The Cleansing Effect of Offshoring in an Analysis of Employment

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Abstract

This paper uses a partial equilibrium heterogeneous firm model to explore distinctive firm-level operational responses to offshoring and the resulting short-run employment effect. We find that the industry-level effect is unambiguously negative and this is largely due to large job destruction from the exits of the least productive firms (*Cleansing Effect*). The numerical analysis, calibrated to the U.S. manufacturing sector, confirms the dominance of the cleansing effect in driving the reduction in industry-level employment. Offshorers still account for the majority of total job destruction; however, this is offset by subsequent job creation, partly from the increase in export opportunities.

JEL: F12, F14, F16
Key Words: cleansing effect, offshoring, employment, job destruction, job creation
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INTRODUCTION

In the past few decades, offshoring has been increasingly blamed for the decline of U.S. manufacturing sector. However, this is not supported by academic studies. Studies find that the industry-level employment effects of offshoring — measured by the degree of imported input usage — is ambiguous. Amiti and Wei [2009] find that the impact is insignificant at the disaggregated level, but positive at a more aggregated level in the U.S. manufacturing sector between 1992 and 2000. In a similar study, Amiti and Wei [2005] find an insignificant effect in the U.K. manufacturing industry between 1995 and 2001. Morissette and Johnson [2007] find that the Canadian industries with intense offshoring did not show significantly different employment growth rates compared to other industries. Koller and Stehrer [2010] use Austrian data and find that offshoring has a negative effect during 1995–2000, but a positive effect during 2000–2003. Mullen and Panning [2009] find offshoring as important as technology improvement in their investigation of the displacement of unskilled workers and the resulting skill upgrading of the workforce.

Layoffs are inevitable at offshoring firms. However, the inconclusive net effects observed in the empirical literature suggest that offshoring also results in job creation. Grossman and Rossi-Hansberg [2008] summarize these opposing forces as substitution and productivity effects. The substitution effect reduces domestic labor demand by replacing domestic workers with foreign workers at lower costs. The productivity effect increases the domestic labor demand by improving offshoring firms' efficiency, lowering the price, hence increasing the demand for the final product. They show that the productivity effect dominates in industries with high offshoring intensity.

In this paper, we investigate the short-run firm- and industry-level employment effects of offshoring by analyzing firm-level operational responses to the feasibility of offshoring usinga partial equilibrium model of offshoring with heterogeneous firms [Melitz, 2003]. We define offshoring as the relocation of a fraction of production process abroad for the purpose of cost reduction without distinction between FDI and an arm‘s-length contract.[1] Firms in this paper make two decisions, whether to offshore and whether to export. Initially there are two symmetric northern countries trading with each other through traditional exporting. The production process consists of two segments, Assembly and Services.[2] As offshoring becomes feasible, some firms choose to offshore their assembly segment to South where wage rate is lower. We analyze how firms with different productivities respond to the feasibility of offshoring. We find that the most productive firms offshore — as found in Kurz [2006] — and the least productive firms are forced to exit. We call the exit of the least-productive firms *the Cleansing Effect of Offshoring*[3]. Where the offshoring cost is low, offshoring enables previously non-exporting firms to export and enjoy the benefits of market expansion. We also find that offshoring not only reduces the number of domestic varieties but also the total number of varieties available to consumers. This finding is consistent with Bernard, Redding, and Schott [2007]. This is due to the fact that offshoring benefits a small number of large (most productive) firms, and the cleansing effect drives a large number of small (least productive) firms out of the market. Lastly, we find that offshoring unambiguously reduces industry-level employment but the net employment effect within offshoring firms is ambiguous.

The main contribution of our paper is that we allow firms to export (market access) and offshore (production cost reduction) simultaneously by working with three countries two Northern countries that consume the final goods and one Southern country that performs tasks at a low cost with no taste for the final products. This setting is particularly valuable in analyzing the link between cost reduction from offshoring and expansion of export opportunities. Bernard, Jensen, Redding, Schott [2012] document a high correlation of 0.79 between exporters and importers. They also show that 41% of exporters import and 79% of importers export. Considering that imported input usage is one form of offshoring, they interpret this fact as an evidence of vertical specialization. While the foreign assembly type offshoring is not observed in this study, one can expect a similarly strong connection between exporting and other types of offshoring as well.

The existing literature that extends Melitz [2003] in an analysis of offshoring allows offshoring driven by only one incentive; one driven by a market access incentive (horizontal motif) and the other by cost reduction (vertical motif). Firms in these studies make only one additional decision once it decides to stay in the market given a productivity draw. The first branch deals with the choice between exporting and offshoring (FDI) as a substitutable strategy to access the foreign market [Helpman, Melitz, and Yeaple, 2004]. Firms from two Northern countries sell in each others market through exporting or FDI. The cost reduction comes from eliminating trade costs.

The second branch deals with the decision on whether to offshore to lower production cost [Antras and Helpman, 2004; Fort, 2013]. There are one Northern country that consumes the final goods and one Southern country that hosts offshoring activities without a market for the final products. All final goods are consumed at home and there is no other foreign market to export to. The sole reason to offshore is lower production cost.

Another contribution of our paper is that we look at the employment effects of firms that respond differently to the feasibility of offshoring separately. This allows us to see what type of firms offshorers or non-offshorers, exporters or non-exporters is responsible for the largest job destruction and creation. This analysis helps us understand what is driving the small and often insignificant industry-level employment effect observed in the empirical literature.

We do not model the labor market friction explicitly. Rather, we implicitly assume that there are enough frictions in the market so that labor mobility across sectors is not perfect in the short run. Under this assumption, displaced workers who are not absorbed by the newly created jobs in the same sector remain unemployed. This allows us to analyze the short-run employment impact in three-country environment and maintain mathematical tractability. While labor market friction is very useful in driving wage and unemployment rate responses, the model needs to be simplified in another dimension to be solvable. In this paper, we choose to let go of labor market friction so that we can focus on the complex firm-level behaviors.[4] See Mitra and Ranjan [2010] and Sethupathy [2013] for well-structured general equilibrium analyses of wages and sectoral unemployment rates.[5]

Using the structural model presented in this paper, we analyze the job creation and destruction separately for non-offshoring firms and offshorers. The workers displaced due to import competition and offshoring tend to be low-skilled and are often not qualified to perform the newly created jobs within the sector. Various federal assistance programs such as the Trade Adjustment Assistance (TAA) program[6] help them prepare for a new career by providing occupational training and other reemployment services. In preparing for this type of federal assistance, the size of job destrcution is more relevant than net employment changes.

We carry out a numerical analysis by using benchmark parameter values that are calibrated to match the initial and offshoring equilibrium to U.S. manufacturing sector in 1992 and 2006, respectively. We find that the net employment loss may reach up to 36% of total initial employment in the industry. However, the majority (50–75%) of such net employment loss is due to the job destruction brought about by the cleansing effect of offshoring rather than layoffs by offshorers. The sensitivity analysis confirms the dominance of the cleansing effect in driving the negative net employment effect. The numerical analysis confirms the previous finding that employment effect within offshoring firms is ambiguous. The separate analysis of job destruction and creation reveals that such a net effect is a sum of large job destruction and similarly large job creation. For the benchmark parameter values, the net effect ranges from a loss of 17% to a gain of 3%. Total job destruction is up to 59% of initial employment. Despite the striking dominance of the cleansing effect in the net employment effect, the layoffs by offshorers indeed account for a larger fraction of total job destruction. This implies that although their net employment effect is ambiguous, layoffs by offshoring firms are an important socio-economic phenomenon that deserves a significant amount of policy attention.

Empirical exploration of firm-level response to offshoring is still a difficult task due to the lack of data sources that cover offshoring activities comprehensively [Kirkegaard, 2007]. The majority of firm-level studies for the U.S. economy utilize the establishment-level data of U.S. multinationals collected by the U.S. Bureau of Economic Analysis (BEA). The operational information provided in the BEA dataset is detailed and rich and higly desirable to address various behaviors of multinational firms. Many of these studies analyze whether foreign-affiliate activities complement or substitute domestic activities. Brainard and Riker [1997] find a small substitution between domestic and foreign activities and stronger substitution among foreign affiliates in low-wage countries. Desai, Foley, and Hines [2005] find complementarity that a 10% rise in foreign employment is associated with a 2.5% increase at U.S. locations. Harrison and McMillan [2011] find complementarity for vertical affiliates, but substitution for horizontal affiliates. Ottaviano, Peri, and Wright [2013] show little substitution[7] and Borga [2005] finds no significant effect. Sethupathy [2013] finds that, in comparison between offshorers and non-offshorers, the domestic job losses in offshoring firms are no greater than those in non-offshoring counterparts.[8] There are similar studies using data on multinationals in other industrial nations. See Muendler and Becker [2010] for Germany and Braconier and Ekholm [2000] for Sweden.

Other firm-level studies use the data on the universe of manufacturing establishments. Monarch, Park, and Sivadasan [2014] use the microdata from the U.S. Census of Manufactures and Annual Survey of Manufactures to investigate various firm-level operational responses to offshoring including wages and employment of production/nonproduction workers, factor intensity and productivity. Jensen and Kletzer [2005, 2008] and Liu and Trefler [2011] look at the service offshoring. See Hummels, Jorgensen, Munch, and Xiang (2014) for the case of Denmark.[9]

The data sets used in these studies provide an extensive amount of detailed firm-level operations and what we learn from them is enormously valuable. However, none of these data sets are capable of capturing all types of offshoring activities. Data on multinationals fail to capture the offshoring activities through arms-length contracts. Census-type data are less accurate in identifying offshorers. Usage of imported inputs is not suitable to capture the final assembly offshoring. And both types rely on the size of establishment-level employment at one point in time during an observation period; therefore, we can only observe net adjustment in employment rather than the size of job destruction and creation separately. Our numerical analysis complements these limitations of existing empirical studies by taking advantage of the structure model.

The rest of the paper is organized as follows. Section 2 introduces the model. Sections 3 and 4 present, respectively, the analytical results and numerical analyses. Section 5 concludes.

MODEL

Initially, there are two symmetric Northern countries that produce and consume manufacturing products. Two countries trade with each other. Firms in both countries are heterogeneous in their productivities. Each firm utilizes only labor as a factor to perform two processes - assembly and services - in order to produce its unique variety. As offshoring becomes feasible, we introduce a third country, South, with a low wage as a host of offshoring activities.

Set-up

A representative consumer has CES preference over a continuum of goods indexed by ω as in $U = \left[\int_{\omega\in\Omega} q(\omega)^{\rho} d\omega\right]^{\frac{1}{\rho}}$. Ω is the set of available varieties. The consumer spends a fixed amount of expenditure, R, on these differentiated varieties. The demand for variety ω is as follows.

$$q(\omega) = \frac{R}{P}\left[\frac{p(\omega)}{P}\right]^{-\varepsilon} \qquad \text{where} \qquad P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \tag{1}$$

ε is the elasticity of substitution and equals $1/(1-\rho)$. P is the market price index.

The basic framework of firm heterogeneity and the decision-making process follows Melitz [2003]. Upon entry into the market, a firm incurs a sunk entry cost, f_e, and draws a productivity z from a cumulative distribution $G(z)$. The firm's unit labor requirement is determined as $1/z$. After observing z, the firm decides whether to stay and produce at a fixed cost of production, f, or to exit. In the absence of offshoring, successful entrants then decide whether to export at an additional fixed export cost, f_x. Where offshoring is feasible, successful entrants choose one of the following options: first, produce at home and only serve domestic market; second, produce at home and serve both domestic and foreign markets (incurring f_x); third, offshore and serve only domestic market (additional fixed cost of offshoring, f_{os}); and lastly, offshore and serve both markets (both f_x and f_{os}).

Variable costs are composed of two segments, assembly and services. The employment share of service segment is fixed at γ. The wage rate in both Northern countries is assumed to be one. After successful entry, every firm faces a death hazard, ξ, every period. In a steady state equilibrium, as some firms die, new entrants fill their spots.

Open Economy without Offshoring

The open-economy equilibrium in the absence of offshoring resembles that of Melitz [2003]. Two identical Northern countries trade their final goods with each other. Every firm produces a unique variety and charges a monopoly price. For domestic sales, the price is simply a constant markup over marginal cost, $1/\rho z$. The export price includes the transportation cost τ, $\tau/\rho z$.

The profits from a firm's domestic and export sales are

$$\pi_{d,hp}(z) = \frac{R}{\varepsilon}\left(P\rho z\right)^{\varepsilon-1} - f \qquad\qquad \pi_{x,hp}(z) = \frac{R}{\varepsilon}\left(\frac{P\rho z}{\tau}\right)^{\varepsilon-1} - f_x \tag{2}$$

The subscripts d and x respectively indicate variables for domestic and export market operation. hp indicates home producers (opposed to offshorers). The total profit for firms that only serve domestic market is $\pi_{d,hp}(z)$. That of an exporter is $\pi_{d,hp}(z) + \pi_{x,hp}(z)$.

The equilibrium is characterized by two productivity cutoffs that summarize two decisions of firms — z^0_{hp} for entry and z^0_x for exporting. Superscript 0 indicates the initial open-economy equilibrium variables. Home producers' total profit function, $\pi_{hp}(z)$ and the pattern of operations are depicted in Figure 1. As in Melitz [2003], we assume $f_x > \tau^{1-\varepsilon} f$ throughout this paper. This assumption ensures existence of both exporters and non-exporters in the market.

[**Figure 1 about here**]

In the equilibrium, the expected value of entry is zero due to free entry; that is $\left[1 - G(z^0_{hp})\right]\bar{\pi}^0 = f_e$. $\bar{\pi}^0$ is the average profit of all operating firms in the initial equilibrium, which is

$$\pi_{d,hp}\left(\tilde{z}(z^0_{hp})\right) + \frac{1 - G(z^0_x)}{1 - G(z^0_{hp})}\pi_{x,hp}\left(\tilde{z}(z^0_x)\right)$$

$\tilde{z}(x)$ is an average productivity of all firms with productivity of x or higher. Using equation (2), we can write the equilibrium condition for the initial economy as the following:

$$fk(z^0_{hp}) + \left[\frac{1 - G(z^0_x)}{1 - G(z^0_{hp})}\right] f_x k(z^0_x) = \frac{\xi f_e}{1 - G(z^0_{hp})} \qquad \text{where} \quad k(\hat{z}) = \left(\frac{\tilde{z}(\hat{z})}{\hat{z}}\right)^{\varepsilon-1} - 1 \tag{3}$$

Open Economy with Offshoring

Offshoring takes the form of relocating the assembly segment to another country. We introduce a third country, South, that can perform assembly and does not consume the final product. δ is the wage rate per efficiency unit of labor in the South and is smaller than one. The production technology is firm-specific, so the productivity, z, is preserved regardless of the location of assembly. If a firm with productivity z offshores, its marginal production cost becomes $mc_{os}(z) = \frac{\lambda}{z}$. λ is a parameter that represents the cost reduction from offshoring and can be written as $\lambda = (1-\gamma)\delta + \gamma$.

We assume that the integration of assembly and service segments is virtual and that production is completed in the South. That is as if the service portion is performed in the firm's home country and shipped to the South for completion, but there is no transport cost involved. Any extra cost involved in the integration process can be captured by fixed offshoring cost, f_{os}. Final goods are shipped to the market directly from the South. The iceberg transport cost, τ, applies to shipment of final goods.[10] One example of this type of production structure is factoryless goods production [FGP; Borga and Moulton, 2014]. FGP firms mainly engage in innovation and marketing and the production of the products is done by firms that specialize in contract-based customized manufacturing services. Goods are shipped from this facility directly to the market.

The transportation structure is summarized in Figure 2. It is depicted for two representative goods produced with the same productivity. The circles represent the national borders; and two prices in each circle represent the prices of local and imported goods, respectively. Panel (a) shows traditional international trade where goods are shipped directly from the origin countries. This applies to all firms in the initial open-economy equilibrium and non-offshorers in the offshoring equilibrium. Firms face price disadvantage in their foreign markets in this case due to transport cost. Panel (b) describes the case for offshorers. Where goods are offshored, the markup over the marginal cost upon completion at the Southern facilities is λP and sold for $\tau\lambda P$ in both Northern markets. Offshoring lowers domestic prices from P to $\tau\lambda P$, while it lowers export prices from τP to $\tau\lambda P$.[11] For this reason, exporters benefit more from offshoring than non-exporters do.

[**Figure 2 about here**]

Offshoring firms incur f_{os} in addition to fixed production cost f and export cost f_x in case of exporting. We can write domestic and export profits of an offshorer separately as the following.

$$\pi_{d,os}(z) = \frac{R}{\varepsilon}\left(\frac{P\rho z}{\tau\lambda}\right)^{\varepsilon-1} - f - f_{os} \qquad\qquad \pi_{x,os}(z) = \frac{R}{\varepsilon}\left(\frac{P\rho z}{\tau\lambda}\right)^{\varepsilon-1} - f_x \tag{4}$$

Figure 3 shows the profit functions for offshorers. Panel (a) shows the case where the fixed cost of exporting is large. In this case, exporting and non-exporting offshorers co-exist and more productive offshorers export. Where f_x is small, all offshorers export as depicted in panel (b). Not to participate in offshoring is an option for firms. We call the firms that choose not to offshore home producers. Their total profit function is depicted in Figure 1.

[**Figure 3 about here**]

Equilibria

Firms make three decisions in the offshoring equilibrium: first, whether to stay in the market; second, whether to produce at home or offshore; finally, whether to export. Such decisions depend on the parameter values (λ, τ, and ε) and fixed costs (f, f_x, and f_{os}). Each set of parameter values and fixed costs can potentially represent a specific industry such as computer manufacturing or textile.

Under the assumptions — $f_x > \tau^{1-\varepsilon} f$ and $\tau\lambda < 1$ — we find five distinctive operational patterns shown in Figure 4. Figure 5 shows the size of fixed costs that correspond to each pattern given other parameter values. α denotes the fixed exporting cost relative to fixed production cost (f_x/f), and β is the fixed offshoring cost relative to f (f_{os}/f). The extent of offshoring depends on the size of offshoring cost. According to Figure 6, pattern A (small β) shows higher degree of offshoring than pattern C.

[**Figure 4 about here**]

[**Figure 5 about here**]

[**Figure 6 about here**]

Since firms' operational responses to offshoring differ across patterns - A through E - the equilibrium analysis should be carried out separately for each pattern. In the next section, we present a detailed model under pattern A. Other patterns will be included in the numerical analysis.

Under pattern A, there are three groups of firms — home producers that only serve the domestic market, offshorers that only serve the domestic market, and offshorers that serve both domestic and foreign markets. The entry cutoff productivity, z_{hp}^A, is the home producers' zero-profit productivity. The offshoring cutoff productivity, z_{os}^A, is where a firm is indifferent between offshoring and home production, $\pi_{d,hp}(z_{os}^A) = \pi_{d,os}(z_{os}^A)$. The export cutoff productivity, z_x^A is the productivity level with which an offshorer's export profit is zero.

Free entry assures that the expected value of entry is zero; that is $\left[1 - G(z_{hp}^A)\right] \bar{\pi}^A = f_e$. $\bar{\pi}^A$ is the average profit of all operating firms in the offshoring equilibrium A and can be written as the following:

$$\bar{\pi}^A = \frac{G(z_{os}^A) - G(z_{hp}^A)}{1 - G(z_{hp}^A)} \pi_{d,hp}(\tilde{z}(z_{hp}^A)) + \frac{1 - G(z_{os}^A)}{1 - G(z_{hp}^A)} \pi_{d,os}(\tilde{z}(z_{os}^A)) + \frac{1 - G(z_x^A)}{1 - G(z_{hp}^A)} \pi_{x,os}(\tilde{z}(z_x^A))$$

Using equations (2) and (4), we can write the equilibrium condition for the offshoring equilibrium pattern A as the following:

$$k(z_{hp}^A) f + \left[\frac{1 - G(z_{os}^A)}{1 - G(z_{hp}^A)}\right] k(z_{os}^A) f_{os} + \left[\frac{1 - G(z_x^A)}{1 - G(z_{hp}^A)}\right] k(z_x^A) f_x = \frac{\xi f_e}{1 - G(z_{hp}^A)} \tag{5}$$

THEORETICAL RESULTS

In this section, we expand the scope to patterns A through C. More specifically, we analyze the subset of the equilibrium space where non-offshorers survive in the market. First, we look at the changes in entry and export cutoff productivities and where offshoring cutoff productivity is located. The location of cutoff productivities is of great importance because it determines the operational responses of firms. For instance, a fall in the entry cutoff productivity force some firms to exit.

A change in export cutoff productivity could either generate or eliminate export opportunities for firms. The location of offshoring cutoff productivity determines the offshoring intensity of the industry. These distinctive responses by different firms, then, determine the impacts of offshoring on various aspects of the economy such as the number of varieties and employment. Proposition 1 and 2 summarize the results.

Proposition 1 Cleansing Effect of Offshoring *The entry cutoff productivity is higher in offshoring equilibrium than in the initial open economy equilibrium. Also, the rise of the entry cutoff productivity is the largest where fixed offshoring cost (f_{os}) is the smallest (pattern A), and the smallest where f_{os} is the largest (pattern C).*

$$z_{hp}^0 < z_{hp}^C < z_{hp}^B < z_{hp}^A$$

Lemma 1 *The offshoring cutoff productivity relative to the entry cutoff productivity is the lowest under pattern A and the highest under pattern C of the offshoring equilibrium. That is,* $\frac{z_{os}^A}{z_{hp}^A} < \frac{z_{os}^B}{z_{hp}^B} < \frac{z_{os}^C}{z_{hp}^C}$

Lemma 2 *The export cutoff productivity relative to the entry cutoff productivity is the lowest under the pattern A and highest under pattern C. The value for pattern C is equal to that for the initial open-economy equilibrium. That is,* $\frac{z_x^A}{z_{hp}^A} < \frac{z_x^B}{z_{hp}^B} < \frac{z_x^C}{z_{hp}^C} = \frac{z_x^0}{z_{hp}^0}$

Proof : See Appendix

The first implication of Proposition 1 is that the entry cutoff productivity rises with offshoring in all offshoring equilibrium patterns. This implies that the least-productive firms exit as offshoring becomes feasible. This is due to the rise in their relative prices as prices of offshoring firms decline. We call this *the Cleansing Effect of Offshoring.*[12] The cleansing effect is directly related to the employment level of the industry. As firms exit, all workers employed by the exiting firms lose their jobs. For this reason, non-offshorers can be a significant source of offshoring-related job losses at the industry level. Where offshoring is relatively easy (pattern A), more firms take advantage of offshoring, driving the price index further down. This enlarges the cleansing effect.

This is the case in industries with easily transferrable technology, less issue of intellectual property right, and smaller potential variations in quality; most likely low-skilled manufacturing sectors such as textile, apparel, and footwear.[13]

Proposition 2 *The cutoff productivity for offshoring is the lowest under the offshoring equilibrium pattern A and the highest under pattern C; that is,*

$$z_{os}^{A} < z_{os}^{B} < z_{os}^{C}$$

Proposition 2 simply implies that offshoring is profitable for firms with lower productivities where the fixed cost of offshoring is lower.

Unlike the entry cutoff productivity, export cutoff productivity does not uniformly rise or decrease with offshoring. Whether it increases depends on the parameter values. Generally export cutoff productivity is low where offshoring cost is small. This is because offshoring benefits exporters more than non-exporters by bringing about a large reduction in exporters' prices in their foreign markets. High degree of offshoring with a smaller offshoring cost expands export opportunities more; therefore, the cutoff productivity for exporting is lower. Under pattern A, the exporter with the lowest productivity is also an offshorer, meaning this firm would not have made positive profit from exporting if offshoring was not feasible. This indicates that offshoring lowered the export cutoff productivity under pattern A: $z_x^A < z_x^0$. Under pattern C, the exporter with productivity z_x^C is a home producer, and its relative price is higher in the offshoring equilibrium. Therefore, z_x^C must be higher than z_x^0. Pattern B is the intermediate case, and the sign of the change in the export cutoff productivity is ambiguous.

Firm-level Operational Responses to Offshoring under Pattern A

In this section, we briefly discuss how different firms respond to offshoring in more detail by presenting the case under pattern A. Figure 6 depicts the cutoff productivities of both the initial and offshoring equilibria. These cutoff productivities divide firms into five groups - (A.b) through (A.f). The firms that fall in the range of (A.a) exit in both equilibria; therefore, they are not relevant for the analysis. The firms in group (A.b) are forced to exit due to the *Cleansing Effect*. Shutdown of these firms generates pure job destruction. The firms in group (A.c) survive as *Home Producers*, but a rise in their relative prices results in layoffs.

The firms in group (A.d) are the firms that switch from being non-exporting home producers to non-exporting offshorers. We call these firms *New Offshorers*. The change in the assembly location involves job destruction; however, the rise in demand from the price reduction generates new service jobs at home. The firms in group (A.e) are *New Exporters* switching from being non-exporting home producers to exporting offshorers. The initiation of export operation brings these firms a whole new market, and this market expansion generates a large pure job creation. In their domestic operations, there is job destruction as well as job creation, as for new offshorers. The firms in group (A.f) are *Existing Exporters*, switching from being exporting home producers to exporting offshorers. They generate both job destruction and creation, but the larger benefits in export operation is likely to bring about a larger job creation compared to *New Offshorers*.

Distributional Assumption

Under a certain functional assumption for the productivity distribution, G(z), we can derive more practical implications. For the rest of the paper, we assume that the productivity draws follow a Pareto Distribution[14] where the CDF is $G(z) = 1 - \left(\frac{z_{min}}{z}\right)^{\eta}$. z_{min} is the minimum value of z, and η is the shape parameter that determines the dispersion of productivity draws. Large η implies a low dispersion; that is, large mass is concentrated at the low productivity, which makes drawing a high productivity less likely. For this reason, the shape parameter is crucial in determining the overall productivity level of an industry and the cutoff productivities in equilibria. We assume $\eta > \varepsilon - 1$, which is required for the average productivity to be finite.

Under the Pareto distribution, the probabilities of offshoring and exporting can be written in a very simple foarm. For example, the probability of exporting in the initial equilibrium is simply $\left(z_{hp}^0 / z_x^0\right)^{\eta}$. Then, Lemmas 1 and 2 have direct implications on the composition of the market. They show that both the fractions of offshorers and exporters among domestic firms are the largest under pattern A. This confirms that offshoring promotes exporting.

Under this distributional assumption, $k(\hat{z})$ is a constant that is independent of $\hat{z}$; $k = \frac{\varepsilon-1}{\eta-\varepsilon+1}$.

Since $\eta > \varepsilon - 1$, k is positive. Using the Pareto distribution and k, we can rewrite equilibrium conditions for the initial open economy equilibrium and the offshoring equilibrium A.

$$\text{Initial equilibrium:} \quad kf + \left(\frac{z_{hp}^0}{z_x^0}\right)^\eta kf_x = \frac{\xi f_e}{1 - G(z_{hp}^0)} \tag{6}$$

$$\text{Offshoring equilibrium A:} \quad kf + \left(\frac{z_{hp}^A}{z_{os}^A}\right)^\eta kf_{os} + \left(\frac{z_{hp}^A}{z_x^A}\right)^\eta kf_x = \frac{\xi f_e}{1 - G(z_{hp}^A)} \tag{7}$$

Equilibrium conditions for patterns B and C can be obtained in a similar manner.

The rank of the entry cutoff productivities shown by Proposition 1 together with the change in the export cutoff productivities discussed in the previous section has a direct implication on the number of varieties in each equilibrium. Let M_d and M_t denote the number of domestic varieties and total available varieties including imported ones in each equilibrium. The following propositions summarize the impact of offshoring on product varieties.

Proposition 3 *The number of domestic varieties decreases as offshoring becomes feasible. The decrease in variety is the largest where fixed offshoring cost (f_{os}) is the smallest (pattern A).*

$$M_d^A < M_d^B < M_d^C < M_d^0$$

Proposition 4 Offshoring Reduces Variety: *The total number of varieties available to consumers decreases as offshoring becomes feasible.*

$$max\{\ M_t^A, M_t^B, M_t^C\ \} < M_t^0$$

Proposition 3 implies, first, that the number of domestic varieties decreases with offshoring, and second, that the decrease in domestic varieties gets larger as offshoring intensifies. This is due to the cleansing effect. As shown in Proposition 1, the magnitude of the cleansing effect is large where offshoring is relatively easy to undertake; therefore, more domestic firms are driven out of the market under pattern A. Unlike domestic varieties, the number of imported varieties does not uniformly increase or decrease. The pattern of increase/decrease resembles that of export cutoff productivities.

Proposition 4 states that the total number of varieties in one market falls unambiguously as offshoring becomes feasible. This is rather surprising because the increase in product variety is often regarded as one of the most important gains from international trade. This reduction in total variety is also a result of the cleansing effect. Especially under pattern A, the number of imported varieties rises; but the decrease in domestic product variety due to the cleansing effect dominates, resulting in a net decrease in total product variety. Since death of firms causes massive job destruction, the changes in product varieties summarized by Propositions 3 and 4 have important implications for the employment effect of offshoring.

Employment

Total employment of an industry consists of production employment by active firms and the investment made by new entrants. The production employment consists of assembly, services and fixed-cost workers. Here, we present the initial open-economy equilibrium and the offshoring equilibrium pattern A. Employment analysis under patterns B and C resembles that of pattern A.

In the initial open-economy equilibrium, M_d^0 firms serve domestic markets and M_x^0 firms export in addition to their domestic operation. Each period, M_e^0 firms make an attempt at entry. In the steady state, number of successful entries each period must be equal to the number of firm deaths; that is $\left[1 - G(z_{hp}^0)\right] M_e^0 = \xi M_d^0$. The total employment in the initial equilibrium, denoted as Emp^0, is sum of prodution workers and entry investment workers. To simplify further, we assume that the total labor compensation is equal to the total expenditure in this industry. We know that Emp^0 is equal R because the wage rate is 1. Then, Emp^0 can be derived from equations (1) and (6) as the following:

$$Emp^0 \;=\; \varepsilon M_d^0 \,(k+1) f \left[1 + \left(\frac{z_{hp}^0}{z_x^0}\right)^{\eta} \frac{f_x}{f}\right] \tag{8}$$

Various operations by different firms in the offshoring equilibrium can be divided into three categories — home producers' domestic operation, offshorers' domestic operation, and offshorers' export operation. There are M_{hp}^A home producers. Their domestic employment includes the fixed-cost employment and both assembly and services workers. M_{os}^A firms offshore and serve the domestic market. Among these firms, M_x^A also serve the foreign market. Their assembly segment is performed in the South, and their home employment only includes service workers and fixed-cost workers.

There are M_e^A new entrants every period with employment f_e. The total employment in this industry, denoted as Emp^A, is then, using equations (1) and (7), as the following:

$$Emp^A = R\left(\frac{\varepsilon-1}{\varepsilon}\right)\frac{M_d^A}{M_d^0}\left\{\frac{1+\left[\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z_{os}^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta}+\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}\left(\frac{z_x^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta}}{1+\tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}}\right\}$$
$$+(k+1)M_d^A f\left[1+\left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z_{hp}^A}{z_x^A}\right)^{\eta}\frac{f_x}{f}\right] \quad (9)$$

Employment Effect of Offshoring We summarize the employment effect of offshoring as the ratio of total employment in the offshoring equilibrium to that of initial equilibrium:

$$\frac{Emp^A}{Emp^0}=\left(\frac{\varepsilon-1}{\varepsilon}\right)\left(\frac{z_{hp}^0}{z_{hp}^A}\right)^{\eta}\left\{\frac{1+\left[\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z_{os}^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta}+\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}\left(\frac{z_x^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta}}{1+\tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}}\right\}+\frac{1}{\varepsilon} \quad (10)$$

The last term, $\frac{1}{\varepsilon}$, represents the employment for fixed costs and the entry investment. This implies that the number of workers hired for these costs is constant at $\frac{R}{\varepsilon}$ which is the markup portion of the total revenue in this industry. This is due to the assumption that the total expenditure in one industry is equal to the total labor compensation.

The first term, $\left(\frac{\varepsilon-1}{\varepsilon}\right)$, indicates the variable cost portion of employment. The second parenthesis - the ratio between two entry cutoff productivities - represents the cleansing effect, the employment adjustment at the extensive margin. z_{hp}^A being larger than z_{hp}^0 implies that the total employment decreases as the economy moves toward the offshoring equilibrium. The expression in the curly brackets is the comparison of average firm-level employment, the employment adjustment at the intensive margin. Offshoring generates a positive net employment effect only if the employment adjustment at the intensive margin is large enough to more than offset the cleansing effect (the first term excluding $\left(\frac{\varepsilon-1}{\varepsilon}\right)$ is equal to one).

Using equation (10) and the equivalent expressions for patterns B and C, we summarize the employment effect of offshoring in Proposition 5.

Proposition 5 Offshoring Results in Net Job Loss: *Offshoring unambiguously reduces the industry-level employment.*

$$Emp^A \; < \; Emp^B \; < \; Emp^C \; < \; Emp^0$$

Emp^B and Emp^C denote total employment under the offshoring equilibrium patterns B and C. Proposition 5 strongly suggests that offshoring hurts employment at the industry level regardless of the degree of offshoring. Different groups of firms (as seen in Figure 6) destroy and create different amount of jobs under different patterns; but the sum of these employment responses is always negative.

NUMERICAL ANALYSES

Proposition 5 may serve as a supporting argument for the public concern that offshoring destroys U.S. manufacturing jobs. However, the blame from public is concentrated on the offshoring firms. As shown by Proposition 1 and Figure 6, the cleansing effect - exits of uncompetitive non-offshorers - generates pure job destruction which could be the main source of the negative employment effect of offshoring. Offshoring firms, on the other hand, create new jobs as well as destroy some. Whether the net impact for offshorers alone is negative requires further investigation. In this section, we perform numerical analysis to quantify the employment implications of different groups of firms - offshorers, non-offshorers, and the cleansing effect.

Calibration

There are five parameters: transport cost (τ), Southern efficiency wage (δ), employment share of the service segment (γ), elasticity of substitution (ε), and the shape parameter of Pareto distribution (η). λ is simply a combination of δ and γ.

First, τ=1.3 is from Anderson and van Wincoop [2004]. Their estimate of international transport cost is equivalent of a 70% ad valorem tariff rate (τ=1.7). Out of this 70%, 30% is variable cost (physical and time cost of transit, tariffs) and 40% is border-related cost (language, currency, information and security). We take 30% to fit to our variable transport cost and leave the remaining 40% to be captured by the fixed exporting cost. Second, δ=0.5 is chosen from the data on manufacturing wage and productivity of the U.S. (BEA) and Mexico (Instituto Nacional de Estadistica y Geografia, INEGI) for 2000. Third, the 2002 Census of Manufactures reports that the share of non-production workers in U.S. manufacturing employment is 29.6%. We use γ=0.3 which yields λ=0.65. Fourth, Broda and Weinstein [2006] estimate elasticities for different aggregation levels of SITC manufacturing industry classifications (Rev.2 for 1972–1988, Rev.3 for 1990–2001). For the period 1990–2001, 4-digit SITC industries have a median of 2.53 and mean of 5.88. We choose ε=3. Lastly, η=4 is chosen for the shape parameter of Pareto distribution. For this, we match the model's prediction on the market share of imports in the initial open economy equilibrium to the 1992 U.S. manufacturing industry. According to BEA's report, imports accounted for 18.08% of the U.S. manufacturing market in 1992. The model's prediction gives us a range of imports' market share for different fixed export costs rather than a single value. The range that fits to 18.08% is generated by η=4.

Net Employment Effect

Figure 7 shows the net employment change as a share of total initial employment. Panel (a) presents the entire α - β space. Recall that α and β refer to f_x/f and f_{os}/f, respectively. Panel (b) presents the net employment effect for selected values of α. As can be seen by equation (10), fixed and sunk costs portion of employment is a fixed share of total initial employment ($1/\varepsilon$) regardless of equilibrium; so the employment response shown in Figure 7 comes solely from the changes in the numbers of assembly and service workers.

Where fixed offshoring cost is very small, the economy loses up to 36% of its initial employment. The employment response is very sensitive to the size of offshoring cost (β). As β increases, the net employment loss decreases dramatically, although it never becomes positive even with a very large value of β. Where offshoring is very costly, the feasibility alone is not enough to induce many firms to offshore. As a small number of firms offshore, the overall effect of offshoring on the economy is also small, resulting in a smaller net job loss. Different sets of parameter values and fixed costs can be interpreted as different industries. In an industry with low offshoring cost, the feasibility of offshoring can bring about a large-scale employment loss.

[**Figure 7 about here**]

Employment Responses by Different Firm Groups For better understanding of the net employment effect of offshoring, we need to look at it at more disaggregate level. Figure 8 presents the net employment effect of five different groups of firms under pattern A discussed in Figure 6. Panel (a) is the net employment effect for all firms and is identical to Figure 7. Overall, the employment effects of different groups differ drastically in signs and sizes. These diagrams show that analysis of industry-level total employment unintentionally discards valuable information. The most noticeable feature is the negative impact of the cleansing effect. The magnitude is overwhelmingly large compared to other groups' responses. Home producers suffer from employment reduction due to the rise in their relative prices. Panels (d) and (f) show that new offshorers and existing exporters fail to generate a net job gain. New exporters, on the other hand, create more jobs than they destroy as shown in panel (e). This shows that one of the major benefits of offshoring is that it generates export opportunities.

Figure 9 shows the cleansing effect as a share of total net employment effect for selected values of α. It takes up to 70–75% of total net employment loss for small β, and more than 50% for the wide ranges of α and β. The lower bound of this share for all selected values of α is around 45% for $\beta > 20$.

[**Figure 8 about here**]

[**Figure 9 about here**]

Sensitivity Analysis Figure 10 presents the cleansing-effect-induced job destruction as a fraction of total net employment effect for various deviations from the benchmark parameter values. There are two main messages. First, the dominance of the cleansing effect is preserved for various sets of parameter values. The smallest cleansing effect is shown in panel (e) with a large demand elasticity. It still accounts for more than 18% of the total net job loss. Second, where offshoring generates large cost reduction, offshoring firms experience a positive net employment effect. However, the employment reduction from the cleansing effect is even larger, preventing the industry-level employment from increasing above the initial level. This is the case in panel (b) - where productivity distribution is more concentrated on low-prodctivities - and panel (d) - where Southern wage rate is much lower than Northern wage rate.

Figure 10 conveys a lot of information about offshoring. Comparing panels (a) and (b) shows that a larger shape parameter of Pareto distribution (η) makes the cleansing effect larger and more sensitive to β. Because a large mass of firms is concentrated in the low-productivity range, a small change in the entry cutoff productivity generates a large cleansing effect. Panels (c) and (d) present the variations in Southern wage rate, δ. The benefit from a large price reduction to offshorers from lower wage rate in the South is translated to more new jobs at home. With a significantly low value of δ, offshorers generate a net job gain. Where consumers are more price-sensitive as in panel (e), high-productivity firms serve a large market share with large employment in the initial equilibrium. This implies fewer workers are employed by firms in the cleansing effect group, hence, smaller job destruction. Panel (f) shows the effect of a smaller transport cost (τ). A smaller transport cost enlarges the price reduction from offshoring, generating a larger cleansing effect.

[**Figure 10 about here**]

Job Destruction

Firms tend to offshore the most low-skilled and labor-intensive parts of their businesses while the newly created jobs tend to be more high-skilled and service-related. For this reason, the displaced workers are not readily employable in the newly created jobs. In order to reduce the adjustment costs of these workers, the U.S. government offers them various assistance programs such as the Trade Adjustment Assistance program. In order to properly assess the funding and service needs for these programs, it is particularly important to measure the size of job destruction.

Figure 11 presents various decompositions of job destruction. Panel (a) shows total job destruction as a share of initial employment. It reaches up to 59%. Panels (b) and (c) show the job destruction of the cleansing effect and offshorers as a share of total job destruction. Although the cleansing effect is dominant in the net employment effect, layoffs by offshorers account for an even larger fraction of the total displacement. Panel (c) shows that layoffs of offshorers account for more than half of total job destruction where offshoring cost is small. Even for larger values of β, they still account for 40–50% of total job destruction. The cleansing effect accounts for 30–40% of total job destruction as can be seen in panel (b). The fact that offshorers create new jobs does not make their layoffs any less important than job destruction due to the cleansing effect. Rather, the cleansing effect includes both assembly and service workers while offshorers' layoffs hurt only the assembly workers. Where labor is not perfectly mobile between segments, displaced service workers will be more employable while the displacement of the assembly workers is more permanent.

[**Figure 11 about here**]

CONCLUSION

As offshoring becomes feasible, some firms relocate their assembly segment to low-wage countries. Prices fall and competition gets fiercer. As a result, the minimum productivity required to survive in the market rises, forcing a large number of less productive firms out of the market. We call this phenomenon the cleansing effect of offshoring. Offshorers lay off assembly workers, then create new service jobs as their demand rises due to price reduction. Offshoring allows some firms to expand their operations to a foreign market which results in a large job creation. In the meantime, non-offshorers experience a fall in demand due to a rise in their relative prices, so they end up downsizing by laying off workers. At the aggregate level, various employment responses to offshoring together generate a net loss of employment. Offshoring also reduces the number of product varieties available for consumption.

The numerical analysis confirms the theoretical finding that offshoring unambiguously reduces aggregate employment. The net employment loss under the benchmark parameter values, which is calibrated to match various moments of the data, reaches 36% of total employment in the initial traditional trade equilibrium where offshoring is not feasible. This negativity of employment effect stems mostly from the cleansing effect. Such job destruction accounts for 50–75% of the industry-level net employment loss. The sensitivity analysis shows robustness of this result. The numerical analysis also supports the findings in the literature that the net employment effect within offshoring firms is ambiguous. Under the benchmark parameter values, their net effect ranges from 17% net loss to 3% net gain in employment. The separate analysis of job destruction shows that analysis of the net employment effect alone throws away a lot of valuable information. The net employment change of up to 36% of total initial employment is sum of job destruction of up to 59% and creation of up to 23%. Investigation of job destruction shows the significance of offshorers' layoffs. Layoffs by offshorers account for 45–55% of total job destruction under the benchmark parameters while the cleansing effect accounts for 29–42%.

Economists acknowledge that there are winners and losers from international trade, and the same goes for offshoring. The winners in this context are the offshoring firms who enjoy a rise in their profits, and the service workers who enjoy more employment opportunities. The low-skilled workers whose jobs are vulnerable are certainly the losers of this game. To reduce the adjustment costs of the displaced workers, proper unemployment policy tools should be prepared. For correct assessment of funding and service needs for such displaced worker programs, careful measurement of job destruction as well as the net employment adjustment is crucial.

The results of the numerical analysis emphasizes the inadequacy of currently available datasets in evaluating the aggregate labor market dynamics that offshoring brings about. It calls for more detailed and thorough data on the offshoring activities of U.S. firms. The data should cover the entire population of firms in each industry rather than offshoring firms alone. They should also convey the number of layoffs and new hires of production and non-production workers separately. Detailed operational information of offshorers will help us establish a meaningful measure of industry-level offshoring intensities which then can be used to measure the levels of competitive pressure that non-offshorers face.

Notes

1. For an offshoring model with a choice of organizational form, see Antras and Helpman [2004]. They investigate the case where heterogeneous firms make simultaneous decisions of organizational choice (integration or outsourcing) and location choice (home or abroad). Their finding is consistent with the literature in that among the firms with the same organizational choice, higher productivity is linked to foreign production. They also show that more productive firms are more likely to integrate.

2. The terms, assembly and services, are used mainly for convenience rather than indicating particular sets of tasks. The offshored tasks can be any part of a firm's production process.

3. The term 'Cleansing Effect' is first used by Caballero and Hammour [1994]. They use the term to refer to firms'

restructuring strategy that cleans outdated techniques or less profitable products out of their plants during recession when adjustment cost is low.

4. Additionally, we can make our model a simple form of general equilibrium model by adding a homogeneous numeraire sector to clear the labor market and balance the trade between countries. However, this would not change the analysis of the heterogeneous sector.

5. Mitra and Ranjan [2010] focus on the link between offshoring and sectoral unemployment rate under the assumption of perfectly competitive[15] firms and perfect intersectoral mobility. They show that unemployment rates fall and wages rise after offshoring. Sethupathy [2013] allows firm heterogeneity and shows that net employment effect within offshoring firms is ambiguous while wages rise in offshoring firms through profit sharing.

6. The TAA program is specially designed for unemployed workers whose layoffs are caused by import competition and offshoring, with the purpose of helping them get a new job sooner. The TAA services and benefits include various training provisions. For more details on te program description and statistics, see Park [2012]

7. They also show that immigrant workers complement the tasks of U.S. native workers using the American Community Survey.

8. Offshorers in this study are identified by the likelihood of offshoring rather than their actual offshoring activities.

9. Monarch et al. [2014] identify offshoring firms by matching TAA certifications to the U.S. Census of Manufactures. Hummels et al. [2014] uses the usage of imported inputs for identification.

10. More standard setup for offshoring is the usage of imported intermediate inputs. These models assume that all final goods are consumed at home; therefore, it is intuitive to finish production at the location of sales. Our model assumes that the final goods production is done in the South to allow export-platform type of offshoring. It is not rare to finish the production process and meet the demand by shipping directly from the foreign production facilities (e.g. computers, cell phones, apparel, and footwear). Especially the firms that serve foreign market have incentives to produce the final goods in the South. Ramondo, Rappoport, Ruhl [2015] show that the majority of products produced in foreign affiliates are sold in the country of production or shipped to a third country rather than shipped

back home. Unlike other theoretical models of offshoring, firms in our model have an option to serve a foreign market; therefore, carrying out the final production process in a low-cost country is sensible.

11. In order to focus the analysis on the cases with sizeable offshoring activities, we assume $\tau\lambda < 1$ for the rest of the paper.

12. This paper is not the first to find such an effect. Melitz [2003] and Helpman et al [2004] theoretically show that the least productive firms exit as a country opens up for free trade or FDI. Bernard et al [2006] closely investigates the response of U.S. manufacturing plants to the imports from low-wage countries and find that this specific import competition raises probability of plant death significantly. They also find that the rise of the death probability is larger for more labor-intensive plants. More labor-intensive firms in their study are equivalent to the least productive firms in this paper since labor is the only factor of production.

13. It is also worth noting that there has been an increase in the availability of offshoring advisory services which potentially reduces the fixed cost of offshoring further down. These services are provided by consulting firms such as Deloitte, EquaTerra, neoIT, PA consulting group, Pace Harmon, PricewaterhouseCoopers, RampRate, and TPI. (source: Forrester Research, Inc. http://www.forrester.com/Research/Document/Excerpt/0,7211,40655,00.html)

14. used by Helpman, Melitz, and Yeaple [2004], Ghironi and Melitz [2005], Bernard, Redding, and Schott [2007], and many others.

15. The most loved market setup in trade literature is the monopolistic competition with either symmetric or heterogeneous firms. Zhou [2010] discusses the impact of international trade in oligopolistic competition.

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A Appendix. Proofs of Propositions and Lemmas

Proof of Proposition 1

Proof of Lemma 1 According to Figure 15, the entry productivity cutoff for offshoring equilibrium patterns A, B, and C are governed by $\pi_{d,hp}(z) = 0$ because the firm surviving with the lowest productivity is a non-exporting home producer. Using equation (2), we can show the following is true for z_{hp}^A, z_{hp}^B, and z_{hp}^C.

$$\left(P\rho z_{hp}^0\right)^{1-\varepsilon} = \frac{R}{\varepsilon f} \qquad \text{where} \quad Q \in \{A, B, C\} \tag{L.1.1}$$

Figure 5 also shows that determination of the offshoring cutoff productivities as follows:

$$\begin{aligned}
&\text{Eqm Pattern A:} \quad && \pi_{d,hp}\left(z_{os}^A\right) = \pi_{d,os}\left(z_{os}^A\right) \\
&\text{Eqm Pattern B:} \quad && \pi_{d,hp}\left(z_{os}^B\right) = \pi_{d,os}\left(z_{os}^B\right) + \pi_{x,os}\left(z_{os}^B\right) \\
&\text{Eqm Pattern C:} \quad && \pi_{d,hp}\left(z_{os}^C\right) + \pi_{x,hp}\left(z_{os}^C\right) = \pi_{d,oss}\left(z_{os}^C\right) + \pi_{x,os}\left(z_{os}^C\right)
\end{aligned}$$

Using equations (2) and (4) along with equation (L.1.1), we can write the offshoring cutoff productivities for the equilibrium patterns A, B, and C as the following.

$$\begin{aligned}
z_{os}^A &= \left[\frac{1}{(\tau\lambda)^{1-\varepsilon} - 1}\left(\frac{f_{os}}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^A \\
z_{os}^B &= \left[\frac{1}{2(\tau\lambda)^{1-\varepsilon} - 1}\left(\frac{f_{os}}{f} + \frac{f_x}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^B \\
z_{os}^C &= \left[\frac{1}{2(\tau\lambda)^{1-\varepsilon} - 1 - \tau^{1-\varepsilon}}\left(\frac{f_{os}}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^C
\end{aligned} \tag{L.1.2}$$

The sizes of fixed costs differ across patterns. Figure 6 shows the range of α $(= f_x/f)$ And β $(= f_{os}/f)$ that correspond to each pattern. That is,

$$\begin{array}{llcl}
\text{Pattern A:} & (\tau\lambda)^{1-\varepsilon} & \leq \ \beta \ < & \left[1 - (\tau\lambda)^{\varepsilon-1}\right]\alpha \\
\text{Pattern B:} & \left[1 - (\tau\lambda)^{\varepsilon-1}\right]\alpha & \leq \ \beta \ < & \left\{\tau^{\varepsilon-1}\left[2(\tau\lambda)^{1-\varepsilon} - 1\right] - 1\right\}\alpha \\
\text{Pattern C:} & \left\{\tau^{\varepsilon-1}\left[2(\tau\lambda)^{1-\varepsilon} - 1\right] - 1\right\}\alpha & \leq \beta &
\end{array} \tag{L.1.3}$$

Equations (L.1.2) and (L.1.3) together yield the following inequalities.

$$\begin{aligned} 1 &\leq \left(\frac{z_{os}^A}{z_{hp}^A}\right)^{\varepsilon-1} && < (\tau\lambda)^{\varepsilon-1}\alpha \\ (\tau\lambda)^{\varepsilon-1}\alpha &\leq \left(\frac{z_{os}^B}{z_{hp}^B}\right)^{\varepsilon-1} && < \tau^{\varepsilon-1}\alpha \\ \tau^{\varepsilon-1}\alpha &\leq \left(\frac{z_{os}^C}{z_{hp}^C}\right)^{\varepsilon-1} && \end{aligned} \tag{L.1.4}$$

The inequalities (L.1.4) proves *Lemma 1.* **q.e.d.**

Proof of Lemma 2 In the initial equilibrium, all firms are home producers but they can be divided into exporters and non-exporters based on their productivity levels. The entry and exporting cutoff productivities are determined by $\pi_{d,hp}\left(z_{hp}^0\right) = 0$ and $\pi_{x,hp}\left(z_x^0\right) = 0$, respectively. Using equation (2), we obtain the following linear relationship between two cutoff productivities.

$$z_x^0 = \tau \left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} z_{hp}^0 \tag{L.2.1}$$

For offshoring equilibrium patterns, we again refer to Figure 5 to find the cutoff productivities for exporters, z_x^A, z_x^B, and z_x^C, as the following.

$$\begin{aligned} &\text{Eqm Pattern A:} && \pi_{x,os}\left(z_x^A\right) = 0 \\ &\text{Eqm Pattern B:} && \pi_{d,hp}\left(z_x^B\right) = \pi_{d,os}\left(z_x^B\right) + \pi_{x,os}\left(z_x^B\right) \\ &\text{Eqm Pattern C:} && \pi_{x,hp}\left(z_x^C\right) = 0 \end{aligned} \tag{L.2.2}$$

Substituting equations (2) and (4) into equation (L.2.2) along with using equation (L.1.1) yields the similar linear relationship between entry and exporter cutoff productivities as follows:

$$z_x^A = \tau\lambda \left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} z_{hp}^A \tag{L.2.3}$$

$$z_x^B = \left[\frac{1}{2(\tau\lambda)^{1-\varepsilon} - 1}\left(\frac{f_{os}}{f} + \frac{f_x}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^B \tag{L.2.4}$$

$$z_x^C = \tau \left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} z_{hp}^C \tag{L.2.5}$$

Equations (L.1.2) and (L.2.3) show that $z_x^B = z_{os}^B$; therefore, the size of z_x^B/z_{hp}^B, from equation

(L.1.4), has the following range.

$$\tau\lambda\left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} \leq \frac{z_x^B}{z_{hp}^B} < \tau\left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} \tag{L.2.6}$$

Then, equations (L.2.3)–(L.2.6) prove *Lemma 2*. **q.e.d.**

Proof of Proposition 1 The proof of Proposition 1 utilizes the method that is used in Melitz [2003], Appendix B. The equilibrium conditions for the initial equilibrium and the offshoring equilibrium pattern A are presented by equations (3) and (5). The equilibrium conditions for offshoring equilibrium patterns B and C can be written identically to equation (5) with $(z_{hp}^B, z_x^B, z_{os}^B)$ and $(z_{hp}^C, z_x^C, z_{os}^C)$ in place of $(z_{hp}^A, z_x^A, z_{os}^A)$, respectively.

I define the following expression for simplicity.

$$j(x) = [1 - G(x)]\, k(x) \tag{A.1.1}$$

$G(x)$ is the cumulative distribution function of the Pareto distribution and $k(x)$ is defined in equation (3). Therefore, we know that $j(x)$ is nonnegative and decreasing in x. Using equation (A.1.1), we can rewrite the equilibrium conditions of the initial open-economy equilibrium and offshoring equilibrium patterns A, B, and C as the following:

$$j(z_{hp}^0)f + j(z_x^0)f_x = \xi f_e \tag{A.1.2}$$
$$j(z_{hp}^A)f + j(z_{os}^A)f_{os} + j(z_x^A)f_x = \xi f_e \tag{A.1.3}$$
$$j(z_{hp}^B)f + j(z_{os}^B)f_{os} + j(z_x^B)f_x = \xi f_e \tag{A.1.4}$$
$$j(z_{hp}^C)f + j(z_{os}^C)f_{os} + j(z_x^C)f_x = \xi f_e \tag{A.1.5}$$

Equations (L.1.2) and (L.2.3) show that all cutoff productivities for exporting and offshoring are linear functions of their corresponding entry cutoff productivities. Therefore, the left-hand sides of equations (A.1.2)–(A.1.5) are decreasing in their entry cutoff productivities, $z_{hp}^0, z_{hp}^A, z_{hp}^B, z_{hp}^C$, respectively.

Suppose that four entry cutoffs, $z_{hp}^0, z_{hp}^A, z_{hp}^B$, and z_{hp}^C, are all equal. Then, from *Lemmas* 1 and 2, the following is true.

$$z_{os}^A < z_{os}^B < z_{os}^C \qquad \text{and} \qquad z_x^A < z_x^B < z_x^C = z_x^0$$

We know that $j(x)$ is decreasing in x, so the left-hand side of equation (A.1.3) is the largest, followed by (A.1.4) and (A.1.5). The left-hand side of equation (A.1.2) is the smallest. This is *contradiction* because the right-hand sides of four equations are equal. For this reason, the following must be true.

$$z_{hp}^0 < z_{hp}^C < z_{hp}^B < z_{hp}^A$$

This proves *Proposition 1.* **q.e.d.**

Proof of Proposition 2

Suppose the offshoring cutoff productivities are the same under the offshoring equilibrium patterns A, B, and C. This implies, from figure 5, the following:

$$z_x^A < z_x^B < z_x^C \tag{A.2.1}$$

This, together with Proposition 1 yields the following three rankings.

$$\begin{aligned} j(z_{hp}^A) &< j(z_{hp}^B) < j(z_{hp}^C) \\ j(z_{os}^A) &= j(z_{os}^B) = j(z_{os}^C) \qquad \text{where } j(x) = [1 - G(x)]\, k(x) \\ j(z_x^A) &< j(z_x^B) < j(z_x^C) \end{aligned}$$

These rankings imply that the left-hand side of equation (A.1.3) is smaller than that of equation (A.1.4), which in turn is smaller than that of equation (A.1.5). This is a contradiction since the right-hand sides of equations (A.1.3)–(A.1.5) are the same. In order to equalize the left-hand sides of equations (A.1.3)–(A.1.5), it must be that

$$z_{os}^A < z_{os}^B < z_{os}^C$$ **q.e.d.**

Proof of Proposition 3

Under the Pareto distribution, average revenue for an active firm in the initial equilibrium is

$$\bar{r}^0 = \varepsilon \left[\bar{\pi}^0 + f + \left(\frac{z_{hp}^0}{z_x^0} \right)^\eta f_x \right] \tag{A.3.1}$$

Total revenue is fixed at R; therefore, equations (A.3.1) and (6) provide the number of domestic firms in the initial equilibrium as follows

$$M_d^0 = \frac{R}{\bar{r}^0} = \frac{R}{\varepsilon(k+1)f \left[1 + \left(\frac{z_{hp}^0}{z_x^0} \right)^\eta \frac{f_x}{f} \right]} \tag{A.3.2}$$

We can obtain equivalent expressions for offshoring equilibrium patterns A, B, and C. It requires using the equilibrium conditions such as equation (7) for the pattern A. The conditions for the patterns B and C re identical to equation (7) if the superscript A is replaced with B and C, respectively. Using equations (A.3.1) and (7) yields the number of domestic firms in the pattern A as the following.

$$M_d^A = \frac{R}{\bar{r}^A} = \frac{R}{\varepsilon(k+1)f\left[1+\left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z_{hp}^A}{z_x^A}\right)^{\eta}\frac{f_x}{f}\right]} \tag{A.3.3}$$

The numbers of domestic firms in the offshoring equilibrium patterns B and C are identifical to equation (A.3.3). Then, I obtain various relative numbers of domestic firms as follows.

$$\frac{M_d^A}{M_d^B} = \frac{1+\left(\frac{z_{hp}^B}{z_{os}^B}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z_{hp}^B}{z_x^B}\right)^{\eta}\frac{f_x}{f}}{1+\left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z_{hp}^A}{z_x^A}\right)^{\eta}\frac{f_x}{f}} \tag{A.3.4}$$

$$\frac{M_d^B}{M_d^C} = \frac{1+\left(\frac{z_{hp}^C}{z_{os}^C}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z_{hp}^C}{z_x^C}\right)^{\eta}\frac{f_x}{f}}{1+\left(\frac{z_{hp}^B}{z_{os}^B}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z_{hp}^B}{z_x^B}\right)^{\eta}\frac{f_x}{f}} \tag{A.3.5}$$

$$\frac{M_d^C}{M_d^0} = \frac{1+\left(\frac{z_{hp}^0}{z_x^0}\right)^{\eta}\frac{f_x}{f}}{1+\left(\frac{z_{hp}^C}{z_{os}^C}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z_{hp}^C}{z_x^C}\right)^{\eta}\frac{f_x}{f}} \tag{A.3.6}$$

Using *Lemmas* 1 and 2, I can show that equations (A.3.4) - (A.3.6) are less than 1, which proves *Proposition 3*. **q.e.d.**

Proof of Proposition 4

For the proof, I compare total number of available varieties of each offshoring equilibrium pattern, M_t^A, M_t^B, M_t^C, to that of the initial equilibrium. First, let us look at the offshoring equilibrium pattern A.

(a) Proof of $M_t^A < M_t^0$

The average productivity of operating firms in the offshoring equilibrium pattern A, $\tilde{z}_t^A$, is defined as the following:

$$\tilde{z}_t^A = \left\{\frac{1}{M_t^A}\left[M_{hp}^A \tilde{z}_{hp}^{A\varepsilon-1} + M_{os}^A\left(\frac{\tilde{z}(z_{os}^A)}{\tau\lambda}\right)^{\varepsilon-1} + M_x^A\left(\frac{\tilde{z}(z_x^A)}{\tau\lambda}\right)^{\varepsilon-1}\right]\right\}^{\frac{1}{\varepsilon-1}} \tag{A.4.1}$$

where $\tilde{z}(x)$ is the average productivity of all firms with productivity x or higher which can be written as

$$\tilde{z}(x) = \left[\frac{1}{1-G(x)} \int_x^{\infty} z^{\varepsilon-1} g(z) dz\right]^{\frac{1}{\varepsilon-1}}$$

$\tilde{z}^A_{hp}$ refers to the average productivity of home producers' varieties and is shown in the text to be

$$\left[\frac{M^A_d}{M^A_{hp}} \tilde{z}(z^A_{hp})^{\varepsilon-1} - \frac{M^A os}{M^A_{hp}} \tilde{z}(z^A_{os})^{\varepsilon-1}\right]^{\frac{1}{\varepsilon-1}} \tag{A.4.2}$$

Combining equations (A.4.1) and (A.4.2) yields the following expression.

$$\begin{aligned}\left(\frac{\tilde{z}^A_t}{z^A_{hp}}\right)^{\varepsilon-1} &= \frac{M^A_d}{M^A_t}\left(\frac{\tilde{z}(z^A_{hp})}{z^A_{hp}}\right)^{\varepsilon-1} + \frac{M^A_{os}}{M^A_t}\left[(\tau\lambda)^{1-\varepsilon} - 1\right]\left(\frac{\tilde{z}(z^A_{os})}{z^A_{os}}\right)^{\varepsilon-1}\left(\frac{z^A_{os}}{z^A_{hp}}\right)^{\varepsilon-1} \\ &+ \frac{M^A_x}{M^A_t}\left(\frac{\tilde{z}(z^A_x)}{z^A_x}\right)^{\varepsilon-1}\left(\frac{z^A_x}{z^A_{hp}}\right)^{\varepsilon-1}\end{aligned} \tag{A.4.3}$$

To simplify equation (A.4.3), I use equation (3) and the fact that $k(z) = k$ under the Pareto distribution. We also utilize the cutoff productivities of offshoring, z^A_{os}, and exporting, z^A_x, written as a linear function of the entry cutoff productivity, z^A_{hp}, taht are as follows.

$$\begin{aligned} z^A_{os} &= \left[\frac{1}{(\tau\lambda)^{1-\varepsilon} - 1}\left(\frac{f_{os}}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z^A_{hp} \\ z^A_x &= \tau\lambda\left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} z^A_{hp}\end{aligned} \tag{A.4.4}$$

Now we can rewrite the equation (A.4.3) as follows.

$$\left(\frac{\tilde{z}^A_t}{z^A_{hp}}\right)^{\varepsilon-1} = (k+1)\left[\frac{M^A_d}{M^A_t} + \frac{M^A_x}{M^A_t}\left(\frac{f_x}{f}\right) + \frac{M^A_{os}}{M^A_t}\left(\frac{f_{os}}{f}\right)\right] \tag{A.4.5}$$

By the same methodology, we can obtain the equivalent expression for the initial open economy equilibrium.

$$\left(\frac{\tilde{z}^0_t}{z^0_{hp}}\right)^{\varepsilon-1} = (k+1)\left[\frac{M^0_d}{M^0_t} + \frac{M^0_x}{M^0_t}\left(\frac{f_x}{f}\right)\right] \tag{A.4.6}$$

Recall $M^0_t = M^0_d + M^0_x$ and $M^A_t = M^A_d + M^A_x$. Then, the term in the square bracket of equation (A.4.6) is a weighted average of 1 and $\frac{f_x}{f}$. Equivalently, the first two terms in the square bracket of equation (A.4.5) is also a weighted average of 1 and $\frac{f_x}{f}$. Again, recall that the outsourcing equilibrium pattern A corresponds to equilibrium b in figure 6. According to table 1, equilibrium b is obtained where $f_x > f + f_{os}$. Thatx is, $\frac{f_x}{f} > 1$.

According to lemma 2, the fraction of exporters among domestic firms is larger in the outsourcing equilibrium pattern A than in the initial open economy equilibrium. This implies the following.

$$\frac{M_t^A}{M_t^A} > \frac{M_x^0}{M_t^0} \tag{A.4.7}$$

Equation (A.4.7) and the fact that $\frac{f_x}{f} > 1$ proves that the first two terms in the square bracket of equation (A.4.5) is larger than the terms in the square bracket of equation (A.4.6), hence

$$\left(\frac{\tilde{z}_t^A}{z_{hp}^A}\right)^{\varepsilon-1} > \left(\frac{\tilde{z}_t^0}{z_{hp}^0}\right)^{\varepsilon-1} \tag{A.4.8}$$

The total revenue available in the initial equilibrium, R, is a sum of revenues of all sruviving firms including some serving foreign markets. The average productivities of all firms that serve the domestic market and the ones that serve the foreign market and can be written as $\tilde{z}(z_{hp}^0)$ and $\tilde{z}(z_x^0)$. Then the total reveue in the market can be written as the following.

$$R = M_d^0 R \left[P\rho\tilde{z}(z_{hp}^0)\right]^{\varepsilon-1} + M_x^0 R \left[\frac{P\rho\tilde{z}(z_x^0)}{\tau}\right]^{\varepsilon-1} \tag{A.4.9}$$

Dividing equation (A.4.9) yields the following expression.

$$\frac{R}{M_t^0} = R(P\rho)^{\varepsilon-1}\left[\frac{M_d^0}{M_t^0}\tilde{z}(z_{hp}^0)^{\varepsilon-1} + \frac{M_x^0}{M_t^0}\left(\frac{\tilde{z}(z_x^0)}{\tau}\right)^{\varepsilon-1}\right] \tag{A.4.10}$$

The expression in the square bracket of equation (A.4.10) is simply $\tilde{z}_t^{0\ \varepsilon-1}$, where $\tilde{z}_t^0$ is the average productivity of all operating firms in the initial equilibrium. So we have

$$(P\rho\tilde{z}_t^0)^{\varepsilon-1} M_t^0 = 1 \tag{A.4.11}$$

The entry cutoff productivity of the initial equilibrium, z_{hp}^0, is simply the zero profit productivity of the firm that only servces the domestic market; that is, equation (2) is zero, hence $(P\rho z_{hp}^0)^{\varepsilon-1} = \frac{\varepsilon f}{R}$. We rewrite equation (A.4.11) as the following.

$$\left(\frac{\tilde{z}_t^0}{z_{hp}^0}\right)^{\varepsilon-1} = \frac{R}{\varepsilon f M_t^0} \tag{A.4.12}$$

The identical expression for the offshoring equilibrium pattern A, $\left(\frac{\tilde{z}_t^A}{z_{hp}^A}\right)^{\varepsilon-1} = \frac{R}{\varepsilon f M_t^A}$, can be obtained in the same manner. We rewrite the inequality (A.4.8) using equation (A.4.12) as $\frac{R}{\varepsilon f M_t^A} \geq \frac{R}{\varepsilon f M_t^0}$, therefore $M_t^0 \geq M_t^A$. **q.e.d.**

(b) Proof of $M_t^B < M_t^0$ and $M_t^C < M_t^0$

The equivalent expressions for equation (A.4.5) for the outsourcing equilibrium patterns B and C are as follow.

$$\left(\frac{\tilde{z}_t^B}{z_{hp}^B}\right)^{\varepsilon-1} = (k+1)\left[\frac{M_d^B}{M_t^B} + \frac{M_x^B}{M_t^B}\left(\frac{f_x}{f}\right) + \frac{M_{os}^B}{M_t^B}\left(\frac{f_{os}}{f}\right)\right] \tag{A.4.13}$$

$$\left(\frac{\tilde{z}_t^C}{z_{hp}^C}\right)^{\varepsilon-1} = (k+1)\left[\frac{M_d^C}{M_t^C} + \frac{M_x^C}{M_t^C}\left(\frac{f_x}{f}\right) + \frac{M_{os}^C}{M_t^C}\left(\frac{f_{os}}{f}\right)\right] \tag{A.4.14}$$

The first two terms in the square brackets of both equations are also weighed average of 1 and $\frac{f_x}{f}$. We know that $\frac{f_x}{f}$ is always larger than 1 in the relevant parameter space shown in Figure 6. Also, lemma 2 implies that $\frac{M_x^B}{M_t^B} > \frac{M_x^0}{M_t^0}$ and $\frac{M_x^C}{M_t^C} > \frac{M_x^0}{M_t^0}$. So, the following must be true.

$$\left(\frac{\tilde{z}_t^B}{z_{hp}^B}\right)^{\varepsilon-1} > \left(\frac{\tilde{z}_t^0}{z_{hp}^0}\right)^{\varepsilon-1} \quad \text{and} \quad \left(\frac{\tilde{z}_t^C}{z_{hp}^C}\right)^{\varepsilon-1} > \left(\frac{\tilde{z}_t^0}{z_{hp}^0}\right)^{\varepsilon-1} \tag{A.4.15}$$

Using the equivalent expressions of equation (A.4.12) for the patterns B and C, equation (A.4.15) implies the following inequalities.

$$\frac{R}{\varepsilon f M_t^B} > \frac{R}{\varepsilon f M_t^0} \quad \text{and} \quad \frac{R}{\varepsilon f M_t^C} > \frac{R}{\varepsilon f M_t^0}$$

Therefore, it must be that $M_t^B < M_t^0$ and $M_t^C < M_t^0$. **q.e.d.**

Proof of Proposition 5

We can obtain total employment as a share of total initial employment in the outsourcing equilibrium patterns B and C using the same methodology used to drive equation (10); and they are as follows.

$$\frac{Emp^B}{Emp^0} = \left(\frac{\varepsilon-1}{\varepsilon}\right)\left(\frac{z_{hp}^0}{z_{hp}^B}\right)^{\eta}\left\{\frac{1+\left[\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z_{os}^B}{z_{hp}^B}\right)^{\varepsilon-1-\eta}}{1+\tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}}\right\}+\frac{1}{\varepsilon} \tag{A.5.1}$$

$$\frac{Emp^C}{Emp^0} = \left(\frac{\varepsilon-1}{\varepsilon}\right)\left(\frac{z_{hp}^0}{z_{hp}^C}\right)^{\eta}\left\{\frac{1+\left[\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1-\tau^{1-\varepsilon}\right]\left(\frac{z_{os}^C}{z_{hp}^C}\right)^{\varepsilon-1-\eta}+\tau^{1-\varepsilon}\left(\frac{z_x^C}{z_{hp}^C}\right)^{\varepsilon-1-\eta}}{1+\tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}}\right\}+\frac{1}{\varepsilon} \tag{A.5.2}$$

In order to prove Proposition 5, I first prove $Emp^A < Emp^B$, then $Emp^B < Emp^C$, and finally $Emp^C < Emp^0$.

(a) Proof of $Emp^A < Emp^B$

Let us suppose that $Emp^B < Emp^A$, then the following must be true.

$$\frac{Emp^B}{Emp^0} < \frac{Emp^A}{Emp^0} \tag{A.5.3}$$

Using equations (10) and (A.5.1), we know that inequality (A.5.3) is satisfied if and only if the following inequality is satisfied.

$$\left(\frac{z_{hp}^A}{z_{hp}^B}\right)^{\eta} < \frac{1+\left[\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z_{os}^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta}+\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}\left(\frac{z_x^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta}}{1+\left[\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z_{os}^B}{z_{hp}^B}\right)^{\varepsilon-1-\eta}} \tag{A.5.4}$$

Using equations (A.4.4) and (L.1.2), the right-hand side of inequality (A.5.4) can be re-written as the following.

$$\frac{1+\frac{\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1}{(\tau\lambda)^{1-\varepsilon}-1}\left(\frac{f_{os}}{f}\right)\left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta}+\frac{\gamma}{\lambda}\left(\frac{f_x}{f}\right)\left(\frac{z_{hp}^A}{z_x^A}\right)^{\eta}}{1+\frac{2\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1}{2(\tau\lambda)^{1-\varepsilon}-1}\left(\frac{f_{os}}{f}+\frac{f_x}{f}\right)\left(\frac{z_{hp}^B}{z_{os}^B}\right)^{\eta}} \tag{A.5.5}$$

The left-hand side of inequality (A.5.4) can also be re-written using the equilibrium conditions for the offshoring equilibrium patterns A and B (equation (7) and the equivalent expression for the pattern B) along with the CDF of the Pareto distribution.

$$\frac{1+\left(\frac{f_{os}}{f}\right)\left(\frac{z^A_{hp}}{z^A_{os}}\right)^{\eta}+\left(\frac{f_x}{f}\right)\left(\frac{z^A_{hp}}{z^A_x}\right)^{\eta}}{1+\left(\frac{f_{os}}{f}+\frac{f_x}{f}\right)\left(\frac{z^B_{hp}}{z^B_{os}}\right)^{\eta}} \tag{A.5.6}$$

From equations (A.5.5) and (A.5.6), we know that inequality (A.5.4) holds as long as γ is larger than λ. However, λ is larger than γ by definition ($\lambda = (1-\gamma)\delta + \gamma$), this is a contradiction. Therefore, Emp^A must be smaller than Emp^B. **q.e.d.**

(b) Proof of $Emp^B < Emp^C$

I follow the same procedure as in the proof of $Emp^A < Emp^B$. First, let us suppose that $Emp^B > Emp^C$; that is,

$$\frac{Emp^C}{Emp^0} < \frac{Emp^B}{Emp^0} \tag{A.5.7}$$

From equations (A.5.1) and (A.5.2), we know that inequality (A.5.7) holds if the following inequality is satisfied.

$$\left(\frac{z^B_{hp}}{z^C_{hp}}\right)^{\eta} < \frac{1+\left[\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z^B_{os}}{z^B_{hp}}\right)^{\varepsilon-1-\eta}}{1+\left[\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1-\tau^{1-\varepsilon}\right]\left(\frac{z^C_{os}}{z^C_{hp}}\right)^{\varepsilon-1-\eta}+\tau^{1-\varepsilon}\left(\frac{z^C_{x}}{z^C_{hp}}\right)^{\varepsilon-1-\eta}} \tag{A.5.8}$$

We can rewrite both left-hand side - using the equilibrium conditions for the offhoring equilibrium patterns B and C that are equivalent to equation (7) - and right-hand side - using equations (L.1.2) and (L.2.5), so that we obtain alternative expression for inequality (A.5.8) as the following.

$$\frac{1+\left(\frac{f_{os}}{f}+\frac{f_x}{f}\right)\left(\frac{z^B_{hp}}{z^B_{os}}\right)^{\eta}}{1+\left(\frac{f_{os}}{f}\right)\left(\frac{z^C_{hp}}{z^C_{os}}\right)^{\eta}+\left(\frac{f_x}{f}\right)\left(\frac{z^C_{hp}}{z^C_x}\right)^{\eta}} < \frac{1+\frac{\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1}{(\tau\lambda)^{1-\varepsilon}-1}\left(\frac{f_{os}}{f}+\frac{f_x}{f}\right)\left(\frac{z^B_{hp}}{z^B_{os}}\right)^{\eta}}{1+\frac{\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1-\tau^{1-\varepsilon}}{2(\tau\lambda)^{1-\varepsilon}-1-\tau^{1-\varepsilon}}\left(\frac{f_{os}}{f}\right)\left(\frac{z^C_{hp}}{z^C_{os}}\right)^{\eta}+\left(\frac{f_x}{f}\right)\left(\frac{z^C_{hp}}{z^C_x}\right)^{\eta}} \tag{A.5.9}$$

Again, γ is always smaller than λ. Therefore, inequality (A.5.9) can not hold; rather, the opposite is true. Therefore, Emp^B must be smaller than Emp^C. **q.e.d.**

(c) Proof of $Emp^C < Emp^0$

Suppose $Emp^C > Emp^0$; then, equation (A.5.2) must be larger than 1. Notice that equation (A.5.2) is a weighted average of 1 and the following.

$$\left(\frac{z_{hp}^0}{z_{hp}^C}\right)^\eta \left\{\frac{1+\left[\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1-\tau^{1-\varepsilon}\right]\left(\frac{z_{os}^C}{z_{hp}^C}\right)^{\varepsilon-1-\eta}+\tau^{1-\varepsilon}\left(\frac{z_x^C}{z_{hp}^C}\right)^{\varepsilon-1-\eta}}{1+\tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}}\right\} \tag{A.5.10}$$

Therefore, $Emp^C > Emp^0$ requires that equation (A.5.10) is larger than 1. Using equations (6), (7), (L.1.2), (L.2.5), and the relationship between the cutoff productivities for entry and exporting in the initial equilibrium, $z_x^0 = \tau\left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} z_{hp}^0$, I can rewrite equation (A.5.10) so that $Emp^C > Emp^0$ requires the following inequality to hold.

$$\frac{1+\left[\frac{\frac{2\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1-\tau^{1-\varepsilon}}{2(\tau\lambda)^{1-\varepsilon}-1\tau^{1-\varepsilon}}\right]\frac{f_{os}}{f}\left(\frac{z_{hp}^C}{z_{os}^C}\right)^\eta+\frac{f_x}{f}\left(\frac{z_{hp}^C}{z_x^C}\right)^\eta}{1+\frac{f_x}{f}\left(\frac{z_{hp}^0}{z_x^0}\right)^\eta} > \frac{1+\frac{f_{os}}{f}\left(\frac{z_{hp}^C}{z_{os}^C}\right)^\eta+\frac{f_x}{f}\left(\frac{z_{hp}^C}{z_x^C}\right)^\eta}{1+\frac{f_x}{f}\left(\frac{z_{hp}^0}{z_x^0}\right)^\eta} \tag{A.5.11}$$

This can be simplified to $\gamma > \lambda$, which is a contradiction. Therefore, Emp^C must be smaller than Emp^0. **q.e.d**

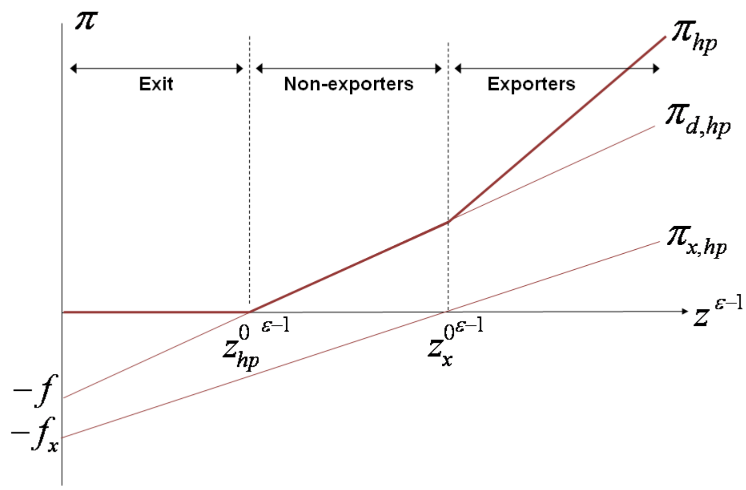


Figure 1: Open Economy Equilibrium

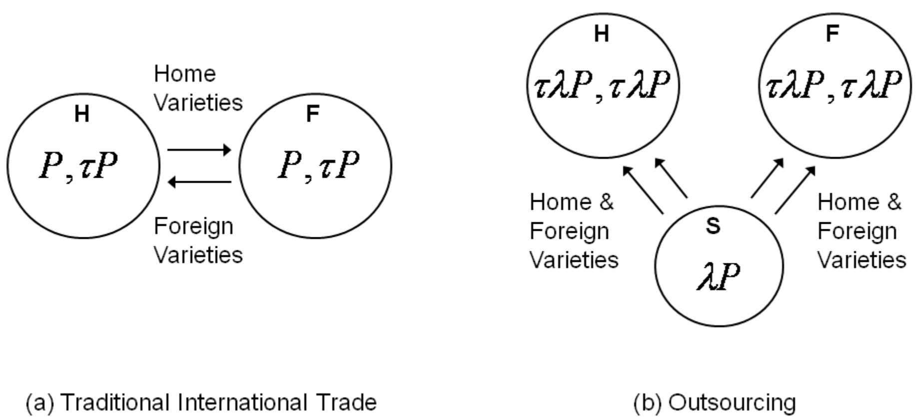
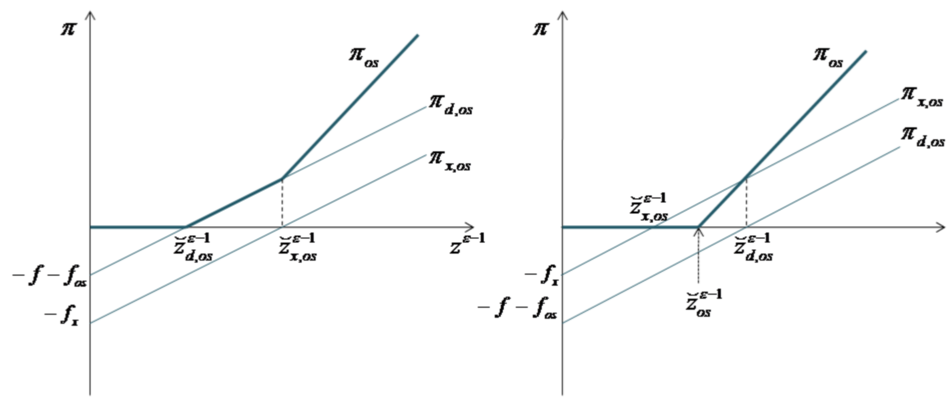


Figure 2: Transportation Structure

*The arrows indicate the direction of final product shipment.
*The first value in each country's border is the price of a local variety. The second value is the price of a foreign variety produced with the same productivity, z.



$f_x > f + f_{os}$ $\qquad\qquad$ $f_x \leq f + f_{os}$

Figure 3: Total Profit Functions of Offshorers

*Subscript os refers to an offshorer.
* Subscript d refers to a firm that only serves the domestic market.
*Subscript x refers to an exporter.

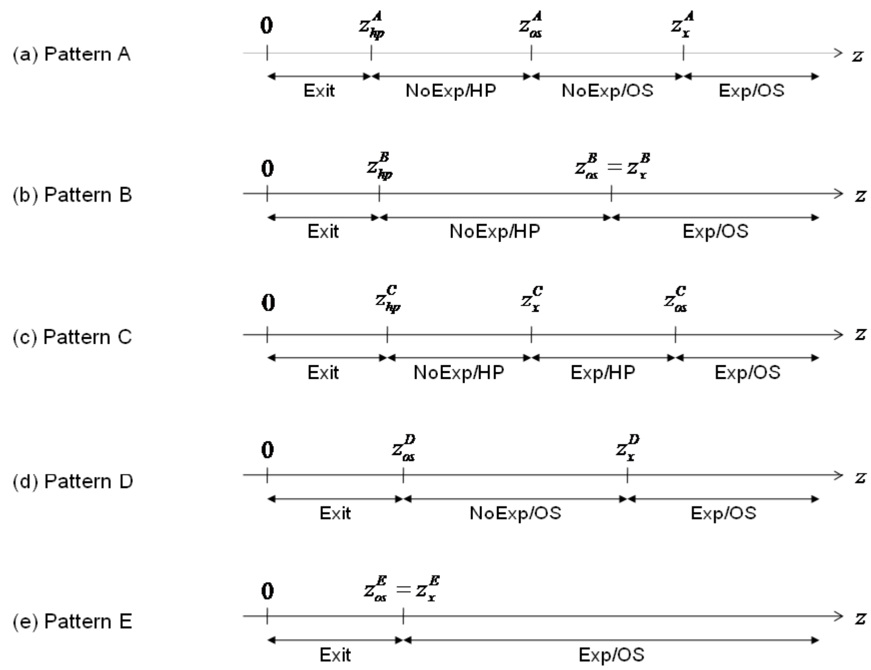


Figure 4: Various Patterns of Offshoring in Offshoring Equilibria

*All z_s are the cutoff productivities.
* z_{hp}: home producers (non-offshorers). cutoff productivity between stay and exit.
* z_{os}: offshoring cutoff. In patterns D and E, this is also the cutoff between stay and exit
* z_x: exporting cutoff

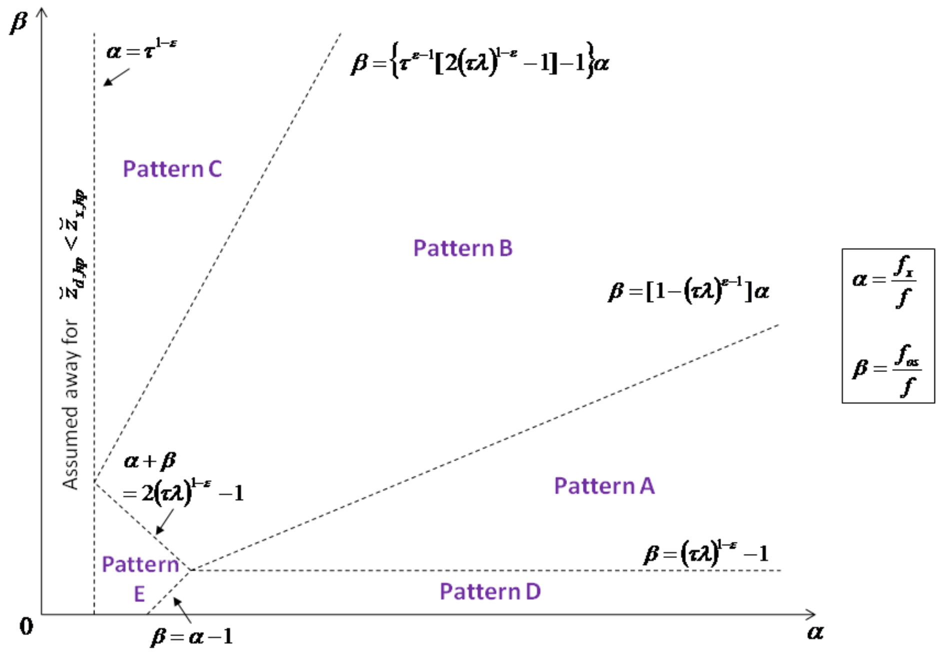


Figure 5: Equilibrium Space

* α: fixed cost of exporting compared to the fixed cost of production (f_x/f)
* β: fixed cost of offshoring (f_{os}/f)

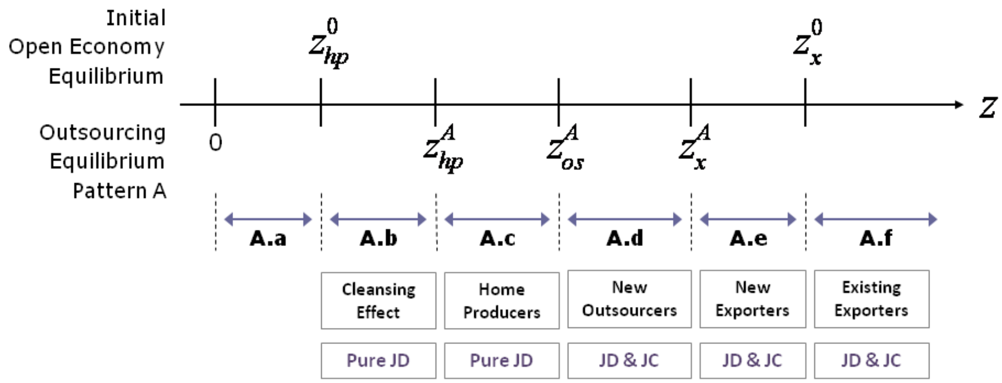
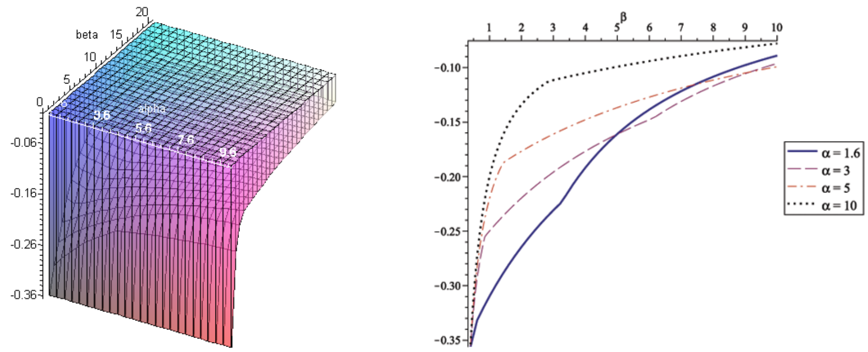
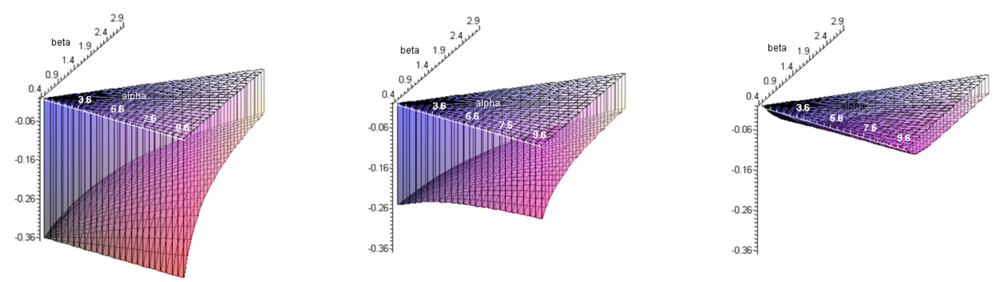


Figure 6: Different Operational Responses by Different Group of Firms under Pattern A

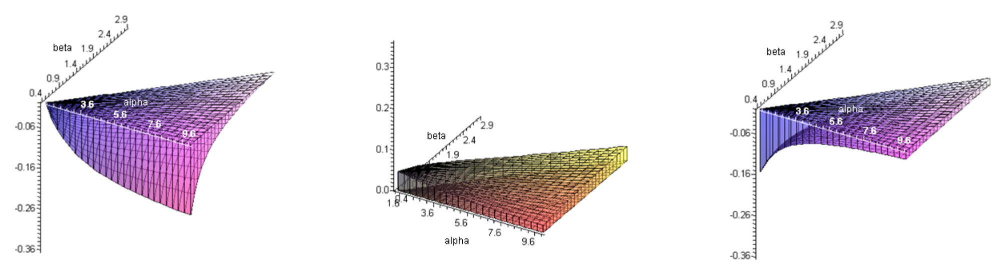


(a) Entire α - β space (b) for selected values of α

Figure 7: Total Net Employment Effect



(a) Total Net Employment Effect (b) Cleansing Effect (A.b) (c) Home Producers (A.c)



(d) New Outsourcers (A.d) (e) New Exporters (A.e) (f) Existing Exporters (A.f)

Figure 8: Net Employment Effect by various firm groups under the Pattern A

* α: fixed cost of exporting (f_x/f)
* β: fixed cost of offshoring (f_{os}/f)

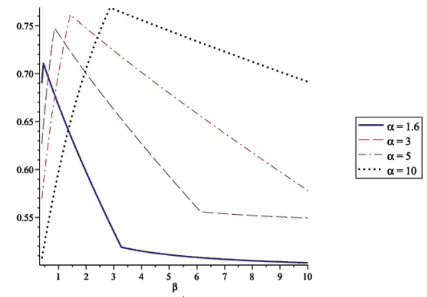


Figure 9: Cleansing Effect as a Share of Total Net Employment Effect

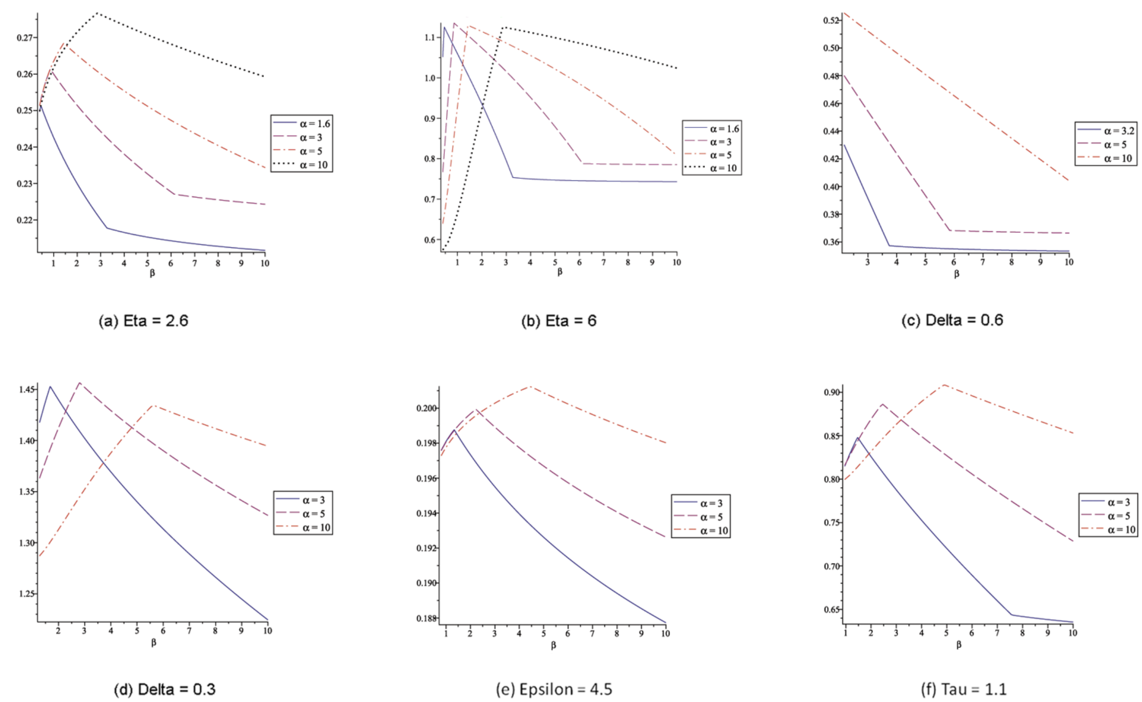
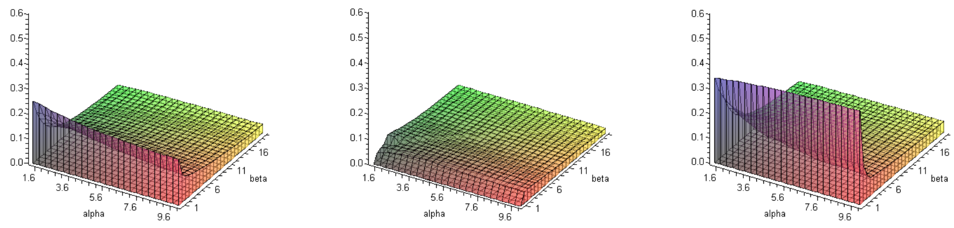
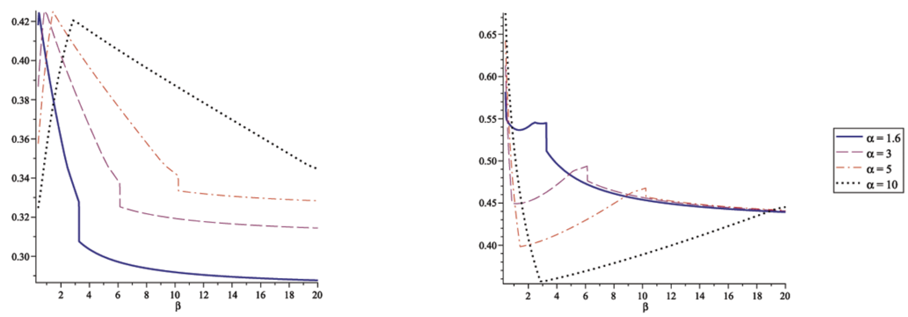


Figure 10: Sensitivity Analysis

* α: fixed cost of exporting (f_x/f)
* β: fixed cost of offshoring (f_{os}/f)



(a) Cleansing Effect (b) Home Producers (c) Outsourcers



(a) Cleansing Effect (b) Outsourcers' Layoffs

Figure 11: Job Destruction

* α: fixed cost of exporting (f_x/f)
* β: fixed cost of offshoring (f_{os}/f)