THREE ESSAYS ON OFFSHORE OUTSOURCING AND LABOR MARKETS

by

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To Mom and Dad

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Chapter I

Introduction

International trade has constantly increased throughout the second half of the 20th century, and this trend will continue well into the 21st century. The practice of international trade has evolved from simple purchase of final goods of foreign origin to trade in intermediate inputs, then further to production process sharing under which firms produce customized inputs for firms in foreign countries. The term that we hear very often in the media especially since the 2004 election campaign, "offshore outsourcing," refers to the use of either foreign firms through arm's length contracts or own subsidiaries in foreign countries to perform some tasks that the outsourcing firms previously performed domestically. Due to the nature of direct replacement of domestic tasks with foreign supplies, offshore outsourcing has been blamed for destroying American jobs. As the practice of offshore outsourcing expands to service-related tasks that affect our daily lives, such as customer service call centers, the general public started see offshore outsourcing as a threat to every American job.

However, discussions around offshore outsourcing tend to be built around the resulting job losses, and the job creation that may be caused by the gain in efficiency is often neglected. In order to truly understand the labor market impact of offshore outsourcing, we should give equal weight to job creation as well as destruction. The change in aggregate domestic employment could be positive if the efficiency gain from offshore outsourcing is large enough to create more jobs that it destroys.

Despite the attention that offshore outsourcing has received for the past few years, there have not been a sufficient amount of empirical studies on this subject to provide us with an answer to whether offshore outsourcing is harmful or beneficial to domestic employment. The findings of currently available empirical research on U.S. multinationals suggest that the effect is ambiguous. The source of such ambiguity is very difficult to identify empirically due to data limitations. In this dissertation, I use structural models to answer this very question. In the second and third chapters, I perform a theoretical analysis of the various employment responses - firm-level as well as aggregate - to offshore outsourcing. The heterogeneity in firm-level productivity that is assumed in the model of chapter II allows us to see what types of firms decide to outsource and how employment changes in different groups of firms in response to the possibility of outsourcing when firms face competition from firms in other countries with comparable technology levels. In chapter III, I look at how aggregate employment changes when homogeneous firms face competition from cheaper goods produced in developing countries - where both wage rate and productivity are lower than for home firms. I also look at the amounts of both job creation and job destruction, identifying the circumstances in which job creation may exceed job destruction.

The analyses of chapters II and III are based on the assumption of perfect labor mobility across occupations. The size of the change in aggregate employment - regardless of whether it is a gain or loss - estimated under this assumption should be understood as a rather a long-run consequence of offshore outsourcing. Job destruction tends to happen in the labor-intensive low skill jobs and the new jobs created tend to be high skill positions. In the short-run, for this reason, the displaced workers are not readily employable in the jobs that are created by offshore outsourcing. It takes retraining of the displaced workers, and this might be a lengthy process. Offshore outsourcing can be beneficial to all agents in an economy through several channels – the rise aggregate income, a rise in available varieties, and reduction in price level - but the displaced workers certainly suffer from this adjustment process in this new era of globalization. The U.S. government established the Trade Adjustment Assistance program in order to reduce the adjustment costs of these workers by providing retraining services and income support during training. The efficacy of the TAA program is analyzed in this dissertation, in chapter IV.

In chapter II, I perform a theoretical analysis of the labor market implications of offshore outsourcing and quantify various employment responses by calibrating parameter values to match the U.S. manufacturing sector. I construct a partial equilibrium model of an industry facing offshore outsourcing with a continuum of firms with heterogeneity in their productivities. In this model, the world market is composed of two developed countries that are identical. Firms from developed countries have the option to outsource part of their process to a low-wage developing country that does not consume the product. Heterogeneity in firm-level productivities generates different firm-level responses to outsourcing: the most productive firms outsource, the least productive firms are forced to exit (the Cleansing Effect), and the firms with intermediate productivity level continue operating as home-producers.

The theory generates a strong prediction that offshore outsourcing unambiguously reduces aggregate employment at home. However, the numerical analysis finds that the net employment effect within outsourcing firms is indeed ambiguous and that, more strikingly, the strong negativity of the overall employment effect stems from the cleansing effect. This result suggests that empirical investigation of multinationals understates the true employment effect of offshore outsourcing. By decomposing net employment loss into job destruction and creation, this paper finds that the net employment change can be less than half of the gross employment change, and that the layoffs by outsourcers account for the majority of total job destruction. These findings suggest that the previous empirical studies, of outsourcing firms alone, understate the negative impact of offshore outsourcing on employment.

In chapter III, I examine the net employment effect - job creation as well as job destruction - of offshoring with a structural model of offshoring with two countries (north for the higher wage country, and south for the lower wage one), two industries (agriculture and manufacturing), and one factor (labor). Offshoring occurs in the monopolistically competitive manufacturing industry where goods are produced through two physically separable processes - assembly and services. Countries differ in wage rates and efficiency levels in their service segments. These differences determine the pattern of outsourcing and, thus, the effect on manufacturing employment in both countries. The numerical analysis finds that outsourcing raises tremendously the share of the market served by northern varieties. For benchmark parameters, there is gain of 48% of the world market from outsourcing. The employment effect is also generally positive, implying that the job creation from the benefits of outsourcing is larger than the job destruction caused directly by the physical relocation of part of the business processes.

Chapters II and III share some common features such as that the business process is composed of two segments, and outsourcing consists of sending part of the process abroad. However, the models in these two chapters are fundamentally different and are used to answer different sets of questions. First, the model of the second chapter focuses on the competition between two developed countries. The developing country is only a host of outsourcing activities and does not consume the finished product. This setup simplifies the analysis enough to allow firm-level heterogeneity in productivity. Since firms behave differently under this assumption, the aggregate employment change is different from the firm-level employment effect. With the analysis of firm-level responses - their outsourcing decision and employment responses, we can see which firms bring about net job destruction and which firms create more jobs than they destroy. The focus on the competition between developed countries also allows us to expand the analysis to include evaluation of anti-outsourcing legislation. In 2004, many policies have been proposed to discourage offshore outsourcing, but these policies do not consider the counterfactuals where US firms are prohibited from outsourcing while their competitors - for instance, European and Japanese firms - still take advantage of cost reducing outsourcing. The loss of US firms' competitiveness in the world market due to the legislations would reduce their market share, so employment by these firms would shrink. Although the analysis of this counterfactual is not performed in the second chapter, it is ready to be performed and is certainly on the future agenda of this research.

On the other hand, the model of chapter III assumes that firms are homogenous. The simplification at this level allows us to analyze the competition between two distinctive countries - one developed country and one developing country. The relative productivities of the two countries differ in two distinct business segments - assembly and services. It therefore could be profitable for firms from a developing country to outsource their service segments if the developed country has far superior technology that more than offsets the disadvantage from their high relative wage. Therefore, in this model, two-way outsourcing is permitted. This can explain the phenomenon that developed countries outsource labor-intensive tasks, such as assembly and call center services, to developing countries and developing countries outsource skill-intensive tasks, such as automobile design and financial consulting, to developed countries. Allowing the developing country to compete against the developed country allows us to analyze the impact of offshore outsourcing on the developing country in terms of employment and the growth of aggregate income. The consumption power of China and India - the two major destinations of offshore outsourcing - are growing rapidly as they enjoy the influx of foreign investment; thus they will grow to be very important consumers of goods of developed countries. This 'breeding the future consumers' effect of offshore outsourcing will have tremendously positive impact on the profitability of firms from developed countries, and also on their employment, and the model of the third chapter can analyze this effect.

In chapter IV, I look at the problem of outsourcing at the level of the workers who suffer from the rise in competition from developing countries by looking at the training services of the TAA program. The efficacy of training services has been evaluated in several studies by comparing TAA trainees and non-trainees. They find that trainees perform better after exiting the program. In this chapter, I measure the success of the training provision of the TAA program in terms of the match between occupations for which workers are trained and the occupations of their later employment. I investigate whether a match improves post-participation outcomes of customers. For the analysis, I use the Trade Act Participant Record (TAPR) acquired through the Freedom of Information Act. This is the first academic paper that utilizes the TAPR dataset.

The dataset shows a matching rate of 44.6% among trainees overall. While post-participation outcomes are greatly affected by the personal characteristics of the customers such as their educational attainment and age, matching significantly improves the post-participation earnings of customers both in absolute terms (post-participation earnings) and relative terms (wage replacement rate). Matching raises the wage replacement rate by 3 to 4 percentage points. Also, while receipt of training services regardless of a match improves the reemployment rates (by 5 percentage points), trainees who failed to find a match but got a job have poorer outcomes - both their levels of earnings and their wage replacement rates - than non-trainees. This implies that achieving a match is an important measure of successful training programs and allocating resources properly to better coordinate training with job opportunities can improve the performance of the TAA program and its cost efficiency.

Chapter II

The Cleansing Effect of Offshore Outsourcing in an Analysis of Employment

1 Introduction

In 2004, offshore outsourcing became so common in the public perception that it became a frequent topic of everybody's dinner-table talk. Especially since it was an election year, it was very much a political matter rather than just an economic phenomenon. Presidential candidates did not hesitate to blame outsourcing for large losses of manufacturing jobs. They went a step further to promise the nation that they would stop the outflow of American jobs. Mankiw and Swagel (2006) show the explosive rise in media references[1] to "outsourcing" in their Figure 1. In 2002 and 2003, the references were around 300 in each year, then it increased to more than 1000 in 2004.

There is yet no consensus definition of offshore outsourcing. Many studies use "offshoring" as carrying out some stages of production at owned affiliates in the foreign country; and "offshore outsourcing" as that using arm's-length contract (Harrison and McMillan, 2006). However, I use "outsourcing" to refer to both foreign production at owned affiliates and through arm's-length contract. "Offshore outsourcing" and "outsourcing" are used interchangeably.

[1]Reference by four major newspapers: The New York Times, Washington Post, Los Angeles Times, and USA Today

Despite the public concern about the link between offshore outsourcing and job loss, empirical studies find that the employment effect of outsourcing is neither unanimously negative nor of significant magnitude. One branch of empirical literature focuses its attention on the activities of foreign affiliate operations of multinational enterprises. They use firm-level data to investigate the within-firm labor substitution between domestic facilities and foreign affiliates. One of the most frequently used datasets is the firm-level surveys on U.S. Direct Investment Abroad collected by the U.S. Bureau of Economic Analysis (BEA). Brainard and Riker (1997) find small substitution between US facilities and foreign affiliates, and stronger substitution among foreign affiliates in low-wage countries. Stronger substitution between US employment and foreign affiliate employment is found by Hanson, Mataloni, and Slaughter (2003). On the other hand, Desai, Foley, and Hines (2005) find complementarity between US locations and foreign affiliates of US multinationals. They find that when foreign employment rises by 10%, US employment within the firm rises by 2.5%. In Contrast, Borga (2005) finds an insignificant effect of offshore outsourcing. Harrison and McMillan (2007) separate horizontal affiliates from vertical affiliates, and also high-cost locations from low-cost locations. They find employment complementarity for vertical affiliates, but substitution for horizontal affiliates. There are also empirical studies on the outsourcing activities of other industrial nations. Muendler and Becker (2006) investigate German multinational enterprises (MNEs) and find strong substitution. Braconier and Ekholm (2000), in their study of Swedish multinationals, find substitution between Swedish facilities and affiliates in high-income countries, but neither substitution nor complementarity between Swedish locations and affiliates in low-income countries.

Although these firm-level data are very rich in various operational information, foreign operation of multinationals should not be the definitive measure of offshore outsourcing activities. In fact, a large portion of offshore outsourcing takes place through arm's-length contracts (Crino, 2007). If offshore outsourcing through own foreign affiliates and through arm's-length contracts are driven by distinct incentives (Grossman and Helpman, 2003), their effect on employment at the headquarter location can also be different.

Another branch of the empirical literature takes a sectoral approach. Studies using this approach construct a measure of offshore outsourcing in each industry - at various levels of aggregation - and look for a correlation between this measure and industry employment. The employment effects from these studies are also weak. Amiti and Wei (2006) use the share of imported inputs as a measure of outsourcing, and find that the employment effect 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 employment effect in the U.K. manufacturing industry between 1995 and 2001. For the Canadian manufacturing sector, Morissette and Johnson (2007) find that the industries with intense outsourcing did not show significantly different employment growth rates composed to other industries. Keller and Stehrer (2008) use Austrian data and find that offshore outsourcing has a negative effect during 1995-2000, but a positive effect during 2000-2003.

These ambiguous results suggest that outsourcers may create a number of jobs that is large enough to offset their layoffs. Outsourcing firms might be the source of job destruction, but they are also the ultimate beneficiaries of outsourcing, and the realized benefits will be translated into new jobs. However, these insignificant net effects might reflect a combination of small job destruction and small job creation, or alternatively large destruction and large creation. Although both may result in net effects of the same magnitude, they imply very different adjustment costs for workers. In many cases, offshore outsourcing takes the form of relocation of the most labor-intensive part of the process. This implies that jobs that are destroyed and jobs that are newly created are likely to be different in their tasks and skill levels. In other words, the laid-off workers are not readily employable for the new jobs. In order to reduce the adjustment cost of workers, it is often necessary to provide them with occupational training and, in some cases, remedial education through a program such as Trade Adjustment Assistance (TAA).[2] In order to properly assist the displaced workers,

[2]The TAA program is specially designed for unemployed workers whose layoffs are caused by international trade, including import competition and relocation of production sites to foreign countries, with the purpose of helping them get a new job sooner. The TAA services and benefits include occupational training, remedial education, and income support during training.

correct understanding and measurement of the size of outsourcing-related separation is required. None of currently available data on outsourcing activities is appropriate for this purpose. Data on multinationals' operations fail to capture outsourcing activities that utilize arm's length contracts. These data also do not report the amount of separation separately from new hires. Data on outsourcing activities measured by usage of imported inputs fail to capture outsourcing in the form of foreign assembly.

For this reason, we need more structural theoretical analysis to capture various labor market dynamics that drive the aggregate impact that we can observe in data. In this paper, I construct a partial equilibrium model of offshore outsourcing with firms that are heterogeneous in their productivity levels (Melitz, 2003). Initially there are two symmetric northern countries that are open for international trade. The manufacturing process consists of two segments, Assembly and Services. As outsourcing becomes feasible, outsourcing firms send their assembly segments to a Southern country that does not consume the final products. Using this structural model, I find that the most productive firms outsource - as found in Kurz (2006) - and that the least productive firms are forced to exit. I call the exit of the least productive firms *the Cleansing Effect of Offshore Outsourcing*.[3] With this structural model, I can quantify job creation separately from job destruction, and the employment response of different groups of firms - the cleansing effect, non-outsourcers, and outsourcers - separately.

I find that outsourcing unambiguously reduces aggregate employment as outsourcing becomes feasible. Whether this result is contrary to previous empirical findings requires further analysis, since this model includes the entire industry rather than only the outsourcers. For this, I perform numerical analysis by using benchmark parameter values that are calibrated to match the initial and outsourcing equilibrium to the U.S. manufacturing sector of 1992 and 2006, respectively. I find that the net employment loss may reach up to 36% of total initial employment. However, the majority (50-75%, 53% for parameter

[3]The term 'Cleansing Effect' is first used by Caballero and Hammour (1994). They use the term to refer to firms' restructuring strategy that clean outdate techniques or less profitable products out of their plants during recession when adjustment cost is low.

values for 2006) of such net employment loss is due to the job destruction brought about by the cleansing effect of outsourcing rather than layoffs by outsourcers. As a sensitivity analysis, I show the cleansing effect as a share of net employment loss for six different sets of parameter values. All six cases confirm the dominance of the cleansing effect in driving the negative net employment effect. Although the cleansing effect is not directly related to outsourcing activities, such job destruction is clearly an outcome of offshore outsourcing. This finding implies that the BEA dataset is only valid for the analysis of within-firm employment effects among outsourcers. In order to discuss the more aggregate employment effects that outsourcing brings about, non-outsourcers, and even the firms that disappear from the market as a result of outsourcing, should be included in the analysis as subjects.

The numerical analysis confirms the previous finding that employment effect of outsourcing on outsourcing firms alone is ambiguous. For the benchmark parameter values, the net effect ranges from 17% net loss to 3% net gain. For six different sets of parameter values, the employment effect in outsourcing firms alone varies from large negative (32% net employment loss) to large positive (12% of net gain). The separate analysis of job destruction and creation shows that the observable net employment change is less than half of the gross job flow. Total job destruction is up to 60% of initial employment and total job creation reaches up to 24%. Despite the striking dominance of the cleansing effect in the net employment effect, the layoffs by outsourcers indeed account for a larger portion of total job destruction, implying that despite the ambiguous net employment effect, the layoffs by outsourcers are an important socio-economic phenomenon that deserves a significant amount of policy attention.

Besides the impact on employment, I show theoretically that outsourcing promotes international trade by eliminating the price disadvantage that exporters face in their foreign market in the absence of outsourcing. Also, I find that outsourcing reduces the total number of varieties available to consumers. This is a surprising result since product variety gain has been discussed as one of the most important benefits of international trade. This result stems from the fact that outsourcing benefits large-scale firms with high productivities, and the cleansing effect drives the small producers out of the market.

The structure of this model can be used for evaluation of various type of anti-outsourcing legislation. For instance, we can analyze the effect of complete prohibition of outsourcing in raising domestic employment by comparing the outsourcing equilibrium presented in the paper to the asymmetric outsourcing equilibrium where firms from one northern country (the home country) is prohibited from outsourcing while outsourcing of the other country's firms and international trade are allowed. The model can be used to evaluate more specific policy proposal. For instance, in order to evaluate the efficacy of John Kerry's policy proposal that repeals the tax break for outsourcing firms[4], I can add one parameter for price distortion caused by changes in tax.[5] Although this is of great policy relevance, it is beyond the scope of this paper.

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.

2 Model

Initially, there are two symmetric Northern countries that produce and consume the manufacturing products. Two countries trade with each other, so each market is served by its local products and imported products. There is a continuum of firms that are heterogeneous in their productivities. Each firm utilizes only labor as a factor to perform two processes - assembly and services - in order to manufacture the final products. A representative consumer has CES preference over the continuum of goods, so demand for each good is determined by its price relative to the market price index. As outsourcing becomes feasible, I introduce a Southern country with a lower wage as a host of outsourcing activities. The South does not have a market for the final products. A Northern firm has an option to

[4]for more detail, see Mankiw and Swagel (2006)

[5]Or more easily, I can adjust the Southern wage rate which then affects the total price of outsourced products.

outsource its assembly segment to the South to save its production cost.

2.1 Set-up

2.1.1 Demand

A representative consumer has CES preference over a continuum of goods (indexed by ω). The utility function is as follows:

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\rho} d\omega \right]^{\frac{1}{\rho}} \tag{1}$$

Ω is the set of available varieties. The consumer spends a fixed amount of expenditure, R, on these differentiated varieties. For each variety, the quantity demanded, $q(\omega)$, and the revenue, $r(\omega)$, are as follows.

$$q(\omega) = \frac{R}{P} \left[\frac{p(\omega)}{P} \right]^{-\varepsilon} \tag{2}$$

$$r(\omega) = R \left[\frac{p(\omega)}{P} \right]^{1-\varepsilon} \tag{3}$$

where ε is the elasticity of substitution and equal to $\varepsilon = 1/(1-\rho)$. P is the price index for the market defined as follows:

$$P = \left[\int_{\omega \in \Omega} p(\omega)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{4}$$

2.1.2 Production Technology

Labor is the only factor of production and the production technology is represented by unit labor requirement. Firms are heterogeneous in their productivity level. Upon entry, a firm draws a productivity z from a cumulative distribution $G(z)$. The firm's unit labor requirement is then determined as $1/z$.

Production of the final good is composed of two segments, assembly and services. Each process utilizes a fixed share of workers with γ as the employment share of service segment.

Therefore, labor requirement for each segment for one unit of final good is the following:

$$\text{Assembly}: \quad (1-\gamma)/z \qquad\qquad \text{Services}: \quad \gamma/z \tag{5}$$

If the firm exports, it incurs an additional fixed cost of exporting, f_x. Outsourcing also involves an additional fixed cost, f_{os}. For instance, total labor requirement for a firm that does neither export nor outsource is

$$l(z) = f + \frac{q(z)}{z} \tag{6}$$

where $q(z)$ is the quantity demanded. The wage rate in both Northern countries is equal to one.

2.1.3 Decision Making Process

A new firm enters the market incurring the sunk entry cost, f_e. The entrant gets a productivity draw, z, from the distribution $G(z)$. After observing z, the firm decides whether to stay and produce at the fixed production cost, f, or to exit. In the absence of outsourcing, successful entrants again decide whether to export to the other Northern country at an additional fixed export cost, f_x. Where outsourcing is feasible, successful entrants choose one of the following options: first, produce at home without exporting; second, produce at home and export (additional fixed export cost, f_x); third, outsource and serve only the domestic market (additional fixed outsourcing cost, f_{os}); and lastly, outsource and export (additional cost $f_x + f_{os}$).

After successful entry, every firm faces a probability of death, ξ, regardless of their productivity levels, every period. In a steady state equilibrium, as some of existing firms exit, new entrants fill their spots.

2.2 Open Economy without Offshore Outsourcing

The set-up and equilibrium of the economy in the absence of outsourcing is borrowed from the open economy model of Melitz (2003). There are two Northern countries who are identical and trade their final goods with each other.

Every firm produces a different variety and charges a monopoly price. For domestic sales, the price is simply a constant markup over marginal cost; that is

$$p_{d,hp}(z) = \left(\frac{\varepsilon}{\varepsilon - 1}\right)\frac{1}{z} = \frac{1}{\rho z} \tag{7}$$

The subscript d and hp respectively indicate variables for domestic operation and variables for home-producers - firms that perform both assembly and services in their home countries. The profit from a firm's domestic sales is

$$\pi_{d,hp}(z) = \left[p_{d,hp}(z) - mc_{d,hp}(z)\right] q_{d,hp}(z) - f = \frac{r_{d,hp}(z)}{\varepsilon} - f \tag{8}$$

where the revenue function, $r_{d,hp}(z)$ is, drawing from equations (3) and (7)

$$r_{d,hp}(z) = R\left(P\rho z\right)^{\varepsilon-1} \tag{9}$$

If this firm decides to export, it will charge the monopoly price inclusive of transport cost. Transport cost takes the form of the iceberg cost. The price of the same product in foreign market is, therefore,

$$p_{x,hp}(z) = \tau p_{d,hp}(z) \tag{10}$$

The subscript x indicates the variables for export operation. All exporters also serve their domestic markets. Since the total fixed cost of an exporter is $f + f_x$ whether it serves its domestic market or not, it is always more profitable to serve its domestic market as well as its foreign market. For this reason, I can separately express the export profit from the domestic profit; and, that is

$$
\begin{aligned}
\pi_{x,hp}(z) &= \frac{r_{x,hp}(z)}{\varepsilon} - f_x \qquad (11)\\
\text{where} \quad r_{x,hp}(z) &= R\left(P\frac{\rho z}{\tau}\right)^{\varepsilon-1} = \tau^{1-\varepsilon} r_{d,hp}(z)
\end{aligned}
$$

The total profit of an exporter is sum of equations (8) and (11).

2.2.1 Initial Open Economy Equilibrium

As seen in Melitz (2003), the equilibrium is characterized by two productivity cut-offs that summarize two decisions of firms - entry and exporting. I let z_{hp}^0 and z_x^0 denote the entry and export cut-off productivity, respectively. Superscript 0 indicates the variables for the initial open economy equilibrium.

First, I define two productivity cut-offs, $\check{z}_{d,hp}$ and $\check{z}_{x,hp}$, whose corresponding profits are zero:

$$
\begin{aligned}
\pi_{d,hp}(\check{z}_{d,hp}) &= \tfrac{r_{d,hp}(\check{z}_{d,hp})}{\varepsilon} - f = 0 \qquad (12)\\
\pi_{x,hp}(\check{z}_{x,hp}) &= \tfrac{r_{x,hp}(\check{z}_{x,hp})}{\varepsilon} - f_x = 0
\end{aligned}
$$

Since both profit functions, $\pi_{d,hp}(z)$ and $\pi_{x,hp}(z)$, are monotonically increasing in z, $\check{z}_{d,hp}$ and $\check{z}_{x,hp}$ provide the cut-off productivity for entry and export. That is, every firm with $z > \check{z}_{d,hp}$ will remain and serve the domestic market and every firm with $z > \check{z}_{x,hp}$ will export in addition to its domestic operation. The total profit of a firm depends on entry and export status, and can be written as follows:

$$
\pi_{hp}(z) = \begin{cases} 0 & \text{if } \; z < \check{z}_{d,hp} \\ \pi_{d,hp}(z) & \text{if } \; \check{z}_{d,hp} \le z < \check{z}_{x,hp} \\ \pi_{d,hp}(z) + \pi_{x,hp}(z) & \text{if } \; z \ge \check{z}_{x,hp} \end{cases} \qquad (13)
$$

In this equilibrium, the entry and export cut-off productivities, z_{hp}^0 and z_x^0, are simply the zero profit productivity cut-offs, $\check{z}_{d,hp}$ and $\check{z}_{x,hp}$, respectively. The equilibrium profit function and the pattern of operation are depicted in Figure 1.

Using equations (9), (11), and (12), z_x^0 can be written as a function of z_{hp}^0.

$$z_x^0 = \tau \left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} z_{hp}^0 \tag{14}$$

In order for both exporters and non-exporters to exist, the fixed export cost must be sufficiently large. More specifically,

$$f_x > \tau^{1-\varepsilon} f \tag{15}$$

I assume that inequality (15) holds throughout this paper.

Let M_d^0 denote the number of domestic varieties in the initial open economy equilibrium, and M_x^0 the number of exporters. Due to symmetry, M_x^0 is also the number of imported varieties. The total number of varieties available to consumers is $M_t^0 = M_d^0 + M_x^0$. I define $\tilde{z}(\hat{z})$ as an average productivity for all firms with productivity higher than $\hat{z}$; that is,

$$\tilde{z}(\hat{z}) = \left[\frac{1}{1-G(\hat{z})} \int_{\hat{z}}^{\infty} z^{\varepsilon-1} g(z) dz\right]^{\frac{1}{\varepsilon-1}} \tag{16}$$

Then the average productivity of the available varieties in the open economy equilibrium, $\tilde{z}_t^0$, is

$$\tilde{z}_t^0 = \left\{\frac{1}{M_t^0}\left[M_d^0 \tilde{z}(z_{hp}^0)^{\varepsilon-1} + M_x^0 \left(\frac{\tilde{z}(z_x^0)}{\tau}\right)^{\varepsilon-1}\right]\right\}^{\frac{1}{\varepsilon-1}} \tag{17}$$

From equations (4), (7), and (17), I can derive two aggregate variables - price index, P_0, and the aggregate revenue, R - as functions of the average productivity, $\tilde{z}_t^0$.

$$P_0 = M_t^{0\ \frac{1}{1-\varepsilon}}\ p_{d,hp}(\tilde{z}_t^0) \tag{18}$$

$$R = M_t^0\ r_{d,hp}(\tilde{z}_t^0) \tag{19}$$

2.2.2 Equilibrium Conditions

Let $\bar{\pi}^0$ denote the average profit of all operating firms in the initial open economy equilibrium. It can be written as

$$\bar{\pi}^0 = \pi_{d,hp}(\tilde{z}(z^0_{hp})) + Pr^0_x \pi_{x,hp}(\tilde{z}(z^0_x)) \tag{20}$$

where Pr^0_x is the probability of exporting upon successful entry, and defined as:

$$Pr^0_x = \frac{1 - G(z^0_x)}{1 - G(z^0_{hp})} \tag{21}$$

Using two zero cut-off profit conditions - equation (12) - together with equations (9) and (11), we can rewrite the average profit function as the following.

$$\bar{\pi}^0 = fk(z^0_{hp}) + \left[\frac{1 - G(z^0_x)}{1 - G(z^0_{hp})}\right] f_x k(z^0_x) \tag{22}$$

where

$$k(\hat{z}) = \left(\frac{\tilde{z}(\hat{z})}{\hat{z}}\right)^{\varepsilon - 1} - 1 \tag{23}$$

There is free entry in the market. Therefore, the expected value of entry must be zero in the equilibrium. Average expected value upon entry is the stream of expected profit with death hazard, ξ.

$$\bar{\nu} = \sum_{t=0}^{\infty} (1 - \xi)^t \, \bar{\pi}^0 = \frac{\bar{\pi}^0}{\xi} \tag{24}$$

The probability of successful entry in the initial open economy equilibrium is $1 - G(z^0_{hp})$, and there is an entry cost f_e. Therefore, the free entry condition for this equilibrium is

$$\bar{\pi}^0 = \frac{\xi f_e}{1 - G(z^0_{hp})} \tag{25}$$

The equilibrium entry cut-off productivity, z^0_{hp}, must satisfy equations (22) and (25) simulatneously. This constitutes the condition for the initial open economy equilibrium as the following.

$$\bar{\pi}^0 = fk(z_{hp}^0) + \left[\frac{1-G(z_x^0)}{1-G(z_{hp}^0)}\right] f_x k(z_x^0) = \frac{\xi f_e}{1-G(z_{hp}^0)} \tag{26}$$

where the cut-off productivity for exporting, z_x^0, is a function of z_{hp}^0, as in equation (14).

2.3 Open Economy with Outsourcing

Outsourcing takes the form of relocating assembly segment to another country. I introduce a Southern country that can perform assembly and does not demand the final product. The South has a lower wage rate, δ, which is smaller than one. (δ is wage rate per efficiency unit of labor, controlling for any differential in labor productivity.) The production technology is firm-specific, so the productivity, z, is preserved regardless of the location of assembly. The only advantage of outsourcing is the lower wage rate, which is equivalent to a productivity improvement in the sense that it lowers production cost.

If a firm with productivity z outsources, its marginal production cost becomes

$$mc_{os}(z) = \left[(1-\gamma)\frac{\delta}{z} + \gamma\frac{1}{z}\right] = [(1-\gamma)\delta + \gamma]\,\frac{1}{z}$$

That is, in comparison with the marginal production cost in the absence of outsourcing,

$$mc_{os}(z) = \lambda \cdot mc_{d,hp}(z) \qquad \text{where} \qquad \lambda = (1-\gamma)\delta + \gamma \tag{27}$$

Since now assembly and services take places in different countries, I need to define the geographical structure of the integration of two production segments and consumption. I assume that the integration of assembly and service segment is virtual and that goods are 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 iceberg transport cost involved. Service and assembly segments are integrated at the location of assembly. Any extra cost involved in the integration process can be captured by the fixed outsourcing cost,

f_{os}. After completion, final goods are shipped to the market for consumption directly from the South. The iceberg transport cost, τ, applies to shipment of final goods. One anecdotal example is computer manufacturing industry. More sophisticated tasks - such as research and development, and management services - are performed in the US while a lot of part manufacturing and final assembly is done in low-wage country, such as China, and the world demand is met by direct shipments from those locations.

The transportation structure is summarized in Figure 2. Panel (a) describes traditional international trade where goods are shipped directly from its origin countries. This applies to all firms in the initial open economy equilibrium and non-outsourcers in the outsourcing equilibrium. Panel (b) describes the case for outsourcers. Figure 2 is depicted for two representative goods that is produced by two firms originated in two Northern countries. These goods are 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. One can see that goods face price disadvantage in their foreign markets.

Where goods are outsourced, the markup over the marginal cost of both goods upon completion at the Southern facilities is λP. These goods are shipped to both markets where they are sold for $\tau\lambda P$. Therefore, outsourcing lowers domestic prices from P to $\tau\lambda P$, while it lowers export prices from τP to $\tau\lambda P$. For this reason, exporters benefit more from outsourcing than non-exporters do. For instance, where $\tau\lambda \leq 1$, non-exporters do not have an incentive to outsource while exporters still might depending on the relative size of domestic and foreign sales.[6]

As described in Figure 1, the price of an outsoucer with productivity z, which is the same for domestic and forein sales, is as follows.

$$P_{d,os}(z) = P_{x,os}(z) = \frac{\tau\lambda}{\rho z} \tag{28}$$

[6] I do not allow partial outsourcing - outsource assembly segment for export sales only while perform both assembly and services at home for domestic sales. For the analysis, I excluded (later) the cases where $\tau\lambda \leq 1$ and focus on the equilibria with sufficient incentive to outsource. The feasibility of partial outsourcing is not relevant where $\tau\lambda < 1$.

Since prices in the home and foreign markets are the same, revenues from the two markets are the same as well.[7]

$$r_{d,os}(z) = r_{x,os}(z) = R\left(\frac{P\rho z}{\tau\lambda}\right)^{\varepsilon-1} \tag{29}$$

There is a fixed cost of outsourcing, f_{os}. Outsourcing firms incur f_{os} in addition to the fixed production cost f, and fixed export cost f_x in case they export. As in the initial open economy equilibrium, all exporting outsourcers also serve their domestic markets; so I can write two separate expressions for domestic and export profits of an outsourcer as the following.

$$\pi_{d,os}(z) = \frac{r_{d,os}(z)}{\varepsilon} - f - f_{os} \tag{30}$$

$$\pi_{x,os}(z) = \frac{r_{x,os}(z)}{\varepsilon} - f_x \tag{31}$$

I define two zero-profit productivity levels $\check{z}_{d,os}$ and $\check{z}_{x,os}$; that is,

$$\begin{aligned} \pi_{d,os}(\check{z}_{d,os}) = 0 \quad &\Longleftrightarrow \quad r_{d,os}(\check{z}_{d,os}) = \varepsilon(f + f_{os}) \\ \pi_{x,os}(\check{z}_{x,os}) = 0 \quad &\Longleftrightarrow \quad r_{x,os}(\check{z}_{x,os}) = \varepsilon f_x \end{aligned} \tag{32}$$

Depending on the sizes of fixed costs, we get two different total profit functions. First, if $f_x > f + f_{os}$, $\check{z}_{x,os}$ will be above $\check{z}_{d,os}$, and the total profit function will look like panel (a) of Figure 3.[8] In this case, exporting requires larger revenue, and some outsourcers are not productive enough to meet the required amount of sales. Therefore, there are non-exporting outsourcers as well as exporting ones; and the total profit function of an outsourcer with productivity z is as follows.

$$\pi_{os}(z) = \begin{cases} 0 & \text{if } z < \check{z}_{d,os} \\ \pi_{d,os}(z) & \text{if } \check{z}_{d,os} \leq z < \check{z}_{x,os} \\ \pi_{d,os}(z) + \pi_{x,os}(z) & \text{if } z \geq \check{z}_{x,os} \end{cases} \tag{33}$$

[7] Revenues depend on price indices. Due to symmetry, price indices are equal in two markets.
[8] This is because domestic and export revenue are equal and monotonically increasing in z.

On the other hand, where $f_x < f + f_{os}$, exporting is very attractive, so all outsourcers export. This case is depicted in panel (b) of Figure 3. In this case, the break-even point is neither at $\check{z}_{d,os}$ nor at $\check{z}_{x,os}$. It is where the total profit - sum of domestic and export profits - is zero. I call this productivity level, $\check{z}_{os}$, and define it as the following.

$$\pi_{d,os}(\check{z}_{os}) + \pi_{x,os}(\check{z}_{os}) = 0 \tag{34}$$

The total profit function for an outsourcer in this case is

$$\pi_{os}(z) = \begin{cases} 0 & \text{if } \; z < \check{z}_{os} \\ \pi_{d,os}(z) + \pi_{x,os}(z) & \text{if } \; z \geq \check{z}_{os} \end{cases} \tag{35}$$

Not to participate in outsourcing is still an option for firms. I call the firms that choose not to outsource home-producers. In this equilibrium, variables for home-producers are indicated by subscript *hp*. Their total profit function is introduced by equations (8), (9), (11)-(14) and is depicted in Figure 1.

2.3.1 Equlibria

Firms make three decisions in the outsourcing equilibrium: first, whether to stay in the market or exit (exit/stay); second, whether to produce at home or outsource (assembly location); finally, whether to export (export status). Such decisions are based on two profit functions, $\pi_{hp}(z)$ - equation (13) - and $\pi_{os}(z)$ - equation (33) and (35). More Specifically, a firm will choose to stay in the market if its profit with either strategy - outsourcing or home-production - is positive. This firm will outsource if outsourcing profit is larger than home-production profit, and will not outsource otherwise. Finally, this firm exports if its productivity is higher than the relevant zero-profit productivity for exporting - $\check{z}_{x,hp}$ or $\check{z}_{x,os}$ - depending on the choice of assembly location. These decisions depend crucially on where $\pi_{hp}(z)$ and $\pi_{os}(z)$ intersect, and where these curves kink. These features of two profit functions, then, depend on parameter values - size of cost reduction (λ), transport cost (τ), elasticity of substitution (ε), and the sizes of fixed costs (f, f_x, f_{os}). According to these parameter values, we have twelve different equilibria where outsourcing is feasible. Table 1 summarizes the conditions for each equilibrium and Figure 4 shows various cut-off productivities and the pattern of operation for each equilibrium. The derivation process is explained in detail in Technical Appendix.[9]

Although each equilibrium is fundamentally different - they correspond to different parameter values - some share the same operational pattern. In practice, different industries have distinctive characteristics; therefore, they respond to the feasibility of offshore outsourcing differently. For this reason, every equilibrium of Figure 4 has its own practical significance and is worth investigating. However, the goal of this paper is to study the response of labor market to offshore outsourcing; so, I devote the attention to the case where outsourcing brings out employment response of significant size. Recall that where $\tau\lambda \leq 1$, non-exporters do not have an incentive to outsource because outsourcing raises the prices for domestic sales. Therefore, I focus on the equilibria under the condition $\tau\lambda < 1$ where outsourcing lowers domestic prices as well as export prices. According to table 1, equilibria a, b, c, d, h, i, and j satisfy the condition.

The operational patterns of these seven equilibria, then, can be summarized as in Figure 5. Equilibrium b shows pattern A; c and i shows pattern B; and, d and j show pattern C. Equilibrium h corresponds to pattern I, and equilibrium a to II. I combine the information provided by table 1 and Figure 5 and show the sizes of fixed costs that correspond to each pattern given other parameter values in Figure 6. α is the size of fixed export cost relative to that of fixed production cost ($\alpha = f_x/f$), and β denotes the size of fixed outsourcing cost relative to f ($\beta = f_{os}/f$).

According to Figure 6, we achieve patterns I and II where fixed outsourcing cost is very small. Under these two patterns, all firms take advantage of outsourcing; therefore, there is no home-producer in the market. In addition to small fixed outsourcing cost, pattern I also has a very small fixed export cost; therefore, every firm exports. Under pattern II, there

[9] avaiable on www.umich.edu/∼ejpark/jypark_cleansing_tech.pdf

exist non-exporting outsourcers as well as exporting ones.

Pattern A, B, and C are where the fixed outsourcing cost is large enough for some firms to choose not to outsource. For a given value of fixed export cost, pattern A has the smallest fixed outsourcing cost, and C has the largest. This determines the number of outsourcers in these three patterns. Under the pattern A (smallest β), outsourcing is more attractive than exporting, so outsourcing cut-off productivity is lower than that of exporting. Under the pattern C, the opposite is true, so the productivity cut-off for exporting is lower than that of outsourcing. Pattern B is the intermediate case, and export cut-off productivity coincides with the outsourcing cut-off productivity. Accordingly, pattern A have the largest number of outsourcers, and the impact of outsourcing on the industry - such as the effect on employment - is the largest.

In order to analyze the impact of outsourcing on the various aspects of the industry, comparison between the initial open economy equilibrium and the outsourcing equilibrium is required. However, this comparison should be carried out separately for each outsourcing equilibrium pattern - I, II, A, B, and C - because the firms' operational responses differ across patterns. In the next section, I present the detailed model under the pattern A where outsourcing affects the economy to a greatest extent. The detailed model for other patterns is not presented in this paper, but other patterns will be included in the analysis.

2.3.2 Equilibrium Pattern A.

The operational pattern A can be observed in the outsourcing equilibrium b. Under this pattern, there are three groups of firms - home producers that only serve their domestic market, outsourcers that only serve their domestic market, and outsourcers that serve both domestic and foreign markets. As can be seen in panel (b) of Figure 4 and panel (c) of Figure 5, the firms with the lowest productivities are home-producers. Therefore, the entry cut-off productivity, z_{hp}^{A}, is at the zero-profit productivity, $\check{z}_{d,hp}$ - equation (12). The outsourcing cut-off productivity, z_{os}^{A}, is where a firm is indifferent between outsourcing and home-production; that is

$$\pi_{d,hp}(z_{os}^A) = \pi_{d,os}(z_{os}^A)$$

All exporters are outsourcers, so the export cut-off productivity, z_x^A is the productivity level with which an outsourcer's export profit is zero - $\check{z}_{x,os}$, equation (32). The superscript A indicates the variables under the pattern A of the outsourcing equilibrium. Using equations (8), (9), and (29)-(32), z_{os}^A and z_x^A can be written as functions of z_{hp}^A as the following:

$$z_{os}^A = \left[\frac{1}{(\tau\lambda)^{1-\varepsilon} - 1}\left(\frac{f_{os}}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^A \tag{36}$$

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

The average productivity of all varieties that are availale in one market is as follows.

$$\tilde{z}_t^A = \left\{\frac{1}{M_t^A}\left[M_{hp}^A \tilde{z}_{hp}^{A\,\varepsilon-1} + M_{os}^A\left(\frac{\tilde{z}(z_{os}^A)}{\tau\lambda}\right)^{\varepsilon-1} + M_x^A\left(\frac{\tilde{z}(z_x^A)}{\tau\lambda}\right)^{\varepsilon-1}\right]\right\}^{\frac{1}{\varepsilon-1}} \tag{37}$$

M_{hp}^A, M_{os}^A, and M_x^A, respectively, denote the numbers of home producers' varieties, outsourcers' varieties, and imported varieties. M_t^A is the total number of varieties that are available in the market; that is $M_t^A = M_{hp}^A + M_{os}^A + M_x^A$. $\tilde{z}_{hp}^A$ is the average productivity of home-producers whose productivities lie between z_{hp}^A and z_{os}^A. $\tilde{z}_{hp}^A$ can be written as the following.

$$\tilde{z}_{hp}^A = \left[\frac{M_d^A}{M_{hp}^A}\tilde{z}(z_{hp}^A)^{\varepsilon-1} - \frac{M_{os}^A}{M_{hp}^A}\tilde{z}(z_{os}^A)^{\varepsilon-1}\right]^{\frac{1}{\varepsilon-1}} \tag{38}$$

M_d^A is the number of domestic varieties, hence, sum of M_{hp}^A and M_{os}^A. The aggregate revenue and the price index are, from equations (7), (18), and (19),

$$R = M_t^A\ r_{d,hp}(\tilde{z}_t^A) \tag{39}$$

$$P_A = M_t^{A\,\frac{1}{1-\varepsilon}}\left(\frac{1}{\rho\tilde{z}_t^A}\right) \tag{40}$$

As in the initial open economy equilibrium, an equilibrium condition is made up of two equations that characterize the average profit of active firms in equilibrium. First, the average profit is sum of average profits of firms with different operational strategies - non-exporting home-producers, non-exporting outsourcers, and exporting outsourcers - weighted by the probability of each strategy upon successful entry. That is,

$$\bar{\pi}^A = Pr^A_{hp}\pi_{d,hp}(\tilde{z}^A_{hp}) + Pr^A_{os}\pi_{d,os}(\tilde{z}(z^A_{os})) + Pr^A_x\pi_{x,os}(\tilde{z}(z^A_x)) \tag{41}$$

where the probability of each strategy is as follows.

$$Pr^A_{hp} = \frac{G(z^A_{os}) - G(z^A_{hp})}{1 - G(z^A_{hp})}; \quad Pr^A_{os} = \frac{1 - G(z^A_{os})}{1 - G(z^A_{hp})}; \quad Pr^A_x = \frac{1 - G(z^A_x)}{1 - G(z^A_{hp})} \tag{42}$$

Using equations (8)-(11), (16), (23), (29)-(31), and (36), equation (41) can be rewritten as the following:

$$\bar{\pi}^A = k(z^A_{hp})f + \left[\frac{1 - G(z^A_{os})}{1 - G(z^A_{hp})}\right] k(z^A_{os})f_{os} + \left[\frac{1 - G(z^A_x)}{1 - G(z^A_{hp})}\right] k(z^A_x)f_x \tag{43}$$

Free entry condition requires that the expected value of entry is equal to the sunk entry cost in the equilibrium; that is,

$$\bar{\pi}^A = \frac{\xi f_e}{1 - G(z^A_{hp})} \tag{44}$$

The derivation of equation (44) is identical to that of equation (25). Finally, the equilibrium is represented by the cut-off productivities that satisfy equations (43) and (44) simultaneously.

$$\bar{\pi}^A = k(z^A_{hp})f + \left[\frac{1 - G(z^A_{os})}{1 - G(z^A_{hp})}\right] k(z^A_{os})f_{os} + \left[\frac{1 - G(z^A_x)}{1 - G(z^A_{hp})}\right] k(z^A_x)f_x = \frac{\xi f_e}{1 - G(z^A_{hp})} \tag{45}$$

3 Theoretical Results

The impact of offshore outsourcing on the economy can be analyzed by comparing features of the outsourcing equilibrium to those of the initial open economy equilibrium. Although the ultimate goal of this paper is to investigate the labor market response to outsourcing, the rich structure of the model allows us to derive many valuable economic implications. In this section, I do not restrict the analysis to the equilibrium pattern A and rather expand the scope to patterns B and C as well. More specifically, I analyze the subset of the equilibrium space introduced by Figure 6; that is

$$\alpha > (\tau\lambda)^{1-\varepsilon} \quad \text{and} \quad \beta > (\tau\lambda)^{1-\varepsilon} - 1 \tag{46}$$

Patterns I and II - where every active firm outsources - are also interesting and are practically plausible, I do not discuss them for the rest of the paper.

First, I look at the changes in entry and export cut-off productivities, and where outsourcing cut-off productivity is located. The location of cut-off productivities is of great importance because it determines the operational responses of firms. For instance, a change in the entry cut-off productivities either forces some firms to exit, or invites more firms to stay active in the market. A change in export cut-off productivities either generates or eliminates export opportunities for some firms. The location of outsourcing cut-off productivities determines how many firms lay off workers to relocate their assembly segments (and improve their profits by doing so). These different responses by different firms, then, determines impact of offshore outsourcing on various aspect of economy such as aggregate productivity, trade flow, number of varieties, and most importantly employment. Proposition 1 and 2 summarize the relative size of cut-off productivities.

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

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

Lemma 1 *The outsourcing cut-off productivity relative to the entry cut-off productivity is the lowest under the pattern A and the highest under the pattern C of the outsourcing 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 cut-off productivity relative to the entry cut-off productivity is the lowest under the pattern A and the highest under the pattern C. The value for the 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 A.1

The first implication of Proposition 1 is that the entry cut-off productivity rises with outsourcing regardless of the pattern of operation in the outsourcing equilibrium. This implies that the least productive firms in the initial open economy equilibrium exit as outsourcing becomes feasible. As prices of outsourcers decrease, non-outsourcers face a rise in their relative prices and a fall in the demand for their products. To the firms who made small profits in the initial open economy equilibrium, such a sales loss is enough to turn their positive profits into negative ones, driving them out of the market. I call this *the Cleansing Effect of Offshore Outsourcing.*[10] The cleansing effect is directly related to the employment level of the industry. As firms exit, all workers hired by the exiting firms lose jobs. This implies that non-outsourcers can be a source of significant amount of outsourcing-related job losses. In section 4, I quantify the size of the job losses due to the cleansing effect by calibrating parameter values.

Proposition 1 also shows that the cleansing effect is larger where outsourcing is relatively

[10]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.

easy (pattern A). In this case, more firms take advantage of outsourcing; therefore, the price index goes further down. This enlarges the cleansing effect. As more firms exit under the pattern A than under the pattern C, job destruction due to the cleansing effect is also larger under the pattern A. Therefore, in an industry where outsourcing is relative easy to carry out - industries with easily transferrable technology, less issue of intellectual property right, and smaller potential variation in quantity, such as textile, apparel, and footwear - the job destruction due to the cleansing effect is expected to be more significant. It is also worth noting that there is a rise in the availability of outsourcing advisory services[11] which potentially reduces the fixed cost of outsourcing. This trend might expand the influence of the cleansing effect on employment.

Proposition 2 *The cut-off productivity for outsourcing is the lowest under the outsourcing equilibrium pattern A and the highest under the pattern C; that is,*

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

Proof : See Appendix A.2

Proposition 2 implies that outsourcing is profitable for firms with lower productivities under the pattern A than under the pattern B or C. In other words, more firms will take advantage of outsourcing opportunities. This is not surprising since pattern A is where the fixed outsourcing cost is the lowest among the outsourcing equilibrium pattern A, B, and C.

Unlike the entry cut-off productivity, export cut-off productivity does not uniformly rise or decrease with outsourcing. Whether it increases or decreases depends on the parameter values and the sizes of various fixed costs. Generally, though, export cut-off productivity is low where fixed outsourcing cost is small (pattern A). This is because outsourcing benefits

[11]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)

exporters more than non-exporters by bringing about a large reduction in exporters' prices in their foreign markets. This generates a significant rise in their revenues. Such an increase in revenue allows firms with lower productivities to export. In other words, outsourcing expands export opportunities; so, the export cut-off productivity is lower where outsourcing is fairly easy. Under pattern A, all exporters are outsourcers; and even the exporter with the lowest productivity (z_x^A) , whose export profit is zero, experiences a rise its revenue. In the absence of outsourcing, this firm's revenue falls short of the fixed export cost; thus, it would not export. For this reason, the export cut-off productivity falls under the pattern A. Under the pattern C, the exporters with the lowest productivity (z_x^C) is a home-producer, and its relative price is higher in the outsourcing equilibrium. In the absence of outsourcing, this firm makes positive profit rather than zero profit, so the xport cut-off productivity - the zero-profit productivity for exporting) must be lower $(z_x^0 < z_x^C)$. Pattern B is the intermediate case, and the sign of the change in the export cut-off productivity is ambiguous.

3.1 Firm-level Operational Responses to Outsourcing under the Pattern A

In this section, I briefly discuss how different firms respond to outsourcing in more detail by presenting the case under the outsourcing equilibrium pattern A. Figure 7 depicts the cut-off productivities of both the initial open economy equilibrium and the outsourcing equilibrium. These cut-off 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. As feasibility of outsourcing results in different operational responses for different groups of firms, the employment implications also differ across groups.

The firms in the group (A.b) are forced to exit due to the *Cleansing Effect*. As these firms shut down, the workers previously employed by these firms will be laid off generating pure job destruction. The firms in the group (A.c) survive as home-producers. I call these firms *Home-Producers*. Although they do not change their operational behavior, their relative prices rise; thus, they suffer from a decrease in sales which, in turn, results in layoffs.

The firms in the group (A.d) are the firms that switch from being non-exporting home-producers to non-exporting outsourcers. I call these firms *New Outsourcers.* The change in the assembly location involves job destruction;however, the price reduction generates a rise in demand. In order to meet the higher demand, these firms have to hire more workers in their service segments creating new jobs. Thus, in this group, there will be both job destruction and job creation. Depending on the relative size of these two effects, the net employment effect may be either positive or negative.

The firms in the group (A.e) are *New Exporters* switching from being non-exporting home-producers to exporting outsourcers. The initiation of export operation brings these firms a whole new market, and the increase in sales due to market expansion generates a large number of new jobs. Especially, the employment in the export operation is pure job creation. In their domestic operations, there is job destruction as well as job creation, as for new outsourcers.

The firms in the group (A.f) are *Existing Exporters*, but they move their assembly operation to the South. In the initial equilibrium, the domestic operation accounts for majority of their sales due to the price disadvantage that they face in their foreign markets. As they outsource, elimination of such price disadvantage raises their foreign sales more than their domestic sales. Thus, larger portion of job destruction occurs in their domestic portion of job destruction occurs in their domestic sales while more jobs are created in the export operations.

When one looks empirically at the aggregate employment Figures over time from the period with little outsourcing to the period with a significant portion of market composed of outsourcers, one only observes the net change in employment, which is a mixture of job destruction and creation in different types of firms. The structural model introduced in sections 2 enables us to separate job destruction and job creation, and the relative size of employment changes in different groups of firms.

3.2 Distributional Assumption

Under a certain functional assumption for the productivity distribution, G(z), we can derive more practical implications. For the rest of the theoretical analysis and the numerical analysis, I assume that the productivity draws follow a Pareto Distribution.[12] The Cumulative Distribution Function $G(z)$ is

$$G(z) = 1 - \left(\frac{z_{min}}{z}\right)^{\eta} \qquad \text{where} \quad \eta > \varepsilon - 1 \ \text{ and } \ z \geq a \tag{47}$$

z_{min} is the minimum value of z, and η is the shape parameter that determines the dispersion of the productivity draws. Large η implies low dispersion; that is, large mass is concentrated at the low productivity. With small η, productivity draws are more evenly distributed, so the chance of drawing higher productivity is larger. For this reason, the shape parameter is crucial in determining the overall productivity level of an industry and the cut-off productivities in equilibria. The inequality, $\eta > \varepsilon - 1$ is required for the average productivity to be finite.

Under the Pareto distribution, the probabilities of outsourcing and exporting can be written in a very simple form. For example, the probability of exporting in the initial open economy equilibrium - equation (21) - can be written as the following.

$$Pr_x^0 = \left(\frac{z_{hp}^0}{z_x^0}\right)^{\eta}$$

Then, lemma 1 and 2 have direct implications on the composition of the market. They show that both the fraction of outsourcers and exporters among domestic firms are the largest under the pattern A and the smallest under the pattern C in the outsourcing equilibrium. This confirms that outsourcing promotes exporting, hence, international trade.

Under this distributional assumption, $k(\hat{z})$ is a constant that is independent of $\hat{z}$. I

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

define k as the constant value of $k(\hat{z})$ as follows.

$$k = k(\hat{z}) = \frac{\varepsilon - 1}{\eta - \varepsilon + 1} \tag{48}$$

Since $\eta > \varepsilon - 1$, k is positive. Using equations (47) and (48), I can rewrite equilibrium conditions for the initial open economy equilibrium and the outsourcing equilibrium A.

$$\bar{\pi}^0 = kf + \left(\frac{z_{hp}^0}{z_x^0}\right)^\eta kf_x = \frac{\xi f_e}{1 - G(z_{hp}^0)} \tag{49}$$

$$\bar{\pi}^A = kf + \left(\frac{z_{hp}^A}{z_{os}^A}\right)^\eta kf_{os} + \left(\frac{z_{hp}^A}{z_x^A}\right)^\eta kf_x = \frac{\xi f_e}{1 - G(z_{hp}^A)} \tag{50}$$

Using the same derivation method that is used in deriving equation (50), we can obtain the equivalent expression that constitute equilibrium conditions for patterns B and C as follows.

$$\bar{\pi}^B = kf + \left(\frac{z_{hp}^B}{z_{os}^B}\right)^\eta k(f_{os} + f_x) = \frac{\xi f_e}{1 - G(z_{hp}^B)} \tag{51}$$

$$\bar{\pi}^C = kf + \left(\frac{z_{hp}^C}{z_{os}^C}\right)^\eta kf_{os} + \left(\frac{z_{hp}^C}{z_x^C}\right)^\eta kf_x = \frac{\xi f_e}{1 - G(z_{hp}^C)} \tag{52}$$

The rank of the entry cut-off productivities shown by Proposition 1 together with the change in the export cut-off productivities discussed in the previous section has a direct implication on the number of varieties in each equilibrium. The following Propositions summarize the impact of outsourcing on product varieties.

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

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

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

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

Proof : See Appendix A.3 and A.4

Proposition 3 implies, first, that the number of domestic varieties decrease with outsourcing, and second, that the decrease in domestic varieties gets larger as outsourcing intensifies. Under the outsourcing equilibrium pattern A - the equilibrium with the greatest extent of outsourcing activities - there are fewer domestic varieties than any other equilibrium. This is due to the cleansing effect. As shown in Proposition 1, the magnitude of the cleansing effect is large where outsourcing 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 (same as the number of exporters) does not uniformly increase or decrease. The pattern of increase and decrease resembles that of the export cut-off productivities. The number of imported varieties under the outsourcing equilibrium pattern A is larger than that of the initial open economy equilibrium ($M_x^A > M_x^0$). Since outsourcing benefits exporters more than non-exporters, the relative easiness of outsourcing promotes exporting very much. Under the pattern C, low-productivity exporters are not outsourcers, and outsourcing generates the cleansing-like effect on home-producing exporters as well. As price index falls in both markets due to outsourcing, home-producing exporters face a rise in their relative prices in their foreign markets. Some firms' profits turn negative and they have to exit. In the process, the number of imported varieties decreases ($M_x^C < M_x^0$). The pattern B is the intermediate case, and the sign of the change in the number of imported varieties is ambiguous.

Proposition 4 summarizes the changes in the numbers of domestic and imported varieties. It states that the total number of varieties that are available to consumers unambiguously falls as outsourcing becomes feasible. This is rather surprising since the increase in product variety is often discussed as one of the most important gains from international trade. This negative effect of outsourcing on product variety is a result of the cleansing effect. Especially under the outsourcing equilibrium pattern A, the number of imported varieties rises; but the decrease in domestic product variety due to the cleansing effect dominates the rise in imported product variety, resulting 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 on the employment effect of outsourcing. However, the total impact should include changes within firms - sales loss of surviving home-producers, layoffs by outsourcers, and sales expansion of outsourcers. The next section presents the employment effect of outsourcing.

3.3 Employment

Total employment of an industry consists of production employment by active firms and the investment made by new entrants. The production employment, then, consists of assembly, services and fixed cost employment of home-producers, outsourcers, exporters and non-exporters. Since each equilibrium - the initial open economy equilibrium and three outsourcing equilibrium patterns - is composed of different groups of firms, the total employment should be calculated separately. In this section, I presents the initial open economy equilibrium, and the outsourcing equilibrium pattern A. Employment under the patterns B an dC resemble that of the pattern A.

3.3.1 Initial Open Economy Equilibrium

There are two types of firms in this equilibrium - non-exporting home-producers and exporting home-producers. We can separate these firms' operations into two categories: first, domestic operation by home-producers and, second, export operation by home-producers. M_d^0 firms - firms with $z \geq z_{hp}^0$ - serve domestic markets and each firm's labor requirement for domestic operation is the same as equation (6). Total employment for domestic operations can be obtained by multiplying the number of firms, M_d^0 to the average labor requirement by these firms, which is as follows.

$$l_{d,hp}(\tilde{z}(z_{hp}^0)) = f + \frac{q_{d,hp}(\tilde{z}(z_{hp}^0))}{\tilde{z}(z_{hp}^0)} \tag{53}$$

$q_{d,hp}(.)$ is the quantity of domestic sales and is defined by equation (2). M_x^0 firms - firms with $z \geq z_x^0$ - export, and the average labor requirement of these firms' export operation is as follows.

$$l_{x,hp}(\tilde{z}(z_x^0)) = f_x + \frac{\tau q_{x,hp}(\tilde{z}(z_x^0))}{\tilde{z}(z_x^0)} \tag{54}$$

Using equations (2), (7), (10), (53), and (54), we obtain the number of production workers as the following.[13]

$$\rho R + M_d^0 f \left[1 + \left(\frac{z_{hp}^0}{z_x^0}\right)^\eta \frac{f_x}{f}\right] \tag{55}$$

The entry investment employment is $M_e^0 f_e$ where M_e^0 is the number of new entrants each period in the equilibrium. In the steady state, number of successful entry each period must be equal to the number of firms death; that is $\left[1 - G(z_{hp}^0)\right] M_e^0 = \xi M_d^0$. Therefore, the entry investment employment is, using equation (49),

$$M_e^0 f_e \;=\; M_d^0 \bar{\pi}^0 \;=\; M_d^0 \; kf \left[1 + \left(\frac{z_{hp}^0}{z_x^0}\right)^\eta \frac{f_x}{f}\right] \tag{56}$$

Equation (56) implies that the total amount of resources used as entry investment is equal to the total profit of active firms. This ensures that the industry as a whole yields zero profit in the equilibrium. Now, the total employment in the initial open economy equilibrium is sum of equations (55) and (56).

$$Emp^0 = \rho R + M_d^0 \; (k+1) f \left[1 + \left(\frac{z_{hp}^0}{z_x^0}\right) \frac{f_x}{f}\right] \tag{57}$$

[13] also used are i) $\tilde{z}(z_x^0) = \tilde{z}(z_{hp}^0)\left(\frac{z_x^0}{z_{hp}^0}\right)$ ii) $M_x^0 = \left(\frac{z_{hp}^0}{z_x^0}\right)^\eta M_d^0$

iii) $P_0^{\varepsilon-1} = \left[M_t^0 \rho^{\varepsilon-1} \tilde{z}_t^{0\varepsilon-1}\right]^{-1}$ equation (18)

iv) $\tilde{z}_t^{0\varepsilon-1} = \frac{M_d^0}{M_t^0} \tilde{z}(z_{hp}^0)^{\varepsilon-1} \left[1 + \tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}\right]$: equation (17)

Emp^0 denotes total employment in this industry in the initial open economy equilibrium. In order to simplify further, I assume that the total labor compensation is eual to the total expenditure in this industry in the initial employment. Since the wage rate is 1, Emp^0 must be R. Then, the total initial employment in this industry, equation (57), can be re-written as the following:

$$Emp^0 = \; R \; = \; \varepsilon M_d^0 \; (k+1) f \left[1 + \left(\frac{z_{hp}^0}{z_x^0} \right)^\eta \frac{f_x}{f} \right] \tag{58}$$

3.3.2 Outsourcing Equilibrium Pattern A

There are three types of firms in this equilibrium: nont-exporting home-producers, non-exporting outsourcers, and exporting outsourcers. Their operations can be divided into three categories; first, home-producers' domestic operation; second, outsourcers' domestic operation; and finally, outsourcers' export operation. There are M_{hp}^A home-producers and their productivities lie between z_{hp}^A and z_{os}^A. Their average productivity, $\tilde{z}_{hp}^A$, is described by equation (38). The average number of workers haired by their domestic operation is as follows.

$$l_{d,hp}(\tilde{z}_{hp}^A) = f + \frac{q_{d,hp}(\tilde{z}_{hp}^A)}{\tilde{z}_{hp}^A} \tag{59}$$

M_{os}^A firms, whose productivities are such that $z \geq z_{os}^A$, outsource and serve their domestic markets. Their assembly segments are sent to the South, and the final product need to be shipped from the South; therefore, the average labor requirement for these firms' domestic operation is

$$l_{d,os}(\tilde{z}(z_{os}^A)) = f + f_{os} + \frac{\tau \gamma q_{d,os}(\tilde{z}(z_{os}^A))}{\tilde{z}(z_{os}^A)} \tag{60}$$

Similary, each outosurcer' export operation - carried out by M_x^A firms - requires the following number of workers on average.

$$l_{x,os}(\tilde{z}(z_x^A)) = f_x + \frac{\tau \gamma q_{d,os}(\tilde{z}(z_x^A))}{\tilde{z}(z_x^A)} \tag{61}$$

The total number of production workers in this industry is $M_{hp}^A \, l_{d,hp}(\tilde{z}_{hp}^A) + M_{os}^A \, l_{d,os}(\tilde{z}(z_{os}^A)) + M_x^A l_{x,os}(\tilde{z}(z_x^A))$. The entry investment employment is again $M_e^A f_e$; and, in the steady state equilibrium, it must be that $\left[1 - G(z_{hp}^A)\right] M_e^A = \xi M_d^A$. From equation (50), the entry investment employment in the outsourcing equilibrium pattern A is as follows.

$$M_e^A f_e \;=\; \bar{\pi}^A M_d^A \;=\; kf\left[1 + \left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta} \frac{f_{os}}{f} + \left(\frac{z_{hp}^A}{z_x^A}\right)^{\eta} \frac{f_x}{f}\right] \tag{62}$$

Then, the total employment in this industry is, using equations (2), (28), (38), (59) - (62), the following[14]:

$$\begin{aligned} Emp^A = R\left(\frac{\varepsilon-1}{\varepsilon}\right)\frac{M_d^A}{M_d^0}\left\{\frac{1+\left[\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z_{os}^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta} + \frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}\left(\frac{z_x^A}{z_{hp}^A}\right)^{\varepsilon-1-\eta}}{1+\tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}}\right\} \\ + (k+1)M_d^A f\left[1 + \left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta}\frac{f_{os}}{f} + \left(\frac{z_{hp}^A}{z_x^A}\right)^{\eta}\frac{f_x}{f}\right] \end{aligned} \tag{63}$$

In a similar manner, we can obtain toal employment in the outsourcing equilibrium patterns B and C.

3.3.3 Employment Effect of Outsourcing

The analysis of the impact of outsourcing on employment requires comparison between total initial employment and total employment in the outsourcing equilibrium employment. The ratio between two total employment can be obtained using equations (58), (63), (A.3.2),

[14]also used are: i) $M_{os}^A = \left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta} M_d^A$; $M_x^A = \left(\frac{z_{hp}^A}{z_x^A}\right)^{\eta} M_d^A$; $M_{hp}^A = \left[1 - \left(\frac{z_{hp}^A}{z_{os}^A}\right)^{\eta}\right] M_d^A$

ii) $\tilde{z}(z_{os}^A) = \tilde{z}(z_{hp}^A)\left(\frac{z_{os}^A}{z_{hp}^A}\right)$; $\tilde{z}(z_x^A) = \tilde{z}(z_{hp}^A)\left(\frac{z_x^A}{z_{hp}^A}\right)$

iii) $\tilde{z}(z_{hp}^A) = \tilde{z}(z_{hp}^0)\left(\frac{z_{hp}^A}{z_{hp}^0}\right)$ iv) $P_A = P_0\left(\frac{z_{hp}^A}{z_{hp}^0}\right)$

v) $P_0^{\varepsilon-1} = \left\{\rho^{\varepsilon-1} M_d^0 \tilde{z}(z_{hp}^0)^{\varepsilon-1}\left[1 + \tau^{1-\varepsilon}\left(\frac{z_x^0}{z_{hp}^0}\right)^{\varepsilon-1-\eta}\right]\right\}^{-1}$: equations (17) & (18)

and (A.3.3)[15], as the following[16] :

$$\frac{Emp^A}{Emp^0} = \left(\frac{\varepsilon-1}{\varepsilon}\right)\left(\frac{z^0_{hp}}{z^A_{hp}}\right)^{\eta}\left\{\frac{1+\left[\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{z^A_{os}}{z^A_{hp}}\right)^{\varepsilon-1-\eta}+\frac{\gamma}{\lambda}(\tau\lambda)^{1-\varepsilon}\left(\frac{z^A_{x}}{z^A_{hp}}\right)^{\varepsilon-1-\eta}}{1+\tau^{1-\varepsilon}\left(\frac{z^0_{x}}{z^0_{hp}}\right)^{\varepsilon-1-\eta}}\right\}+\frac{1}{\varepsilon} \tag{64}$$

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 fixed costs and entry investment is, from equation (58), constant at $\frac{R}{\varepsilon}$ which is the markup portion of the total revenue in this industry. This means that the total expenditure in this industry goes entirely to workers - both Northern and Southern workers - as a compensation.

The first part of the first term $\left(\frac{\varepsilon-1}{\varepsilon}\right)$ indicates the variable cost portion of employment. If the first term excluding $\left(\frac{\varepsilon-1}{\varepsilon}\right)$ is equal to one, outsourcing has no impact on total employment. The second part of the first tem - the ratio between two entry cut-off productivities - represents the cleansing effect. As z^A_{hp} is larger than z^0_{hp}, employment in the outsourcing equilibrium decrease. The terms in the curly bracket is the comparison of average firm-level employment.

Using equation (64) and the equivalent expressions for the outsourcing equilibrium patterns B and C, I can summarize the effect of outsourcing on total employment of the subject industry in Proposition 5.

Proposition 5 Outsourcing Results in Net Job Loss: *Outsourcing unambiguously reduces the aggregate employment.*

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

[15]from Appendix 3

[16]Also uses the fact that $\frac{M^A_d}{M^0_d} = \left(\frac{z^0_{hp}}{z^A_{hp}}\right)^{\eta}$ which is obtained from equations (A.3.2), (A.3.3), (49), and (50) in the following way: $\frac{\bar{\pi}^0}{\bar{\pi}^A} = \frac{1-G(z^A_{hp})}{1-G(z^0_{hp})} = \left(\frac{z^0_{hp}}{z^A_{hp}}\right)^{\eta} = \frac{1+\left(\frac{z^0_{hp}}{z^0_x}\right)^{\eta}\frac{f_x}{f}}{1+\left(\frac{z^A_{hp}}{z_{os}}\right)^{\eta}\frac{f_{os}}{f}+\left(\frac{z^A_{hp}}{z^A_x}\right)^{\eta}\frac{f_x}{f}} = \frac{M^A_d}{M^0_d}$

Proof: See Appendix A.5

Emp^B and Emp^C denote total employment levels under the outsourcing equilibrium patterns B and C. Proposition 5 strongly suggest that outsourcing does hurt employment at the aggregate level regardless of the difficulty of outsourcing. Different groups of firms (as seen in Figure 7) destroy and create different amount of jobs under different patterns; but the sum of various employment responses is always negative.

4 Numerical Analyses

Proposition 5 may serve as a supporting argument for the public concern that outsourcing destroys U.S. manufacturing jobs. However, the blame by the public is very concentrated on the outsourcing firms rather than the whole economy. As shown by Proposition 1 and Figure 7, there are firms that exit due to lack of competitiveness and, they generate pure job destruction which could possibly explain the negative employment effect. Whether outsourcing firms alone bring out net employment loss requires further investigation. For this purpose, I perform various numerical analyses to quantify the employment implications of different groups of firms, and their job destruction and creation separately. This provides valuable information on the employment dynamics that is not observable without very detailed operational data on every firm in the economy.

4.1 Calibration

There are six parameters in this model, transport cost (τ), relative Southern efficiency wage (δ), employment share of the service segment (γ), marginal production cost of outsourcers relative to home producers (λ), elasticity of substitution (ε), and the shape parameter of Pareto distribution (η).

First, τ=1.3 is chosen 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 transit cost, time cost of transit, and tariffs) and the remaining 40% is border-related cost (language, currency, information, and security). Since I have a fixed cost of exporting in addition to transport cost, I take 30% of the tariff-equivalent transport cost for the analyses. Second, δ=0.5 is chosen from the data on manufacturing wage and productivity of the US (from Bureau of Economic Analysis, BEA) and Mexico (Instituto Nacional de Estadistica y Geografia, INEGI) for 2000.[17] Third, the 2002 Census of Manufactures reports that the share of non-production workers in US manufacturing employment is 29.6%. I use γ=0.3. Fourth, λ is simply a combination of δ and γ, equation (27), with δ=0.5 and γ=0.3 implying that λ=0.65.

Fifth, Broda and Weinstein (2006) estimate various elasticities for different aggregation levels (3-, 4-, 5-digit) of SITC manufacturing industry classifications (Rev.2 for 1972-1988, Rev.3 for 1990-2001). I use the estimates of 4-digit SITC for the period 1990-2001 whose median is 2.53 and mean is 5.88. The high value of the mean is due to a few outliers. For the analyses, I choose ε=3. Lastly, η=4 is chosen for the shape parameter of Pareto distribution. For this, I match the model's prediction on the market share of imports of the initial open economy equilibrium to the 1992 US manufacturing industry. According to BEA's report, imports accounted for 18.08% of the US manufacturing market in 1992. The model's prediction gives us a range of market share of imports for different size of fixed export cost rather than a single value. The range that includes 18.08% is generated by η=4.

[17] Chinese efficiency wage was 40% of the US in 2000. Data source: National Bureau of Statistics of China

4.2 Net Employmnet Effect

The total employment includes the production workers - assembly and service workers, workers hired as fixed production cost, fixed export cost, and fixed outsourcing cost - and the entry investment employment - the sunk entry cost portion of employment. In the equilibrium, the entry investment employment accounts for 17% of the total initial employment under the benchmark set of parameters.

Figure 8 shows the net employment change as a share of total initial employment. Panel (a) presents the entire $\alpha - \beta$ space.[18] It tells us that for very small β, the economy loses up to 36% of its initial employment. As can be seen by equation (64), (A.5.1), and (A.5.2),[19] the fixed and sunk costs portion of employment is a fixed share of total initial employment regardless of equilibrium; so the employment response shown in Figure 8 comes solely from the changes in the numbers of assembly and service workers.

Panel (a) also tells us that the net employment loss depends greatly on the size of β and relatively little on the size of α. As β increases - as outsourcing becomes more difficult - the net employment loss decreases dramatically. In this model, the feasibility of outsourcing is the only shock to the economy. Where outsourcing is very difficult (large β), the feasibility alone is not enough to induce many firms to outsource. As smaller number of firms outsource, the overall effect of outsourcing on the economy is also small, resulting in a smaller net job loss. Panel (b) presents net employment effect for selected values of alpha. This shows the dependency of employment response on the size of β more clearly. Net employment effect approaches to zero where β is very large, but never becomes positive. Overall, the net job loss is quite sizeable for reasonable value of β.

In order to understand the net employment effect of outsourcing better, we need to look at it at more disaggregate level. Figure 9 presents the net employment effect of

[18]Recall $\alpha = \frac{f_x}{f}$ and $\beta = \frac{f_{os}}{f}$

[19]from Appendix A.5

five different groups of firms under the Pattern A discussed in Figure 7. The vertical axes show the size of employment change as a share of total initial employment. Overall, the employment effects of different groups of firms differ dramatically in signs, sizes, and shapes. These diagrams show that analysis of only the aggregate employment change unintentionally discards a lot of valuable information. Panel (a) is the net employment effect for all firms and is identical to Figure 8. Also, summing panels (b) to (f) of Figure 9 yields panel (a).

The most noticeable features are the negative employment effect of the cleansing effect. As can be seen by comparing the units of measurement along the vertical axes, the magnitude is overwhelmingly large compared to other groups' employment effects. Other firm groups show different responses to offshore outsourcing, but their magnitudes are all small relative to that of the cleansing effect. For the benchmark parameters, non-exporting outsourcers - New Outsourcers, panel (d) - and exporting outsourcers who previously exported - Existing Exporters, panel (f) - fail to create net job gain. The increase in sales is not large enough to offset the layoffs of assembly workers. New exporters, on the other hand, create more jobs than they destroy. Although the magnitude is small, it shows that one of the major benefits of offshore outsourcing is that it gives some of outsourcers the opportunity to expand their business to foreign market. Overall, the net job loss that outsourcing brings about is driven by job destruction due to the cleansing effect; and, its negative effect is somewhat offset by the net job creation of new exporters who are give then opportunities to export due to the price reduction from outsourcing.

Patterns B and C do not share the same categorization of firms as presented in Figure 7. However, in all equilibria, firms can be categorized into three major groups. First, *Cleansing Effect* - the firms that initially were non-exporting home-producers who then are forced to exit in the outsourcing equilibrium; second, *Home-Producers* - home-producers that survive and choose not to outsource regardless of their export orientation; and finally, *Outsourcers* - outsourcing firms regardless of their export orientation. For pattern A, the group (A.b) Cleansing Effect belongs to the firm group Cleansing Effect for obvious reason. The group (A.c) Home-Producers belongs to the firm group Home-Producers, the rest of firms, group (A.d) New Outsourcers, (A.e) New Exporters, and (A.f) Existing Exporters, belong to the firm group Outsourcers. The export orientation of Home-Producers changes across patterns. For instance, no home-producers in pattern A export, but some in pattern C do. There are non-exporting as well as exporting outsourcers in pattern A, but all outsourcers export in pattern C.

Figure 10 presents the net employment effect of the cleansing effect, home-producers, and outsourcers for the entire $\alpha - \beta$ space. The cleansing effect again shows dominance in magnitude. One can also notice the resemblance of the net employment of the cleansing effect alone - panel (a) - to panel (a) of Figure 8. This confirms the dominance of the cleansing effect in driving the overall effect of outsourcing on total employment. The effect of home-producers is generally small. The net employment effect of outsourcers is very negative for very small β, but the magnitude decreases rapidly as β rises, and in fact becomes positive for a certain range of α and β. This implies that job creation of outsourcers exceeds their job destruction in that range. Overall, the net employment loss by outsourcers is less than 10% of total initial employment, and is smaller for relatively large values of β.

Figure 9, and 10, strongly suggest the dominance of the cleansing effect in employment responses to offshore outsourcing. In an attempt to summarize, Figure 11 shows the net employment loss due to the cleansing effect as a share of total net employment effect for selected values of α. Job destruction due to cleansing effect takes up to 70-75% of total net employment loss for small value of β, and more than 50% for the most range of α and β. As β rises, the cleansing effect gets quite small (panel (a), Figure 10); however, total net job loss also decreases, keeping the fraction of it due to the cleansing effect approximately constant after $\beta = 20$. The lower bound for the value of *beta* for the values of *alpha* shown is around 45%.

One might wonder whether the dominance of the cleansing effect in outsourcing-related employment response is specific to the parameter values chosen for the benchmark case. Figure 12 presents the net employment effect for various deviations from the benchmark parameter values. The first column shows the total net employment effect, the second column is that due to the cleansing effect, and the last column is that of survivors. All figures are relative to the total initial employment, so that the sum of the second and third columns yields the first column. These figures show how total net employment effect change and how significant the cleansing effect is in driving the aggregate net employment change for different sets of parameter values. Figure 13 shows the cleansing effect as a share of total net employment effect for the six sets of parameter values that are analyzed in Figure 12.

There are three main messages that we can learn from Figures 12 and 13. First, the dominance of the cleansing effect in employment response to offshore outsourcing is preserved for various sets of parameter values. This is easier to see in Figure 13. The cleansing effect takes up significant portion of total employment loss in all six cases although the size varies across different parameter values used. In panel (b) and (d), job destruction from cleansing effect exceeds the total net employment loss. In these two cases, survivors together generate net gain of jobs for a certain values of α and β. In panel (a) and (e), the cleansing effect is smaller, but still is more than 18% of total net employment loss.

Second, as mentioned briefly above, survivors generate net employment gain for some parameter values. Panel (d) shows the most significant job gain. This is where the Southern wage rate is very low relative to Northern wage rate. Lower Southern wage rate is directly related to the size of benefits that one firm can realize from relocating its assembly segment. Outsourcing lowers outsourcers price very much, in turn raises their sales volume very much. Outsourcers have to newly hire large number of service workers in order to meet the massive increase in sales.

Third, total net employment effect is always very negative. This is the case even when there is significant amount of job creation by outsourcers - as in panel (d). The cleansing effect is always significantly large to more than offset the job creation. This can be easily explained why. Where the benefit from outsourcing is very large, so outsourcers generate large amount of new jobs, more firms will want to outsource. As a result, the overall price level falls greatly, more of home-producers with low productivity will eventually be driven out of market; thus, larger cleansing effect. Whenever outsourcing affect the market in a larger scale, the cleansing effect gets larger as well, generating net loss of employment in any case.

Besides the three major points, Figures 12 and 13 convey a lot of valuable information about outsourcing. The labor market responses to offshore outsourcing in their magnitude and the sensitivity to the size of fixed export and outsourcing costs differ across different sets of parameter values. In comparison between panels (a) and (b), the job destruction due to the cleansing effect of small shape parameter of Pareto distribution is much less sensitive to the value of β. From panel (a) and (b) of Figure 13, we can also see that in the case of small shape parameter, the cleansing effect accounts for much smaller portion of total net employment effect. Under a small shape parameter (η), productivity draws are more evenly distributed. Therefore, more firms belong to the groups of outsourcers and home-producers, and less firms belong to the group of the cleansing effect compared to the case with high η. A smaller number of firms in the cleansing effect group directly implies smaller job destruction due to the cleansing effect. Where η is high, large mass is concentrated at the bottom of productivity spectrum, so there are more firms in the cleansing effect group, and less firms in the groups home-producers and outsourcers.

The high sensitivity of the net employment effect under high η also stems from the high concentration of firms at low productivity. Where outsourcing is very easy (very low β), the cut-off productivity for outsourcing is low enough to reach the range of productivity with significant mass of firms. In this case, outsourcing affects substantial portion of the market; and, the large fall in price index will generate large cleansing effect, and hence, large change in employment. However, since the mass is so concentrated at the bottom of productivity spectrum, it requires a very small value of β to generate this result. For a reasonably high value of β, the cut-off productivity for outsourcing would not be low enough to induce a lot of outsourcing activity. The market is simply not affected by outsourcing much in this case, generating very small employment response as can be seen in panel (b) in Figure 12.

Panels (c) and (d) present the sensitivity of employment responses to the size of Southern wage rate, δ. Southern wage rate determines the attractiveness of outsourcing. Under the benchmark parameter value ($\delta = 0.5 \leftrightarrow \lambda = 0.65$), the price reduction from outsourcing is 15% for domestic sales ($\tau\lambda = 0.845$) and 35% for foreign sales ($lambda = 0.65$). Given τ =1.3, $\delta = 0.6$ - panel (c) - implies that the price reduction for domestic sales is only 6% ($\tau\lambda = 0.936$) and that for foreign sales is 28% ($\lambda = 0.72$). There is very small incentive to outsource if a firm does not export. Outsourcing is still attractive to exporters because of the elimination of price disadvantage in their foreign market. Therefore, there are outsourcing firms, but less than in the case with small δ. Also, the effect of outsourcing on the price index is small since the price reduction from it is small. For this reason, the overall employment response is also small - small cleansing effect, small net employment loss by survivors, and hence, small total net employment loss. On the other hand, $\delta = 0.3$ - panel (d) - implies 34% price reduction for domestic sales and 49% price reduction for foreign sales. Small δ enlarges the benefit of outsourcing, outsourcers generate net employment gain. The job creation is so big, the net employment effect of survivors is still positive even after combining job destruction from home-producers. However, as discussed above, the attractiveness induces large number of firms to outsource, lowering the price index by much, thus raising the magnitude of the cleansing effect. Despite the large net employment gain by survivors, the total net employment effect is still negative due to the large cleansing effect.

Panel (e) shows the net employment effect under high elasticity of substitution (ε). The cleansing effect is the smallest among the six cases studied in Figures 12 and 13 in terms of its share of total net employment loss. High ε means that consumers are more price-sensitive. In the initial open economy equilibrium, low price (high productivity) firms serve larger share of the market with high η, hence, employ larger portion of the total employment. This implies less workers are hired by firms in the cleansing effect group. Thus, the cleansing effect from outsourcing results in smaller number of job destruction. Despite the smaller cleansing effect, the net employment loss under high ε is very large. This is driven by large job losses of survivors. This is somewhat counter-intuitive since high elasticity is often translated into larger consumption switch in response to price reduction. The price reduction from outsourcing is expected to generates large sales gain, thus, large job creation. However, there is another dimension to consider. Outsourcers employ large numbers of assembly workers as well as service workers in the initial equilibrium. As they outsource, the number of workers they outsource is also very large; and in this case the larger job destruction dominates the large job creation that high ε brings about. Also, the sensitivity of consumer response to outsourcers' price reduction reduces the sales of home-producers whose relative prices rise. Home-producers are significant source of job destruction in this case.

Panel (f) shows the effect of size of transport cost (τ) in employment response. The size of τ also affects the incentive to outsource. Given $\delta = 0.5$ ($\lambda = 0.65$), $\tau\lambda = 0.715$, meaning 28% price reduction for domestic sales, and 35% price reduction for foreign sales. The interesting thing to notice in this case is the disparity between panel (f) and (d). Both small δ and small τ increases the price reduction, but the net employment effects of survivors in two cases are vastly different. This is because how τ and δ raise the attractiveness of outsourcing are fundamentally different. Small value of τ is relevant for both the initial equilibrium and the outsourcing equilibrium, while δ is only relevant to the outsourcing equilibrium. Small τ means that the price disadvantage that an exporter faces in the initial equilibrium is small; hence, exporting is more profitable. Therefore, there would be more exporters in the initial equilibrium; and, those exporters employ more workers to serve larger quantities in their foreign market than in the case with high τ. As exporters are the high productivity firms, they are more likely to belong to the group of outsourcers than non-exporters. As outsourcing becomes feasible and these firms relocate their assembly segment to the South, their job destruction is larger since they initially employed more workers - in assembly as well as service segment. Therefore, low τ brings more job destruction by outsourcers than low δ. Also, low δ has larger price reduction for foreign sales than low τ although the price reduction for domestic sales is similar. So, outsourcing with low δ creates more jobs than with low τ. As a result, the net employment effect of survivors in panel (d) is positive while that in panel (f) is very negative.

To sum up, the cleansing effect plays a dominant role in generating net employment loss from outsourcing. This should not be interpreted as that outsourcers are not responsible for the unemployments that workers experience in the wake of offshore outsourcing. It should rather be interpreted as that when we measure the employment responses to outsourcing, we should not only focus on the employment changes within outsourcing firms and that the workers employed by non-outsourcers and, more importantly, the firms who disappear due to lack of competitiveness in the outsourcing equilibrium are very much affected and should be the subject of analyses.

4.3 Job Destruction and Creation

If the purpose of all the attempts that we make to measure the labor market implications of offshore outsourcing is to prepare proper policy tools to reduce the adjustment costs of laid-off workers, it is particularly important to measure the size of job destruction. It is often the case, in the manufacturing sector, that employment is not only decreasing, the composition of employment is moving toward a higher ratio of high-skilled jobs. This is especially true for outsourcing-related layoffs. Since labor cost reduction is the major benefit of outsourcing, firms tend to send the most low-skilled and labor-intensive parts of their businesses abroad. For this reason, the displaced workers are not readily employable in the newly created jobs that tend to be high-skilled managerial tasks.

Even if labor is quite mobile across occupations, correctly measuring the amount of job destruction is still of great importance in regard to the length of unemployment. Every job loss involves a period of unemployment, and the length of unemployment depends greatly on the availability of vacancies in the economy. As jobs are destroyed due to offshore outsourcing - from various sources; the cleansing effect, sales loss of home-producers, and relocation of assembly segment by outsourcers -, new jobs are also created by outsourcers. These jobs will absorb fraction of unemployment generated by outsourcing. Under the assumption that workers are perfectly mobile between assembly and services, the size of job destruction is the total number of unemployment. The size of job creation indicates the number of temporary unemployment, and the difference between total number of job destruction and creation, which is total net employment loss that is presented in Figure 8, measures the number of permanent employment. Again, if establishment of proper labor policy is the concern, the policy tool for permanent displacement should be different from that for temporary unemployment. For that, separate measurement of permanent and temporary unemployment is crucial.

Figure 14 compares the total net employment, total job destruction, and total job creation. While the net job loss is up to 36% of initial employment, job destruction and creation separately reach up to 59% and 23% of initial employment. This shows that looking only at net employment effect discard a lot of valuable information on changes in the labor market. According to Figure 14, 59% of workers lose their jobs. 39% of these job losses (23% of all workers) are temporary, and the rest, 61%, are of permanent nature.

Figure 15 presents decomposition of the job destruction caused by outsourcing. Panel (a) shows the total job destruction which is identical to panel (b) of Figure 14. Panel (b) is job destruction due to the cleansing effect and identical to panel (a) of Figure 10 in magnitude. Figure 16 presents job destruction due to the cleansing effect as a share of total job destruction. Where β is small, the cleansing effect accounts for 30-40% of total job destruction, then decreases as β increases. However, even for larger β, the cleansing effect is around 30% of total job destruction. Panel (c) of Figure 15 shows the job destruction by surviving home-producers. For a very small value of β, nearly every surviving firm outsources, leaving a small number of firms to stay as home-producers. The size of job destruction by home-producers is also small for that reason. Except when β is very small, the magnitude of this type of job destruction is rather constant at around 2-4% of initial employment. As β increases, the number of home-producers rises, but the impact of outsourcing on the price level gets smaller; therefore, each firm loses smaller number of workers. This together with rising number of home-producers maintains the relatively constant size of job destruction.

Panel (d) shows job destruction caused by outsourcers' relocation of assembly segment. It depends largely on the value of β because it determines how many firms outsource. The more firms outsource, the more assembly workers are let go. One should notice that outsourcers' job destruction is larger than the cleansing effect.

Although the analysis of net employment effect in the previous section finds the dominance of the cleansing effect, layoffs by outsourcers account for larger portion of the total unemployment caused by offshore outsourcing. In terms of net employment effect, new jobs that they create offset a fraction of their large number of layoffs (sometimes more than offset as seen in panel (d) of Figure 12), making their net employment loss smaller than the cleansing effect (again, they may bring net job gain). The smaller net job loss of outsourcers does not means that the new jobs created by outsourcers are filled by the workers displaced by outsourcers; therefore the job destruction by outsourcers is not less important than the cleansing effect. Rather, the cleansing effect includes both assembly and service workers while outsourcers' layoffs only include assembly workers. If labor is not perfectly mobile between segments, the service workers who are laid off due to the cleansing effect will be more easily reemployed to fill up the new service jobs created by outsourcers. However, the unemployment of the assembly workers who are laid off by outsourcers is more permanent.

Figure 16 shows the size of job destruction due to the cleansing effect and that due to the relocation of assembly segments by outsourcers as a share of total job destruction. Two panels confirm that outsourcers' job destruction is larger than what the cleansing effect brings about. According to panel (b), outsourcers' layoffs account for more than half of total job destruction cause by outsourcing where outsourcing is relatively easy to undertake (small β). For larger value of β, outsourcers' job destruction accounts for 40 - 50% of total job destruction. Panel (a) of figure 16 can be compared to figure 12. We can clearly see that the significance of the cleansing effect is substantially reduced in the context of job destruction alone, compared to that of total net employment effect.

It is also interesting to see how jobs are created by outsourcers. Figure 17 presents job creation by different type of outsourcers under Pattern A. Recall that, under the pattern A, there are New Outsourcers - non-exporting outsourcers that used to be non-exporting home-producers, New Exporters - exporting outsourcers that used to be non-exporting home-producers, and Existing Exporters - exporting outsourcers that used to be exporting home-producers. Since pattern A requires the smallest value of β, it includes largest number of outsourcers and more types outsourcers (three, more precisely) than other patterns. The total job creation is between 9-23% of initial employment, and new exporters' job creation - panel (c) - accounts for more than 60% of it (7-14% of initial employment). Where β is very small, and α is relatively large, new outsourcers - panel (b) - generate sizeable job creation because more firms belong to this category. This Figure shows that the expansion of export opportunity due to outsourcing is very important benefit of offshore outsourcing.

5 Conclusion

As outsourcing becomes feasible, some - not all - firms start outsourcing their assembly segment to the South where the wage rate is only a fraction of the Northern one. The overall price level decreases, and competition gets fiercer. As a result, the minimum productivity required to survive in the market rises, forcing large number of firms who operated at the bottom of the productivity spectrum out of the market. This is called *the cleansing effect of offshore outsourcing.* The surviving firms choose either to stay as home-producers or to start outsourcing. Home-producers destroy jobs as their relative prices rise and demand decreases. Outsourcers lay off assembly workers, but they create new service jobs as their demand rises due to price reduction. Outsourcing allows some firms to expand their operations from only their home market to their foreign market. These firms realize the largest benefits from outsourcing. At the aggregate level, various employment responses to outsourcing together generate a net loss of employment in all cases. Outsourcing also reduces the number of product varieties available for consumption.

The numerical analysis confirms the theoretical finding that outsourcing unambiguously reduces the aggregate employment. The net employment loss under the benchmark parameter values, which is calibrated to match various moments of the data, reaches up to 36% of total initial employment. This negativity of employment effect stems mostly from the cleansing effect. As a large number of small firms exit, they let go of all of their workers. Such job destruction accounts for 50-75% of the aggregate net employment loss. The sensitivity analysis shows that the dominance of the cleansing effect in driving the negative net employment effect is not specific to the benchmark parameter values and is rather a general result.

The numerical analysis also supports the previous empirical finding that the net employment effect of outsourcing firms is ambiguous. Under the benchmark parameter values, the net effect could be negative or positive depending on the difficulty of outsourcing. It ranges from 17% net loss to a net gain that is equivalent to 3% of the initial employment. Sensitivity analysis confirms the ambiguity of the employment effect of outsourcers. For different parameter values that are studied, the employment effect could be very negative (32% net employment loss) or significantly positive (12% of net gain).

The separate analysis of job destruction and creation 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 total job destruction up to 60% and total job creation up to 24%. Investigation of job destruction alone shows the significance of outsourcers' layoffs. The layoffs by outsourcers account for 45-55% of total job destruction under the benchmark parameters while the cleansing effect accounts for 29-42%.

Economists always acknowledge the fact that there are winners and losers of international trade, and it is also the case for offshore outsourcing. The winners in this context are the outsourcing firms, who enjoy a rise in their profits, and the service workers, who enjoy more employment opportunity. In this partial equilibrium model, the Northern wage is fixed at one; however, in reality, the rise in demand for service (skilled) workers will raise their wage rate while it lowers the wage rate of assembly (low-skilled) workers. In this model, it is also assumed that labor is perfectly mobile between assembly and service segments. However, this is generally not the case. In order to reduce the adjustment costs of the displaced assembly workers, proper unemployment policy tools should be prepared. As discussed above, outsourcing causes permanent as well as temporary unemployment. In order to establish an unemployment policy that serves both types of unemployment, the correct measure of the size of each type of unemployment is a prerequisite.

The results of the numerical analysis emphasize the inadequacy of currently available datasets in evaluating the aggregate labor market dynamics - gross rather than net - that outsourcing brings out. It also calls for a more detailed and thorough dataset on the outsourcing activities of U.S. manufacturing firms. The dataset should include the entire manufacturing sector rather than multinational firms alone. It should also convey the number of layoffs and new hires of production and non-production workers separately. Detailed operational information of outsourcers will help us establish a meaningful measure of industry-level outsourcing activities which then can be used to measure the levels of competitive pressure that non-outsourcers face.

Appendix. Proofs of Propositions and Lemmas

A.1 Proof of Proposition 1

A.1.1 Proof of Lemma 1

Equation (36) shows the outsourcing cut-off productivity as a function of the entry cut-off productivity for outsourcing equilibrium pattern A. The outsourcing cut-off productivities of patterns B and C are as follows.

$$z_{os}^{B} = \left[\frac{1}{2(\tau\lambda)^{1-\varepsilon}-1}\left(\frac{f_{os}}{f}+\frac{f_x}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^{B} \tag{L.1.1}$$
$$z_{os}^{C} = \left[\frac{1}{2(\tau\lambda)^{1-\varepsilon}-1-\tau^{1-\varepsilon}}\left(\frac{f_{os}}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^{C}$$

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,

$$\begin{array}{llcl} \text{pattern A:} & (\tau\lambda)^{1-\varepsilon} & \leq \beta < & \left[1-(\tau\lambda)^{\varepsilon-1}\right]\alpha \\ \text{pattern B:} & \left[1-(\tau\lambda)^{\varepsilon-1}\right]\alpha & \leq \beta < & \left\{\tau^{\varepsilon-1}\left[2(\tau\lambda)^{1-\varepsilon}-1\right]-1\right\}\alpha \\ \text{pattern C:} & \left\{\tau^{\varepsilon-1}\left[2(\tau\lambda)^{1-\varepsilon}-1\right]-1\right\}\alpha & \leq \beta & \end{array} \tag{L.1.2}$$

Equations (36), (L.1.1), and (L.1.2) together yield the following inequalities.

$$\begin{array}{rcl} 1 & \leq \left(\frac{z_{os}^{A}}{z_{hp}^{A}}\right)^{\varepsilon-1} & < (\tau\lambda)^{\varepsilon-1}\alpha \\ (\tau\lambda)^{\varepsilon-1}\alpha & \leq \left(\frac{z_{os}^{B}}{z_{hp}^{B}}\right)^{\varepsilon-1} & < \tau^{\varepsilon-1}\alpha \\ tau^{\varepsilon-1}\alpha & \leq \left(\frac{z_{os}^{C}}{z_{hp}^{C}}\right)^{\varepsilon-1} & \end{array} \tag{L.1.3}$$

Equation (46) ensures that the first inequality is valid, and equation (L.1.3) proves *Lemma 3.* **q.e.d.**

A.1.2 Proof of Lemma 2

Equations (14) and (36) show the export cut-off productivities as functions of the corresponding entry cut-off productivities for the initial equilibrium and outsourcing equilibrium pattern A. For patterns B and C,

$$z_x^B = \left[\frac{1}{2(\tau\lambda)^{1-\varepsilon} - 1}\left(\frac{f_{os}}{f} + \frac{f_x}{f}\right)\right]^{\frac{1}{\varepsilon-1}} z_{hp}^B \tag{L.2.1}$$

$$z_x^C = \tau\left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} z_{hp}^C \tag{L.2.2}$$

Equations (L.1.1) and (L.2.1) show that $z_x^B = z_{os}^B$; therefore, the size of z_x^B/z_{hp}^B, from equation (L.1.3), has the following range.

$$\tau\lambda\left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} \leq \frac{z_{os}^B}{z_{hp}^B} < \tau\left(\frac{f_x}{f}\right)^{\frac{1}{\varepsilon-1}} \tag{L.2.3}$$

Then, equations (14), (36), (L.2.2), and (L.2.3) prove *Lemma 4*. **q.e.d.**

A.1.3 Proof of Proposition 1

The proof of this Proposition utilizes the method that is used in Melitz (2003), Appendix B. The qulibrium conditions for the initial open economy - equations (26) - and the outsourcing equilibrium pattern A - (45) - can be rewritten as the following:

$$f\left[1 - G(z_{hp}^0)\right]k(z_{hp}^0) + f_x\left[1 - G(z_x^0)\right]k(z_x^0) = \xi f_e \tag{A.1.1}$$

$$f\left[1 - G(z_{hp}^A)\right]k(z_{hp}^A) + f_{os}\left[1 - G(z_{os}^A)\right]k(z_{os}^A) + f_x\left[1 - G(z_x^A)\right]k(z_x^A) = \xi f_e \tag{A.1.2}$$

The equivalent expressions for outsourcing equilibrium pattern B and C are as follows.

$$f\left[1 - G(z_{hp}^B)\right]k(z_{hp}^B) + f_{os}\left[1 - G(z_{os}^B)\right]k(z_{os}^B) + f_x\left[1 - G(z_x^B)\right]k(z_x^B) = \xi f_e \tag{A.1.3}$$

$$f\left[1 - G(z_{hp}^C)\right]k(z_{hp}^C) + f_{os}\left[1 - G(z_{os}^C)\right]k(z_{os}^C) + f_x\left[1 - G(z_x^C)\right]k(z_x^C) = \xi f_e \tag{A.1.4}$$

I define the following function.

$$j(x) = [1 - G(x)]\, k(x) \tag{A.1.5}$$

Using equations (16) and (23), we know that $j(x)$ is nonnegative, and is decreasing in x. That is,

$$j'(x) = \frac{1-\varepsilon}{x^{\varepsilon}} \int_{x}^{\infty} z^{\varepsilon-1} g(z) dz \ < 0$$

Using equation (A.1.5), I rewrite equations (A.3.1) - (A.3.4) as follows.

$$j(z^0_{hp}) f + j(z^0_x) f_x = \xi f_e \tag{A.1.6}$$

$$j(z^A_{hp}) f + j(z^A_{os}) f_{os} + j(z^A_x) f_x = \xi f_e \tag{A.1.7}$$

$$j(z^B_{hp}) f + j(z^B_{os}) f_{os} + j(z^B_x) f_x = \xi f_e \tag{A.1.8}$$

$$j(z^C_{hp}) f + j(z^C_{os}) f_{os} + j(z^C_x) f_x = \xi f_e \tag{A.1.9}$$

Equations (14), (36), (L.1.1), (L.2.1), and (L.2.2) show that all cut-off productivities are linear functions of their corresponding entry cut-off productivities. Therefore, the left-hand sides of equations (A.1.6)-(A.1.9) are decreasing in their entry cut-off productivities, $z^0_{hp}, z^A_{hp}, z^B_{hp}, z^C_{hp}$, respectively.

Suppose that four entry-cutoffs, $z^0_{hp}, z^A_{hp}, z^B_{hp}$, and z^C_{hp}, are all equal. Then, from *lemma* 3 and 4, the following is true.

$$z^A_{os} < z^B_{os} < z^C_{os} \qquad \text{and} \qquad z^A_x < z^B_x < z^C_x = z^0_x$$

Then, since $j(x)$ is decreasing in x, the left-hand side equation (A.1.7) is the largest, followed by (A.1.8) and (A.1.9). The left-hand side of equation (A.1.6) is the smallest. This is *contradiction* since the right-hand side of four equations are equal. In order to achieve the equality of left-hand and right-hand side for all equations, the size of entry cut-off productivities should be as follows.

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

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

A.2 Proof of Proposition 2

Suppose the outsourcing productivity cut-offs are the same under the outsourcing 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.

$$j(z_{hp}^A) < j(z_{hp}^B) < j(z_{hp}^C)$$
$$j(z_{os}^A) = j(z_{os}^B) = j(z_{os}^C)$$
$$j(z_x^A) < j(z_x^B) < j(z_x^C)$$

These rankings imply that the left-hand side of equation (A.1.7) is smaller than that of equation (A.1.8), which in turn is smaller than that of equation (A.1.9). This is a contradiction since the right-hand sides of equations (A.1.7) - (A.1.9) are the same. In order to equalize the left-hand sides of equations (A.1.7) - (A.1.9), it must be that

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

q.e.d.

A.3 Proof of Proposition 3.

In initial equilibrium, average revenue for an active firm is

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

Since total revenue is fixed at R, equations (A.3.1) and (49) 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 outsourcing equilibrium patterns A, B, and C. For instance, the number of domestic firms in pattern A is,

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

Using equations (A.3.2), (A.3.3), and the equivalent expressions for patterns B and C, 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* 3 and 4, I can show that equations (A.3.4) - (A.3.6) are less than 1, which then proves *Proposition 3*. **q.e.d.**

A.4 Proof of Proposition 4.

For the proof, I compare total number of available varieties of each outsourcing equilibrium pattern to that of the initial equilibrium. Firs, let us look at the outsourcing equilibrium pattern A.

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

The entry cut-off productivity under the pattern A, z_{hp}^A, is home-producers' zero profit productivity of entry as described by equation (12). Then, combining equations (9), (12), and (14) yields the following expression.

$$\left(\frac{\tilde{z}_t^A}{z_{hp}^A}\right)^{\varepsilon-1} = \frac{R}{\varepsilon f M_t^A} \tag{A.4.1}$$

$\tilde{z}_t^A$ is defined by equation (37). Substituting equation (38) into equation (37), then dividing the expression by z_{hp}^A gives us an alternative expression of equation (A.4.1) as the following.

$$\left(\frac{\tilde{z}_t^A}{z_{hp}^A}\right)^{\varepsilon-1} = \frac{M_d^A}{M_t^A}\left(\frac{\tilde{z}(z_{hp}^A)}{z_{hp}^A}\right)^{\varepsilon-1} + \frac{M_{os}^A}{M_t^A}\left[(\tau\lambda)^{1-\varepsilon}-1\right]\left(\frac{\tilde{z}(z_{os}^A)}{z_{os}^A}\right)^{\varepsilon-1}\left(\frac{z_{os}^A}{z_{hp}^A}\right)^{\varepsilon-1}$$
$$+\frac{M_x^A}{M_t^A}\left(\frac{\tilde{z}(z_x^A)}{z_x^A}\right)^{\varepsilon-1}\left(\frac{z_x^A}{z_{hp}^A}\right)^{\varepsilon-1} \tag{A.4.2}$$

Using equations (23), (36) and (48), I can re-write equation (A.4.2) as follows.

$$\left(\frac{\tilde{z}_t^A}{z_{hp}^A}\right)^{\varepsilon-1} = (k+1)\left[\frac{M_d^A}{M_t^A} + \frac{M_x^A}{M_t^A}\left(\frac{f_x}{f}\right) + \frac{M_{os}^A}{M_t^A}\left(\frac{f_{os}}{f}\right)\right] \tag{A.4.3}$$

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

$$\left(\frac{\tilde{z}_t^0}{z_{hp}^0}\right)^{\varepsilon-1} = (k+1)\left[\frac{M_d^0}{M_t^0} + \frac{M_x^0}{M_t^0}\left(\frac{f_x}{f}\right)\right] \tag{A.4.4}$$

Recall $M_t^0 = M_d^0 + M_x^0$ and $M_t^A = M_d^A + M_x^A$. Then, the term in the square bracket of equation (A.4.4) is a weighted average of 1 and $\frac{f_x}{f}$. Equivalently, the first two terms in the square bracket of equation (A.4.3) 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 $f_x > f + f_{os}$. That 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.

$$\frac{M_t^A}{M_t^A} > \frac{M_x^0}{M_t^0} \tag{A.4.5}$$

Equation (A.4.5) and the fact that $\frac{f_x}{f} > 1$ proves that the first two terms in the square bracket of equation (A.4.3) is larger than the terms in the square bracket of equation (A.4.4). Therefore, $\left(\frac{\tilde{z}_t^A}{z_{hp}^A}\right)^{\varepsilon-1} > \left(\frac{\tilde{z}_t^0}{z_{hp}^0}\right)^{\varepsilon-1}$. Then, we know from equation (A.4.1) the following:

$$\frac{R}{\varepsilon f M_t^A} > \frac{R}{\varepsilon f M_t^0}$$

Therefore, $M_t^A < M_t^0$. **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.4.3) for the outsourcing equilibrium patterns B and C are as follow.

$$\left(\frac{\tilde{z}_t^B}{z_{hp}^B}\right)^{\varepsilon-1} = (k+1)\left[\frac{M_d^B}{M_t^B} + \frac{M_x^B}{M_t^B}\left(\frac{f_x}{f}\right) + \frac{M_{os}^B}{M_t^B}\left(\frac{f_{os}}{f}\right)\right] \tag{A.4.6}$$

$$\left(\frac{\tilde{z}_t^C}{z_{hp}^C}\right)^{\varepsilon-1} = (k+1)\left[\frac{M_d^C}{M_t^C} + \frac{M_x^C}{M_t^C}\left(\frac{f_x}{f}\right) + \frac{M_{os}^C}{M_t^C}\left(\frac{f_{os}}{f}\right)\right] \tag{A.4.7}$$

The first two terms in the square brackets of both equations are also weighed average of 1 and $\frac{f_x}{f}$. According to equation (46), $\frac{f_x}{f}$ is always larger than 1 in the relevant parameter space. 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.

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

Using the equivalent expressions of equation (A.4.1) for the patterns B and C, equation (A.4.8) implies the following inequalities.

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

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

A.5 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 (64); and they are as follows.

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

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

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

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

Using equations (36) and (L.1.1), the right-hand side of inequality (A.5.4) can be re-written as the following.

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

The left-hand side of inequality (A.5.4) can also be re-written, using equations (47), (50), and (51), as the following.

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

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, equation (27) shows that $\gamma < \lambda$ by definition. This is 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 equations (47), (51), and (52) - and right-hand side - using equations (L.1.1) and (L.2.2), 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, from equation (27), 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 (14), (47), (49), (50), (L.1.1), and (L.2.2), 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**

$f_x > f + f_{os}$	
$\tau\lambda < 1$	$\tau\lambda \geq 1$
if $\frac{f_{os}}{f} < (\tau\lambda)^{1-\varepsilon} - 1$ eqm.a if $\frac{f_{os}}{f} \geq (\tau\lambda)^{1-\varepsilon} - 1$ i) $\frac{f_{os}}{f_x} \geq 1 - (\tau\lambda)^{\varepsilon-1}$ eqm.b ii) $1 - (\tau\lambda)^{\varepsilon-1} \leq \frac{f_{os}}{f_x} < \frac{2(\tau\lambda)^{1-\varepsilon}}{\tau^{1-\varepsilon}} - 1$ eqm.c iii) $\frac{2(\tau\lambda)^{1-\varepsilon}}{\tau^{1-\varepsilon}} - 1 \leq \frac{f_{os}}{f_x}$ eqm.d	if $\tau^{\varepsilon-1} + 1 < 2\lambda^{1-\varepsilon}$ i) $\frac{f_{os}}{f_x} < \frac{2(\tau\lambda)^{1-\varepsilon}}{\tau^{1-\varepsilon}} - 1$ eqm.e ii) $\frac{f_{os}}{f_x} \geq \frac{2(\tau\lambda)^{1-\varepsilon}}{\tau^{1-\varepsilon}} - 1$ eqm.f if $\tau^{\varepsilon-1} + 1 < 2\lambda^{1-\varepsilon}$ eqm.g

$f_x \leq f + f_{os}$	
$\tau\lambda < 1 \iff \tau^{\varepsilon-1} + 1 < 2\lambda^{1-\varepsilon}$	$\tau\lambda \geq 1$
if $\frac{f_{os}}{f} + \frac{f_x}{f} < 2(\tau\lambda)^{1-\varepsilon} - 1$ eqm.h if $2(\tau\lambda)^{1-\varepsilon} - 1 \leq \frac{f_{os}}{f} + \frac{f_x}{f} < \tau^{\varepsilon-1}[2(\tau\lambda)^{1-\varepsilon} - 1]\frac{f_x}{f}$ i if $\tau^{\varepsilon-1}[2(\tau\lambda)^{1-\varepsilon} - 1]\frac{f_x}{f} \leq \frac{f_{os}}{f} + \frac{f_x}{f}$ eqm.j	if $\tau^{\varepsilon-1} < 2\lambda^{1-\varepsilon} \leq \tau^{\varepsilon-1} + 1$ eqm.k if $2\lambda^{1-\varepsilon} \leq \tau^{\varepsilon-1}$ eqm.l

Table 2.1. Relevant Parameter Values for each equilibrium

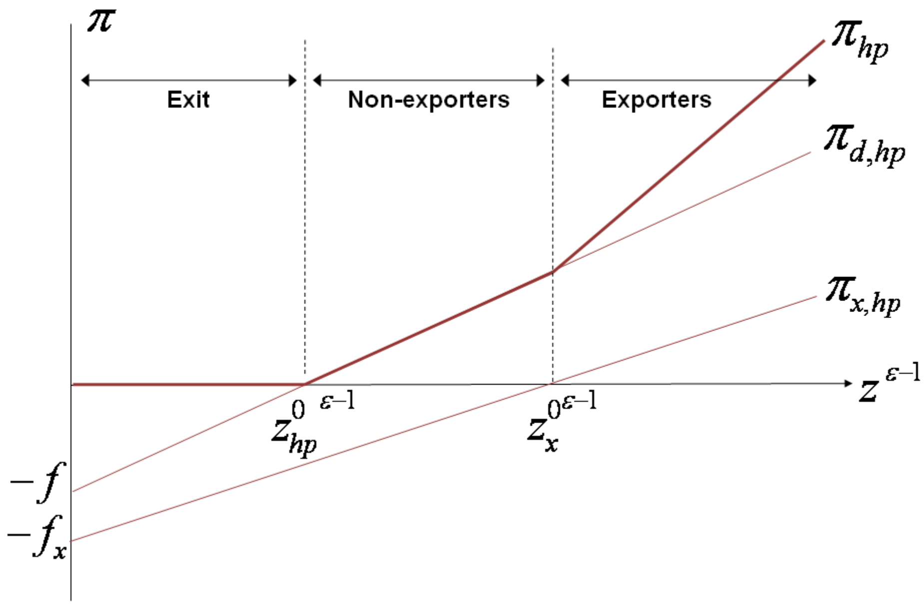
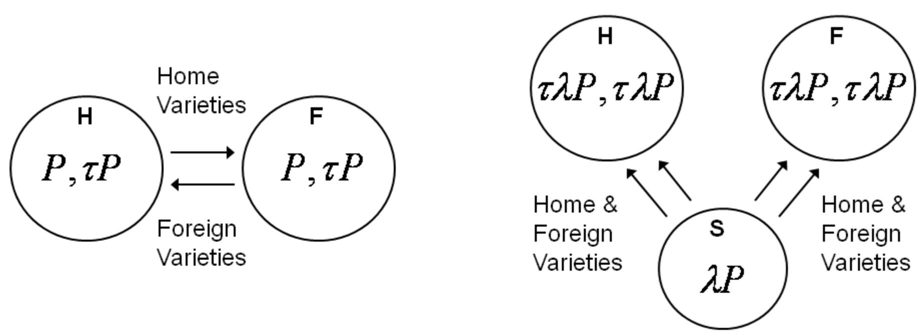


Figure 2.1: Open Economy Equilibrium



(a) Traditional International Trade

(b) Outsourcing

Figure 2.2: Transportation Structure

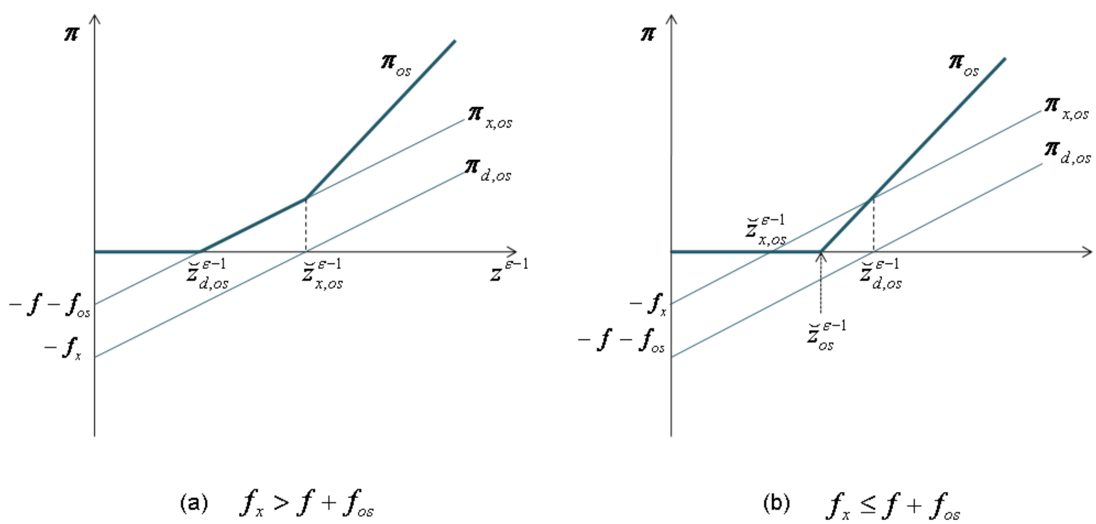


Figure 2.3: Total Profit Functions of Outsourcers

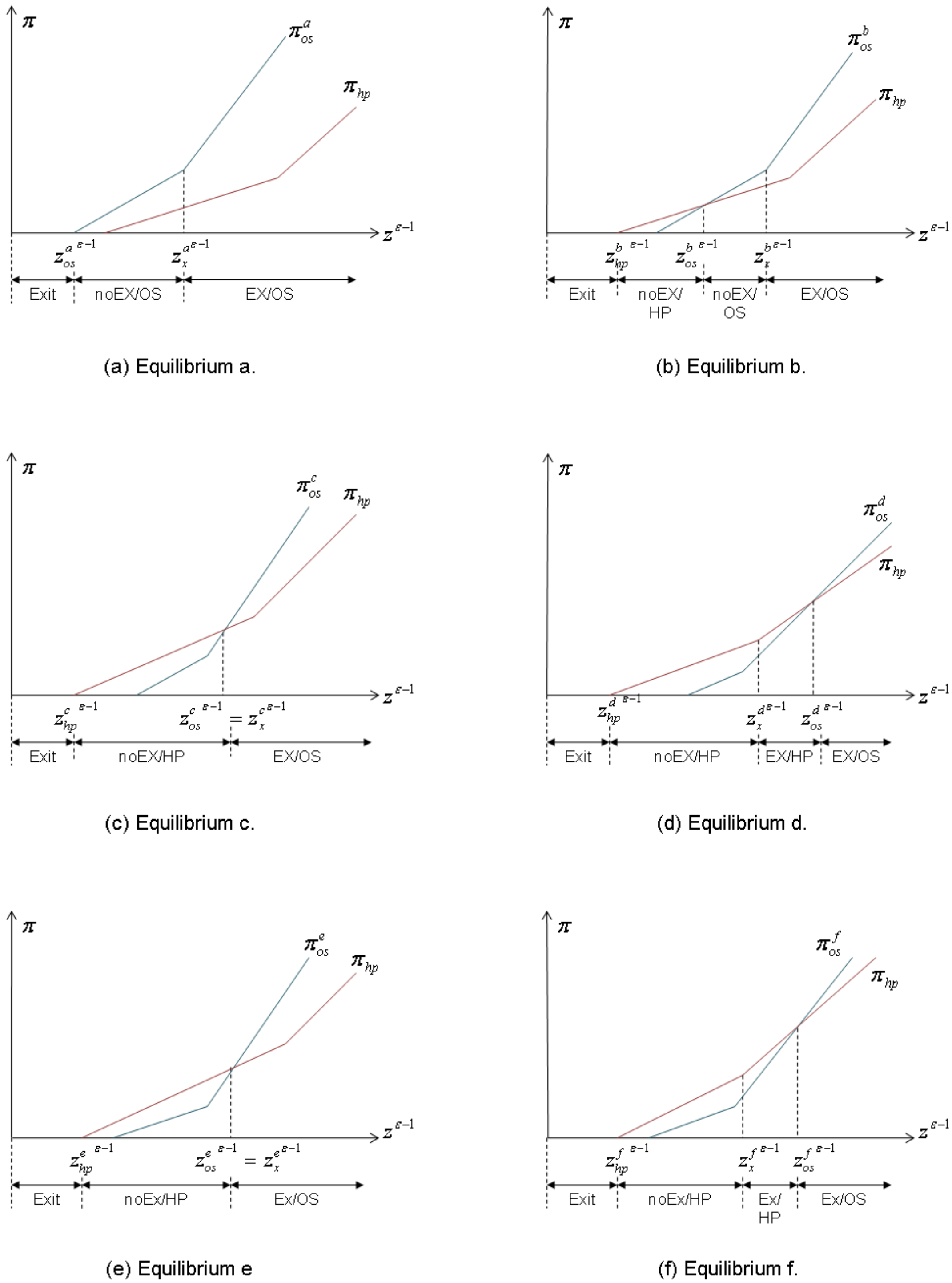
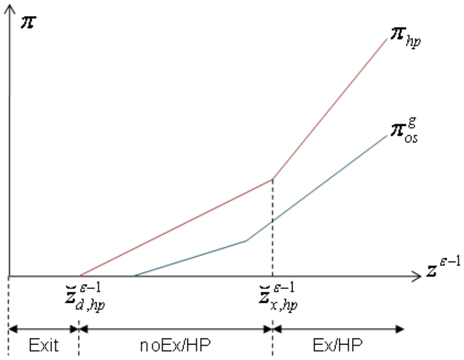
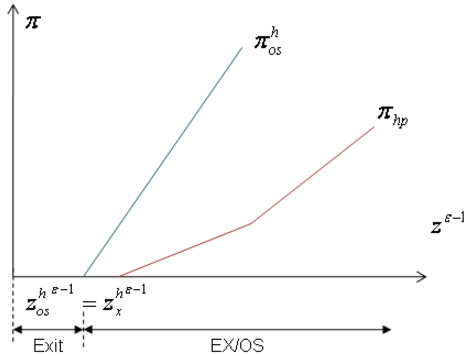


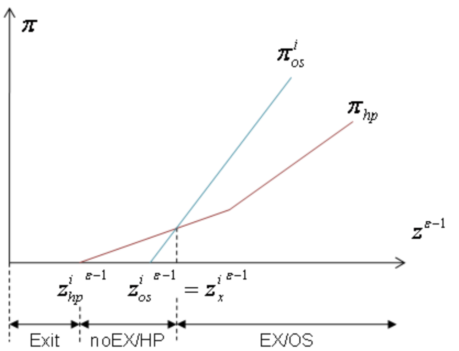
Figure 2.4: Twelve Equilibria under Outsourcing (1)



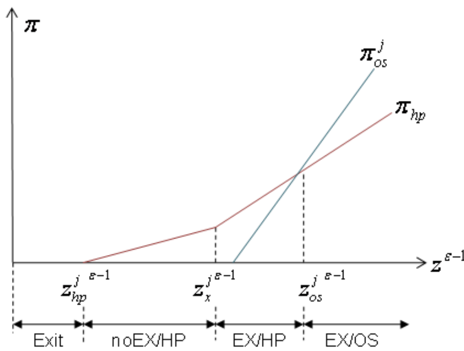
(g) Equilibrium g.



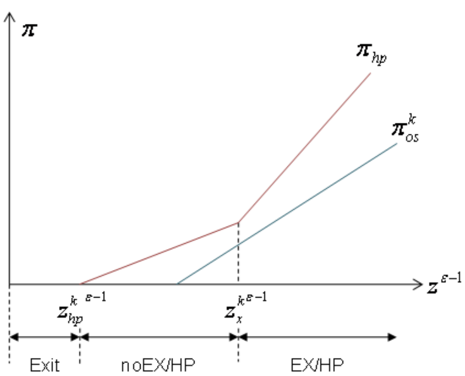
(h) Equilibrium h.



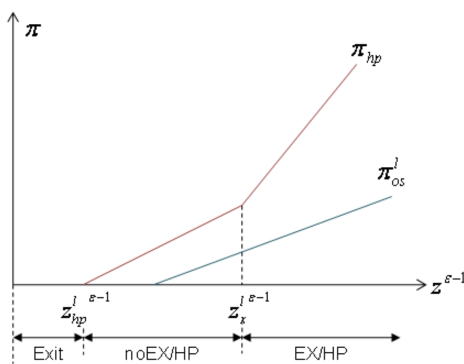
(i) Equilibrium i



(j) Equilibrium j



(k) Equilibrium k



(l) Equilibrium l

Figure 2.4: Twelve Equilibria under Outsourcing (2)

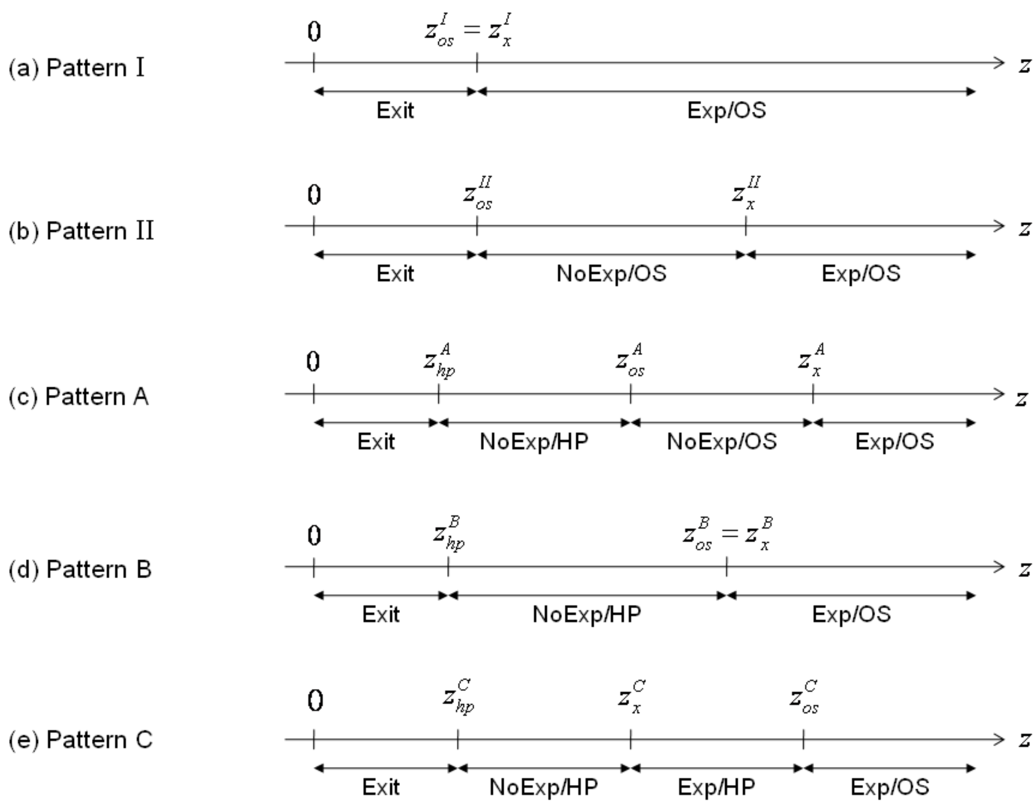


Figure 2.5: Various Patterns of Outsourcing in Outsourcing Equilibria

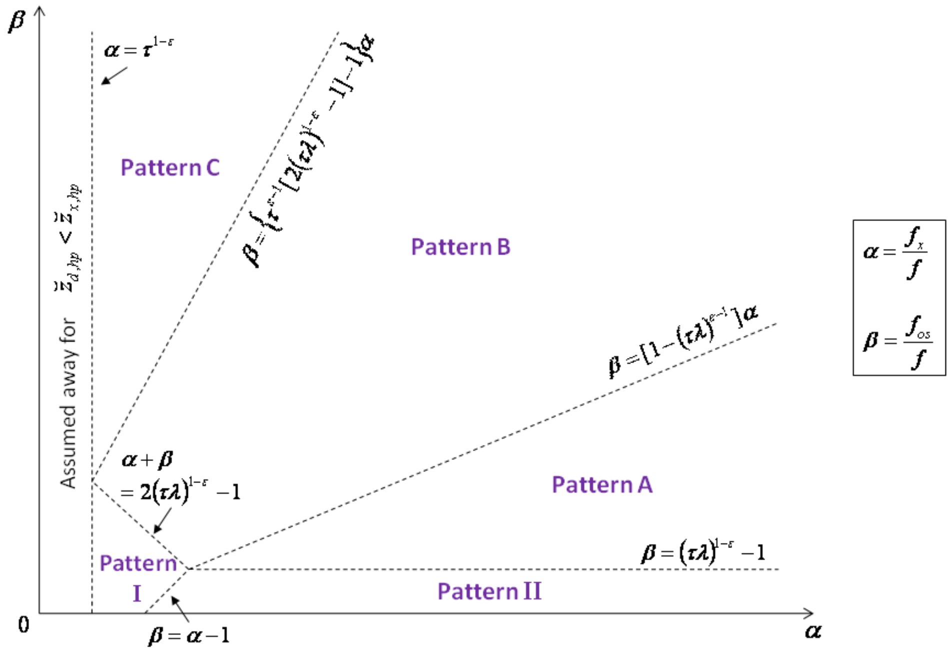


Figure 2.6: Equilibrium Space

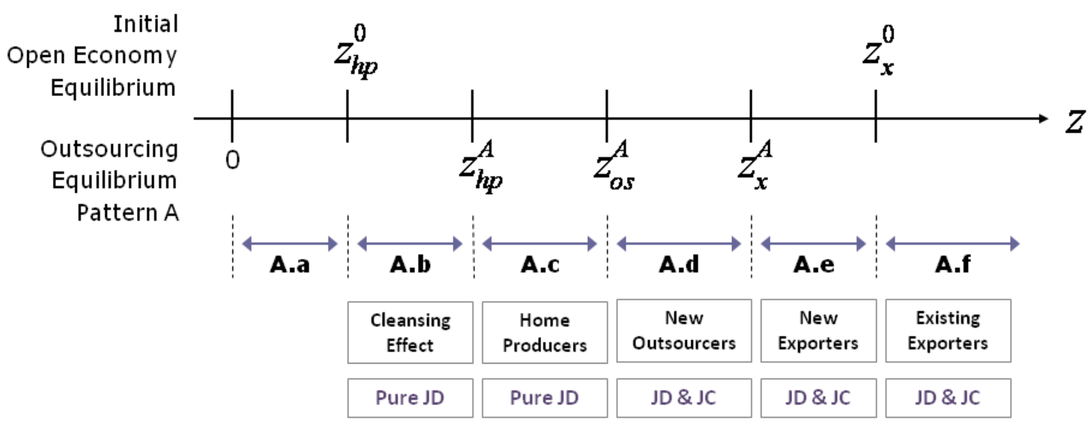
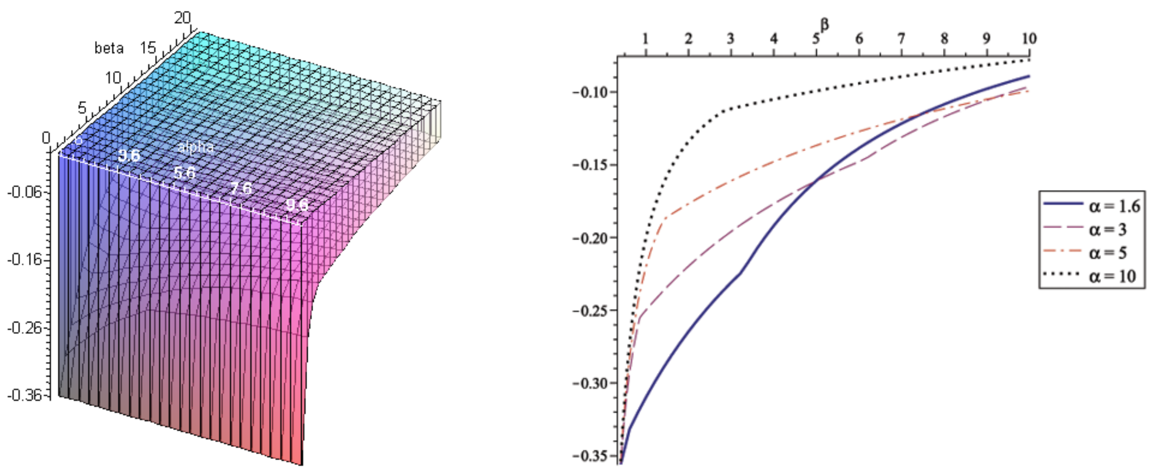


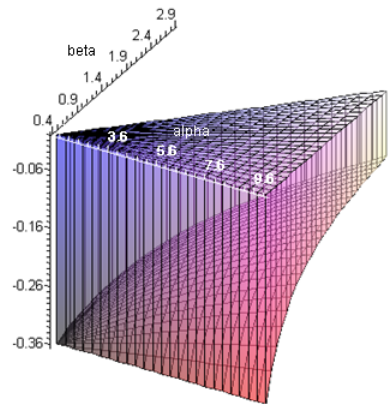
Figure 2.7: Different Operational Responses by Different Group of Firms under Pattern A



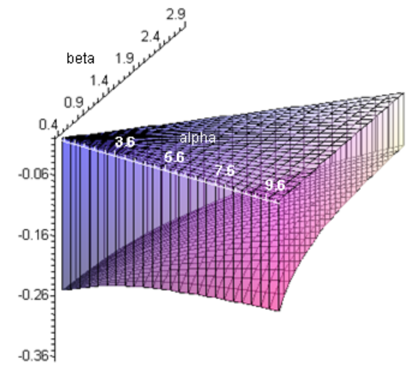
(a) Entire α - β space

(b) for selected values of α

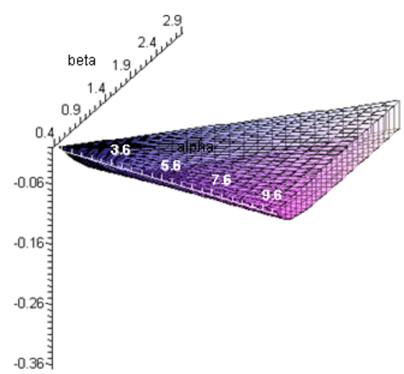
Figure 2.8: Total Net Employment Effect



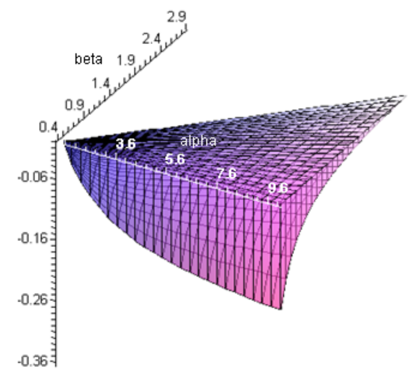
(a) Total Net Employment Effect



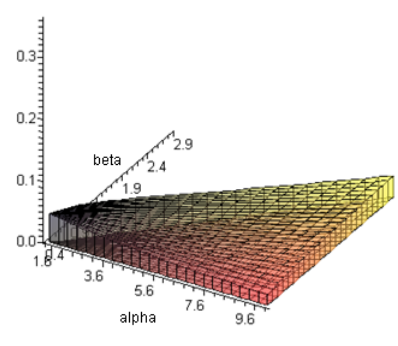
(b) Cleansing Effect (A.b)



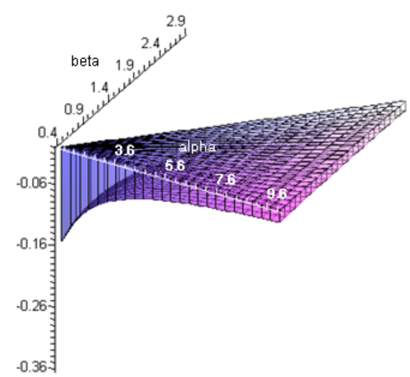
(c) Home Producers (A.c)



(d) New Outsourcers (A.d)



(e) New Exporters (A.e)



(f) Existing Exporters (A.f)

Figure 2.9: Net Employment Effect by various firm groups under the Pattern A

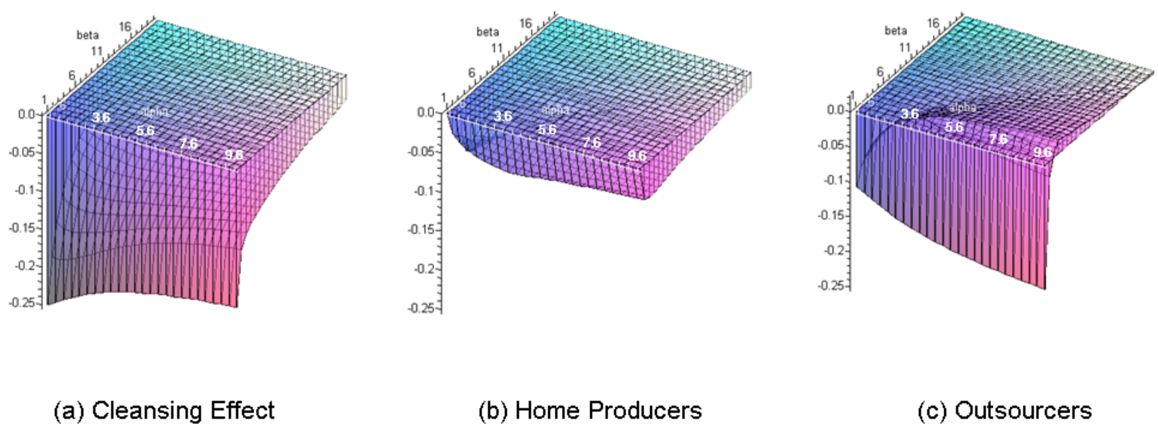


Figure 2.10: Net Employment Effect: Cleansing Effect, Home-Producers, and Outsourcers

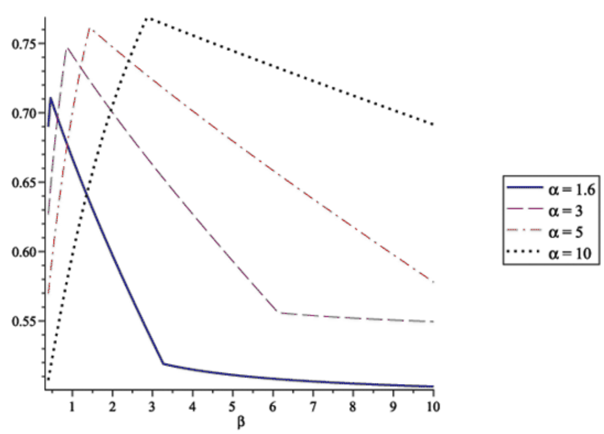
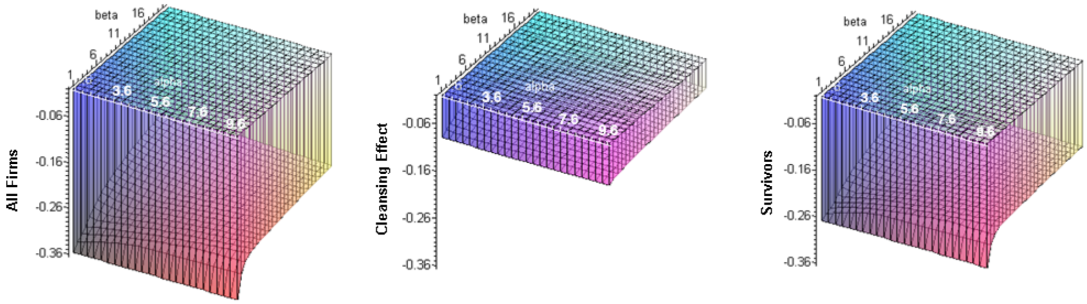
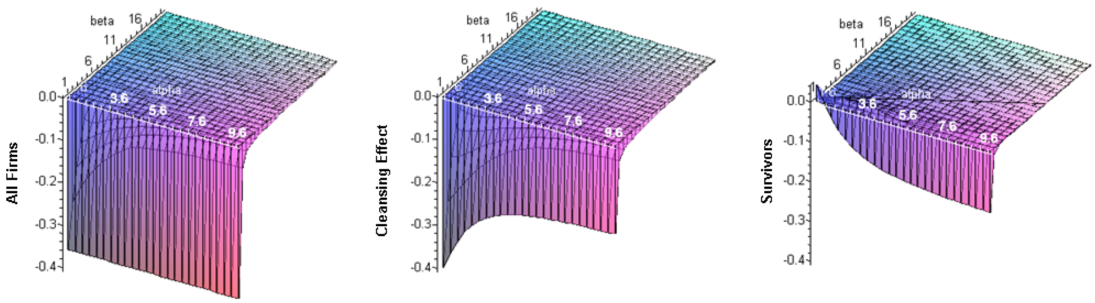


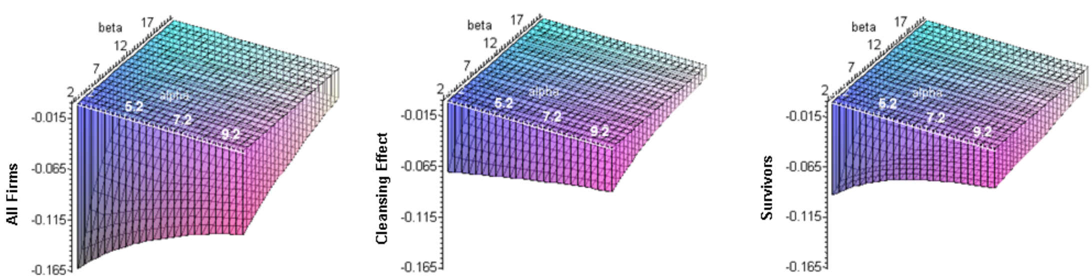
Figure 2.11: Cleansing Effect as a Share of Total Net Employment Effect



(a) High Dispersion of Productivity Draws : η = 2.6

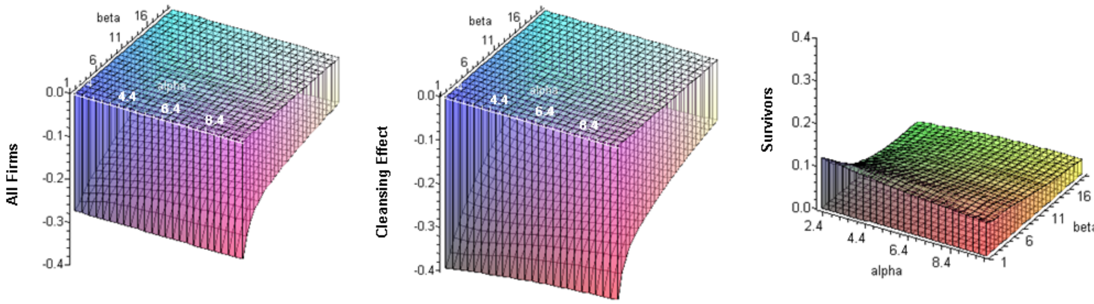


(b) Low Dispersion of Productivity Draws : η = 6

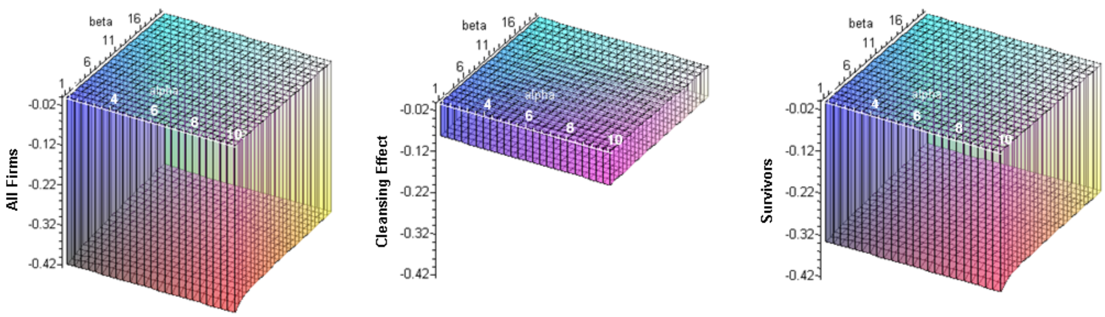


(c) High Southern Wage : δ = 0.6

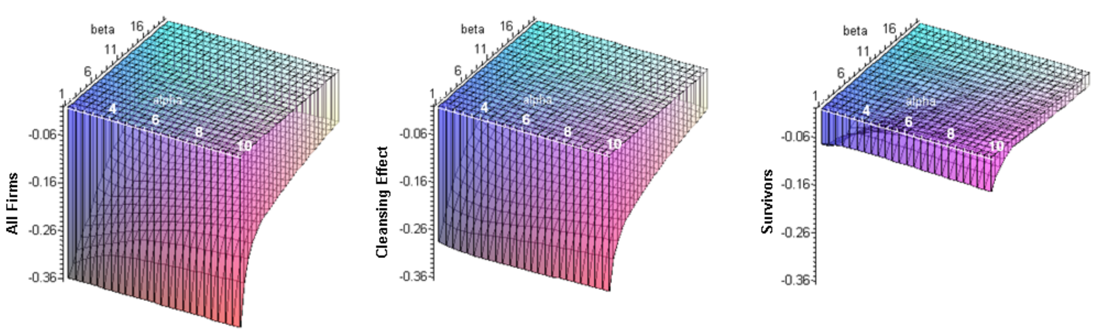
Figure 2.12: Various Deviations from Benchmark Parameters (1)



(d) Low Southern Wage : δ = 0.3



(e) High Elasticity of Substitution : ε = 4.5



(f) Small Transport Cost : τ =1.1

Figure 2.12: Various Deviations from Benchmark Parameters (2)

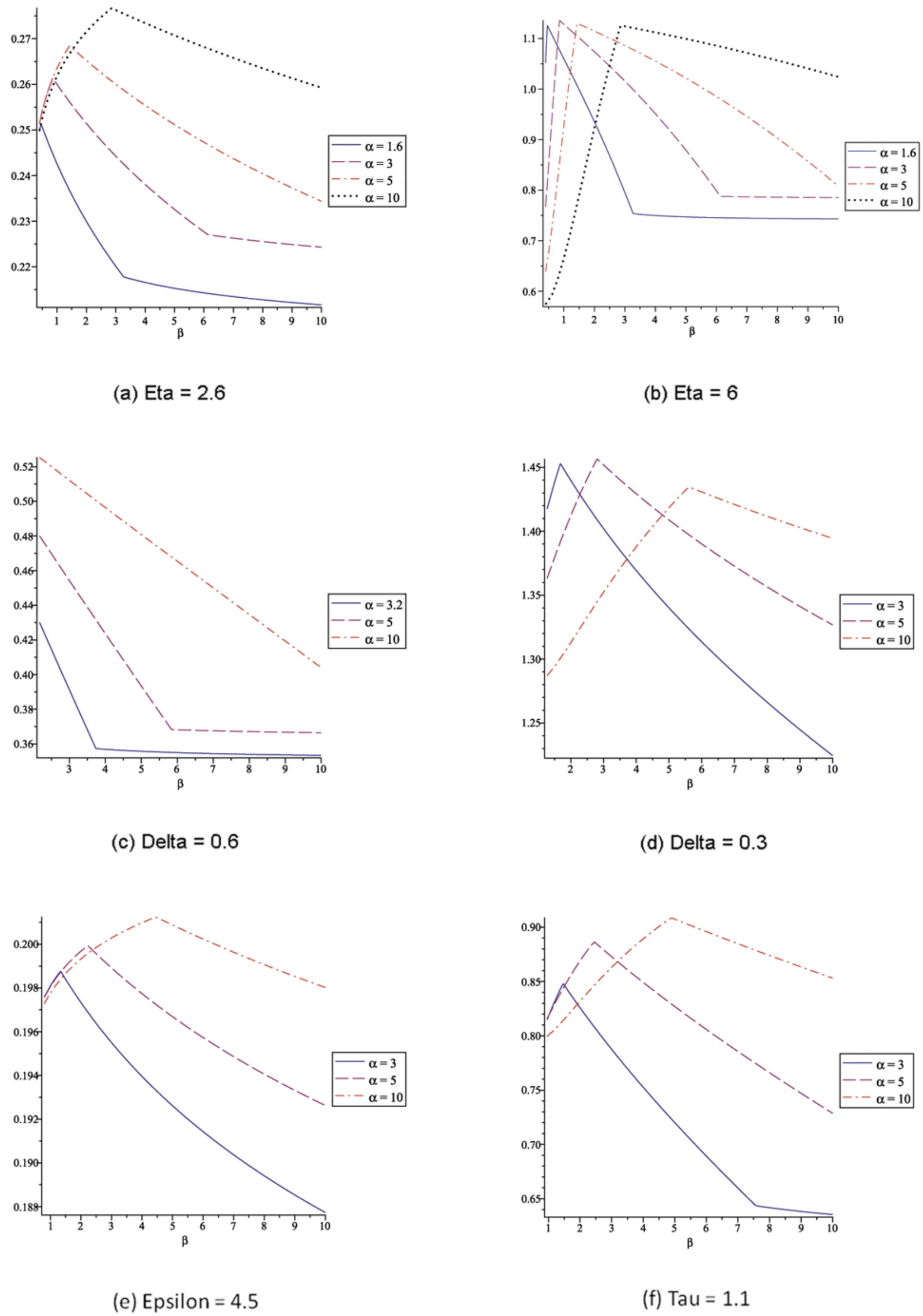


Figure 2.13: Cleansing Effect as a Share of Total Net Employment Loss
Various Deviations from Benchmark Parameters

Figure 2.14: Net Employment Effect, Job Destruction, and Job Creation

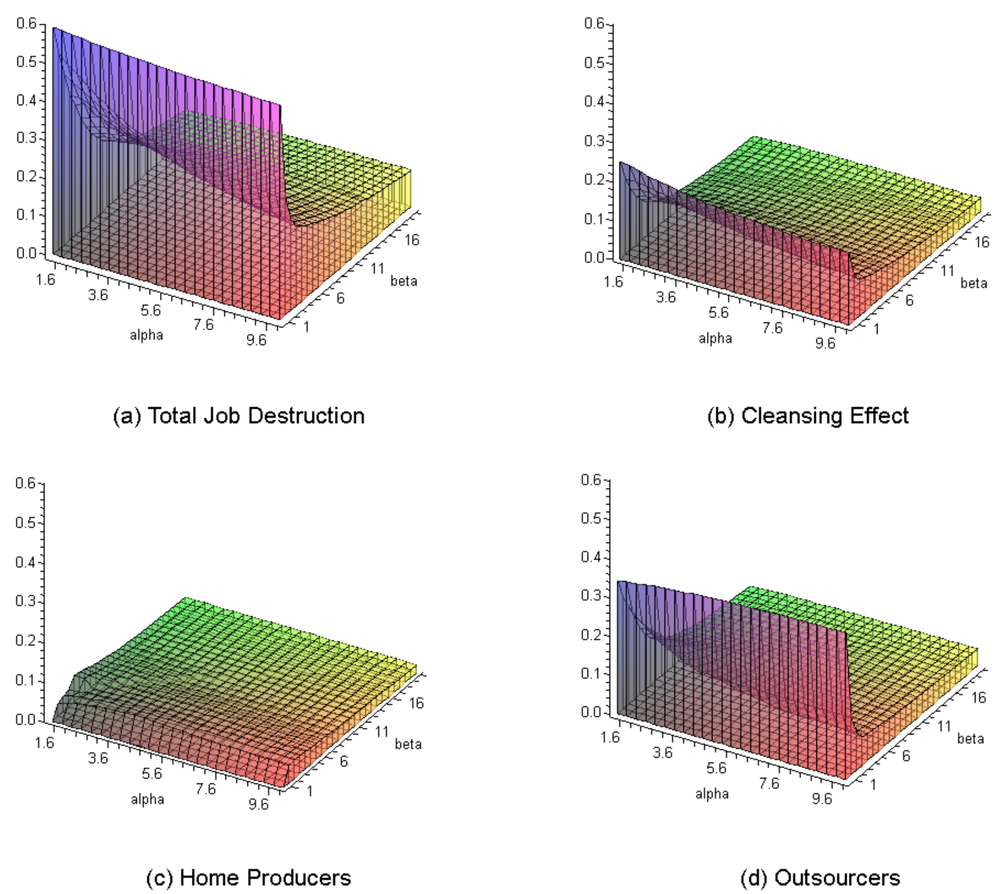
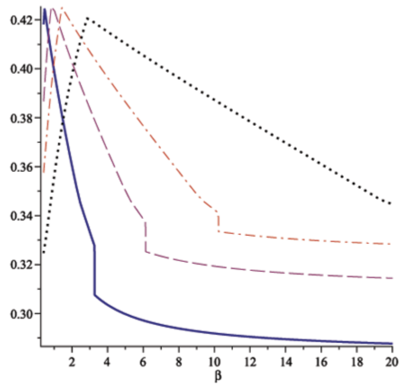
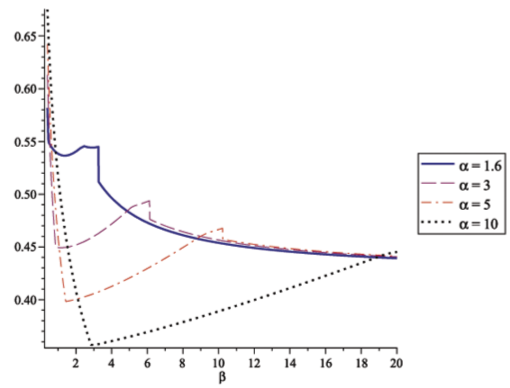


Figure 2.15: Decomposition of Total Job Destruction

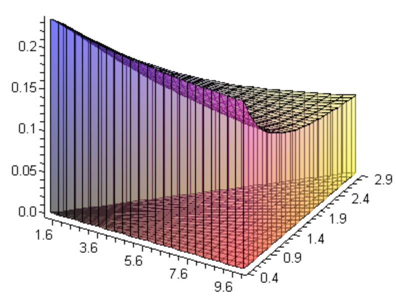


(a) Cleansing Effect

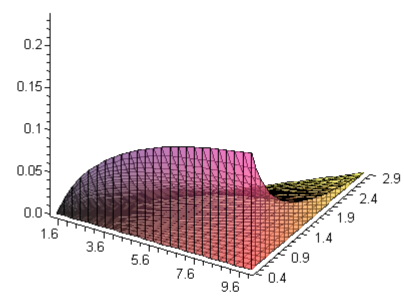


(b) Outsourcers' Layoffs

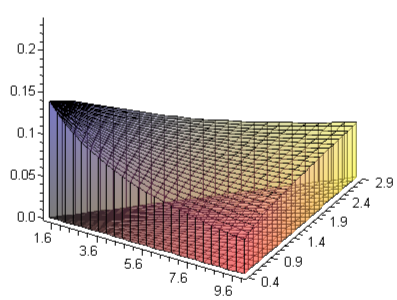
Figure 2.16: Cleansing Effect and Outsourcers' Layoffs as a share of Total Job Destruction



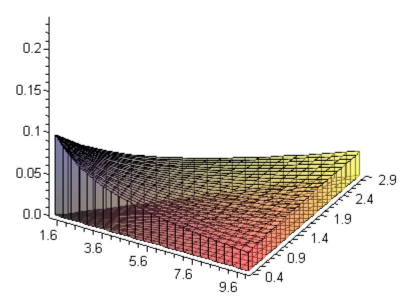
(a) Total Job Creation



(b) New Outsourcers



(c) New Exporters



(d) Existing Exporters

Figure 2.17: Job Creation by Outsourcers under Pattern A

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Chapter III

Offshore Outsourcing and Employment in the US Manufacturing Sector

1 Introduction

In the year 2004, the one word that we heard on TV over and over, nearly as frequently as *terrorism* and *national security*, was "offshore outsourcing." The United States was experiencing a jobless recovery from one of the most severe recessions in recent history and offshoring was blamed for slow job creation. An Associated Press-Ipsos poll in May 2004 showed that 69% of Americans thought offshoring hurt the US economy, while only 17% thought it helped.[20]

The technical definition of offshore outsourcing is the delegation of non-core operations or jobs from internal production to an external firm that is located in a foreign country through arm's-length contract or a usage of an own foreign subsidiary. Technological development enabled fragmentation, and physical separation of the various phases of a production process, and a reduction of trade restrictions enabled firms to benefit from offshore outsourcing. Despite the cost efficiency that offshore outsourcing brings to firms, not everybody welcomes this growing phenomenon because sending part of production process abroad is directly associated with layoffs of the workers who were previously contributing to the processes that are being sent abroad.

[20] http://www.pollingreport.com/trade.htm

The rise of offshore outsourcing is well investigated using input-output tables of several nations by Hummels et al. (2001). They find, in ten OECD countries[21] and four emerging markets, [22] that off-shoring increased 30% between 1970 and 1990 and accounted for 30% of the growth in these countries' exports. Yeats (1998) finds significance of this trend in international trade. In 1995, shipments of components from developing countries (Singapore, Taiwan, Korea, Malaysia, Mexico) to OECD countries exceeded $100 billion, which demonstrates the interdependence of economies in terms of manufacturing input supply. He also shows that this international input trade is concentrated in a relatively few product groups - transport and machinery products, textiles and clothing, leather goods, footwear and other labor-intensive manufactures - as predicted by the theory of comparative advantage. Recent trends include offshoring of service jobs such as telemarketers, IT engineers, bank loan processors, insurance claims adjusters and even legal assistants. Forrester Research Inc. released, in 2004, its estimate that the number of US service jobs moving offshore by the end of 2005 would be 830,000. This is an updated estimate from 588,000, its 2002 estimate. It also suggests that 3.3 million service jobs will have gone overseas by 2015. However, the employment loss in manufacturing is far larger than this estimate. Computer and electronic product manufacturing alone lost 433,198 jobs between 2001 and 2004.

There is substantial amount of empirical literature on the employment effects of international trade (Kletzer (2002)); the empirical evidence on the impact of offshore outsourcing remain insufficient. The most significant reason for this is limited data availability. Unlike exports and imports, there is no data specifically collected on offshoring activities. For this reason, many studies utilize firm-level data from the Bureau of Economic Analysis (BEA) on the foreign direct investment position of U.S. firms. The results of these studies on employment effects are mixed. Brainard and

[21]US, UK, france, Italy, Japan, Canada, Germany, Australia, Denmark, and the Netherlands
[22]Ireland, Korea, Taiwan, and Mexico's maquiladoras

Riker (2001) find weak employment substitution effects between parents and affiliates while Slaughter (2003) finds complementary effects. Harrison and McMillan (2007) address the controversy by examining endogeneity, sample selection, and methodological issues. They find substitution effects for affiliates in low wage countries and complementarity for those in high wage countries.

Although the BEA's dataset provides very detailed information on the operations of MNCs, the dataset does not contain any information on arm's length contracts with foreign suppliers, a widely used means of outsourcing. The 1987 and 1992 Census of Manufactures (CMF) and Annual Survey of Manufactures (ASM) provide data on the purchase of inputs from foreign sources. A number of studies utilize these data to analyze the impact of outsourcing.

Berman, Bound, and Griliches (1994) investigate the shift in labor demand during the1980s and find the demand shift to be largely correlated with skill-biased technological change. They also find that outsourcing (measured by the share of materials purchased from foreign sources) explains only a marginal portion of this shift. Using an improved measure of outsourcing, Feenstra and Hanson (1996a) find that, during the same period, 15-33% of wage inequality increases are explained by outsourcing. In a later study, Feenstra and Hanson (1996b) analyze the impact of outsourcing on the relative wages of both non-production and production workers. Finding a positive connection between outsourcing and non-production worker's real wage, the researchers did not identify a similar correlation for production workers. While most studies aggregate the data to 4-digit SIC industries, Kurz (2006) is the first establishment- and firm-level outsourcing study utilizing the Census datasets. Investigating the characteristics of outsourcers and outsourcing's effect on plant-level productivity growth, Kurz finds outsourcing firms to be larger, more skill-intensive, and more productive. He also finds that outsourcing firms exhibit significantly higher productivity growth. Unfortunately, after 1992, the CMF and ASM questionnaires no longer include the purchase of inputs from foreign sources so comparable analysis for more recent years is not feasible.

These employment losses in both services and manufacturing sectors are the main detriment of international trade and offshore outsourcing. While most economists agree on net welfare gain from freer trade through an increase in overall economic efficiency and aggregate income, we also admit that there are losers as well as winners. The biggest losers in this game are the workers who are laid-off due to offshore relocation of production facilities and reduction in production because of import competition.

The public generally makes two mistakes. First, they tend to focus on the negative side of the story. In case of outsourcing, there are two forces working against each other; a negative one and a positive one. The negative one is the job loss from the segment sent off to foreign countries. The positive one is the competitiveness gain such as a rise in the sales due to lower prices. Offshoring is often viewed as unpatriotic acts of greedy businesses. This implies that even the critics of offshoring admit that offshoring is beneficial to most firms' performance. However, they only see the connection between employment and the physical relocation of tasks, not that between employment and the performance enhancement.

Second, the public disregard the discussion of the counterfactual which is not observable. In the absense of offshoring, US firms keep all jobs at home, but this is not the end of the story. It does not prevent foreign competitors from outsourcing and lowering costs and prices. Overtime, the price differential between US goods and the rival goods will increases, US goods lose their competitiveness, lose their share in the world market. US firms will have to decreases their production, which will eventually reduce employment. This means prohibiting outsourcing saves domestic employment only temporarily, but not permanently. My prediction for outsourcing is that the sign of the total effect on post-outsourcing employment is ambiguous. Some outsourcing events destroy more jobs than they create; the others create more than they destroy. Knowing that, one-size-fits-all type of policy can undesirably prohibit job generating ones. The overall impact on employment is determined systematically rather than arbitrarily. Knowledge about the mechanism behind the employment outcome enables us to make more customized policy that improves US labor market.

In this study, I establish a structural model with two countries - the north and the south, two sectors, and one factor of production - labor. The wage rate in the south is lower than the northern wage rate, and the relative wage rate is fixed by agricultural sector with homogenous products. Outsourcing occurs in the manufacturing sector where goods are differentiated. Manufacturing process consists of two segments, assembly and services. As technology advances, physical separation of two segments become possible, providing firms opportunities to take advantage of the cross-country differences in wage rates and technology. In the numerical analysis, I find that outsourcing raises the share of the market served by northern varieties tremendously. For benchmark parameters, there is gain of 48% of the world market from outsourcing. Employment effect is also generally positive, implying that the job creation from the benefits of outsourcing is larger than the job destruction directly caused by the physical relocation of part of the business processes.

In section II, the theoretical model is introduced. Section III derives the free trade equilibrium and the outsourcing equilibrium. Section IV present the theoretical and numerical results, Section V concludes.

2 Model

There are two countries, the north and the south. Southern variables are marked with an asterisk. These countries only differ in that southern workers are less productive than northern workers. Labor endowment is the same in two countries as

L. Consumer preferences are also identical across countries. There are two sectors, agriculture and manufacturing, and both sectors are tradable and only use labor as a factor of production. Agricultural products are homogeneous, so they are traded under one world price. This world agricultural price determines the wage rates in two countries as long as both countries produce positive amount of output in agricultural sector.

Manufacturing products are differentiated and produced through two processes, assembly and services; and each segment hires a fixed number of workers. The assembly segment is technologically identical across countries, but the northern service segment is technologically superior; that is, the service labor requirement is smaller for a northern firm than for a southern firm. As technology advances, fragmentation - physical separation of assembly and services - becomes feasible. Manufacturing firms outsource one or both segments abroad if it is profitable.

2.1 Demand

Northern and Southern consumers have identical preferences that are represented by a two-tier utility function. The upper tier utility function is of a Cobb-Douglas form where u_A and u_M are subutilities from consumption of agricultural and manufacturing products, respectively.

$$U(u_A, u_M) = u_A^z u_M^{1-z} \tag{12}$$

u_A is the utility from consuming agricultural products, and is linear in the quantity of consumption. u_M is the utility from consuming manufacturing products, and it takes the form of CES utility function.

$$u_A = x_A \qquad \text{and} \qquad u_M(x_1, ..., x_N) = \left[\sum_{j=1}^{N} x_j^{\rho}\right]^{\frac{1}{\rho}} \tag{13}$$

N is the number of varieties, and the elasticity of substitution is $\varepsilon = 1/(1-\rho)$. The demand for manufacturing variety j is as follows.

$$q_j = \frac{EP_j^{-\varepsilon}}{G^{1-\varepsilon}} \tag{14}$$

E is the total expenditures on manufcaturing varieties in the north and is $(1-z)wL$. G is the manufacturing price index.

$$G = \left[\sum_{j=1}^{N} P_j^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \tag{15}$$

2.2 Production

There are two sectors, agriculture and manufacturing, in both countries. Labor is the only factor of production, so technology is represented as unit labor requirement.

2.2.1 Agriculture

Agricultural products are produced both in both countries and are tradable. In each country, the size of agricultural sector is sufficiently large, so neither country completely specializes in manufacturing. Since agricultural sector is perfectly competitive, each country's wage rate is determined by the world agricultural price. One unit of agricultural product is produced by one unit of labor in the north. Southern workers are less productive, so one worker produces only ? unit of output. Workers are paid their marginal product. Therefore, no matter which country is the exporter of agricultural products, the ratio of labor productivity determines the wage rates in two countries, and the relative wage rate is the same as the relative labor productivity.

That is,

$$w^* = \delta w \qquad \text{where} \;\; \delta < 1 \tag{16}$$

Since the northern and southern labor endowment is equal, δ again determines the relative size of the southern economy. Southern GDP, which is δwL is lower than northern GDP, which is wL. δ also implies the relative manufacturing expenditure.

$$E^* = \delta E \tag{17}$$

2.2.2 Manufacturing: under Free Trade without Outsourcing

Each firm in the manufacturing sector produces a unique variety. Production of each unit is composed of two separate segments, assembly and services, and each segment hires a fixed number of workers, l_0^A and l_0^S respectively. The labor requirement for one unit of manufacturing output is the sum of those two.

$$l_0 = l_0^A + l_0^S \qquad \text{and} \qquad l_0^* = l_0^{A^*} + l_0^{S^*} \tag{18}$$

There is no technology differential in the assembly segment ($l_0^A = l^A{*_0}$), but northern service technology is superior to the southern one, so the service labor requirement is smaller in the north. Let γ and γ^* denote the size of service segment as a share of the unit labor requirement in the north and the south, respectively.

$$\gamma = \frac{l_0^S}{l_0} \qquad \text{and} \qquad \gamma^* = \frac{l_0^{S^*}}{l_0^*} \tag{19}$$

Let R be the ratio of unit labor requirement between a southern and a northern manufacturing firm, and R_S be the ratio of labor requirement in the service segment for unit production. So, we have $l_0^* = Rl_0$ and $l_0^S = R_S l_0^S$. R and R_S measure the size of inefficiency of the overall southern manufacturing sector and the southern service segment, respectively, compared to the northern counterparts. Both are greater than one. Using equation (19), I can write R and R_S as follows.

$$R = \frac{1-\gamma}{1-\gamma^*} \qquad \text{and} \qquad R_S = \frac{\gamma^*}{\gamma}\frac{1-\gamma}{1-\gamma^*} \tag{20}$$

There is a fixed overhead production cost, f. f is measured in labor unit and same for both northern and southern firms. Where Q is the quantity of output, the total labor requirement for a northern firm is, therefore, $Ql_0 + f$. It is $Ql_0^* + f$ for a southern firm.

2.2.3 Manufacturing: under Free Trade with Offshoring

Later, technological advancement allows fragmentation of business processes; so, assembly segment and service segment become physically separable. Offshoring one or more segments is an option to both northern and southern firms. Offshoring provides firms an opportunity to take advantage of cross-country differences in wage rates and technology. When one segment is outsourced to the other country, the labor requirement for the segment in the host country is relevant for the production. That is, if a northern firm outsources its assembly segment to the south, the firm needs to hire $l_0^{A^*}$ southern workers for assembly and l_0^S northern workers for services.

However, offshoring causes inefficiency such as coordination difficulties caused by physical distance, language barrier, cultural difference, etc. This inefficiency can be resolved by putting more resources. Therefore, offshoring firms hire additional workers, $\varphi - 1$ workers per production worker. If a firm outsources only part of its entire process, the outsourcing cost only applies to the segment that is sent abroad. For the northern firms that outsources the assembly segment to the south, the unit labor requirement for this firm will be $\varphi l_0^{A^*} + l_0^S$.

After fragmentation becomes feasible, a firm, either southern or northern, has four operating options; first, to perform both segment at home as before; second, to outsource only the assembly segment from a foreign country; third, to outsource only the service segment from a foreign country; last, to outsource both segments from a foreign country. Since two segments are perfectly separable, cost for each segment is also independent. Therefore, outsourcing decision can be made for each segment separately. A firm compares the costs for outsourcing and home operation, and chooses what costs less.

Consider a northern firm that decides whether to outsource either segment or both. First, the firm compares the cost of keeping the assembly segment at home and outsourcing it to the south. The relevant labor costs for the assembly segment are

$$\begin{aligned} &\text{i) Offshore Outsourcing:} \quad w^*\varphi l_0^{P^*} = \delta\varphi(1-\gamma)wl_0 \\ &\text{ii) Home Operation:} \quad wl_0^P = (1-\gamma)wl_0 \end{aligned} \tag{21}$$

A northern firm sends its assembly segment to the south if and only if

$$\delta < \frac{1}{\varphi} \tag{22}$$

This is where the relative southern wage rate is low enough to offset the cost of dealing with the additional inefficiency.

Then, the northern firm shifts its attention to the labor costs of service segment. That is,

$$\begin{aligned} &\text{i) Offshore Outsourcing:} \quad w^*\varphi l_0^{S^*} = \delta\varphi\gamma^* \left(\frac{1-\gamma}{1-\gamma^*}\right) wl_0 \\ &\text{ii) Home Operation:} \quad wl_0^S = \gamma wl_0 \end{aligned} \tag{23}$$

A northern firm sends its service segment if and only if

$$\delta < \frac{1}{\varphi R_S} \tag{24}$$

This is where the southern wage is low enough to offset the inferior technology and the additional outsourcing inefficiency.

Southern firms make their offshoring decision in exactly the same manner. A southern sends its assembly segment to the north if and only if

$$\delta > \varphi \tag{25}$$

This inequality can not hold since $\delta < 1$ and $\varphi > 1$. Therefore, southern firms never outsource their assembly segment to the north. This is because there is no technology advantage in the northern assembly segment, but the wage is higher and also there is extra inefficiency to take care of in case of outsourcing. Then, offshoring of service segment will be decided if and only if

$$\delta > \frac{\varphi}{R_S} \tag{26}$$

A firm can reduce the cost by utilizing the superior northern technology despite of higher wage and additional inefficiency. This is possible where the southern wage rate is not low enough relative to northern one.

Equations (22), (24), and (26) determine the pattern of outsourcing of the manufacturing firms in the north and the south. The pattern is summarized in figure 1. Different industries with different partner countries choose different pattern of outsourcing depending on the sizes of the technology and wage differentials.

3 Equilibrium

The importance of agricultural sector is in fixing the relative wage rate. Since the goal of this analysis is in finding the employment effect of offshore outsourcing which is only feasible in manufacturing sector, I only discuss variables in that sector. First, I characterize the equilibrium before offshore outsourcing is feasible, second, the outsourcing equilibrium. The comparison will follow.

3.1 Free Trade Equilibrium: Equilibrium without Outsourcing

In the initial free trade equilibrium, firms perform both assembly and services segment at home utilizing the local workers. The northern and southern wage rates are fixed by the world price of agricultural products as w and $w^* = \delta w$ respectively. The marginal cost of a manufacturing product is the wage rate multiplied by the unit labor requirement; that is,

$$MC_0 = wl_0 \qquad \text{and} \qquad MC_0^* = w^* l_0^* \tag{27}$$

Each firm produces a unique variety, so all firms are monopolists. Each firm charges its monopoly price, a constant markup over the marginal cost. The markup is common for all firms, both southern and southern. The prices of northern and southern manufacturing products are the following.

$$P_0 = \left(\frac{\varepsilon}{\varepsilon - 1}\right) wl_0 \qquad \text{and} \qquad P_0^* = \left(\frac{\varepsilon}{\varepsilon - 1}\right) w^* l_0^* \tag{28}$$

From equations (16) and (18), the price differential can be expressed as the wage differential adjusted for the technology differential.

$$P_0^* = \delta R P_0 \tag{29}$$

There is iceberg transport cost. In order for one unit of goods to be sold in the foreign market, τ unit must be shipped. That is, the transport cost is equivalent to ad valorem tariff of $\tau - 1$. Prices in the foreign market will be adjusted for the transport cost; therefore, the relative prices between the northern and southern products in two markets are different. One unit of northern and southern products is sold for P_0 and τP_0^*, respectively, in the northern market, and τP_0 and P_0^* in the southern market. The relative price in each market determines the relative demand for northern and southern varieties according to equation (14).

Let n_0 and n_0^* denote the number or northern and southern varieties, respectively. The asymmetry in labor productivity across countries results in different numbers of northern and southern varieties. From equations (15) and (29), the manufacturing price indices in two market, G_0 and G_0^*, are

$$G_0 = \left\{ \left[1 + N_0 (\tau \delta R)^{1-\varepsilon} \right] n_0 P_0^{1-\varepsilon} \right\}^{\frac{1}{1-\varepsilon}} \tag{30}$$

and

$$G_0^* = \left\{ \left[\tau^{1-\varepsilon} + N_0 (\delta R)^{1-\varepsilon} \right] n_0 P_0^{1-\varepsilon} \right\}^{\frac{1}{1-\varepsilon}} \tag{31}$$

N_0 is the ratio of the number of southern firms and the number of northern firms in free trade equilibrium, that is $N_0 = n_0^*/n_0$.

The demand function, equation (14), with price indices, equations (30) and (31), yields the quantity demanded for each variety. The quantity required to serve the foreign market includes the transport cost. The total quantity each northern firm produces to meet the demand from the northern and southern market is the following.

$$Q_0 = \left(\frac{\varepsilon - 1}{\varepsilon} \right) \frac{(1-z)L}{n_0 l_0} \left[\frac{1}{1 + N_0 (\tau \delta R)^{1-\varepsilon}} + \frac{\delta \tau^{1-\varepsilon}}{\tau^{1-\varepsilon} + N_0 (\delta R)^{1-\varepsilon}} \right] \tag{32}$$

For a southern firm, it is

$$Q_0^* = (\delta R)^{-\varepsilon} \left(\frac{\varepsilon - 1}{\varepsilon}\right) \frac{(1-z)L}{n_0 l_0} \left[\frac{\tau^{1-\varepsilon}}{1 + N_0(\tau\delta R)^{1-\varepsilon}} + \frac{\delta}{\tau^{1-\varepsilon} + N_0(\delta R)^{1-\varepsilon}}\right] \tag{33}$$

The manufacturing sector is free to enter, so all firms' profits will be driven down to zero in the equilibrium. Firms will produce their zero profit quantities, Q_0 for a northern firm and Q_0^* for a southern firm.

$$Q_0 = \frac{(\varepsilon - 1)f}{l_0} \qquad \text{and} \qquad Q_0^* = \frac{(\varepsilon - 1)f}{Rl_0} \tag{34}$$

Equations (32), (33), and (34) characterize the goods market clearing conditions in the equilibrium. These conditions will fix the numbers of northern and southern varieties as follows.

$$n_0 = (\delta R)^{1-\varepsilon} \frac{(1-z)L}{\varepsilon f} \left\{\frac{\delta(1 + \delta\tau^{2-2\varepsilon}) - (1+\delta)(\tau\delta R)^{1-\varepsilon}}{[\delta - (\tau\delta R)^{1-\varepsilon}]\,[(\delta R)^{1-\varepsilon} - \delta\tau^{1-\varepsilon}]}\right\} \tag{35}$$

$$n_0^* = \frac{(1-z)L}{\varepsilon f} \left\{\frac{\delta(1 + \delta\tau^{2-2\varepsilon}) - (1+\delta)(\tau\delta R)^1 - \varepsilon}{[\delta - (\tau\delta R)^{1-\varepsilon}]\,[(\delta R)^{1-\varepsilon} - \delta\tau^{1-\varepsilon}]}\right\} \tag{36}$$

In equilibrium, northern and southern varieties can co-exist because the manufacturing products are differentiated, and there is demand for high price northern varieties as well as low price southern varieties. However, where the price differential is too large, the demand for northern varieties may not be large enough to generate revenue enough to cover the fixed production cost. Therefore, in an extreme case, the world market for manufacturing products could be taken over by varieties from one country. Where the northern price is too high compared to the southern one, which requires very small δR, all northern firms will exit. This is the case where the number of northern varieties, equation (35), becomes zero. Likewise, all southern firms will exit if southern price is too high compared to the northern one, which requires a very large value of δR. This is the case where the number of southern varieties, equation

(36), becomes zero. Instead of analyzing these two cases based on the value of δR, I focus on the value of δ.

$\underline{\delta}_0$ and $\overline{\delta}_0$ denote the value of the wage differential where n_0 ad n_0^* become zero, respectively. In equilibrium, given R, we will only see northern varieties if δ is lower than $\underline{\delta}_0$, only southern varieties if δ is higher than $\overline{\delta}_0$, and both varieties if δ is between the two threshold values. $\underline{\delta}_0$ and $\overline{\delta}_0$ satisfy the following conditions which is obtained from equations (35) and (36).

$$\left(\overline{\delta}_0 R\right)^{1-\varepsilon}\left(\overline{\delta}_0 + \tau^{2-2\varepsilon}\right) - \tau^{1-\varepsilon}\overline{\delta}_0(1+\overline{\delta}_0) = 0 \tag{37}$$

$$\underline{\delta}_0\left(1 + \underline{\delta}_0\tau^{2-2\varepsilon}\right) - (1+\underline{\delta}_0)\left(\tau\underline{\delta}_0 R\right)^{1-\varepsilon} = 0$$

Finally, the free trade equilibrium in the absence of offshore outsourcing is characterized by the two threshold values of δ, $\underline{\delta}_0$ and $\overline{\delta}_0$, and the numbers of northern and southern varieties, n_0 and n_0^*.

$$(Eqm_{FT}.A)\quad n_0 = 0 \quad \text{and} \quad n_0^* = \frac{(1+\delta)(1-z)L}{\delta\varepsilon f} \qquad \text{if} \quad \delta \leq \underline{\delta}_0 \tag{38}$$

$$(Eqm_{FT}.B)\quad N_0 = \frac{n_0^*}{n_0} = \frac{(\delta R)^{1-\varepsilon}(\delta + \tau^{2-2\varepsilon}) - \tau^{1-\varepsilon}\delta(1+\delta)}{(\delta R)^{1-\varepsilon}\left[\delta(1+\delta\tau^{2-2\varepsilon}) - (1+\delta)(\tau\delta R)^{1-\varepsilon}\right]} \quad \text{if} \quad \delta \in (\underline{\delta}_0, \overline{\delta}_0) \tag{39}$$

$$(Eqm_{FT}.C)\quad n_0 = \frac{(1+\delta)(1-z)L}{\varepsilon f} \quad \text{and} \quad n_0^* = 0 \qquad \text{if} \quad \delta \geq \overline{\delta}_0 \tag{40}$$

3.1.1 Free Trade Equilibrium A : South only Equilibrium

In this equilibrium, only southern firms serve the world manufacturing market and the north specializes in agricultural production. Thus, the employment in each sector in the north is

$$L_0^M = 0 \qquad \text{and} \qquad L_0^A = L \tag{41}$$

In the south, there are n_0^* manufacturing firms, equation (38). amd eacj firm produces Q_0^*, equation (34). The total employment in each sector in the south is

$$L_0^{A*} = \left[1 - \frac{(1+\delta)(1-z)}{\delta}\right] L \qquad \text{and} \qquad L_0^{M*} = \frac{(1+\delta)(1-z)L}{\delta} \tag{42}$$

3.1.2 Free Trade Equilibrium B: Co-Existence Equilibrium

In this equilibrium, both northern and southern firms co-exist in the manufacturing market. Each firm produces its zero profit quantity, Q_0 and Q_0^*, equation (34). Since every firm produces its fixed zero profit quantity which only depends on the marginal cost and the elasticity of substitution, the numbers of northern and southern firms are crucial in determining the share of world market the North or the South serves and the level of employment in manufacturing sector in each country. The numbers of varieties is summarized by the ratio, N_0, in the co-existence range, equilibrium B, equation (**??**). The ratio is decreasing in δ and R. That is, as δR rises, southern varieties lose the price advantage, so the market is less favorable for them. Since each firm's supply is fixed by the zero profit quantity, equation (34), it reduces the ratio, N_0, so that there are relatively more northern varieties than southern ones in the market.

The total employments in manufacturing sector in the North and in the South are the following.

$$L_0^M = (\delta R)^{1-\varepsilon}(1-z)L\left\{\frac{\delta(1+\tau^{2-2\varepsilon})-(1+\delta)(\tau\delta R)^{1-\varepsilon}}{\left[\delta-(\tau\delta R)^{1-\varepsilon}\right]\left[(\delta R)^{1-\varepsilon}-\delta\tau^{1-\varepsilon}\right]}\right\} \tag{43}$$

$$L_0^{M*} = (1-z)L\left\{\frac{(\delta R)^{1-\varepsilon}(\delta+\tau^{2-2\varepsilon})-\tau^{1-\varepsilon}\delta(1+\delta)}{\left[\delta-(\tau\delta R)^{1-\varepsilon}\right]\left[(\delta R)^{1-\varepsilon}-\delta\tau^{1-\varepsilon}\right]}\right\} \tag{44}$$

The northern varieties together get the revenue of $n_0P_0Q_0$ while southern varieties make the revenue of $n_0^*P_0^*Q_0^*$. This with equations (29), (34), (35), (36), and (39) yield the northern share of the world market for manufacturing varieties, which is

$$MS_0 = \frac{1}{\delta N + 1} \tag{45}$$

As N_0 is decreasing in δ, the market share of northern varieties is also decreasing in δ. Again, larger δ means smaller price advantage of southern varieties, so larger portion of the world manufacturing market is served by northern varieties.

3.1.3 Free Trade Equilibrium C : North Only Equilibrium

There are n_0 northern firms, equation (40), in the market and each produces its zero profit quantity, Q_0, equation (34). Therefore, the total employment in the manufacturing sector in the north is

$$L_0^M = (1+\delta)(1-z)L \tag{46}$$

Figure 2 summarizes the northern manufacturing employment for different value of δ, equations (41), (43), and (46).

3.2 Outsourcing Equilibrium

Once fragmentation becomes feasible, firms make outsourcing decisions according to their decision criteria, equations (22), (24), (26). As shown in figure 1, various patterns of outsourcing are possible depending on the parameter values. In this section, I only discuss the most plausible case where northern firms outsource their assembly segment to the south while the southern firms do not outsource. This is the case where δ satisfies the following inequality.

$$\frac{1}{\varphi R_S} \;\leq\; \delta \;<\; \frac{\varphi}{R_S} \tag{47}$$

The variables under the outsourcing equilibrium are presented with subscript 1.

Since northern firms outsource its assembly segment, the relevant marginal cost comes from the first equation in equations (21) and the second equation in equations (23). So, the marginal cost for a northern firm is

$$MC_1 = [\;\delta\varphi(1-\gamma)+\gamma\;]\,wl_0 \tag{48}$$

I define λ as follows.

$$\lambda = \delta\varphi(1-\gamma)+\gamma \tag{49}$$

Using equation (49), I can rewrite the marginal cost of a northern variety in outsourcing equilibrium as $MC_1 = \lambda MC_0$. λ is the relative marginal cost of a northern variety in the outsourcing equilibrium compared to the initial free trade equilibrium. In other words, the cost saving from outsourcing is $1-\lambda$. Southern varieties are produced in the south as in the initial free trade equilibrium; therefore, the marginal cost does not change. The prices of northern and southern varieties are a constant markup over their marginal costs, that is

$$P_1 = \lambda \left(\frac{\varepsilon}{\varepsilon - 1} \right) wl_0 \qquad \text{and} \qquad P_1^* = \delta R \left(\frac{\varepsilon}{\varepsilon - 1} \right) wl_0 \tag{50}$$

The price differential between northern and southern varieties is now

$$P_1^* = \frac{\delta R}{\lambda} P_1 \tag{51}$$

Unfinished products from the assembly segments are to be processed through the service segment in order to be ready for sale. In case two segments are located in different countries, the products must be shipped to the location of the service segment. I assume that there is no additional transport cost in this process. One can understand this as that the additional outsourcing inefficiency cost $(\varphi - 1)$ includes the cost of transporting the assembled products to the service location. Then, products will be ready for sale, and shipped to the other country for exporting. This shipment will require the transport cost of $\tau - 1$.

The manufacturing price indices are obtained in the same manner as those of the initial free trade equilibrium. The price index of the northern market is

$$G_1 = \left\{ \left[1 + N_1 \left(\tau \frac{\delta R}{\lambda} \right)^{1-\varepsilon} \right] n_1 P_1^{1-\varepsilon} \right\}^{\frac{1}{1-\varepsilon}} \tag{52}$$

and that of the southern market is

$$G_1^* = \left\{ \left[\tau^{1-\varepsilon} + N_1 \left(\frac{\delta R}{\lambda} \right)^{1-\varepsilon} \right] n_1 P_1^{1-\varepsilon} \right\}^{\frac{1}{1-\varepsilon}} \tag{53}$$

n_1 and n_1^* are the numbers of northern and southern varieties, respectively. N_1 is the ratio between n_1^* and n_1.

The quantity demanded for each variety, including the additional unit for transportation cost, is obtained using equations (14), (52), and (53). They are, for a northern firm,

$$Q_1 = \left(\frac{\varepsilon-1}{\varepsilon}\right)\frac{(1-z)L}{n_1\lambda l_0}\left[\frac{1}{1+N_1\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}}+\frac{\delta\tau^{1-\varepsilon}}{\tau^{1-\varepsilon}+N_1\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}}\right] \tag{54}$$

and for a southern firm,

$$Q_1^* = \left(\frac{\varepsilon-1}{\varepsilon}\right)\frac{(1-z)L}{n_1\lambda l_0}\left(\frac{\delta R}{\lambda}\right)^{-\varepsilon}\left[\frac{\tau^{1-\varepsilon}}{1+N_1\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}}+\frac{\delta}{\tau^{1-\varepsilon}+N_1\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}}\right] \tag{55}$$

Free entry assures that each firm produces its zero profit quantity in the equilibrium. The quantities are

$$Q_1 = \frac{(\varepsilon-1)f}{\lambda l_0} \qquad \text{and} \qquad Q_1^* = \frac{(\varepsilon-1)f}{R l_0} \tag{56}$$

Goods market clearing conditions are characterized by equations (54), (55), and (56). This yields the numbers of northern and southern varieties as follows.

$$n_1 = \frac{(1-z)L}{\varepsilon f}\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\left\{\frac{\delta\left(1+\delta\tau^{2-2\varepsilon}\right)-(1+\delta)\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}}{\left[\delta-\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\right]\left[\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}-\delta\tau^{1-\varepsilon}\right]}\right\} \tag{57}$$

$$n_1^* = \frac{(1-z)L}{\varepsilon f}\left\{\frac{\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\left(\delta+\tau^{2-2\varepsilon}\right)-\tau^{1-\varepsilon}\delta(1+\delta)}{\left[\delta-\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\right]\left[\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}-\delta\tau^{1-\varepsilon}\right]}\right\} \tag{58}$$

As in the initial free trade equilibrium, the world market could be dominated by the varieties from only one country in extreme cases. We will be in the South Only equilibrium where n_1 becomes zero, and in the North Only equilibrium where n_1^* becomes zero. Where both n_1 and n_1^* are positive, we will be in the Co-Existence equilibrium. These three equilibria are, again, separated by two threshold values of δ, $\overline{\delta}_1$ and $\underline{\delta}_1$. That is, there will be only southern varieties in the market if δ is smaller than $\underline{\delta}_1$, only northern varieties if δ is larger than $\overline{\delta}_1$, and both varieties if δ

lies between the two threshold values. $\overline{\delta}_1$ and $\underline{\delta}_1$ satisfy the following conditions.

$$\left(\frac{\overline{\delta}_1 R}{\lambda}\right)^{1-\varepsilon}\left(\overline{\delta}_1+\tau^{2-2\varepsilon}\right)-\tau^{1-\varepsilon}\overline{\delta}_1(1+\overline{\delta}_1)=0 \tag{59}$$

$$\underline{\delta}_1\left(1+\underline{\delta}_1\tau^{2-2\varepsilon}\right)-(1+\underline{\delta}_1)\left(\tau\frac{\underline{\delta}_1 R}{\lambda}\right)^{1-\varepsilon}=0$$

The outsourcing equilibrium is characterized by the numbers of northern and southern varieties and two threshold values of δ.

$$(Eqm_{OS}.A)\quad n_1=0 \quad \text{and} \quad n_1^*=\frac{(1+\delta)(1-z)L}{\delta\varepsilon f} \qquad \text{if } \delta\le\underline{\delta}_1 \tag{60}$$

$$(Eqm_{OS}.B)\quad N_1=\frac{n_1^*}{n_1}=\frac{\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\left(\delta+\tau^{2-2\varepsilon}\right)-\tau^{1-\varepsilon}\delta(1+\delta)}{\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\left[\delta\left(1+\delta\tau^{2-2\varepsilon}\right)-(1+\delta)\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\right]} \qquad \text{if } \delta\in(\underline{\delta}_1,\overline{\delta}_1) \tag{61}$$

$$(Eqm_{OS}.C)\quad n_1=\frac{(1+\delta)(1-z)L}{\varepsilon f} \quad \text{and} \quad n_1^*=0 \qquad \text{if } \delta\ge\overline{\delta}_1 \tag{62}$$

3.2.1 Outsourcing Equilibrium A : South Only Equilibrium

In this equilibrium, only southern firms serve the manufacturing market and the north specializes in agricultural production. Since behavior of southern firms is not altered by the feasibility of fragmentation, this equilibrium is identical to the South Only Free Trade equilibrium ($Eqm_{FT}.A$). Therefore, the manufacturing employment in two countries are

$$L_1^M=0 \tag{63}$$

$$L_1^{M^*}=n_1^*\left(Q_1^*l_\cdot^*+f\right)=n_1^*\cdot\varepsilon f=\frac{(1+\delta)(1-z)L}{\delta} \tag{64}$$

3.2.2 Outsourcing Equilibrium B: Co-Existence Equilibrium

Northern and southern varieties co-exist in the market. The northern share of the market depends on the relative prices, $\lambda/\delta R$ - equation (51). Again, each firm produces a fixed amount of output, hence hires a fixed number of workers. The ratio of numbers of southern and northern varieties, N_1, is crucial in determining the market share and the total employment of the northern firms. Larger δ and larger R implies smaller price advantage of southern varieties, and smaller λ implies larger cost reduction from outsourcing. These work in favor of northern varieties, lowering the ratio N_1. Therefore, N_1 is decreasing in δ and R, and increasing in λ. The northern share of the market directly depends on the ratio of numbers of varieties, so it is also decreasing in δ and R, and increasing in λ.

$$MS_1 = \frac{1}{1 + \delta N_1} \tag{65}$$

However, employment in outsourcing equilibrium does not only depend on N_1 because γ, the size of service segment, determines the size of layoff due to the outsourcing and also affects the relative marginal cost, λ. Larger γ means smaller assembly segment which is translated to smaller layoffs, but it also means smaller cost reduction which reduces the benefits to the northern firms, so smaller sale increase and, hence, smaller job creation. The total manufacturing employment is still increasing in δ and R.

The total employment in manufacturing in the north and the south can be written as the following.

$$L_1^M = (1-z)L\left[\frac{(\varepsilon-1)\gamma+\lambda}{\varepsilon\lambda}\right]\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\left\{\frac{\delta\left(1+\delta\tau^{2-2\varepsilon}\right)-(1+\delta)\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}}{\left[\delta-\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\right]\left[\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}-\delta\tau^{1-\varepsilon}\right]}\right\} \tag{66}$$

$$L_1^{M*} = \frac{(1-z)L}{\left[\delta - \left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\right]\left[\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon} - \delta\tau^{1-\varepsilon}\right]}\{\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\left(\delta + \tau^{2-2\varepsilon}\right) \tag{67}$$

$$- \tau^{1-\varepsilon}\delta(1+\delta) + \frac{\varphi(1-\gamma)(\varepsilon-1)}{\varepsilon\lambda}\left(\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\left[\delta\left(1+\delta\tau^{2-2\varepsilon}\right) - (1+\delta)\left(\tau\frac{\delta R}{\lambda}\right)^{1-\varepsilon}\right]\}$$

3.2.3 Outsourcing Equilibrium C : North Only Equilibrium

There are only northern firms in manufacturing sector and the south specializes in agricultural sector. In the outsourcing equilibrium, the northern firms hire southern workers in their assembly segment, so the southern manufacturing employment is positive even though there is no southern varieties in the market. The total employment in the northern and southern manufacturing sector is

$$L_1^M = (1+\delta)(1-z)L\frac{(\varepsilon-1)\gamma+\lambda}{\varepsilon\lambda} \tag{68}$$

$$L_1^{M*} = (1+\delta)(1-z)L\frac{\varphi(\varepsilon-1)(1-\gamma)}{\varepsilon\lambda} \tag{69}$$

Figure 3 summarizes the northern manufacturing employment for different value of δ, equations (63), (66), and (68).

4 Results

Each equilibrium consists of three different ranges of δ, South-only, Co-Existence and North-only range. The thresholds between the ranges are determined by equations (37) and (59). Outsourcing changes the threshold values, and it is summarized in proposition 1 and 2.

Proposition 6 *The threshold values of wage ddifferential that separates South Only equilibrium and Co-Existence equilibrium decreases with outsourcing. That is,*

$$\underline{\delta}_1 < \underline{\delta}_0$$

Proposition 7 *The threshold values of wage differential that separates Co-Existence equilibrium and North Only equilibrium decreases with outsourcing. That is,*

$$\overline{\delta}_1 < \overline{\delta}_0$$

The panel (a) of Figure (4) shows the market compositions before and after outsourcing. As the thresholds decrease with outsourcing, northern firms survive in wider range of δ given the size of technology differential, R. They survive in the range $\delta \in (\underline{\delta}_0, 1]$ in the absence of outsourcing, but in the $\delta \in (\underline{\delta}_1, 1]$ in the outsourcing equilibrium. There is a gain of a range $\delta \in (\underline{\delta}_0, \underline{\delta}_1]$.

The threshold values of δ are dominated by three parameters; transport cost (τ), the size of the technological advantage in the North (R), and the size of the service segment (γ). High transport cost expands the width of the Co-Existence range; and, large northern technological advantage, R, moves the Co-existence range down along the spectrum of δ. The small service segment, γ, enlarges the size of the threshold decrease between the equilibria; in other words, the changes summarized in proposition 1 and 2 get larger where service segment is a smaller fraction of manufacturing process.

Panel (b) depicts the size of the northern manufacturing employment in two equilibria. Both have increasing trend as shown in Figure 2 and 3, but the positions of the kinks differ as threshold values of δ decrease as shown in panel (a). Panel (c) shows the net employment change after the outsourcing which is the employment in the outsourcing equilibrium net of the employment in the initial free trade equilibrium.

The employment response can be analyzed for five different regions as shown as A to E in panel (a). In region A, where the southern wage rate is very low, the market is occupied by the southern varieties, so the north specializes in agriculture. The size of employment in the northern manufacturing sector is zero in both equilibria. In region B, the northern share of the world market increases from zero to positive; therefore, the effect of outsourcing on the employment is positive. In region C, northern and southern varieties compete against each other in both equilibria. In outsourcing equilibrium, the Northern varieties gain competitiveness by lowering their prices, resulting in a transfer of a fraction of the market from southern varieties to northern ones. For low values of δ, the initial market share is very small, and so is the size of the job destruction. The job creation exceeds the job destruction by a large amount, so the net employment effect is positive and large. For higher values of δ, the net employment change is relatively small due to the large size of job destruction. In region D, the northern varieties were quite competitive initially, so the gain from the price reduction is small, and so is the net employment change. In region E, there are no southern varieties, so northern varieties compete against each other. The price reduction from outsourcing takes market share from each other. There is still job creation since prices fall where the total expenditure on manufacturing products is fixed. The total quantity of consumption rises; so firms hire more workers in the service segment. However, northern manufacturing sector loses the assembly segment, generating large job destruction. Therefore, the net employment effect is negative.

4.1 Numerical Results

For the numerical analysis, I choose a set of parameter values. There are six parameters in the model; the ratio of the southern wage to the northern wage (δ), the elasticity of substitution (ε), size of the service segment (γ), transport cost (τ), inefficiency cost of outsourcing (φ), and the technological advantage of the northern manufacturing sector (R). The benchmark value chosen for ε is 5. Broda and Weinstein (2006) estimate various elasticities for different aggregation level (3-, 4-, and 5-digit) of SITC manufacturing industry classifications (Rev.2 for 1972-1988, Rev.3 for 1990-2001). I use the estimates of 4-digit SITC for the period 1990-2001 whose median value is 5.88. γ is 0.4 implying that the size of services account for 40% of business process for a typical firm. 2002 Census of Manufactures shows that the share of non-production workers in the total manufacturing payroll is 40%. The transport cost is equivalent of 70% ad valorem tariff rate ($\tau = 1.7$). This is estimated from the trade flow data using gravity equation (Anderson and van Wincoop, 2004). The inefficiency cost, φ, and the technological differential, R, are arbitrarily chosen as $\varphi = 1.15$ and $R = 3$. These values imply outsourcing raises the production cost by 15% due to inefficiency, and northern manufacturing technology is three times more efficient than the southern counterpart. The values $R = 3$ and $\gamma = 0.4$ implies that $R_s = 6$; in other words, the northern service segment is six times more efficient than the southern counterpart.

First, I present the impact of offshore outsourcing on the northern share of various markets in figure 5. The range of δ is that of coexistence range. Since threshold values $\underline{\delta}$ and $\overline{\delta}$, fall with outsourcing, the range shown lies on the lower values of δ for outsourcing equilibrium. For the δ above the range shown, the northern share of the world market is 100%since there will only be northern varieties. Due to transport costs, the imported goods have price disadvantages in both northern and southern market. Therefore, the northern share of the northern market is higher than that of the southern market. This is the case in the outsourcing equilibrium since the transportation structure is preserved. The comparison between two panels should be made not only on the shape of the curves, but also the value of δ. The wage differential does not change with outsourcing because the relative wage rate of one country compared to the other is determined in the agricultural sector. Therefore, the comparison should be made for the same value of delta. For instance, for $\delta = 0.3$ - southern wage rate is 30% of the northern wage rate -, northern varieties serve 2% of the southern market, 55% of the northern market, that is 42% of the world market in the absence of outsourcing. When northern firms outsource their assembly segment, and reduce their prices, they together serve 63% of the southern market, 98% of the northern market, that is 90% of the world manufacturing market. Outsourcing completely changes the composition of the market, in favor of those who take advantage of outsourcing.

Figure 6 shows the panel (b) and (c) of figure 4 for the benchmark parameter values. In panel (a), we can see that the threshold values decrease with outsourcing. Panel (b) shows the net employment effect. Since the equilibrium is calculated under the case where the northern firms outsource their assembly segments, and the southern firms outsource neither segment, I present the net employment change only for the relevant range of the wage differential, equation (36). That is $\delta \in [0.1449, 0.1917)$ for the benchmark case. In the relevant range of ?, the net employment effect is positive. That is the benefit from outsourcing generates job creation that is larger than the job destruction from sending the assembly jobs to the south.

This result could be driven by the parameter values chosen for the benchmark case. I replicate figure 6 for different parameter values in figure 7. The left column shows the level of northern manufacturing employment in two equilibria. In all six cases, we can see that the threshold values fall with outsourcing, generating job creation from moving south-only equilibrium to co-existence equilibrium. We can also see that in North only equilibrium, employment falls with outsourcing. This is because the competition is among northern firms even in the free trade equilibrium, so the gain from outsourcing for the northern manufacturing sector as a whole is not large enough to offset the job destruction from physical relocation of assembly segment. In most cases, the net employment effect is positive. In two cases - the one with low elasticity of substitution and the other with large assembly segment -, the relevant range of δ fall in the south only equilibrium, leaving northern manufacturing sector with zero employment.

5 Conclusion

As technology advances, physical separation of different manufacturing stages becomes possible. Firms take advantage of the cost reducing opportunity, and send part of their businesses to foreign countries where wage rates are lower. The theoretical model presented in this study has two countries where manufacturing firms within each country share the same production technology to produce differentiated products. The wage rate is lower in the south, but the northern service segment is technologically superior. Northern firms could outsource either assembly or service segment, or both to the south depending on the parameter values, but southern firms will only consider outsourcing the service segment. As firms explore the profit improving options, both job destruction and creation occur. Job destruction comes from the physical relocation of one or more segments, and job creation comes from the realized benefit of outsourcing - sales increase.

In the analysis of the case where northern firms outsource their assembly segments to the south while southern firms outsource neither segment, there is significant increase in northern share of the market. As prices of northern varieties fall, the decrease in relative price of northern varieties generate large consumption shift from the southern varieties to the northern varieties. For the benchmark parameters considered in the numerical analysis shows 61 percentage point increase in the northern share of the southern market, 43 percentage point increase in the northern market; together

35 percent of the world market shifts from southern varieties to northern ones.

Outsourcing widens the range of wage differential over which northern firms can compete in the world market. In other words, in the absence of outsourcing, the relative price of northern varieties is so high that there is no market for northern varieties. The price reduction that outsourcing brings to the northern varieties enables the northern firms to compete in the market. In the process, there is large gain in the northern share of the market, which in turn generates large job creation. Employment analysis shows that such job creation is larger than the job destruction from the assembly segment that is sent to the south, yielding net employment gain for various sets of parameter values investigated.

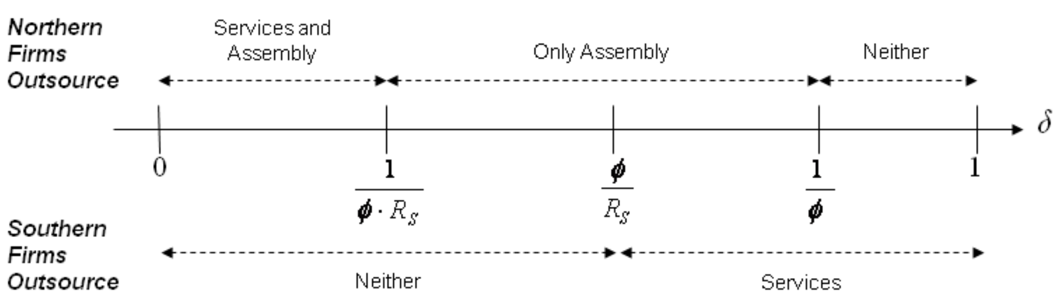


Figure 3.1: Pattern of Offshore Outsourcing

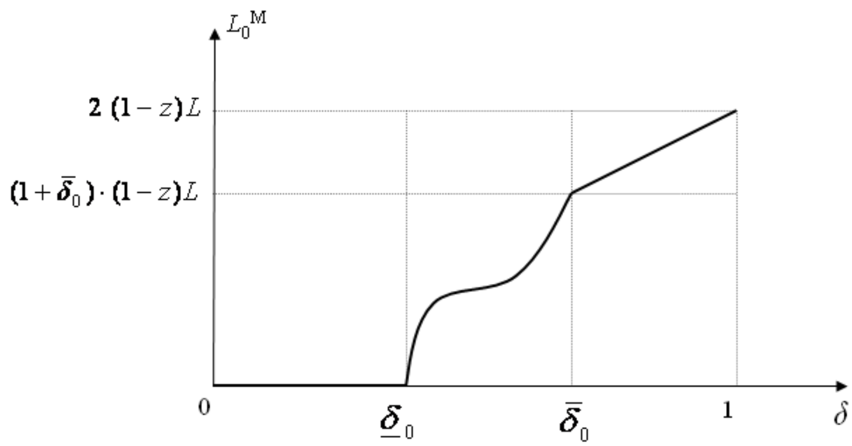


Figure 3.2: Size of Northern Manufacturing Employment in the Free Trade Equilibrium

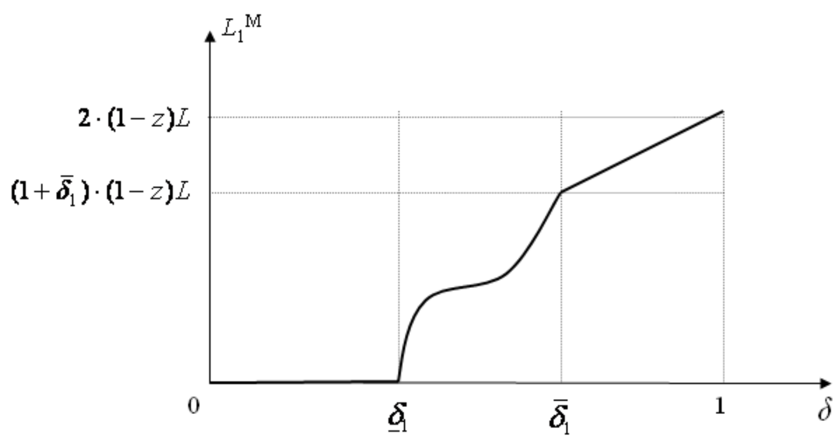


Figure 3.3: Size of Northern Manufacturing Employment in the Outsourcing Equilibrium

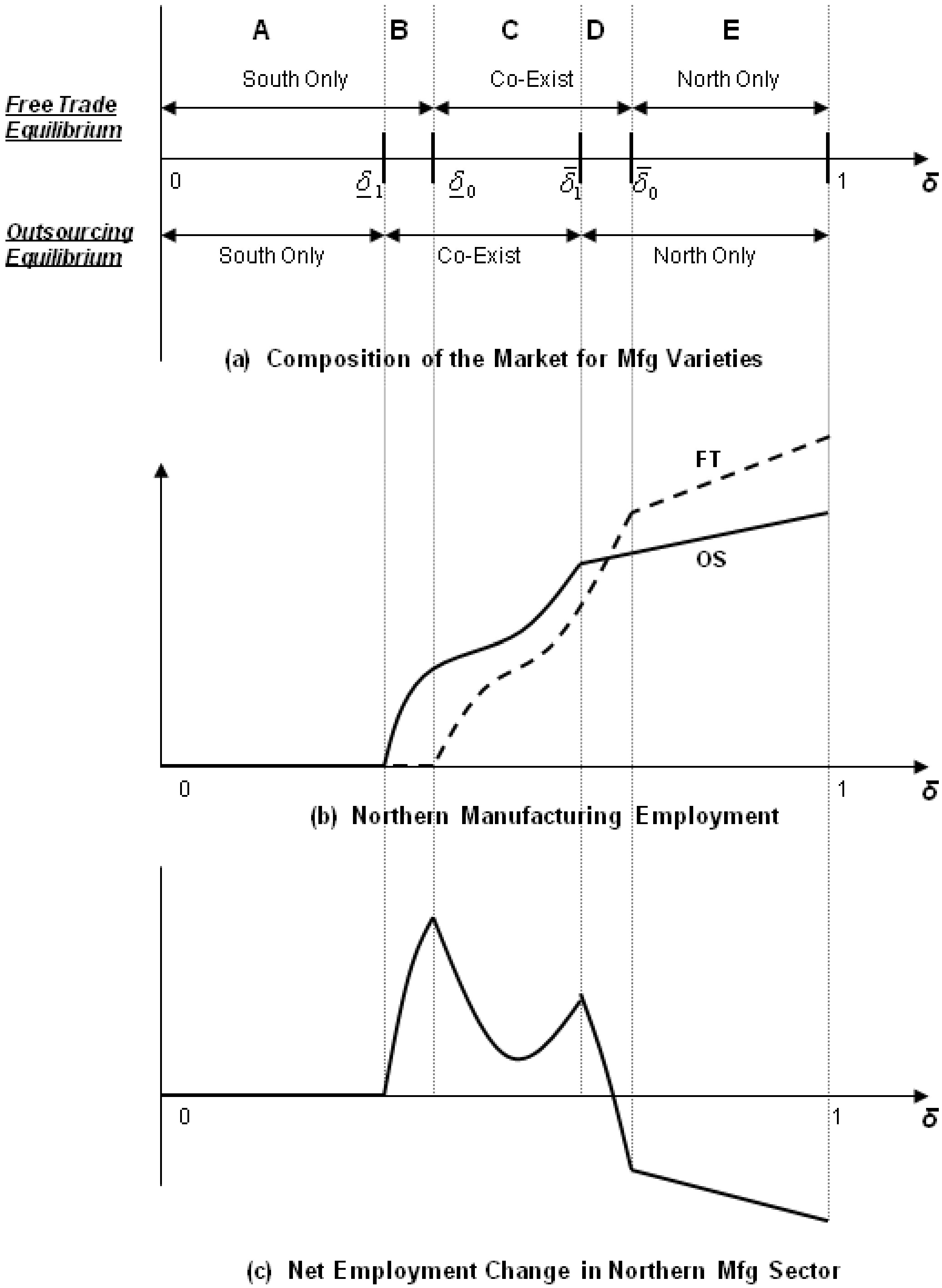
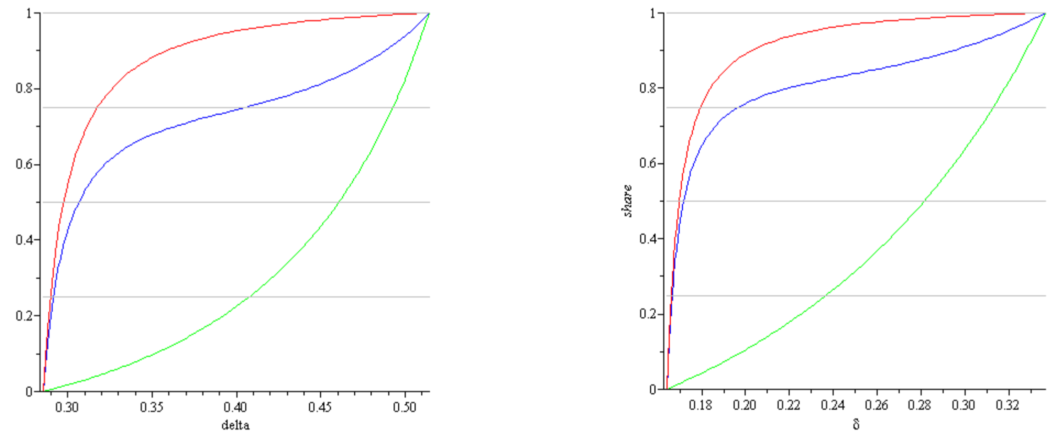
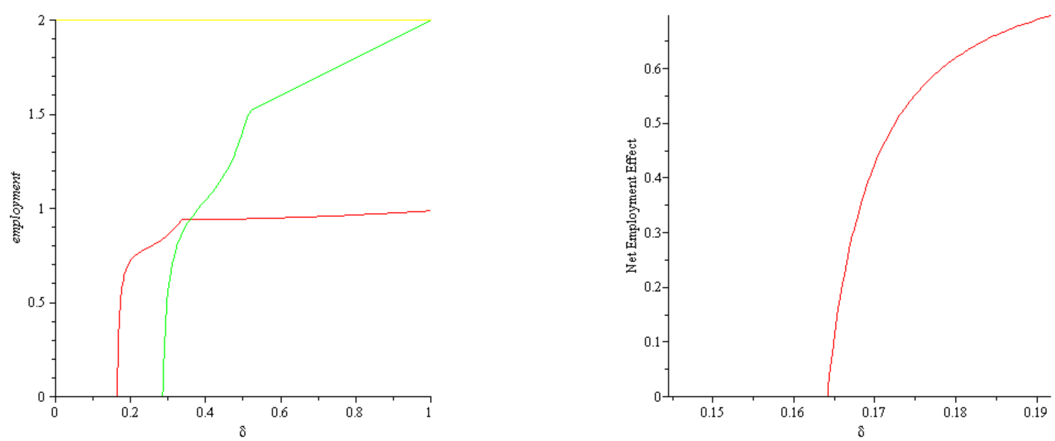


Figure 3.4: Comparison of Equilibria



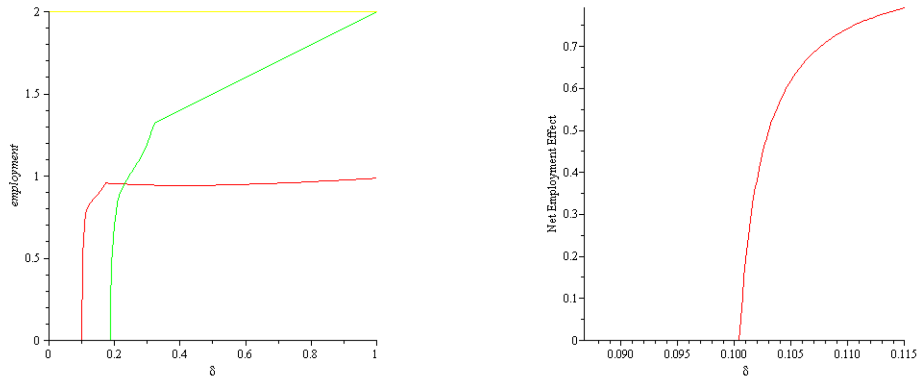
(a) Free Trade Equilibrium (b) Outsourcing Equilibrium

Figure 3.5: Northern Share of Various Markets

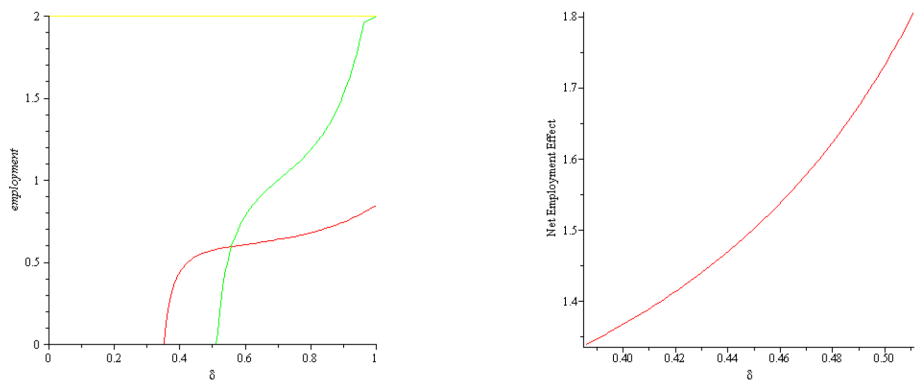


(a) Employment (b) Net Employment Change

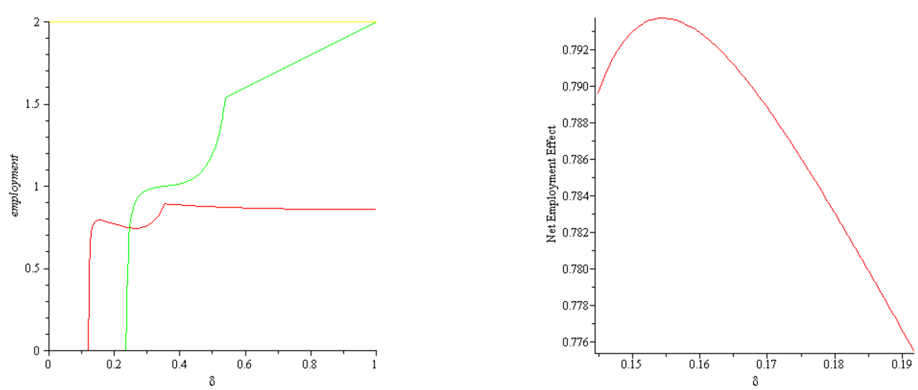
Figure 3.6: Employment Effect on the Benchmark Case



(a) Large Technology Differential: R = 5

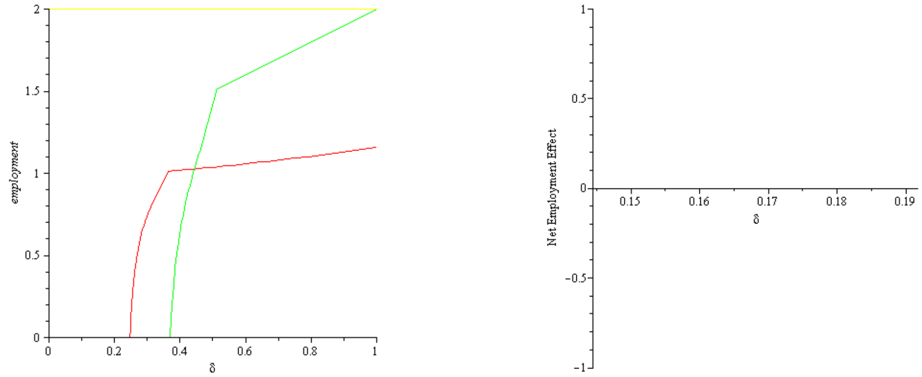


(b) Small Technology Differential: R = 1.5

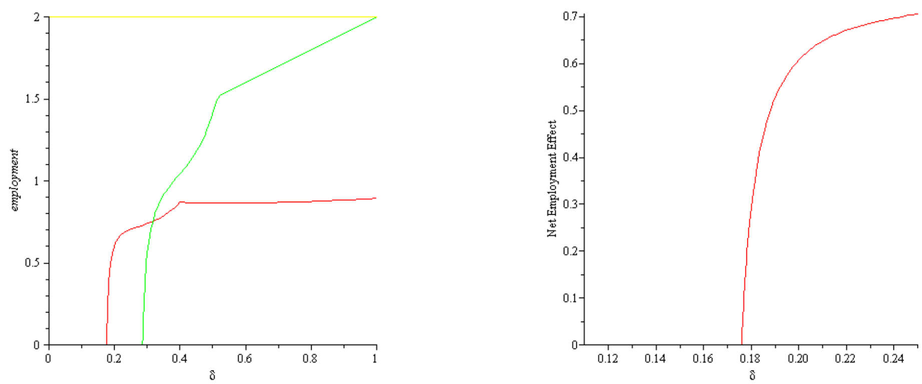


(c) High Elasticity of Substitution: ε = 10

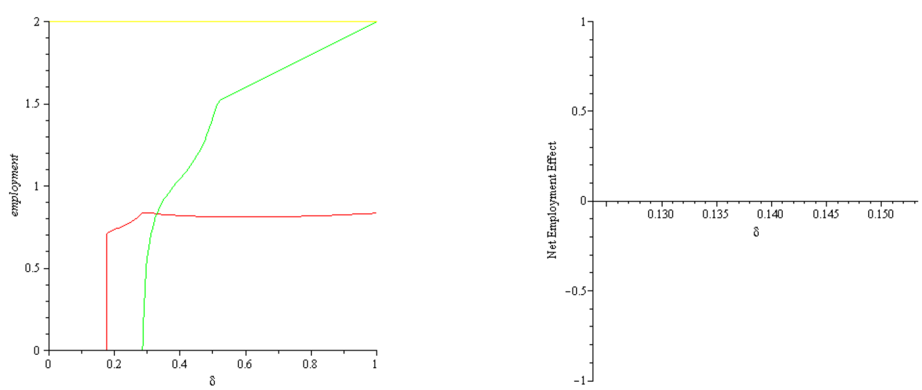
Figure 3.7: Net Employment Effects with Various Sets of Parameter Values (1)



(d) Low Elasticity of Substitution: $\varepsilon = 3$



(e) High Outsourcing Cost: $\varphi = 1.5$



(f) Large Assembly Segment: $\gamma = 0.3$

Figure 3.7: Net Employment Effects with Various Sets of Parameter Values (2)

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Chapter IV

Does Occupational Training by the Trade Adjustment Assistance Program Really Help Reemployment? Success Measured as Matching

1 Introduction

International trade has constantly increased throughout the second half of the 20th century, and the trend will continue well into 21st century. International trade used to be mostly in finished goods; however, continuous technological advancement and the resulting reduction in transport cost expanded international trade to include inputs (Yeats [1998], Hummels et al. [2001]). As virtually every good (and even services) becomes tradable, international trade is more active than ever.

International trade has changed the competitive structure between developing and developed countries, and this affects the employment in both groups of countries. First, goods from developed countries have to compete against cheaper goods from developing countries. This is a more traditional type of competition. Since the goods from developed countries lose their market shares to goods from developing countries due to their high relative prices, employment in these countries decreases in the sectors that face high import competition (see Kletzer, 2002). Second, workers from developed countries have to compete against low-wage workers from developing countries. International trade and fragmentation together provide great cost-reducing opportunities for firms. Firms utilize the practice of offshore outsourcing, either by establishing their own subsidiaries in low wage countries or by using arm's length contracts with foreign firms, to perform tasks that were previously performed by high-wage domestic workers. The tasks that are being outsourced offshore are not only production-related, but also services (Amiti and Wei, 2005). This has both positive and negative effects on employment in the developed countries. Employment may rise as efficiency of outsourcing firms increases, their prices fall and market shares rise. Firms maintain some parts of their business process at home, and increases in sales will expand employment in the domestic part of their business as well as the foreign part. If sales gain is substantial, it is possible that employment in the domestic portion of those firms actually rises above the level prior to outsourcing. However, the workers whose tasks are replaced by activities of workers in developing countries lose their jobs.

While most economists agree on there being a net welfare gain from freer trade through an increase in overall economic efficiency and aggregate income, larger variety of consumer products, and lower prices, they do not deny the fact that there are winners and losers. The biggest losers from international trade are the workers displaced due to the increase in competition from imports and offshoring. The Trade Adjustment Assistance program (TAA) is specifically designed to compensate these workers.

Many studies find that TAA participants are, compared to a broader group of displaced workers such as Unemployment Insurance (UI) beneficiaries, more likely to have a harder time finding a job. Baicker and Rehavi (2004) show that TAA participants are older, less educated, and include a higher fraction of people without an adequate level of English proficiency. Corson and Decker (1995) show that the majority (72% compared to 31% for UI exhaustees) are displaced due to plant/company closures; therefore they are less likely to be recalled by their previous employers.[23] Their tenure with previous employers is also higher than UI exhaustees. These facts indicate that TAA participants may benefit from moving to different occupations, and that they are not very likely to have employable skills. This suggests the need for provision of vocational training services. For this reason, training

[23] 23% of TAA participants reported that recall is likely while 43% of UI exhaustees reported so.

and income support during training are the most important benefits of the TAA program. Other benefits are summarized in Table 1.

The performance of the TAA program is officially assessed by three performance measures: Average Earnings (or Wage Replacement Rate, up to 2006), Reemployment Rate, and Retention Rate as of fiscal year 2008. Table 2 summarizes the performance of the TAA program for fiscal years 2003-2007. These performance measures provide a general idea of whether TAA participants find a job that replaces reasonably well the job prior to participation. However, these performance measures do not directly measure the efficacy of the training service in helping participants' re-employment and post-exit economic welfare.

An article in *The New Yorker* by Katherine Boo (2004)[24] tells a story about a woman who was laid off from the Fruit of the Loom plant located in Harlingen, TX, at the end of 2003. She received medical-assistant training, applied for twenty-nine positions, got three interviews, but ended up serving lunch at a nearby construction site. The article describes the reality of the training program in Cameron County as follows:

> In the past five years, more than a thousand displaced manufacturing workers had been retrained as medical assistants or air-conditioning repairmen or computer-maintenance technicians. . . . The state workforce commission had predicted that twenty-five medical-assistant jobs would open in Cameron County in 2003, but it would be difficult to secure one. In one class of laid-off textile workers alone, eighty-five people had been trained for the profession.

This article suggests that many participants receive training in occupations in which there are not enough job openings and end up in occupations unrelated to their training. There are studies investigating whether trainees do better after program exit compared to non-trainees in terms of the above three performance measures - see Corson and Decker (1995) for the TAA program, and Heckman, LaLonde, and Smith (1999) for federal training programs in general. However, how much obtaining skills for a specific occupation through classroom training contributed to their reemployment is still not well explored.

The information on TAA participants, services that they received, and the outcomes is

[24] "Letter from South Texas: The Churn," *The New Yorker*, March 29th, 2004

reported by Trade Act Participant Report (TAPR). TAPR reports the 8-digit Occupational Skill Training Code (OSTC) and Occupational Code of Employment (OCE) for each participant who received training service. From a preliminary investigation of TAA participants who exited the program between July, 2004 and September, 2007, I find that only 45% of people who received occupational skills training have identical codes for OSTC and OCE.[25] This might indicate that for 55% of trainees, training was a waste of resources. This is an inherent problem of federal training programs since the supply of trainees is only loosely linked to the demand for newly trained workers. The mismatch between supply and demand for trainees is not only a problem of the federal programs of the US. For the cases of apprenticeship systems of Germany and Denmark, see Rasmussen and Westergaard-Nielsen (1999). According to the US General Accounting Office (GAO), the cost of training - tuition for training classes and additional TRA payments - accounted for 48.36% of TAA expenditure for fiscal years 1995-1999.[26] The supply and demand mismatch issue indicates that there is ssignificant room to improve the cost efficiency and program performances of training programs. For this reason, a good understanding of the mismatch problem is very important.

In this project, I investigate the efficacy of the retraining service provided through the Trade Adjustment Assistance (TAA) program, focusing on the match between OSTC and OCE reported in TAPR. More specifically, I investigate what the probability is of matching between OSTC and OCE, and how matching is affected by the individual characteristics of participants and the services that they received. I also look at whether matching improves the participants' post-participation economic welfare - measured by reemployment rates, average earnings, wage replacement rates, and retention rates - by comparing the outcome measures for trainees with a match, trainees without a match, and non-trainees.

First I investigate the hypothesis that matching is a result of successful training. I

[25] The total number of observations is 143,301. Only 30,538 of them have valid codes for both OSTC and OCE. 45% matching is among those 30,538 trainees.

[26] Training and Additional TRA accounted for 29.95% and 18.41%, repectively, of the total expenditure. Most of the rest of TAA expenditure was used to pay Basic TRA. Non-training-related services - reemployment services, job search allowances, and relocation allowances - accounted for a negligible fraction of the total expenditure.

use educational attainment as a proxy for learning ability, which would help participants succeed in their training. Education shows an insignificant or negative effect on matching, however, unless the occupational choices of participants are controlled for. This might be because more educated people receive training that is more generally applicable, such as management, so a match is not a dominant factor in choice of employment for them. As the highly educated tend to choose a non-match occupation for their employment - compared to the less educated who has limited sets of skills that can only be applied to certain occupations - the link between learning ability and matching becomes blurred.

Investigation of reemployment rates shows that occupational skills training and OJT improve the chance of reemployment by 5 and 10 percentage points, respectively. Education also helps. participants with Bachelor's degree show 5 percentage points higher chance of reemployment than those with less than a high school degree. The most important factor for reemployment rate, though, is the age of the participant. Age shows an upside-down U-shape relationship with the reemployment rate, indicating that workers between age 21 and 30 are most favored by employers. The impact of old age is extremely negative - 41% lower chance of reemployment for workers between age 61 and 65 compared to workers between age 41 and 50, but this can partially be explained by voluntary withdrawal from the labor market.

Matching significantly affects both post-participation earnings and the wage replacement rate. This effect is unaffected by different occupational choices by participants for both outcome measures. The wage replacement rates for trainees with a match are 3 to 4 percentage points higher than those of non-trainees. However, education and age affect earnings by substantially larger magnitudes than matching. The impact of higher-than-Bachelor's-degree is 10 times larger than the impact of having a match. Age again shows an upside-down U-shape relationship with highest earnings for participants of age between 41 and 50. For wage replacement, the influence of education is of similar size to that of a match. However, the negative impact of age increases monotonically with age. Workers between age 16 and 21 have a 27 percentage point higher wage replacement rate than those of age between 41 and 50. Workers of age between 61 and 65 have a 15-18% lower rate compared to the 41-50 age group. Matching does not improve the retention rate. The retention rate is affected by occupational skills training - by 1% - and OJT - by 3%. The impact of education is positive, but smaller than 2%.

Although determining what aspect of training leads to a match needs further investigation, achieving a match is important in improving post-participation outcomes - especially earnings-related measures - of participants. The results show that although outcome measures for trainees are generally better than non-trainees, occupational skills training alone - training that does not lead to a match - does not improve the outcome measure. This implies that the focus of the TAA program on provision of training services can only be fruitful if it is accompanied by emphasis on choosing the right occupations for participants by thorough career assessment and counseling.

The rest of the paper is organized as follows. Section II describes the TAA program in more detail, section III introduces the data set and provides various descriptive statistics. Section IV presents the analytical methodology and results. Section V concludes.

2 Trade Adjustment Assistance

The TAA program is a dislocated worker program administered by the Employment and Training Administration of the U.S. Department of Labor (DOL). TAA was first established in 1962, but it has only been actively implemented since the Trade Act of 1974. The North American Free Trade Agreement (NAFTA) Implementation Act of 1993 added a separate NAFTA-TAA program to help workers who are affected by the free trade agreement. The Trade Reform Act of 2002 integrated NAFTA-TAA into the regular TAA program.

When layoffs occur at a certain establishment, a group of three or more workers from the establishment or any entity representing them may file a petition with the DOL. The petitions are filed at the plant level. The Division of Trade Adjustment Assistance investigates the case and issues a certification if they find evidence that employment of the group of workers is adversely affected by any of the following: shift in production to a foreign country, increase in company imports, increase in participant imports, or high and rising aggregate US imports. Once certified, all workers who are laid off from that establishment between the initial layoffs (impact date) and 2 years from the certification date are entitled to the services and benefits listed in Table 1. If a worker is over age 50, he/she may apply for the Alternative TAA (ATAA) program instead of TAA. ATAA is a wage insurance program that subsidizes 50% of the difference between the pre-layoff wage rate and the wage rate in the new job, up to $10,000 a year, in case the worker obtains reemployment no later than 26 weeks from the date of separation.

The most important benefits are training and income support. If career counseling determines that the participant does not have a skill useful for reemployment, the worker may enroll in occupational skills training up to 104 weeks. If the participant lacks basic education such as English proficiency or high school education, the participant may enroll in remedial training for an additional 26 weeks in addition to the regular training. Training enrollment is permitted only if it is believed that the participant would benefit from training and has a higher chance of reemployment with training. If this is not the case, the participant may obtain a training requirement waiver. The training waiver is issued if the participant does not need training - if she has marketable skills or will soon be recalled by the previous employer - or is not able to take training - health issues or inability to find a suitable training program. While enrolled in training, TAA participants are entitled to an income support (basic TRA, additional TRA, and remedial TRA). The workers must apply for TRA before 8 weeks from the date of certification or 16 weeks from the date of the most recent qualified separation, whichever comes sooner. participants who obtained a training waiver can receive the basic TRA without enrolling in a training program.

Choice of training occupation is made by participants with the help of local TAA staff through a proper assessment of the worker's ability. The ability assessment is measured based on applicant's education, work history, potential barriers to employment, basic skills capabilities, aptitudes and work skills, family situation, attitudes toward work, behavioral patterns, supportive service needs, and interests for careers and training as they relate to the local labor market. Information is gathered primarily using questionnaires, individual interviews, paper and pencil tests, performance tests, behavioral observation, and career guidance instruments.

3 Data

Since the initiation of the TAA program in 1962, a substantial number of workers have received various benefits through the program. However, the collection of participant data became obligatory only for participants who exited the program since July 1, 1999. Throughout the last quarter of 2008[27] , 314,964 participant cases are reported on TAPR. In 2005, TAPR's coding system was revised so that reporting of occupational codes for training and employment were unified. Prior to the 2005 revision, OSTC and OCE were reported using various classification systems: 8-digit O*Net code, 5-digit OES code, and 9-digit DOT code. The 2005 Revision requires usage of the O*Net code. Since OSTC and OCE are the main variables of interest, I only use observations collected after the revision - data reported since the fourth quarter of 2005 - to avoid error due to imperfect correspondence. This restricts the sample size to 143,301.

TAPR consists of three sections. The first section, *Identification and Participant Characteristics*, collects personal information of participants such as date of birth, gender, ethnicity, and education level. Any information regarding the qualifying separation (date of separation, tenure with previous employer, and TAA petition number) is also reported in this section. Section II, *Activity and Service Record*, summarizes the TAA benefits a participant received. If the participant received training, it reports what type of training - occupational skills training (along with OSTC), remedial training, on-the-job training, or customized training - he/she received. For all participants, receipt of financial assistance

[27]This is the reporting quarter. Each participant is monitored for three quarters from his/her date of program exit before being reported on TAPR. The last program exit date reported by the end of 2008 is 9/30/2007.

- basic Trade Readjustment Allowance (TRA), additional TRA, remedial TRA, job search allowance, and relocation allowance - is reported. Finally, section III, *Outcomes*, reports whether the participant is employed, which occupation he/she is employed in (OCE), and how much they earn during three quarters following the program exit.

Table 3 summarizes the data set. Columns 1 to 4 summarize data for different years of program exit. The last column summarizes the entire sample. Individual characteristics of the participants differ across exit years. Over time, the fraction of participants of age 55 and above increased while the fraction of workers of age between 30 and 44 noticeably decreased. One might guess that participation of older workers is encouraged with the establishment of the Alternative TAA (ATAA) program.[28] However, with a little over 5%[29] of participants of age 50 or above participating in ATAA, the hypothesis is hardly plausible. Also, participants' average educational attainment decreased slightly. On the other hand, the fraction of participants with limited English ability increased. However, most of these changes are small.

Service delivery also changed over time. First, surprisingly large fraction of participants obtained training waivers. For the entire sample, nearly 67% of participants obtained training waivers while 74% of the sample received training services. This implies that at least half of the participants with training waivers end up receiving training services. This shows that obtaining training waiver does not always imply participants' unwillingness to participate in training programs. The high fraction of participants with training waivers -compared to the fraction of trainees - can be explained in two ways. First, training waiver could be used as a tool to postpone the training enrollment process. participants who can not find a suitable training program soon enough have an incentive to obtain a training

[28]ATAA was added to the regular TAA program by the TAA Reform Act of 2002. It is a wage insurance program established to speed up reemployment of relatively older TAA participants (50 or older) who would not fully benefit from retraining. If an eligible worker accepts a job that pays less than $50,000 annually within 26 weeks from participation, DOL provides 50% of the difference between the previous wage and the new wage up to $10,000 for up to two years.

[29]5.69% for 2006 and 6.35% for 2007. The participation rates for 2004 and 2005 are only 0.73% and 2.43%, respectively. This is probably because the ATAA was not fully taken advantage of for those early participants. Participants of ATAA are also reported in the TAPR, and they are included in the sample of this study.

waiver because they are entitled to 26 weeks of income support, basic TRA, once obtain the waiver. According to Table 3, 23.68% of training waivers are issued because training enrollment is unavailable at the training enrollment deadline.[30] These people may begin their training when the program enrollment becomes available. Also participants with marketable skills may later realize that they are not able to find a job with their existing skill sets; therefore they enroll in training program. Second, the fraction of trainees could be exaggerated. There are trainees who receive workshop-like training of very short duration. Among 90,503 trainees who reported valid dates for the first and last day of training, 6,972 received training shorter than a week.

The fraction of trainees fell noticeably in 2006 while the fraction of participants who obtained training waivers shows a large increase. However, as the fraction of trainees increased back to the previous level in 2007, the issuance of training waivers did not decrease. This can be explained by a substantial rise in the fraction of participants with marketable skills for exit years 2006 and 2007. The fraction of trainees who received occupational skills (classroom) training decreased significantly over time. This again might be explained by the rise in the number of participants who have marketable skills. On-the-job training is used only for a negligible fraction of trainees; but, remedial training is relatively well utilized. Among participants who received remedial training, 42.45% had less than high school education, and 16.39% had limited English proficiency.

Outcome variables are summarized in Table 4. The first section summarizes the outcome measures across different exit years, and the second section summarizes them across different levels of pre-participation earnings. The earnings level is interesting because of its linkage to the participants' potential outcomes. Outcome measures do not vary much across exit years except for the matching rate which increased over time from 40% in 2004 to 50.89% in 2007. One can clearly see that trainees have much higher chance of reemployment than non-trainees although the difference narrows over time. Wage replacement rates are higher

[30] In order to receive the basic TRA, participants are required to enroll in a training program within a certain time period from their program participation. If a participant fails to enroll before the deadline, the only way to receive the basic TRA is by obtaining a training waiver.

for trainees with a match compared to non-trainees. Overall, trainees with a match show substantially higher rate of wage replacement than trainees without a match except for exit year 2005. Also, the difference between trainees with a match and without a match is larger than the difference between trainees without a match and non-trainees. This might be an indication that finding a job in the training occupation indeed improves the post-participation performance of the trainees. However, the causal relationship is ambiguous and needs more thorough investigation. Retention rates do not differ much across exit years and across different groups of trainees. Trainees show slightly higher retention rates than non-trainees, and a larger fraction of trainees without a match stay employed after they are initially hired. However, the difference is very small.

Looking at the outcome measures across different earnings levels provides another dimension to what we observe across exit years. First of all, matching rates are higher for participants with low earnings level. This could be because these workers have a very limited set of skills; they are less likely to find a job outside the training occupations. participants within the medium range of pre-participation earnings find a job more easily than the higher earnings group. This trend is shown by both trainees and non-trainees, but the rates are substantially higher for trainees at all earnings levels. Wage replacement rates show a very interesting pattern. For all levels of pre-participation earnings except for the second category $5,000-$9,999, trainees without a match show significantly higher wage replacement rates. However, the second category has the largest number of observations so that the mean wage replacement rates for trainees with a match are higher than those without a match. This shows that the link between a match and post-participation performance is loose. Trainees show higher rates of retention compared to non-trainees, but trainees with and without a match do not show a clear pattern.

participants' choices of training occupations deserve a closer look. O*Net occupation codes are composed of the first two digits representing the occupational groups, the next four digits of occupation codes within each group, and the last two digits for additional sub-categories. There are 23 occupation groups such as management, and business and financial operations. These occupation groups are listed in Table 5. Some occupation groups, e.g. Management, are more generally applicable than others, e.g. Building and Grounds Cleaning and Maintenance. Therefore, the probability of matching might vary across occupational groups. Table 5 shows that the participants are widely distributed to most of the 23 occupation groups in their training choices, while employment is concentrated in a few groups.

Tables 6 and 7 summarize individual characteristics of participants and the matching rate for each occupation group of their training occupations and occupations of employment. The first column shows that matching rates vary greatly across different occupation groups. Especially, the matching rates shown in Table 7 show that the majority of employees in some occupations groups - legal (23) and healthcare practitioners and technical (29) - received training specific to the occupations, while training does not seem necessary to be employed in some occupations - sales and related (41) and farming, fishing, and forestry (45).

Gender is vastly relevant for the participants' occupational choices. While some occupation groups - construction and extraction (47), installation, maintenance, and repair (49) , and transportation and material moving (53) - are extremely male-oriented, some occupations groups - legal (23), healthcare support (31), and office and administrative support (43) - are highly female-oriented. This pattern is preserved for occupations groups of employment. The importance of English proficiency also differs greatly across occupations. In training choices, people with limited English proficiency show high concentration in three occupation groups - food preparation and serving related (35), building and grounds cleaning and maintenance (37), and personal care and service (39). These three occupation groups hire more workers with limited English proficiency, but farming, fishing, and forestry group (45) is the major employer of these workers.

Table 6 also shows that different ethnic groups choose different occupations. Training in farming, fishing, and forestry (45) is the most popular choice for white participants while Asians choose to be trained for occupation group building and grounds cleaning and maintenance (37) and personal care and service (39). African American participants tend to choose community and social services (21) and education, training, and library (25), Hispanic participants choose personal care and services (39) and office and administrative support (43). These choices are reflected in their employment as well. One noticeable thing, though, is the high concentration of Asian participants employed in architecture and engineering (17) and Hispanic participants in military specific (55). However, the military group is too small for this high concentration of Hispanic employees to be meaningful. The level of education is a very important factor in choosing occupations. Trainees with different education levels display distinctive choices of occupation groups. This pattern is preserved in their employment with higher intensity.

Table 8 summarizes the link between occupational choices and post-participation performance. Occupational choices certainly matter for the chance of reemployment after training. Reemployment rates range from 71.43% for farming, fishing, and forestry (45) to 88.79% for protective service (33). Once employed, retention rates and wage replacement differ across the occupations of employment. Architecture and engineering (17) and healthcare practitioners and technical (29) show superior post-participation performance with high retention and wage replacement rates. Since choices of occupation influence the post-participation outcomes, and different personal characteristics show different patterns of occupational choice, it is expected that gender, ethnicity, and education level are linked to the outcomes.

4 Analysis

As shown in the previous section, matching is linked with various personal characteristics of participants, and the outcomes of the program are not only influenced by matching but also by many other individual characteristics. In this section, I investigate the effect of each variable on matching and on other outcome measures. This is to improve our understanding on how matching is achieved and how the performance of the TAA program can improve through better matching. First, I look at how individual characteristics of participants influence the probability of a match. Then, I look at how matching and other characteristics of participants affect the outcome - probability of reemployment, wage replacement rate, post-participation earnings, and probability of remaining employed.

4.1 What affects Matching?

In a non-experimental setting, there always is a selection into participation in a social program. The TAA program is not an exception. Basic TRA is paid to the participants only after their unemployment insurance benefits exhaust; therefore, people who are able to find desirable work - potentially those people with better education and skill sets - within 26 weeks from separation would not participate in the TAA program. However, this selection issue is not the main focus of this project. More relevant issues are selection into occupational skills training and having a match between OSTC and OCE. All participants receive employment counseling and career assessment. Occupational skills training is recommended to participants who can benefit the most from it: possibly participants with higher learning ability. Matches also have selection problem. If a match between OSTC and OCE is a preferred employment option to a non-match, the selection problem would be relatively well defined. For instance, workers who have high ability would tend to have a match, and better wage replacement rates and retention rates. In this case, the high correlation between a match and better outcome measures is caused by trainees with high ability selecting into a match. However, in practice, a match may not be an indicator of higher ability. Some trainees might choose a non-match occupation because it offers more desirable compensation or work environment, but others might fail to find a match because they were not qualified for the occupation that they were trained for. In order to understand the selection into a match, I investigate the impact of various personal characteristics on the probability of a match.

The outcome variable here is the match. '1' indicates a match and '0' indicates a match failure. I use Probit analysis for this analysis as the following:

$$\Pr(Match_i = 1) = c + \alpha OCC_i + \beta X_i + \delta_1 D_{5i} + \delta_2 D_{6i} + \delta_3 D_{7i} + \varepsilon_i \tag{70}$$

OCCi is a vector of dummy variables for the occupation groups listed in Table 5. '1' indicates the occupation group of training. As shown in Table 6 and 7, the probability of matching varies across occupation group. Vector α will capture such variation. X is a vector of individual characteristics such as gender, ethnicity, educational attainment, completion of training, and age at program exit. D_{5i}, D_{6i}, and D_{7i} are dummy variables for exit years. Reemployment depends on the economic situation at the end of training; some years might have a generally lower probability of matching due to recession. For this estimation, only the observations with valid OSTC and OCE will be used. Therefore, all participants used in the analysis necessarily received occupational skills training. For this reason, only the selection into a match will be investigated.

There are six specifications. Specification 1 uses only the personal characteristics included in vector X. The reference group for this specification is white females with less than high school education between ages 41 and 50. Specification 2 also includes the years of exit, 2005, 2006, and 2007. The reference year is 2004. Specification 3 includes 21 indicator variables for occupation groups of training. Group 11, Management, is used as a reference group. Also, occupation group 55, Military Specific, is omitted since training and hiring process for military personnel is different from other occupation groups. Group 55 only accounts for 0.07%[31] of the sample, so it would not affect the analysis in a significant way. Specification 4 includes both years of program exit and occupations groups. Specification 5 includes states of participants. California is used as reference group. Specification 6 includes years of exit as well as states. These six specifications will be used for other analysis. For each specification, I perform the analysis with or without the indicator variable for training completion. This is because completion of training might be endogenous. Again,

[31]This is different from the figure shown in the fifth column of Table 5 because it is calculated from the observations with valid codes for both OSTC and OCE.

there are two measures of education used in the analysis. First, education is measured as degree attainment, so five dummy variables for high school degree or equivalent, some college, associate degree, bachelor's degree, and more than bachelor's degree are used. Second measure of education is years of schooling. Analyses using the first measure are marked with '*a*,' and those using the second measure are marked with '*b*.'

For this analysis, observations from states Oklahoma and Virginia are omitted because they show 100% and 99.97% of matching rate. This is shown in Table 9. Although this is not impossible, it is likely a result of miscoding. The sample from Oklahoma and Virginia accounts for 5.00% of the sample. The matching rate for observations with valid OSTC and OCE code decreases to 34.25% from 44.56% if Oklahoma and Virginia observations are excluded.

Table 10.a. summarizes how individual characteristics affect matching. The numbers reported are the marginal effect of each variable on the chance of matching. One hypothesis to consider is that a match is a result of the participant's successful performance in training. There are two variables that might indicate the success in training; one is training completion and the other is education. Education is a less direct indicator, but a proxy for learning ability. In all specifications, completion of training is very significant. Considering that the matching rate for the sample studied here is 34.25%, completion of training raising the chance of matching by 22 to 26 percentage points, depending on specifications, is substantial. However, training completion could be endogenous. participants might withdraw from training because they find a job that does not require completion of the current training, and that is better than the ones that they can potentially get after completion. Alternatively, they might withdraw because they find that the occupational choices were not optimal - they find the occupations uninteresting, or they are not able to learn the material properly. In either case, the occupation of employment is likely to be different from that of training. This causes a selection problem. Non-completion occurs when a match is not desirable or not attainable, enforcing high correlation between completion and a match.

Education, as a proxy for learning ability, is expected to help success of training, hence a match. However, the first column of Table 10.a shows that a higher level of education has a negative or insignificant effect on matching, providing evidence against this hypothesis. One explanation of why highly educated participants - Bachelor's degree or more - do not show a significantly higher matching rate than people who did not complete high school education can be taken from Table 6. More educated people tend to choose occupations that are more generally applicable, such as management. According to Table 6, trainees with Bachelor's degree or more account for 5.58% of the sample, but account for 12.95% of management. The matching rate for the management group is only 25.48%, which is substantially lower than 44.60%. Besides management, trainees with bachelor's degree or more show high concentration in business and financial operations (13), computer and mathematical (15), architecture and engineering (17), and education, training, and library (25) in which skill sets are less occupation specific. In this case, matching may not be a dominant choice for employment, so they might be indifferent between a match and no match, reducing the matching rate for highly educated people. On the other hand, the less educated show more concentration on healthcare support (31), food preparation and serving related (35), building and grounds cleaning and maintenance (37), production (51), and transportation and material moving (53), which are more job specific. This hypothesis is supported by specifications 3 and 4. Once occupation groups are added, higher education levels become significant and positive. The occupations with high concentration of less educated people match with the occupation groups that have significantly positive effects on matching in specifications 3 and 4.

Ethnicity is another important factor. Asians and African Americans show significantly lower matching rates than white participants, and this is stable across specifications. However, Hispanic participants show a significantly higher matching rate than white participants only if training completion is included in the analysis. Hispanic participants indeed show a higher rate of training completion (85.12% compared to 79.04% for all ethnicities). Age at the time of program exit is very significant and the size of the effect is stable across specifications. The highest matching rate is shown by trainees with age between 21 and 40, approximately 4 percentage points higher than age group 41-50. The youngest group shows the same rate as the reference group, and matching decreases with age. This indicates the upside-down U-shape curve for the relationship between matching and age. Inclusion of the years of exit does not affect other variables, but it is significant. It also indicates that the labor market in 2004, the reference year, is typically bad.

Inclusion of states changes the effects of most variables besides age. This is because composition of TAA participants differs greatly across states. This is shown in Table 9 along with gender, English proficiency, ethnicity, and levels of education as a fraction of observations for each state. Limited English proficiency varies greatly across states ranging from 0 in some states to 23.64% in California and 33.3% in Rhode Island. When states are added into the analysis, limited English proficiency is found to lower the matching rate significantly by 12 percentage points. Also, the ethnicity indicator for Hispanics becomes one of the most important factors lowering the chance of matching by 23 to 24 percentage points. In magnitude, it is as big as training completion. Besides changing the size of the effects of other variables, state variables are very significant themselves. The significance of states can stem from two reasons. First, the labor market situation differs across states, so the performance of job applicants would differ as well. Second, state variables might be capturing the quality of coding that differs across states. The second column in Table 9 shows the matching rate for each state. The matching rates range from 0% (Alabama, Arizona and a few others) to 99.97% (Virginia) and 100% (Oklahoma). It is plausible that such a great range is caused by coding issues. Inclusion of state variables will control for those problems.

Table 10.b. shows the same analysis using years of schooling as a measure of education level. The size and sign of the effects of all variables are basically unaffected. Schooling again shows a significant and negative effect on the chance of matching.

4.2 Effects of training and training with match on Outcome Measures

The conventional literature on evaluation of training programs compares trainees to non-trainees. That comparison asks a simple question - Does training work? However, it does not answer why training works. If trainees' outcome measures are significantly better than those of non-trainees, it could be because what they need is successful transition away from the previous occupations - for which any type of training suffices - or because they need transition into a specific occupation, so that which training you get becomes very relevant for reemployment.

If the outcome measures of non-trainees do not differ from those of trainees, the failure might arise from three possible reasons. First, training was not necessary, and all participants generally had marketable skills already. Second, training does not work properly; that is, the training programs are poorly designed to teach the participants proper skill sets. And the last, training works, but occupational choices are poorly made; that is, training did not help participants to earn the skills that are in demand - the occupations with vacancies - even though the participants successfully acquired new skill sets. It is important to figure out which is causing the failure of training programs because each cause has different solutions.

All these possible stories can be summarized in two questions: does training works in general? and does a choice of training occupation affect the impact of training? For the first question, instead of simply comparing trainees and non-trainees, I compare trainees without a match to non-trainees, so as to truly test the general validity of training. The second question can be answered by comparing trainees with a match and trainees without a match.

Using the following estimation equation, I can answer both.

$$Y_i = \alpha_0 + \alpha_i M_i^{occ} + \alpha_2 TR_i^{occ} + \alpha_3 TR_i^{rmd} + \alpha_4 TR_i^{ojt} + \alpha_5 TR_i^{cst} + \beta X_i + \delta_1 D_{5i} + \delta_1 D_{6i} + \delta_1 D_{7i} + \varepsilon_i \qquad (71)$$

The outcome variable, Y_i, is any one of the outcome measures - reemployment, post-participation earnings, wage replacement rate, and retention rate. Depending on the dependent variable, I use either Probit analysis - for reemployment rate and retention rate - or OLS - for earnings and wage replacement rate. TR's are indicator variables for various types of training, TR_i^{occ} is 1 if participant i received occupational skills training. TR_i^{rmd}, TR_i^{ojt}, and TR_i^{cst} are indicator variables for remedial training, on-the-job training, and customized training, respectively. M_i^{occ} is the matching variable - 1 if matched, 0 otherwise. X is a vector of individual characteristics of participants that are used in the first analysis. D_{5i}, D_{6i}, and D_{7i} are dummy variables for exit years.

α_1 captures the impact of matching on the various outcome measures. α_2, on the other hand, captures the effect of skill training without leading to a matching. Therefore, the difference between α_1 and α_2 will provide the comparison between skill trainees with and without a match. α_2 itself measure the impact of occupational skills training over no training. Positive α_1 implies that the choice of training occupation is relevant to the outcome, and the occupational choice should be made with caution. If neither α_1 and α_2 is significant, it comes down to either 'occupational skills training is not necessary' or 'training programs are not a good source of new skills.' Good outcome measures for both trainees and non-trainees would signal toward the former, poor overall performance would signal the latter. α_3 to α_5 capture the effect of remedial training, OJT, and customized training in general.

4.2.1 Reemployment Rate

The dependent variable is an indicator variable for employment. It takes the value 1 if a participant is employed for at least one quarter during three quarters following exit. In this analysis, the major comparison is between trainees and non-trainees. I perform Probit analysis. Matching should not be included in this analysis because the participants with match are necessarily all employed. Therefore, the observations from Oklahoma and Virginia are included. Table 11 summarizes the analysis. Only specifications from 1 to 5 are used.

First, all types of training except for remedial training influence the chance of reemployment significantly. The biggest effect comes from on-the-job training. This is expected because employers can enjoy the benefit only by actually hiring the trainees. However, the employment under OJT does not necessarily continue after the training period. In the sample, 86.18%[32] of OJT trainees are employed at least for one quarter during three quarters following exit. That is, 13.82% of them lose their employment after their OJT period expires. Occupational skills training improves the chance of reemployment while customized training lowers it. Customized training is the training program that is specially designed to meet the skill needs of a specific firm. That is, if a trainee is not hired by the firm, the skills acquired through this training may not be applicable to other jobs. More education improves the chance of reemployment, and the size of the effect is stable across specifications except for specification 5 with state variables.

Age variables again show the upside-down U-shape. The highest reemployment rates are shown for age group between 21 and 30, and decreases with age. Especially participants with age between 61 and 65 show substantially lower reemployment rate compared to other age groups. This could be discrimination against older job applicants at the hiring process or voluntary withdrawal from the job market by participants who are close to retirement. Among 9,069 participants between 61 and 65 who obtained a training requirement waiver, 810 (8.9%) reported retirement as a reason. This is surprisingly high considering that only 1.02% of training waivers issued - for all age groups - are issued for the reason of retirement. Ethnicity also matters, but the magnitude of the effect is smaller than education or training. Gender and English proficiency do not matter significantly. The exit years are also not significant. This indicates that people do find a job somehow even if the overall quality deteriorates in bad labor market situations.

Specifications *b*, education measured as years of schooling, show the same result as specifications *a*. The effect of an additional year of schooling is significant and negative,

[32]Compared to 82.83% for classroom skill training trainees, 77.55% for remedial trainees, and 81.70% for customized training trainees

but the magnitude is small compared to education measured as degree. This can be an indication of a nonlinear relationship between education and reemployment rates.

4.2.2 Post-Participation Earnings

The dependent variable is the logarithm of average quarterly earnings during the three quarters following exit. This analysis utilizes the matching variable, so the observations from Oklahoma and Virginia are excluded. Also, participants who received occupational skills training but do not have occupational codes (OSTC) are excluded. Since the match indicator is 1 if there is a match and 0 otherwise, the participants who have a match that is not reported are treated the same as people who failed at a match. In order to avoid bias, trainees with no OSTC reported should be omitted. For each specification, I try the analysis without or with the log of earnings prior to participation. Tables 12.a and 12.b summarize the analysis with two measures of education.

The pre-participation earnings variable is very significant and large in magnitude; that is, people with high earnings prior to participation still earn more than people with low pre-participation earnings. This is not surprising because higher earnings generally indicate higher education and skill level. Even after the layoffs, people with higher education and sophisticated skill sets find a job with higher earnings. For that reason, pre-participation earnings might very well be highly correlated with the level of education. In both specifications a and b, inclusion of pre-participation earnings reduces the size of coefficients on education variables by half. Still, the significance and the signs of education variables are not hurt by the pre-participation earnings. Education is certainly a very important factor for earnings with a larger effect for higher level degrees.

Having a match is a significant factor that improves post-program earnings. However, the magnitude is smaller than the effect of an additional degree. The level of education determines the participants' class of earnings potential while match can only improve trainees' earnings within the class. On the other hand, participants who received occupational skills training but failed to find a match earn less than non-trainees which is the reference group.

This might be because the participants for whom occupational skills training is necessary are more likely to have a very limited skill set; once they failed to find a job in the occupation that they are trained for, it is rather difficult to find a job with comparable pay. The negative effects of remedial training can be explained with similar logic. The participants who need remedial training have the lowest level of education, which results in low earnings.

Ethnicity matters in an interesting way. Asians have higher post-program earning than white participants while African American and Hispanic participants have lower earnings. The difference in earning levels across ethnic groups can be explained by their different occupational choices. Table 6 shows how different ethnic groups choose different occupation groups and Table 9 summarizes the mean earning level of each occupation group. According to Table 9, the five occupation groups with highest earnings are groups 11, 13, 15, 17, 19, and 27. The lowest earnings groups are 31, 35, 39, 41, and 45. From Tables 6 and 7, we can see that only White and Asian trainees show high concentration in high earnings groups for their training choices and also employment. Especially, Asians show high concentration in architecture and engineering, the highest earnings group, in their employment. Although Asian trainees also show high concentration in low earnings groups, African American trainees are very highly concentrated in those groups in their employment. All three occupation groups with high concentration of Hispanic trainees belong to the low earnings groups.

Gender is also very significant and large. Male in general has higher earnings than female, and the reduction in coefficient with inclusion of pre-participation earnings indicates that they used to earn more than female workers prior to participation. Age again shows the upside-down U-shape. participants with age between 41-50 make the highest earnings, followed by age group 31-40. Younger workers and older workers generally have lower earning. Exit years matter significantly for the earnings. In years with a better labor market situation (2007), participants receive higher earnings than they would have received in a bad year (2004).

4.2.3 Wage Replacement Rates

Wage replacement rates are the ratio of post-participation earnings to pre-participation earnings. Each earnings level takes the average quarterly earnings during three quarters preceding participation and three quarters following exit. For the same reason as in the previous section, observations from Oklahoma and Virginia are excluded. Trainees who received Occupational skills training without OSTC are also omitted. Again, each specification will be analyzed with or without pre-participation earnings. The results are summarized by Tables 13.a and 13.b.

One noticeable thing for this analysis is that the effects of education variables have opposite signs when pre-participation earnings are included. That is, participants with higher education generally suffer from larger earnings loss, but they suffer smaller earnings loss compared to people with the same pre-participation earnings and lower educational attainment. The large and negative coefficient on pre-participation earnings indicates convergence in earnings after participation. The standard deviation of post-participation earnings is $4011.10, which is 18.44% smaller than that of pre-participation earnings. The education variables are not affected by controlling for states.

Matching improves the wage replacement rates of trainees significantly regardless of inclusion of pre-participation earnings. The size of its effect becomes larger with pre-participation earnings controlled for, making the effect of occupational skills training without a match negative. This negativity can again be explained by the limited skill sets that these trainees have. For a similar reason, remedial training lowers the wage replacement rates. Gender is significant and not affected by pre-participation earnings. Male participants suffer 1 to 2 percentage point smaller earnings loss than female participants.

Age shows a rather linear relationship in this section. The younger a participant is, the higher the wage replacement rate is. However, the upside-down U-shape relationship is restored by controlling for pre-participation earnings. Age variables are also not affected by controlling for states. Exit years are very significant and not affected by pre-participation earnings or state variables. Hispanic participants show higher wage replacement rates, but this is due to low pre-participation earnings. This is shown by negative marginal effect with pre-participation earnings. Higher wage replacement rates for Asian participants when pre-participation earnings are controlled for is likely to be caused by the selection into high earning occupation groups in their employment.

4.2.4 Retention Rates

The indicator variable for retention is 1 if a participant is still employed during the remainder of the observation period (up to three quarters) once she is employed, and 0 otherwise. I perform a Probit analysis in this section. Since the matching variable is used, observations from Oklahoma and Virginia are omitted as well as the trainees who received occupational skills training but do not have OSTC reported. Table 14 summarizes the results for both education measures. The analyses with pre-participation earnings do not differ significantly from the ones without it, so are not reported.

Matching does not affect retention rates and neither does ethnicity. Occupational skills training and OJT improves the retention rate, but occupational skills training becomes insignificant as the occupational groups are controlled for. This shows that OJT helps the trainees get employed and stay employed. The upside-down U-shape relationship for the age variable does not show for the retention rate. Older participants generally have lower retention rates, but the youngest workers show the same retention rate as the reference group of age between 41 and 50.

Gender is significant, but the size is very small. Female participants have less than 1 percentage point higher retention rate than male participants. Gender becomes insignificant when occupation groups are added indicating that females choose occupations that have slightly higher retention rates. No occupation group shows a significantly lower rate than group 11. The groups with significantly higher retention rate than group 11, by 2-3 percentage points, are groups 21, 23, 29, 31, and 43. According to Tables 6 and 7, male workers account for a very small fraction of these groups, supporting the hypothesis that female participants select into occupations with higher retention rates. States have very little effect on the results. Overall, the retention rate for the entire sample is quite high (around 90%), and the variables of individual characteristics and service received have very small effects even if they are significant.

5 Conclusion

Technology continues to advance and it becomes easier to utilize various resources in foreign countries by means of international trade. Imports of cheaper final goods used to be blamed for replacing domestic goods and jobs of workers who produced the goods that were replaced, but the rise of offshore outsourcing has certainly made the replacement more direct and massive. As most of labor-intensive manufacturing production no longer takes place in the U.S., many factory workers go through painful layoffs. Now with the improvement of network technology, this trend is expanding to service workers.

In order to reduce the adjustment costs of these workers, the US Department of Labor established a dislocated worker program called TAA. Since the workers who are displaced by rising import competition tend to be less educated and have limited skill sets, TAA focuses on providing its participants the opportunities to acquire new skills that are in demand in order to improve their chance of reemployment. In this paper, I investigate whether such occupational skills training truly helps participants to find stable employment that also pays relatively well. I look into the match between the occupation of training and employment.

First I investigate how individual characteristics of participants affect the chance of matching. One hypothesis that I look into is that matching is the result of successful training. This hypothesis is supported by a largely positive effect of training completion. Trainees who completed the occupational skills training have 25 percentage points higher chance of matching compared to those who did not complete their training. This is a very large effect considering that the probability of matching for the sample is 34.25%. However, the validity of training completion as an indication of successful training is rather questionable due to potential endogeneity. Alternatively I use educational attainment as a proxy for learning ability, which in turn leads to success in training classes. Interestingly, education displays a negative or insignificant effect on matching. This insignificance, though, is not robust. When occupation groups are controlled for, the effect of education becomes positive; this supports the hypothesis that learning ability improves the chance of matching. What seems more important is which occupation a trainee chooses as a training occupation. If a trainee chooses a managerial occupation, the skills that are acquired through training can be applied to other occupations. For this reason, trainees of occupation group 11, management, experience lower matching rates. Training in a certain production technique tends to lead to a match. In other words, a match is a preferred choice of employment for some occupation groups while it is not for other groups.

Investigation of reemployment rates shows that occupational skills training and OJT improves the chance of reemployment by 5 and 10 percentage points, respectively. Education also helps. participants with Bachelor's degree show 5 percentage points higher chance of reemployment compared to those with less than a high school degree. The most important determinant of the reemployment rate, though, is the age of the participants. Age shows an upside-down U-shape relationship with the reemployment rate, but the negative slope at old age is substantially larger than the positive slope at young age. participants with age between 21 and 30 are 4 percentage points more likely to be reemployed, while participants with age between 51 and 60 are 10 percentage points less likely than people of age between 41 and 50.

Matching affects both post-participation earnings and the wage replacement rate significantly. Matching raises the wage replacement rate by 3 to 4 percentage points. This effect is not affected by different occupational choices by participants for both outcome measures. The impact of larger magnitude for the earnings level comes from education and age. The impact of having education of more than a Bachelor's degree is 10 times larger than the impact of having a match. Age again shows an upside-down U-shape relationship, with the highest earnings for participants of age between 41 and 50. The magnitude of the impact of education is much smaller for wage replacement, very similar to that of a match. However, age has a very large and monotonically decreasing impact. Workers of age between 16 and 21 have 27 percentage points higher wage replacement rate than those of age between 41 and 50. Workers of age between 61 and 65 show 15 to 18 percentage points smaller rates compared to the 41-50 age group.

Matching does not influence the retention rate by much. OJT is the biggest contributor in improving the retention rate, raising the rate by more than 3 percentage points. Education is another important factor; however the impact is still smaller than 2%. Occupational Skills training improves the rate by 1 percentage point. Retention rate for the sample is 90% and seems to be affected by factors other than personal characteristics of participants or service delivery of the TAA program.

In conclusion, achieving a match is important in improving post-participation outcomes of participants. Even though the outcome measures are more largely affected by the participants' education level or age, the improvement by training and the resulting match is the contribution of the TAA program. The results show that although outcome measures for trainees are generally better than non-trainees, occupational skills training alone - training that does not lead to a match - does not improve the outcome measure. Therefore, the TAA program should place more emphasis on career assessment and counseling so that participants can choose an occupation that is suitable for their needs and ability which will directly lead to employment in that occupation.

Table 4.1. Benefits and Services Provided by the TAA Program

Name	Description	
Rapid Response Assistance	Inform workers of various services available for them. Available for all displaced workers, certification not necessary	
Reemployment Services	Assist workers with reemployment by providing career counseling and assessment, job search related workshops, job search assistance and referrals. Career assessment determines whether and which training is beneficial to each participant.	
Relocation Allowance	When a participant gets a job that requires moving, the program compensates 90% of moving expenses with a stipend of three weeks' wage. Maximum of $1,250[a]	
Job Search Allowance	Compensates 90% of the cost of job searches outside commuting area. Maximum of $1,250[a]	
Training	Participants are eligible for training up to 104 weeks. To be eligible, the following criteria must be met: i) no suitable employment ii) training would be beneficial to the worker iii) training would lead to employment iv) training must be available v) the workers would be able to complete the training vi) training cost is reasonable	Training waiver may be issued to a participant if i) she will be recalled soon ii) she has marketable skills iii) she has a health problem iv) training is not available v) enrollment is not available
	Classroom Training	Targeted to obtain skill sets that are specific to an occupation of choice. Training provided by local community colleges or vocational training schools.
	Remedial Training	Eg. Literacy, English as a Second Language (ESL), and GED Can occur concurrently with other training or during additional 26 weeks from the end of regular training
	On the Job Training(OJT)	If a participant is employed under OJT, the TAA program pays 50% of the wage rate to the employer during the training
	Customized Training	The training is customized to tasks of a specific firm, but the trainees are not necessarily employed by this firm.
Trade Readjustment Allowance (TRA)	A participant is eligible to receive income support for up to 104 weeks as the following: i) 26 weeks following separation: UI ii) 26 weeks following exhaustion of UI: Basic TRA iii) 52 weeks following exhaustion of Basic TRA: Additional TRA	
	Basic TRA	During the first 26 weeks from exhaustion of UI. This requires training enrollment unless[b] i) the participant has obtained a training waiver ii) has completed approved training
	Additional TRA	During 52 weeks from exhaustion of Basic TRA. Training enrollment is required without exception.
	Remedial TRA	Participants who are enrolled in remedial training qualify for 26 weeks of income support in addition to 104 weeks of UI, basic TRA, and additional TRA.
Health Insurance Tax Credit (HITC)[c]	This is a subsidy of 65% of the qualifying health insurance premium paid. The subsidy will be paid as a Tax Credit. All TAA and NAFTA-TAA participants all are eligible.	

Source: Employment and Training Administration, DOL (http://www.doleta.gov/tradeact/benefits.cfm)

(a) Max $800 prior to Reform Act of 2002
(b) These exceptions do not apply to NAFTA-TAA participants. Training enrollment is required for NAFTA-TAA participants to receive basic TRA.
(c) This is added to TAA benefits by 2002 Reform Act

Table 4.2. Summary of TAA Performance Goals and Outcomes

Fiscal Year	Number of TAA Certifica-tions Issued	Estimated[i] Number of Workers Covered by Certifica-tions	Wage Replacement Rate (%)[ii]		Average Earnings ($)[ii]		Reemployment Rate (%)		Retention Rate (%)	
			Goal	Outcome	Goal	Outcome	Goal	Outcome	Goal	Outcome
2003	1,894	197,748	90	73			78	62	90	86
2004	1,813	149,705	90	74			70	63	88	89
2005	1,564	118,024	80	76			70	70	89	91
2006	1,448	119,605	80	89			70	72	85	90
2007	1,465	146,898			12,000	13,915	70	70	85	88

Source : ETA, US Department of Labor (http://www.doleta.gov/tradeact/taa_stats.cfm)

(i) These figures are constructed from the number of workers indicated in petition forms. The report is supposed to be an approximate number; therefore, these figures differ from the actual number of workers covered by the petitions certified in each year.

(ii) The performance measure Wage Replacement Rate is replaced by Average Earnings since fiscal year 2007.

Table 4.3. Summary Statistics of Participants across Years of Program Exit

Year of Program Exit	2004	2005	2006	2007	All
Number of Participants	27,559[ii]	45,783	43,972	25,987[ii]	143,301
Participant Characteristics[i]					
Gender					
Male	49.51	51.36	52.37	53.21	51.65
Female	50.49	48.64	47.63	46.79	48.35
Age at Participation					
Under 30	10.25	9.53	9.32	9.11	9.53
30-44	39.88	38.13	35.99	33.51	36.97
45-54	32.17	33.15	33.57	34.89	33.40
55 and more	17.70	19.20	21.12	22.50	20.10
Mean Age at Participation (years)	44.02	44.58	45.12	45.62	44.83
Ethnicity					
Hispanic/Latino	13.93	10.45	6.22	5.65	8.87
American Indian/Alaska Native	0.99	0.77	1.00	0.94	0.92
Asian	4.00	3.48	2.32	2.31	2.99
Black or African American	16.07	13.79	15.14	16.13	15.07
Hawaiian Native or Pacific Islander	0.44	0.35	0.29	0.28	0.33
White	64.57	71.16	75.04	74.69	71.82
Education					
Less than High School	19.88	18.45	20.16	20.49	19.63
High School Graduate or Eqv.	54.34	55.73	55.95	55.43	55.49
Some Post High School	19.83	19.61	17.81	17.37	18.70
College Graduate or Eqv.	5.47	5.78	5.37	5.95	5.62
Not Identified	0.48	0.43	0.71	0.76	0.56
English Proficiency					
Not Proficient	5.13	5.23	4.20	4.13	4.70
Benefits & Services Received[i]					
Received Any Training	76.12	76.61	69.76	75.44	74.20
Among Trainees					
Occupational Skill Training	70.82	71.76	66.40	54.95	66.98
On-The-Job Training	3.78	3.00	0.88	0.62	2.14
Remedial Training	14.33	14.63	16.97	16.32	15.57
Completed Training	68.90	65.82	59.12	48.96	61.39
Average Weeks of Training	57.64 wks	61.42wks	63.67wks	61.25wks	61.19wks
Rec'd Travel Allowance	11.55	14.57	17.93	13.34	14.72
Rec'd Subsistence Allowance	1.91	1.32	1.14	0.72	1.28
Training Waiver	56.07	57.21	70.48	76.73	64.60
Recall	7.03	8.50	8.98	1.84	6.98
Marketable Skills	36.93	43.77	59.76	72.45	54.16
Retirement	0.97	1.16	1.91	2.11	1.58
Health problem	1.88	0.89	0.27	0.58	0.78
Enrollment/Training Unavailable	23.68	20.39	19.30	20.30	20.55
Reason unknown	29.50	25.28	9.77	2.72	15.94
Basic TRA	61.29	63.52	61.08	56.83	61.13
Additional TRA	30.40	35.57	30.87	26.18	31.43
Job Search Allowance	1.07	1.12	1.59	1.99	1.41
Relocation Allowance	1.03	1.14	1.47	1.46	1.28

(i) Units in % unless specified otherwise.
(ii) Numbers of participants in 2004 and 2007 are smaller because the data are not collected throughout the whole year.

Table 4.4. Summary of the Performance Measures of the TAA program across Exit Years and Pre-participation earnings level

Across Exit Years			reemployment rate[iv] (%)		wage replacement rate (%)			retention rate (%)		
Exit Year	Number of Obs.	% Match[i]	trainees	non-trainees	trainees w/ match	trainees w/o match	non-trainees	trainees w/ match	trainees w/o match	non-trainees
2004	27,559	40.20	82.27	68.44	91.55	88.55	86.00	91.37	93.66	88.57
2005	45,783	43.38	81.20	70.15	95.38	94.19	88.10	89.87	90.42	86.79
2006	43,972	46.93	79.96	71.07	97.08	93.45	89.81	91.21	91.52	88.99
2007	25,987	50.89	78.92	72.66	95.59	87.72	89.34	92.11	93.78	89.41
All	143,301	44.60	80.64	70.61	95.12	91.62	88.62	90.93	91.95	88.36

Across Pre-Participation Earnings level			reemployment rate[iv] (%)		wage replacement rate (%)			retention rate (%)		
Quarterly Earnings prior to Participation($)[ii]	Number of Obs.[iii]	% Match	trainees	non-trainees	trainees w/ match	trainees w/o match	non-trainees	trainees w/ match	trainees w/o match	non-trainees
2,001 – 4,999	31,833	47.70	79.48	67.62	119.59	123.58	103.92	89.37	89.95	86.47
5,000 – 9,999	57,486	47.58	82.36	72.85	88.29	84.53	77.68	91.50	91.85	89.63
10,000 – 19,999	29,682	37.58	83.03	75.42	67.08	72.54	64.10	92.03	93.72	88.73
20,000 – 29,999	3,955	30.85	80.43	71.89	44.13	52.15	49.90	89.56	95.17	88.82
30,000 – 39,999	1,008	34.35	75.86	62.91	23.12	32.86	35.12	92.50	96.15	85.04
40,000 or higher	561	21.43	76.95	52.86	17.36	26.16	24.60	90.00	92.11	87.50
All	124,525	44.56	81.64	71.96	91.10	89.06	77.89	91.01	92.06	88.60

(i) This is the percentage of matches among observations with valid occupation codes for both OSTC and OCE. The numbers of such observations are 7,272 in 2004, 10,706 in 2005, 8,422 in 2006, 4,138 in 2007, and, hence, 30,538 for the entire sample.

(ii) There are 6,515 observations with average pre-participation earnings of $2,000 or less. TAPR reports the quarterly earnings of participants for three quarters prior to participation rather than the date of separation. Therefore, these earnings records sometimes show the temporary positions that participants held between separation and participation. These figures could be meaningful, but they should not be used in calculating wage replacement rates. For instance, these observations show an inconceivably high wage replacement rate of 2,600%. The threshold $2,000 is quarterly earning if a person works for 30 hours at minimum wage ($5.15). One can expect that any figure below this does not mean the earning from the qualifying separation.

(iii) This is the number of observations that are associated with the specified earning bracket. However, many observations do not have enough information to construct the reemployment rate, retention rate, and wage replacement rate. The three outcome measures represented here are obtained from a smaller number of observations than specified in this column.

(iv) Employed at any point during the three quarters of observation following program exit.

Table 4.5. Occupation Categories in O*Net system

Code	Training Occupation Obs.	Training Occupation %	Reemployment Occupation Obs.	Reemployment Occupation %	Occupation Group
11	3,050	4.88	1,294	3.29	Management
13	1,779	2.85	712	1.81	Business and Financial Operations
15	4,085	6.54	1,421	3.62	Computer and Mathematical
17	2,323	3.72	1,440	3.67	Architecture and Engineering
19	429	0.69	167	0.43	Life, Physical and Social Science
21	977	1.56	350	0.89	Community and Social Services
23	474	0.76	132	0.34	Legal
25	2,213	3.54	861	2.19	Education, Training, and Library
27	636	1.02	264	0.67	Arts, Design, Entertainment, Sports, and Media
29	6,069	9.71	2,212	5.63	Healthcare Practitioners and Technical
31	6,501	10.41	2,610	6.64	Healthcare support
33	678	1.09	434	1.10	Protective Service
35	551	0.88	616	1.57	Food Preparation and Serving Related
37	362	0.58	854	2.17	Building and Grounds Cleaning and Maintenance
39	1,759	2.82	854	2.17	Personal Care and Service
41	437	0.70	1,227	3.12	Sales and Related
43	8,985	14.38	4,401	11.20	Office and Administrative Support
45	91	0.15	255	0.65	Farming, Fishing, and Forestry
47	1,924	3.08	1,287	3.28	Construction, and Extraction
49	6,171	9.88	2,863	7.29	Installation, Maintenance, and Repair
51	7,940	12.71	11,518	29.32	Production
53	4,994	7.99	3,474	8.84	Transportation and Material Moving
55	45	0.07	42	0.11	Military Specific
all	62,473	100.00	39,288	100.00	

Table 4.6. Participant Characteristics and Matching Rates for Occupation Groups of Training

				Ethnicity (%)					Education (%)					
OSTC[i] Group	% Match	% Male	% Limited English	White	Asian	Black	Hispan	Other	Less than HS	High School	Some College	Assoc	Bache	More than Bache
11	25.48	49.05	1.97	66.72	1.74	14.20	3.02	14.33	4.95	45.21	27.87	9.02	10.69	2.26
13	31.98	39.00	2.14	64.02	2.59	13.27	3.26	16.86	4.67	45.47	27.99	8.09	11.92	1.85
15	36.52	66.51	2.89	57.14	4.53	11.29	5.07	21.98	5.85	43.89	27.12	9.28	11.82	2.03
17	32.13	85.45	2.54	59.36	4.26	8.01	4.00	24.37	4.61	42.66	31.08	9.04	11.06	1.55
19	18.03	56.67	3.26	60.14	2.80	10.72	2.10	24.24	2.10	41.72	33.10	8.16	12.59	2.33
21	25.73	31.38	1.94	51.18	1.74	29.89	4.09	13.10	5.94	47.59	28.45	10.75	6.35	0.92
23	38.33	20.93	1.27	60.13	1.05	11.39	3.38	24.05	3.59	49.37	26.37	11.39	7.81	1.48
25	29.47	31.50	7.32	51.92	2.35	23.36	8.09	14.28	13.10	47.31	18.89	5.87	12.74	2.08
27	25.40	53.91	4.56	53.93	4.87	8.49	4.72	27.99	5.97	43.40	30.50	8.65	9.59	1.89
29	50.46	27.82	2.11	58.89	2.42	15.36	5.29	18.04	5.93	57.60	24.49	5.67	5.34	0.97
31	51.62	11.14	7.92	51.70	2.28	20.67	11.94	13.41	16.54	64.90	13.26	3.52	1.57	0.22
33	22.07	65.14	1.47	60.62	0.59	16.37	3.54	18.88	6.19	62.98	22.86	5.31	2.21	0.44
35	29.01	37.42	18.15	40.83	5.26	10.34	8.17	35.39	27.59	50.45	16.52	2.54	2.72	0.18
37	45.41	51.08	22.10	41.16	11.60	8.29	4.14	34.81	35.08	46.96	12.71	1.93	2.76	0.55
39	45.23	16.20	18.65	31.32	11.31	17.74	14.55	25.07	24.84	54.63	13.93	4.83	1.65	0.11
41	29.65	45.62	5.49	58.81	3.43	16.48	3.89	17.39	21.51	42.79	23.57	5.49	6.18	0.46
43	28.75	13.78	7.49	56.15	2.25	17.37	11.64	12.59	15.08	58.33	17.38	6.15	2.69	0.36
45	23.91	45.05	3.30	74.73	2.20	7.69	2.20	13.19	12.09	48.35	24.18	6.59	7.69	1.10
47	40.35	95.09	4.42	62.11	1.56	10.60	9.20	16.53	12.16	60.40	19.70	4.26	3.17	0.31
49	40.61	94.54	3.81	62.05	3.42	10.91	7.58	16.04	11.23	60.46	20.00	5.51	2.45	0.36
51	72.93	48.84	3.98	64.13	1.93	18.88	4.65	10.42	32.13	50.58	13.98	1.34	1.73	0.25
53	65.92	84.05	4.49	60.87	0.50	19.48	9.13	10.01	23.03	60.69	11.05	2.84	2.02	0.36
55	33.33	48.89	0.00	66.67	0.00	11.11	0.00	22.22	6.67	80.00	6.67	2.22	4.44	0.00
Total	44.60	47.05	5.16	58.02	2.73	16.10	7.52	15.63	14.85	54.70	19.50	5.37	4.80	0.78

(i) Occupational Skills Training Code

Table 4.7. Participant Characteristics and Matching Rates for Occupation Groups of Employment

				Ethnicity (%)					Education (%)					
OCE[i] Group	% Match	% Male	% Limited English	White	Asian	Black	Hispan	Other	Less than HS	High School	Some College	Assoc	Bache	More than Bache
11	42.23	56.25	1.39	70.32	1.70	6.26	1.78	19.94	5.33	37.71	22.33	9.43	19.01	6.18
13	48.28	40.68	1.97	61.94	1.69	6.18	2.39	27.81	4.49	32.72	25.42	12.78	20.08	4.49
15	62.88	67.11	2.18	52.78	3.87	5.63	2.67	35.05	5.00	34.98	28.92	8.44	19.42	3.24
17	38.23	83.88	2.36	49.86	7.43	4.65	2.64	35.42	3.82	28.82	30.35	12.29	21.39	3.33
19	33.87	65.87	1.80	59.28	0.60	5.99	1.80	32.34	2.99	37.13	29.94	8.38	16.17	5.39
21	42.86	38.57	3.71	62.29	0.86	19.43	4.00	13.43	7.43	46.00	26.29	10.29	8.57	1.43
23	75.65	19.85	0.76	54.55	0.76	8.33	4.55	31.82	5.30	42.42	30.30	11.36	9.09	1.52
25	38.56	34.81	1.39	59.35	0.81	20.44	2.21	17.19	3.83	38.10	22.18	11.27	21.25	3.37
27	38.83	64.50	2.65	53.41	5.30	2.65	4.55	34.09	3.41	36.36	29.17	11.74	15.91	3.41
29	72.46	30.69	1.72	64.83	1.85	7.59	3.07	22.65	4.43	54.16	26.72	6.37	6.92	1.40
31	67.02	9.66	5.17	60.27	1.95	18.89	4.90	13.98	12.30	66.93	14.48	4.37	1.61	0.31
33	24.62	67.82	0.92	62.21	0.23	16.59	2.53	18.43	7.14	61.06	20.28	5.76	5.30	0.46
35	19.41	28.16	12.66	55.36	5.84	15.58	4.22	18.99	23.38	56.17	14.94	3.41	2.11	0.00
37	17.42	51.15	15.46	56.09	2.46	14.29	7.38	19.79	33.14	51.52	9.60	2.93	2.58	0.23
39	53.78	16.65	14.52	44.15	7.14	16.98	7.49	24.24	20.14	57.14	14.87	5.15	2.22	0.47
41	6.93	37.76	2.44	64.06	1.39	12.63	3.10	18.83	12.31	54.20	17.77	7.17	7.58	0.98
43	29.57	21.68	3.86	63.08	2.11	11.13	5.39	18.29	8.34	56.31	21.90	8.23	4.77	0.45
45	10.68	43.14	51.37	77.25	1.57	1.18	8.24	11.76	60.00	29.41	7.06	2.35	0.78	0.39
47	40.99	93.70	3.73	65.50	2.10	4.51	6.92	20.98	10.72	58.66	20.90	4.43	4.66	0.62
49	53.23	93.64	3.07	62.84	3.18	6.88	4.89	22.21	10.41	57.11	22.84	6.18	2.97	0.49
51	37.94	51.08	7.88	59.05	5.21	15.32	6.62	13.80	24.92	54.07	14.72	3.52	2.34	0.44
53	56.41	76.36	4.72	61.95	1.24	16.06	5.93	14.82	22.63	58.46	13.41	2.76	2.42	0.32
55	22.22	56.10	2.38	61.90	0.00	7.14	9.52	21.43	9.52	59.52	16.67	2.38	9.52	2.38
Total	44.60	50.60	5.56	60.36	3.33	12.39	5.16	18.76	15.58	52.72	18.88	5.77	5.97	1.08

(i) Occupational Code of Employment

Table 4.8. Performance Measures for Occupation Groups of Training and Employment

Occupation Group	Among Trainees(i) Reemployment Rate (%)	Among Employees(ii) Retention Rate (%)	Wage Replacement rate (%)	Average Quarterly Earnings ($)
11	82.69	91.01	87.25	10,489
13	82.12	91.27	93.93	9,528
15	81.57	90.23	95.81	9,757
17	83.60	93.75	103.27	12,224
19	82.98	92.21	87.12	9,072
21	83.11	94.10	87.65	5,977
23	83.97	90.76	89.03	7,325
25	80.70	92.97	77.14	6,163
27	76.10	89.61	93.33	9,372
29	87.79	94.11	106.44	8,130
31	87.09	92.80	85.83	5,280
33	88.79	94.09	90.11	6,911
35	81.67	90.40	80.00	4,645
37	77.62	90.00	88.39	5,658
39	73.39	87.46	87.48	5,070
41	75.29	90.13	78.20	5,627
43	80.80	91.79	84.20	6,216
45	71.43	63.11	91.59	5,583
47	78.07	88.21	91.37	8,440
49	83.97	91.78	89.99	8,918
51	80.50	91.88	96.67	7,301
53	85.84	89.44	94.58	7,348
55	73.33	91.43	82.94	7,167
Total	82.85	91.37	91.48	7,475

(i) For each occupation group of training.
(ii) For each occupation group of reemployment. These observations include both trainees and non-trainees as long as occupation codes for reemployment are reported.

Table 4.9. States and Other Variables

State	% of sample	% Match	% Male	% Lmtd English Profic	Ethnicity (%) White	Asian	Black	Hisp	Other	Education (%) HS	Some College	Assoc	Bachel	More than B
AK	0.12	44.23	77.01	0.57	77.01	5.17	2.3	0.57	14.94	39.66	31.61	0	18.39	1.72
AL	0.83	0	41.28	0	70.21	1.45	25.28	0.51	2.55	54.81	28.34	0	5.45	1.28
AR	1.21	0	45.06	1.29	74.23	0.64	23.44	0.88	0.82	86.32	6.78	0	0.7	0.06
AZ	0.86	0	56.23	0.74	56.39	4.02	4.02	33.28	2.30	29.34	16.48	0	4.26	1.39
CA	1.91	46.29	47.95	23.64	0	0	0	37.27	62.73	25.64	27.74	0	7.62	1.7
CO	1.02	34.55	58.33	6.7	74.36	8.91	2.83	11.13	2.76	35.25	34.9	0	17.21	7.67
CT	1.16	0	48.01	8.23	56.66	4.96	10.65	18.34	9.38	24.88	14.65	0.06	3.57	0
DE	0.08	0	60.00	6.09	69.57	6.09	20.87	0.87	2.61	69.57	6.09	6.09	4.35	0
FL	0.66	0	36.62	11.46	38.87	3	14.56	38.87	4.71	66.49	12.42	0.64	4.6	1.07
GA	2.58	23.26	34.55	1.18	50.18	1.45	46.48	0.66	1.23	58.97	18.94	1.48	1.2	0.22
IA	0.81	21.43	48.39	2.26	94.87	0.87	0.78	0.78	2.69	58.3	31.54	0.26	5.65	1.48
ID	0.92	29.10	54.91	6.52	11.96	0.31	0.15	26.46	61.12	41.41	21.24	5.83	7.44	0
IL	3.23	19.70	52.47	4.55	78.3	2.68	8.69	5.75	4.59	64.74	15.98	0.15	5.68	1.15
IN	5.29	28.13	64.27	1.2	48.03	0.41	4.35	0.74	46.47	68.68	16.47	0.72	4.07	0.8
KS	0.82	23.28	59.62	1.12	79.38	4.04	10.91	2.75	2.92	52.41	27.23	3.61	7.82	2.06
KY	2.27	12.43	43.89	1.49	89.7	0.22	5.59	0.4	4.10	68.93	11.73	5.09	2.48	0.22
LA	0.08	57.14	39.66	0	61.21	1.72	31.9	0	5.17	68.97	10.34	0	7.76	0.86
MA	2.61	22.55	55.26	15.12	76.19	8.1	4.48	8.64	2.59	50.78	6.21	7.4	8.5	3.4
MD	0.67	0.00	42.81	1.67	63.13	1.25	30	0.73	4.90	71.35	11.67	0.94	1.88	0.31
ME	2.33	33.07	62.43	2.7	94.2	0.91	1.76	0.12	3.00	54.84	13.57	1.91	4.98	1.76
MI	7.14	43.78	60.75	3.9	86.9	1.86	10.02	0	1.22	61.97	10.13	0.94	8.11	2
MN	1.11	46.43	59.32	19.49	74.97	6.43	2.99	5.67	9.94	69.04	20.89	0	5.41	0.57
MO	1.23	31.02	42.29	0.17	83.26	0.57	8.4	0.8	6.97	69.89	14.17	1.26	1.54	0.29
MS	2.04	21.36	41.15	1.45	20.33	0.14	15.25	0.03	64.25	42.67	16.53	22.54	3.39	0.45
MT	0.26	47.66	74.86	0.88	94.71	0.22	0	0.88	4.19	66.3	22.03	0	2.64	0.66
NC	9.81	34.13	39.36	4.44	62.17	2.43	31.22	1.88	2.30	56.74	13.43	12.06	3.37	0.37
ND	0.05	0	43.94	0	98.48	0	0	0	1.52	43.94	21.21	27.27	6.06	0
NE	0.18	43.92	37.75	0.8	94.78	1.61	0.8	0	2.81	71.89	21.69	0	3.61	0

NH	0.57	39.60	60.32	13.1	51.3	4.7	1.11	12.36	30.53	61.43	10.14	0.37	9.02	2.1
NJ	1.24	5.24	50.80	16.39	38.68	4.5	15.93	30.69	10.19	65.48	9.74	3.27	4.05	1.13
NM	0.17	62.50	67.23	0.85	38.3	2.13	1.7	54.47	3.40	61.28	32.34	0	4.68	1.7
NV	0.03	75.00	77.55	4.08	71.43	0	10.2	14.29	4.08	36.73	26.53	2.04	18.37	8.16
NY	5.72	22.22	62.22	1.55	74.47	2.81	6.37	5.04	11.31	66.79	11.51	6.69	3.97	0.92
OH	5.82	46.54	59.93	0.02	84.22	0.52	11.92	1.32	2.02	68.15	18.15	0	3.11	1.86
OK	1.02	100.00	43.32	0.9	52	2.55	9.44	0.14	35.88	50.76	30.1	0	9.57	1.65
OR	1.33	70.56	62.46	10.13	46.5	6.26	0.8	9.07	37.38	51.33	20.47	6.68	8.38	3.02
RI	0.74	57.22	45.39	33.3	77.83	5.09	7.29	8.73	1.06	48.75	10.17	0.77	5.28	0.67
SC	5.31	13.04	44.80	0.85	50.47	1.29	39.37	0.54	8.33	58.42	14.27	0	3.16	0.5
SD	0.38	26.56	44.20	2.21	94.48	1.29	2.03	1.47	0.74	66.11	7.73	12.15	10.87	1.84
TN	7.83	0	45.54	0.97	88.32	0.41	9.18	0.11	1.97	46.5	2.45	1.04	0.82	0.26
TX	4.05	0	51.01	15.88	28.51	6.18	7.92	54.35	3.03	44.31	15.01	2.06	4.81	0.42
UT	0.33	42.41	53.15	19.96	79.18	13.45	0.65	1.95	4.77	46.2	27.55	0.22	7.38	1.08
VA	4.01	99.97	36.93	0	68.03	0.4	30.15	0.44	0.98	36.15	13.33	0.18	2.05	0.18
VT	0.16	18.75	50.00	1.29	96.12	0.86	0.43	0	2.59	53.02	21.55	0	11.21	1.29
WA	4.47	28.06	64.16	7.86	11.81	12.43	3.49	1.47	70.80	44.39	30.19	10.53	8.97	0.08
WI	4.30	29.93	53.52	3.94	89.58	1.18	5.61	1.62	2.00	65.43	18.75	0.31	5.04	0.82
WV	1.22	0.00	72.29	0.06	86.2	0.12	3.65	0	10.03	59.36	15.42	4	3.83	0.7
WY	0.01	75.00	81.25	0	100	0	0	0	0.00	31.25	50	12.5	6.25	0
Total	100.00	44.60	51.65	4.69	64.57	2.56	13.46	6.22	13.20	56.05	15.17	3.53	4.64	0.98

Table 4.10.a. What Affects Matching? : Education as Degree Attainment

	1a		2a		3a		4a		5a		6a	
independent Variable	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
Male	0.015*	0.010	0.016*	0.010	0.018*	0.011	0.019*	0.012	0.001	-0.006	0.002	-0.006
Limited Engl Proficiency	0.004	0.005	-0.001	0.000	-0.007	-0.006	-0.011	-0.010	-0.123**	-0.120**	-0.125**	-0.122**
Eth: Hispanic	0.015	0.031*	0.021	0.037**	0.014	0.026	0.019	0.031*	-0.240**	-0.231**	-0.241**	-0.231**
Eth: Asian	-0.102**	-0.111**	-0.086**	-0.095**	-0.104**	-0.114**	-0.091**	-0.100**	-0.164**	-0.164**	-0.161**	-0.161**
Eth: Black	-0.075**	-0.094**	-0.071**	-0.090**	-0.094**	-0.112**	-0.091**	-0.109**	-0.053**	-0.068**	-0.055**	-0.069**
Eth: Others	0.005	0.003	0.019*	0.017*	0.009	0.008	0.021*	0.020	-0.241**	-0.231**	-0.242**	-0.232**
Edu: High School	-0.024*	-0.023*	-0.020	-0.019	-0.002	0.001	0.002	0.006	-0.032**	-0.022**	-0.033**	-0.022
Edu: Some College	-0.035**	-0.027*	-0.028*	-0.020	0.021	0.035**	0.028*	0.041**	-0.078**	-0.059**	-0.076**	-0.058**
Edu: Associate	-0.089**	-0.069**	-0.083**	-0.063**	-0.007	0.019	-0.002	0.024	-0.122**	-0.082**	-0.124**	-0.084**
Edu: Bachelor's	-0.024	-0.012	-0.020	-0.008	0.071**	0.091**	0.075**	0.095**	-0.077**	-0.058**	-0.077**	-0.057**
Edu: More than B	-0.008	0.003	-0.004	0.006	0.102**	0.123**	0.105**	0.126**	-0.097**	-0.085*	-0.094**	-0.081*
Training Cmpltd	0.238**		0.239**		0.218**		0.218**		0.258**		0.261**	
Age: 16_20	0.003	0.003	0.004	0.003	0.015	0.016	0.014	0.014	0.019	0.013	0.014	0.008
Age: 21_30	0.044**	0.042**	0.045**	0.043**	0.054**	0.054**	0.055**	0.055**	0.054**	0.052**	0.056**	0.054**
Age: 31_40	0.039**	0.040**	0.039**	0.040**	0.040**	0.042**	0.040**	0.041**	0.045**	0.046**	0.046**	0.047**
Age: 51_60	-0.027**	-0.028**	-0.028**	-0.030**	-0.031**	-0.033**	-0.032**	-0.034**	-0.033**	-0.035**	-0.035**	-0.037**
Age: 61_65	-0.059**	-0.062**	-0.062**	-0.065**	-0.044*	-0.046*	-0.048	-0.050**	-0.048*	-0.055**	-0.052*	-0.058**
Exit Year 2005			0.039**	0.046**			0.041**	0.047**			0.020*	0.027**
Exit Year 2006			0.081**	0.084**			0.079**	0.081**			0.056**	0.057**
Exit Year 2007			0.113**	0.110**			0.097**	0.094**			0.113**	0.102**
13.Business & Financial					0.063**	0.067**	0.065**	0.068**				
15.Computer, Math					-0.016	-0.005	-0.013	-0.003				
17.Architecture					0.074**	0.077**	0.077**	0.080**				
19.Science					-0.111**	-0.103**	-0.110**	-0.102**				
21.Community Service					0.041	0.051	0.041	0.050				
23.Legal					0.172**	0.173**	0.176**	0.176**				
25.Education, Training					0.089**	0.099**	0.087**	0.097**				

27.Arts, Design					0.025	0.033	0.031	0.040				
29.Healthcare Pract'r					0.275**	0.284**	0.274**	0.282**				
31.Healthcare Support					0.336**	0.360**	0.337**	0.360**				
33.Protective Service					-0.002	-0.009	-0.004	-0.012				
35.Food Prep & Serving					0.134**	0.130**	0.130**	0.125**				
37.Building Maintenance					0.268**	0.280**	0.264**	0.276**				
39.Personal Care&Service					0.291**	0.316**	0.289**	0.313**				
41.Sales and Related					0.071	0.065	0.077	0.070				
43.AdministrativeSupport					0.028	0.040*	0.029	0.040*				
45.Farming & Fishing					-0.143	-0.134**	-0.136	-0.127				
47.Construction					0.157**	0.174**	0.157**	0.174**				
49.Installation & Repair					0.173**	0.190**	0.175**	0.191**				
51.Production					0.161**	0.174**	0.159**	0.172**				
53.Transportation					0.377**	0.417**	0.375**	0.415**				
States									Yes	Yes	Yes	Yes
Number of obs	24,142	24,142	24,142	24,142	24,142	24,142	24,142	24,142	28,694	28,694	28,694	28,694
LR chi2	1,432.8	284.8	1,567.8	418.4	2,933.8	2,032.1	3,040.9	2,137.1	8,859.3	7,815.6	8,959.2	7,896.7
Prob >chi2	0	0	0	0	0	0	0	0	0	0	0	0
Pseudo R2	0.046	0.009	0.051	0.014	0.095	0.066	0.098	0.069	0.225	0.198	0.227	0.200

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

Table 4.10.b. What affects Matching?: Education as Years of Schooling

	1b		2b		3b		4b		5b		6b	
ind. Variable	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
Male	0.016**	0.011	0.017**	0.012	0.024**	0.018*	0.024**	0.018*	0.001	-0.006	0.001	-0.006
Limited Engl Proficiency	0.006	0.007	0.001	0.001	-0.008	-0.008	-0.013	-0.013	-0.124**	-0.123**	-0.126**	-0.125**
Eth: Hispanic	0.019	0.034*	0.025	0.040**	0.016	0.027*	0.021	0.033*	-0.236**	-0.228**	-0.237**	-0.228**
Eth: Asian	-0.101**	-0.110**	-0.085**	-0.094**	-0.100**	-0.109**	-0.087**	-0.095**	-0.160**	-0.160**	-0.156**	-0.157**
Eth: Black	-0.076**	-0.095**	-0.072**	-0.091**	-0.095**	-0.113**	-0.092**	-0.110**	-0.055**	-0.070**	-0.056**	-0.071**
Eth: Others	0.006	0.005	0.020*	0.018*	0.014	0.014	0.026**	0.026**	-0.235**	-0.226**	-0.236**	-0.227**
Schooling	-0.005**	-0.004**	-0.005**	-0.004**	0.001	0.002	0.002	0.003*	-0.013**	-0.011**	-0.013**	-0.011**
Training Cmpltd	0.237**		0.238**		0.219**		0.219**		0.257**		0.260**	
Age: 16_20	0.007	0.005	0.007	0.004	0.010	0.008	0.009	0.006	0.026	0.019	0.021	0.014
Age: 21_30	0.043**	0.041**	0.044**	0.042**	0.052**	0.051**	0.053**	0.052**	0.054**	0.052**	0.056**	0.054**
Age: 31_40	0.038**	0.039**	0.038**	0.039**	0.040**	0.041**	0.040**	0.041**	0.045**	0.046**	0.046**	0.047**
Age: 51_60	-0.026**	-0.027**	-0.028**	-0.029**	-0.028**	-0.030**	-0.030**	-0.032**	-0.034**	-0.035**	-0.036**	-0.037**
Age: 61_65	-0.058**	-0.061**	-0.061**	-0.064**	-0.042*	-0.044*	-0.046*	-0.048*	-0.048*	-0.055**	-0.052*	-0.059**
Exit Year 2005			0.039**	0.045**			0.041**	0.047**			0.020*	0.027**
Exit Year 2006			0.079**	0.083**			0.079**	0.081**			0.053**	0.054**
Exit Year 2007			0.114**	0.111**			0.098**	0.094**			0.115**	0.104**
13.Business & Financial					0.064**	0.069**	0.066**	0.070**				
15.Computer, Math					-0.018	-0.006	-0.015	-0.004				
17.Architecture					0.072**	0.075**	0.074**	0.078**				
19.Science					-0.110**	-0.102**	-0.110**	-0.101**				
21.Community Service					0.037	0.047	0.036	0.046				
23.Legal					0.168**	0.169**	0.172**	0.172**				
25.Education, Training					0.090**	0.100**	0.089**	0.098**				
27.Arts, Design					0.020	0.028	0.027	0.035				
29.Healthcare Pract'r					0.269**	0.277**	0.268**	0.275**				
31.Healthcare Support					0.325**	0.346**	0.327**	0.348**				
33.Protective Service					-0.011	-0.021	-0.012	-0.023				
35.Food Prep & Serving					0.123	0.115**	0.118**	0.110**				
37.Building Maintenance					0.257**	0.265**	0.252**	0.262**				
39.Personal Care&Service					0.280**	0.302**	0.278**	0.300**				

41.Sales and Related					0.064	0.056	0.071	0.061				
43.AdministrativeSupport					0.019	0.029	0.021	0.030				
45.Farming & Fishing					-0.152*	-0.142	-0.145	-0.134				
47.Construction					0.145**	0.159**	0.145**	0.159**				
49.Installation & Repair					0.160**	0.173**	0.162**	0.175**				
51.Production					0.150**	0.159**	0.148**	0.157**				
53.Transportation					0.364**	0.401**	0.361**	0.398**				
States									Yes	Yes	Yes	Yes
Number of obs	24,142	24,142	24,142	24,142	24,142	24,142	24,142	24,142	28,694	28,694	28,694	28,694
LR chi2	1406.4	270.9	1542.2	404.4	2895.6	1978.0	3003.0	2083.3	8880.2	7848.6	8980.8	7930.7
Prob >chi2	0	0	0	0	0	0	0	0	0	0	0	0
Pseudo R2	0.045	0.009	0.050	0.013	0.093	0.064	0.097	0.067	0.225	0.199	0.228	0.201

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

Table 4.11. Reemployment Rates : Education as Degree Attainment and Years of Schooling

	1a	2a	3a	4a	5a	1b	2b	3b	4b	5b
Independent Variables	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
Male	0.004	0.004	0.006*	0.006*	-0.002	0.004	0.004	0.006**	0.006**	-0.002
Limited Engl Proficiency	-0.002	-0.002	-0.001	-0.001	-0.012*	-0.006	-0.006	-0.004	-0.004	-0.016**
Eth: Hispanic	0.027**	0.027**	0.025**	0.025**	0.003	0.020**	0.021**	0.018**	0.019**	-0.002
Eth: Asian	-0.020**	-0.020**	-0.016*	-0.016*	-0.049**	-0.022**	-0.021**	-0.018*	-0.018*	-0.050**
Eth: Black	0.012**	0.012**	0.011**	0.011**	0.016**	0.012**	0.011**	0.010**	0.010**	0.016**
Eth: Others	-0.003	-0.002	-0.004	-0.003	-0.024**	-0.003	-0.002	-0.003	-0.003	-0.024**
Edu: High School	0.055**	0.055**	0.055**	0.055**	0.038**					
Edu: Some College	0.062**	0.062**	0.063**	0.063**	0.042**					
Edu: Associate	0.081**	0.081**	0.081**	0.081**	0.060**					
Edu: Bachelor's	0.052**	0.052**	0.054**	0.054**	0.027**					
Edu: More than B	0.061**	0.061**	0.063**	0.062**	0.038**					
Schooling						0.006**	0.006**	0.006**	0.006**	0.003**
Age: 16_20	0.026	0.026	0.026	0.026	0.028	0.025	0.025	0.025	0.025	0.027
Age: 21_30	0.038**	0.038**	0.038**	0.038**	0.042**	0.038**	0.038**	0.038**	0.038**	0.042**
Age: 31_40	0.026**	0.026**	0.026**	0.026**	0.028**	0.027**	0.027**	0.026**	0.026**	0.029**
Age: 51_60	-0.100**	-0.100**	-0.099**	-0.099**	-0.099**	-0.100**	-0.101**	-0.100**	-0.100**	-0.100**
Age: 61_65	-0.411**	-0.411**	-0.409**	-0.409**	-0.406**	-0.413**	-0.414**	-0.411**	-0.412**	-0.408**
Train: Occupational	0.056**	0.056**	0.044**	0.044**	0.048**	0.059**	0.059**	0.047**	0.047**	0.051**
Train: Remedial	0.001	0.001	0.001	0.001	-0.008	-0.008*	-0.008*	-0.008*	-0.008*	-0.015**
Train : OJT	0.095**	0.096**	0.097**	0.097**	0.116**	0.098**	0.098**	0.099**	0.100**	0.117**
Train: Customized	-0.093**	-0.093**	-0.085**	-0.085**	-0.066**	-0.086**	-0.085**	-0.077**	-0.076**	-0.061**
Marketable Skills	0.019**	0.018**	0.018**	0.017**	0.010**	0.018**	0.017**	0.018**	0.016**	0.010**
Exit Year 2005		0.000		0.001			0.001		0.002	
Exit Year 2006		-0.002		-0.001			0.000		0.001	
Exit Year 2007		0.007		0.008*			0.009*		0.010**	
13.Business & Financial			-0.003	-0.003				-0.002	-0.002	
15.Computer, Math			-0.004	-0.004				-0.004	-0.003	
17.Architecture			0.003	0.003				0.004	0.004	
19.Science			-0.012	-0.012				-0.011	-0.011	

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
21.Community Service			0.000	0.000				0.004	0.004	
23.Legal			0.001	0.001				0.004	0.004	
25.Education, Training			0.005	0.006				0.005	0.006	
27.Arts, Design			-0.047**	-0.047**				-0.044*	-0.044*	
29.Healthcare Pract'r			0.048**	0.048**				0.049**	0.050**	
31.Healthcare Support			0.061**	0.061**				0.061**	0.061**	
33.Protective Service			0.043**	0.043**				0.045**	0.045**	
35.Food Prep & Serving			0.026	0.026				0.025	0.025	
37.Building Maintenance			-0.005	-0.006				-0.009	-0.010	
39.Personal Care&Service			-0.075**	-0.075**				-0.076**	-0.076**	
41.Sales and Related			-0.026	-0.026				-0.027	-0.027	
43.AdministrativeSupport			0.011*	0.011*				0.012*	0.012*	
45.Farming & Fishing			-0.084	-0.084				-0.086	-0.085	
47.Construction			-0.035**	-0.035**				-0.035**	-0.035**	
49.Installation & Repair			0.020**	0.020**				0.020**	0.020**	
51.Production			0.005	0.004				0.006	0.006	
53.Transportation			0.048**	0.048**				0.046**	0.046**	
States					YEs					Yes
Number of Obs	139,291	139,291	139,291	139,291	139,291	139,291	139,291	139,291	139,291	139,291
LR Chi2	10,854.5	10,862.7	11,200.8	11,209.2	11,956.9	10,762.4	10,770.8	11,102.5	11,111.5	11,832.6
Prob > Chi2	0	0	0	0	0	0	0	0	0	0
Pseudo R2	0.076	0.076	0.078	0.078	0.083	0.075	0.075	0.077	0.077	0.082

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

Table 4.12.a. Post-Participation Earning: Education as Degree Attainment

Independent Variables	1a without	1a with	2a without	2a with	3a without	3a with	4a without	4a with	5a without	5a with	6a without	6a with
Male	0.297**	0.167**	0.297**	0.167**	0.272**	0.149**	0.272**	0.149**	0.281**	0.168**	0.281**	0.168**
Limited Engl Proficiency	-0.049**	-0.019	-0.051**	-0.021*	-0.040**	-0.010	-0.042**	-0.012	-0.084**	-0.035**	-0.084**	-0.036**
Eth: Hispanic	-0.062**	-0.025**	-0.053**	-0.018**	-0.058**	-0.022**	-0.049**	-0.014*	-0.115**	-0.033**	-0.114**	-0.033**
Eth: Asian	0.138**	0.085**	0.147**	0.091**	0.133**	0.084**	0.142**	0.090**	0.039**	0.038**	0.043**	0.039**
Eth: Black	-0.081**	-0.006	-0.080**	-0.005	-0.074**	-0.002	-0.073**	-0.002	-0.064**	-0.017**	-0.065**	-0.017**
Eth: Others	0.087**	0.060**	0.095**	0.064**	0.084**	0.060**	0.092**	0.064**	-0.025**	-0.003	-0.022**	-0.003
Edu: High School	0.083**	0.024**	0.083**	0.024**	0.082**	0.024**	0.082**	0.024**	0.068**	0.021**	0.068**	0.022**
Edu: Some College	0.222**	0.103**	0.223**	0.104**	0.215**	0.100**	0.215**	0.100**	0.185**	0.093**	0.184**	0.094**
Edu: Associate	0.211**	0.115**	0.212**	0.114**	0.205**	0.112**	0.205**	0.111**	0.220**	0.123**	0.218**	0.122**
Edu: Bachelor's	0.428**	0.228**	0.429**	0.228**	0.422**	0.226**	0.423**	0.227**	0.382**	0.217**	0.383**	0.218**
Edu: More than B	0.577**	0.309**	0.577**	0.309**	0.576**	0.311**	0.576**	0.311**	0.540**	0.308**	0.543**	0.311**
Age: 16_20	-0.280**	-0.059	-0.285**	-0.065	-0.283**	-0.061	-0.289**	-0.068	-0.298**	-0.081	-0.302**	-0.087*
Age: 21_30	-0.112**	0.009	-0.112**	0.009	-0.115**	0.006	-0.115**	0.006	-0.097**	0.008	-0.096**	0.009
Age: 31_40	-0.015**	0.033**	-0.015**	0.033**	-0.018**	0.030**	-0.018**	0.031**	-0.009*	0.033**	-0.008	0.033**
Age: 51_60	-0.079**	-0.092**	-0.080**	-0.093**	-0.076**	-0.090**	-0.077**	-0.091**	-0.078**	-0.091**	-0.079**	-0.092**
Age: 61_65	-0.301**	-0.270**	-0.302**	-0.272**	-0.295**	-0.267**	-0.296**	-0.269**	-0.300**	-0.275**	-0.301**	-0.277**
MATCH	0.056**	0.040**	0.055**	0.039**	0.054**	0.039**	0.052**	0.037**	0.029**	0.015*	0.028**	0.015*
Train: Occupational	-0.048**	-0.040**	-0.045**	-0.039**	-0.074**	-0.048**	-0.078**	-0.053**	-0.062**	-0.064**	-0.058**	-0.062**
Train: Remedial	-0.099**	-0.023**	-0.103**	-0.026**	-0.097**	-0.021**	-0.101**	-0.025**	-0.082**	-0.042**	-0.088**	-0.044**
Train : OJT	0.048**	0.044*	0.052**	0.044*	0.038*	0.038*	0.040*	0.037*	0.045**	0.055**	0.049**	0.056**
Train: Customized	0.202**	0.119**	0.197**	0.117**	0.193**	0.112**	0.187**	0.109**	0.133**	0.089*	0.128**	0.087*
Marketable Skills	0.055**	0.029**	0.044**	0.022**	0.055**	0.029**	0.044**	0.022**	0.023**	0.000	0.013**	-0.005
log(Prev Earning)		0.457**		0.457**		0.454**		0.454**		0.438**		0.438**
Exit Year 2005			0.025**	0.037**			0.026**	0.037**			0.032**	0.041**
Exit Year 2006			0.038**	0.035**			0.041**	0.038**			0.055**	0.044**
Exit Year 2007			0.068**	0.050**			0.072**	0.053**			0.076**	0.055**
13.Business & Financial					0.054**	-0.002	0.064**	0.007				
15.Computer, Math					0.060**	0.037**	0.071**	0.048**				
17.Architecture					0.194**	0.124**	0.203**	0.133**				

19.Science					0.128**	0.074*	0.137**	0.083**				
21.Community Service					-0.061**	-0.059**	-0.053**	-0.051				
23.Legal					0.095**	0.051	0.106**	0.061*				
25.Education, Training					-0.082**	-0.071**	-0.075**	-0.064**				
27.Arts, Design					0.085**	0.035	0.095**	0.044				
29.Healthcare Pract'r					0.109**	0.061**	0.118**	0.069**				
31.Healthcare Support					-0.053**	-0.059**	-0.044**	-0.051**				
33.Protective Service					0.077**	0.065**	0.084**	0.071**				
35.Food Prep & Serving					-0.048	-0.095**	-0.041	-0.087**				
37.Building Maintenance					-0.048	-0.044	-0.043	-0.039				
39.Personal Care&Service					-0.091**	-0.083**	-0.083**	-0.076**				
41.Sales and Related					0.032	-0.020	0.045	-0.007				
43.AdministrativeSupport					-0.031**	-0.034**	-0.022*	-0.025*				
45.Farming & Fishing					-0.162*	-0.193*	-0.151*	-0.186*				
47.Construction					0.031*	0.017	0.039*	0.025				
49.Installation & Repair					0.060**	0.028*	0.068**	0.036**				
51.Production					0.040**	0.029*	0.045**	0.035**				
53.Transportation					0.048**	0.034**	0.055**	0.041**				
Constant	8.540**	4.558**	8.509**	4.529**	8.554**	4.598**	8.520**	4.569**	8.746**	4.852**	8.705**	4.820**
States									Yes	Yes	Yes	Yes
Number of obs	67,734	45,808	67,734	45,808	67734	45808	67734	45808	67,734	45,808	67,734	45,808
F(22, 67711)	882.6	1,221.4	784.5	1,084.9	465.2	636.6	440.2	599.5	508.5	626.5	483.2	591.6
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.223	0.380	0.225	0.381	0.232	0.385	0.234	0.386	0.261	0.392	0.263	0.393
Adj R-squared	0.223	0.380	0.224	0.381	0.232	0.384	0.234	0.385	0.260	0.391	0.263	0.392
Root MSE	0.439	0.396	0.438	0.395	0.436	0.394	0.436	0.394	0.428	0.392	0.427	0.392

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

Table 4.12.b. Post-Participation Earnings: Education as Years of Schooling

	1b		2b		3b		4b		5b		6b	
Independent Variables	without	with	without	with	without	with	without	with	without	with	without	with
Male	0.309**	0.168**	0.308**	0.168**	0.286**	0.151**	0.286**	0.152**	0.292**	0.169**	0.292**	0.169**
Limited Engl Proficiency	-0.057**	-0.018	-0.058**	-0.020*	-0.046**	-0.008	-0.047**	-0.010	-0.095**	-0.036**	-0.095**	-0.037**
Eth: Hispanic	-0.075**	-0.026**	-0.064**	-0.018*	-0.068**	-0.022**	-0.058**	-0.014*	-0.133**	-0.037**	-0.131**	-0.037**
Eth: Asian	0.159**	0.095**	0.169**	0.101**	0.154**	0.094**	0.164**	0.100**	0.053**	0.046**	0.057**	0.047**
Eth: Black	-0.089**	-0.007	-0.088**	-0.006	-0.080**	-0.003	-0.080**	-0.002	-0.069**	-0.018**	-0.070**	-0.019**
Eth: Others	0.095**	0.065**	0.104**	0.069**	0.091**	0.064**	0.099**	0.068**	-0.023**	0.000	-0.020**	0.001
Schooling	0.020**	0.011**	0.021**	0.011**	0.020**	0.010	0.020**	0.010**	0.017**	0.009**	0.017**	0.010**
Age: 16_20	-0.290**	-0.047	-0.296**	-0.054	-0.292**	-0.049	-0.298**	-0.056	-0.312**	-0.072	-0.316**	-0.078
Age: 21_30	-0.118**	0.011	-0.119**	0.011	-0.122**	0.008	-0.123**	0.008	-0.102**	0.011	-0.102**	0.011
Age: 31_40	-0.013**	0.035**	-0.013**	0.036**	-0.018**	0.033**	-0.017**	0.033**	-0.007	0.035**	-0.007	0.036**
Age: 51_60	-0.075**	-0.089**	-0.077**	-0.090**	-0.072**	-0.087**	-0.073**	-0.088**	-0.074**	-0.089**	-0.076**	-0.090**
Age: 61_65	-0.297**	-0.267**	-0.298**	-0.269**	-0.292**	-0.264**	-0.293**	-0.266**	-0.298**	-0.273**	-0.299**	-0.274**
MATCH	0.063**	0.042**	0.061**	0.041**	0.065**	0.044**	0.064**	0.050**	0.028**	0.013	0.027**	0.013
Train: Occupational	-0.044**	-0.039**	-0.041**	-0.038**	-0.057**	-0.039**	-0.068**	-0.051**	-0.058**	-0.063**	-0.055**	-0.062**
Train: Remedial	-0.131**	-0.031**	-0.135**	-0.034**	-0.126**	-0.028**	-0.131**	-0.032**	-0.109**	-0.050**	-0.115**	-0.053**
Train : OJT	0.034*	0.034	0.038*	0.035	0.032	0.033	0.044**	0.037*	0.034*	0.048**	0.038*	0.049**
Train: Customized	0.236**	0.134**	0.229**	0.131**	0.229**	0.128**	0.218**	0.123**	0.156**	0.101**	0.151**	0.099**
Marketable Skills	0.053**	0.026**	0.042**	0.019**	0.054**	0.027**	0.042**	0.019**	0.026**	0.001	0.015**	-0.003
log(Prev Earning)		0.480**		0.480**		0.476**		0.475**		0.461**		0.460**
Exit Year 2005			0.028**	0.037**			0.028**	0.038**			0.035**	0.043**
Exit Year 2006			0.043**	0.037**			0.045**	0.039**			0.061**	0.046**
Exit Year 2007			0.075**	0.052**			0.078**	0.054**			0.080**	0.056**
13.Business & Financial					0.071**	0.007	0.087**	0.020				
15.Computer, Math					0.075**	0.046**	0.093**	0.062**				
17.Architecture					0.204**	0.129**	0.220**	0.143**				
19.Science					0.152**	0.085**	0.168**	0.100**				
21.Community Service					-0.051**	-0.053*	-0.036	-0.041				
23.Legal					0.098**	0.050	0.116**	0.064*				
25.Education, Training					-0.057**	-0.052**	-0.045**	-0.041*				

27.Arts, Design					0.090**	0.039	0.107**	0.053*				
29.Healthcare Pract'r					0.103**	0.056**	0.119**	0.069**				
31.Healthcare Support					-0.081**	-0.074**	-0.066**	-0.062**				
33.Protective Service					0.059**	0.053	0.073**	0.065**				
35.Food Prep & Serving					-0.069*	-0.108**	-0.056*	-0.096**				
37.Building Maintenance					-0.069*	-0.056	-0.058	-0.046				
39.Personal Care&Service					-0.116**	-0.098**	-0.101**	-0.086**				
41.Sales and Related					0.018	-0.031	0.040	-0.012				
43.AdministrativeSupport					-0.048**	-0.043**	-0.032**	-0.030**				
45.Farming & Fishing					-0.172*	-0.201*	-0.153*	-0.187*				
47.Construction					0.002	-0.001	0.017	0.012				
49.Installation & Repair					0.028**	0.008	0.043**	0.021				
51.Production					0.016	0.015	0.029**	0.027*				
53.Transportation					0.002	0.009	0.015	0.019				
Constant	8.417**	4.280**	8.379**	4.249**	8.436**	4.330**	8.395**	4.299**	8.676**	4.601**	8.628**	4.567**
States									Yes	Yes	Yes	Yes
Number of obs	67,734	45,808	67,734	45,808	67734	45808	67734	45808	67,734	45,808	67,734	45,808
F(22, 67711)	892.7	1,417.1	775.5	1,229.3	430.9	671.0	406.4	628.7	478.9	657.0	453.7	617.1
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.192	0.370	0.194	0.371	0.203	0.375	0.205	0.377	0.233	0.382	0.236	0.383
Adj R-squared	0.192	0.370	0.194	0.371	0.203	0.375	0.205	0.376	0.233	0.381	0.235	0.382
Root MSE	0.447	0.399	0.447	0.398	0.444	0.397	0.444	0.397	0.436	0.395	0.435	0.395

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

Table 4.13.a. Wage Replacement Rates: Education as Degree Attainment

	1a		2a		3a		4a		5a		6a	
Independent Variables	without	with	without	with	without	with	without	with	without	with	without	with
Male	0.017**	0.158**	0.017**	0.159**	0.008	0.143**	0.008	0.143**	0.023**	0.159**	0.023**	0.159**
Limited Engl Proficiency	0.007	-0.023*	0.005	-0.025**	0.014	-0.015	0.012	-0.017	0.014	-0.038**	0.013	-0.039**
Eth: Hispanic	0.016*	-0.037**	0.023**	-0.029**	0.019*	-0.033**	0.026**	-0.025**	0.053**	-0.040**	0.053**	-0.040**
Eth: Asian	0.009	0.066**	0.015	0.072**	0.015	0.066**	0.019	0.071**	0.037**	0.031**	0.037**	0.032**
Eth: Black	0.068**	0.002	0.069**	0.003	0.070**	0.005	0.071**	0.006	0.039**	-0.003	0.039**	-0.003
Eth: Others	0.023**	0.055**	0.026**	0.059**	0.026**	0.055**	0.029**	0.058**	0.035**	0.005	0.034**	0.005
Edu: High School	-0.039**	0.028**	-0.038**	0.028**	-0.039**	0.028**	-0.039**	0.028**	-0.036**	0.024**	-0.036**	0.024**
Edu: Some College	-0.035**	0.105**	-0.034**	0.106**	-0.037**	0.101**	-0.037**	0.102**	-0.025**	0.096**	-0.024**	0.096**
Edu: Associate	-0.033**	0.115**	-0.034**	0.115**	-0.034**	0.112**	-0.035**	0.111**	-0.023	0.124**	-0.024	0.123**
Edu: Bachelor’s	-0.005	0.223**	-0.004	0.223**	-0.007	0.220**	-0.006	0.220**	0.008	0.214**	0.008	0.214**
Edu: More than B	-0.002	0.283**	-0.002	0.282**	-0.004	0.282**	-0.004	0.282**	0.011	0.282**	0.013	0.284**
Age: 16_20	0.277**	-0.023	0.272**	-0.028	0.277**	-0.024	0.273**	-0.030	0.270**	-0.042	0.266**	-0.047
Age: 21_30	0.166**	0.026**	0.166**	0.025**	0.165**	0.023**	0.165**	0.023**	0.158**	0.024**	0.158**	0.025**
Age: 31_40	0.077**	0.029**	0.077**	0.029**	0.075**	0.026**	0.075**	0.027**	0.074**	0.028**	0.074**	0.029**
Age: 51_60	-0.077**	-0.065**	-0.077**	-0.065**	-0.076**	-0.063**	-0.077**	-0.064**	-0.077**	-0.064**	-0.078**	-0.064**
Age: 61_65	-0.155**	-0.179**	-0.157**	-0.180**	-0.154**	-0.176**	-0.155**	-0.178**	-0.160**	-0.182**	-0.161**	-0.184**
MATCH	0.031**	0.045**	0.030**	0.044**	0.031**	0.043**	0.030**	0.041**	0.029**	0.027**	0.029**	0.027**
Train: Occupational	-0.008	-0.026**	-0.007	-0.025**	0.017	-0.029**	0.012	-0.035**	-0.032**	-0.043**	-0.030**	-0.041**
Train: Remedial	0.048**	-0.028**	0.045**	-0.031**	0.050**	-0.027**	0.047**	-0.031**	0.015*	-0.041**	0.014	-0.043**
Train : OJT	0.007	0.015	0.007	0.016	0.013	0.013	0.012	0.012	0.029	0.022	0.029	0.023
Train: Customized	0.003	0.082*	0.000	0.079*	0.007	0.078*	0.003	0.074*	0.017	0.057	0.015	0.055
Marketable Skills	0.002	0.027**	-0.003	0.021**	0.003	0.027**	-0.002	0.020**	-0.021**	-0.002	-0.022**	-0.006
log(Prev Earning)		-0.490**		-0.490**		-0.493**		-0.493**		-0.509**		-0.509**
Exit Year 2005			0.033**	0.033**			0.032**	0.034**			0.036**	0.034**
Exit Year 2006			0.039**	0.036**			0.038**	0.038**			0.031**	0.039**
Exit Year 2007			0.039**	0.045**			0.038**	0.048**			0.031**	0.044**
13.Business & Financial					-0.068**	-0.009	-0.061**	0.000				
15.Computer, Math					-0.027	0.019	-0.018	0.030*				
17.Architecture					0.035*	0.104**	0.042**	0.112**				
19.Science					-0.008	0.066*	0.001	0.075*				

21.Community Service					-0.036	-0.033	-0.029	-0.026				
23.Legal					-0.019	0.052	-0.010	0.061*				
25.Education, Training					-0.063**	-0.052**	-0.058**	-0.045**				
27.Arts, Design					-0.022	0.033	-0.014	0.042				
29.Healthcare Pract'r					0.041**	0.072**	0.048**	0.080**				
31.Healthcare Support					-0.081**	-0.069**	-0.075**	-0.061**				
33.Protective Service					0.007	0.049*	0.013	0.056*				
35.Food Prep & Serving					-0.118**	-0.077**	-0.111**	-0.069*				
37.Building Maintenance					-0.032	-0.013	-0.026	-0.007				
39.Personal Care&Service					-0.083**	-0.078**	-0.077**	-0.071**				
41.Sales and Related					-0.100*	0.009	-0.090*	0.021				
43.AdministrativeSupport					-0.057**	-0.041**	-0.050**	-0.033**				
45.Farming & Fishing					-0.191*	-0.180*	-0.186*	-0.174*				
47.Construction					-0.015	0.025	-0.008	0.032*				
49.Installation & Repair					-0.034**	0.013	-0.027*	0.021				
51.Production					0.002	0.017	0.007	0.023*				
53.Transportation					-0.012	0.024*	-0.006	0.030*				
Constant	0.898**	5.183**	0.869**	5.154**	0.904**	5.219**	0.875**	5.191**	0.904**	5.444**	0.878**	5.417**
States									Yes	Yes	Yes	Yes
Number of obs	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808
F(22, 67711)	78.9	678.5	71.4	603.5	43.8	356.9	42.0	336.5	52.4	351.7	49.9	332.2
Prob > F	0	0	0	0	0	0	0	0	0	0	0	0
R-squared	0.037	0.254	0.038	0.255	0.040	0.260	0.041	0.261	0.050	0.265	0.051	0.266
Adj R-squared	0.036	0.254	0.037	0.255	0.040	0.259	0.040	0.260	0.049	0.265	0.050	0.266
Root MSE	0.441	0.388	0.440	0.387	0.440	0.386	0.440	0.386	0.438	0.385	0.438	0.385

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

Table 4.13.b. Wage Replacement Rate: Education as Years of Schooling

Independent Variables	1a without	1a with	2a without	2a with	3a without	3a with	4a without	4a with	5a without	5a with	6a without	6a with
Male	0.018**	0.159**	0.018**	0.159**	0.008	0.145**	0.008	0.146**	0.024**	0.160**	0.024**	0.160**
Limited Engl Proficiency	0.012	-0.023*	0.011	-0.024**	0.019	-0.013	0.018	-0.015	0.018	-0.039**	0.018	-0.040**
Eth: Hispanic	0.021**	-0.038**	0.029**	-0.030**	0.025**	-0.034**	0.032**	-0.025**	0.057**	-0.044**	0.056**	-0.044**
Eth: Asian	0.011	0.075**	0.017	0.081**	0.017	0.075**	0.021	0.081**	0.039**	0.038**	0.039**	0.039**
Eth: Black	0.067**	0.001	0.068**	0.002	0.069**	0.004	0.070**	0.005	0.038**	-0.004	0.038**	-0.004
Eth: Others	0.023**	0.059**	0.027**	0.064**	0.026**	0.059**	0.029**	0.063**	0.035**	0.008	0.034**	0.008
Schooling	-0.001	0.011	-0.001	0.011**	-0.001*	0.010**	-0.001	0.010**	-0.001	0.010**	0.000	0.010**
Age: 16_20	0.277**	-0.012	0.273**	-0.018	0.278**	-0.014	0.274**	-0.020	0.270**	-0.034	0.266**	-0.039
Age: 21_30	0.165**	0.028**	0.165**	0.028**	0.164**	0.025**	0.163**	0.024**	0.156**	0.027**	0.157**	0.027**
Age: 31_40	0.076**	0.031**	0.076**	0.032**	0.075**	0.029**	0.075**	0.029**	0.073**	0.031**	0.074**	0.032**
Age: 51_60	-0.075**	-0.062**	-0.076**	-0.063**	-0.075**	-0.060**	-0.075**	-0.061**	-0.076**	-0.062**	-0.076**	-0.062**
Age: 61_65	-0.153**	-0.176**	-0.155**	-0.178**	-0.152**	-0.174**	-0.153**	-0.175**	-0.158**	-0.180**	-0.160**	-0.182**
MATCH	0.031**	0.047**	0.030**	0.046**	0.032**	0.048**	0.030**	0.046**	0.029**	0.025**	0.029**	0.025**
Train: Occupational	-0.011*	-0.025**	-0.010	-0.024**	0.016	-0.020	0.011	-0.026**	-0.034**	-0.042**	-0.033**	-0.040**
Train: Remedial	0.054**	-0.037**	0.051**	-0.040**	0.057**	-0.034**	0.054**	-0.038**	0.020**	-0.049**	0.019**	-0.051**
Train : OJT	0.004	0.006	0.005	0.007	0.012	0.008	0.010	0.006	0.026	0.015	0.026	0.016
Train: Customized	0.004	0.095**	0.001	0.092*	0.007	0.092*	0.003	0.089*	0.018	0.068	0.016	0.066
Marketable Skills	0.001	0.024**	-0.004	0.018**	0.002	0.025**	-0.003	0.018**	-0.021**	-0.001	-0.022**	-0.004
log(Prev Earning)		-0.468**		-0.469**		-0.473**		-0.473**		-0.488**		-0.488**
Exit Year 2005			0.033**	0.034**			0.032**	0.035**			0.036**	0.036**
Exit Year 2006			0.039**	0.038**			0.037**	0.040**			0.031**	0.042**
Exit Year 2007			0.039**	0.046**			0.038**	0.049**			0.031**	0.046**
13.Business & Financial					-0.068**	0.000	-0.062**	0.008				
15.Computer, Math					-0.027	0.028*	-0.018	0.038**				
17.Architecture					0.035*	0.108**	0.042*	0.118**				
19.Science					-0.008	0.077*	0.000	0.087**				
21.Community Service					-0.038	-0.028	-0.031	-0.020				
23.Legal					-0.021	0.051	-0.013	0.061*				
25.Education, Training					-0.059**	-0.034*	-0.054**	-0.028				

27.Arts, Design					-0.024	0.037	-0.016	0.046				
29.Healthcare Pract'r					0.038**	0.068**	0.045**	0.077**				
31.Healthcare Support					-0.084**	-0.083**	-0.077**	-0.075**				
33.Protective Service					0.003	0.039	0.008	0.046				
35.Food Prep & Serving					-0.120**	-0.088**	-0.114**	-0.081**				
37.Building Maintenance					-0.031	-0.023	-0.025	-0.017				
39.Personal Care&Service					-0.085**	-0.091**	-0.079**	-0.084**				
41.Sales and Related					-0.102*	-0.001	-0.091*	0.012				
43.AdministrativeSupport					-0.059**	-0.050**	-0.053**	-0.042**				
45.Farming & Fishing					-0.193*	-0.188*	-0.188*	-0.181*				
47.Construction					-0.019	0.009	-0.012	0.017				
49.Installation & Repair					-0.038	-0.005	-0.031*	0.003				
51.Production					-0.001	0.004	0.005	0.011				
53.Transportation					-0.012	0.000	-0.007	0.007				
Constant	0.885**	4.918**	0.854**	4.887**	0.891**	4.966**	0.861**	4.936**	0.893**	5.201**	0.865**	5.171**
States									Yes	Yes	Yes	Yes
Number of obs	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808	45,808
F(22, 67711)	93.8	775.0	82.7	673.3	47.0	371.2	44.8	348.1	56.1	363.0	53.1	341.2
Prob > F	0	0	0	0	0	0	0	0	0	0	0	0
R-squared	0.036	0.243	0.037	0.245	0.040	0.250	0.040	0.251	0.049	0.254	0.050	0.255
Adj R-squared	0.035	0.243	0.036	0.244	0.039	0.249	0.040	0.250	0.048	0.254	0.049	0.255
Root MSE	0.441	0.391	0.441	0.390	0.440	0.389	0.440	0.389	0.438	0.388	0.438	0.388

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

Table 4.14. Retention : Education as Degree Attainment and Years of Schooling

Independent Variables	1a.	2a.	3a.	4a.	5a.	1b	2b	3b	4b	5b
Male	-0.006**	-0.006**	0.000	0.000	-0.006**	-0.006**	-0.006**	0.000	0.000	-0.006**
Limited Engl Proficiency	-0.016**	-0.015*	-0.014*	-0.013*	-0.013*	-0.017**	-0.016**	-0.015**	-0.014*	-0.015*
Eth: Hispanic	0.001	0.001	0.000	0.000	-0.007	-0.001	-0.001	-0.001	-0.001	-0.008
Eth: Asian	0.012	0.012*	0.011	0.012	0.005	0.011	0.012	0.011	0.011	0.005
Eth: Black	0.003	0.003	0.003	0.003	-0.003	0.003	0.002	0.003	0.003	-0.003
Eth: Others	0.000	0.001	-0.001	0.000	-0.003	0.000	0.001	-0.001	0.000	-0.003
Edu: High School	0.015**	0.015**	0.013**	0.013**	0.015**					
Edu: Some College	0.020**	0.020**	0.017**	0.017**	0.018**					
Edu: Associate	0.014**	0.015**	0.012*	0.012*	0.016**					
Edu: Bachelor's	0.012*	0.012*	0.010	0.010*	0.013*					
Edu: More than B	0.016	0.016	0.014	0.014	0.020*					
Schooling						0.001**	0.001**	0.001**	0.001**	0.001**
Age: 16_20	-0.016	-0.014	-0.016	-0.013	-0.014	-0.017	-0.014	-0.016	-0.014	-0.014
Age: 21_30	-0.014**	-0.014**	-0.015**	-0.015**	-0.013**	-0.014**	-0.014**	-0.015**	-0.015**	-0.013**
Age: 31_40	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003	0.002	0.004
Age: 51_60	-0.017**	-0.017**	-0.017**	-0.017**	-0.017**	-0.017**	-0.017**	-0.017**	-0.017**	-0.017**
Age: 61_65	-0.101**	-0.100**	-0.100**	-0.099**	-0.101**	-0.102**	-0.101**	-0.101**	-0.100**	-0.102**
MATCH	0.005	0.006	0.005	0.005	0.009*	0.005**	0.006	0.005	0.005	0.009*
Train: Occupational	0.016**	0.016**	-0.002	-0.002	0.010**	0.017**	0.017**	-0.001	-0.002	0.011**
Train: Remedial	0.003	0.002	0.002	0.001	-0.002	0.000	0.000	-0.001	-0.002	-0.005
Train : OJT	0.033**	0.034**	0.028**	0.029**	0.032**	0.033**	0.034**	0.028**	0.030**	0.032**
Train: Customized	0.008	0.008	0.007	0.006	0.007	0.008	0.007	0.007	0.006	0.008
Marketable Skills	0.009**	0.007**	0.009**	0.007**	0.005	0.009**	0.007**	0.009**	0.007**	0.005
Exit Year 2005		-0.024**		-0.024**			-0.024**		-0.023**	
Exit Year 2006		-0.010**		-0.009**			-0.010**		-0.008**	
Exit Year 2007		-0.003		-0.002			-0.003		-0.001	
13.Business & Financial			0.024**	0.025**				0.024**	0.025**	
15.Computer, Math			0.019**	0.020**				0.019**	0.020**	
17.Architecture			0.014	0.015				0.014	0.015*	

19.Science			0.021	0.022				0.021	0.023	
21.Community Service			0.031**	0.031**				0.031**	0.032**	
23.Legal			0.036**	0.037**				0.037**	0.037**	
25.Education, Training			0.021**	0.022**				0.021**	0.022**	
27.Arts, Design			0.011	0.010				0.012	0.011	
29.Healthcare Pract'r			0.036**	0.037**				0.037**	0.038**	
31.Healthcare Support			0.031**	0.032**				0.031**	0.032**	
33.Protective Service			0.024*	0.025*				0.025*	0.026*	
35.Food Prep & Serving			-0.031	-0.030				-0.030	-0.029	
37.Building Maintenance			-0.006	-0.006				-0.006	-0.006	
39.Personal Care&Service			-0.009	-0.008				-0.009	-0.008	
41.Sales and Related			0.025	0.027				0.025	0.027	
43.AdministrativeSupport			0.021**	0.022**				0.021**	0.022**	
45.Farming & Fishing			-0.002	0.002				-0.001	0.002	
47.Construction			0.007	0.008				0.008	0.008	
49.Installation & Repair			0.016**	0.016**				0.016**	0.017**	
51.Production			0.020**	0.021**				0.020**	0.021**	
53.Transportation			-0.009	-0.009				-0.010	-0.009	
States					Yes					Yes
Number of Obs	83,521	83,521	83,521	83,521	83,521	83,521	83,521	83,521	83,521	83,521
LR Chi2	488.5	565.4	601.4	680.8	710.2	471.6	548.3	588.8	668.2	692.7
Prob > Chi2	0	0	0	0	0	0	0	0	0	0
Pseudo R2	0.009	0.010	0.011	0.012	0.013	0.009	0.010	0.011	0.012	0.013

- * and ** indicate significance at 95% and 99% confidence interval, respectively.

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Chapter V

Conclusion

This dissertation investigates how the increase in international trade, expanded to the practice of offshore outsourcing, affects labor markets in developed countries, especially the US, and how the government compensates the displaced workers. The second and third chapters focus on theoretical and numerical analyses of the various employment effects of offshore outsourcing. The fourth chapter presents the empirical analysis of the efficacy of the TAA program, which is designed to help the workers who are displaced due to rising import competition and offshore outsourcing.

In chapters II and III, firms are initially in an open economy equilibrium without offshore outsourcing. The business process of each firm is composed of two segments - assembly and services. As technology advances, physical separation of the two segments becomes possible, so that firms can, if it is profitable, send either or both segments to a foreign country where the wage rate and productivity level differs. The Home country is the north (a developed country). Chapters II and III make different assumptions within this basic setup and examine different issues. Chapter II make the following three assumptions. First, firms are heterogeneous in their productivity levels, so they respond to the feasibility of outsourcing differently. Second, the competing foreign country is also in the north and is identical to the home country. The Southern country in this chapter is only a host of outsourcing activities and does not have a market for the finished product. Finally, only the assembly segment is outsourceable. The assumptions made in chapter III are the following. First, firms produce unique varieties; but they have identical productivity levels. Therefore, all firms in one country make the same decision, and the aggregate effect is proportional to the firm-level effect. Second, the competing foreign country is the south. South has a lower wage and is less productive in the service segment. Third, both assembly and service segments are outsourceable. In case the relative productivity of service segment of northern firms is very high, we may observe that southern firms outsource their service segments to the north. Two-way outsourcing - one country specializing in one segment - is also possible. In both chapters, I quantify various employment effects by calibrating model parameters to the U.S. manufacturing sector.

The theoretical analysis of Chapter II finds that offshore outsourcing reduces home employment unambiguously. When outsourcing becomes a feasible option with a fixed cost, different firms respond differently. The most productive firms outsource; the firms with medium productivity stay as non-outsourcers, and the least productive firms are forced to exit due to the lack of competitiveness. This last is called the cleansing effect.

In the numerical analysis, I find that the cleansing effect accounts for the majority of the net job destruction. The net employment effect of outsourcing firms alone is ambiguous; signs and magnitude change depending on the parameter values. This is a very important finding because it suggests that the results from currently available empirical studies on this subject do not capture the whole story. Most of these investigate the substitution between employment in the headquarter countries and at the foreign affiliates using the operational data on multinational enterprises. They have not found a consensus answer, however, and overall they suggest that the effect is very small even if a sign can be identified. However, these datasets by definition exclude both non-outsourcing firms and the exiting firms which destroy a massive amount of jobs in chapter II of this dissertation. The finding of this chapter suggests that in order to measure the true size of the employment effect of offshore outsourcing, the employment responses of non-outsourcers and exiting firms should be taken into account.

The separation of job destruction and creation shows that the negative net aggregate employment effect stems from separate job destruction and creation effects that are very large. This indicates that there is a massive movement of workers from destroyed jobs to newly created jobs. The numerical analysis also shows that when only job destruction is separated from job creation, the job destruction by outsourcing firms accounts for the majority of the aggregate job destruction. The ambiguous net employment effect of outsourcing firms is a combination of large job destruction and comparably large job creation. Even if their massive job destruction is mostly offset by their own job creation, their destructive employment effects should not be understated.

This result has very important policy relevance. Job destruction tends to be concentrated in low-skilled jobs, while the newly created jobs are likely to be high-skilled. In order to reduce adjustment costs of workers displaced due to outsourcing, we need a dislocated-workers program that can aid workers' transition across occupations - such as the TAA program, which is the subject of investigation in chapter IV. The quantification of job destruction and identification of its sources are necessary for effective policy preparation.

In chapter III, firms are homogeneous, so they behave identically. These firms within each country - either north or south - share the same productivity technology to produce differentiated products. Northern firms initially compete against cheap southern goods. As outsourcing becomes feasible, northern firms get a chance to improve their price competitiveness in the world market by sending their assembly or their service segment, or both, to the low-wage south. While southern firms have no incentive to outsource their assembly segments to the north, it could be profitable to outsource their service segments to the north if technology differential in that segment is sufficiently large.

If the technology differential in the service segment is not large enough to compensate the disadvantage of northern firms due to their high wage, northern firms outsource their assembly segments to the south and southern firms outsource neither segment. In this case, there is significant increase in northern share of the market. As prices of northern varieties fall, the decrease in relative price of northern varieties generate a large consumption shift from the southern varieties to the northern varieties. For the benchmark parameters considered, the numerical analysis shows a 61 percentage point increase in the northern share of the southern market, and a 43 percentage point increase in the northern market; together 35 percent of the world market shifts from southern varieties to northern ones.

In the absence of outsourcing, northern firms suffer greatly from their high relative prices. If the overall technology differential of the entire production process is not large enough, northern firms can not compete against the low wage of southern firms. In practice, the technology used in firms of developed and developing countries is not vastly different in some labor-intensive sectors such as apparel, textiles, footwear, and low-end furniture industries. In these industries, northern firms will eventually lose their market shares to southern firms and we have observed such a trend. Many developing countries practice national strategies to improve their technology levels. As a result, the technology gap between the north and south will continue to shrink in many sectors, and northern firms will be forced out of the market in the traditional setting of international trade. Offshore outsourcing widens the range of wage differentials over which northern firms can compete in the world market. The price reduction that outsourcing brings to the northern varieties enables the northern firms to compete in the sector where they would not be able to compete in the absence of offshore outsourcing. In the process, there is large gain in the northern share of the market, which in turn generates large job creation. The numerical analysis shows that such job creation can be larger than the job destruction from the assembly segment that is sent to the south, yielding net employment gain for various sets of parameter values investigated.

The analyses of chapters II and III are based on the assumption of perfect labor mobility across occupations. The investigation of job destruction separately from creation in both chapters suggests that there is massive turnover of jobs. As mentioned above, the jobs that are destroyed are the tasks replaced by low-skilled southern workers; therefore, the workers who are displaced in this process tend to be less educated and have limited skill sets. The TAA program is specifically designed to help these workers who need to acquire a new set of skills that are in demand, with its main focus on retraining services and income supports during training. In chapter IV, I investigate the efficacy of training services. Instead of comparing trainees and non-trainees among the customers, I take a more direct approach to measure the success in training service by looking at the match between Occupational Skills Training Code (OSTC) and Occupational Code of Employment (OCE).

However, a match can serve as a good measure of training success only if a match is a dominant career option; that is, trainees who can find a match will choose to get a job in the occupation of a match. The first set of analysis tests the hypothesis that a match is preferred over a non-match. For this analysis, I use two sets of variables: first, individual characteristics of customers such as gender and ethnicity; and second, characteristics that are related to learning ability such as educational attainment. Once occupational groups are controlled for, trainees with higher ability do have a higher probability of matching, which supports the hypothesis. However, trainees with higher education tend to choose occupations whose skills are more generally applicable - e.g. management; therefore, their matching rate is lower than that of less educated trainees if occupational groups are not controlled for.

The second set of analysis investigates whether trainees with a match perform better compared to trainees without a match and non-trainees in terms of the post-participation earnings, wage replacement rates, and retention rates. Trainees show significantly higher reemployment rates than non-trainees. The receipt of occupational skills training services - regardless of a match - improves the reemployment rate by 5 percentage points. On-the-Job Training (OJT) improves the reemployment rate by 10 percentage points. However, the most important determinant of the reemployment rate is the age of the customers. Age shows an upside down U-shape relationship with reemployment rates, with much larger influence of old age than young age. Customers with age between 21 and 30 show reemployment rates 4 percentage points higher than the customers of age between 41 and 50; while customers with age between 51 and 60 have the reemployment rates that are 10 percentage points lower than those of the age group 41-50.

I find that matching substantially improves both wage replacement rate and post participation earnings. Matching raises the wage replacement rates by more than 4 percentage points, and this is robust across various specifications. It is interesting to find that the trainees without a match have lower post-participation earnings and wage replacement rates than non-trainees. This implies that receiving training services alone does not guarantee better post-participation performance. Although matching shows positive effects on post-participation earnings and wage replacement rates, these earnings variables are again mainly governed by individual characteristics in terms of the size of influence. The effect of gender is very large. Male workers have wage replacement rates 15 percentage points higher than those of female workers. The effect remains at 14 percentage points positive even when occupation groups are controlled for - which are highly gender specific. Age and education are highly important. The retention rates are not affected by matching. However these rates are largely stable across variations in any variables.

In conclusion, achieving a match is important in improving post-participation outcomes of customers. The results show that although outcome measures for trainees are generally better than non-trainees, occupational skills training alone - training that does not lead to a match - does not improve the outcome measure. Since the training services account for the majority of the total TAA expenditure, more efforts need to be made to better assess the potential of the customers in successfully completing the training programs and to assist the customers in choosing the occupations that will lead to desirable employment.