality. We have also shown that technological progress in Singapore is likely to be biased toward the unskilled, and that an enhancement of the provision of service links shifts the relative demand curve outward, pushing the wage gap up.

9. Conclusion

We have developed a general equilibrium model for a small open economy in which the extent of variety of specialized service links affects the extent of international production fragmentation in manufacturing. A decrease in the cost of education or a

decrease in the fixed cost of setting up service links will raise the relative supply of skilled workers, increase the extent of variety of specialized service links, and decrease the price of aggregate services. As a result, the market for skill-intensive component manufacturing is enlarged, raising the relative demand for skilled workers. This endogenous shift in the relative demand for skilled workers due to international outsourcing illustrates an important channel through which the incentive to acquire education is retained despite a rapid rise in the relative supply of skilled workers in the process of economic development.

Empirically, we have provided evidence that the endogenous change in international outsourcing, instead of skill-biased technological progress, is the main factor in explaining a modest decline in the skilled-unskilled wage gap despite a rapid rise in the relative supply of skilled workers in the Singapore economy from 1978 to 2000. Other variables representing telecommunications service links and reduction in cost of education are statistically significant with the correct signs as predicted by the model.

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Table 1: Expected signs

Dependent Variable	WGAP_M or WGAP_ALL
Independent Variables	Expected Sign of Coefficient
GERD	Positive/Negative
FDI_LEI_M	Positive
CALLS2	Positive
EXP_ED2	Negative
SD_EDUC4	Negative

Table 2: Results with FDI_LEI_M

	Regression 1 (WGAP_M)		Regression 2 (WGAP_ALL)	
Sample	1978-2000		1978-2000	
Variable	Coefficient	t-statistics	Coefficient	t-statistics
GERD	-0.968115*	-1.779313	-0.294534	-1.285767
FDI_LEI_M	1.342988***	4.652658	0.453168***	3.728980
EXP_ED2	-0.224899***	-4.063047	-0.091346***	-3.919734
CALLS2	0.054883***	3.136521	0.015993**	2.170961
SD_EDUC4	-11.92073***	-3.299532	-4.312813**	-2.835385
Constant	4.801847***	13.29454	3.721981***	24.47601
Adjusted R^2	0.931470		0.937353	
DW statistic	1.813084		1.959838	
F-statistics	58.08720		63.84264	

Note: *, **, and *** mean 10%, 5%, and 1% level of statistical significance, respectively.

Table 3: Results without FDI_LEI_M

	Regression 3 (WGAP_M)		Regression 4 (WGAP_ALL)	
Sample	1978-2000		1978-2000	
Variable	Coefficient	t-statistics	Coefficient	t-statistics
GERD	-1.121676	-1.430067	-0.300406	-1.058996
EXP_ED2	-0.185911**	-2.316157	-0.082780**	-2.851581
CALLS2	0.010719	0.670496	-0.000623	-0.107782
SD_EDUC4	-0.598056	-0.173597	-0.313025	-0.251232
Constant	5.577518***	11.30933	3.980807***	22.31840
Adjusted R^2	0.837341		0.896845	
DW statistic	0.480437		0.967246	
F-statistics	29.31308		48.81774	

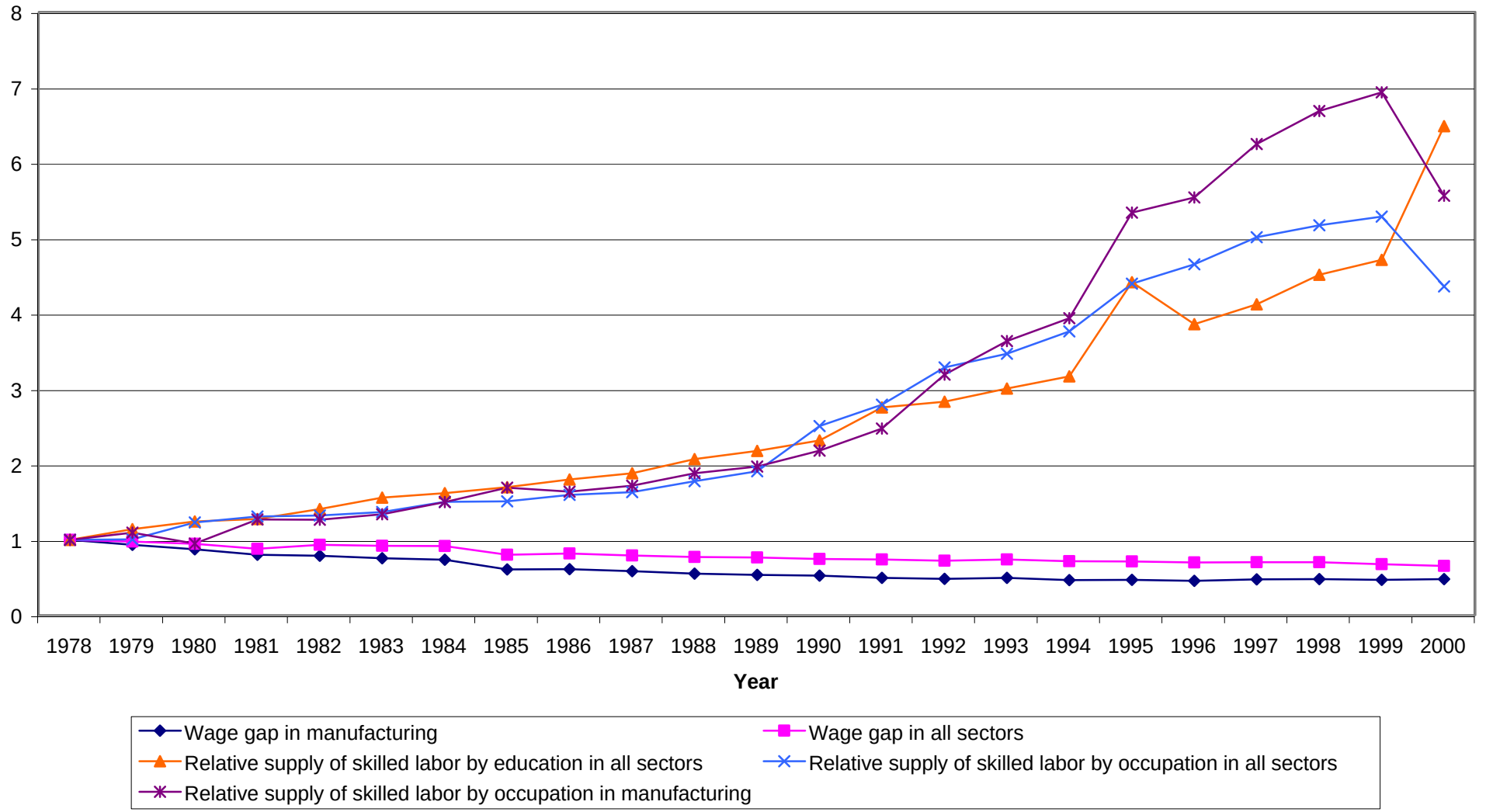
Note: ** and *** mean 5%, and 1% level of statistical significance, respectively.

Table 4: Importance of international outsourcing

	WGAP_M		WGAP_ALL	
	Regression 1	Regression 3	Regression 2	Regression 4
FDI_LEI_M	1.342988***		0.453168***	
SD_EDUC4	-11.92073**	-0.598056	-4.312813**	-0.313025

Note: Extracted from results from regressions 1 to 4. ** means 5% level of statistical significance and *** means 1% level of statistical significance.

Figure 1: Wage gap and relative supply of skilled labor, 1978 to 2000



Source: Computed from *Yearbook of Statistics* (various issues) and *Report on Wages in Singapore* (various issues).

Figure 2: Decrease in κ