Trade Reform and Labor Market Dynamics

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Abstract

We present an equilibrium-search model with heterogenous workers who search for a job in one of two sectors and who lose part of their skills during unemployment. We show that an import tariff increase the wage and the employment prospects in the protected sector. This results in a labor market distortion because it changes the comparative advantage of the least specialised workers. Trade reform results in sectoral reallocation of workers which affects employment in both sectors through quantity and quality effects and increases unemployment persistently. Replacing the tariff by a wage-cost subsidy financed by means of lump-sum taxation prevents unemployment from rising after trade has been reformed. However, giving a wage-cost subsidy to both sectors is cheaper since then comparative advantage of workers will no longer be distorted, although unemployment will temporarily rise.

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1. Introduction

It is well known that import tariffs distort both product markets and the labor market. However, when trade reform increases income inequality and unemployment, the support for reform programs may decrease unless instruments are included in the reform package that try to limit these adverse effects. In this paper we will focus on the dynamic labor market effects of trade reform by taking an explicit look at worker heterogeneity, imperfect information, and the potential for short-run increases in unemployment to become permanent.

The standard Ricardian model assumes that labor is the only factor of production and it is assumed to be able to move freely from one sector to the other. As a consequence, every individual is made better of as a result of free trade because trade does not affect the distribution

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of income (see Krugman and Obstfeld, 1997). Since some factors can move more freely than others in practice, the Ricardian model has been extended to the specific factors model (see Samuelson, 1971 and Jones, 1971). Some factors of production are specific to certain industries, for example land for agriculture and capital for manufactures. Now there is an effect of trade reform on the income distribution since specific factors give rise to diminishing returns to labor in each sector.

However, in the specific factors model it is still argued that labor is perfectly mobile, which is only true for some worker types (Blanchard and Katz, 1991). When one allows for worker heterogeneity, labor can be divided in one part that is more or less sector-specific (the 'specialists') and another part (the 'generalists') that is much more flexible, although they are assumed to respond with a lag as well. Tariffs, by raising wages and employment prospects in the import sector, affect the comparative advantage of workers which will result in a sub-optimal allocation of generalists over firms. Limiting free trade may not only prevent specialisation on the basis of comparative advantage of countries, but also of workers. Modelling heterogeneity allows one to analyse which workers are more or less specific and which workers move in response to the abolishment of an import tariff. This way we are able to determine the effects of trade reform on the distribution of wages without incorporating diminishing returns.

Suppose furthermore that firms, ex-ante, do not know the quality of the job seekers. Then the fact that it are the generalists which move could have important consequences for job reallocation after trade has been reformed. For example, what will happen to the average quality of job seekers in the agricultural respectively the industrial sector? The answer to this question depends on whether generalists are the most talented workers, who are productive in both sectors, or are they the least-skilled workers? The effect on the expected quality of job seekers in both sectors determines the sectoral employment response after trade reform. This response is also affected by the 'quantity-effect': after the tariff has been abolished, more workers search for a job in the industrial sector and less in the agricultural sector. How will this affect employment in both sectors?

Another effect of trade reform on the quality of job seekers in each sector comes from the fact that abolishing a tariff could increase short-run unemployment. When workers lose some of their skills during unemployment, the average quality of job seekers decreases. This may in turn provide a channel through which temporary shocks could increase unemployment persistently. That trade reform could increase short-run unemployment is well-understood (see Rodrik 1987, Buffie, 1984, and Edwards 1988 and 1993). However, short-run wage stickiness lies behind these increases in unemployment and these models do not analyse the potential for this temporary increase to become permanent. Could trade reform increase unemployment persistently and if so, which sector will show the largest increase? Recently, the effects of trade liberalization on wage inequality and unemployment of less-skilled workers has received considerable attention. Although there is no consensus, the majority view seems to be that technology changes, and not trade, is the principal reason behind these labor market trends (see, Albuquerque and Rebelo, 1998). Indeed, one of the conclusions coming from our model is that one cannot say in general that trade reform implies increased income inequality, nor can one say that unemployment effects will be concentrated at the least-skilled workers.

Which additional measures should be included in the reform package to prevent unemployment from rising after trade has been reformed? This last question has a long-history in the first-best literature on tariffs versus alternative instruments to accomplish one's goals. As is well known, a production subsidy is preferable to an import tariff since then the product market will no longer be distorted, although the labor market will. This is also the case in our model since giving the formerly import protected sector a wage-cost subsidy still distorts the comparative advantage of workers. We argue that giving both sectors a subsidy can eliminate not only the standard product market distortion, but also the labor market distortion. Moreover, the fact that comparative advantage of workers will no longer be distorted also implies that giving a subsidy to both sectors is cheaper than only giving a wage-cost subsidy to the formerly protected sector. In the later case, too many workers search for a job in the agricultural sector and as a consequence too many jobs are subsidised.

To analyse the questions raised above, we extend the model by Pissarides (1992). Pissarides shows that if unemployed workers lose some of their skills during unemployment, aggregate employment can exhibit persistence that outlasts both the duration of the shock that moves it from the steady state and the maximum duration of unemployment. In his model sector-specific shocks are the same as aggregate shocks as there is only one sector. Therefore, his model is not concerned with spillover effects of sector-specific shocks, such as trade reform, which arise when labor is (imperfectly) mobile between sectors.

To introduce heterogeneity among workers in Pissarides model, we use part of the set-up developed by Heckman and Honoré (1990). Although they use a static full-employment model and are mainly concerned with the distribution of earnings, our approach has a common element: given that workers are heterogeneous and given the fact that each workers productivity can be different in different sectors, how do workers determine in which sector they are going to search for a job? We follow Heckman and Honoré (1990) by arguing that workers try to exploit their comparative advantage which allows us to determine the fraction of the population searching for a job in either sector and the productivity costs of tariffs.

Other papers with related models are, for example, Blanchard and Katz (1992), Caplin and Leahy (1993) and Lilien (1982). Blanchard and Katz (1992) setup a model in which different (U.S.) states produce different goods. After a state-specific shock, relative wages and unemployment change which in turn leads to labor mobility across states. They argue that labor mobility is an important mechanism through which the effects of state-specific shocks on employment are mitigated. Caplin and Leahy (1993) show that the interaction between investment and information dynamics has important macroeconomic consequences. In their model, an imbalance between investment and disinvestment is the propagation mechanism through which sectoral shocks may have persistent effects on the aggregate economy. In our case, the assumption that unemployed workers lose part of their skills and the interaction between the 'quantity' and 'quality' effects of sector-specific shocks forms the basis for both the persistence and the propagation mechanism of sector-specific shocks.

Lilien (1982) shows that shifts of employment demand between sectors necessitate continuous labor reallocation. Since it takes time for workers to reallocate between sectors, it becomes hard to disentangle cyclical unemployment from fluctuations in the 'natural' rate of unemployment. Mortensen and Pissarides (1994), Blanchard and Diamond (1989), and Abraham and Katz (1986) all try to disentangle these sectoral shifts from common shocks. Under sectoral shifts, rates of job creation and job destruction are presumed to move in the same direction, while common shocks should have divergent effects on these rates.[1]

Our paper is organized as follows. Section 2 develops the model in steady state and discusses the productivity costs of tariffs. In section 3 we discuss the effects of trade reform on employment in each sector and the resulting dynamics of aggregate employment and unemployment. In section 4 we present some numerical examples. Section 5 discusses the potential to include additional measures in the reform package to offset the increase in unemployment while preserving optimal production. Section 6 concludes and discusses some applications and implications of our model. The appendix contains the derivations of the main mathematical results.

[1] On the importance of job turnover and worker reallocation see Davis and Haltiwanger (1990).

2. The Model in Steady State

In our model workers search for jobs in two sectors, labelled x (agriculture) and z (manufactures). These jobs are offered by employers, who are not mobile across the sectors. The matching procedure between job searchers and employers is assumed to be as follows. Every worker decides at the beginning of every period in which of the two sectors, x or z, he wants to search for a job. Workers can work in only one sector in any period and can move from one sector to the other without incurring any costs. Each worker chooses the sector in which he expects to earn the largest wage given his ability level in each sector. He reports his choice to the job centre which has two distinct departments for the two sectors. Each employer inspects the amount and expected quality of the job seekers in his sector. Then he decides on the number of vacancies to open. Now each department matches the workers to the vacancies using a particular matching technology. This gives us the steady state level of employment in each sector.

The model is in discrete time and the dynamics derive from two overlapping generations of workers, each of which is of fixed size L, and a variable number of jobs that last for one period only. Thus there are a total of $2L$ workers present in the population at each time t. In each of the two periods of their life workers are in one of two states, either employed or unemployed. This allows for a division of the workers into two types. The first type is labelled the short term unemployed (stu) workers. This group consists of the new entrants (the young) and the (old) employed workers of the previous period who are still alive today. The second type of workers is labelled the long term unemployed (ltu) workers. This group consists of the (old) workers that were unemployed in the previous period and are still alive today.

For every worker two positive ability levels are drawn from a bivariate lognormal probability distribution $f(.,.)$. We label the means and variances of the underlying marginal normal distributions as μ_x, u_z, and σ_{xx}, σ_{zz} respectively and the covariance between ability in sector x and z is labelled σ_{xz}. Furthermore, we introduce $\sigma^2 = \sigma_{xx} + \sigma_{zz} - 2\sigma_{xz}$. Denote the realizations of $f(.,.)$ for worker i by $\theta^{i,x}$ and $\theta^{i,z}$ for sector x and z respectively. We assume that the distribution is independent of the workers' employment record and that the young inherit the ability pair from the old who die. Thus the ability pairs drawn at time 0 remain present in the population forever after.[2] To get a worker's skill level, the ability of an stu worker is multiplied

[2] In a large population this assumption can also be interpreted as drawing new skill levels for each new generation. A large population argument then ensures that the results remain the same.

by 2 and the ability of an *ltu* worker is multiplied by $2y$ with $0 < y < 1$.[3] Hence, *ltu* workers are less productive than *stu* workers. Since the distribution of ability is fixed, workers do not become less able when they have been unemployed. In our set-up the loss of productivity stems from the fact that we assume that workers who were unemployed in the previous period are less able to transform their ability into output compared to workers who were employed in the former period. A justification for this assumption could be that, although they still posses the same ability as before, they are less able than the employed workers of the former period to use the (new) machines and the equipment. Therefore, although two workers of different types may have the same ability, they produce different levels of output.

When a vacancy is filled by a *stu* worker, say worker i, he receives a payoff $\alpha 2 p_t^j \theta^{i,j}$, where p_t^j is the given price level in sector $j = x, z$ and α is the fraction of the worker's productivity that accrues to him. This fraction originates from static Nash-bargaining between the worker and the employer. If a vacancy is filled by a *ltu* worker, the worker receives a payoff $\alpha 2 y p_t^j \theta_t^{i,j}$. The expected wage income of a worker in sector j is now equal to his expected payoff when he's employed multiplied by the expected probability, $\mathbb{E} q_t^j$, that he is actually matched to a vacancy.[4] We assume that workers base their decision to search in one sector or the other on the matching probability at time $t-1$; i.e. $\mathbb{E} q_t^j = q_{t-1}^j$. We make the same assumption regarding prices, i.e. $\mathbb{E} p_t^j = p_{t-1}^j$. Thus we explicitly assume backward-looking (adaptive) expectations. A worker chooses to search for a job in the sector where his expected wage income is the highest.[5] Furthermore we assume $p_t^x = p_t^z$. Suppose that sector x (agriculture) is the import competing sector and sector z is the exporting sector and that an import tariff, T, is levied such that the domestic price raises to $p_t^x (1 + T)$. Worker i will search in sector x at time t if,

$$p_{t-1}^x (1 + T) \theta^{i,x} \cdot q_{t-1}^x > p_{t-1}^z \theta^{i,z} \cdot q_{t-1}^z \tag{2.1}$$

Notice that since α is the same in both sectors (and for both worker types), it does not influence the decision in which sector to search. We define $L_t^j = 2L\lambda_t^j$ to be the number of workers that search for a job in sector j at time t. Since there is a total of $2L$ workers in the population, at every time t the relation $L_t^x + L_t^z = 2L$ must hold.

When $T = 0$ and since $p_t^x = p_t^z$ half of the labor force would be searching for a job in the

[3] The factor 2 is introduced for notational convenience only.

[4] As in Pissarides (1992) we assume that q_t^j is not only the average probability that a worker meets a vacancy, but that it is also the actual probability for each worker in sector j.

[5] Jovanovic and Moffitt (1990) also discuss a model in which the origins of labor mobility come from either sectoral shocks or worker-employer mismatch. In our case, labor becomes mobile when matching probabilities change because of sectoral or a-symmetric shocks.

agricultural sector and the other half in the industrial sector. For, the structure of our model is such that both sectors are completely identical except for the presence of the tariff so that $q^x_{t-1} = q^z_{t-1}$. Now it is also easy to see that the presence of $T > 0$ changes the comparative advantage of some workers. The 'generalists' for which $\theta^{i,x} - \theta^{i,z}$ is negative but small, will search for a job in the agricultural sector although they are more productive in the industrial sector. The number of workers for whom this is optimal times their loss of productivity gives us the costs in terms of lost productivity of the tariff. Notice that this conclusion does not depend on any form of diminshing returns.[6] The tariff does not only increase the wage directly, but because (as we will see in a moment) it also raises q^x_t it increases the probability of being matched to a job as well.

Following Heckman and Honoré (1990) we define the proportion of the population joining the matching process in sector x as[7]

$$\lambda^x_t = \int_0^\infty \int_0^{\mathbf{E}\beta^x_t\theta^x/\mathbf{E}\beta^z_t} f(\theta^x, \theta^z) d\theta^z d\theta^x, \tag{2.2}$$

where $\mathbf{E}\beta^x_t = \mathbf{E}p^x_t\,(1+T)\cdot q^x_t = p^x_{t-1}\,(1+T)\cdot q^x_{t-1} = \beta^x_{t-1}$ is the expected ability price in sector x at time t which is equal to the ability price in sector x at time $t-1$. Thus this parameter is given at time t, but can change over time, although with a lag. As a consequence, the proportion of workers in each sector can vary over time. An immediate implication of (2.2) is that, if the relative price of ability in sector x increases at time t, a greater proportion of workers will join the matching process in sector x at time $t+1$.

The population density of ability in sector x is

$$f^x(\theta^x) = \int_0^\infty f(\theta^x, \theta^z) d\theta^z \tag{2.3}$$

The (conditional) density of ability of people who join the matching process in sector x differs from this population density of ability and is equal to:

$$g_t(\theta^x \mid \beta^x_{t-1}\theta^x > \beta^z_{t-1}\theta^z) = \frac{1}{\lambda^x_t} \int_0^{\beta^x_{t-1}\theta^x/\beta^z_{t-1}} f(\theta^x, \theta^z) d\theta^z \tag{2.4}$$

[6] Alternatively, instead of modelling heterogeneity in terms of differences in ability in a two-sector economy, one could model heterogeneity as the difference in location in a two-country framework. Then, a tariff levied in one country would give rise to migration of those workers who live closest to the border.

[7] Note that similar expressions hold for sector z.

In sector z this density is,

$$g_t(\theta^z \mid \beta^x_{t-1}\theta^x < \beta^z_{t-1}\theta^z) = \frac{1}{\lambda^z_t} \int_0^{\beta^z_{t-1}\theta^z/\beta^x_{t-1}} f(\theta^x, \theta^z) d\theta^x \tag{2.5}$$

As individuals pursue their comparative advantage, the observed distribution of ability of the workers searching for a job in each sector differs from the population distribution of abilities.

Given the average ability and proportion of workers who choose to search for a job in sector j, employers now determine the amount of jobs they want to offer. Thus we now turn to the second stage of the matching process, the supply of vacancies. The supply of vacancies by employers depends on the costs of opening a vacancy and on the expected profit of doing so, which is a function of the fraction of *stu* and *ltu* workers, the average ability of the workers, the number of workers searching, and the price, all evaluated in the sector where the employer is located.

First, we assume that when a firm and a worker do not come to an agreement when they meet, the vacancy disappears, because jobs last for one period only, and the worker becomes or remains unemployed for this period. The pay-off from this state are zero for both the employer and the worker. Both firms and workers take part in matching with fixed intensity of search, normalized to unity. The probability that a worker meets a job in some period t in sector j is q^j_t. By the assumption of fixed intensities this probability is independent of anything that the worker does. It depends only on the aggregate inputs of firms and workers into matching, which is equal to the number of jobs and the number of workers. Similarly, the probability that a job meets a typical worker is independent of the actions of the firm. It is derived from q^j_t by making use of the property that jobs and workers meet in pairs. Since jobs meet at most one worker in each round of matching, in equilibrium all meetings will lead to successful job matches, and so the probability that each worker becomes employed is also equal across worker types: it is independent of the workers' ability level and irrespective of whether he is *stu* or *ltu*.

We are now able to determine the probability, $pr^{stu,j}_t$, that a job meets a *stu* worker. Half of the job seekers in sector j in period $t-1$ die at time t and they are replaced by *stu* workers. Moreover, the number of employed workers in the previous period still alive today are also *stu*. Since we concentrate in this section on the steady state solution of our model, we determine $pr^{stu,j}_t$ on the basis that workers are not moving between the two sectors. Then, as $L^j_{t-1} = L^j_t$:

$$pr^{stu,j}_t = \frac{\frac{1}{2}.L^j_{t-1} + \frac{1}{2}.L^j_{t-1} \cdot q^j_{t-1}}{L^j_t} = \frac{1}{2}\left(1 + q^j_{t-1}\right). \tag{2.6}$$

and, since we look at the model in steady state, $q_{t-1}^{j}=q_{t}^{j}=q^{j}$, we have $pr_{t}^{stu,j}=\frac{1}{2}\left(1+q^{j}\right)=pr_{t-1}^{stu,j}=pr^{stu,x}$. The amount of ltu workers in sector j is equal to the amount of workers who did not have a job in the previous period and are still alive today. Then $pr_{t}^{ltu,j}=pr^{ltu,j}$, the probability that a job meets a ltu worker, is equal to

$$pr^{ltu,j}=1-pr^{stu,x}=\frac{1}{2}\left(1-q^{j}\right) \tag{2.7}$$

These probabilities are one determinant of the average quality of job seekers in sector j and therefore they are also a determinant of the number of jobs offered in each sector. The total number of jobs offered in sector j at time t is denoted by J_{t}^{j}, while $e_{t}^{j}=q_{t}^{j}\cdot L_{t}^{j}$ is defined to be the total employment in sector j at time t, which is equal to the number of vacancy-worker matchings in sector j at time t. Now we can express the average probability that a vacancy in sector j is filled, as

$$\frac{e_{t}^{j}}{J_{t}^{j}}=\frac{q_{t}^{j}\cdot L_{t}^{j}}{J_{t}^{j}} \tag{2.8}$$

The employer does not know if his vacancy meets a stu or a ltu worker. Moreover, he is unable to observe the productivity of a potential job seeker. Therefore, in deciding how many vacancies to open, he looks at the expected marginal profit $\mathbf{E}\pi_{t}^{j}$ of opening a vacancy. This expected marginal profit is equal to the employer's fraction of the expected value of output which is produced by a particular worker type if the vacancy is filled. Written down in natural logarithms this yields

$$\mathbf{E}_{t}\ln\pi_{t}^{j}=\ln(1-\alpha)+\ln p_{t}^{j}\left(1+T^{j}\right)+\mathbf{E}_{t}\ln\theta^{j}+\ln 2\left[pr_{t}^{stu,j}+y\cdot pr_{t}^{ltu,j}\right]+\ln\frac{q_{t}^{j}\cdot L_{t}^{j}}{J_{t}^{j}}. \tag{2.9}$$

where $T^{z}=0$. As we have assumed that the employer in sector j is unable to observe the productivity of a worker he has to form an expectation about it. This expectation, $\mathbf{E}_{t}\ln\theta^{j}$, is equal to

$$\mathbf{E}_{t}\ln\theta_{t}^{j}=\mathbf{E}\left(\ln\theta^{j}\mid\beta_{t-1}^{j}\cdot\theta^{j}>\beta_{t-1}^{i}\cdot\theta^{i}\right),\ j,i=x,z,\ i\neq j, \tag{2.10}$$

for which an explicit expression is given in Heckman and Honoré (1990), equation (13).

We assume the cost of opening a vacancy for one period in sector j to be a constant $1/k^{j}$. In equilibrium the number of vacancies created will be determined by equating marginal benefits of opening a vacancy to marginal costs. Taking account of the fact that we write our model in logs, this results in

$$\mathbb{E}_t \ln \pi_t^j = -\ln k^j \tag{2.11}$$

We now introduce a specific matching function $\chi(J_t^j, L_t^j)$ for matching vacancies to workers. This function has the number of vacancies and the number of workers looking for a job as arguments and it is assumed to be at least twice differentiable, with positive first-order and negative second-order derivatives, homogeneous of degree 1 (constant returns to scale), and it satisfies $\chi(0, L_t^j) = \chi(J_t^j, 0) = 0$.

The total number of job matchings in sector j will be equal to this matching function, unless the number of workers or the number of vacancies is smaller. Thus,

$$e_t^j = \min\left[\chi(J_t^j, L_t^j), J_t^j, L_t^j\right] \tag{2.12}$$

It is clear from this equation that the only variables that can change the outcome of matching from one period to the next are the endogenous numbers of vacancies and workers. Like Pissarides (1992) we ignore any trivial equilibrium. Non-trivial matching problems arise when $\chi(.,.)$ is less than both J_t^j and L_t^j. Then we have that in equilibrium $\mathbb{E} \ln \pi_t^j + \ln k^j = 0$ and using (2.9) we get

$$\ln J_t^j = \ln(1-\alpha) + \ln p_t^j \left(1 + T^j\right) + \mathbb{E}_t \ln \theta^j + \ln 2\left[pr_t^{stu,j} + y \cdot pr_t^{ltu,j}\right] + \ln\left(q_t^j \cdot L_t^j\right) + \ln k^j \tag{2.13}$$

This last equation shows the equilibrium number of vacancies for sector j. The amount of vacancies in sector j is higher if, ceteris paribus, workers are more likely to find the vacancies (q_t^j higher), when more workers choose to search for a job in sector j (L_t^j higher), when the cost of opening a vacancy in sector j is less ($\ln k^j$ larger), when employers receive a larger fraction of the value of output (α lower), when the value of output is larger (p_t^j and/or T^j larger), when the long-term unemployed are more productive (y larger), when the expected average productivity of workers searching in sector j is larger ($\mathbb{E}_t \ln \theta^j$ higher), and when the previous period matching probability is larger ($pr_t^{stu,j}$ larger, $pr_t^{ltu,j}$ smaller).

This last aspect of the supply of jobs is the source of persistence. The higher the proportion of *ltu* workers among potential job applicants, the fewer the number of vacancies that come into the market. The market becomes 'thin', as there are relatively more job seekers who's ability is transformed into low productivity. When a shock occurs that raises the number of *ltu* workers, the probability of unemployment for the new cohort increases. So then the market remains thin, even though the old unemployed have all left unemployment after a maximum of two periods. Thus what we see is that a thin market leads to more job shortage which in turn perpetuates the thinness, as is the case in Pissarides (1992). In our model, this persistence in sector j is reinforced by the fact that L_t^j is a positive function of q_{t-1}^j. When q_{t-1}^j is lower, L_t^j decreases which results in job destruction in sector j, while it results in job creation in sector $i \neq j$.

To derive an expression for the matching probability q_t^j we need to assume a specific matching technology. We assume a Cobb-Douglas matching technology

$$\chi(J_t^j, L_t^j) = \left[aJ_t^j\right]^b \cdot \left[L_t^j\right]^b, \tag{2.14}$$

where $0 < b < 1$. In this equation $a > 0$ is a scaling constant measuring the efficiency of the matching technology. Following our earlier assumption that $\chi(.,.)$ is less than both J_t^j and L_t^j, we have that $e_t^j = q_t^j \cdot L_t^j = \chi(J_t^j, L_t^j)$. Using this relationship and (15), we have

$$q_t^j = \frac{\left[aJ_t^j\right]^b \cdot \left[L_t^j\right]^b}{L_t^j} \tag{2.15}$$

Assuming that $b = \frac{1}{2}$, i.e. that firms and workers are equally effective in finding partners, and expressing (16) in logs we have

$$\ln q_t^j = \frac{1}{2}\ln a + \frac{1}{2}\ln J_t^j - \frac{1}{2}\ln L_t^j \tag{2.16}$$

Substituting J_t^j from (2.13) and rewriting results in

$$\ln q_t^j = \ln a + \ln 2 + \ln(1-\alpha) + \ln p_t^j\left(1 + T^j\right) + \mathbb{E}_t \ln\theta^j + \ln\left[pr_t^{stu,j} + y \cdot pr_t^{ltu,j}\right] + \ln k^j \tag{2.17}$$

This is a difference equation in q_t^j, since $\mathbb{E}_t\ln\theta^j$ and both $pr_t^{stu,j}$ and $pr_t^{ltu,j}$ depend on q_{t-1}^j. In stationary (steady state) equilibrium we have $q_t^j = q_{t-1}^j = q^j$ and we know that workers do not move between the two sectors, $\lambda_t^j = \lambda_{t-1}^j = \lambda^j$ and we can thus solve for q^j, which we do implicitly. We choose the parameters a, k^j, α, y, T and p^j in such a way that $\ln q_t^j \leq 0$ so that $0 \leq q_t^j \leq 1$.

Using the following equation for aggregate employment,

$$\ln E_t = \ln e_t^x + \ln e_t^z = \ln\left(q_t^x \cdot L_t^x\right) + \ln\left(q_t^z \cdot L_t^z\right), \tag{2.18}$$

we have

$$\ln e_t^j = \ln a + \ln(1-\alpha) + \ln p_t^j \left(1 + T^j\right) + \mathbb{E}\ln\theta^j + \ln 2 \left[pr_t^{stu,j} + y \cdot pr_t^{ltu,j}\right] + \ln k^j + \ln L_t^j \quad (2.19)$$

Notice the difference between equations (2.17) and (2.19). The expression for the matching probability in sector j is independent of the number of workers searching in that sector, and thus depends only on the 'quality' of the workers searching for a job in that sector. Employment in each sector also depends on the number of workers searching in either sector, the 'quantity', and thus exhibits both quality and quantity effects.

So now we have a model which includes imperfect information, worker heterogeneity, and a source of persistence with which we can analyse the consequences of trade reform for employment in the agricultural sector and in the industrial sector. Moreover, we will be able to say something about the effects of trade reform on the distribution of wages.

3. Trade Reform and Employment

When a tariff is abolished in the agricultural sector, employment in both this and the industrial sector are affected through various channels. Moreover, since workers lose part of their skills during unemployment, aggregate employment may decrease in a persistent way. Before we are able to express the consequences of the abolishment of the tariff for employment in both sectors and aggregate employment, we first have to specify the fractions of *stu* and *ltu* workers in both sectors, when the system is not in steady state. Out of steady state, expressions (2.6) and (2.7) change since we have to account for (costless) labor mobility.

Since at time $t+1$ people move out of sector x and into sector z after the decrease in p_t^x, we have that

$$pr_{t+1}^{stu,x} = \frac{1}{2}\left(1 + q_t^x\right), \quad (3.1)$$

$$pr_{t+1}^{stu,z} = \frac{1}{2}\frac{L_t^z + L_t^z q_t^z}{L_{t+1}^z} + \frac{L_{t+1}^z - L_t^z}{L_{t+1}^z} pr_{t+1}^{stu,x}, \quad (3.2)$$

Given our assumptions, the number of workers that move to the other sector is proportionally divided over the different types of workers. Hence, a proportion $pr_{t+1}^{stu,x}$ ($pr_{t+1}^{ltu,x}$) of the workers moving from sector x to z consists of *stu* (*ltu*) workers. Thus, the proportions of workers of a certain type in sector x do not change as a consequence of workers moving out of this sector[8]. This explains (3.1). In sector z, $L_t^z q_t^z$ workers were *stu* in the previous period. Of these workers, $\frac{1}{2}L_t^z q_t^z$ are still alive at $t+1$. Also, $\frac{1}{2}L_t^z$ workers in total die between t and $t+1$ and are replaced by new entrants which are *stu*. Hence the first term in (3.2). The second term shows the number of workers moving out off sector x and into sector z times the probability that these workers were matched to a job in the previous period.

Using these two expressions we are now going to state our analytical results for the consequences of the permanent abolishment of the import tariff that was levied on the agricultural product., respectively in sector x (in section 3.1) and in sector z (in section 3.2).

3.1. The Effects of Trade Reform in Sector x

Using equations (3.1) and (3.2) and the framework developed in the previous section we are now able to analytically characterize the effects of trade reform for the sector that was initially protected.[9] Almost all of these effects can be illustrated by looking at the effects of this shock on q_t^x and q_{t+1}^x respectively on q_t^z and q_{t+1}^z. The change in p^x at time t due to the reform, affects employment in sector x at t, but not in sector z at t. Sector z is affected as soon as workers start to move. Labor moves with a lag and, therefore, sector z will not be affected until time $t+1$. Thus [10]

$$\frac{\partial \ln e_t^x}{\partial p_t^x} = \frac{\partial \ln q_t^x}{\partial p_t^x} =$$

$$\frac{\partial \ln p_t^x}{\partial p_t^x} + \frac{\partial \mathbb{E}_t \ln \theta^x}{\partial p_t^x} + \frac{\partial \ln \left(pr_t^{stu,x} + y \cdot pr_t^{ltu,x} \right)}{\partial p_t^x} = \frac{1}{p_t^x} \tag{3.3}$$

From equation (3.3) it is easy to see that employment in sector x at time t depends positively on the change in the price level. The only effect on employment in sector x of the shock to the price level arises because of its direct impact on the expected profitability of opening vacancies. At time t there is neither an effect on the distribution of skills of the workers searching for a job in sector x nor on the probabilities that a job meets either a *stu* or a *ltu* worker. In other words, the composition of workers searching for a job in sector x has not been affected yet by the shock at time t and employment decreases only because of the direct impact of the negative shock to the price level.

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[8] Note that $pr_{t+1}^{stu,x} \neq pr_t^{stu,x}$, since $\frac{\partial q_t^x}{\partial p_t^x} \neq 0$ and thus also $\frac{\partial pr_{t+1}^{stu,x}}{\partial p_t^x} \neq 0$, as is derived below.

[9] In the next section we will give some numerical illustrations of this analytical solution and discuss the sensitivity of these effects to variation in parameter values.

[10] See appendix A.1 for details on the derivation.

What will happen in sector x at time $t+1$? At $t+1$ some workers, exploiting their comparative advantage, move out of sector x and instead search for a job in sector z. The workers that move out of the agricultural sector are the generalists; i.e. those workers for which the difference in ability between the two sectors is smallest. Workers will move because the abolishment of the tariff decreases the wage directly and because q_t^x has decreased, while q_t^z has not changed. In other words, the wage and employment prospects in the agricultural sector have decreased. The workers that move are the ones that moved into the agricultural sector in response to the tariff in the first place.

The effects on the matching probability in x at $t+1$ depends on a number of factors. First of all, employment has decreased in sector x at time t which has increased the number of ltu workers at $t+1$ in the population and therefore the number of ltu searching for a job in that sector. However, at the same time the workers that move out may not have been the most productive in x, thereby increasing the average skill level of the workers who keep on searching for a job in x. The effect of the abolishment of the import tariff at t on the matching probability in x at $t+1$ depends on whether the overall impact of these effects is positive or negative. In appendix $A.1$ we show that:

$$\begin{aligned}\frac{\partial \ln q_{t+1}^x}{\partial p_t^x} &= -\frac{\sigma_{xx}-\sigma_{xz}}{\sigma^2}\cdot h'\left(-c_{*,t+1}^x\right)\cdot\frac{2}{p_t^x}+\frac{\partial \ln\left(pr_{t+1}^{stu,x}+y\cdot pr_{t+1}^{ltu,x}\right)}{\partial p_t^x} = \\ &\quad -\frac{\sigma_{xx}-\sigma_{xz}}{\sigma^2}\cdot h'\left(-c_{*,t+1}^x\right)\cdot\frac{2}{p_t^x}+\frac{1}{1+y+(1-y)\,q_t^x}\cdot\frac{1-y}{p_t^x}, \qquad (3.4)\end{aligned}$$

with $h(.)$ and $c_{*,t+1}^x$ as given in the appendix.

The first term on the rhs of (3.4) denotes the effect of the price change on mean ability in sector x. Since workers move out of sector x and into sector z, the composition of workers searching for a job in x has changed. We assume that $\sigma_{xx}>\sigma_{xz}$, where σ_{xz} can be equal to zero, negative or positive. For example, $\sigma_{xz}<0$ indicates specialization: a high ability level implies that the worker has specialized on producing in one sector and then the probability is large that this worker is not very productive in the other sector, while $\sigma_{xz}>0$ indicates that a worker with high ability in one sector tends to have higher ability in the other sector as well.

The workers that move from sector x and to sector z are those whose difference in ability between the two sectors is the smallest, since it is for these workers that the reform may shift their comparative advantage from sector x to sector z. Among other things, this effect is captured by $h'(-c_{*,t+1}^x)$, which is positive. As a consequence, the first term on the rhs of (3.4) is negative and the movement of workers out of sector x and into sector z has a positive effect on mean ability in sector x, because of the negative shock to p_t^x. The reason is straightforward. After the reform, only the most able ('specialists') workers stick with agricultural production. Thus the direct impact at time t of the shock to the matching probability between jobs and workers in sector x, is mitigated by labor moving out of this sector at $t+1$.

However, there is a second effect of the shock on the quality of workers searching for a job in x. This second effect is captured by the second term on the *rhs* of (3.4) and it shows how the shock affects the effectiveness of workers in converting their ability into output. The decrease in q_t^x decreases the number of *stu* workers in x and increases the number of *ltu* workers. The movement of workers has no further effect on the fraction of *stu* and *ltu* in sector x. This second term on the *rhs* of (3.4) is positive which implies that the negative shock to the price level at t decreases the fraction of *stu* at $t+1$ which in turn decreases the matching probability at $t+1$ in sector x. This decrease in the quality of workers searching for a job in sector x combined with the increase due to the effect that average ability of the job seekers has increased determines the 'quality' effect of the shock in sector x.

Recall from our previous discussion that we can separate the effect of a sector-specific shock on the log of sectoral employment into this 'quality' effect and a 'quantity' effect:

$$\frac{\partial \ln e_{t+1}^x}{\partial p_t^x} = \frac{\partial \ln q_{t+1}^x}{\partial p_t^x} + \frac{\partial \ln L_{t+1}^x}{\partial p_t^x}, \tag{3.5}$$

where the first term on the *rhs* refers to the 'quality' effect and the second term on the *rhs* refers to the 'quantity' effect of a sector-specific shock on sectoral employment and where $\frac{\partial \ln L_{t+1}^x}{\partial p_{t+1}^x}$ is an expression similar to (A.24). This quantity effect is negative as workers move out of sector x. Depending on the effect of the shock on the matching probability, employment may either increase or decrease in sector x from t to $t+1$. In section 4, numerical examples show that in general employment will decrease as a result of the shock.

3.2. The Effects of Trade Reform in Sector z.

The effect of trade reform on employment in sector z at t is given by

$$\frac{\partial \ln q_t^z}{\partial p_t^x} = \frac{\partial \ln L_t^z}{\partial p_{t+1}^x} = \frac{\partial \ln e_t^z}{\partial p_t^x} = 0 \tag{3.6}$$

The shock to p_t^x has no effect on either the composition of job seekers in z nor on the amount of workers searching for a job in the industrial sector and, therefore, has no effect on employment in this sector at time t.

In appendix $A.2$ we show that

$$\frac{\partial \ln q_{t+1}^{z}}{\partial p_{t}^{x}}=\frac{\sigma_{zz}-\sigma_{zx}}{\sigma^{2}}\cdot h^{'}\left(-c_{*,t+1}^{z}\right)\cdot\frac{2}{p_{t}^{x}}+\frac{\partial \ln\left(pr_{t+1}^{stu,z}+y\cdot pr_{t+1}^{ltu,z}\right)}{\partial p_{t}^{x}}, \tag{3.7}$$

with $h(.)$ and $c_{*,t+1}^{z}$, as well as an explicit expression for the second term on the rhs, as given in the appendix. Equation (3.7) shows that the quality effect in sector z is also determined by both the change in the distribution of skills after workers have moved to this sector and by the effect of this movement of labor on the fractions of stu respectively ltu workers in z at $t+1$.

By similar reasoning as above, we can establish that the first term on the rhs is positive. Therefore, this effect causes the decrease in p_t^x to decrease average ability of the workers searching for a job in z. The intuition behind this result is that only the workers for whom the difference in ability between the two sectors is small are moving. As a result, the workers that enter sector z are the least specialized workers. Since employers cannot observe the ability of job seekers, the average ability level of the workers searching for a job in z has decreased which in turn decreases the matching probability at $t+1$.

The second term refers to the fact that after trade has been reformed, the fraction of stu workers in x decreases while the fraction of ltu workers increases. Since workers move from x to z, the quality of workers searching for a job in the industrial sector could be affected through this channel as well. If the fraction of ltu workers was higher is x than in z, the movement of workers together with imperfect information by employers implies that the quality of job seekers in z would be negatively affected.

Employment in sector z may either increase or decrease as for this sector the quantity effect is positive since the amount of job seekers in this sector has increased. Finally, we briefly consider what happens to aggregate employment at $t+1$

$$\frac{\partial \ln E_{t+1}}{\partial p_{t}^{x}}=\frac{\partial \ln e_{t+1}^{x}}{\partial p_{t}^{x}}+\frac{\partial \ln e_{t+1}^{z}}{\partial p_{t}^{x}}=\frac{\partial \ln q_{t+1}^{x}}{\partial p_{t}^{x}}+\frac{\partial \ln q_{t+1}^{z}}{\partial p_{t}^{x}}, \tag{3.8}$$

as in the aggregate the quantity effects of shocks cancel out. The effect of the shock on aggregate employment at $t+1$ depends on the relative impact of the shock on the quality of job seekers in the sectors x and z. Aggregate employment can either increase or decrease and it will be interesting to consider what has happened to aggregate (un)employment after the economy has settled in its new steady state. We take this issue up in our numerical examples in the next section.

Finally, it is very difficult to discuss in general the effects of trade reform for the distribution of wages. What we can say is that by moving to the industrial sector, the generalists limit the negative effect of trade liberalization on their wage, although their expected wage still decreases. The agricultural specialists see their wage decrease because of the direct of the trade reform, but also because employment opportunities have decreased. The industrial workers earn the same wage if matched to a job, although their expected wage decreases as well because of increased competition for jobs which increases the probability of unemployment. This effect arises because the industrial workers cannot be distinguished from the agricultural workers that moved in. So the decrease in expected wages is largest for agricultural specialists, then for generalists that switch to another sector in response to trade liberalization, and smallest for industrial workers.

4. Numerical Illustrations.

Although we obtained an analytical solution of our model, it is instructive to give some numerical illustrations. In this section we will analyse the effects of trade reform in the form of abolishing an import tariff completely at time 1 for the amount of job seekers and unemployment in each sector as well as its effects on aggregate unemployment. We discuss how sensitive our conclusions are to variation in the parameters of interest, such as the degree of loss of skills and the variance of the distribution of ability.

In our base scenario we assume the following parameter values: $y = 0.90$,, $k^x = k^z = 0.6$, $\mu_x = \mu_z = 1$, $\sigma_{xx} = \sigma_{zz} = 1$, and $\sigma_{xz} = 0$. $L = 1000$ so that in total there are 2000 job seekers of which, on the basis of comparative advantage, 1077.06 search for a job in the agricultural sector and 922.94 search for a job in the industrial sector. In this case, the following steady state values are obtained: $q^x = 0.8991$, $q^z = 0.8626$, $e^x = 968.43$, $e^z = 796.12$, and $E = 1764.55$. We assume that the tariff levied on the agricultural good raised the price of agricultural products with 10%. After the tariff is abolished, $p_1^x = p_1^x = 1$. The 10% tariff results in a situation in which approximately 77 workers see their comparative advantage change such that they search for a job in the agricultural sector, although they are more able in the industrial sector. The results are presented in table **??**. The first row of the table indicates the contents of each column, where $\%u_t^j$, $j = x, z$, stands for the unemployment percentage in sector j and $\%U$ indicates the aggregate unemployment percentage.

Table 1 *here.*

As one can see from the table, the direct impact of the trade reform at time $t = 1$ is to decrease the matching probability in sector x and, as a consequence, to increase the aggregate unemployment rate in this sector to 16.174%. Labor moves with a lag and as a consequence sector z is unaffected at $t = 1$. So aggregate unemployment increases only because of the direct negative impact of the shock on employment in sector x.

At $t = 2$ labor starts to move. The decrease in q_1^x has increased the fraction of *ltu* and has therefore decreased average skill in sector x. Nevertheless, we see that q_2^x has increased compared to the previous period. We conclude that average ability of the workers that remain in x must have increased considerably.

Many workers move and, as we discussed in the previous section, this affects the quality of the workers searching for a job in z (and therefore q_2^z) through two channels. First of all, the decrease in q_1^x decreases the fraction of *stu* workers in z at time 2. Second, average ability in z decreases. Both effects depress the average quality of job seekers in the industrial sector and the unemployment rate in this sector increases to a maximum of 17.037% before decreasing. The effects on unemployment in sector x and z of labor movement almost cancel out since the aggregate unemployment rate is more or less stable after period 1. Thus, this illustration seems to suggest that the persistent increase in the aggregate unemployment rate almost entirely depends on the direct impact of the trade reform. Labor movement between sectors does, however, affect sectoral (un)employment. In this illustration we see overshooting before the economy finally settles in its new steady state at $t = 11$.

Suppose that a larger tariff, $T = 20\%$, was in place. The results of trade reform in this case are presented in Table 2.

Table 2 here.

The results are qualitatively the same as for $T = 10\%$ although all the effects are more or less two times as large. We proceed by looking at an illustration in which the degree of loss of skills is larger. More specifically, $y = 0.8$; i.e. unemployed workers are less capable of transforming their ability into productivity. The results are summarized in Table 3.

Table 3 here.

With $y = 0.8$, unemployment is larger in both sectors in the intial, protected, steady state. The aggregate unemploymen rate increases more after trade has been reformed compared to the case in which $y = 0.9$. Up to now, we have assumed that both sectors are identical before any shocks hit the economy. We will now analyse how our results change when we introduce differences between sectors, for example because $\sigma_{xx} = 1$ while $\sigma_{zz} = 2$ for $k^x = k^z = 0.55$.

Table 4 *here.*

In the initial steady state the unemployment rate is now very high in the agricultural sector and much smaller in sector z. Some workers now have a very high ability in z compared to their ability in x and as a consequence, more workers are searching for a job in z than in x compared to the situation in which both sectors were identical. After trade has been reformed, less workers move compared to the case in which both sectors became identical after the reform since workers in agriculture are more specialised. The aggregate unemployment rate increases by less percentage points after trade has been reformed, although the rise in unemployment in the industrial sector becomes larger compared to Table 1. The reason for this is that the workers who were searching for a job in x before the shock are relatively unable workers in z. Then, after the shock, only a small amount of workers move, but this movement of workers reduces the average quality of job seekers in z a lot precisely because they have low ability in z. Moreover, as one can see from equation (A.29), because q^x is smaller than q^z, the fraction of *stu* workers in z decreases if workers move in from x after the tariff has been abolished.

Suppose now that $\sigma_{xx} = 2$ and $\sigma_{zz} = 1$ for $k^x = k^z = 0.55$.

Table 5 *here.*

Compared to the case presented in Table 4, unemployment in sector x increases by more and unemployment in z by less percentage points. Labor mobility and the change in the aggregate unemployment rate are more or less the same as for $\sigma_{xx} = 1$ and $\sigma_{zz} = 2$ for $k^x = k^z = 0.6$. The employment rate in z is much less adversely affected after the reform since, in this case, the workers that move in general do not have very low ability. Moreover, because q^x is much larger than q^z before the shock, the fraction of *stu* worker in z may actually increase after the shock.

These simulations give some insight into the interactions between the quantity and quality effects that arise after trade has been reformed. Labor movement together with imperfect information implies that spill-overs between sectors arise when one sector faces increased competition. If workers move with a lag and lose part of their skills during unemployment, aggregate unemployment is permanently higher after an import tariff has been abolished, unless other measures are included in the reform package that prevent unemployment from rising. We discuss this in the next section, but before we do this one final remark. From our model, there is no reason to expect that it are the least-skilled workers that become unemployed after trade has been liberalised. Therefore, if employers face uncertainty about the ability of job seekers, our model predicts that increased free trade cannot be the underlying reason for why unemployment of the least-skilled workers has increased and this confirms to the majority opinion that recent labor market trends are predominantly technology driven (see also the introduction).

5. Replacing the Import Tariff by a Production Subsidy

A tariff levied on the agricultural product distorts both the goods market and the product market. The later distortion comes from the fact that a tariff distorts the comparative advantage of workers. Although we did not take the distortion in the product market caused by the tariff into account, it is well known that a production subsidy is often a better instrument than a tariff because it targets directly the particular activity we want to encourage. One of these activities could be the protection of domestic jobs. As we saw above, abolishing an import tariff increases unemployment permanently. If we replace the import tariff by some form of production subsidy, so that in general the product market distortion will no longer exist, can we then also get rid of the labor market distortion created by the tariff?

First of all, suppose that we want to replace the tariff by a wage-cost subsidy such that employment in both sectors remains constant. One can see from equation (2.17) that replacing the tariff, T, by a subsidy, s, which decreases the costs of opening a vacancy such that $T = s$ results in:

$$\ln q_t^j = \ln a + \ln 2 + \ln(1-\alpha) + \ln p_t^j + \mathbb{E}_t \ln\theta^j + \ln\left[pr_t^{stu,j} + y \cdot pr_t^{ltu,j}\right] + \ln k^j\,(1+s) \quad (5.1)$$

As a consequence, the matching probability in both sectors will remain the same when a wage cost subsidy of 10% is given to the agricultural sector instead of levying an import tariff. The same amount of workers search in each sector as was the case with the tariff in place and employment in each sector remains the same. Then we get rid of the product market distortion although the labor market distortion is still present. For, with the tariff in place we saw that the comparative advantage of workers changes in such a way that from an ability point of view too many people work in the agricultural sector which decreases the productive potential of the economy. This was caused by the fact that a tariff increases the wage in the agricultural sector and the probability of finding a job. Then, replacing an import tariff by an equal wage-cost subsidy eliminates the product market distortion, but not the labor market distortion, as is the case in standard stories of trade liberalisation.

However, one could overcome the labor market distortion as well. The way to do this is by giving a wage-cost subsidy to both sectors such that workers work in the sector where they are most able and such that aggregate unemployment will not increase. Moreover, this will be less expensive than giving a subsidy to the agricultural sector alone. To give an indication of the size of this subsidy, see the following simulation result (for $k^x = k^z = 0.6$, $T = 10\%$, $y = 0.90$, $\sigma_{xx} = \sigma_{zz} = 1$):

Table 6 *here.*

So subsidising both sectors, financed by lump-sum taxation, protects long-term employment to the same degree as levying an import tariff on one sector and does not distort product and labor markets. Moreover, subsidizing both sectors is cheaper than subsidizing only the agricultural sector. For in the later case one gives a 10% subsidy to 968.43 jobs ($q_1^x \times L_1^x$) while in the former case, a 5% subsidy is given to 968.43 jobs in x respectively a 5% subsidy for 796.12 jobs in the industrial sector. The reason for this cost advantage of a general subsidy is that if you only subsidize employment in the previously protected sector, you are giving subsidies to too many workers. So the fact that a sector-specific subsidy does not eliminate the labor market distortion is also the cause for why such a specific subsidy is more expansive than a general wage-cost subsidy. However, giving only a subsidy to the agricultural sector leaves sectoral employment and aggregate unemployment completely at their former, import-protected, levels. A general subsidy results in transitional dynamics in which aggregate unemployment temporarily rises.

6. Concluding Comments

In this paper we discussed an equilibrium-search model with worker heterogeneity, imperfect information, and loss of skills during unemployment. The heterogeneity of workers gave us an important mechanism through which an import tariff distorts the labor market. For we saw that such a tariff changes the comparative advantage of the least-specialised workers. The wage and the employment prospects of these genralists are larger in the protected agricultural sector although they are more able in the industrial sector. Limiting free trade may not only prevent specialisation on the basis of comparative advantage of countries, but also of workers.

Because a tariff distorts both the product market and the labor market, trade reform sounds like a plausible thing to do. However, although labor is not sector-specific it is not completely mobile as well. When labor moves with a lag, employers face imperfect information concerning the ability of job seekers, and workers lose part of their skills during unemployment, trade reform increases the aggregate unemployment rate persistently. Moreover we argued that there are distributional implications associated with trade reform. The most specialised workers in the agricultural sector have most to lose, the generalists by switching sectors mitigate their loss, but still they lose. Finally, industrial workers experience fiercer competition for jobs than was the case when trade was still protected. Since we saw in our simulations that the unemployment rate in the industrial sector increased considerably after the reform this may be an important aspect of trade reform as well.

However, although a tariff may protect domestic employment, a wage cost subsidy is generally more efficient on the grounds that it does not distort the product market. We showed that simply replacing the tariff for a wage-cost subsidy to the agricultural sector has the disadvantage that it does not alleviate the labor market distortion. Because this distortion remains present it is also a relatively costly way to protect domestic employment sinse too many jobs will be subsidised. We argued that it is better to give a wage-cost subsidy to both sectors since then comparative advantage of workers will no longer be distorted which will also make it cheaper compared to a sector-specific subsidy. The picture that emerges from our paper then is that if one wants to reform trade to prevent the distortion of comparative advantage of workers, the cheapest way to do so is to replace the import tariff by a general wage-cost subsidy which will prevent unemployment from rising permanently.

Although we applied our model to the specific setting of trade reform, it is more general and can be used to analyse other forms of sector-specific shocks as well. From this point of view, two final observations are relevant. First of all, including sector-specific learning-by-doing may result in a higher level of employment to start with, but larger unemployment in the long-run, after shocks have hit the economy, as workers become less mobile between sectors. Less mobility between sectors is then the result of workers waiting for the shock to pass as they do not want to run the risk of losing that part of their skills that was accumulated in the previous period. Stimulating people to become 'generalists' instead of 'specialists' may then be an interesting long run option, although it comes at a short run cost.

The fact that specialization may turn out to be disadvantageous over the long run in our model has an immediate application to the distinction between specialization on the basis of absolute versus comparative advantage. Again, employment will probably be larger in the short-run if the economy specializes on the basis of comparative advantage. However, if the economy is hit by repeated shocks, unemployment may be lower in the long-run if the economy had produced on the basis of absolute advantage. Countries specializing in the production of one good in the presence of persistent unemployment, sector-specific shocks, and lagged labor mobility, may be less desirable in the long run as workers have no where to go if a shock hits the economy unless workers are mobile internationally.

A. Appendix

We are interested in the influence of a shock to p_t^x on q_{t+s}^j, for $j = x, z$, $s = 0, 1, 2, \ldots$. These effects are illustrated by looking at the effect of a negative shock, coming from trade reform, in p_t^x on q_t^x, q_{t+1}^x, q_t^z and q_{t+1}^z. The effects at times $t+s$, $s \geq 2$ do not add much insight and are therefore neglected. They can be deduced in a similar fashion. The analytical derivations of the formulae for the partial derivatives are in two separate subsections.

A.1. Derivative of q_t^x and q_{t+1}^x with respect to p_t^x.

In this subsection we determine $\frac{\partial \ln q_t^x}{\partial p_t^x}$ and $\frac{\partial \ln q_{t+1}^x}{\partial p_t^x}$. First

$$\frac{\partial \ln q_t^x}{\partial p_t^x} = \frac{\partial \ln p_t^x}{\partial p_t^x} + \frac{\partial \mathbf{E}_t \ln \theta^x}{\partial p_t^x} + \frac{\partial \ln \left(pr_{t+1}^{stu,x} + y \cdot pr_{t+1}^{ltu,x} \right)}{\partial p_t^x} = \frac{\partial \ln p_t^x}{\partial p_t^x} = \frac{1}{p_t^x},$$

since a change in p_t^x does not affect the expected skill level in sector x at time t or the probability of meeting a worker of either type at time t.

Second,

$$\begin{aligned} \frac{\partial \ln q_{t+1}^x}{\partial p_t^x} &= \frac{\partial \ln p_{t+1}^x}{\partial p_t^x} + \frac{\partial \mathbf{E}_{t+1} \ln \theta^x}{\partial \ln \mathbf{E}\beta_{t+1}^x} \cdot \frac{\partial \ln \mathbf{E}\beta_{t+1}^x}{\partial p_t^x} + \frac{\partial \ln \left(pr_{t+1}^{stu,x} + y \cdot pr_{t+1}^{ltu,x} \right)}{\partial p_t^x} = \\ &= \frac{\partial \mathbf{E}_{t+1} \ln \theta^x}{\partial \ln \mathbf{E}\beta_{t+1}^x} \cdot \frac{\partial \ln \beta_t^x}{\partial p_t^x} + \frac{\partial \ln \left(pr_{t+1}^{stu,x} + y \cdot pr_{t+1}^{ltu,x} \right)}{\partial p_t^x}, \end{aligned} \tag{A.1}$$

as we consider the case of a permanent sector-specific shock and $\ln \mathbf{E}\beta_{t+1}^x = \ln \beta_t^x$.

Heckman and Honoré (1990) show that

$$\frac{\partial \mathbf{E}_{t+1} \ln \theta^x}{\partial \ln \mathbf{E}\beta_{t+1}^x} = \frac{\partial \mathbf{E}_{t+1} \left(\ln \theta^x | \ln P_x > \ln P_z \right)}{\partial \ln \mathbf{E}\beta_{t+1}^x} = -\frac{\sigma_{xx} - \sigma_{xz}}{\sigma^2} \cdot h'\left(-c_{*,t+1}^x\right) \tag{A.2}$$

with

$$
\begin{aligned}
c_{t+1}^{x} &= \ln \frac{E\beta_{t+1}^{x}}{E\beta_{t+1}^{z}} + \mu_x - \mu_z, \\
c_{*,t+1}^{x} &= \frac{c_{t+1}^{x}}{\sigma},
\end{aligned}
$$

and where $h'(.)$ indicates the first derivative of $h(.)$ with respect to $\ln \mathbb{E}\beta_{t+1}^{x}$. Furthermore,

$$
\begin{aligned}
\frac{\partial \ln \beta_t^x}{\partial p_t^x} &= \frac{\partial \ln \left(q_t^x \cdot p_t^x\right)}{\partial p_t^x} = \frac{\partial \ln q_t^x}{\partial p_t^x} + \frac{\partial \ln p_t^x}{\partial p_t^x} = \\
&= \frac{1}{p_t^x} + \frac{1}{p_t^x} = \frac{2}{p_t^x},
\end{aligned}
\tag{A.3}
$$

and thus

$$
\frac{\partial \ln q_{t+1}^{x}}{\partial p_t^x} = -\frac{\sigma_{xx} - \sigma_{xz}}{\sigma^2} \cdot h'\left(-c_{*,t+1}\right) \cdot \frac{2}{p_t^x} + \frac{\partial \ln \left(pr_{t+1}^{stu,x} + y \cdot pr_{t+1}^{ltu,x}\right)}{\partial p_t^x}
\tag{A.4}
$$

Now, we determine the final term in this expression. Substituting $pr_{t+1}^{ltu,x}$ gives

$$
\frac{\partial pr_{t+1}^{ltu,x}}{\partial p_t^x} = \frac{\partial \left(1 - pr_{t+1}^{stu,x}\right)}{\partial p_t^x} = -\frac{\partial pr_{t+1}^{stu,x}}{\partial p_t^x},
\tag{A.5}
$$

and thus

$$
\frac{\partial \ln \left(pr_{t+1}^{stu,x} + y \cdot pr_{t+1}^{ltu,x}\right)}{\partial p_t^x} = \frac{\partial \ln \left(y + (1-y)\, pr_{t+1}^{stu,x}\right)}{\partial p_t^x} =
\tag{A.6}
$$

$$
= \frac{\partial \ln \left(y + (1-y)\, pr_{t+1}^{stu,x}\right)}{\partial \left(y + (1-y)\, pr_{t+1}^{stu,x}\right)} \cdot \frac{\partial \left(y + (1-y)\, pr_{t+1}^{stu,x}\right)}{\partial p_t^x} =
$$

$$
= \frac{1}{y + (1-y)\, pr_{t+1}^{stu,x}} \cdot (1-y)\, \frac{\partial pr_{t+1}^{stu,x}}{\partial p_t^x},
\tag{A.7}
$$

as $\frac{\partial y}{\partial p_t^x} = 0$. From equations (3.1) and (2.17), one can see that $\frac{\partial pr_{t+1}^{stu,x}}{\partial p_t^x} = \frac{1}{2}\frac{\partial q_t^x}{\partial p_t^x} = \frac{1}{2p_t^x}$ so that:

$$
\begin{aligned}
\frac{\partial \ln \left(pr_{t+1}^{stu,x} + y \cdot pr_{t+1}^{ltu,x}\right)}{\partial p_t^x} &= \frac{1}{y + (1-y)\frac{1}{2}\left(1 + q_t^x\right)} \cdot \frac{1-y}{2p_t^x} = \\
&= \frac{1}{1 + y + (1-y)\, q_t^x} \cdot \frac{1-y}{p_t^x}
\end{aligned}
$$

.

Summarizing the above leads to

$$
\frac{\partial \ln q_{t+1}^{x}}{\partial p_t^x} = -\frac{\sigma_{xx} - \sigma_{xz}}{\sigma^2} \cdot h'\left(-c_{*,t+1}^{x}\right) \cdot \frac{2}{p_t^x} + \frac{1}{1 + y + (1-y)\, q_t^x} \cdot \frac{1-y}{p_t^x}
\tag{A.8}
$$

A.2. Derivative of q_t^z and q_{t+1}^z with respect to p_t^x.

First of all, because of adaptive expectations we have that $\frac{\partial q_t^z}{\partial p_t^x} = 0$. Second, as

$$\ln q_{t+1}^z = \ln a + \ln 2 + \ln k^z + \ln(1-\alpha) + \ln p_{t+1}^z + \mathbf{E}_{t+1} \ln \theta^z + \ln \left(pr_{t+1}^{stu,z} + y \cdot pr_{t+1}^{ltu,z} \right), \quad \text{(A.9)}$$

we have that

$$\frac{\partial \ln q_{t+1}^z}{\partial p_t^x} = \frac{\partial \ln p_{t+1}^z}{\partial p_t^x} + \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial p_t^x} + \frac{\partial \ln \left(pr_{t+1}^{stu,z} + y \cdot pr_{t+1}^{ltu,z} \right)}{\partial p_t^x} \quad \text{(A.10)}$$

Now $\frac{\partial \ln p_{t+1}^z}{\partial p_t^x} = 0$, since the price in sector z does not change because of change in the price in sector x.

As before, we have that

$$\frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial p_t^x} = \frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial \mathbf{E} \ln \beta_{t+1}^x} \cdot \frac{\partial \mathbf{E} \ln \beta_{t+1}^x}{\partial p_t^x} \quad \text{(A.11)}$$

From Heckman and Honoré (1990) we have

$$\frac{\partial \mathbf{E}_{t+1} \ln \theta^z}{\partial \ln \mathbf{E} \beta_{t+1}^x} = \frac{\partial \mathbf{E}_{t+1} \left(\ln \theta^z | \ln P_z > \ln P_x \right)}{\partial \ln \mathbf{E} \beta_{t+1}^x} = \frac{\sigma_{zz} - \sigma_{zx}}{\sigma^2} \cdot h' \left(-c_{*,t+1}^z \right), \quad \text{(A.12)}$$

where

$$\begin{aligned} c_{t+1}^z &= \ln \frac{E \beta_{t+1}^z}{E \beta_{t+1}^x} + \mu_z - \mu_x \\ c_{*,t+1}^z &= \frac{c_{t+1}^z}{\sigma} \\ h(-c_*) &\equiv \frac{1}{\Phi(c_*)} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2} c_*^2} \end{aligned}$$

From (A.3) we have $\frac{\partial \mathbf{E} \ln \beta_{t+1}^x}{\partial p_t^x} = \frac{2}{p_t^x}$. This leaves us with determining $\frac{\partial \ln \left(pr_{t+1}^{stu,z} + y \cdot pr_{t+1}^{ltu,z} \right)}{\partial p_t^x}$. First, we rewrite this expression using (A.7) for sector z, yielding

$$\frac{\partial \ln \left(pr_{t+1}^{stu,z} + y \cdot pr_{t+1}^{ltu,z} \right)}{\partial p_t^x} = \frac{1}{y + (1-y)\, pr_{t+1}^{stu,z}} \cdot (1-y) \frac{\partial pr_{t+1}^{stu,z}}{\partial p_t^x}, \quad \text{(A.13)}$$

which leaves us with determining $\frac{\partial pr_{t+1}^{stu,z}}{\partial p_t^x}$.

Substituting (3.1) into (3.2) gives

$$pr_{t+1}^{stu,z} = \frac{1}{2} \frac{L_t^z + L_t^z q_t^z}{L_{t+1}^z} + \frac{L_{t+1}^z - L_t^z}{L_{t+1}^z} \cdot \frac{1}{2} \left(1 + q_t^x \right). \quad \text{(A.14)}$$

Notice that if $q_t^z = q_t^x$, then $pr_{t+1}^{stu,z} = \frac{1}{2} \left(1 + q_t^z \right)$ and $pr_{t+1}^{ltu,z} = \frac{1}{2} \left(1 - q_t^z \right)$. In general, we have to determine the derivatives of both parts of the expression. First,

$$\frac{\partial}{\partial p_t^x}\left[\frac{L_t^z + L_t^z q_t^z}{L_{t+1}^z}\right] = \frac{L_{t+1}^z \cdot \left(\frac{\partial L_t^z}{\partial p_t^x} + \frac{\partial L_t^z}{\partial p_t^x} q_t^z + \frac{\partial q_t^z}{\partial p_t^x} L_t^z\right) - \left(L_t^z + L_t^z q_t^z\right) \frac{\partial L_{t+1}^z}{\partial p_t^x}}{\left(L_{t+1}^z\right)^2} \tag{A.15}$$

Now

$$\frac{\partial L_t^z}{\partial p_t^x} = \frac{\partial 2L\lambda_t^z}{\partial p_t^x} = 2L\frac{\partial \lambda_t^z}{\partial p_t^x}, \tag{A.16}$$

and

$$\lambda_t^z = \int_0^\infty \int_0^{\mathbf{E}\beta_t^z \theta^z / \mathbf{E}\beta_t^x} f(\theta^x, \theta^z) d\theta^x d\theta^z, \tag{A.17}$$

where $\mathbf{E}\beta_t^j = \mathbf{E}p_t^j \cdot \mathbf{E}q_t^j = p_{t-1}^j \cdot q_{t-1}^j = \beta_{t-1}^j$, $j = x, z$. Thus we have

$$\lambda_t^z = \int_0^\infty \int_0^{p_{t-1}^z \cdot q_{t-1}^z \theta^z / p_{t-1}^x \cdot q_{t-1}^x} f(\theta^x, \theta^z) d\theta^x d\theta^z, \tag{A.18}$$

which is independent of p_t^x and therefore

$$\frac{\partial L_t^z}{\partial p_t^x} = 2L\frac{\partial \lambda_t^z}{\partial p_t^x} = 0 \tag{A.19}$$

Now given this and $\frac{\partial q_t^z}{\partial p_t^x} = 0$, the expression $\frac{\partial}{\partial p_t^x}\left[\frac{L_t^z + L_t^z q_t^z}{L_{t+1}^z}\right]$ can be reduced to:

$$\frac{\partial}{\partial p_t^x}\left[\frac{L_t^z + L_t^z q_t^z}{L_{t+1}^z}\right] = -\frac{L_t^z}{\left(L_{t+1}^z\right)^2}\left(1 + q_t^z\right)\frac{\partial L_{t+1}^z}{\partial p_t^x}$$

We are left with determining

$$\frac{\partial L_{t+1}^z}{\partial p_t^x} = \frac{\partial 2L\lambda_{t+1}^z}{\partial p_t^x} = 2L\frac{\partial \lambda_{t+1}^z}{\partial p_t^x} \tag{A.20}$$

From (A.18) it is immediate that

$$\frac{\partial \lambda_{t+1}^z}{\partial p_t^x} = \frac{\partial}{\partial p_t^x} \int_0^\infty \int_0^{p_t^z q_t^z \theta^z / p_t^x q_t^x} f(\theta^x, \theta^z) d\theta^x d\theta^z \tag{A.21}$$

which can be rewritten as

$$\frac{\partial \lambda_{t+1}^z}{\partial p_t^x} = \int_0^\infty \frac{\partial}{\partial p_t^x}\left[\int_0^{p_t^z q_t^z \theta^z / p_t^x q_t^x} f(\theta^x, \theta^z) d\theta^x\right] d\theta^z \tag{A.22}$$

Integrating with respect to θ^x yields

$$\frac{\partial \lambda_{t+1}^z}{\partial p_t^x} = \int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x\left(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x}, \theta^z\right) - F^x(0, \theta^z)\right] d\theta^z = \int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x\left(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x}, \theta^z\right)\right] d\theta^z, \tag{A.23}$$

as $F^x(0,\theta^z)$ is not a function of p_t^x. At this point, we choose not to rewrite this expression any further by substituting the multivariate lognormal cumulative density. So now we have

$$\frac{\partial L_{t+1}^z}{\partial p_t^x} = 2L\int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x},\theta^z)\right]d\theta^z \tag{A.24}$$

and thus:

$$\frac{\partial}{\partial p_t^x}\left[\frac{L_t^z + L_t^z q_t^z}{L_{t+1}^z}\right] = -\frac{L_t^z}{\left(L_{t+1}^z\right)^2}\left(1+q_t^z\right)2L\int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x},\theta^z)\right]d\theta^z \tag{A.25}$$

Now we have to determine the second part of $\frac{\partial pr_{t+1}^{stu,z}}{\partial p_t^x}$

$$\frac{\partial}{\partial p_t^x}\left[\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}\cdot\frac{1}{2}\left(1+q_t^x\right)\right] = \frac{1}{2}\left(1+q_t^x\right)\frac{\partial}{\partial p_t^x}\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z} + \frac{1}{2}\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}\frac{\partial q_t^x}{\partial p_t^x}.$$

We have

$$\begin{aligned}
\frac{\partial}{\partial p_t^x}\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z} &= \frac{L_{t+1}^z\frac{\partial\left(L_{t+1}^z - L_t^z\right)}{\partial p_t^x} - \left(L_{t+1}^z - L_t^z\right)\frac{\partial L_{t+1}^z}{\partial p_t^x}}{\left(L_{t+1}^z\right)^2} = \\
&= \frac{L_{t+1}^z\frac{\partial L_{t+1}^z}{\partial p_t^x} - L_{t+1}^z\frac{\partial L_{t+1}^z}{\partial p_t^x} + L_t^z\frac{\partial L_{t+1}^z}{\partial p_t^x}}{\left(L_{t+1}^z\right)^2} = \frac{L_t^z}{\left(L_{t+1}^z\right)^2}\frac{\partial L_{t+1}^z}{\partial p_t^x} = \\
&= \frac{L_t^z}{\left(L_{t+1}^z\right)^2}2L\int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x},\theta^z)\right]d\theta^z
\end{aligned} \tag{A.26}$$

and

$$\frac{1}{2}\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}\frac{\partial q_t^x}{\partial p_t^x} = \frac{1}{2p_t^x}\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}.$$

As a result:

$$\begin{aligned}
\frac{\partial pr_{t+1}^{stu,z}}{\partial p_t^x} &= \frac{\partial}{\partial p_t^x}\left[\frac{1}{2}\frac{L_t^z + L_t^z q_t^z}{L_{t+1}^z} + \frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}\cdot\frac{1}{2}\left(1+q_t^x\right)\right] = \\
& \frac{1}{2}\frac{L_t^z}{\left(L_{t+1}^z\right)^2}\left[\begin{array}{c} -\left(1+q_t^z\right)L\int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x},\theta^z)\right]d\theta^z + \\ \left(1+q_t^x\right)L\int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x},\theta^z)\right]d\theta^z \end{array}\right] + \frac{1}{2p_t^x}\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}
\end{aligned} \tag{A.27}$$

$$\frac{1}{2}\frac{L_t^z}{\left(L_{t+1}^z\right)^2}\left(q_t^x - q_t^z\right)L\int_0^\infty \frac{\partial}{\partial p_t^x}\left[F^x(\frac{p_t^z q_t^z \theta^z}{p_t^x q_t^x},\theta^z)\right]d\theta^z + \frac{1}{2p_t^x}\frac{L_{t+1}^z - L_t^z}{L_{t+1}^z}. \tag{A.28}$$

In this expression we can distinguish three distinct influences of a negative change in p_t^x on $pr_{t+1}^{stu,z}$. First, there is the difference in matching probability between both sectors. A second effect can be ascribed to the number of workers moving from sector x to sector z. Third, there is the effect of the (multivariate) distribution of productivity in the sectors.

Substituting (A.14) and (A.28) into (A.13) now yields the result.

$$\frac{\partial \ln\left(pr_{t+1}^{stu,z}+y\cdot pr_{t+1}^{ltu,z}\right)}{\partial p_t^x}=\frac{1-y}{y+(1-y)\left[\frac{1}{2}\frac{L_t^z+L_t^z q_t^z}{L_{t+1}^z}+\frac{L_{t+1}^z-L_t^z}{L_{t+1}^z}\cdot\frac{1}{2}\left(1+q_t^x\right)\right]}\cdot$$

$$\left\{\frac{1}{2}\frac{L_t^z}{\left(L_{t+1}^z\right)^2}\left(q_t^x-q_t^z\right)L\int_0^\infty\frac{\partial}{\partial p_t^x}\left[F^x\left(\frac{p_t^z q_t^z\theta^z}{p_t^x q_t^x},\theta^z\right)\right]d\theta^z+\frac{1}{2p_t^x}\frac{L_{t+1}^z-L_t^z}{L_{t+1}^z}\right\} \tag{A.29}$$

In other words, the movement of workers out of the agricultural sector and into the industrial sector does not affect the relative fractions of stu and ltu workers in each sector. We conclude by once more stating the result:

$$\frac{\partial \ln q_{t+1}^z}{\partial p_t^x}=\frac{\sigma_{zz}-\sigma_{zx}}{\sigma^2}\cdot h'\left(-c_{*,t+1}^z\right)\cdot\frac{2}{p_t^x}+\frac{\partial \ln\left(pr_{t+1}^{stu,z}+y\cdot pr_{t+1}^{ltu,z}\right)}{\partial p_t^x} \tag{A.30}$$

with $\frac{\partial \ln\left(pr_{t+1}^{stu,z}+y\cdot pr_{t+1}^{ltu,z}\right)}{\partial p_t^x}$ as given in $A.29$.

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Time	q_t^x	q_t^z	L_t^x	$\%U_t^x$	L_t^z	$\%U_t^z$	$\%TotU_t$
0	0.8991	0.8626	1077.06	10.086	922.94	13.741	11.773
1	0.8174	0.8626	1077.06	18.260	922.94	13.741	16.174
2	0.8462	0.8296	969.65	15.382	1030.35	17.037	16.235
3	0.8348	0.8408	1011.14	16.522	988.86	15.916	16.222
4	0.8389	0.8367	995.92	16.108	1004.08	16.330	16.219
5	0.8374	0.8382	1001.49	16.259	998.51	16.178	16.219
6	0.8380	0.8377	999.46	16.204	1000.54	16.233	16.219
7	0.8378	0.8379	1000.20	16.224	999.80	16.213	16.219
8	0.8378	0.8378	999.93	16.217	1000.07	16.221	16.219
9	0.8378	0.8378	1000.03	16.219	999.97	16.218	16.219
10	0.8378	0.8378	999.99	16.218	1000.01	16.219	16.219
11	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
12	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
13	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
14	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
15	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
16	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
17	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
18	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
19	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
20	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
21	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
22	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
23	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
24	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219

Table A.1: The effects of trade reform with $T = 10\%$.

Time	q_t^x	q_t^z	L_t^x	$\%U_t^x$	L_t^z	$\%U_t^z$	$\%TotU_t$
0	0.9594	0.8860	1146.93	4.061	853.07	11.402	7.192
1	0.7995	0.8860	1146.93	20.051	853.07	11.402	16.362
2	0.8539	0.8222	942.09	14.611	1057.91	17.784	16.289
3	0.8320	0.8436	1021.36	16.804	978.64	15.637	16.233
4	0.8399	0.8357	992.14	16.006	1007.86	16.433	16.221
5	0.8370	0.8386	1002.88	16.297	997.12	16.141	16.219
6	0.8381	0.8375	998.95	16.190	1001.05	16.247	16.219
7	0.8377	0.8379	1000.38	16.229	999.62	16.208	16.219
8	0.8379	0.8378	999.86	16.215	1000.14	16.223	16.219
9	0.8378	0.8378	1000.05	16.220	999.95	16.217	16.219
10	0.8378	0.8378	999.98	16.218	1000.02	16.219	16.219
11	0.8378	0.8378	1000.01	16.219	999.99	16.219	16.219
12	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
13	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
14	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
15	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
16	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
17	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
18	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
19	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
20	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
21	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
22	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
23	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
24	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219
25	0.8378	0.8378	1000.00	16.219	1000.00	16.219	16.219

Table A.2: The effects of trade reform with $T = 20\%$.

Time	q_t^x	q_t^z	L_t^x	$\%U_t^x$	L_t^z	$\%U_t^z$	$\%TotU_t$
0	0.8939	0.8563	1077.85	10.615	922.15	14.367	12.345
1	0.8126	0.8563	1077.85	18.741	922.15	14.367	16.724
2	0.8377	0.8235	970.43	16.227	1029.57	17.649	16.959
3	0.8280	0.8327	1009.66	17.198	990.34	16.735	16.969
4	0.8311	0.8296	996.85	16.892	1003.15	17.042	16.967
5	0.8301	0.8306	1001.02	16.991	998.98	16.943	16.967
6	0.8304	0.8303	999.67	16.959	1000.33	16.975	16.967
7	0.8303	0.8304	1000.11	16.969	999.89	16.964	16.967
8	0.8303	0.8303	999.97	16.966	1000.03	16.968	16.967
9	0.8303	0.8303	1000.01	16.967	999.99	16.967	16.967
10	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
11	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
12	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
13	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
14	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
15	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
16	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
17	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
18	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
19	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
20	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
21	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967
22	0.8303	0.8303	1000.00	16.967	1000.00	16.967	16.967

Table A.3: The effects of trade reform with $T = 10\%$, $y = 0.8$.

Time	q_t^x	q_t^z	L_t^x	$\%U_t^x$	L_t^z	$\%U_t^z$	$\%TotU_t$
0	0.7948	0.9341	976.37	20.521	1023.32	6.586	13.390
1	0.7225	0.9341	976.37	27.746	1023.32	6.586	16.918
2	0.7403	0.8952	908.55	25.974	1091.20	10.476	17.517
3	0.7339	0.9071	932.25	26.615	1067.47	9.289	17.366
4	0.7358	0.9032	924.48	26.418	1075.25	9.679	17.418
5	0.7352	0.9045	926.97	26.484	1072.76	9.552	17.401
6	0.7354	0.9041	926.14	26.463	1073.59	9.593	17.406
7	0.7353	0.9042	926.41	26.470	1073.32	9.579	17.404
8	0.7353	0.9042	926.32	26.468	1073.41	9.584	17.405
9	0.7353	0.9042	926.35	26.469	1073.38	9.582	17.405
10	0.7353	0.9042	926.34	26.469	1073.39	9.583	17.405
11	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
12	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
13	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
14	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
15	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
16	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
17	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
18	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
19	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
20	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
21	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405
22	0.7353	0.9042	926.34	26.469	1073.39	9.582	17.405

Table A.4: The effects of trade reform with $T = 10\%$, $\sigma_{xx} = 1$, and $\sigma_{zz} = 2$.

Time	q_t^x	q_t^z	L_t^x	$\%U_t^x$	L_t^z	$\%U_t^z$	$\%TotU_t$
0	0.9671	0.7513	1123.37	3.294	876.41	24.869	12.750
1	0.8791	0.7513	1123.37	12.086	876.41	24.869	17.688
2	0.9130	0.7308	1055.74	8.699	943.98	26.925	17.302
3	0.9012	0.7369	1079.06	9.879	920.68	26.314	17.445
4	0.9051	0.7348	1071.47	9.488	928.26	26.516	17.392
5	0.9039	0.7355	1073.99	9.614	925.74	26.452	17.409
6	0.9043	0.7353	1073.19	9.572	926.54	26.474	17.403
7	0.9041	0.7353	1073.45	9.586	926.28	26.467	17.405
8	0.9042	0.7353	1073.37	9.581	926.36	26.469	17.405
9	0.9042	0.7353	1073.40	9.583	926.33	26.468	17.405
10	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
11	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
12	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
13	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
14	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
15	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
16	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
17	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
18	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
19	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
20	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
21	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405
22	0.9042	0.7353	1073.39	9.582	926.34	26.469	17.405

Table A.5: The effects of trade reform with $T = 10\%$, $\sigma_{xx} = 2$, and $\sigma_{zz} = 1$.

Time	q_t^x	q_t^z	L_t^x	$\%U_t^x$	L_t^z	$\%U_t^z$	$\%TotU_t$
0	0.8991	0.8626	1077.06	10.086	922.94	13.741	11.773
1	0.8589	0.9063	1077.06	14.114	922.94	9.366	11.923
2	0.8910	0.8736	969.65	10.905	1030.35	12.637	11.797
3	0.8791	0.8854	1011.08	12.089	988.92	11.457	11.777
4	0.8834	0.8811	995.96	11.658	1004.04	11.887	11.773
5	0.8819	0.8827	1001.47	11.814	998.53	11.731	11.772
6	0.8824	0.8821	999.47	11.757	1000.53	11.787	11.772
7	0.8822	0.8823	1000.19	11.778	999.81	11.767	11.772
8	0.8823	0.8823	999.93	11.770	1000.07	11.774	11.772
9	0.8823	0.8823	1000.03	11.773	999.97	11.772	11.772
10	0.8823	0.8823	999.99	11.772	1000.01	11.773	11.772
11	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
12	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
13	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
14	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
15	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
16	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
17	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
18	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
19	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
20	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
21	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
22	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
23	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772
24	0.8823	0.8823	1000.00	11.772	1000.00	11.772	11.772

Table A.6: Replacing the tariff by a wage-cost subsidy in both sectors.