Should Policy Makers be Concerned About Adjustment Costs?*

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Even the most strident advocates of free trade would readily admit that it takes time for economies to reap the benefits from trade liberalization. As trade patterns change, some workers lose their jobs and must seek reemployment in expanding sectors. There may be some cases in which these workers need to retool in order find new jobs. Of course, these workers do not produce any output while they search for reemployment and/or retrain. As a result, during the adjustment process, there may be a period during which welfare falls below its initial level. Policy makers often have a difficult time weighing these short run adjustment costs against the long run benefits from freer trade and this has made some countries reluctant to reduce barriers to trade. Growing concern about the importance of the adjustment process in the policy community is evident, as recent studies commissioned by the World Bank (Brahmbhatt 1997) and the WTO (Bacchetta and Jansen 2003) clearly indicate. Beyond concerns for equity, a full understanding of the magnitude and scope of adjustment can inform our views of the political economy of protectionism. In this paper, we investigate the nature of the adjustment process and try and get some handle on the magnitude of the costs involved in order to determine whether such concerns are warranted.

Recent research suggests that the personal cost of worker dislocation may be quite high. Jacobson, LaLonde and Sullivan (1993a, b) find that the average dislocated worker suffers a loss in lifetime earnings of $80,000. Yet, as disturbing as this finding may be, it tells us nothing about the aggregate costs of adjustment. It is quite possible for individual workers to lose a great deal while at the same time the economy is suffering only minor aggregate adjustment costs. Nevertheless, those who oppose trade liberalization often point to such personal losses, along with wage losses to those who remain employed in import competing industries, and ask whether the gains from freer trade are really worth such costs. Academic economists tend to dismiss such concerns by either suggesting that the aggregate costs of adjustment are probably very small compared to the gains from trade or by pointing out that the gains from trade are always large enough that we can fully compensate all those who suffer personal losses without exhausting the gains. Unfortunately, there are problems with both of these arguments. The latter argument ignores the fact that such compensation rarely, if ever, takes place. And,
the problem with the former argument is that there is almost no solid research on which to base such claims. That is, we know very little about the magnitude and scope of aggregate adjustment costs.

Estimates of aggregate adjustment costs are rare.\(^1\) The two main contributions are Magee (1972) and Baldwin, Mutti, and Richardson (1980), both of which follow a similar approach. First, estimates were made about the number of workers who would lose their jobs due to liberalization. These job losses were then evaluated based on an appropriate measure of the displaced workers’ wages. Finally, the authors then assumed that these workers would find reemployment after a length of time determined by estimates of the average duration of unemployment. Both papers conclude that adjustment costs are probably very small when compared to the gains from liberalization. For example, with a 10 percent discount rate, they both estimate that the short run costs of adjustment would eat away no more than 5 percent of the long run gains from trade.\(^2\)

It is hard to know what to make of these estimates. Neither paper attempts to take into account either the time or resource costs that are involved in the retraining that dislocated workers may be forced to go through. The resource cost of job search is also ignored. Moreover, since the reemployment process is not modeled, it is hard to take into account any displacement that may occur as dislocated workers find reemployment in new sectors. There are other problems as well, but all stem from the same basic issue – since there is no model of the adjustment process underlying these estimates, there may be many general equilibrium spillover effects that are not being captured. This is not intended as a criticism of these papers. At the time that these papers were written, rigorous models that explicitly allow for the trade frictions and informational asymmetries that lead to equilibrium unemployment were only in their

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\(^1\) A number of authors have attempted to measure adjustment costs within specific industries. See, for example, de Melo and Tarr (1990) who focus on the US textile, auto and steel industries or Tackas and Winters (1991) who studied the British footwear industry.

\(^2\) In a recent paper Trefler (2001) examined the short run adjustment costs and long run efficiency gains from trade liberalization in Canada by quantifying the impact of NAFTA on specific Canadian industries subject to large tariff cuts. He found evidence of substantial short run adjustment costs – a 15% decline in employment and a 10% decline in output. Balanced against these costs were only moderate productivity gains of about 1% per year. However, Trefler made no attempt to measure the aggregate gains and losses from NAFTA.
infancy.³ It would have been difficult to extend the type of general equilibrium models typically used for trade analysis to allow for equilibrium unemployment and retraining. The empirical approach adopted by these authors was entirely appropriate given the state of the trade literature at that time.

There is another line of research that is relevant for what follows. This research simply assumes that adjustment costs are non-trivial and then examines the implications of this for the optimal time path of liberalization. It has been argued that in order to minimize adjustment costs, trade barriers should be removed gradually (see, for example, Cassing and Ochs 1978, Karp and Paul 1994, Gaisford and Leger 2000, and Davidson and Matusz 2002).⁴ The rationale behind this rests on the assumption that as workers flee the import-competing sector and seek jobs in the expanding export sectors, congestion externalities will arise that increase the cost of adjustment. If the government removes trade barriers slowly, it can control the flow of workers, reduce congestion, smooth out the adjustment process and minimize the social cost of adjustment.

Our goal in this paper is to build on recent advances in the theory of equilibrium unemployment by presenting a simple general equilibrium model of trade that includes unemployment and training. We then use the model to explore the scope and magnitude of adjustment costs relative to the gains from trade. In our model, workers differ in ability and jobs differ in the types of skills they require. Workers sort themselves by choosing occupations based on expected lifetime income. These workers then cycle between periods of employment, unemployment and training with the length of each labor market state determined by the turnover rates in each sector. One of the advantages of the model is that it is simple enough to allow us to solve analytically for the adjustment path between steady states; thereby allowing us to calculate the adjustment costs associated with trade reform. Another advantage is that many of the key parameters (e.g., labor market turnover rates) are observable, so that we can rely on existing data to determine their likely values. However, one of the shortcomings of the model is that there are few

³ We are referring to the literatures on trading frictions (search theory), efficiency wages, and insider/outsider models of the labor market, among others.
⁴ For a survey of this literature, see Falvey and Kim (1992). Other recent contributions that do not focus on the role of congestion include Li and Mayer (1996) and Furusawa and Lai (1999).
existing estimates on which to base assumptions about the resource and time costs associated with training and these values play important roles in our analysis. We therefore solve the model for a wide variety of assumptions about these values and look for conclusions that are robust.

In developing our model, we purposefully abstract from congestion externalities by assuming that after liberalization, the job acquisition rate in the export sector remains at its pre-liberalization level. We do so for two reasons. First, our main goal is to show that by including the resource and time costs associated with training and job search we obtain estimates of adjustment costs that are substantially larger than those in the existing literature. In doing so, we want to ensure that our estimates are conservative, and by abstracting from congestion externalities, we are likely to be underestimating the true magnitude of these costs. Moreover, this ensures that our estimates are not driven by a (potentially) controversial assumption about the search process. The second reason that we assume away congestion has to do with the nature of the liberalization process itself. In this paper we are not interested in adding to the literature on the optimal time path of liberalization. As we mentioned above, previous work has shown that when congestion externalities are present, removing trade barriers gradually can lower aggregate adjustment costs. However, in the absence of congestion, there is no reason for gradualism. By assuming away congestion externalities we can keep our analysis simple and focus on the magnitude of the adjustment costs that arise when liberalization is complete and immediate.

Our results are surprising and contrast sharply with the previous literature. First, our model predicts that adjustment will take place relatively quickly, with net output returning to its pre-liberalization level within 2.5 years. This result, which is partly due to our assumption that post-liberalization export sector labor markets are not troubled by congestion, implies that an empirical analysis of adjustment based on yearly data could easily lead to the conclusion that adjustment costs are quite small. However, this is not the case in our model. Even with our most modest assumption concerning training costs we find that their inclusion in the model significantly increases our estimates of aggregate adjustment costs. For example, we find that when we take the time cost of retraining into account the short run adjustment costs amount to (at least) 10 to 15 percent of the long run benefits from
liberalization. When the resource costs of retraining are taken into account as well, our estimates jump to 30 to 80 percent of the long run gains from freer trade! The fact that we obtain these results in a model in which the job acquisition rate in the export sector does not fall after liberalization is particularly noteworthy.

In the latter part of the paper we turn to a related issue, and ask whether there is any way to know a priori which types of economies are likely to face relatively large adjustment costs. Labor markets and the institutions that govern them vary greatly across the world. Jobs tend to last longer in the U.S. than they do in Europe and Japan. The average duration of unemployment is relatively short in the U.S., while it can be quite long in some European countries. The implication is that all labor market turnover rates tend to be higher in the U.S. than they are in most European countries. In addition, wages are more flexible in U.S. labor markets than they are in their European counterparts. Consequently, labor economists typically characterize U.S. labor markets as flexible while European labor markets are considered sluggish. One would expect that the flexibility of the labor market would play a key role in determining the relative importance of adjustment costs.

We investigate this issue by determining how the ratio of adjustment costs to the gains from trade varies as turnover rates increase uniformly. In our model, we find, perhaps as expected, that relative adjustment costs are decreasing in the degree of labor market flexibility so that economies with slothful labor markets face higher costs of adjustment than economies with either flexible or sluggish labor markets. However, somewhat surprisingly, we find that the net benefits from trade reform have the same relationship with labor market flexibility so that economies with slothful labor markets have the most to gain from liberalization.

This surprising result has its roots in the manner in which tariffs distort economies with different degrees of labor market flexibility. We find that tariffs distort slothful labor markets more than sluggish ones. The removal of the tariff therefore generates large benefits in such economies; in fact, they are even

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5 It is worth noting that while our conclusion that short run adjustment costs may be quite high is quite different from those reached by Magee (1972) and Baldwin, Mutti, and Richardson (1980), it is consistent with basic message of
large enough to swamp the economy’s high level of short run adjustment costs. As a result, economies with the most slothful labor markets gain the most from trade liberalization.

In the conclusion we discuss the appropriate way to view our results. We emphasize that although our estimates of adjustment costs are quite high, this should not be misinterpreted as a warning about the dangers of liberalization. Instead, we argue that economists and politicians should spend more time worrying about the appropriate way to compensate those who bear the burden of these costs and that these policies should be an important component of the liberalization process. We also point out that our results suggest that the cost of new protectionist policies may be substantially higher than previous estimates indicate since newly created barriers to trade generate adjustment costs as well.

2. The Model

A. Background

In developing our model, we have several goals in mind. First, we want to use a general equilibrium trade model that is rich enough to capture some essential features of the employment process. In particular, we want a model that explicitly allows for both a training process in which workers acquire the skills required to find a job and a search process that those same workers must go through to find an employer. Second, we want to keep the model simple and tractable in order to be able to solve analytically for the transition path between steady states. This allows us to calculate the adjustment costs associated with trade reform. Third, we want the model to be general enough to allow for cross-country differences in labor market structure so that we may investigate the relationship between labor market flexibility and adjustment costs.

The basic structure of the model is as follows. We have an economy in which workers with differing abilities must choose between two types of jobs – those that do not require many skills and offer low pay and those that require significant training and pay relatively high wages. Jobs in the low-tech sector are easy to find, do not last very long (there is high turnover) and require skills that are job specific.

Trefler’s (2001) study of the impact of NAFTA on select Canadian industries (see footnote 2).
In contrast, high-tech jobs are relatively hard to find, presumably because the matching problem is harder to solve, last longer once employment is secured and require a combination of job specific and general skills. We assume that in each sector high-ability workers produce more output than their low-ability counterparts. Under certain assumptions, this implies that in equilibrium workers sort themselves so that high-ability workers train for high-tech jobs while low-ability workers are drawn to the low-tech sector.

We begin by assuming that the low-tech sector is protected by a tariff. This raises the return to training in that sector and causes some workers who should train in the high-tech sector to seek low-tech jobs instead. When the tariff is removed, these workers shift to the high-tech sector. This shift is gradual, however, since these workers will first have to enter the high-tech training process and then search for jobs. In addition, some of the workers who may eventually want to shift sectors may already hold low-tech jobs and since training and search are costly, they may choose to wait until they lose their low-tech jobs before making the switch. As a result, it may take significant time before the economy gets close to the new steady state. In this setting, adjustment costs are measured by comparing what the economy could gain if it could jump immediately to the new steady state with what it actually gains taking into account the costly transition that it experiences in moving to the new steady state.

B. Formalizing the Model and Finding the Initial Steady State

We consider a continuous time model of a small open economy consisting of two sectors and a single factor of production, labor. We use $a_i$ to denote worker $i$’s ability level and we assume that $a_i$ is uniformly distributed across $[0,1]$ with the total measure of workers equaling $L$. To obtain a job in either sector, workers must first acquire the requisite skills. Training is costly, both in time and resources. In sector $j$, workers seeking a job must pay a flow cost of $p_j c_j$ while training, where $p_j$ denotes the price of good $j$ (so that sector $j$ training costs are measured in units of the sector $j$ good). The length of the training process is assumed to be random, with sector $j$ trainees exiting at rate $\tau_j$. This implies that the average length of training in sector $j$ is $1/\tau_j$. Our notion that training is more costly both in time and
resources in sector 2, the high-tech sector, is captured by assuming that $c_1$ and $\tau_2$ are small while $c_2$ and $\tau_1$ are large (we will be more precise below). We use $L_{jt}(t)$ to denote the measure of workers training in sector $j$ at time $t$.

After exiting the training process, workers must search for employment.\footnote{The assumption that the training process takes place before search is not crucial for the analysis. We could assume instead that training takes place after completion of search without altering the nature of our results.} Jobs in the low-tech sector are plentiful, so that jobs are found immediately.\footnote{Of course, many low-ability workers face difficulty finding any job whatsoever and therefore face a long expected duration of unemployment whenever they lose their job. We believe that this is largely due to their work history and overall ability level. By assuming that low-tech jobs are plentiful (so that sector 1 employment can be found immediately), we are trying to capture the notion that the marginal worker (who has the ability to train for a high tech job) would be able to find menial employment quite easily if she chooses to do so.} In contrast, it takes time to find high-tech jobs and we use $e$ to denote the steady-state job acquisition rate in that sector. It follows that in the initial steady state the average spell of sector 2 unemployment is $1/e$. We use $L_{s}(t)$ to denote the measure of workers searching for high-tech jobs at time $t$.

Once a job is found, a type $i$ sector $j$ worker produces a flow of $q_ja_i$ units of output as long as she remains employed. Since output is increasing in $a_i$, higher ability workers produce more than their lower ability counterparts in each sector.\footnote{The assumption that the training process takes place before search is not crucial for the analysis. We could assume instead that training takes place after completion of search without altering the nature of our results.} This output is sold at $p_j$ and all of the revenue goes to the worker in the form of earned income (so that the sector $j$ wage earned by a type $i$ worker is $p_jq_ja_i$). We assume that in a steady-state sector $j$ workers lose their jobs at rate $b_j$, so that the average duration of a sector $j$ job is $1/b_j$. Since high-tech jobs are assumed to be more durable than low-tech jobs, it follows that $b_1 > b_2$. The measure of workers employed in sector $j$ at time $t$ is denoted by $L_{je}(t)$.

Upon separation, a worker must retrain if her skills are job specific. In contrast, if her skills are general, she can immediately begin to search for reemployment. As noted above, we assume that the skills acquired during low-tech training are job specific. We make this assumption because, to us, it seems natural. While training, a store clerk may need to learn the layout of the store in which she is
employed, the procedure involved in opening and closing the store, the functioning of a particular type of cash register, and so on; but, in gaining this knowledge the worker learns nothing about how to prepare fast food (or perform other low-skill tasks). In contrast, high-tech workers like accountants, managers and lawyers all must complete college and obtain some post-graduate education. If they lose their job, many of these workers will be able to obtain reemployment in the same field and in doing so they will not be required to go back through school. Moreover, even if these workers choose to change occupation, they will have acquired some general skills along the way that may allow them to land new jobs without acquiring additional skills. The implication is that all unemployed low-tech workers need to retrain in order to find reemployment, while some high-tech workers can move into a new job without having to retrain. To make this precise, we assume that with probability \( \phi \) high-tech workers need not retrain after losing their jobs.

The dynamics of the two labor markets are depicted in Figures 1 and 2. The evolution of the labor markets over time can be described with the aid of these figures. Let \( \dot{X}(t) \) denote the growth rate of \( X \) at time \( t \). These growth rates can be found by comparing the flows into and out of each labor market state. For example, in sector 1, the flow out of training is equal to the measure of workers who complete the training process and take low-tech jobs, \( \tau_1 L_{1T}(t) \). The flow into training is equal to the measure of low-tech workers who lose their jobs due to exogenous separation, \( b_1 L_{1E}(t) \). It follows that the growth rate of low-tech trainees is given by

\[
(1) \quad \dot{L}_{1T}(t) = b_1 L_{1E}(t) - \tau_1 L_{1T}(t)
\]

Similar logic can be used to find the growth rates of employment, \( \dot{L}_{2E}(t) \), and the unemployment pool in sector 2, \( \dot{L}_2(t) \). We have

\[
(2) \quad \dot{L}_{2E}(t) = e L_2(t) - b_2 L_{2E}(t)
\]

\(^{8}\) Ability could refer to attributes that the worker is born with, or it could refer to a combination of attributes that are either innate or acquired during the elementary education process.
In (2), the flow into high-tech employment consists of searching workers who find employment, $eL_S(t)$, while the flow out is made up of employed high-tech workers who lose their jobs, $b_2L_{2E}(t)$. In (3), the flow into the pool of searchers is made up of those who complete the high-tech training process, $\tau_2L_{2T}(t)$, and those workers who lose their high-tech jobs but do not have to retrain because their skills are transferable, $b_2\phi L_{2E}(t)$. The flow out of unemployment is equal to the measure of high-tech searchers who find jobs, $eL_S(t)$.\(^9\) Finally, in sector 1, workers are either employed or training, while in sector 2, they are employed, training, or searching. Thus, we have the following adding up conditions (where $L_j(t)$ denotes measure of sector $j$ workers at time $t$):

\begin{align*}
(4) \quad L_1(t) &= L_{1E}(t) + L_{1T}(t) \\
(5) \quad L_2(t) &= L_{2E}(t) + L_{2T}(t) + L_S(t)
\end{align*}

If we set the left hand side of (1)-(3) equal to zero, then we can use (1)-(5) to solve for the steady-state measure of workers in each labor market state. In Appendix A we show that these differential equations can also be used to solve for transition path between steady states.

It is important to note that the transition rates ($e$, $b_1$, and $b_2$) in (1)-(3) are set at their steady-state values. There are two reasons for this. First, as we mentioned above, we want to abstract from congestion externalities that might lower $e$ during the transition period by holding $e$ fixed at its steady state level. Second, as we show below, once liberalization occurs all economically inefficient jobs are immediately destroyed as some low-tech workers quit their jobs and switch sectors. Thus, the job destruction rate increases endogenously but it does so instantaneously and then returns to its steady-state level immediately after. It follows that the increase in job destruction shows up not in the differential equations

\(^9\) Similar growth equations for $L_{1E}$ (low-tech employment) and $L_{2T}$ (trainers in sector 2) could also be defined. However, given the adding up conditions in (4) and (5) they would be redundant.
describing labor market flows, but in the initial conditions that hold once liberalization occurs ($L_{2T}$ jumps up immediately once the tariff is removed).

Of course, in order to solve (1)-(5) we must first explain how to solve for $L_1(t)$ and $L_2(t)$. These values are determined by the behavior of individual workers, who choose their occupations based on the lifetime income that they expect to earn in each sector. When workers initially enter the labor market they have no skills. Thus, their initial choice depends on the relative values of $V_{1T}$ and $V_{2T}$, which measure the expected lifetime income for workers training in sectors 1 and 2, respectively. If we define $V_{2S}$ as the expected lifetime income for sector 2 workers who are currently searching for a job and use $V_{jE}$ to denote the expected lifetime income for employed workers in sector $j$, then we have the following asset value equations (with $r$ denoting the discount rate and $\gamma$ denoting the tariff on good 1)

\begin{align}
(6) & \quad rV_{1T}(t) = -p_1(1+\gamma)c_1 + r_1[V_{1E}(t) - V_{1T}(t)] + \dot{V}_{1T}(t) \\
(7) & \quad rV_{1E}(t) = p_1(1+\gamma)q_1a_1 + b_1[V_{1T}(t) - V_{1E}(t)] + \dot{V}_{1E}(t) \\
(8) & \quad rV_{2T}(t) = -p_2c_2 + r_2[V_{2S}(t) - V_{2T}(t)] + \dot{V}_{2T}(t) \\
(9) & \quad rV_{2S}(t) = 0 + \epsilon[V_{2E}(t) - V_{2S}(t)] + \dot{V}_{2S}(t) \\
(10) & \quad rV_{2E}(t) = p_2q_2a_j + b_2\phi V_{2S}(t) + (1-\phi)V_{2T}(t) - V_{2E}(t)] + \dot{V}_{2E}(t)
\end{align}

In (6) - (10), the first term on the right hand side represents flow income. For employed workers, flow income is equal to the value of the output they produce ($p_jq_ia_j$ for a type $i$ worker in sector $j$). Trainees and searching workers earn nothing while unemployed, and trainees must pay training costs while acquiring their skills. Thus, current income for searchers is equal to zero while trainees lose their training costs. The second term on the right hand side of each equation is the product of the capital gain (or loss) from changing labor market status and the rate at which such changes take place. For example, the flow rate from searching to employment in sector 2 is $e$ while the capital gain associated with employment is $V_{2E} - V_{2S}$. Note that for workers who are employed in the high-tech sector, there are two possibilities
when they lose their job. With probability $\phi$ these workers retain their skills and begin to search for a new job immediately, while with the remaining probability they must retrain before they can seek a new job. The final term on the right hand side, the $\dot{V}$ term, represents the growth rate of $V$. This term captures the appreciation (or depreciation) of the asset value over time and it is equal to zero in a steady state.

In order to describe the initial steady state equilibrium, we now set each $\dot{V}$ term in (6)-(10) equal to zero and solve for the expected lifetime income associated with each labor market state. We obtain

$$V_{1E} = \frac{p_1(1 + \gamma)(r + \tau)q_1a_1 - b_1c_1}{r\Delta_1}$$

$$V_{1R} = \frac{p_1(1 + \gamma)(\kappa q_1a_i - (r + b_1)c_1)}{r\Delta_1}$$

$$V_{2T} = \frac{p_2(\tau e\kappa q_2a_i - [(r + b_2)(r + e) - \phi b_2]c_2)}{r\Delta_2}$$

where $\Delta_1 = r + b_1 + \tau_1$ and $\Delta_2 = (r + b_2)(r + \tau_2 + e)$.

Unemployed workers with no skills choose to train in the low-tech sector if $V_{1T} \geq \max\{V_{2T}, 0\}$ and they choose to train in the high-tech sector if $V_{2T} \geq \max\{V_{1T}, 0\}$. Workers with ability levels such that $0 \geq \max\{V_{1T}, V_{2T}\}$ stay out of the labor market since it is too costly for them to train for any job. These workers are effectively shut out of the labor market – there are no jobs available for them to train for since their training costs would exceed any income that they could expect to earn after finding employment.

As for employed and searching workers, we assume that they are free to change occupations, but each time they do so they must start out by retraining. It follows that, in any steady-state equilibrium, these workers never switch sectors. However, changes in parameters or world prices may result in these workers changing occupations if the expected lifetime income associated with training in the other sector exceeds what they expect to earn as a searcher or an employed worker in their current sector.
To complete the characterization of equilibrium we must place some restrictions on our parameters. What we have in mind is a model in which high-ability workers are better suited to produce the high-tech good. It is clear from (12) and (13) that $V_{1T}$ and $V_{2T}$ are linear and increasing in $a_i$. Moreover, in each sector there is a critical value for $a_i$, denoted by $a_j$, below which $V_{jT}(a_i) < 0$. Workers separate in the desired way if $V_{2T}$ is steeper than $V_{1T}$ at the initial world prices and if $a_1 < a_2$. This is the case if $p_1(r + \tau_1)q_1\Delta_2 < p_2\tau_2eq_2\Delta_1$ and $(r + b_1)c_1\tau_2eq_2 < [(r + b_2)(r + e) - \phi eb_2]c_2\tau_2q_1$. With these two assumptions in place, $V_{1T}$ and $V_{2T}$ are as depicted in Figure 3. Note that the figure includes two new terms, $a_L$ and $a_H$, with $a_L \equiv a_1$ and $a_H$ defined as the ability level for the worker who is just indifferent between training in sector 1 or sector 2, that is $(1 - a_H)L = (1 - a_H)L$. From Figure 3, it is clear that workers with ability levels below $a_L$ do not enter the labor force. For these workers, the cost of training for any job is too high. Workers with ability levels $a_i \in [a_L, a_H]$ find the low-tech sector more attractive and choose to train in sector 1. It follows that $L_1 = (a_H - a_L)L$. Finally, workers with ability levels above $a_H$ find the high-tech sector relatively more attractive. These workers train for high-tech jobs, so that $L_2 = (1 - a_H)L$.

We can now return to (1)-(5), set the $L$ terms equal to zero and solve for the measure of workers in each labor market state in the initial steady state. We obtain $(L_5$ is omitted since it is not used in the subsequent analysis)

\begin{align*}
L_{1T} & = \frac{b_1(a_H - a_L)L}{b_1 + \tau_1} \\
L_{1E} & = \frac{\tau_1(a_H - a_L)L}{b_1 + \tau_1} \\
L_{2T} & = \frac{(1 - \phi)eb_2(1 - a_H)L}{(e + b_2)\tau_2 + (1 - \phi)eb_2}
\end{align*}
where, from (12) and (13),

\[ a_H = \frac{p_2 c_2 \Delta_1 ((r + b_2)(r + e) - \phi e b_2) - p_1 (1 + \gamma) c_1 \Delta_2 (r + b_1)}{p_2 \tau e q_2 \Delta_1 - p_1 (1 + \gamma) \tau q_1 \Delta_2} \]

\[ a_L = \frac{(r + b_1) c_1}{\tau q_1}. \]

These values can now be used to determine \( Y_{ss} \), the initial steady state value of output measured at world prices and net of training costs. Since the average low-tech worker produces \( \frac{1}{2} q_1 (a_L + a_H) \) units of output while the average high-tech workers produces \( \frac{1}{2} q_2 (1 + a_H) \) units, we have

\[ Y_{ss} = p_1 \{ 0.5 q_1 (a_L + a_H) L_{1E} - c_1 L_{1T} \} + p_2 \{ 0.5 q_2 (1 + a_H) L_{2E} - c_2 L_{2T} \} \]

Finally, to turn net output into utility, we assume that all workers have the same utility function given by

\[ U(Z_1, Z_2) = Z_1^\alpha Z_2^{1-\alpha} \] where \( Z_j \) denotes consumption of good \( j \). In Appendix C, we show that with this specification for utility, national welfare in the initial steady state is given by \( W_{ss} = \eta(\gamma) Y_{ss} / r \) where

\[ \eta(\gamma) = \frac{\alpha^\alpha [(1 - \alpha)(1 + \gamma)]^{1-\alpha}}{\alpha + (1 - \alpha)(1 + \gamma)}. \]

C. Adjustment

Changes in world prices cause the \( V_{JT} \) curves in Figure 3 to pivot with the point at which \( V_{JT} = 0 \) remaining fixed. Thus, if sector 1 is initially protected by a tariff, then when trade is liberalized \( V_{JT} \) pivots down causing \( a_H \) to fall. If we use \( a_{FT} \) to denote the new value of \( a_H \) (with the sub-script referring to "free trade"), then all workers with ability levels in the interval \([a_{FT}, a_H]\) eventually want to switch from the low-tech to the high-tech sector. Trainees switch immediately while those employed in the low-tech sector must decide whether to quit their jobs and switch sectors immediately or keep their
jobs and switch only after losing their jobs. If we use \( a_Q \) to denote the ability level of the low-tech worker who is just indifferent between quitting and keeping her job, then it is straightforward to show that \( a_Q \in [a_{FT}, a_H] \). Employed workers with \( a \in [a_Q, a_H] \) quit immediately and start to train for high-tech jobs while those with \( a \in [a_{FT}, a_Q] \) wait and switch after losing their low-tech job.

Because of the model’s simple structure, it is possible to solve analytically for the transition path between steady states. We begin by noting that all \( V \) terms jump immediately to their new steady state values once trade is liberalized. This is due to the fact that these values depend only on prices, ability, turnover rates and other parameters that are independent of time (see 11-13). Thus, \( a_H \) jumps to its new value immediately as well. The gradual transition to the new steady state occurs in the labor market and involves only those workers with ability levels in the range \( [a_{FT}, a_H] \). For these workers, the measures of trainees, searchers and employed workers change according to the differential equations in (1)-(5). We provide the solution to this system of differential equations in Appendix A and show how they can be used to calculate the net output produced by these workers in each sector during the adjustment process. We use \( X_j(a_{FT}, a_Q) \) to denote the present discounted value of the net output produced in sector \( j \) by workers with \( a \in [a_{FT}, a_Q] \) during adjustment and use \( X_j(a_Q, a_H) \) to play the same role for those workers with \( a \in [a_Q, a_H] \). These values are given by (A.11)-(A.12) and (A.15) in Appendix A.

Liberalization does not alter the behavior of those workers with \( a \leq a_{FT} \) or \( a \geq a_H \). The former group remains attached to the low-tech sector whereas the latter group continues to train, search and work in the high tech sector. It is possible that as workers flow from the low-tech sector to the high-tech sector, labor market congestion might cause the job acquisition rate in the high-tech sector to fall. If congestion externalities are present, they would increase the cost of adjustment and slow down the transition to the new steady state. However, as we mentioned in the introduction, in order to keep our analysis as simple and tractable as possible, we abstract from this issue by assuming that all workers seeking high tech jobs continue to find them at the steady state job acquisition rate of \( e \). This assumption ensures that our
estimate of adjustment costs will be on the conservative side. It also implies that for workers with \( a \leq a_{FT} \) the measures of workers training and employed in the low-tech sector after liberalization are given by (14) and (15), respectively, with \( (a_H - a_L) \) replaced by \( (a_{FT} - a_L) \). We use \( L_{1T}^{FT} \) and \( L_{1E}^{FT} \) to represent these values. Note that for those workers with \( a \geq a_H \), the measures training, searching and employed in the high-tech sector after liberalization are still given by (16)-(17).

Given the solutions provided in Appendix A, we can calculate the value of output net of training costs along the transition path, \( Y(t) \). We have

\[
Y(t) = p_1 \{0.5q_1(a_L + a_{FT})L_{1E}^{FT} - c_1L_{1T}^{FT}\} + p_2 \{0.5q_2(1 + a_H)L_{2E} - c_2L_{2T}\} + X_1(a_{FT}, a_Q) + X_2(a_{FT}, a_Q) + X_2(a_Q, a_H)
\]

To find welfare after liberalization, taking the adjustment path into account, we first transform net output into utility and then integrate over time. Given our specification of utility, we obtain

\[
W_A = \int e^{-\eta \tau} \eta(0)Y(t)dt.
\]

The last step in solving for the cost of adjustment is to compare \( W_A \) with the welfare that the economy could achieve if it were able to jump immediately to the new (free trade) steady-state equilibrium \( (W_{FT}) \). To find this value, define \( Y_{FT} \) as the value of output net of training costs in the new steady state equilibrium. This value is given by (20) with \( a_{FT} \) replacing \( a_H \) so that \( W_{FT} = \eta(0)Y_{FT}/r \). 10

Typical time paths for \( Y_{SS}, Y(t) \) and \( Y_{FT} \) are depicted in Figure 4. Liberalizing trade increases steady state net output from its initial value of \( Y_{SS} \) to its new free trade value of \( Y_{FT} \). However, to reach the new steady state, the economy must first go through a costly transition with net output following along the \( Y(t) \) path. Note that there is a period of time (up to \( t^* \)) during which net output falls below its initial steady state value. The potential gain from trade reform is defined by the properly discounted area below \( Y_{FT} \) and above \( Y_{SS} \); or, \( W_{FT} - W_{SS} \). The actual gain is the properly discounted difference between

10 Note that we are using the compensating variation to measure the change in welfare due to liberalization.
the areas below $Y_{ss}$ and $Y(t)$; or, $W_A - W_{SS}$. It follows that aggregate adjustment costs are measured by the appropriately discounted area below $Y_{FT}$ but above $Y(t)$; or, $W_{FT} - W_A$.\textsuperscript{11} In the next section, we simulate the model, calculate aggregate adjustment costs and compare them to the potential gains from reform.\textsuperscript{12} We do so by focusing on two key variables. The first variable is $t^*$, which measures the length of time it takes for the economy to get back to its original level of net income (so that $t^*$ solves $Y_{ss} - Y(t^*) = 0$). By looking at $t^*$ we are able to get some sense as to how long it takes the economy to begin to reap the benefits from liberalization. The second variable of interest is $R^*$, defined as the ratio of aggregate adjustment costs to the potential benefits from trade reform:

$$R^* = \frac{W_{FT} - W_A}{W_{FT} - W_{SS}}$$

D. Strengths and Weaknesses of our Model

At this point, it is useful to highlight some features of our model that we consider strengths as well as some of the weaknesses. There are several attractive features that are worth emphasizing. First, we have modeled the training and search processes that workers must go through in order to find jobs. This allows us to take into account both the time and resource costs that dislocated workers must incur after losing their jobs. This is a unique and innovative feature of our model and we consider it one of its main strengths. The second important feature is that we have managed to keep the framework relatively simple and tractable. In fact, it is so simple that we can solve explicitly for the transition path between steady states by solving the differential equations in (1)-(5).

Another attractive feature of our model is that many of the key parameters, for example, the labor market turnover rates, are observable. This makes it easy to calibrate the model and find estimates of aggregate adjustment costs for parameter values that have some empirical significance. Moreover, as we

\textsuperscript{11} This method for calculating adjustment costs was suggested by Neary (1982).

\textsuperscript{12} In Davidson and Matusz (2001) we explore other aspects of the adjustment path including the time paths of employment and unemployment during the adjustment period.
emphasized in the introduction, it is well known that labor markets in Europe, the United States and Japan differ significantly in their structure and that much of the difference has to do with differences in turnover rates. Since it is these turnover rates that drive our analysis, we can easily model the differences in labor market structure across these regions and see how our estimate of adjustment costs relative to the benefits from trade liberalization vary with labor market flexibility.

Finally, there is one other positive feature of our model that we would like to underscore. In Appendix B we show that the equilibrium in our model is efficient. This is unusual for search models. It is usually the case that search decisions are rife with externalities. For example, if an unemployed worker chooses to seek a job in a particular sector, this may make it more difficult for other unemployed workers to find a job (that is, there may be congestion externalities). Such externalities typically distort behavior and lead to sub-optimal equilibria. This is not the case in our model. In fact, we set up our model with certain features (such as exogenous job acquisition rates) specifically designed to avoid this problem. The reason that we did this is so that we can be sure that when we calculate adjustment costs and compare them to the gains from trade we can be certain that our results do not depend on how trade liberalization affects the distortions created by controversial, hard to measure search generated externalities.

While there is considerable merit in assuming fixed job acquisition rates, there is also a downside. Agents face changing economic incentives as trade is liberalized. Some workers in the import competing sector quit and this results in an immediate increase in the job destruction rate. At the same time, since the pool of unemployed workers is swelling in the export sector, the job acquisition rate may fall due to congestion. As mentioned in the introduction, this possibility has been the focus of several papers in which it has been suggested that gradual liberalization may be warranted in order to avoid congestion in export sector labor markets. By treating the job acquisition rate as an exogenously specified parameter, we are ignoring these possibilities and obtaining estimates of adjustment costs that are probably too low.

Another weakness in our analysis concerns the parameters that measure the costs of retraining ($c_j$ and $\tau_j$). Although these parameters play a key role in our analysis, we know very little about their
likely values. We handle this problem in two ways. First, since it is unlikely that training costs in the low-tech sector are significant, we set \( c_t \) equal to zero and assume that \( \tau_t \) is quite high (so that low-tech training is very brief). Given that we have also assumed that there are no resource costs associated with job search, this is another reason to suspect that our estimates of aggregate adjustment costs are likely to be biased downward. Second, we consider a wide variety of assumptions about the magnitude of high-tech training costs and then try to draw conclusions that are robust across these sets of assumptions.

2. Aggregate Adjustment Costs

The parameters of our model include those that determine the average durations of sector-\( j \) training (\( \tau_j \)), sector-\( j \) employment (\( b_j \)) and high-tech search (\( e \)), those that determine the resource cost of sector-\( j \) training (\( c_j \)), those that help to determine output per worker in sector \( j \) (\( q_j \)), the rate of transferability of high-tech skills across jobs (\( \phi \)), the discount rate (\( r \)), and the share of income devoted to consumption of good 1 (\( \alpha \)). In this section, we choose values for these parameters solve the model and provide measures of the aggregate adjustment costs associated with trade reform. We do so under the assumption that the low tech-sector is initially protected by a 5% tariff (thus, \( \gamma = 0.05 \)).

To make certain that we do not discount the future too heavily, we set \( r = 0.03 \), the lowest discount rate considered by Baldwin et. al. (1980) and Magee (1972).\textsuperscript{13} The average duration of unemployment in the U.S. can be found in The 2001 Economic Report of the President (see Table B-44). Although this value has fluctuated over the years, it remains fairly stable at about one quarter (or 13 weeks). Our model is consistent with such estimates if we set \( e = 4 \). Since this value rarely fluctuates by more than a week or two, this is the only value for \( e \) that we consider.

For the average duration of employment in the high-tech sector, we turn to the job creation and destruction data of Davis, Haltiwanger and Schuh (1996), who report that the average annual rate of job

\textsuperscript{13} This again biases our result in terms of minimizing the magnitude of adjustment costs, since a low discount rate places relatively little weight on current costs versus the future benefits of reform.
destruction in U.S manufacturing during the period 1973-1988 was about 10% (this translates into an average job duration of 10 years). There is some variation in this number across years, with the largest rate of job destruction coming in 1975 at 16.5% (implying an average job duration of about 6 years).\textsuperscript{14} We therefore assume, for our base case, that an average high-tech job lasts ten years (which is the case if $b_2 = 0.10$). However, we also solve the model and report results for the case in which high-tech jobs last only six years (which is the case if $b_2 = 0.167$).

It is hard to find data on the average duration of a job in the low-tech sector. We consider these to be transitory, undesirable jobs and although many of these jobs may be found in the manufacturing sector, it is not possible to look at industry-wide data and draw conclusions about how long the worst jobs in each industry last. So, we take a different approach. Our low-tech jobs require few skills and little training. These are the types of jobs that many hold while still in school or when they are just starting out in the labor force. If we look at data on the number of jobs held over the lifetime, we find that up to the age of 24 workers hold (roughly) one new job every two years.\textsuperscript{15} We therefore consider two cases – one in which low-tech jobs last two years (so that $b_1 = 0.5$) and another in which they last just one year (so that $b_1 = 1.0$). Combining these two cases with the assumptions that we have made about job tenure in the high-tech sector leaves us with four different settings. In the setting with high turnover in both sectors, jobs last a year in the low-tech sector and six years in the high-tech sector. In the setting with low turnover in both sectors, jobs last two years in the low-tech sector and ten years in the high-tech sector. In the other two cases, jobs last either three or ten times as long in the high-tech sector than they do in the low-tech sector. This gives us a wide range of assumptions about labor market turnover.

Turn next to the parameters of the training processes. Since very little is known about the magnitude of training costs we want to be careful not to assume values that seem unreasonably high, and we want to make sure that we consider a wide range of possible values. As we mentioned above, we

\textsuperscript{14} See Table 2.1 on p. 19 in Davis, Haltiwanger and Schuh (1996).
\textsuperscript{15} See Table 8.1 on p. 210 in Hamermesh and Rees (1988).
assume that there are no resource costs associated with low-tech training (i.e., $c_1 = 0$). In addition, we assume that the low-tech training process takes only one week (so that $\tau_1 = 52$). For the high-tech sector, we turn to the limited information that is available on training costs. A review of what is known about turnover costs can be found in Hamermesh (1993) where turnover costs are assumed to include both the costs of recruiting and training the newly hired worker. This literature suggests that such costs may be quite high. For example, a large firm in the pharmaceutical industry estimated that the present value of the cost of replacing one worker amounted to roughly twice that worker’s annual salary. Similar, although not quite so dramatic, estimates were obtained for less-skilled jobs. One study estimated that the cost of replacing a truck driver amounted to slightly less than half of that worker’s annual pay. The lowest estimate of turnover costs reported by Hamermesh appears to be about three weeks worth of salary. Similar estimates can be found in Acemoglu and Pischke’s (1999) study of the training process in the German apprentice system. They report estimates of training costs that vary from 6 month’s to 15 month’s of the average worker’s annual income, depending on the size of the firm. To capture this wide range of estimates, we assume that high-tech training lasts four months ($\tau_2 = 4$) and then we vary the value of $c_2$. At the low end, we choose $c_2$ so that training costs for the average worker in the high-tech sector are equal to one month’s pay. At the high end, we choose $c_2$ so that the average high-tech worker’s training costs equal 15 months of pay. We also consider two intermediate cases in which training costs equal 5 and 10 months of the worker’s annual salary. This gives us a wide range of values for high-tech training costs. Below we look for results that are robust across this range of estimates.

With $c_1 = 0$ we have $a_1 = 0$ so that all workers enter the labor market.

High-tech workers pay a flow cost of $p_2c_2$ while training and training lasts, on average, $1/\tau_2$ periods. Thus, training costs are given by $p_2c_2/\tau_2$. Annual income for the average worker in the high-tech sector is $p_2q_2(a_H + a_L)/2$.

At this point, it is useful to first clarify what we mean by training costs. While acquiring the skills necessary to perform certain tasks, there may be periods during which no production occurs whatsoever (while workers are in school, going through orientation, getting hands-on on-the-job training, and so on). However, there may also be a period during which the worker is producing and yet productivity is below its ultimate level because the worker is still learning about the production process. The output lost during the period of learning-by-doing should also be considered as part of training costs. With this interpretation, it is hard to imagine that our most modest assumptions – that there are no resource cost to training in the low-tech sector, that the low-tech training process takes only one
This leaves $q_1$ and $q_2$, the productivity parameters in the two sectors, $\phi$, which measures how often high-tech workers need to retrain after losing their jobs, and $\alpha$, the parameter in the utility function. Our simulations indicate that our results are quite insensitive with respect to $\alpha$. Adjustment costs are minimized for $\alpha = \frac{1}{2}$ and rarely vary by more than 0.02 for other values of $\alpha$. As for $\phi$, we have argued that high-tech jobs require both general and job-specific training with much of the training general. The implication is that retraining is not all that common in the high-tech sector, which means that $\phi$ should be fairly high. In Tables 1 and 2 we provide estimates of the two variables that we are interested in, $R^*$ and $t^*$, under the assumption that $\phi = 0.8$. However, we also calculated these values assuming that $\phi$ ranged between 0.5 and 0.9 and found that the values in Tables 1 and 2 were affected only at the third decimal place. Thus, we conclude that our estimates are also largely insensitive to our assumptions about $\phi$, provided that this value remains above 0.5.

For $q_1$ and $q_2$, what matters is their relative value. Thus, we set $q_2 = 1.4$ and then vary $q_1$. As $q_1$ varies the relative attractiveness of the two sectors changes and thus, $a_H$, which determines the fraction of the workforce that starts out in the low-tech sector, is altered. For completeness, we consider five different values for $q_1$ for each combination of turnover rates. These are the values that correspond to $a_H$ equal 0.2, 0.33, and 0.5. This gives us a sense as to how our measures of $R^*$ and $t^*$ vary with the size of the sector that is initially protected (sector 1) relative to the size of the sector that is associated with significant training costs (sector 2).

Our estimates of $R^*$ and $t^*$, are reported in Table 1. They were obtained by assuming that the world prices of the two goods are the same and that the low-tech sector is initially protected by a 5% tariff. Three results stand out. First, our model predicts that adjustment will take place quickly, with...
output reaching its pre-liberalization level in about 2 years. The immediate implication is that if one were to look for evidence of adjustment costs using yearly data, it would appear that such costs are quite low.

Nevertheless, the second result that stands out is that our estimates of adjustment costs are considerably higher than any obtained by Baldwin et. al. (1980) or Magee (1972). Our lowest estimate in Table 1 is that adjustment costs eat away about one third of the gains from trade reform. At the other extreme, some estimates are as high as .8! Given that we have assumed away search costs and resource costs for low-tech training and abstracted from congestion externalities in the expanding export sector labor markets, these estimates are surprisingly high.

Third, the results with respect to \( R^* \) and \( t^* \) are remarkably robust across our assumptions about steady state break-up rates – going from high turnover in both sectors to low turnover in both sectors never changes \( R^* \) by more than 0.02. Our estimates of are also fairly insensitive to our assumptions about the initial size of the low-tech sector. As \( a_H \) increases, \( R^* \) and \( t^* \) tend to fall with the rate of decrease increasing in the magnitude of high-tech training costs.\(^{19}\) In fact, it is the magnitude of these training costs that clearly matter the most. Not surprisingly, as training costs increase, so do \( R^* \) and \( t^* \).

One natural question to ask at this point is whether our results are driven by our assumption that training involves a real resource cost or whether the costs are this high simply because the training and search processes take time and no production occurs while search and training take place. To get some handle on this issue, we introduce two new terms, \( R_{GO}^* \) and \( t_{GO}^* \). These terms are defined in exactly the same manner as \( R^* \) and \( t^* \) with one exception – they measure only gross output (i.e., they ignore the resource cost of training). So, for example, \( t_{GO}^* \) measures the amount of time it takes for gross output to get back to its pre-liberalization level. Our estimates of \( R_{GO}^* \) and \( t_{GO}^* \) are reported in Table 2. While our estimates fall significantly, they remain considerably above those found in previous studies. Most of the

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\(^{19}\) Increasing the initial size of the low-tech sector has two effects on \( R^* \). On the one hand, if the low-tech sector is large then trade reform will generate large benefits. On the other hand, with a large low-tech sector trade reform will also lead to a great deal of worker reallocation and this will increase adjustment costs.
estimates indicate that when we take into account only the time cost of training, around 15 to 20% of the gains in gross output are lost due to adjustment costs. Moreover, gross output returns to its pre-liberalization level before net output, making it even harder to find evidence of significant adjustment costs in annual (or even quarterly) data. These estimates are robust across our assumptions concerning break-up rates and the initial size of the low-tech sector, but do vary significantly as we change our assumptions about the magnitude of high-tech training costs.

4. Adjustment Costs and Labor Market Flexibility

Tables 1-2 indicate that changes in break-up rates have little influence over our estimates of aggregate adjustment costs. Yet, if we look across the world, it is not only break-up rates that vary but also the rate of job acquisition. In the U.S. most unemployed workers find reemployment relatively quickly and long-term unemployment is not a significant problem. In contrast, many European economies face serious problems with a large population of workers who have been classified as long-term unemployed. Combining this with the fact that job duration is also longer in Europe leads to the conclusion that labor markets are much more flexible in U.S. than they are in Europe. This difference in labor market flexibility has been emphasized by labor economists and macroeconomists studying a variety of issues.20 In this section, we investigate the implications for aggregate adjustment costs.

To do so, we add a new variable $s$ to our model, which we refer to as speed. We introduce this term by multiplying the turnover rates in the high-tech sector, $b_2$ and $e$, by $s$.21 As $s$ increases, high-tech jobs become easier to find but they also become less durable. Thus, an economy with a high value for $s$ has a great deal of turnover in the high-tech sector while an economy with a low value for $s$ has a high-tech sector with a long average duration of unemployment and a relatively long expected job tenure. It

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20 See, for example, Freeman (1994) and Layard, Nickell, and Jackman (1991).
21 Similar results can be obtained by multiplying all turnover rates by $s$ so that an increase in $s$ results in higher turnover in both sectors. However, since turnover plays a more prominent role in the high tech sector, it turns out that changes triggered by changes in the high tech rates dominate those driven by changes in the low tech rates. A brief description of this case can be found in Davidson and Matusz (2000).
follows that \( s \) measures the flexibility of the labor market with increases in speed associated with more flexible labor markets.\(^{22}\)

Figure 5a shows how \( R^* \) varies with \( s \) for the case in which there is low turnover in the high-tech sector, high turnover in the low-tech sector, high-tech training costs are equal to 5 months of the average high-tech worker’s income and one-third of the labor force starts out in sector 1 (i.e., \( b_1 = 1.0, b_2 = 0.1 \) and \( a_H = 0.33 \)). Qualitatively similar figures apply for all other parameter values in Tables 1-2. As expected, there is a negative relationship between the two measures – increases in labor market flexibility always reduce relative adjustment costs. The implication is that Americans should be less concerned about the costs of adjustment than Europeans and/or the Japanese.

The negative relationship depicted in Figure 5a suggests that it would be useful to look at how the actual gains from trade (net of adjustment costs) vary with \( s \). To do so, define \( NB \) to be the benefit from liberalization net of adjustment costs (as a percentage of initial steady state welfare):

\[
(23) \quad NB \equiv 100 \left( \frac{W_A - W_{SS}}{W_{SS}} \right)
\]

Figure 5b shows how \( NB \) varies with \( s \) for the parameter values that generate Figure 5a. Surprisingly, as with \( R^* \), the relationship is negative. Even though economies with the least flexible labor markets have the highest adjustment costs, as indicated by high values of \( R^* \), they have the most to gain from liberalization, as indicated by high values of \( NB \).

The surprising outcome depicted in Figure 5b can be traced to the manner in which the gross benefit from trade varies with speed. The gross benefit from trade reform depends on the amount of workers who switch sectors as a result of liberalization. The more workers that switch, the greater the increase in gross output. Figure 3 can be used to see how the amount of worker reallocation varies with \( s \). Trade reform lowers the return to training in the low-tech sector, causing the \( V_{1T} \) curve to pivot down.

\(^{22}\) Note that we do not multiply the turnover rates associated with training by \( s \). It is our view that the length of the training process is determined by the complexity of the job and this is a feature that is linked to technology, not the
The amount of worker reallocation that occurs then depends on the slope of the $V_{2T}$ curve with a flatter curve implying more reallocation. It is straightforward to show that this curve is relatively flat when $s$ is either very low or very high. Intuitively, if $s = 0$ a worker who is currently training has no hope of ever finding a job (since the job acquisition rate is 0) and thus ability, which only affects output while employed, plays no role in determining the value from training. In this case, the $V_{2T}$ curve is horizontal. Increasing $s$ leads to an increase in the fraction of life spent employed and makes ability more important. Thus, when $s$ is low an increase in $s$ causes the $V_{2T}$ curve to become steeper. It follows that trade reform results in a great deal of reallocation when $s$ is very low – thus, when the tariff is removed, large benefits accrue to economies with slothful labor markets. In fact, Figure 5b reveals that the benefits are so large that they swamp the high costs of adjustments that these economies face.

These results can be viewed one of two ways. On the one hand, there is good news for economies with slothful labor markets -- they have much to gain from trade reform, even though they will face high costs of adjustment during the transition to the new steady-state. However, the reason that they gain so much is the bad news – in such economies tariffs have large distortionary effects because they cause a great deal of worker reallocation. Removing the tariff therefore generates gross benefits that are large enough to swamp the adjustment costs.

It does, however, take time for the economy with the slothful labor markets to realize these large gains and since turnover is low it may be quite some time before net output returns to its pre-reform level. For example, for the case reported in Table 5, while it takes 2 years for the base case economy ($s = 1$) to get net output back to its initial level, it takes an additional 2.5 years for the most stagnant economy (with $s = 0.15$ we find that $t^* = 4.5$). The implication is that although the gains from liberalization may be quite large in such economies, it may be very difficult to find any politician willing to push for such reform.
Recent evidence suggests that one possible way to interpret these results would be to have the U.S. play the role of the flexible economy, Western European countries (e.g., France, Belgium and the U.K.) play the role of the sluggish economies and countries in Eastern Europe (e.g., Estonia, Slovenia, Bulgaria, Hungary, and Romania) play the role of the slothful economies. The case of Estonia is particularly noteworthy. Haltiwanger and Vodopivec (2000) provide evidence that at the time of significant price and trade reforms (in 1989) Estonian labor markets were essentially stagnant. Shortly after instituting these reforms, the Estonian government also began to implement policies aimed at increasing the flexibility of their factor markets. As a result, the economy suffered huge costs in the short run, with real output falling a cumulative 31% between 1991 and 1993. However, the massive reallocation seemed to be nearing completion by 1994 and real output has risen steadily since then. Estonia is largely viewed as a major success story and our results provide some insight as to why they have been so successful. The initial stagnant nature of their factor markets indicated that they had a tremendous amount to gain from reform. In addition, by increasing the flexibility of their labor markets they have been able to realize these gains much quicker than other transition economies.

5. Conclusion

There is no dispute about the fact that workers lose jobs due to changes in trade patterns and that protecting an industry saves jobs. For example, Hufbauer and Elliott (1994) estimate that eliminating protection in the U.S. apparel industry would cost over 150,000 workers their jobs. It is also well documented that dislocated workers suffer large personal losses with some estimates for the average loss as high as $80,000 in lifetime earnings (Jacobson, LaLonde and Sullivan 1993a, b). It is therefore not surprising that political leaders are sometimes hesitant about trade reform. Those who lose may lose a great deal and are likely to remember who is at fault when the next election nears. The gains are delayed and are spread out over many so that those who do gain probably gain much less than the few who lose.

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Nevertheless, there is probably no other position in economics that has as much widespread support as the belief in the benefits from freer trade. Academic economists typically respond to public concerns about the losses to dislocated workers by explaining that such concerns are misplaced and misguided. This view was summarized and, we feel, appropriately criticized by Baldwin, Mutti, and Richardson (1980) in their article on adjustment costs:

Economists have sometimes dismissed such adjustment costs with the comment that the displaced factors become reemployed “in the long run.” But this is bad economics, since in discounting streams of costs and benefits for welfare calculations, the near-present counts more heavily than “the long-run.”

In this paper, we have tried to take a serious look at the possible magnitude of the adjustment costs that are likely to arise from trade reform. The novelty of our approach is that we have modeled the training and search processes that workers must go through in order to find jobs. This allows us to take into account the time and resource costs of retraining and job search. We have tried to be modest in our assumptions concerning these costs. We have assumed away the resource costs associated with job search and low-tech training and assumed that the time costs involved in low-tech training are very small. We have also assumed that workers fleeing the import-competing sector do not encounter congestion when trying to secure reemployment in the export sector. Finally, we have looked at a wide variety of assumptions concerning the cost of training in the high-tech sector.

Our results are surprising. Even with our most modest assumption concerning the cost of high-tech training (that they equal one month of the average high tech worker’s annual earnings), we find that adjustment costs are a significant fraction of the gross benefits from trade reform. Our lowest estimate is that roughly 30% of the gross benefits will be eaten away by adjustment. At the other extreme, we find that when high-tech training is costly (15 months of the average worker’s annual salary) as much as 80% of the gross benefits may disappear during the transition period. Even when we focus attention on gross output (so all that matters are the time costs of training and job search) we find that our estimates of adjustment costs are at least twice as high as previous estimates (Magee 1972 and Baldwin et. al. 1980). We also find that the transition period may be quite short, with net output returning to its pre-
liberalization level in 2.5 years or less. We have argued that such quick adjustment may mask the true nature of the adjustment process, perhaps implying that adjustment costs are low when they are, in fact, quite high.

In the latter part of the paper we investigate the relationship between labor market flexibility, the gains from trade reform and aggregate adjustment costs. It is well documented that turnover rates vary significantly across countries (Freeman 1994). Part of the reason for this is that countries vary in generosity of the social safety nets they provide for the poor and the jobless. Firing costs and generous unemployment insurance programs contribute to long term unemployment and low turnover throughout Europe (Ljungqvist and Sargent 1998). In addition, the wide-spread influence of unions in Europe contrasts sharply with their role in the US, resulting in more rigid wages in European labor markets. Labor and macroeconomists have recognized that this difference in labor market structure has important implications for issues such as job training and macroeconomic performance (see, for example, Layard, Nickell, and Jackman 1991). As far as we know, we are the first to investigate the implications for the net gains from trade liberalization.

Again, our main result could not have been anticipated. We find that tariffs create the biggest distortions in economies with slothful labor markets. As a result, when trade is liberalized these economies have the most to gain. This is true in spite of the fact that adjustment costs are high when there is very low turnover. Thus, our analysis indicates that policy makers in economies with slothful labor markets should not be reluctant to reduce barriers to trade, even though their economies are likely to face high adjustment costs.

We close with a word of caution about the interpretation of our results. Although we have argued that adjustment costs are probably higher than previous studies indicate, it is still clear that trade liberalization is the correct path to take – after all, adjustment costs, although high, are always less than the gains from reform. However, what our results do imply is that we should take more seriously the issue of how to compensate those who bear the burden of adjustment and those who lose when trade barriers are removed. In addition, it would be worthwhile to investigate the manner in which various
labor market policies affect the speed with which the economy makes the transition to free trade and the manner in which these policies affect the distribution of income during the transition period. Our results in the Section 4 indicate that the answers to these questions will be particularly important for countries with slothful labor markets.

Finally, there is one other important lesson that can be gleaned from our analysis -- the costs associated with new protectionist measures are probably higher than previously imagined. Not only do such measures distort the economy, but, our results imply that the cost of moving from an initial steady state to a new one characterized by higher trade barriers is quite high. This gives yet another reason to resist protectionist policies. Moreover, our analysis in Section 4 indicates that it is economies with flexible or slothful labor markets that have the most to lose from new policies that restrict trade.
Appendix A

In this Appendix we show how to solve the differential equations in (1)-(5) and obtain a closed form solution for the transition path to the new steady-state equilibrium. As discussed in the text, workers with ability levels in the intervals \((a_L, a_{FT})\) and \((a_H, 1)\) do not change their behavior after liberalization. Those in the former interval remain attached to sector 1 while those in the latter interval remain attached to sector 2. It follows that the measure of workers in these intervals that are training or employed are given by (14)-(17) with the \(a_H\) term in (14) and (15) replaced by \(a_{FT}\).

The remaining workers, those with ability levels in the interval \((a_{FT}, a_H)\), want to switch from sector 1 to sector 2. Some will do so immediately, either because they are training at the time of liberalization or because they choose to quit their low-tech job, whereas others opt to keep their low-tech job and make the switch after that job dissolves. We refer to all of these workers as the “switchers.” To figure out how many switchers are in each labor market state at time \(t\), we begin by introducing some new notation. We define \(S^Q_T(t)\) as the measure of workers with \(a \in [a_{FT}, a_Q]\) who switch from sector 1 to sector 2 following liberalization and are training in sector 2 at time \(t\). Similarly define \(S^Q_S(t)\) as the measure of workers with \(a \in [a_{FT}, a_Q]\) who switch from sector 1 to sector 2 and are searching at time \(t\) and we use \(S^Q_{E_j}(t)\) to denote the measure of switchers with \(a \in [a_{FT}, a_Q]\) who are employed in sector \(j\) at time \(t\). Finally, we define \(S^H_T(t)\), \(S^H_S(t)\), and \(S^H_{E_j}(t)\) analogously for those switchers with \(a \in [a_Q, a_H]\).

Since we are using \(a_Q\) to denote the ability level of the switcher who is just indifferent between quitting and not quitting her low-tech job after liberalization, \(a_Q\) is the value of \(a_i\) that equates \(V_{1T}(a_i)\) with \(V_{1E}(a_i)\) after liberalization (with \(V_{1E}(a_i)\) adjusted to take into account the fact that the worker switches sectors after losing his/her low-tech job). It follows that all workers with \(a \in [a_Q, a_H]\)
switch sectors immediately after liberalization, whereas workers with \( a \in [a_T, a_Q] \) who are employed when the tariff is removed retain their job until it dissolves. Then, for those switchers with \( a \in [a_T, a_Q] \), the system of differential equations can be written as in (A.1) - (A.4):

\[
\begin{align*}
(A.1) & \quad \dot{S}^Q_{E_1} = -b_2 S^Q_{E_1} \\
(A.2) & \quad \dot{S}^Q_{E_2} = e S^Q_S - b_2 S^Q_{E_2} \\
(A.3) & \quad \dot{S}^Q_S = b_2 \phi_2 S^Q_{E_2} + \tau_2 S^Q_T - e S^Q_S \\
(A.4) & \quad (a_Q - a_T) L = S^Q_{E_1} + S^Q_{E_2} + S^Q_S + S^Q_T
\end{align*}
\]

where, for notational convenience, we have suppressed the time argument. Equation (A.1) is a simple differential equation, which has the following solution

\[
(A.5) \quad S^Q_{E_1}(t) = \frac{\tau_1}{\tau_1 + b_1} (a_Q - a_T) L e^{-b t}.
\]

In solving (A.1), we make use of the initial condition that \( S^Q_{E_1}(0) = \frac{\tau_1}{\tau_1 + b_1} (a_Q - a_T) L \).

To solve (A.2) - (A.4), substitute (A.5) into (A.4), solve for \( S^Q_T \) in terms of \( S^Q_{E_1} \) and \( S^Q_S \) and then substitute the result into (A.3). This leaves us with (A.2) and (A.3) which form a system of two differential equations that can be written in matrix form:

\[
(A.6) \quad \begin{bmatrix} \dot{S}^Q_{E_1} \\ \dot{S}^Q_S \end{bmatrix} = \begin{bmatrix} -b_2 & e \\ b_2 \phi_2 - \tau_2 & -(e + \tau_2) \end{bmatrix} \begin{bmatrix} S^Q_{E_1} \\ S^Q_S \end{bmatrix} + \begin{bmatrix} 0 \\ h(t) \end{bmatrix}
\]

where \( h(t) = \tau_2 L (a_Q - a_T) \left( 1 - \frac{\tau_1}{\tau_1 + b_1} e^{-b t} \right) \). The method for solving a system of this form can be found in Boyce and DiPrima (1977), pp. 329-331. Using the initial conditions that \( S^Q_{E_1}(0) = S^Q_S(0) = 0 \), the solutions are
\( S_{E_{1}}^{O} (t) = \frac{e^{\tau t} (a_{Q} - a_{FT})}{\lambda_{2} - \lambda_{1}} \left[ \frac{e^{\lambda_{2} t} - e^{\lambda_{1} t}}{\lambda_{2} - \lambda_{1}} \right] + \frac{e^{\tau t} (a_{Q} - a_{FT})}{(\tau + b_{1})(\lambda_{2} - \lambda_{1})} \left[ \frac{e^{\lambda_{1} t} - e^{\lambda_{2} t}}{\lambda_{1} + b_{1}} \right] - \frac{e^{\tau t} (a_{Q} - a_{FT})}{\lambda_{2} \lambda_{1}} \frac{e^{-b_{1} t}}{(\tau + b_{1})(\lambda_{1} + b_{1})(\lambda_{2} + b_{1})} \)

\( S_{E_{2}}^{O} (t) = \frac{\tau b_{2} (a_{Q} - a_{FT})}{\lambda_{1} \lambda_{2}} \left[ \frac{e^{\lambda_{2} t} - e^{\lambda_{1} t}}{\lambda_{2} - \lambda_{1}} \right] + \frac{\tau b_{2} (a_{Q} - a_{FT})}{(\tau + b_{1})(\lambda_{2} - \lambda_{1})} \left[ \frac{b_{2} + \lambda_{1} e^{\lambda_{1} t} - b_{2} + \lambda_{2} e^{\lambda_{2} t}}{b_{1} + \lambda_{1}} \right] - \frac{\tau b_{2} (a_{Q} - a_{FT})}{(\lambda_{2} - \lambda_{1})} \left[ \frac{b_{2} + \lambda_{1} e^{\lambda_{1} t} - b_{2} + \lambda_{2} e^{\lambda_{2} t}}{\lambda_{1}} \right] - \frac{\tau b_{2} (a_{Q} - a_{FT})}{(\tau + b_{1})(\lambda_{1} + b_{1})(\lambda_{2} + b_{1})} \frac{e^{-b_{1} t}}{e^{\lambda_{1} t}} \)

where \( \lambda_{1} \) and \( \lambda_{2} \), the eigenvalues of the coefficient matrix in (A.6), are given by:

\( \lambda_{1} = \frac{-(b_{2} + e + \tau_{2}) - \sqrt{(b_{2} + e + \tau_{2})^{2} - 4b_{2}(1 - \phi_{2})}}{2} \)

\( \lambda_{1} = \frac{-(b_{2} + e + \tau_{2}) + \sqrt{(b_{2} + e + \tau_{2})^{2} - 4b_{2}(1 - \phi_{2})}}{2} \).

Finally, the measure of workers with \( a \in [a_{FT}, a_{Q}] \) training in sector 2 at time \( t \) is given by

\( S_{E_{1}}^{O} (t) = (a_{Q} - a_{FT}) \int e^{-\tau_{1} t} d\tau_{1} \)
For those switchers with \( a \in [a_Q, a_H] \), the system of differentials is given by (A.2)-(A.4) with the \( Q \) superscript replaced by \( H \). Equation (A.1) is no longer valid, since all of these switchers quit their jobs. Following the solution method described above yields

\[
S_E^H(t) = (a_H - a_Q)Le^\tau_2 \left\{ \frac{1}{\lambda_1^1} + \frac{1}{\lambda_2^1} \left[ e^{\lambda_1^1 t} - e^{\lambda_2^1 t} \right] \right\}
\]

(A.13)

\[
S_S^H(t) = (a_H - a_Q)Le^\tau_2 \left\{ \frac{b_2}{\lambda_1^2} + \frac{1}{\lambda_2^1} \left[ \frac{b_2 + \lambda_2^1}{\lambda_2^1} e^{\lambda_1^1 t} - \frac{b_2 + \lambda_1^1}{\lambda_1^1} e^{\lambda_2^1 t} \right] \right\}
\]

(A.14)

and \( S_T^H(t) = (a_H - a_{FT})L - S_E^H(t) - S_S^H(t) \). The discounted present value of the net output produced in sector 2 by this group of workers is therefore given by

\[
X_2(a_Q, a_H) = p_2 \int e^{-\tau_2} \{ (a_H + a_Q)q_2 S_E^H(t) - c_2 S_T^H(t) \} dt
\]

(A.15)
Appendix B

In this appendix we show that the laissez-faire equilibrium in our model is efficient. To do so, we calculate the dynamic marginal product of labor in each sector and show that these values are equal in the market equilibrium.

The dynamic marginal product of sector $j$ labor measures the increase in net output that occurs if the steady state is disturbed by adding an additional worker to that sector taking into account the adjustment path to the new steady state. To calculate the dynamic marginal products we follow the method developed in Diamond (1980).

We begin by defining $\chi_i(\theta)$ as the present discounted value of output net of training costs produced in sector $i$ when a (small) measure $\theta$ of new workers is added to that sector. These workers are assumed to have ability level $a_h$. Equilibrium is efficient if $\chi_1'(\theta) = \chi_2'(\theta)$.

Start with sector 1. We have

$$\chi_1(\theta) = \int_0^\infty e^{-\tau t} \left[ a_h q_1 p_1 \theta I(t) - \theta p_1 c_1 [1 - I(t)] \right] dt$$

where $\dot{\theta}_1^E = \tau_1 \theta - (\tau_1 + b_1) \theta_1^E$ and $I(t)$ is an indicator function that takes on the value of 1 when the worker is employed and equals zero at all other times. To find $\chi_1'(\theta)$ we start by using the fundamental equation of dynamic programming which states that

$$r \chi_1(\theta) = a_h q_1 p_1 \theta I(t) - \theta p_1 c_1 [1 - I(t)] + \frac{\partial \chi_1}{\partial \theta_1^E} \dot{\theta}_1^E$$

Substituting for $\dot{\theta}_1^E$ from above allows us to write this as

$$r \chi_1(\theta) = a_h q_1 p_1 \theta I(t) - \theta p_1 c_1 [1 - I(t)] + \frac{\partial \chi_1}{\partial \theta_1^E} \{ \tau_1 \theta - (\tau_1 + b_1) \theta_1^E \}$$

(B.1)

24 The equation of motion for $\dot{\theta}_1^E$ is obtained in the following manner. Since search is not required to find employment in sector 1, we have $\dot{\theta}_1^E = \tau_1 \theta_1^E - b_1 \theta_1^E$. Now, we know that the total measure of trainers (out of the $\theta$) in sector 1 is equal to the difference between $\theta$ and the measure of employed workers in that sector. Substituting for $\theta_1^E$ yields the desired result.
Differentiating with respect to $\theta$ yields

$$r \chi'_1(\theta) = a_H q_1 p_i t - p_i c_i [1 - I(t)] + \tau_1 \frac{\partial \chi_1}{\partial \theta^E}$$

but, at $t = 0$, $I(a_H, 0) = 0$ so that we have

$$(B.2) \quad r \chi'_1(\theta) = -p_i c_i + \tau_1 \frac{\partial \chi_1}{\partial \theta^E}$$

To complete our derivation, we must now calculate $\frac{\partial \chi_1}{\partial \theta^E}$. To do so, we solve (B.1) for $\frac{\partial \chi_1}{\partial \theta^E}$.

We obtain

$$\frac{\partial \chi_1}{\partial \theta^E} = \frac{r \chi_1 - a_H q_1 p_i \theta I(t) + \theta p_i c_i [1 - I(t)]}{\tau_1 \theta - (\tau_1 + b_1) \theta^E}$$

In the initial steady state, the right-hand side of this equation equals $0/0$. Applying L’Hopital’s Rule, we have (note that we are differentiating with respect to $\theta^E$, which is the same as $\theta I(t)$)

$$\frac{\partial \chi_1}{\partial \theta^E} = \frac{r \frac{\partial \chi_1}{\partial \theta^E} - a_H q_1 p_i - p_i c_i}{-(\tau_1 + b_1)}$$

or

$$\frac{\partial \chi_1}{\partial \theta^E} = \frac{a_H q_1 p_i + p_i c_i}{r + \tau_1 + b_1}$$

We can now substitute this value into (B.2) to obtain the dynamic marginal product of labor in sector 1:

$$(B.3) \quad r \chi'_1(\theta) = \frac{\tau_1 a_H q_1 p_i - (r + b_1) p_i c_i}{r + \tau_1 + b_1}$$

Note that this dynamic marginal product equals $r V'_1(a_H)$.

We now turn next to sector 2. We have

$$\chi_2(\theta) \equiv \int_0^\infty e^{-\theta} [a_H p_2 q_2 \theta I(t) - c_2 p_2 \theta [1 - I(t) - H(t)]] dt$$
where \( \dot{\theta}^E = e \theta^S - b_2 \theta^E \), \( \dot{\theta}^S = \tau_2 \theta + (b_2 \phi - \tau_2) \theta^E - (\tau_2 + e) \theta^S \), \( I(t) \) is an indicator function that equals one when the worker is employed and zero otherwise and \( H(t) \) is an indicator function which equals one when the worker is searching and zero otherwise.

As above, we start by applying the fundamental equation of dynamic programming which implies that

\[
 r \chi_2(\theta) = a_H p_2 q_2 I(t) - c_2 p_2 \theta [I(t) - H(t)] + \frac{\partial \chi_2}{\partial \theta^E} \theta^E + \frac{\partial \chi_2}{\partial \theta^S} \theta^S
\]

If we now use the equations of motion to substitute for \( \dot{\theta}^E \) and \( \dot{\theta}^S \) and then differentiate with respect to \( \theta \) we obtain

\[
 r \chi'_2(\theta) = a_H p_2 q_2 I(t) - c_2 p_2 \theta [I(t) - H(t)] + \frac{\partial \chi_2}{\partial \theta^E} \tau_2
\]

But, in the initial steady state (at \( t = 0 \)), we know that \( I(0) = H(0) = 0 \); so that

\[
 (B.4) \quad r \chi'_2(\theta) = -c_2 p_2 + \tau_2 \frac{\partial \chi_2}{\partial \theta^S}
\]

The final step requires us to solve for \( \frac{\partial \chi_2}{\partial \theta^S} \) and then substitute that value into (B.4). Again following Diamond (1980), we differentiate the fundamental equation of dynamic programming with respect to \( \theta^E \) and \( \theta^S \). We obtain

\[
 \begin{bmatrix}
 \frac{\partial \chi_2}{\partial \theta^E} \\
 \frac{\partial \chi_2}{\partial \theta^S} \\
 \frac{\partial \chi_2}{\partial \theta^S}
\end{bmatrix} = \begin{bmatrix}
 a_H p_2 q_2 + c_2 p_2 & c_2 p_2 \\
 -e & r + b_2 & -(b_2 \phi - \tau_2)
\end{bmatrix}^{-1}
\]

Solving this system of equations for \( \frac{\partial \chi_2}{\partial \theta^S} \) yields

\[
 (B.5) \quad \frac{\partial \chi_2}{\partial \theta^S} = \frac{p_2 (a_H q_2 e_2 + c_2 (e_2 + r + b_2))}{(r + b_2) (r + \tau_2 + e_2) + e_2 \tau_2 - e \phi b_2}
\]
Substituting (B.5) into (B.4) and collecting terms results in

\[ r\chi_2'(\theta) = \frac{p_z\{a_{1t}q_te - [ (r + b_z)(r + e_z) - e_z\phi b_z]c_z\}}{(r + b_z)(r + \tau_z + e) + e_z\tau_z - e_z\phi b_z} \]

Note that (B.6) is also equal to \( rV_{27}(a_{1t}) \). Thus, since both dynamic marginal products equal the expected lifetime income for a worker training in that sector, and, since workers are allocated so that the expected lifetime income from training is the same in both sectors, the dynamic marginal products are equal in equilibrium. As a result, equilibrium is efficient.
Appendix C

In this Appendix our goal is to show how to transform our measure of aggregate income in the initial steady state into utility. In particular, we want to show that utility is given by \( \eta(\gamma)Y_{ss} \) with

\[
\eta(\gamma) = \frac{\alpha^\alpha[(1-\alpha)(1+\gamma)]^{1-\alpha}}{\alpha + (1-\alpha)(1+\gamma)}.
\]

Given our assumption that the utility function for each consumer is given by \( U(Z_1,Z_2) = Z_1^\alpha Z_2^{1-\alpha} \), it follows that the aggregate consumption bundle is given by

\[
Z_1 = \frac{\alpha I}{1+\gamma}
\]

and \( Z_2 = (1-\alpha)I \) where \( I \) is a measure of aggregate income and both world prices have been set to 1. It follows that \( Z_2 = \frac{(1-\alpha)(1+\gamma)}{\alpha} Z_1 \). Now, in the tariff-distorted equilibrium, it must be the case that the value of output equals the value of the consumption bundle when both are evaluated at world prices. The value of output is given by \( Y_{ss} \). It follows that \( Z_1 + Z_2 = Y_{ss} \). If we now substitute for \( Z_2 \) and solve for \( Z_1 \) we obtain \( Z_1 = \frac{\alpha Y_{ss}}{\alpha + (1-\alpha)(1+\gamma)} \). This implies that \( Z_2 = \frac{(1-\alpha)Y_{ss}}{\alpha + (1-\alpha)(1+\gamma)} \). Plugging these values into the utility function then yields the desired result.
References


Figure 1: Labor Market Dynamics in Sector 1
Figure 2: Labor Market Dynamics in Sector 2

\[
\begin{align*}
\text{Training} & \quad \tau_2 L_{2T} \quad \text{Searching} \quad eL_s \quad \text{Employed} \\
& \quad b_2 \phi L_{2E} \\
& \quad b_2 (1 - \phi) L_{2E}
\end{align*}
\]
Figure 3: The Equilibrium Allocation of Workers
Figure 4: The Value of Output Net of Training Costs Over Time
Figure 5a: $R^*$ as a Function of $s$
Figure 5b: $NB$ as a Function of $s$
Table 1: Aggregate Adjustment Costs as a Fraction of the Gross Benefits from Trade Reform ($R^*$)

<table>
<thead>
<tr>
<th>Training Costs</th>
<th>$a_{HI}$</th>
<th>$b_1=.5$</th>
<th>$b_2=.1$</th>
<th>$b_1=.5$</th>
<th>$b_2=.167$</th>
<th>$b_1=1$</th>
<th>$b_2=.1$</th>
<th>$b_1=1$</th>
<th>$b_2=.167$</th>
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<td>.20</td>
<td>.33</td>
<td>.50</td>
<td>.66</td>
<td>$t^*$</td>
<td>.34</td>
<td>.34</td>
<td>$t^*$</td>
<td>.34</td>
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<tr>
<td>1 month</td>
<td>.42</td>
<td>.39</td>
<td>.36</td>
<td>.34</td>
<td>1.3 – 1.4</td>
<td>1.3 – 1.4</td>
<td>1.4 – 1.5</td>
<td>1.4 – 1.6</td>
<td></td>
</tr>
<tr>
<td>5 months</td>
<td>.66</td>
<td>.63</td>
<td>.57</td>
<td>.53</td>
<td>1.5 – 1.8</td>
<td>1.5 – 1.9</td>
<td>1.8 – 2.3</td>
<td>1.8 – 2.3</td>
<td></td>
</tr>
<tr>
<td>10 months</td>
<td>.75</td>
<td>.74</td>
<td>.69</td>
<td>.65</td>
<td>1.7 – 2.1</td>
<td>1.7 – 2.1</td>
<td>2.1 – 2.6</td>
<td>2.2 – 2.6</td>
<td></td>
</tr>
<tr>
<td>15 months</td>
<td>.78</td>
<td>.80</td>
<td>.76</td>
<td>.72</td>
<td>1.9 – 2.3</td>
<td>2.0 – 2.3</td>
<td>2.4 – 2.7</td>
<td>2.4 – 2.7</td>
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Table 2: Aggregate Adjustment Costs as a Fraction of the Gross Benefits from Trade Reform Ignoring the Resource Costs From High-Tech Training ($R_{GO}^*$)

<table>
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<tr>
<th>Training Costs</th>
<th>$a_H$</th>
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<th>.33</th>
<th>.50</th>
<th>.66</th>
<th>$t_{GO}^*$</th>
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<td>$b_1 = .5$</td>
<td>$b_2 = .1$</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>1 month</td>
<td></td>
<td>.20</td>
<td>.23</td>
<td>.24</td>
<td>.25</td>
<td>1.2 - 1.3</td>
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<tr>
<td>5 months</td>
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<td>.12</td>
<td>.16</td>
<td>.18</td>
<td>.20</td>
<td>1.0 - 1.2</td>
</tr>
<tr>
<td>10 months</td>
<td></td>
<td>.08</td>
<td>.11</td>
<td>.14</td>
<td>.16</td>
<td>0.8 - 1.1</td>
</tr>
<tr>
<td>15 months</td>
<td></td>
<td>.06</td>
<td>.09</td>
<td>.11</td>
<td>.13</td>
<td>0.7 - 1.1</td>
</tr>
<tr>
<td>$b_1 = .5$</td>
<td>$b_2 = .167$</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1 month</td>
<td></td>
<td>.19</td>
<td>.22</td>
<td>.23</td>
<td>.24</td>
<td>1.2</td>
</tr>
<tr>
<td>5 months</td>
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<td>.10</td>
<td>.14</td>
<td>.17</td>
<td>.18</td>
<td>0.9 - 1.2</td>
</tr>
<tr>
<td>10 months</td>
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<td>.12</td>
<td>.14</td>
<td>0.7 – 1.1</td>
</tr>
<tr>
<td>15 months</td>
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<td>.10</td>
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<td>0.6 - 1.0</td>
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<td>0.9 – 1.2</td>
</tr>
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