Monitoring costs, Offshoring and Comparative Advantage with Heterogeneous Firms

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Draft: June 9, 2008. Comments welcome!

Abstract

We present a model in which monitoring costs determine firms' outsourcing and offshoring decisions. We predict that the most productive firms outsource in the South, while the least productive produce in-house in the North. Within the range of intermediate productivities, firms with lower productivity outsource in the North, and those with higher productivity engage in FDI (in-house production) in the South. In a Heckscher-Ohlin setting, under costly trade the incentive to offshore is greatest in the North's comparative disadvantage industry, raising the return to the North's abundant factor, skilled labour, also raising average productivity in that industry. This is accompanied by an increase in the return to Southern skilled labour, through an expansion of exporting to the North in the skilled labour intensive industry. The distributional effects of trade liberalisations depend on the initial level of trade costs. At initially high trade costs, a trade liberalisation in the presence of offshoring has relatively larger distributional effects in the North than in the South. This is reversed for initially low trade costs. The reason is that offshoring by Northern firms implies Northern relative wages converge more quickly to their free trade level than would be the case without offshoring.

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1 Introduction

Firms face a number of trade-offs in choosing the organisational form and location in which to produce. A powerful source of such trade-offs identified in the literature is the existence of transaction costs, which arise in economic environments of incomplete information. Where the costs of transacting in an arm's length relationship are high, firms may choose to vertically integrate production. Two key drivers of this choice are the desire of firms to avoid the problem of 'hold-up', originating in non-contractible, relationship specific investments, and the problem of monitoring and incentive provision. The literature on offshoring and fragmentation has to date stressed the former over the latter.

Holmstrom and Roberts (1998) write that "firms are complex mechanisms for coordinating and motivating individuals' actions. They have to deal with a much richer variety of problems than simply the provision of investment incentives and the resolution of hold ups". In what follows we apply this reasoning to the modelling of firms' outsourcing and offshoring decisions. In particular we consider a setting in which entrepreneurs, acting as Principals, seek to contract with workers, acting as Agents, for whom effort is imperfectly observable and output is subject to shocks. The combination of imperfectly observable effort and risk aversion on the part of (at least) the worker gives the entrepreneur a non-trivial mechanism design problem, in which (s)he must trade off risk and incentives in writing the optimal wage contract. In positing differences in the effectiveness of monitoring across organisational forms, we seek to explain which firms choose to outsource or offshore, and why.

Jabbour (2005) provides some evidence to suggest that firms regard the ability to monitor output to be an important factor in making the offshoring decision. Of a sample of 2,723 French industrial firms, 63% 'perfectly agree' or 'agree' that control over the quality of production is a motive favouring vertically integrated supply. 60% choose internalisation to ensure stability of supply. Similarly, Feenstra and Hanson (2004), in an analysis of Chinese export processors, find that the disintegration of ownership of production facilities from control over input sourcing is more common in Southern coastal provinces, where there exist thick export markets and relatively efficient courts, in comparison to interior and northern provinces, where integration is more likely. Their approach admits both incentive system and property-rights interpretations: by the former, one might regard the increased prevalence and earlier establishment of export processing in the Southern region as more conducive to better monitoring, e.g. through better established common working practices and access to communications technology. Navaretti and Venables (2004) cite the example of Rowntree, a well known British producer of confectionary, which expanded into South Africa in 1900. Distribution was subsequently licensed to a local agent, which undertook a low cost, low effort marketing strategy, in contrast to the wishes of headquarters. In 1950 then, Rowntree acquired majority control over the venture in South Africa, strengthening its own ability at monitoring and control. In taking an incentive system approach in what follows therefore, we stress the importance of this kind of influence, thought of as the ability to 'monitor', or the 'riskiness' of production, in determining firms' outsourcing and offshoring decisions[1]. We suggest that these considerations might be

[1]Imperfect monitoring and 'risky' production are two sides of the same coin in what follows. Imperfect monitoring implies the entrepreneur can distinguish imperfectly between two possible causes of low output: low worker input and independent adverse shocks to production. In this sense production characterised by imperfect monitoring is also 'riskier' *in*

particularly significant in firms' *North-South* offshoring decisions, where distance, language and common work practices may provide particular barriers to low cost monitoring. Moreover the North-South setting appears to be an important one both empirically and in contemporary policy debates[2].

In the model that follows, firms may produce at home by either outsourcing or producing in-house. Northern firms may also *offshore*, under which they may either perform FDI (produce in-house in the South) or outsource in the South[3]. On the basis of the ability of entrepreneurs to monitor output more effectively under in-house relationships than outsourced, and in the North than in the South, the most productive Northern firms outsource in the South, while the least productive produce in-house in the North. In the intermediate range of productivities, firms with lower productivity choose to outsource at home in the North , and those with higher productivity engage in FDI (produce in-house in the South)[4]. Firms which outsource at home or offshore enjoy savings on variable costs from doing so, but these organisational forms are chosen at the expense of worse monitoring, or more risky output. Since all agents are risk averse in the model, more risky output is *ceteris paribus* associated with lower certainty equivalent profits for entrepreneurs. Entrepreneurs operating firms in more risky organisational forms must also compensate their workers for the additional risk, which effectively increases variable costs, reducing the attractiveness of outsourcing and offshoring. Only when monitoring is sufficiently good can firms profitably choose these organisational forms. And when it is so, only the most efficient firms can compensate their entrepreneurs for the additional risk involved, giving rise to the ordering of organisational forms in productivity described above.

Further, we embed the model in a factor abundance/Heckscher-Ohlin setting. Under free trade, the incentive to offshore is 'balanced' across industries, owing to factor price equalisation. Under costly trade, the incentive for Northern firms to offshore is greater in the North's comparative disadvantage industry, where labour costs are relatively high. Where offshoring confers some saving on variable costs, raising effective productivity net of monitoring risk, a liberalisation of offshoring or an improvement in Southern monitoring effectively raises productivity by relatively more in the North's comparative disadvantage industry, and this relative difference is greater if trade is more restricted. This reduces by relatively more demand for the scarce factor in the North (unskilled labour), raising relative demand for the abundant factor in the North (skilled labour). The rise in the North's relative skilled wage then encourages an expansion of Southern exports in the skilled labour intensive industry, raising the South's relative skilled wage also. Thus skilled wage premia move in the same direction in both countries. These predictions of the model conform to recent evidence suggesting that offshoring in advanced countries has played some

observational terms than production subject to perfect monitoring. Workers risk having adverse production shocks being mistaken for low effort, and entrepreneurs risk mistaking low effort for adverse production shocks.

[2]While the outflows of FDI continue to originate predominantly from advanced countries, an increasing share is flowing into developing economies. Navaretti and Venables (2004) for example cite UNCTAD data illustrating that 90% of FDI outflows in 2002-4 originated in advanced economies, while inflows into advanced economies accounted for only 65% of global flows, with 35% flowing into developing and transition economies in that year. Moreover, the share flowing to developing and transition economies has been growing, up from 26% in 1970-3.

[3]Elsewhere these organisational choices have been referred to as *Horizontal* and *Vertical* FDI respectively.

[4]Thus the model we present here predicts that larger, more productive firms will be those performing FDI or Southern outsourcing. Although we do not choose to distinguish headquarter and component intensive sectors, by contrast with the ordering of Antras and Helpman (2004) for headquarter intensive firms we predict the most productive firms choose Southern outsourcing, not Southern FDI, when monitoring costs are important.

role in widening inequality between skilled and unskilled wages[5]. There is also evidence of rising skills premia in some developing and emerging economies[6].

In the model, offshoring by Northern firms implies Northern relative wages converge more quickly to their free trade factor price equalisation level than would otherwise be the case. Then gradual liberalisations of trade taxes entail faster adjustment of relative wages to the free trade level in the North than in the South. This implies that distributional conflict associated with trade liberalisations is relatively more severe in the North than the South at initially high tariff levels, but relatively more severe in the South at low tariff levels.

Without offshoring, partial trade liberalisations raise productivity relatively more in each country's comparative advantage industry, just as in Bernard, Redding and Schott (2007). Without trade, offshoring raises productivity by relatively more in the North's comparative disadvantage industry. Then combined trade and offshoring liberalisations feature more 'balanced' productivity increases than trade liberalisations alone.

This paper relates to the existing literature as follows. Numerous authors have documented the recent trend towards increasingly fragmented patterns of production across countries[7]. In tandem with these empirical stylised facts, a number of recent papers have sought to establish the theoretical basis for these observed changes[8]. Most papers have, following Antras (2003), taken a 'hold-up' approach, stressing the provision of investment incentives in supplier-producer relationships. Grossman and Helpman (2004) take an incentive system approach, though their model is hard to relate to heterogeneous firm monopolistic competition models a la Melitz (2003), and predicts that the least productive firms engage in FDI and Southern outsourcing, which appears at odds with the existing evidence.

The emergent empirical evidence concerning firm heterogeneity and organisational form is, however, in its infancy. There is great heterogeneity among the extant empirical approaches, including issues of definition, data coverage, and organisational forms under study. While some studies appear to confirm selected predictions of the existing 'hold-up' approach, others obscure the picture by providing apparently contradictory evidence. While Tomiura (2007) finds an organisational form ordering pattern similar to that of Antras and Helpman (2004) for a sample of Japanese firms, the study does not distinguish between Northern and Southern offshoring, nor does it appear to include domestic outsourcing as a possible organisational form, limiting its use as supportive of the hold-up model. By contrast Jabbour (2005) finds evidence to suggest the ordering of organisational forms in productivity proposed by existing

[5] See inter alia Tomiura (2005) for Japan, Hijzen, Gorg and Hine (2005) for the UK and Feenstra and Hanson (1999) for the US, though note that offshoring is not the only factor implicated.

[6] See e.g. Wood (1997) for the case of Latin America.

[7] See in particular Feenstra (1998) and Hummels, Ishii and Yi (2001). The former, for example, documents growth in the share of imported to domestic intermediate inputs for a selection of advanced countries from 1970s to the 1990s. For the UK this share grew from 13.4% in 1974 to 21.6% in 1993 for all manufacturing industries. For the US, the share doubled from 4.1% in 1974 to 8.2% in 1993. The latter documents growth in vertical specialisation across 10 OECD and four emerging markets of 30% between 1970 and 1990.

[8] See, inter alia, McLaren (2000), Antras (2003), Antras and Helpman (2004), Grossman, Helpman and Szeidl (2005), Grossman and Helpman (2004), Antras, Garicano and Rossi-Hansberg (2006*a*), Antras, Garicano and Rossi-Hansberg (2006*b*), and Marin and Verdier (2003).

theories is not fully supported in data on French multinationals[9]. A related problem is that existing studies do not fully address the underlying causes of observed organisational form orderings. Confirmation of a prediction of a theory is not equivalent to confirmation of the causal process proposed by that theory.

We begin with a description of the model of the Northern economy under autarky, before considering offshoring and trade with a 'Southern' economy.

2 The Model: Closed Economy

2.1 Preferences

Each agent j seeks to maximise the following utility function

$$U_j = \sum_i^2 \eta_i \int_0^1 \beta_{z_i} \ln Q_{z_i} dz_i \quad i = 1, 2 \tag{1}$$

$$\text{where } Q_{z_i} = \left[\int_{\gamma \in \Gamma} q(\gamma)^{\frac{\sigma-1}{\sigma}} d\gamma \right]^{\frac{\sigma}{\sigma-1}}, \sum_i^I \eta_i = 1, \int_0^1 \beta_{z_i} dz_i = 1 \tag{2}$$

for $\sigma > 1$, where each $i = 1, 2$ represents a different *industry*, each of which contains a continuum of *sectors* indexed by $z_i \in [0, 1]$. Further, within each sector there will be a population of firms producing differentiated varieties $\gamma \in \Gamma$. In what follows, sectors will vary exogenously according to the ease with which output can be monitored, while industries will vary according to the intensity of their factor use. So with two factors of production and two industries which differ in the intensity of their factor use, within each industry output will be easier to monitor in some sectors than others. We may perform two stage budgeting to give demand for an individual firm in a given industry sector as

$$q_{z_i}(\gamma) = \theta_{z_i} p(\gamma)^{-\sigma} \tag{3}$$

where $\theta_{z_i} \equiv \frac{\eta_i \beta_{z_i} E}{P_{z_i}^{1-\sigma}}$, in which E is economy-wide expenditure and P_{z_i} is the sector's ideal price index, defined by $P_{z_i} \equiv \left[\int_{\gamma \in \Gamma} p(\gamma)^{1-\sigma} d\gamma \right]^{\frac{1}{1-\sigma}}$.

Since all agents have concave utility functions, they are all risk averse, and care about outcomes adjusted for risk, or certainty equivalents. With imperfect monitoring, entrepreneurs cannot accurately distinguish whether low output is due to low worker input, or due to independent adverse output shocks. Workers then must incur some of this monitoring risk in their wage contracts. For this reason they will require a risk premium for operating in situations in which output is not perfectly monitored. En-

[9] In particular, for component intensive sectors, she finds that an increase in productivity is associated with a higher probability of Northern outsourcing than Southern outsourcing, in contrast to the predictions of Antras and Helpman (2004). Similarly, for headquarter intensive sectors, the ordering of country location in productivity is found to be the reverse of that of the model. Note this finding is also contrary to the predictions of Grossman and Helpman (2004) who take an incentive system approach, which in their case predicts outsourcing by both the lowest and highest productivity firms. There is a problem however in viewing Jabbour's evidence as directly relevant to Antras and Helpman (2004)'s model, as her data is truncated to exclude firms which operate only domestically.

trepreneurs will also demand risk premia in environments of imperfect monitoring, as output is subject to imperfectly distinguishable input and output shocks.

We assume the risk premium any agent must receive rises as the 'riskiness' of production rises, which does so as the ability to monitor output falls. The curvature of the utility function determines how quickly the risk premium rises in response to a more uncertain environment, and this is the amount the agent must receive to be just indifferent between operating in two environments involving different levels of risk. Formally, a worker's risk premium s must be such that her certainty-equivalent income is constant across environments. So, for example, for an endogenously determined factor reward w, a worker is indifferent between operating in a risk free environment in which she receives w, and a risky one in which she receives $w+s$. Similarly, for entrepreneurs, a given profit level subject to shocks π must be lowered by an amount S in order to give the certainty equivalent profit level $\pi - S$. In what follows we assume s and S to be functions of the ability to monitor. Thus we can think of an agent maximising the above utility function subject to a budget constraint in which income comprises a factor reward together with a risk premium, where the latter is determined 'exogenously' by the curvature of the utility function and the riskiness of their environment.

2.2 The Structure of Production

Entrepreneurs are drawn from the economy's pool of labour. They run firms, which are heterogeneous, drawing their productivity level φ independently from the identical cumulative distribution function $G(\varphi)$ defined over finite support $[0, \bar{\varphi}]$, with associated probability distribution function $g(\varphi)$ [10]. Because firms vary according to their productivity, and each produces a unique variety, we may index varieties by φ. Their costs depend both on this, and on their choice of organisational form. In the closed economy, firms may choose either to produce in-house, that is, remain vertically integrated, or outsource production domestically, that is, vertically disintegrate. Production uses labour, for which we denote the wage cost by $\tilde{w}_i$. This will vary depending on the industry in which a given firm operates, which in turn determines that firm's factor intensity. With two factors, skilled (K) and unskilled (L) labour, two industries $i = 1, 2$, and Cobb-Douglas technology, this may be written $\tilde{w}_i = w_K^{\delta_i} w_L^{1-\delta_i}$. To keep things simple, suppose that each industry uses one factor of production exclusively, so that $\delta_1 = 1$ and $\delta_2 = 0$. Then we may write $\tilde{w}_i = w_i$.

In-House production. We write in-house costs of production as

$$c_{z_i}^{in}(\varphi) = \frac{w_i}{\varphi} q + f w_i \tag{4}$$

where f is a fixed labour cost of in-house production, and the unit labour input requirement is equal to unity. We assume that in-house production entails no monitoring costs, hence producing in this organisational form is 'risk-free'[11].

[10] For example, for consistency with existing work on trade and heterogeneous firms, one might use a Generalised Pareto Distribution, which allows for a finite support. In this case the distribution function is given by $G(\varphi) = 1 - \left(1 - \frac{\varphi}{\bar{\varphi}}\right)^{\bar{\varphi}}$, and the p.d.f. by $g(\varphi) = \left(1 - \frac{\varphi}{\bar{\varphi}}\right)^{\bar{\varphi}-1}$, though this is by no means the only admissible distribution function for what follows.

[11] The assumption of riskless in-house production may easily be relaxed. The important assumption then is that in-

Outsourced production. Costs for firms which choose to outsource differ from in-house costs in two respects. First, there is a saving on variable costs $\bar{\alpha} < 1$, originating for example in a reduction in per worker health and safety, pension, and other costs. Second, output is subject to shocks which are imperfectly observed. In particular, an entrepreneur cannot accurately distinguish between higher input requirements due to low worker effort e, or exogenous shocks ϵ. We model this by supposing that per unit labour input requirements are given by $\frac{\bar{\alpha}}{e} + \epsilon_{z_i}$ per unit of output, where $\epsilon_{z_i} \sim N(0, v_{z_i})$. v_{z_i} is the variance of shocks to input requirements, and we assume this to be exogenously given and increasing in z_i. So as we move from $z_i = 0$ to $z_i = 1$, the riskiness of production rises, or the ability to monitor output falls. We assume the workers may choose effort $e \in [\underline{e}, \bar{e}]$, which is costly for them to exert. Given that entrepreneurs can imperfectly monitor effort, they must provide workers with incentive payments to induce exertion. Imperfect monitoring exposes workers to risk however, and given that workers are risk averse, they will also demand a risk premium to be employed in outsourced relationships. Hence the extra payment workers' receive in outsourced relationships, s, reflects both the variance of measured effort, and the cost of effort. In particular, we assume $s = s_{z_i}(e)$. The sub-index z_i relates the incentive payment to monitoring technology v_{z_i} in sector z_i. Since we have assumed v_{z_i} to be increasing in z_i, it is natural to assume likewise that s_{z_i} increases in z_i too. That is, as the variance of measured effort rises, or monitoring technology deteriorates, workers demand higher risk premia. Similarly, since effort is costly to workers, we assume that $s'_{z_i}(e) > 0$. That is, to induce higher effort, entrepreneurs must pay higher incentive payments. Finally, the classic Principal-Agent model a la Holmstrom and Milgrom (1991) features rising optimal incentive payments as the marginal value of output rises. Here, the latter is given by firm price, p. Then in sum, each worker exerting effort e in an outsourced employment relationship receives a risk premium equal to $p \times s_{z_i}(e)$.

At the optimal level of effort e^*, each worker then receives a total of $w + ps_{z_i}(e^*)$. This must be just sufficient to leave workers indifferent between working in-house and under outsourcing. That is, the certainty equivalent utility value of the wage for in-house production w, and that for outsourced production $w + ps_{z_i}(e^*)$ must be exactly equal. In the jargon of the Principal-Agent model, workers' *participation constraints* bind.

Lastly, as written below, we also assume that while productivity raises the output obtained per unit of labour employed, it does not reduce the risk premium workers require. So higher productivity firms benefit in that they enjoy higher labour productivity, but this does not mean that they pay smaller risk premia independently of differences in the prices they choose to set. With the value of shocks to output equal to zero in expectation, we may write the expected cost function for outsourced production as

$$c^o_{z_i}(\varphi) = \frac{\alpha(e)w_i}{\varphi}q + \alpha(e)ps_{z_i}(e)q + fw_i \tag{5}$$

where $\alpha(e) \equiv \bar{\alpha}/e$ is the *effort adjusted* labour input requirement. This reaches its minimum when effort is at its maximum, namely $\bar{\alpha}/\bar{e}$. Note that we have assumed the fixed cost associated with outsourcing to be identical to that associated with in-house production[12].

house production is *less risky* than outsourcing, implying that entrepreneurs and workers demand lower risk premia when operating in in-house environments.

[12]We may easily relax this assumption and allow fixed costs to vary across organisational forms. For further discussion, see footnote 14.

In addition to monitoring problems, we add another feature to the standard heterogeneous firms model. We assume that firms require entrepreneurs to operate them, and it is these agents who choose the organisational form under which the firm will operate. Entrepreneurs share the same utility function as workers, which by concavity implies that they also are risk averse. They therefore require a risk premium to operate in risky environments; alternatively, one can think that, for a given level of profit, an increase in riskiness reduces the certainty equivalent value of that profit, which is what entrepreneurs ultimately care about. We have assumed in-house production to be risk-free — output is perfectly monitored — and so certainty equivalent profit is equal to total profit for in-house producers. Not so if entrepreneurs choose to outsource. This exposes them to shocks to output, which requires compensation. As with workers, the size of the risk premium is increasing in riskiness (decreasing as monitoring improves across sectors), which varies exogenously, and in the curvature of the utility function, which is also exogenous. Thus we posit that when entrepreneurs set up firms which outsource, certainty equivalent profits are lower by a fixed amount $S^o_{z_i} > 0$ which is increasing in z_i, which acts like a fixed cost[13]. Assuming monopolistic competition, and taking the competitive environment, organisational form, and worker effort as given, entrepreneurs then choose prices to maximise certainty equivalent profits of

$$\pi_{in,z_i}(\varphi) = pq - c^{in}_{z_i}(\varphi) \tag{6}$$

$$\pi_{o,z_i}(\varphi) = pq - c^{o}_{z_i}(\varphi) - S^o_{z_i} w_i \tag{7}$$

which after substituting for demand, and standard arguments, gives equilibrium prices of

$$p_{in}(\varphi) = \frac{w_i}{\rho\varphi} \tag{8}$$

$$p_o(\varphi) = \frac{\alpha(e)w_i}{\rho\varphi[1-\tilde{s}_{z_i}(e)]} \tag{9}$$

where $\tilde{s}(e) \equiv \alpha(e)s(e)$ and $\rho \equiv \frac{\sigma}{\sigma-1}$. Thus with lower unit input requirements, firms which outsource tend to charge lower prices, while the risk premium s associated with outsourcing works to increase prices. Substituting in equilibrium prices and quantities gives profits for each mode of production as

$$\pi_{in}(\varphi) = \theta_{z_i}\tilde{\rho} w_i^{1-\sigma}\varphi^{\sigma-1} - fw_i \tag{10}$$

$$\pi_o(\varphi) = \theta_{z_i}\tilde{\rho}[\alpha(e)w_i]^{1-\sigma}[1-\tilde{s}_{z_i}(e)]^{\sigma}\varphi^{\sigma-1} - fw_i - S^o_{z_i}w_i \tag{11}$$

where $\tilde{\rho} \equiv (1-\rho)\rho^{\sigma-1}$. Given these profit functions, what is the optimal amount of worker effort for entrepreneurs who outsource? The derivative of the profit function with respect to effort captures the net marginal benefit to entrepreneurs of inducing higher effort. This of course depends on the balance between the lower input requirements that higher effort brings about, and the cost through incentive payments of so doing. Clearly, optimising entrepreneurs wish to set $\frac{d\pi_o}{de} = 0$, which defines optimal effort e^*. In the appendix, we show that the optimal effort depends only on model parameters, and not on endogenous variables. So for given monitoring technology, entrepreneurs choose a unique effort level $e^*_{z_i}$, which determines the unit labour requirements $\alpha_{z_i} \equiv \bar{\alpha}/e^*_{z_i}$. Then, accounting for fixed optimal effort,

[13]It will be analytically convenient to normalise this risk adjustment with reference to the wage rate, w_i, then $S^o w_i$ enters entrepreneurs' profit functions. This assumption is made for convenience, and should not qualitatively change the results that follow. See footnote 15 for further discussion

we may write the profit function for outsourcing as

$$\pi_o(\varphi) \quad = \quad \theta_{z_i}\tilde{\rho}[\alpha_{z_i}w_i]^{1-\sigma}[1-\tilde{s}_{z_i}]^{\sigma}\varphi^{\sigma-1} - fw_i - S^o_{z_i}w_i \tag{12}$$

We will explore the implications of different monitoring technology for effort across sectors shortly. We first examine within sector organisational choices.

Sorting within sectors. From the above profit functions, we begin to see a sorting pattern in adjusted productivity $\varphi^{\sigma-1}$ as long as workers' risk premium s_{z_i} is not too large. Formally, the required condition is that $s_{z_i} < \frac{1-\alpha_{z_i}^{\frac{\sigma-1}{\sigma}}}{\alpha_{z_i}}$, and when this is the case, outsourcing per se enjoys an exogenous 'productivity advantage' over in-house production, owing to the saving on variable costs. Thus, when this holds, π_o is steeper than π_{in} in $\varphi^{\sigma-1}$, while $S^o > 0$ implies that the former cuts the latter from below[14]. The switch from in-house to outsourced production occurs at productivity level φ_{o,z_i} defined by[15]

$$\pi^{in}_{z_i}(\varphi_{o,z_i}) = \pi^o_{z_i}(\varphi_{o,z_i}) \tag{13}$$

Similarly, positive fixed costs for in-house production ensure the existence of an entry productivity cut-off $\underline{\varphi}_{z_i}$ below which firms choose optimally to exit, rather than incur negative profits, defined by

$$\pi^{in}_{z_i}(\underline{\varphi}_{z_i}) = 0 \tag{14}$$

Using this, the sector equilibrium configuration is illustrated in Figure 1, and provides us with the following Proposition:

Proposition 1 *In the closed economy, when outsourced production is harder to monitor than in-house production, the most productive firms outsource, the least productive exit, and those of intermediate productivity produce in-house.*

Note that both the entry cut-off and the outsourcing cut-off depend on endogenous variables which are to be determined in equilibrium. Before we describe this equilibrium however, consider what happens as we move across sectors.

Sorting across sectors. Suppose we move from z_i to $z_i' > z_i$. Monitoring gets harder as z_i increases, hence outsourced production becomes more risky. Further, in the appendix we show that the optimal amount of effort chosen by entrepreneurs falls as monitoring gets harder, if workers' marginal cost of effort is sufficiently high. Intuitively, when this is the case, the extra cost of inducing higher effort in

[14] For generalised fixed costs f^{in}, f^o, this will be the case as long as $f^{in} < f^o + S^o$. Thus the result is robust to some generalisation of fixed costs, but this is bounded by the requirement that the difference between in-house and outsourcing fixed costs is not too large relative to entrepreneurs' risk premium. For simplicity, we have assumed in the text that $f^{in} = f^o$, though as noted there are limits to the set of generalisations to this that leave this sorting result unchanged.

[15] Consider the impact of assuming the risk adjustment S_o is normalised with reference to the wage rate. Suppose first it was not, and the wage rate were to rise. This pivots both profit curves downwards, causing the outsourcing cut-off φ_o to rise. Now add in the effect of the rise in the wage rate on the term $S_o w_i$, and we find that the effect is to reinforce the reduction in outsourcing arising from a rise in the wage rate. Thus we argue that, while analytically convenient in what follows, this normalisation of the risk adjustment with respect to the wage rate will not qualitatively affect results.

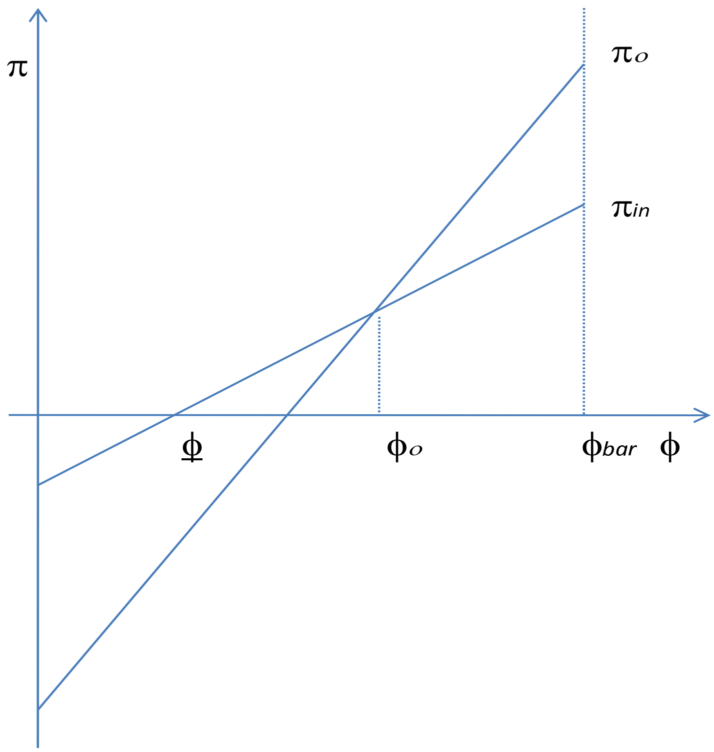

Figure 1: Sector equilibrium in the closed economy without offshoring

the presence of harder monitoring outweighs the benefits of reduced unit inputs, such that $de^*_{z_i}/dz_i < 0$. Thus unit costs, α_{z_i}'s, rise as we move across sectors on account of lower effort. Second, since riskiness has increased, workers demand higher risk premia independently of effort levels, further raising variable costs. Thus α_{z_i} and s_{z_i} both rise as we move across sectors, pivoting downwards the outsourcing profit curve.

Second, entrepreneurs' risk premia, the $S^o_{z_i}$'s also rise as we move across sectors, once more reflecting harder monitoring, or riskier production. This shifts the outsourcing profit curve downwards. The net result is that the threshold above which outsourcing occurs unambiguously increases. By this simple argument, φ_{o,z_i} is increasing in z_i, up until some sector $\tilde{z}_i$ at which $\varphi_{o,\tilde{z}_i} = \bar{\varphi}$. Thus for sectors above $\tilde{z}_i$, all production takes place in-house; these are the sectors for which outsourcing is riskiest, or monitoring is worst.

Proposition 2 *When monitoring deteriorates across sectors (equivalently with risk increasing), the amount of outsourcing decreases. Then with an upper limit on possible productivity draws, there exists a threshold sector $\tilde{z}_i$ such that firms both produce in-house and outsource for $z_i \in [0, \tilde{z}_i)$, while only producing in-house for $z_i \in [\tilde{z}_i, 1]$.*

2.3 Free entry and Equilibrium at the Sector level

In what follows, we drop the sector index z_i for presentational clarity. Equilibrium at the sectoral level may be fully described once we know the exit productivity cut-off, $\underline{\varphi}$, from which we may derive sector average productivity, $\tilde{\varphi}_o$, a 'sufficient statistic' for the sector in question. In the case where firms may produce in-house or outsource at home, this average productivity level is defined by

$$\tilde{\varphi}_o^{\sigma-1} \equiv \frac{1}{1-G(\underline{\varphi})}\left\{\int_{\underline{\varphi}}^{\varphi_o} \varphi^{\sigma-1} g(\varphi) d\varphi + \int_{\varphi_o}^{\bar{\varphi}} \left(\frac{\alpha}{1-\tilde{s}}\right)^{1-\sigma} \varphi^{\sigma-1} g(\varphi) d\varphi\right\} \tag{15}$$

Note that when domestic outsourcing diminishes to zero, this reduces to the model of Melitz (2003) with homogeneous organisational forms. Denoting average productivity in this case (with in-house production only) by $\tilde{\varphi}$, we may then write average productivity with outsourcing as

$$\tilde{\varphi}_o^{\sigma-1} = \tilde{\varphi}^{\sigma-1} + \lambda_o \int_{\varphi_o}^{\bar{\varphi}} \varphi^{\sigma-1} \frac{g(\varphi)}{1-G(\underline{\varphi})} d\varphi \tag{16}$$

$$\text{where } \lambda_o \equiv \left(\frac{\alpha}{1-\tilde{s}}\right)^{1-\sigma} - 1 \tag{17}$$

Thus, compared to the model with homogeneous organisational forms, positive amounts of outsourcing add to average sector productivity whenever $\lambda_o > 0$, or $\tilde{s}$ is not too big. Equivalently monitoring must be sufficiently good to allow firms to enjoy the variable cost savings of outsourcing. Just as in the homogeneous organisational forms case, average sector productivity is increasing in the exit cut-off in the presence of domestic outsourcing as well.

From (13) we may write the *outsourcing* cut-off φ_o as a function of exogenous parameters and the exit cut-off alone (see appendix), $\varphi_o = \Lambda_o \underline{\varphi}$, $\Lambda_o > 1$. Then the average sector level productivity is fully determined by the *exit* cut-off. Given the cut-off for exit, it will also be convenient to define the ex-post distribution of productivities $\mu(\varphi)$ by $\mu(\varphi) \equiv \frac{g(\varphi)}{1-G(\underline{\varphi})}$. We then follow the familiar approach of Melitz (2003) in determining sector level equilibrium, by deriving (i) a zero profit cut-off and (ii) a free entry condition, both in terms of average profits adjusted for risk, or *certainty equivalent average profits.*

First, we assume that for entry each firm requires one entrepreneur. If the firm is in the skilled labour using industry, potential entrepreneurs must come from the pool of skilled labour (and vice versa for unskilled labour using firms). With a cut-off of $\underline{\varphi}$, the probability of successful entry is $[1 - G(\underline{\varphi})]$. If firms make certainty equivalent profits $\bar{\pi}$ on average, free entry ensures that the expected certainty equivalent profit must equal entry costs, or $[1-G(\underline{\varphi})]\bar{\pi} = w_i$. That is, expected certainty equivalent profits must exactly equal the entrepreneur's outside option, which is to work as production labour earning a certainty equivalent payment equal to the wage rate. Rearranging, this gives the *free entry condition* (FE) as

$$\bar{\pi} = \frac{w_i}{[1 - G(\underline{\varphi})]}. \tag{18}$$

Second, from (14), we may write $r(\underline{\varphi}) = f w_i$, where $r(.)$ denotes firm revenue for an in-house firm defined by $r(\varphi) \equiv \theta_{z_i} \tilde{\rho} w_i^{1-\sigma} \varphi^{\sigma-1}$. We then make use of the fact that $r(\varphi)/r(\varphi') = (\varphi/\varphi')^{\sigma-1}$ in writing $r(\tilde{\varphi}) = (\tilde{\varphi}/\varphi)^{\sigma-1} f w_i$. Further, we must adjust average profits to account for the riskiness involved with outsourcing in order to arrive at certainty equivalent average profits. Each firm that outsources requires this adjustment to give its certainty equivalent profits, so the adjustment required for *average* certainty equivalent profits involves subtracting the expected entrepreneur risk premium, given by the integral of S_o over the range of firms that outsource. Hence the adjustment is $\int_{\Lambda_o \underline{\varphi}}^{\bar{\varphi}} w_i S_o \mu(\varphi) d\varphi$. Then since certainty equivalent average profits $\bar{\pi}$ must equal average revenue, less fixed costs, and adjusted for outsourcing risk, we may write the *zero-profit cut-off condition* (ZPC) as

$$\bar{\pi} = \left[\left(\frac{\tilde{\varphi}_o(\underline{\varphi})}{\underline{\varphi}} \right)^{\sigma-1} - 1 \right] f w_i - w_i \int_{\Lambda_o \underline{\varphi}}^{\bar{\varphi}} S_o \mu(\varphi) d\varphi \tag{19}$$

Note that in comparison to Melitz (2003), the FE condition is qualitatively identical[16], but ZPC differs. We may explore this further, defining $k(\varphi) \equiv [(\tilde{\varphi}/\underline{\varphi})^{\sigma-1} - 1]$ just as in Melitz (2003), allowing us to write ZPC as

$$\bar{\pi} = k(\varphi) f w_i + f w_i \int_{\Lambda_o \underline{\varphi}}^{\bar{\varphi}} \left[\lambda_o \left(\frac{\varphi}{\underline{\varphi}} \right)^{\sigma-1} - \frac{S_o}{f} \right] \mu(\varphi) d\varphi \tag{20}$$

Clearly then, the ZPC under outsourcing may lie to the left or the right of that under homogeneous organisational forms, depending on the sign of the term in square brackets. What is the intuition for this ambiguity? First, outsourcing raises average productivity wherever $\lambda_o > 0$, which *ceteris paribus* works to shift the ZPC to the right. However, outsourcing is also risky, and since we are concerned here with certainty equivalent profits, these may fall on average on account of the higher average level of risk associated with production. For the productivity effect to dominate, we require a restriction on the size of entrepreneurs' risk premia, S_o, just as we did for workers' risk premia s above. Thus, when $S_o < \lambda_o f(\varphi/\underline{\varphi})^{\sigma-1}$, outsourcing raises average certainty equivalent profits, as the productivity gain exceeds the rise in risk, shifting ZPC to the right relative to the case with homogeneous organisational forms.

The equilibrium exit cut-off is determined by solving (18) and (19) simultaneously. Just as in Melitz (2003), a sufficient condition for a unique equilibrium is that FE be increasing and ZPC be decreasing in $\underline{\varphi}$. Analogously, a sufficient condition for this is that $[1 - G(\varphi)]k(\varphi) + \int_{\Lambda_o \underline{\varphi}}^{\bar{\varphi}} \left[\lambda_o \left(\frac{\varphi}{\underline{\varphi}} \right)^{\sigma-1} - \frac{S_o}{f} \right] g(\varphi) d\varphi$ is decreasing in $\underline{\varphi}$. From Melitz, this is the case for the term $[1 - G(.)]k(.)$, and it is also the case for the second term (due to outsourcing) by inspection[17]. Thus we conclude that we obtain a unique equilibrium, which under outsourcing entails a higher exit cut-off, and higher average productivity, than the case with in-house production only. This is illustrated in Figure 2. The curve $ZPC_{in-house}$ corresponds to Melitz (2003)'s model. The relevant ZPC curve with outsourcing too is given by ZPC_{out-s}. When outsourcing confers a productivity gain, it lies to the right of $ZPC_{in-house}$.

Proposition 3 *When the productivity gain from outsourcing exceeds the rise in riskiness from outsourcing, certainty equivalent average profits rise. This entails a higher exit productivity cut-off, and higher average productivity in equilibrium.*

[16] The only difference being constants.

[17] Raising $\underline{\varphi}$ both raises the lower limit on the integral, and lowers the size of the term under the integral.

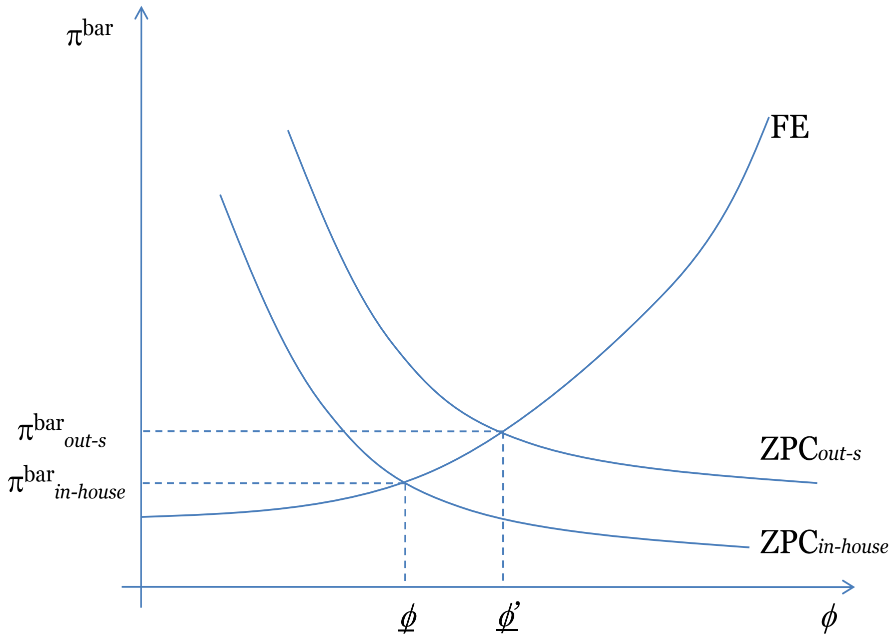

Figure 2: Sectoral equilibrium, with and without outsourcing

Intuition for this result may be provided by considering the impact of increased outsourcing on the price index. Since firms which outsource, if not too risky, gain an effective productivity boost, they charge lower prices in equilibrium. This works to lower the sector price index, and since other firms' profits are increasing in this index, other firms' profits must fall. This harms in particular those firms operating at the margin, with the lower productivity draws, forcing them to exit.

Consider two 'parallel' industry-sectors, z_1, z_2. These two sectors differ only according to their factor use. In particular, they feature identical monitoring technologies, entry costs, etc. An implication of this is that *the exit cut-off in each parallel-sector is identical*, since this is determined by model parameters only, and these are the same in each parallel sector. This implies that average productivities are also identical for two such sectors. This will provide us with an important benchmark when we later consider free and costly trade.

The characterisation of the sectoral equilibrium is not yet complete: we need also to determine the equilibrium number of firms. Straightforwardly, the number of firms n is equal to the number of entrepreneurs who undertake successful entry. So the number of active firms must equal the total number of entrants n_e times the probability of successful entry, or $n = [1 - G(\underline{\varphi})]n_e$.

Substituting these equilibrium conditions into the expression for the sector price index then gives $P_{z_i} = n_{z_i}^{\frac{1}{1-\sigma}} p(\tilde{\varphi}_{z_i})$. The impact of outsourcing on the price index is then ambiguous: on the one hand it raises average productivity, lowering average prices. But higher average productivity also ceteris paribus reduces the number of active firms, by raising the exit cut-off. This latter effect raises the price index, giving an ambiguous effect overall.

2.4 Goods and Labour market equilibrium

We now illustrate the determination of equilibrium in goods and factor markets at the industry level. We work in *certainty equivalent* terms, meaning that, for a given sector, we equate certainty equivalent labour payments and certainty equivalent profits to certainty equivalent revenues[18]. For expositional purposes, consider an economy initially comprised of one sector and one industry, which uses one factor, labour (L) in addition to entrepreneurs (we will generalise this in what follows). For this sector, total certainty equivalent revenues R must exactly equal total certainty equivalent payments to labour used in production $w \times L_p$ plus total certainty equivalent profits Π. In order for workers to be indifferent between being employed in-house or under outsourcing, they must receive the same certainty equivalent wage w in either set-up[19]. Thus we must have that $R = wL_p + \Pi$. Further, total sector certainty equivalent profits Π may be written $\Pi = n\bar{\pi}$. Dividing the FE condition by that for the equilibrium number of firms $n = [1 - G(\underline{\varphi})]n_e$, and rearranging, gives $n\bar{\pi} = wn_e$. This says that the total value of certainty equivalent profits must equal the total value of entrants' outside options, the labour wage. The total labour supply L must equal labour used in production L_p plus entrepreneurs who attempt entry n_e, so $L = L_p + n_e$. Using this, we then have that

$$wL = R \tag{21}$$

In the simple one sector, one industry example, since the cut-off is uniquely determined, setting $w = 1$ as the numeraire ties down total revenue in terms of the size of the labour force. Exactly this procedure may be used to determine equilibrium in the two industry, two factor case with a continuum of sectors. In particular, in each individual sector, the cut-off is uniquely determined in terms of parameters, including whether or not outsourcing takes place, which is determined by the monitoring in that sector. We assume that each *industry* features exactly the same profile of ability to monitor (therefore risk premia) across sectors, such that industries differ only according to their factor use. Thus each industry is characterised by a vector of cutoffs $\underline{\Phi}_i \equiv \{\underline{\varphi}_{z_i}\}_{z_i=0}^{z_i=1}$, which is identical across industries in the absence of any cross industry differences in entry costs, monitoring, etc. Total revenue in each industry must then equal payments to labour, as above, or $w_i l = R_i$, $l = K, L$ for $i = 1, 2$ respectively. Total economy-wide revenue is $R = R_1 + R_2$. Assuming equal shares in expenditure of $\eta_1 = \eta_2 = \eta$ on industries 1 and 2 respectively, industry 1 using exclusively skilled labour, and industry 2 using exclusively unskilled labour, we may then write

$$w_K K = \eta_1 R \tag{22}$$
$$w_L L = \eta_2 R \tag{23}$$

[18]'Actual' magnitudes may then be straightforwardly obtained from these magnitudes by correcting for the exogenously given risk premia entrepreneurs and workers in outsourced relationships demand.

[19]Total payments to a worker in an outsourced relationship will be $w\left(1 + \frac{\tilde{s}}{\rho(1-\tilde{s})}\right)$, where the term in brackets is the risk premium in equilibrium, calculated after substituting the equilibrium price into total payments under outsourcing of $w + \varphi\alpha p(\varphi)s$, as defined in the outsourcing cost function above. Likewise total profits earned by a given entrepreneur will be given by $\pi(\varphi) + S_o$.

which in turn may be used to determine the relative (autarkic) wage rate as

$$\omega \equiv \frac{w_K}{w_L} = \frac{L}{K}. \tag{24}$$

Clearly then, under autarky and domestic outsourcing only, the relative return to skilled labour is lower when skilled labour is relatively abundant.

What about the equilibrium number of firms? Revenue in a given industry-sector is given by $R_{z_i} = \eta_i \beta_{z_i} R = \beta_{z_i} R_i$. Then we may write a sector's revenue as $\beta_{z_i} R_i = \beta_{z_i} w_i l = n_{z_i} \bar{r}(\tilde{\varphi}_{z_i})$, for $l = K, L$, $i = 1, 2$ respectively. Assuming symmetrical expenditure across all industry sectors $\beta_{z_i} = \beta, \forall z_i, i = 1, 2$, we may then write

$$\omega \frac{K}{L} = \frac{n_{z_1} \bar{r}(\tilde{\varphi}_{z_1})}{n_{z_2} \bar{r}(\tilde{\varphi}_{z_2})} \tag{25}$$

The left hand side of this expression is equal to unity, using the autarkic wage rate derived above. Since average productivities (and therefore average revenues) are equal for the two parallel industry-sectors, the number of firms in each parallel industry sector must also be equal.

3 The Open Economy: Trade and Offshoring with 'The South'

We now assume the economy described so far is the Northern country, and is skilled labour abundant ($K/L > 1$). We wish to introduce a second, Southern country, with which the Northern country may trade goods, and to which Northern firms may offshore production. For simplicity, we assume the Southern country is identical to the Northern country[20], with the exception of two key features. First, using asterisks to denote Southern variables, assume the South is unskilled labour abundant, $K^*/L^* < 1$. Then under autarky, equilibrium in the Southern economy looks exactly as that in the North just described, with the only difference being that the South exhibits a relatively high nominal return to skilled labour, compared to the North. A corollary of this is that a relative industry-sector 1 price index under autarky is higher in the South than in the North, or $P_1/P_2 < P_1^*/P_2^*$ (see appendix). Second, we will assume that only Northern firms may fragment production internationally owing to some superior access by Northern entrepreneurs to offshoring technology; that is, only Northern firms may undertake FDI or Foreign Outsourcing. Before we consider this in detail, we first examine equilibrium with free trade, but without offshoring.

3.1 Free Trade, with no Offshoring

3.1.1 Sectoral Equilibria

First, what is the impact of moving from autarky to free trade on sector-level cut-offs and average productivity? Under autarky, these were completely determined by model parameters, and since these

[20]Including entry costs, probability of failure, fixed costs, and so on. Note also that we permit Southern firms to outsource domestically.

are identical for two parallel industry-sectors (z_1, z_2), the cut-offs are identical. Under free trade, this continues to be the case. In particular, since neither the FE or ZPC conditions are altered in the presence of free trade, a move from autarky to the free movement of goods implies no change in sector exit cut-offs. Likewise, sector average productivities are the same. This is exactly as in Bernard et al. (2007). As they explain, free trade creates an export market for domestic firms, increasing demand, but also provides more competition in the domestic market, reducing demand. There is, of course, resource reallocation, which we discuss further below.

3.1.2 Goods and Factor market equilibrium

Since we have assumed symmetric countries in every respect other than factor abundance, and exclusive use of one factor by each industry, it should be clear that factor price equalisation will occur[21]. More fully, in the absence of offshoring, sector cut-offs are determined independently of factor rewards, just as in the closed economy case. World revenue may be written $\bar{R} = R_1 + R_1^S + R_2 + R_2^S$, where S denotes Southern firms' revenues. Payments to factors then reflect expenditure shares on each industry, which are the same for all agents. If these expenditure shares are once again equal for each industry, the free trade relative wage rate which prevails in both countries is

$$\omega = \omega^* = \frac{\bar{L}}{\bar{K}} \tag{26}$$

where $\bar{K}, \bar{L}$ represent the sum of North and South factor endowments. In moving from autarky to free trade, the Stolper-Samuelson theorem holds, following from the fact that the North is skill abundant relative to the South.

A movement from autarky to free trade also involves some reallocation of resources according to comparative advantage in each country, as in Bernard et al. (2007). This may be seen by considering the equilibrium number of firms under free trade. As before, for the North, we may write

$$\omega \frac{K}{L} = \frac{n_{z_1} \bar{r}(\tilde{\varphi}_{z_1})}{n_{z_2} \bar{r}(\tilde{\varphi}_{z_2})} \tag{27}$$

Under autarky, the left hand side of this expression equals unity. Under free trade however, it does not, using the free trade relative wage derive above. In particular, if the world taken as a whole is relatively unskilled labour abundant, $\omega > 1$. Since $K/L > 1$ for the North by assumption, but cut-offs and therefore average productivities are equal, we must therefore have that

$$n_{z_1} > n_{z_2} \tag{28}$$

That is, sectors in the North's comparative advantage industry expand relative to those in its comparative disadvantage industry in moving from autarky to free trade.

[21] Formally, the Factor Price Equalisation set is 'rectangular', bounded by the dimensions of the sum of North and South factor endowments.

3.2 Free Trade with Offshoring to The South

We now allow Northern firms to engage in FDI (in-house production in the South), or to outsource in the South. We assume both of these activities involve imperfect monitoring. In particular, assume that FDI is always more risky than in-house production at home, which reduces entrepreneurs' certainty equivalent profit by an amount $S^F_{z_i}$, where F denotes "FDI". Outsourcing in the South is riskiest of all, with the worst monitoring of all organisational forms, commanding a certainty equivalent profit reduction of $S^{o*}_{z_i} > S^o_{z_i}, S^F_{z_i}$, with $o*$ denoting "outsourcing in South". We then have to choose a plausible ordering of riskiness, or efficacy of monitoring, between FDI and outsourcing in the North. We choose here to emphasise the inferiority of monitoring in the South vis-a-vis the North, rather than outsourcing vis-a-vis in-house production. So we shall assume that $S^F > S^o$.[22] This assumption will imply, as we shall see, that the most productive firms will be those that locate production overseas, while the least productive remain at home. Thus this assumption also brings with it some empirical plasibility[23]. The main point of what follows however is to capture the idea that riskiness, or the ability to monitor, is a key determinant of outsourcing and offshoring decisions. Thus, in sum, the riskiness of each organisational form is assumed to be indexed by the following inequalities in which $S^o_{z_i} < S^F_{z_i} < S^{o*}_{z_i}$.

While offshoring may be more risky, reducing entrepreneurs' certainty equivalent profit, we suppose however that offshoring also saves on variable costs, just as outsourcing in the North does. Thus we assume labour requirements of $\alpha^F \equiv \bar{\alpha}^F/e$ and $\alpha^{o*} \equiv \bar{\alpha}^{o*}/e$ for FDI and Southern outsourcing respectively, when workers exert effort e. As before, optimal effort will depend only on model parameters, and not on endogenous variables. There are two effects to consider here. The first is that worse monitoring for offshore production, be it FDI or outsourcing in the South, reduces optimal effort, as above. Intuitively, higher risk premia increase the marginal cost of inducing effort. The second is that lower $\bar{\alpha}'s$ raise optimal effort. Intuitively, lower $\bar{\alpha}'s$ raise the marginal benefit workers' exertion, so entrepreneurs wish to induce more. The combination of these two effects is ambiguous. If the net result is lower effort, the cost savings of offshoring will be somewhat mitigated; if it is higher effort, they will be enhanced. If optimal effort were sufficiently low, the cost savings may be wiped out all together, and offshoring would never be profitable. We assume in what follows therefore that the two effects are not greatly lop-sided, maintaining a cost saving associated with offshoring, giving unit input requirements of $\alpha^F_{z_i}$ and $\alpha^{o*}_{z_i}$, where $\alpha^{o*}_{z_i} < \alpha^F_{z_i} < \alpha_{z_i}$.

In line with the above ordering of riskiness, workers in the South employed by Northern firms demand risk premia of $s^F_{z_i}$ and $s^{o*}_{z_i}$ for FDI and Southern outsourcing respectively, where $s_{z_i} < s^F_{z_i} < s^{o*}_{z_i}$. With w^* denoting the Southern wage, expected cost functions for FDI and Southern outsourcing, taking into account the constancy of optimal effort, are given by

$$c^F_{z_i}(\varphi) = \frac{\alpha^F_{z_i} w^*_i}{\varphi} q + \alpha^F p s^F_{z_i} q + f w^*_i \quad (29)$$

$$c^{o*}_{z_i}(\varphi) = \frac{\alpha^{o*}_{z_i} w^*_i}{\varphi} q + \alpha^{o*}_{z_i} p s^{o*}_{z_i} q + f w^*_i \quad (30)$$

Entrepreneurs choose price so as to maximise certainty equivalent profits, just as above, which in the

[22] These could be reversed were monitoring in the South relative to monitoring under outsourced production to improve.

[23] See the survey in Navaretti and Venables (2004), Ch. 1, which provides evidence to suggest that firms performing FDI tend to be larger and more productive than purely 'national' firms.

absence of trade costs gives prices of

$$p_F = \frac{\alpha_{z_i}^F w_i^*}{\rho\varphi(1-\tilde{s}_{z_i}^F)} \quad (31)$$

$$p_{o*} = \frac{\alpha_{z_i}^{o*} w_i^*}{\rho\varphi(1-\tilde{s}_{z_i}^{o*})}. \quad (32)$$

We may then write certainty equivalent profit under FDI and Southern outsourcing as

$$\pi_F(\varphi) = \theta_{z_i}\tilde{\rho}(\alpha_{z_i}^F w_i^*)^{1-\sigma}(1-\tilde{s}_{z_i}^F)^\sigma \varphi^{\sigma-1} - f w_i^* - S_{z_i}^F w_i \quad (33)$$

$$\pi_{o*}(\varphi) = \theta_{z_i}\tilde{\rho}(\alpha_{z_i}^{o*} w_i^*)^{1-\sigma}(1-\tilde{s}_{z_i}^{o*})^\sigma \varphi^{\sigma-1} - f w_i^* - S_{z_i}^{o*} w_i \quad (34)$$

Sorting within sectors. For now, take both North and South wages as given. Then the slopes of each profit function in $\varphi^{\sigma-1}$ depend crucially on the relative sizes of the risk premia paid to labour under the different organisational forms, the wage rates, and the variable cost (labour input) coefficients. The slope of profit for each organisational form is increasing in riskiness as long as $w_i^{1-\sigma} < \frac{(\alpha_{z_i} w_i)^{1-\sigma}}{(1-\tilde{s}_{z_i})^{-\sigma}} < \frac{(\alpha_{z_i}^F w_i^*)^{1-\sigma}}{(1-\tilde{s}_{z_i}^F)^{-\sigma}} < \frac{(\alpha_{z_i}^{o*} w_i^*)^{1-\sigma}}{(1-\tilde{s}_{z_i}^{o*})^{-\sigma}}$. Just as in the closed economy case, when labour risk premia are not too large and increase as we move from FDI to home outsourcing, and from home to foreign outsourcing, and there are sufficient variable cost savings as production is moved from the North to the South, this will be the case. Then we have some additional cut-offs for organisational forms to consider. As before, the level of in-house production giving zero profit defines $\underline{\varphi}_{z_i}$. Similarly, Northern outsourcing is defined by the equality of in-house and Northern outsourcing profit functions, giving φ_{o,z_i}. The Northern outsourcing profit function is subsequently cut by the FDI profit function, which in turn is cut by the Southern outsourcing profit function, defining further cut-offs implicitly by

$$\pi_o(\varphi_{F,z_i}) = \pi_F(\varphi_{F,z_i}) \quad (35)$$

$$\pi_F(\varphi_{o*,z_i}) = \pi_{o*}(\varphi_{o*,z_i}). \quad (36)$$

So we arrive at the cut-off ordering $\underline{\varphi}_{z_i} < \varphi_{o,z_i} < \varphi_{F,z_i} < \varphi_{o*,z_i}$, illustrated in Figure 3. That is, in a sector in which monitoring is sufficiently easy, low productivity firms will choose to produce in-house, followed by those choosing to outsource in the North, next by FDI, while the most productive outsource in the South.

Proposition 4 *When monitoring gets harder as we move from in-house production to Northern outsourcing, from Northern outsourcing to FDI, and FDI to Southern outsourcing, risk premia are not too large, and offshoring confers a variable cost saving, the least productive firms exit and the most productive firms outsource in the South. In the intermediate range, as productivity increases, firms choose first to produce in-house, then to outsource in the North, and then to do FDI.*

Sorting across sectors. One may think of the above as charactersing a sector in which monitoring is relatively good. But as we move across sectors, suppose as before that the ability to monitor deteriorates, and that it does so in both North and South in a uniform way. We may think of the move from sector z_i, in which monitoring is effective, to sector $z_i' > z_i$ where it is not. As risk premia demanded by labour

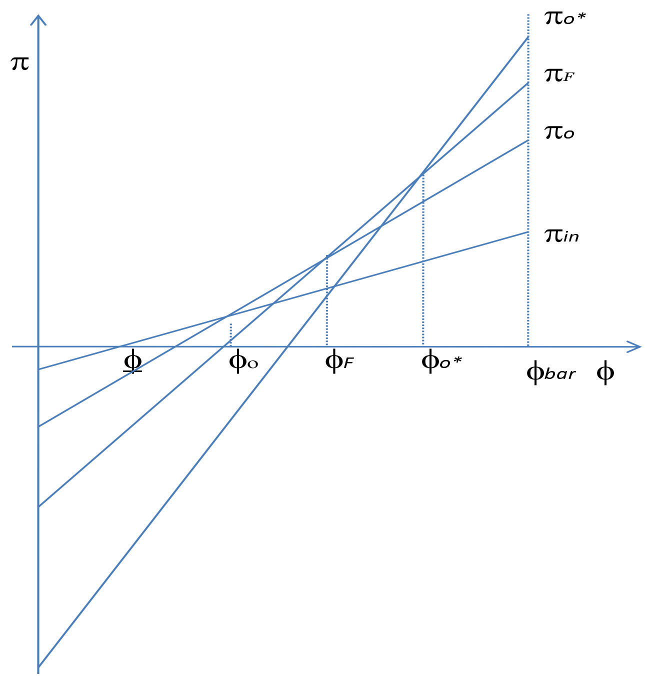

Figure 3: Sector equilibrium with offshoring

rise, and optimal effort falls, just as in the autarky case above, the slopes of the profit functions for organisational forms other than in-house production pivot downwards. In addition, the 'fixed' reduction to entrepreneurs' profits, the S's, increase, shifting the profit curves downwards. Hence as we move across sectors, the organisational cut-offs will rise. Southern offshoring becomes unviable first, illustrated in panel (a) of Figure 4. This occurs in sector z_i^* where $\varphi_{o*,z_i^*} = \bar{\varphi}$. Then beyond sector z_i^*, firms either produce in-house, outsource in the North, or do FDI in the South. Next, the FDI cutoff φ_{F,z_i} also 'catches up' with the upper limit on productivity draws $\bar{\varphi}$, illustrated in panel (b) of Figure 4. In sector z_i^F, $\varphi_{F,z_i^F} = \bar{\varphi}$, beyond which the intercept of the FDI curve becomes too small for it to cut the outsourcing curve. Thus beyond z_i^F, sectors feature only outsourcing and in-house production in the North. Finally, when $\varphi_{o,\tilde{z}_i} = \bar{\varphi}$ in sector $\tilde{z}_i$, sectors $z_i > \tilde{z}_i$ feature in-house production only, illustrated in panel (c) of Figure 4. Under these conditions, we therefore have a sorting pattern *across* sectors under which for

$$z_i \in [0, z_i^*] \text{ all organisational forms exist} \tag{37}$$

$$z_i \in (z_i^*, z_i^F] \text{ in-house, Northern outsourcing and FDI only} \tag{38}$$

$$z_i \in (z_i^F, \tilde{z}_i] \text{ in-house and Northern outsourcing only} \tag{39}$$

$$z_i \in (\tilde{z}_i, 1] \text{ in-house only} \tag{40}$$

illustrated in Figure 5. So the riskiest sectors, or those in which monitoring is worst, exhibit a 'proximity bias', in which Northern firms try to retain control over production by first producing in-house, then by producing in the North only, followed by extensions into offshoring as risk falls, first by producing in-house in the South via FDI, and finally by outsourcing in the South where risk is lowest or monitoring

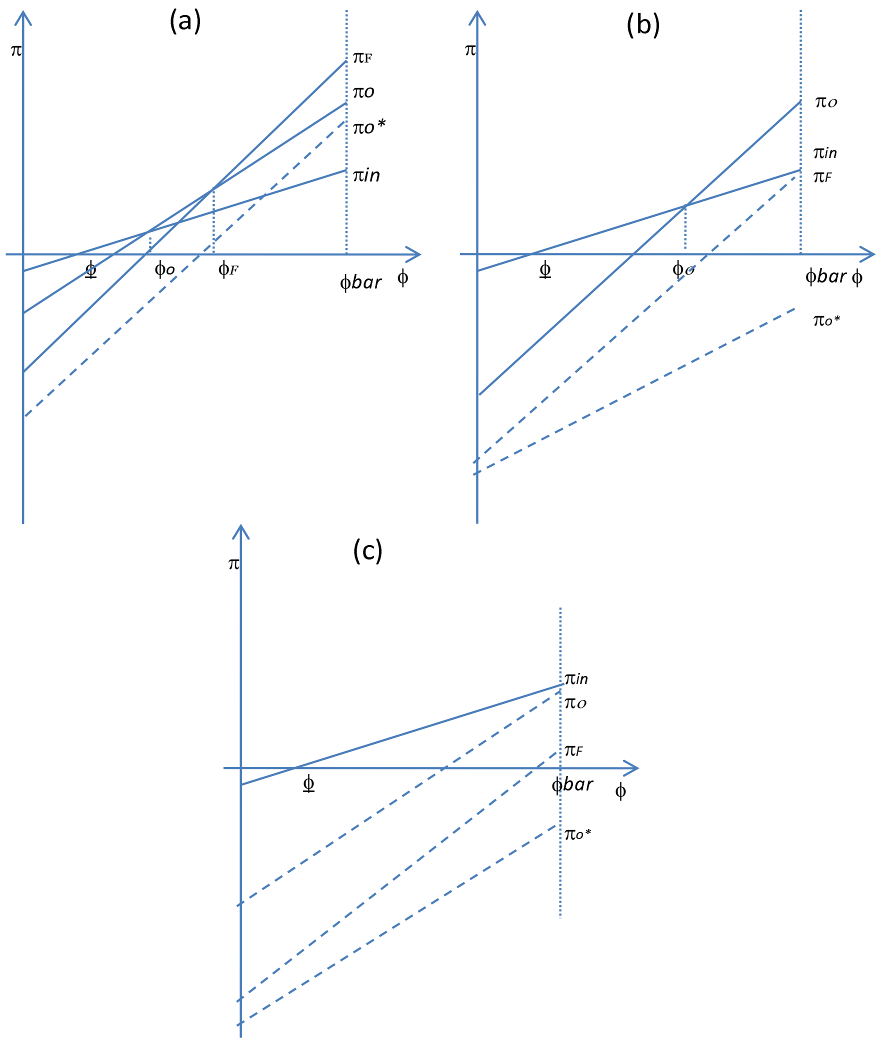

Figure 4: Changes in sector equilibria as monitoring deteriorates

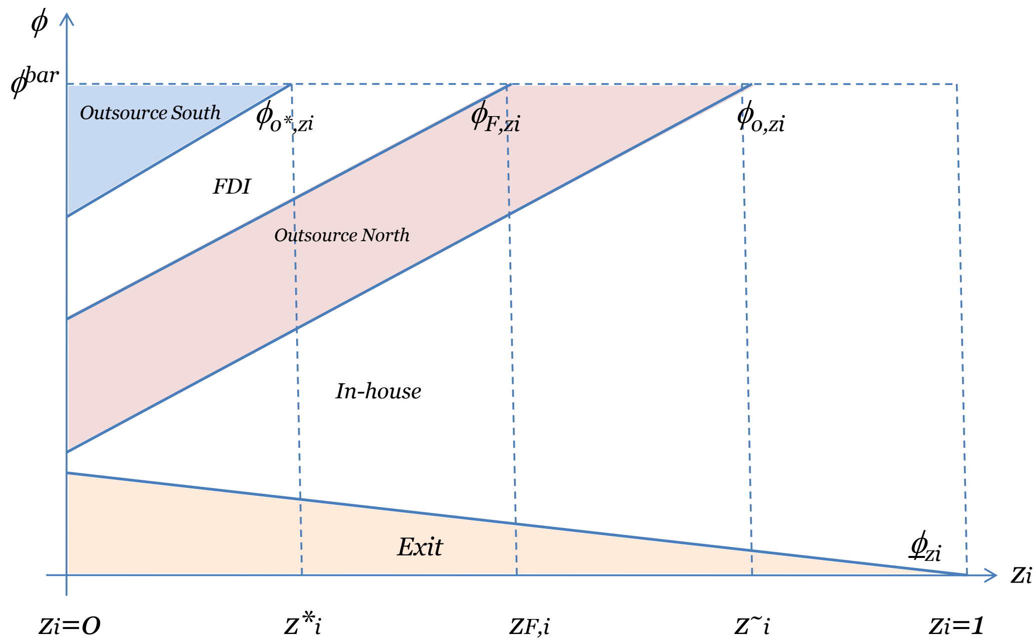

Figure 5: Sorting across sectors

is best.

Note that an implication of this is that empirical tests which seek to rank organisational forms in productivity may feature an omitted variable if they do not control for some measure of firms' ability to monitor output. For example, in the above, Southern outsourcing only becomes available to the most productive firms conditional on monitoring in the South being sufficiently good. When it is not, FDI is chosen by the most productive firms. Similarly, FDI does not take place in all sectors; only in some do firms of adequate productivity choose this organisational form.

Note also that in comparison to the hold up approach of Antras and Helpman (2004), the most productive firms continue to offshore, but the ordering within the subset of firms that offshore is reversed, with the most, not least productive firms doing so via Southern outsourcing. Of course the source of the difference lies in the different view we take here of the type of incentive problem facing firms. Here, the additional costs of monitoring effectively increase the fixed costs of outsourcing over and above those of FDI. If we were to allow also more generalised fixed costs of *production*, with these being lower for southern outsourcing than FDI, say, the sorting result obtained here would still hold as long as the saving on fixed costs of production under outsourcing is exceeded by the extra costs due to monitoring.

3.2.1 Sectoral Equilibria

In the North, firms' zero profit cut-off condition must be modified to account for FDI and foreign outsourcing. And moreover in the presence of offshoring, the ZPC in the North will in general depend on the relative North/South wage in that industry, as this in part determines the attractiveness of producing overseas. This influence is clear when we write the FDI, outsourcing and foreign outsourcing cut-offs in terms to the domestic exit cutoff, as

$$\varphi_o = \Lambda_o \underline{\varphi} \tag{41}$$

$$\varphi_F = \Lambda_F (w^*/w) \underline{\varphi} \tag{42}$$

$$\varphi_{o*} = \Lambda_{o*} (w^*/w) \underline{\varphi} \tag{43}$$

where the Λ's for FDI and Southern outsourcing are functions of relative wages relevant to that particular sector z_i (see appendix for the expressions). That is, for firms operating in a sector within industry 1, the relevant relative wage is that between Northern and Southern skilled labour, while for those in industry 2, it is that between Northern and Southern unskilled labour. Note then that both Λ_F and Λ_{o*} are increasing in w^*/w, indicating a reduction in FDI and Southern outsourcing as the Southern wage increases, all else equal.

For Northern firms, the free entry condition takes exactly the same form as before. The ZPC condition however is modified to account for (i) the change in productivity that occurs as a result of offshoring and (ii) the change in riskiness. In all, we may write

$$\bar{\pi} = \left[\left(\frac{\tilde{\varphi}_{o*}}{\underline{\varphi}} \right)^{\sigma-1} - 1 \right] f w_i - w_i \int_{\varphi_o}^{\varphi_F} S_o \mu d\varphi - w_i \int_{\varphi_F}^{\varphi_{o*}} S_F \mu d\varphi - w_i \int_{\varphi_{o*}}^{\bar{\varphi}} S_{o*} \mu d\varphi \tag{44}$$

where now, relative to the case of homogeneous organisational forms, sectoral average productivity is

$$\tilde{\varphi}_{o*}^{\sigma-1} = \tilde{\varphi}^{\sigma-1} + \lambda_o \int_{\varphi_o}^{\varphi_F} \varphi^{\sigma-1} \mu d\varphi + \lambda_F \int_{\varphi_F}^{\varphi_{o*}} \varphi^{\sigma-1} \mu d\varphi + \lambda_{o*} \int_{\varphi_{o*}}^{\bar{\varphi}} \varphi^{\sigma-1} \mu d\varphi \tag{45}$$

$$\lambda_F \equiv \left(\frac{\alpha_F}{(1-\tilde{s}^F)} \frac{w^*}{w} \right)^{1-\sigma} - 1 \tag{46}$$

$$\lambda_{o*} \equiv \left(\frac{\alpha^*}{(1-\tilde{s}^{o*})} \frac{w^*}{w} \right)^{1-\sigma} - 1 \tag{47}$$

Consider a case where we move from allowing domestic in-house and outsourcing only, to allowing FDI as well. Then a new threshold arises at φ_F, beyond which firms do FDI in the South, enjoying a larger variable cost saving, boosting effective productivity, but also operating with worse monitoring. For the first effect to dominate the second, we require that $S_F - S_o < \frac{f}{\underline{\varphi}} \varphi^{\sigma-1}(\lambda_F - \lambda_o)$, or that the additional risk premium is not too big relative to the variable cost saving. In this case, the ZPC under both home production plus FDI lies to the right of that for just home production alone, exactly analogously to the case discussed above in which domestic outsourcing was added to in-house production as an organisational possibility. Analogously, allowing Southern outsourcing in addition to FDI shifts the ZPC further to the right as long as $S_{o*} - S_F < \frac{f}{\underline{\varphi}} \varphi^{\sigma-1}(\lambda_{o*} - \lambda_F)$. We then may predict that sectors in which monitoring is sufficiently good to enable offshoring will feature ceteris paribus higher domestic exit cut-offs. This, together with the variable cost savings that offshoring brings, raising effective productivity, implies that offshoring will raise sector average productivity relative to sectors in which no offshoring takes place.

As well as these new organisational forms affecting the ZPC via average productivity, we also noted that the attractiveness of offshoring will depend, inter alia, on the relative North/South wage rate.

Since this relative wage rate helps to determine the new organisational form cut-offs, and these cut-offs in turn determine average productivity and the risk adjustment, the ZPC will now also depend on the North/South relative wage. This in turn implies the combination of FE and ZPC conditions now determines the exit cut-off $\underline{\varphi}$ *conditional* on the North/South relative wage, $\underline{\varphi}(w^*/w)$.

3.2.2 Goods and Factor Market Equilibrium

We now ask the question: does FPE arise under free trade with offshoring as well? We argue that it does.

Above, we argued that in moving from autarky to free trade, sector cut-offs do not change. Moreover under free trade, FPE prevails. Now suppose free trade continues and offshoring is liberalised. What is the relative incentive to offshore across the two different industries? We argue that it is exactly equal under free trade. In particular, both industries enjoy the same variable cost savings from offshoring. Similarly, since FPE occurs, neither industry faces a pure factor cost incentive to offshore; that is, since $w_i/w_i^* = 1$, factor costs are not a driver of offshoring. Offshoring still occurs in equilibrium due to the variable cost saving. But it does so in exactly equal amounts for parallel industry-sectors, and these amounts are constrained by the monitoring technology available in these sectors. For example, for FDI, we may write the relative cut-off for two parallel sectors as

$$\frac{\varphi_{F,z_1}}{\varphi_{F,z_2}} = \frac{\Lambda_{F,z_1}(w_K^*/w_K)\underline{\varphi}_{z_1}}{\Lambda_{F,z_2}(w_L^*/w_L)\underline{\varphi}_{z_2}} \tag{48}$$

$$= \frac{\Lambda_{F,z_1}(1)\underline{\varphi}_{z_1}}{\Lambda_{F,z_2}(1)\underline{\varphi}_{z_2}} \tag{49}$$

$$= \frac{\underline{\varphi}_{z_1}}{\underline{\varphi}_{z_2}} = 1 \tag{50}$$

(The analogous exercise may be performed for the Southern outsourcing cut-off.) Then since the reduction in labour demand is symmetrical across both industries, the relative skilled wage does not change. The result is that factor price equalisation continues to prevail, and at the same skill premium as under free trade only.

As a result of offshoring, Northern firms become more productive on average. This implies a rise in the exit cut-off across Northern sectors, and a change in the equilibrium number of firms. First, for a Northern industry-sectors, we repeat equation (27) here, giving

$$\omega\frac{K}{L} = \frac{n_{z_1}\bar{r}(\tilde{\varphi}_{z_1})}{n_{z_2}\bar{r}(\tilde{\varphi}_{z_2})} \tag{51}$$

Since FPE continues to hold under free trade with offshoring, the left hand side of this expression is unchanged. On the right hand side, average firm revenues rise owing to offshoring. They do so however by the same amount in the two industries; therefore relative firm numbers *across industries in the North* are unaffected.

We may also perform North-South comparisons of firm numbers. Analogously to the above, we write $\frac{K}{K^*} = \frac{n_{z_1}\bar{r}(\tilde{\varphi}_{z_1})}{n_{z_1}^S\bar{r}(\tilde{\varphi}_{z_1}^S)}$, with the analogous expression for the unskilled labour using industry, and rearrange to obtain

$$\frac{n_{z_1}}{n_{z_1}^S} = \underbrace{\frac{K}{K^*}}_{>1} \underbrace{\frac{\bar{r}^S(\tilde{\varphi}_{z_1})}{\bar{r}(\tilde{\varphi}_{z_1})}}_{\text{decreases}} \tag{52}$$

$$\frac{n_{z_2}}{n_{z_2}^S} = \underbrace{\frac{L}{L^*}}_{<1} \underbrace{\frac{\bar{r}^S(\tilde{\varphi}_{z_2})}{\bar{r}(\tilde{\varphi}_{z_2})}}_{\text{decreases}} \tag{53}$$

The right hand side of each of these expressions falls, since Northern average revenues rise, but Southern average revenues remain the same, pinned down by parameter values. But owing to the North's skill abundance, the right hand side of (52) falls by relatively more than that of (53), that is, in the skilled labour using industry. Then *relative to the South*, firm numbers decline by relatively more in the North's comparative advantage industry-sectors. The reason is that initially low numbers of Southern firms in the North's comparative advantage sector amplify the proportional reduction in firm numbers in the North's comparative advantage industry due to offshoring.

Proposition 5 *Under free trade, a liberalisation of offshoring gives rise to*

1. *continued factor price equalisation;*
2. *a greater proportional reduction in Northern firm numbers in the North's comparative advantage industry relative to the South.*

Hence the effect on relative industry size works *against* that which occurs in moving from autarky to free trade alone.

4 Costly Trade

Trade in goods is most plausibly thought to be subject to non-trivial trade costs (Anderson and van Wincoop 2004). Incorporating iceberg transport costs (which may also represent tariffs) and fixed costs of exporting is the next task. In models of this kind, trade costs will in general imply some market segmentation; to the extent that iceberg trade costs raise marginal costs of production, firms will optimally charge different prices across markets. And with fixed costs of exporting, there will also be selection into export markets, depending on whether firms are productive enough to cover this extra barrier to market entry. Allowing for internationally fragmented production patterns implies that, in the presence of trade costs, some firms will choose to serve different markets with different organisational forms. For example, trade costs reduce the efficiency of serving a domestic market with overseas production. Conversely, trade costs also reduce the efficiency of serving a foreign market with domestic production. Thus in what follows we expect to find that a given firm may undertake more complex integration strategies depending on the market they are serving; they may choose to integrate in country k to serve one market k, but to disintegrate in country k' to serve market k'. Trade costs may also prevent a firm from serving a given market at all. Thus under costly trade, the price indices prevailing in different countries will in general differ, and we denote them by P_{z_i} and $P^*_{z_i}$ for markets in the Northern and Southern countries respectively. Notationally, we shall continue to denote a Southern firm by superscript S, and the Southern market by superscript $*$. So for example X^{S*} denotes a variable belonging to a Southern firm in the Southern market, while X denotes one for a Northern firm in the Northern market, and so on.

Suppose there exist 'iceberg' trade costs $\tau \geq 1$ per unit in transporting output from one country to another. This raises firms' marginal costs of production in serving market k from market k'. We also assume that if firms wish to serve a foreign market, they must pay a fixed 'set-up' cost of f^*. So for Southern firms serving the Northern market, marginal costs rise by a factor τ, and they must be able to afford the extra fixed cost. For Northern firms serving the Northern market, trade costs imply that producing at home gains an advantage over producing abroad and importing, which incurs the variable trade cost τ. Prices charged by Northern firms in the Northern market then rise if they produce using FDI or Southern outsourcing, to $p^F = \frac{\tau \alpha^F w_i^*}{\rho\varphi(1-\tilde{s}^F_{z_i})}$ and $p^{o*} = \frac{\tau \alpha^* w_i^*}{\rho\varphi(1-\tilde{s}^*_{z_i})}$ respectively. In terms of firms' profit functions in adjusted productivity $\varphi^{\sigma-1}$, both π_F and π_{o*} have shallower slopes as a result. This must raise φ_F and φ_{o*}, while lowering φ_o: in serving the Northern market, relatively more Northern firms prefer to produce in-house or outsource than to offshore.

In serving the Southern market, Northern firms must overcome an additional fixed cost. Attributing this fixed cost wholly to a firm's 'export profits' as an accounting convention then allows us to examine the firm's entry decision into the foreign market. That is, we may write a Northern firm's total profits from all activities simply as $\bar{\pi} = \pi + \pi^*$, where the $*$ indicates profits accruing to the firm from serving to the Southern market. A Northern firm will then serve the Southern market as long as $\pi^* > 0$, which defines a productivity cut-off above which firms export as

$$\pi^*_{in}(\underline{\varphi}^*, \tau) = 0 \quad \Rightarrow \quad r^*(\underline{\varphi}^*) = f^* w_i \tag{54}$$

Using the domestic entry cut-off, $\pi_{in}(\underline{\varphi}) = 0$, written as $r(\underline{\varphi}) = f w_i$, we may relate the export cut-off to the domestic exit cut-off by

$$\underline{\varphi}^* = \Lambda^* \underline{\varphi} \tag{55}$$

where $\Lambda^* \equiv \tau \left(\frac{R}{R^*}\frac{f^*}{f}\right)^{\frac{1}{\sigma-1}} \frac{P}{P^*}$. Whenever $\Lambda^* > 1$, there will be selection into export markets, which, as other authors note, is empirically commonplace. Thus we may assume for example that τ and f^* are large enough to ensure selection takes place. We illustrate this foreign entry cut-off for Northern firms producing in-house in Figure 6. Further cut-offs are derived analogously to the zero trade cost case above, defined as usual by $\pi^*_{in}(\varphi^*_o, \tau) = \pi^*_o(\varphi^*_o, \tau)$, $\pi^*_o(\varphi^*_F, \tau) = \pi^*_F(\varphi^*_F)$ and $\pi^*_F(\varphi^*_{o*}) = \pi^*_{o*}(\varphi^*_{o*})$. Re-written, these are

$$\varphi^*_o = \Lambda^*_o \underline{\varphi}^* \tag{56}$$

$$\varphi^*_F = \Lambda^*_F \underline{\varphi}^* \tag{57}$$

$$\varphi^*_{o*} = \Lambda^*_{o*} \underline{\varphi}^* \tag{58}$$

(see appendix for the full expressions). Northern firms' cut-offs for serving the Northern market must also be modified to account for trade costs, which may be written analogously to the no trade cost case above

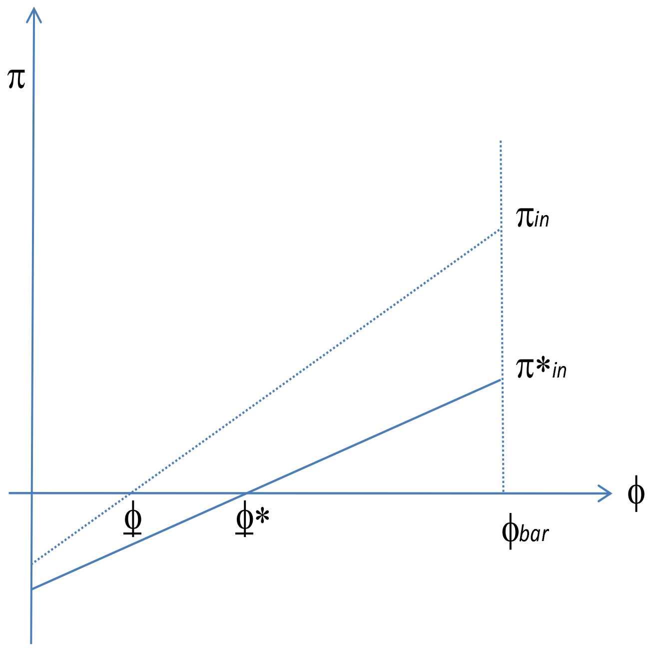

Figure 6: Northern firms' Southern entry cut-offs for in-house production in the North

for production in the North, while production in the South now incurs extra costs. Similarly, Southern firms serving the Northern market now incur trade costs as well. Cut-offs for these firms are analogous to those for Northern firms producing at home and serving the South. As mentioned, the presence of trade costs implies that firms may choose different organisational forms in serving different markets. That is, the cut-offs for organisational forms in different markets will not in general coincide in the presence of trade costs. If trade costs are high enough, the only viable way for Northern firms to serve the Southern market may be via FDI or outsourcing in the South. Hence the usual trade cost evading motive for FDI exists in this model.

We may usefully define the probability of exporting χ as $\chi \equiv \frac{1-G(\varphi^*)}{1-G(\underline{\varphi})}$. Then Northern firms' free entry condition must now account for profits earned in the Southern market, so is modified to be written

$$[1 - G(\underline{\varphi})][\bar{\pi} + \chi\bar{\pi}^*] = w_i \tag{59}$$

where $\bar{\pi}^* = \bar{\pi}^*(\tilde{\varphi}^*)$. That is, average profits accruing to exporters may be written as a function of the average productivity of exporters, $\tilde{\varphi}^*$, which in turn is defined analogously to that for domestic producers by

$$(\tilde{\varphi}^*)^{\sigma-1} \equiv \frac{1}{1-G(\underline{\varphi}^*)}[\int_{\underline{\varphi}^*}^{\bar{\varphi}} \tau^{1-\sigma}\varphi^{\sigma-1}gd\varphi + \lambda_o \int_{\varphi_o^*}^{\varphi_F^*} \varphi^{\sigma-1}gd\varphi + \lambda_F \int_{\varphi_F^*}^{\varphi_{o*}^*} \tau^{1-\sigma}\varphi^{\sigma-1}gd\varphi + \lambda_{o*}\int_{\varphi_{o*}^*}^{\bar{\varphi}} \varphi^{\sigma-1}gd\varphi] \tag{60}$$

Hence for exporters, trade costs reduce the effective average productivity of producing in-house or outsourcing in the North. Likewise, the ZPC must account for expected certainty equivalent profits earned by exporters, so we wish to define $\bar{\pi} + \chi\bar{\pi}^*$ in terms of the domestic entry cut-off and the exporting cut-off. Since we may represent the latter as a function of the former, we may define ZPC as a function of the domestic exit cut-off only. Using $\bar{\pi} = r(\tilde{\varphi}) - fw_i - w_i \left[\int_{\varphi_o}^{\varphi_F} S_o \mu d\varphi + \int_{\varphi_F}^{\varphi_{o*}} S_F \mu d\varphi + \int_{\varphi_{o*}}^{\bar{\varphi}} S_{o*} \mu d\varphi\right]$, and likewise $\bar{\pi}^* = r^*(\tilde{\varphi}^*) - f^* w_i - w_i \left[\int_{\varphi_o^*}^{\varphi_F^*} S_o \mu d\varphi + \int_{\varphi_F^*}^{\varphi_{o*}^*} S_F \mu d\varphi + \int_{\varphi_{o*}^*}^{\bar{\varphi}} S_{o*} \mu d\varphi\right]$, we may write the ZPC condition as

$$\bar{\pi} + \chi\bar{\pi}^* = \left[\left(\frac{\tilde{\varphi}}{\underline{\varphi}}\right)^{\sigma-1} - 1\right] fw_i - w_i \tilde{S} + \chi \left\{ \left[\Lambda^* \left(\frac{\tilde{\varphi}}{\underline{\varphi}}\right)^{\sigma-1} - 1\right] f^* w_i - w_i \tilde{S}^* \right\} \tag{61}$$

where $\tilde{S} \equiv \int_{\varphi_o}^{\varphi_F} S_o \mu d\varphi + \int_{\varphi_F}^{\varphi_{o*}} S_F \mu d\varphi + \int_{\varphi_{o*}}^{\bar{\varphi}} S_{o*} \mu d\varphi$ and $\tilde{S}^* \equiv \int_{\varphi_o^*}^{\varphi_F^*} S_o \mu d\varphi + \int_{\varphi_F^*}^{\varphi_{o*}^*} S_F \mu d\varphi + \int_{\varphi_{o*}^*}^{\bar{\varphi}} S_{o*} \mu d\varphi$ are the risk adjustments for domestic and exporting producers respectively. We may see immediately then that, in comparison to the closed economy case, the costly trade case adds a second term to the ZPC, shifting it to the right, indicating a ceteris paribus increase in the domestic exit cut-off for both Northern and Southern firms relative to the autarky case. Moreover, the size of the shift depends on Λ^*, which itself reflects the relative North/South price indices, which now differ due to costly trade. We may write these more fully, for given sectors, as

$$P^{1-\sigma} = n(\underline{\varphi}) p(\tilde{\varphi})^{1-\sigma} + \chi^S n^S (\underline{\varphi}^S) p(\tilde{\varphi}^S)^{1-\sigma} \tag{62}$$

$$(P^*)^{1-\sigma} = n^S (\underline{\varphi}^{S*}) p(\tilde{\varphi}^{S*})^{1-\sigma} + \chi n(\underline{\varphi}) p(\tilde{\varphi}^*)^{1-\sigma} \tag{63}$$

4.1 Trade and Offshoring liberalisation

4.1.1 Partial Trade liberalisation *without* offshoring

Exclude for one moment the possibility of foreign offshoring. Then a partial trade liberalisation in this model has exactly analogous effects to those in the model of Bernard et al. (2007). In particular, since the North is relatively abundant in skilled labour, and the South relatively scarce, the costly trade price indices will lie somewhere in between the autarkic and free trade indices, at which they are equalised in both countries. The relative skilled wage will be low in the North compared to the South, in line with the factor abundances, and Λ^* will be smaller in all skill intensive industry-sectors than in unskilled intensive industry-sectors. Since the export cut-off is correspondingly lower across industry 1, the domestic exit cut-off must be higher across industry 1, as the larger segment of exporting firms provide fiercer competition via factor markets for skilled labour in that industry. So partial trade liberalisations without foreign offshoring, as Bernard et al. (2007) state, raise the relative skilled wage in the North (and the relative unskilled wage in the South), and the comparative advantage industry in each country enjoys a greater average productivity gain than the comparative disadvantage industry.

4.1.2 Liberalizing Offshoring, or improved Southern monitoring

Given costly trade, suppose foreign offshoring is liberalised (or, equivalently, there is a one-off improvement in monitoring in the South), so Northern firms may choose to do FDI and foreign outsourcing. They choose to do relatively more of this where w^*/w is low, or factor cost savings are greatest, which is in the North's comparative disadvantage industry. If offshoring confers a variable cost saving, or 'effective' productivity gain therefore, it will be greater in the North's comparative disadvantage industry. We may show this by considering the relevant relative offshoring cut-offs. For example, for Southern outsourcing in serving the Northern and Southern markets respectively, we may write (see appendix)

$$\frac{\varphi_{o*,z_1}/\underline{\varphi}_{z_1}}{\varphi_{o*,z_2}/\underline{\varphi}_{z_2}} = \frac{\omega^*}{\omega} > 1 \tag{64}$$

$$\frac{\varphi^*_{o*,z_1}/\underline{\varphi}^*_{z_1}}{\varphi^*_{o*,z_2}/\underline{\varphi}^*_{z_2}} = \frac{\omega^*}{\omega} > 1 \tag{65}$$

where we have used that $\omega^* > \omega$ under costly trade. In other words, the Southern outsourcing cut-off relative to the exit cut-off is higher in the North's comparative advantage industry-sectors (for serving both Northern and Southern markets). Higher relative Southern outsourcing cut-offs correspond to a smaller relative range of Northern firms choosing to produce under this organisational form. (In the appendix we show the same for FDI cut-offs.) Because of greater offshoring in the North's comparative disadvantage industry, the drop in labour demand experienced by unskilled labour will be relatively larger, raising relative demand for skilled labour in the North, raising the North's skilled wage.

The size of this relative effect depends on factor price differences. In particular, above we showed that under free trade and FPE, the incentive to offshore is exactly the same across industries. Thus there is no relative effect on factor rewards. Conversely, under pure autarky, the 'imbalance' between the relative incentives to offshore across industries is greatest. The largest impact of offshoring on factor rewards therefore occurs when offshoring is liberalised under autarky[24]. The case of costly trade lies somewhere in between these two extremes. As long as $\omega < \omega^*$, the incentive to offshore will be relatively larger in the North's comparative disadvantage industry, and this will in turn be more pronounced under more restrictive trade regimes[25].

More fully, under costly trade with offshoring, the relative Northern skilled wage may be written

$$\omega = \frac{L}{K}\frac{R_1 + \chi_1 R_1^* - \omega^*(K^F + K^{o*})}{R_2 + \chi_2 R_2^* - (L^F + L^{o*})} \tag{66}$$

where $\chi_i \equiv \int_0^1 \chi_{z_i} dz_i$ represents industry i's export probability, and the terms $\omega^*(K^F + K^{o*})$ and $(L^F + L^{o*})$ represent payments to Southern skilled and unskilled labour respectively (that is, factor cost times factor demand). Without offshoring, these last two terms disappear; with offshoring their impact on the Northern relative wage depends upon their relative size. If ex ante the South has a relatively high skilled wage, $(L^F + L^{o*})$ will exceed $\omega^*(K^F + K^{o*})$, tending to raise the Northern skilled wage.

[24] Or as close to autarky as one can get to autarky while still allowing goods produced by domestic firms overseas to be shipped back to the domestic market. Such an (unrealistic) situation would correspond to a case where the Southern country was used aa a pure 'production plant', with no consumption of Northern goods by Southern consumers, and no consumption of Southern goods by Northern consumers.

[25] A simple intuition for this phenomenon is to think of offshoring in 'factor migration terms'. Mundell (1957) pointed out that the incentives for factor migration are highest when trade is most costly. Offshoring can be thought of analogously here.

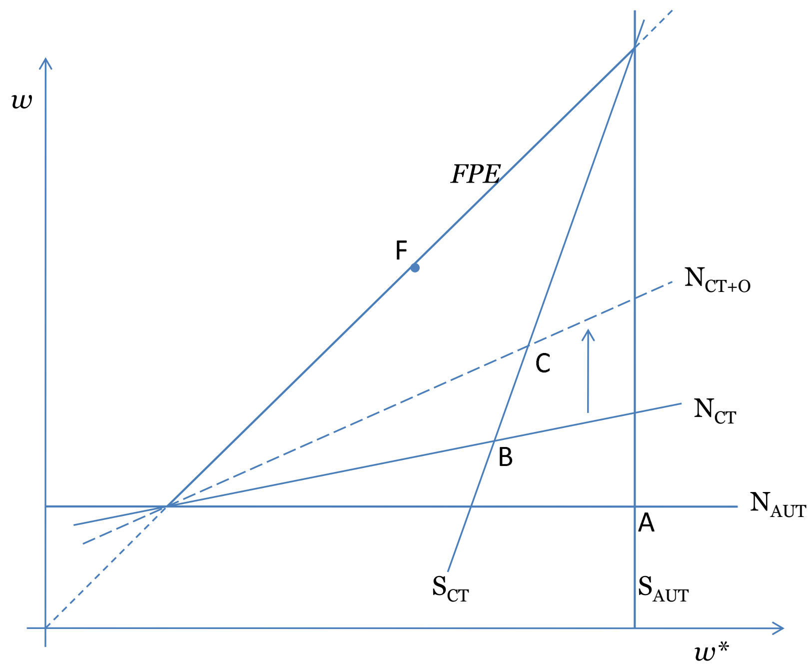

Figure 7: North and South relative wages

The full impact of an offshoring liberalisation depends on feedbacks through general equilibrium effects; in particular, the probability of (or proportion of) exporting from a given industry χ_i depends on relative North/South wages. To isolate these effects, we need also the Southern relative wage, which may be written

$$\omega^* = \frac{L^*}{K^*} \frac{R_1^{S*} + \chi_1^S R_1^S}{R_2^{S*} + \chi_2^S R_2^S} \tag{67}$$

Now, Southern firms export relatively more in the industry in which Northern wages are higher. Similarly then, a *rise* in the Northern relative skilled wage implies more profitable exporting by Southern firms in the skill intensive industry. That is, χ_1^S rises relative to χ_2^S. This implies that *the Southern relative skilled wage rises too.*

A graphical analysis. To illustrate this idea further, we develop the following diagram, shown in Figure 7. Making use of the results for relative wages derived earlier, we may first plot the Northern and Southern autarkic relative wage rates, given by the lines N_{AUT} and S_{AUT} respectively. Clearly, since autarkic relative wages depend only on domestic factor endowments, these lines are horizontal and vertical in (ω^*, ω) space respectively. They intersect at point A for 'autarky' in the figure. Second, we plot the FPE line which has a slope of 1, corresponding to points consistent with FPE across the two countries. Point F for 'free trade' on this line gives the free trade relative wage rate, derived above, which is also that which prevails under free trade plus offshoring. The triangle defined by the curves FPE, N_{AUT} and S_{AUT} then defines the space in which relative wages must lie under costly trade. Now consider the North's relative wage rate under costly trade without offshoring, given by

$$\omega = \frac{L}{K}\frac{R_1 + \chi_1 R_1^*}{R_2 + \chi_2 R_2^*} \tag{68}$$

A rise in the Southern relative skilled wage raises the relative profitability of Northern firms exports from industry 1 to the South, raising χ_1 relative to χ_2, driving up the North's relative skilled wage. This is the trade channel through which the two countries' factor rewards are linked, and gives a positive relationship between each country's relative skilled wage, giving the curve N_{CT}, where 'CT' denotes 'costly trade'. By analogous reasoning, we may construct the equivalent curve for the south, S_{CT}, which likewise displays a positive relationship between the two countries' relative skilled wages. Equilibrium relative wages in the two countries are then determined at the intersection of N_{CT} and S_{CT}, or point B. Clearly, relative to autarky, a partial trade liberalisation raises the relative skilled wage in the North, and reduces it in the South, along familiar Stolper-Samuelson lines.

Now allow for Northern firms' offshoring too. What is the impact on N_{CT}? The relevant relationship is given in equation (66), and clearly contains a second channel of interaction between Southern and Northern wages via the offshoring terms on the right hand side. In particular, as already noted, these terms are larger when Southern wages are smaller; that is, offshoring is more attractive where the Southern factor cost savings are greater. Now consider again a rise in the relative Southern skilled wage. As well as the trade effect identified above, this also discourages offshoring by relatively more in the North's skilled rather than unskilled intensive industry, putting further upward pressure on the North's relative skilled wage. That is, the North's relative skilled wage becomes *more responsive* to a given change in Southern relative wages in the presence of offshoring. We denote this relationship by N_{CT+O}, where $CT+O$ refers to 'Costly Trade plus Offshoring', and it must be steeper than N_{CT} by the above reasoning. Hence a liberalisation of offshoring gives equilibrium at point C, raising the relative skilled wage in both countries.

Proposition 6 *Under costly trade, liberalisations of foreign offshoring give rise to*

1. *more offshoring in the North's comparative disadvantage industry and a greater fall in demand for the North's scarce factor;*
2. *a rise in the profitability of Southern exports in the North's comparative advantage industry, raising the demand for the South's scarce factor, therefore;*
3. *a rise in the relative skilled wage in both North and South.*

These relative effects are more pronounced the more restricted is trade in goods. When trade is completely free, the impact of offshoring across industries is equalised.

Second, since offshoring is greatest in the North's comparative disadvantage industry, we obtain the now familiar productivity effect, which raises average productivity by relatively more in that industry.

Proposition 7 *Since offshoring is greatest in the North's comparative disadvantage industry, and offshoring confers a productivity advantage, the rise in average productivity will be greatest in the North's* *comparative disadvantage industry. This relative effect is more pronounced the more restricted is trade in goods.*

Once again, under free trade, the productivity impact of offshoring is equal across industries, following the fact that the incentive to offshore is equalised across industries. When trade is restricted, liberalisations of offshoring have different productivity impacts across industries, and these differences grow as trade becomes more restricted.

4.1.3 Partial trade liberalisation.

Finally, we may contrast the impacts of partial trade liberalisations in the absence and presence of liberalised offshoring. First, without offshoring, the relevant curves are N_{CT} and S_{CT}. A reduction in trade costs τ reduces the productivity wedge Λ^* between exporters and domestic firms in both industries and in both countries, raising χ_i, the probability of exporting, in both industries for both countries. The size of these changes interacts however with ex ante factor prices, with there being a greater rise in the probability of exporting in each country's comparative advantage industry. Thus N_{CT} pivots upwards, while S_{CT} pivots downwards, giving Stolper-Samuelson rises in factor rewards to the abundant factor in each country.

What is the impact in the presence of offshoring too? Consider first a fall in τ from an initially high level. As already noted, the equilibrium relative wage curve for the North with offshoring N_{CT+O} must be steeper than that without offshoring. Then relatively more of the adjustment to lower trade costs falls on Northern factors, tending to accentuate the rise in the relative skilled wage in the North, while dampening the rise in the unskilled wage in the South. In figure 8, point C, the partially liberalised equilibrium without offshoring, lies below and to the left of point D, the partially liberalised equilibrium with offshoring, illustrating this point. Thus in the presence of offshoring, distributional conflict resulting from trade liberalisations in the North is accentuated, while it is reduced in the South, as long as trade costs start from a high level. We know however that the equilibrium under free trade with offshoring gives rise to the same relative factor rewards as free trade without offshoring. So in Figure 8, successive reductions in τ must eventually converge to the same point on the FPE line with and without offshoring. Knowing this, and with N_{CT+O} being steeper, we can say that at initially low trade costs, further liberalisations reverse the above patterns and call forth greater relative wage change in the South than in the North. That is, at initially *low* trade costs, further liberalisations will accentuate distributional conflict in the South relative to the North. Put differently, since offshoring implies the North's equilibrium wage curve converges more quickly to the FPE curve as trade costs fall, the locus of points tracing equilibrium with offshoring will be steeper at high trade costs, but shallower at low trade costs, than that without offshoring. These two loci are illustrated in Figure 9, denoted by W_{CT+O} and W_{CT} respectively.

Proposition 8 *The presence of offshoring dampens the Stolper-Samuelson effects on factor rewards in the South, but accentuates them in the North, as a result of reductions in trade costs from initially high levels. At low trade costs however, the pattern is reversed, with greater relative wage effects in the South than in the North resulting from reductions in trade costs.*

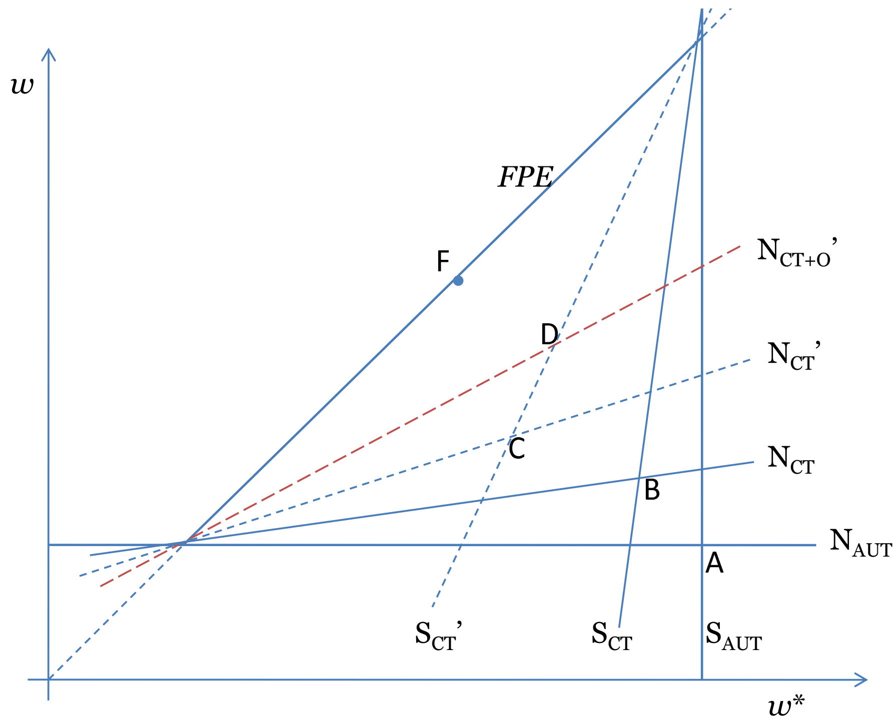

Figure 8: Partial trade liberalisation

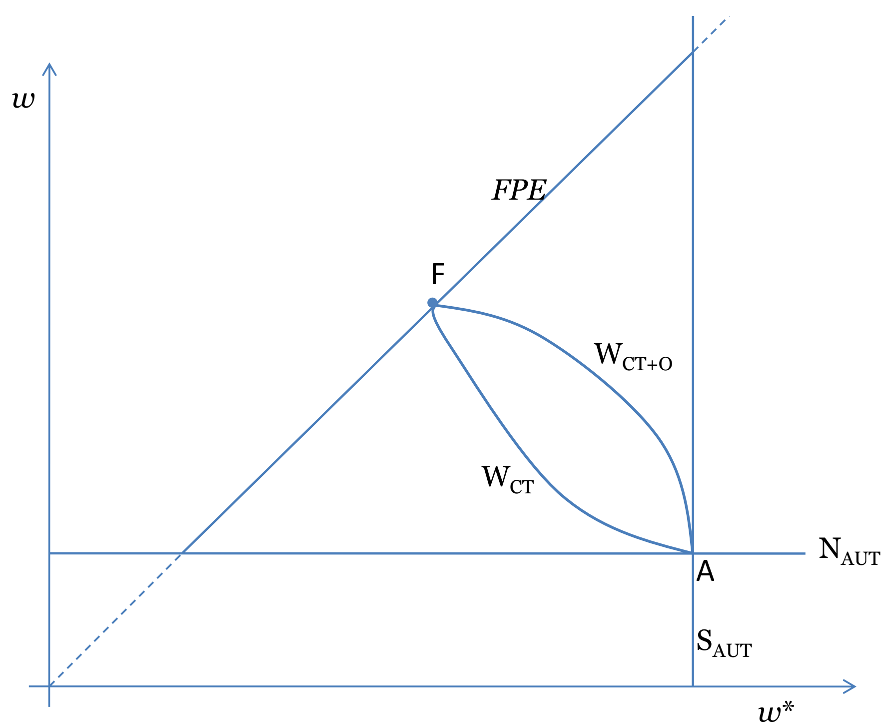

Figure 9: Path of relative wages as trade is liberalised

Further, the volume of offshoring across the two industries follows the changes in Southern factor rewards. Since w_K^*/w_L^* is initially slow to fall according to the locus W_{CT+O} in Figure 9, there will be relatively less offshoring in the North's comparative advantage industry following trade liberalisations at initially high trade costs. But as the 'pace' of the fall in w_K^*/w_L^* 'accelerates' as trade costs continue to fall, relative offshoring in the comparative advantage industry will 'catch-up' with that in the comparative disadvantage industry. So at high trade costs, liberalisations of trade and offshoring give relatively greater productivity gains in the comparative advantage industry due to the tariff reduction, but relatively greater productivity gains in the comparative disadvantage industry due to the offshoring increase.

Proposition 9 *Trade liberalisation alone tends to increase productivity relatively more in the comparative advantage industry. Offshoring liberalisation alone tends to increase productivity relatively more in the comparative disadvantage industry. Simultaneous trade and offshoring liberalisations combine these effects.*

5 Conclusions

We have presented a model in which firms' ability to monitor output is a key driver of outsourcing, FDI and foreign outsourcing decisions. Only when monitoring is sufficiently effective can firms take advantage of the variable cost savings due to fragmentation. Where in-house production is characterised by better monitoring, and production in the South is characterised by worse monitoring than the North, the most productive firms outsource in the South, and the least productive produce in-house in the North. In intermediate ranges, the least productive outsource in the North and the most productive engage in FDI. As monitoring deteriorates across sectors, firms first cease to outsource in the South, then to perform FDI, and finally to perform outsourcing in the North. An implication for empirical studies is that firms' organisational choices are conditional on their ability to monitor output, and this variable should be included in any econometric analysis of offshoring.

We view this theory of offshoring based on monitoring as complementary to the theory of Antras and Helpman (2004) based on hold up and investment incentives. Both explore the effects of imperfect information on firms' choices regarding the international location and fragmentation of production, but differ in the 'microfoundations' they posit. In reality firms are likely to be active in tackling both problems of hold up and monitoring, plus more. As firms invest across national boundaries they confront these informational issues, and it may be that the problem of monitoring and production incentives is more important in pure assembly operations, where the problem of hold-up is more prevalent in situations where greater activism on the part of sub-contractors is required. Ultimately more empirical work is require to investigate.

Beyond this, the model presented here investigates fragmentation in a Heckscher-Ohlin setting. Under autarky, accounting for differences in factor abundance between North and South indicates a greater incentive to offshore in the North's comparative disadvantage industry, or the South's comparative advantage industry, as this is where Southern wage costs, relative to the North's, are lowest. Under free trade, the incentive to offshore is balanced across industries. Where trade is costly, the relative incentive to offshore is greatest in the North's comparative disadvantage industry, but this incentive differential is decreasing as trade costs fall.

When offshoring confers variable cost savings, raising effective productivity, then the greatest average productivity gains following a liberalisation of offshoring under costly trade will be enjoyed by the North's comparative disadvantage industry. Relative demand for the North's abundant factor will rise, raising its relative return. Thus for the North, liberalisations of offshoring tend to look like trade liberalisations in their effects on factor rewards, but look like the *opposite* of trade liberalisations in their effects on the distribution of industry level productivity gains. The higher skilled wage in the North then provides for an expansion of Southern exports in that industry, raising the Southern skilled wage as well.

The presence of offshoring mediates the impact of trade liberalisations on factor rewards. In particular, at initially high trade costs, the presence of offshoring by Northern firms implies a greater adjustment in the North's relative skilled wage than the South's following a reduction in trade costs. At low trade costs, the opposite is true, with the greater adjustment occurring in the South. The reason for this is that offshoring implies relative wages in the North converge to their free trade factor price equalisation level more quickly than in the South following trade cost reductions. With offshoring, distributional conflict is higher in the North and lower in the South following liberalisations from high trade costs, with the reverse being true for liberalisations from low trade costs.

Since trade liberalisations are associated with reductions in the South's relative skilled wage, Northern offshoring rises by relatively more in the skill intensive industry as trade costs fall. Trade liberalisations raise average productivity North's comparative advantage industry, but in the presence of offshoring also raise average productivity in the North's comparative disadvantage industry.

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A Appendix

A.1 Optimal effort under outsourcing

A.1.1 For a given sector

Entrepreneurs set the derivative of profit under outsourcing with respect to effort equal to zero, equating the marginal benefits and costs of higher effort. Analytically, we then have

$$\frac{d\pi_{o,z_i}}{de} = \theta_{z_i}\tilde{\rho}\varphi^{\sigma-1}\{[1-\sigma]\left(\frac{\bar{\alpha}w_i}{e}\right)^{-\sigma}\left(\frac{-\bar{\alpha}w_i}{e^2}\right)\left(1-\frac{\bar{\alpha}s_{z_i}(e)}{e}\right)^{\sigma} + \left(\frac{\bar{\alpha}w_i}{e}\right)^{1-\sigma}\sigma\left(1-\frac{\bar{\alpha}s(e)}{e}\right)^{\sigma-1}\left[\frac{\bar{\alpha}s(e)}{e^2}-\frac{\bar{\alpha}}{e}s'(e)\right]\} = 0 \quad (69)$$

Setting the term inside the {} brackets equal to zero then requires that the following holds

$$\frac{e^*\bar{\alpha}s'(e^*)-\bar{\alpha}s(e^*)}{e^*-\bar{\alpha}s(e^*)} = \frac{\sigma-1}{\sigma} \quad (70)$$

which defines optimal effort e^*. This condition is independent of endogenous variables, hence is uniquely determined by model parameters. We may assume a functional form for the cost of effort function $s(e)$. The only restriction in the model is that it is increasing in e. For example, suppose $s(e) \equiv s\exp(te)$, where s is a parameter reflecting the risk premium workers demand, and t is a parameter reflecting the marginal cost of effort, $s'(e) = ts\exp(te) = ts(e)$. We may then write the optimal effort condition as

$$\frac{\bar{\alpha}s(e^*)[te-1]}{e^*-\bar{\alpha}s(e^*)} = \frac{\sigma-1}{\sigma} \quad (71)$$

A.1.2 Effort across sectors

As monitoring technology changes across sectors, riskiness changes, and thus so do risk premia s, so we write s_{z_i}. It is clear from (71) then that optimal effort e^* also varies across sectors according to monitoring technology. Totally differentiating (71) with respect to s_{z_i}, one can show that $de^*_{z_i}/dz_i < 0$ for sufficiently large t if s_{z_i} is increasing in z_i, that is , if monitoring gets harder as z_i increases. Then with optimal effort declining as monitoring gets harder, unit inputs $\alpha_{z_i} = \bar{\alpha}/e^*_{z_i}$ increase across sectors, contributing to a reduction in the variable cost savings associated with outsourcing. More fully, the expression for $\partial e/\partial s$ is

$$\frac{\partial e}{\partial s} = \frac{s(e)\left[-t\bar{\alpha} - \bar{\alpha}\frac{(et-\zeta-1)}{s}\right]}{\bar{\alpha}[et-\zeta-1]ts(e)-\zeta} \tag{72}$$

using $s(e) = s\exp(te)$, $ds(e)/ds = s(e)/s$ and $s'(e) = ts(e)$, and where $\zeta \equiv (\sigma-1)/\sigma$. A sufficiently large t ensures the top of this expression is negative, and the bottom positive.

A.2 Proposition 1

For the proposition, we require that (i) the intercept of the outsourcing profit function lies below that of the in-house profit function. This is the case whenever $S_o > 0$. We further require that (ii) the slope of the outsourcing profit function exceeds that of the in-house profit function in productivity. Let $\hat{\varphi} \equiv \varphi^{\sigma-1}$, then

$$\frac{d\pi_{in}}{d\hat{\varphi}} = \theta_{z_i}\tilde{\rho}w_i^{1-\sigma} \tag{73}$$

$$\frac{d\pi_o}{d\hat{\varphi}} = \theta_{z_i}\tilde{\rho}(\alpha w_i)^{1-\sigma}(1-\tilde{s})^{\sigma} \tag{74}$$

then clearly

$$\frac{d\pi_{in}}{d\hat{\varphi}} < \frac{d\pi_o}{d\hat{\varphi}} \text{ if } \alpha^{1-\sigma}(1-\tilde{s})^{\sigma} > 1 \tag{75}$$

which requires that $s_{z_i} < \frac{1-\alpha^{\frac{\sigma-1}{\sigma}}}{\alpha}$ for Proposition 1.

A.3 Proposition 2

First we find an expression for the outsourcing and exit cut-offs, defined respectively by $\pi_{in}(\varphi_o) = \pi_o(\varphi_o)$ and $\pi_{in}(\underline{\varphi}) = 0$. From the profit functions these may be written

$$\underline{\varphi} = \frac{fw_i}{\theta_{z_i}\tilde{\rho}w_i^{1-\sigma}} \tag{76}$$

$$\varphi_o = \frac{S_o w_i}{\theta_{z_i}\tilde{\rho}w_i^{1-\sigma}[\alpha^{1-\sigma}(1-\tilde{s})^{\sigma}-1]} \tag{77}$$

Dividing the first by the second , we may then write

$$\varphi_o = \Lambda_o \underline{\varphi} \tag{78}$$

$$\text{where } \Lambda_o \equiv \left(\frac{S_o}{f[\alpha^{1-\sigma}(1-\tilde{s})^{\sigma} - 1]} \right)^{\frac{1}{\sigma-1}} \tag{79}$$

Since then that Λ_o is increasing in both S_o and $\tilde{s}$, which are themselves increasing in risk, by assumption, φ_o rises relative to $\underline{\varphi}$ as risk increases, indicating a reduction in outsourcing as monitoring worsens.

A.4 Unique Equilibrium in the Closed Economy with domestic outsourcing

In the Melitz (2003) case with homogeneous organisational forms, equating the FE and ZPC conditions gives

$$\frac{\delta f_e}{f} = [1 - G(\underline{\varphi})]k(\varphi) \tag{80}$$

$$\text{where } k(\varphi) \equiv \left(\frac{\tilde{\varphi}}{\underline{\varphi}} \right)^{\sigma-1} - 1 \tag{81}$$

$$\text{where } \tilde{\varphi}^{\sigma-1} \equiv \frac{1}{1 - G(\underline{\varphi})} \int_{\underline{\varphi}}^{\bar{\varphi}} \varphi^{\sigma-1} g(\varphi) d\varphi \tag{82}$$

Then a unique equilibrium occurs when $[1 - G(\underline{\varphi})]k(\varphi)$ is monotonically decreasing in $\underline{\varphi}$, for which a sufficient condition is that $\frac{g(.)k(.)}{1-G(.)} < 0$. In the case considered here with domestic outsourcing too, equating FE and ZPC conditions we may write

$$\frac{\delta f_e}{f} = [1 - G(\underline{\varphi})]k(\varphi) + \int_{\Lambda_o \underline{\varphi}}^{\bar{\varphi}} \left[\lambda_o \left(\frac{\varphi}{\underline{\varphi}} \right)^{\sigma-1} - \frac{S_o}{f} \right] \tag{83}$$

Then the right hand side is monotonically decreasing in $\underline{\varphi}$ if $\frac{g(.)k(.)}{1-G(.)} < 0$, exactly the sufficient condition identified in Melitz (2003), since the second term on the right hand side is also decreasing in $\underline{\varphi}$ by inspection.

A.5 Proposition ??

We may write sector z_i's price index P_{z_i} as

$$P_{z_i} = n(\underline{\varphi})^{\frac{1}{1-\sigma}} \frac{w_i}{\rho \tilde{\varphi}} \tag{84}$$

Then clearly since n is decreasing in $\underline{\varphi}$, and $\sigma > 1$ by assumption, the price index falls when $\underline{\varphi}$ rises on account of a smaller n, or fewer varieties. However, a higher $\underline{\varphi}$ also raises average productivity $\tilde{\varphi}$, lowering the average price by $p(\tilde{\varphi}) = \frac{w_i}{\rho \tilde{\varphi}}$. This works to reduce the price index, giving an ambiguous effect overall.

A.6 Autarkic price indices

Under autarky, the relative price index for two 'parallel' sectors z_1 and z_2 in different industries 1 and 2 may be written

$$\frac{P_{z_1}}{P_{z_2}} = \frac{w_K}{w_L} \tag{85}$$

by virtue of the assumption of symmetric monitoring across industries, and in the absence of differences in entry costs, probability of failure, and 'endowments' of entrepreneurs (i.e. $N_{z_1} = N_{z_2}$) between sectors. Then autarkic price indices are tied to autarkic factor rewards, which in turn are determined by domestic factor endowments. Since the North is assumed skill abundant and the South skill scarce, we may also write

$$\frac{P_{z_1}}{P_{z_2}} < \frac{P^*_{z_1}}{P^*_{z_2}} \tag{86}$$

as claimed in the text.

A.7 Offshoring cut-offs

The cut-off for domestic outsourcing is exactly as given above. For FDI and Southern outsourcing, by equating the relevant profit functions, cut-offs may be fully written as

$$\begin{aligned}
\varphi_F &= \Lambda_F \underline{\varphi} && (87)\\
\text{where } \Lambda_F &\equiv \left(\frac{S_F - S_o + f\left(\frac{w_i^*}{w} - 1\right)}{f[\left(\alpha_F \frac{w_i^*}{w_i}\right)^{1-\sigma}(1-\tilde{s}^F)^\sigma - \alpha^{1-\sigma}(1-\tilde{s})^\sigma]} \right)^{\frac{1}{\sigma-1}} && (88)\\
\varphi_{o*} &= \Lambda_{o*}\underline{\varphi} && (89)\\
\text{where } \Lambda_{o*} &\equiv \frac{w_i^*}{w_i}\left(\frac{S_{o*} - S_F}{f[(\alpha^*)^{1-\sigma}(1-\tilde{s}^*)^\sigma - \alpha_F^{1-\sigma}(1-\tilde{s}^F)^\sigma]} \right)^{\frac{1}{\sigma-1}} && (90)
\end{aligned}$$

in which Λ_F and Λ_{o*} are increasing in the relative Southern wage w^*/w. Then clearly increases in the relative Souther wage rate, which raise φ_F and φ_{o*} reduce the amount of offshoring that firms choose in equilibrium, ceteris paribus.

A.8 Payments to Southern factors by Northern firms

We wish to investigate what happens to total payments to Southern factors via Northern offshoring when the southern wage changes. For a Northern firm which outsources to the South in a given sector, we may write its total payments to Southern labour as the product of the Southern wage and the firm's labour demand, which must equal its unit input requirements ($\frac{\alpha^*}{\varphi}$) times its output $q(.)$. Then for all outsourcing firms in a given sector, we write

$$w_i^* \int_{\varphi_{o*}}^{\bar{\varphi}} \frac{\alpha^*}{\varphi} q(\varphi) n\mu(\varphi) d\varphi = \left(\frac{w_i^*}{\rho}\right)^{-\sigma} \frac{n(.)}{1 - G(\underline{\varphi})} \int_{\varphi_{o*}}^{\bar{\varphi}} (\alpha^*)^{1-\sigma}(1-\tilde{s}^*)^\sigma \varphi^{\sigma-1} g(\varphi) d\varphi \tag{91}$$

the right hand side of which is decreasing in w_i^* since $\sigma > 1$ and φ_{o*} is increasing in w_i^*. Since this will be the case across all sectors in which Southern outsourcing takes place, total payments to Southern factors due to Southern outsourcing are decreasing in the Southern wage rate. One can make an exactly analogous argument for payments to Southern factors via FDI. Then $w_i^*(l^F + l^{o*})$, $l = K, L$, are both decreasing in the relevant Southern wage.

Since $w_i^*(l^F + l^{o*})$, $l = K, L$ is decreasing in the Southern wage, we may write that $w_L^*(L^F + L^{o*})/w_K^*(K^F + K^{o*})$ is decreasing in w_L^*/w_K^*. So a rise in the relative Southern unskilled wage implies a fall in relative payments to Southern unskilled labour by Northern firms via offshoring. Conversely, if the South is abundant in unskilled labour, such that its relative unskilled wage is low, payments to Southern unskilled labour will be high relative to those to Southern skilled labour via offshoring.

A.9 Cut-offs with trade costs

A.9.1 Northern firms serving the *Northern* market

Northern firms producing at home incur no trade costs. Those offshoring however, do. We may write the relevant cut-offs as

$$\underline{\varphi}^{\sigma-1} = \frac{fw_i}{\theta\tilde{\rho}w_i^{1-\sigma}} \tag{92}$$

$$\varphi_o^{\sigma-1} = \frac{S_o w_i}{\theta\tilde{\rho}w_i^{1-\sigma}[\alpha^{1-\sigma}(1-\tilde{s})^\sigma - 1]} \tag{93}$$

$$\varphi_F^{\sigma-1} = \frac{S_F w_i - S_o w_i + f(w_i^* - w_i)}{\theta\tilde{\rho}w_i^{1-\sigma}[\left(\tau\alpha_F \frac{w_i^*}{w_i}\right)^{1-\sigma}(1-\tilde{s}_F)^\sigma - \alpha^{1-\sigma}(1-\tilde{s})^\sigma]} \tag{94}$$

$$\varphi_{o*}^{\sigma-1} = \frac{S_{o*}w_i - S_F w_i}{\theta\tilde{\rho}(w_i^*\tau)^{1-\sigma}[(\alpha^*)^{1-\sigma}(1-\tilde{s}^*)^\sigma - \alpha_F^{1-\sigma}(1-\tilde{s}_F)^\sigma]} \tag{95}$$

A.9.2 Northern firms serving the *Southern* market

Now domestic production incurs trade costs, but offshoring does not. We write cut-offs as

$$(\underline{\varphi}^*)^{\sigma-1} = \frac{f^* w_i}{\theta^*\tilde{\rho}(\tau w_i)^{1-\sigma}} \tag{96}$$

$$(\varphi_o^*)^{\sigma-1} = \frac{S_o w_i}{\theta^*\tilde{\rho}(\tau w_i)^{1-\sigma}[\alpha^{1-\sigma}(1-\tilde{s})^\sigma - 1]} \tag{97}$$

$$(\varphi_F^*)^{\sigma-1} = \frac{S_F w_i - S_o w_i + f(w_i^* - w_i)}{\theta^*\tilde{\rho}(\tau w_i)^{1-\sigma}[\left(\frac{\alpha_F}{\tau}\frac{w_i^*}{w_i}\right)^{1-\sigma}(1-\tilde{s}_F)^\sigma - \alpha^{1-\sigma}(1-\tilde{s})^\sigma]} \tag{98}$$

$$(\varphi_{o*}^*)^{\sigma-1} = \frac{S_{o*}w_i - S_F w_i}{\theta^*\tilde{\rho}(w_i^*)^{1-\sigma}[(\alpha^*)^{1-\sigma}(1-\tilde{s}^*)^\sigma - \alpha_F^{1-\sigma}(1-\tilde{s}_F)^\sigma]} \tag{99}$$

A.9.3 Comparing cut-offs across markets

We may now compare cut-offs across markets. First, in a given industry-sector serving the Northern market, we may write

$$\left(\frac{\varphi_{o*,z_i}}{\underline{\varphi}_{z_i}}\right)^{\sigma-1} = \frac{S_{o*}-S_F}{f}\left(\frac{w_i}{w_i^*}\right)^{1-\sigma}\frac{1}{\tau^{1-\sigma}[(\alpha^*)^{1-\sigma}(1-\tilde{s}^*)^{\sigma}-\alpha_F^{1-\sigma}(1-\tilde{s}_F)^{\sigma}]} \tag{100}$$

Then for a parallel sectors in industries 1 and 2, by symmetry, we may write the relative Southern outsourcing cut-off as

$$\frac{\varphi_{o*,z_1}/\underline{\varphi}_{z_1}}{\varphi_{o*,z_2}/\underline{\varphi}_{z_2}} = \frac{w_L}{w_K}\frac{w_K^*}{w_L^*} > 1 \tag{101}$$

$$\text{by } \frac{w_L}{w_K} > 1, \ \frac{w_K^*}{w_L^*} > 1 \tag{102}$$

Exactly analogously, for serving the Southern market, we may write

$$\frac{\varphi^*_{o*,z_1}/\underline{\varphi}^*_{z_1}}{\varphi^*_{o*,z_2}/\underline{\varphi}^*_{z_2}} = \frac{w_L}{w_K}\frac{w_K^*}{w_L^*} > 1 \tag{103}$$

by the same argument. Then for sectors in industry 1, the North's comparative advantage industry, Southern outsourcing cut-offs are relatively higher than those for the North's comparative disadvantage industry, for serving both Northern and Southern markets. Thus Southern outsourcing is relatively larger in the North's comparative disadvantage industry, and the South's comparative advantage industry.

For FDI, we may write

$$\left(\frac{\varphi_{F,z_i}}{\underline{\varphi}_{z_i}}\right)^{\sigma-1} = \frac{S_F - S_o + f\left(\frac{w_i^*}{w_i}-1\right)}{f}\frac{1}{\left[\left(\tau\alpha_F\frac{w_i^*}{w_i}\right)^{1-\sigma}(1-\tilde{s}_F)^{\sigma}-\alpha^{1-\sigma}(1-\tilde{s})^{\sigma}\right]} \tag{104}$$

This ratio will be higher whenever w_i^*/w_i is higher, which is the case in industry 1, since $w_K^*/w_K > w_L^*/w_L$. We then conclude that

$$\frac{\varphi_{F,z_1}/\underline{\varphi}_{z_1}}{\varphi_{F,z_2}/\underline{\varphi}_{z_2}} > 1 \tag{105}$$

Once again, one may also show that

$$\frac{\varphi^*_{F,z_1}/\underline{\varphi}^*_{z_1}}{\varphi^*_{F,z_2}/\underline{\varphi}^*_{z_2}} > 1 \tag{106}$$

Then for sectors in industry 1, the North's comparative advantage industry, FDI is used relatively less to serve both Northern and Southern markets relative to industry 2, the North's comparative disadvantage industry.

For domestic outsourcing, we may write

$$\left(\frac{\varphi_{o,z_i}}{\underline{\varphi}_{z_i}}\right)^{\sigma-1} = \frac{S_o}{f}\frac{1}{[\alpha^{1-\sigma}(1-\tilde{s})^{\sigma}-1]} \tag{107}$$

$$= \left(\frac{\varphi^*_{o,z_i}}{\underline{\varphi}^*_{z_i}}\right)^{\sigma-1} \tag{108}$$

Implying straightforwardly that

$$\frac{\varphi_{o,z_1}/\underline{\varphi}_{z_1}}{\varphi_{o,z_2}/\underline{\varphi}_{z_2}} = 1 = \frac{\varphi^*_{o,z_1}/\underline{\varphi}^*_{z_1}}{\varphi^*_{o,z_2}/\underline{\varphi}^*_{z_2}} \tag{109}$$

Thus the domestic outsourcing cut-off is always a fixed relative interval above the exit cut-off, for serving both Northern and Southern markets.

Finally,

$$\left(\frac{\underline{\varphi}_{z_i}}{\underline{\varphi}^*_{z_i}}\right)^{\sigma-1} = \frac{f}{f^*}\frac{\theta^*_{z_i}\tau^{1-\sigma}}{\theta_{z_i}} \tag{110}$$

Then we use that $\theta^*_{z_i}/\theta_{z_i} = (R^*/R)(P^*_{z_i}/P_{z_i})^{\sigma-1}$ to argue that

$$\frac{\theta^*_{z_1}/\theta_{z_1}}{\theta^*_{z_2}/\theta_{z_2}} = \frac{P^*_{z_1}}{P^*_{z_2}}\frac{P_{z_2}}{P_{z_1}} > 1 \tag{111}$$

by costly trade comparative advantage. Then

$$\frac{\underline{\varphi}^*_{z_1}}{\underline{\varphi}_{z_1}} < \frac{\underline{\varphi}^*_{z_2}}{\underline{\varphi}_{z_2}} \tag{112}$$

Thus the in-house exporting cut-off is relatively closer to the domestic exit cut-off in the North's comparative advantage sector. Ceteris paribus, just as in Bernard et al. (2007), this implies that $\underline{\varphi}_{z_1} > \underline{\varphi}_{z_2}$. However, note that the effect of a lower exporting cut-off in the comparative advantage industry identified in Bernard et al. (2007) is mitigated in this model by less offshoring, tending to lessen the productivity advantage gained in the comparative advantage sector. Thus while a lower exporting cut-off ($\underline{\varphi}^*_{z_i}$) increases expected certainty equivalent profits, increasing competition, and raising average productivity by raising the domestic entry cut-off ($\underline{\varphi}_{z_i}$), with less offshoring in the comparative advantage industry (relatively higher φ_{F,z_i} and φ_{o*,z_i}), this average productivity effect is dampened. With higher φ_{F,z_i} and φ_{o*,z_i} in sectors in industry 1, relatively more production takes place in the North for the North's comparative advantage industry.