Terms of Trade Shocks and Endogenous Search Unemployment: A Two-sector Model with Non-Traded goods

Yu Sheng[†] Xinpeng Xu[†‡]

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Keywords: two-sector search model; trade and unemployment; non-traded good.

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I. Introduction

Significant progress has been made in the past few decades towards liberalizing trade, and nations now have been integrating more with each other than ever before. One important implication of this trend of liberalization and integration is that many countries, in particular those small open economies, are now subject to more frequent shocks from international market, with terms of trade shocks being the most prominent. There is increasing public concern on how the variations in terms of trade may affect unemployment (Edwards 1986, Fernandez 1992, Matusz 1994, and Mendoza 1997). Do short-term fluctuations of terms of trade for manufactured goods (Backus and Crucini 2000) and the long-term declining terms of trade of primary goods (Zanias 2005) lead to higher unemployment? If yes, would trade protection be an effective tool to deal with the unemployment problem? The key to answering these questions lies in a better understanding of the mechanism through which terms of trade shocks affect unemployment.

There have been numerous studies on the economic impact of terms of trade shocks, yet little is known about how changes in terms of trade affect domestic unemployment. Traditional trade models assuming full employment and perfectly competitive labor markets are simply not well equipped to answer questions about unemployment. Although there are some early attempts to model the impact of terms of trade shocks on unemployment (Brecher 1974, 1992), the typical assumption is a labor market featuring higher than equilibrium wages that leads to unemployment.

The recent development of micro-based models of unemployment has emphasized that unemployment may arise endogenously as a result of labor market frictions as it

takes time and other resources for the unemployed to find jobs and for firms to fill vacancies (McCall 1970, Diamond 1982, Mortensen 1982 and Pissarides 1985). This contrasts with the assumption in classical equilibrium theory where a smooth and instantaneous adjustment in, for example the wage, a centralized labor market will always lead to full employment. Emphasis on labor market frictions and the development of search theory (Pissarides 2000), along with other micro-based models of unemployment, make it possible to study the problem of unemployment in a general equilibrium framework.

In a pioneering work that integrates search theory into a traditional general equilibrium model, Davidson, et al (1988) developed a two-sector model with search unemployment in one sector. The introduction of search unemployment into the two-sector model leads to inefficient equilibria and changes the basic relationship between factor rewards and commodity prices compared with that in a frictionless economy. This, for the first time, provides a framework that is very much in the spirit of the neoclassical two-sector model, yet allows for frictional unemployment, to examine some employment related economic issues, such as the incidence of income taxation, the effects of employment protection, and the impact of minimum wage laws.

Davidson et al (1999) took up the issue – the impact of trade on unemployment – by developing a two-good and two-factor (2×2) model with search unemployment in a special two country setting where a relatively capital-abundant large country trades with a small, relatively labor-abundant country and trade liberalization leads to specialization for the small country while the large country remains diversified. As it takes time for unemployed factors (capital and labor) to find each other and start a productive partnership, the characteristics of labor market institutions such as the degree of efficiency of job search and job dissolution (search technology) matter for unemploy-

ment. In this special setting, Davidson et al (1999), followed by Davidson and Matusz (2004), were able to derive a result that explicitly links trade to unemployment, whereby trade between a small country and a capital-abundant large country with a relatively more efficient search technology increases the aggregate unemployment rate in the large country. Nevertheless, the impact of terms of trade shocks on unemployment was not modeled explicitly.

In a similar vein, Hosios (1990) also develops a two-sector, two-factor general equilibrium model with labor market search frictions featuring the Nash Non-Cooperative Bargaining surplus sharing rule that is constrained Pareto efficient. However, Hosios' (1990) focuses are mainly on the impact of changes in terms of trade on income distribution, as well as changes in factor endowment on sectoral output. A recent attempt made by Walde and Weiss (2006) extends Pissarides (2000) model to a two-sector case, which explicitly accounts for the effects of changes in the relative product price on wages and unemployment of a small open economy. They show that a decrease in the world relative price leads to an increase in the unemployment, while the employment effect of relative price changes disappears if workers hold all of the bargaining power in a specific factor model.

The objective of our paper is to investigate the mechanism through which the variations of terms of trade impact on unemployment in a small open economy with non-traded goods. Differing from previous studies, our two-sector search model distinguishes between the traded and non-traded sectors. To keep the model tractable, we endogenize search unemployment using the theory of optimal stopping rules (McCall 1970), which links unemployment with workers' expected lifetime income through their reservation productivity (Pissarides 2000, p. 37). This simple model allows us to show analytically

how an improvement in the terms of trade leads to a reduction in the unemployment rates in both the traded and non-traded sectors, while deterioration in terms of trade increases the unemployment rates in both sectors.

The structure of the paper is as follows - in the next section we develop a two-sector model that distinguishes between the traded and non-traded sectors and endogenizes sectoral search unemployment. The third section applies the two-sector search model with non-traded goods to examine how changes in the terms of trade affect search unemployment. The final section concludes.

II. A Two-sector Search Model with Non-traded Goods

Consider an economy that produces three goods: two intermediate goods and one final consumption good. Intermediate goods are produced by using workers when they are matched with job vacancies.[1]and the final consumption good is produced by using the two intermediate goods; that is, the traded and non-traded intermediate goods denoted by subscripts T and N, respectively. Both the traded intermediate goods and final consumption goods can be traded internationally. The production technology for the final consumption good takes a constant elasticity of substitution (CES) form:

$$q = [\tau(q_T^D)^\rho + (1-\tau)(q_N^D)^\rho]^{1-\rho}, \qquad (\rho \succ 0) \tag{1}$$

where q is the output of the final consumption good, and is the demand for intermediate

[1]Although we exclude capital in our discussion, we do have two factors to search: vacancy and unemployed worker. There are broadly two approaches in the literature in modeling job search with capital. Davidson et al (1988) unified vacancies and capital while Pissarides (2000, pp. 23) demonstrates that vacancy and capital can be separated and the inclusion of capital will not altered the essential feature of the unemployment model. We follow the latter to simplify the model. See the conclusion section for more discussion.

goods in sector i ($i = T, N$). The elasticity of substitution between the traded and non-traded intermediate goods is $1/(1-\rho)$, and τ parameterizes the relative importance of traded intermediate goods.

There is a continuum of infinitely lived, risk-neutral and homogenous workers with measure normalized to 1, who provide labor services for producing intermediate goods as a worker. We further assume that the proportion of workers in the traded sector is $\mu \in (0,1)$, and that in the non-traded sector is then $(1-\mu)$.

Workers' preferences are assumed to be defined over the final consumption good alone. Following Pissarides (2000, p. 77), it is also assumed that consumption is undertaken based on a household with Z members (which is large enough) so that each worker can smooth his risk with other family members. This assumption ensures the homogeneous preference of individuals. Time is continuous and the discount factor is $r \in (0,1)$.

Workers in either the traded or non-traded sector may be in one of two states: employed or unemployed. If workers are employed, they will earn a wage, which is equal to their marginal product value ($p_i x$), where p_i is the relative price of intermediate goods in sector i in terms of final consumption good whose price is normalized to 1, and $x \in (0, \overline{x})$ is a worker's productivity (or unit output per employed worker).[2] A worker's productivity is assumed to be a random variable, which may be interpreted as follows: although workers are homogeneous, they can have different productivity when they are combined with different job positions. The difference in productivity may be associated with a difference in the technology of each job vacancy. Assume

[2] Since we assume that workers are both firms' owners and employees, wage is equal to the value of firms' output. This can be seen as an extreme case of the Non-Cooperative Nash Bargaining solution (Pissarides, 2000).

that a worker's productivity x comes from an exogenous distribution, characterized by a cumulative density function $F(X)$ defined by $prob\{x \leq X\} = F(X)$, where x is assumed to be non-negative $F(0) = 0$, non-decreasing, and continuous from the right with $F(\infty) = 1$. It is further assumed that workers' productivity is bounded (i.e., $\overline{x} \prec \infty$ such that $F(\overline{x}) = 1$). The relative price of sectoral goods p_i is assumed to be determined by international market (small country assumption). If workers are unemployed, they will receive unemployment subsidy b, which can be more generally interpreted as also including the imputed return from any unpaid leisure activities, such as home production or recreation.

Since workers' expected income from employment is usually more than that from unemployment, unemployed workers are always active in job searching. Given that unemployed workers and job vacancy meet each other with the exogenous arrival rate (a_i), unemployed workers decide whether to accept job opportunities by using the optimal 'stopping' strategy: there exists a reservation wage $\overline{w} = p_i x_i^R$, where x_i^R is defined as a worker's reservation productivity similar to Pissarides (2000, p.37), but from the perspective of workers rather than firms, such that unemployed workers may accept the first job opportunity available with a value higher than reservation wage $\overline{w}$ or with a productivity higher than his reservation productivity x_i^R, given exogenous sectoral price p_i. Meanwhile, all jobs in sector are assumed to end at exogenous job destruction rate λ_i.

We assume that newly unemployed workers can freely choose which sector to search but once they make the decision to search in a particular sector, they will continue searching in the sector so that the unemployed worker is counted towards the unemployment in that sector. In other words, unemployed workers, job vacancies and job

matching processes are assumed to be sector specific though the two sectors are connected through mobility of unemployed workers (similar to the assumption of Hosios, 1990, p. 329).

We first consider a representative unemployed worker, who is searching for a job in sector i. Let U_i and V_i denote the present value of the expected income stream when unemployed and employed, respectively. If it is assumed that the worker can meet a job opportunity at a random future time s ($s \sim \varepsilon(t)$), and determine whether to match it when the first work opportunity arrives, income when unemployed can be defined as:[3]

$$U_i = E[\int_0^s e^{-rt} b dt + e^{-rs} E_i], \qquad \forall i = T, N \tag{2}$$

where the probability of being employed has been included within the expectation operator $E[\bullet]$.

Unemployed workers will maximize the present value of the expected income stream with 'optimal choice'. If it is assumed that the time span that the unemployed worker spends in looking for job opportunities follows an exponential distribution $\exp[-\int_0^s a_i(t)dt]$, the unemployed worker's flow (per period) income can be derived as a Bellman equation:

$$rU_i = b + \int_{x_i^R}^{\overline{x}} [E_i(x) - U_i] dF(x), \qquad \forall i = T, N. \tag{3}$$

We now turn to a representative employed worker whose decision making is also based on maximizing the present value of his expected income stream. If it is assumed that any existing job will end up with a probability λ_i at a future time s' ($s' \sim \varepsilon(t)$), the employed worker's present value of his expected income stream can be written as:

[3] See Mortenson and Pissarides (1999) for details.

$$E_i = E[\int_0^{s'} e^{-rt} w_i dt + e^{-rs'} U_i], \qquad \forall i = T, N. \tag{4}$$

Given that an employed worker's income is a function of productivity, $E_i = E_i(x)$ (since an employed worker's wage is $w_i = p_i x$), the worker's flow (per period) income can be derived as a Bellman equation:

$$rE_i(x) = p_i x + \lambda[U_i - E_i(x)], \qquad \forall i = T, N. \tag{5}$$

Equations (3) and (5) are two fundamental equations in the theory of search. They can be interpreted as the 'asset value' in a perfect capital market with risk-free interest rate r, with the assets being the unemployed worker's human capital in (3), and the employed worker's human capital in (5), respectively. Equations (3) and (5) show that employed workers' (or unemployed workers) present value of expected income is always equal to their current income plus opportunity costs (revenue) from possibly being unemployed (or employed) in the future.

Combining equations (3) and (5) and using the 'individual rationality' condition ($E_i(x_i^R) = U_i$), the relationship between a worker's reservation productivity and the relative price of sectoral intermediate goods can be written as:

$$x_i^R - \frac{a_i}{r + \lambda} \int_{x_i^R}^{\overline{x}} [1 - F(x)] dx = \frac{b}{p_i}, \qquad \forall i = T, N. \tag{6}$$

Equation (6) is the key equation in our model. It characterizes the determination of the reservation productivity x_i^R given the sectoral relative price, and has the familiar interpretation as an optimal problem of an unemployed worker making the decision as to whether to accept an offer or to wait for better offers. To see it more clearly, we can rearrange (6) to give $p_i x_i^R - b = \frac{p_i a_i}{r+\lambda} \int_{x_i^R}^{\overline{x}} [1 - F(x)] dx$. The left side, $p_i x_i^R - b$, is the cost

of searching one more time when an offer with wage $p_i x_i^R$ is in hand. The right side is the expected benefit of searching one more time in terms of the expected present value associated with drawing $p_i x_i \succ p_i x_i^R$, with effective discount rate being $r + \lambda_i$, which takes into account the probability that the job is destroyed. Thus, the agent's optimal decision is to set reservation productivity x_i^R so that the cost of searching one more time equals the benefit.

Figure 1. The Determination of A Worker's Reservation Productivity

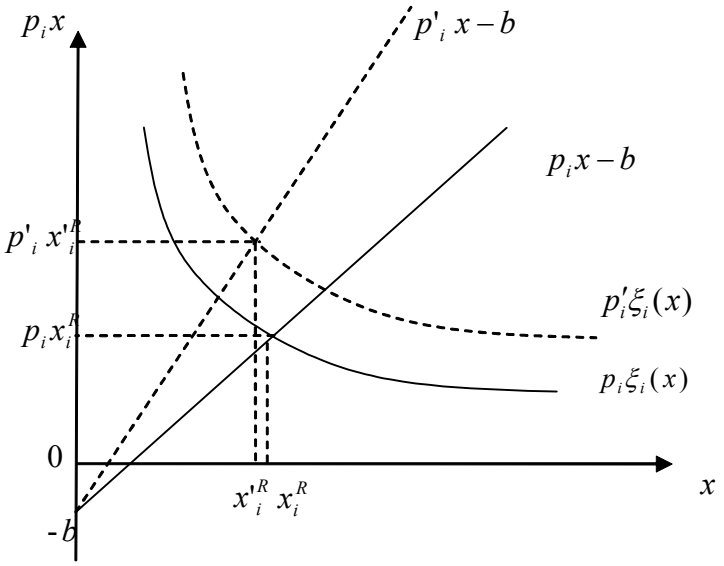


Figure 1 plots two curves, an upward sloping linear curve representing the cost of searching one more time $(p_i x - b)$ with slope p_i and intercept $-b$, and a convex curve representing the expected benefit of searching one more time $p_i \xi_i(x)$, where $\xi_i(x) = \frac{a_i}{r+\lambda} \int_{x_i^R}^{\overline{x}} [1 - F(x)] dx$. The intersection of the two curves determined uniquely a worker's reservation productivity in sector i, x_i^R.

An increase in the relative sectoral prices p_i will exert an impact on both the cost

and benefit of searching one more time, which shifts the cost curve to the left and the benefit curve to the right. Whether the new reservation productivity $x_i'^R$ would be lower or higher than the old x_i^R depends on the degree of relative shifts of both cost and benefit curves after the price shocks. From (6), we know that $x_i^R \succ \xi_i(x)$; hence, an increase in p_i will lead to an increase in the cost of searching one more time by $p_i x$, and an increase in benefit by $\triangle p_i \xi_i(x)$, if a worker's reservation productivity remains unchanged. Intuitively, at the initial reservation productivity x_i^R the increase in cost of searching one more time clearly outweighs the increase in benefit for searching one more time after the price shock, which violates the worker's optimization rule. Consequently, the worker adjusts down his reservation productivity to $x_i'^R$ so that at the new price p_i' the optimal stopping rule still applies. To put it another way, when the price of sectoral goods (p_i) increases, the expected present value of job offers faced by unemployed workers in the same sector ($E_i(x)$) increases. Thus, a job offer which generates lower productivity and will be rejected at initial price p_i can now be accepted. Therefore, we established that the employed worker's reservation productivity in sector (x_i^R) is a decreasing function of the relative price of sectoral goods (p_i), $dx_i^R/dp_i \prec 0$, if $F(x)$ is assumed to be non-degenerate. This is summarized in Lemma 1.

Lemma 1 *An increase (decrease) in the relative price of sectoral goods p_i reduces (increases) workers' reservation productivity in that sector.*

In equilibrium, job creation should be equal to job destruction for each sector, with search unemployment in sector being written as:

$$u_i = \frac{\lambda_i}{\lambda_i + a_i[1 - F(x_i^R)]}, \qquad \forall i = T, N. \tag{7}$$

Equation (7) shows that the search unemployment rate in sector i is increasing

with respect to job destruction rate (λ_i) and employed worker's reservation productivity (x_i^R), while decreasing with respect to the probability of an unemployed worker encountering a job opportunity (a_i). This is closely related to the well-known Beveridge relation (Beveridge, 1944), which combined with (6), determines sectoral search unemployment in both the traded and non-traded sectors.

As it is assumed that there is no cost for unemployed workers to move across sectors, unemployed workers in both the traded and non-traded sectors expect the same reward in equilibrium, i.e., $rU_T = rU_N$. This provides a crucial link between the equilibria of sectoral search employment in the traded and non-traded intermediate sectors, that is,

$$p_T x_T^R = p_N x_N^R. \tag{8}$$

Equation (8) suggests that in equilibrium unemployed workers are indifferent to choosing which sector to search from as they expect the same expected present value from employment in any sector. However, since their sectoral wages can be different (due to different price of sectoral intermediate goods and workers' productivity), their duration of unemployment (or the unemployment rates in different sectors) can be different, a result which also arises in efficiency wage models (Shapiro and Stiglitz 1984). Thus, search unemployment in our two-sector model with non-traded goods can be uniquely determined.

The balance of payments is made between the traded intermediate goods and the final consumption goods, $p_T M_T = q - c$, where q and c denote domestic production and consumption of final goods, respectively, and p_T is exogenous due to the small country assumption. If the economy exports (imports) traded intermediate goods, it will import (export) final consumption goods. Thus, p_T can be regarded as the economy's terms

of trade, and the quantity of the final consumption goods (q) can be normalized to 1.

Finally, the production functions for sectoral goods can be written as the product of employed workers' productivity and sectoral unemployment. The market clearing condition holds for both traded and non-traded intermediate goods in equilibrium. For traded intermediate goods, net import is equal to domestic demand minus domestic supply, and for non-traded intermediate goods, domestic demand is equal to domestic supply. Market clearing conditions for traded intermediate goods and non-traded intermediate goods can be specified as follows:

$$M_T = (\frac{\tau}{p_T})^{\frac{1}{1-\rho}} - \mu(1-u_T)\int_{x_T^R}^{\overline{x}} x dF(x), \tag{9}$$

$$(\frac{1-\tau}{p_N})^{\frac{1}{1-\rho}} = (1-\mu)(1-u_N)\int_{x_N^R}^{\overline{x}} x dF(x). \tag{10}$$

where M_T represents the net import of traded intermediate goods.

The equilibrium of the two-sector search model with non-traded goods depends on three groups of conditions: sectoral search unemployment conditions ([6] and [7]); no-arbitrage condition across sectors ([8]); and product market clearance conditions ([9] and [10]). Although simultaneous equations (6)-(10) cannot be solved explicitly, one can easily prove the existence and the uniqueness of equilibrium solution in the model. For simplicity, assume a worker's sectoral productivity x_i is a uniform distribution with support at the unit interval [0, 1] (Ljungqvist and Sargent 2005). Substituting (6) and (7) into (9) and (10), one can get:

$$M_T = (\frac{\tau}{p_T})^{\frac{1}{1-\rho}} - \frac{1}{2}\mu\frac{a_T(1-x_T^R)}{\lambda_T + a_T(1-x_T^R)}[1-(x_T^R)^2], \tag{11}$$

$$0 = (\frac{1-\tau}{p_N})^{\frac{1}{1-\rho}} - \frac{1}{2}(1-\mu)\frac{a_N(1-x_N^R)}{\lambda_N + a_N(1-x_N^R)}[1-(x_N^R)^2]. \quad (12)$$

Since (6) defines the monotonic decreasing relationship between p_T and x_T^R ($dx_T^R/dp_T \prec 0$), and (11) defines the monotonic increasing relationship between p_T and x_T^R ($dx_T^R/dp_T \succ 0$), when we control the relative scale of the traded sector μ,[4] there exists a unique combination of sectoral relative price (p_T) and employed workers' reservation (x_T^R) in the traded sector. By the same token, (6) and (12) uniquely determine the combination of sectoral relative price and a worker's reservation productivity in the non-traded sector. Combining the two sectoral equilibria with the no-arbitrage condition for unemployed workers across sectors ([8]), the relative scale of the traded sector can then be uniquely determined. Thus, the general equilibrium solution for the two-sector search trade model with non-traded intermediate goods exists and can be uniquely determined.[5]

III. Terms of Trade Shocks and Unemployment

The two-sector model with non-traded goods and endogenous search unemployment that we outlined in the previous section sets up the link between terms of trade shocks, worker's reservation productivity and the determination of employment. This provides a framework to analyze the impact of terms of trade shocks on search unemployment in a frictional labor market.

Lemma 2 *An improvement (deterioration) in the terms of trade will result in a larger (smaller) labor force adhered to the traded sector .*

[4] This condition ensures that M_T and μ are not changing, so that the relationship between p_T and x_T^R in (11) could be specified clearly.

[5] This result can be easily extended to a general case where the cumulative distribution function of workers' productivity is assumed to take a non-degenerate form (See Appendix for discussion).

Proof. Equation (12) can be rearranged as: $\mu = 1 - 2(\frac{1-\tau}{p_N})^{\frac{1}{1-\rho}} / \frac{a_N(1-x_N^R)}{\lambda_N + a_N(1-x_N^R)}[1 - (x_N^R)^2]$. Let $\Pi = \frac{a_N(1-x_N^R)}{\lambda_N + a_N(1-x_N^R)}[1-(x_N^R)^2]$,we have $\mu = 1-2(\frac{1-\tau}{p_N})^{\frac{1}{1-\rho}}/\Pi$. Since $d\Pi/dx_N^R \prec 0$, and $dx_N^R/dp_T \prec 0$, we have $d\Pi/dp_T \succ 0$. Thus, given $\Pi \succ 0, d\mu/dp_T = 2 \cdot \frac{(\frac{1-\tau}{p_T})^{1/(1-\rho)} \cdot \tau \cdot \Pi + (\frac{1-\tau}{p_T})^{1/(1-\rho)} \cdot d\Pi/dp_T}{\Pi^2} \succ 0$. ■

The result of Lemma 2 confirms that in our model the conventional channel whereby trade impacts on employment by changing the reallocation of employment across sectors is still operative.

Proposition 1 *An improvement (deterioration) in the terms of trade reduces (increases) search unemployment in the traded sector.*

Proof. From (6), an improvement in the terms of trade (p_T) will decrease workers' reservation productivity in the traded sector (x_T^R). Therefore, we have (see Appendix for a proof):

$$dx_T/dp_T = -\frac{b}{p_T^2[1 + \frac{a_T}{r+\lambda_T}(1 - x_T^R)]} \prec 0. \tag{13}$$

From (7), a decrease in workers' reservation productivity in the traded sector will result in a decrease of search unemployment in equilibrium. Thus, we have (see Appendix for a proof):

$$du_T/dx_T^R = \frac{a_T\lambda_T}{[\lambda_T + a_T(1 - x_T^R)]^2} \succ 0. \tag{14}$$

Combining (13) and (14) and using the 'rule of chains', the relationship between sectoral search unemployment rate (u_T) and terms of trade (p_T) can be written as $du_T/dp_T \prec 0$. That is, an improvement (deterioration) in the terms of trade will reduce (increase) equilibrium search unemployment. ■

Although the implication from Proposition 1 seems to be the same as that from the traditional trade theory, the logic behind them is quite different. Specifically, in traditional trade models, terms of trade shocks affect the determination of employment only by reallocating labor across sectors. Since an increase in the relative price of traded goods may lead to an expansion of the traded sector, the traded sector with a positive price shock may post a gain and a negative one may lose employment. However, in the two–sector search model, terms of trade shocks affect sectoral search employment not only by changing the relative scale of the traded sector, as confirmed in Lemma 2, but also by changing the willingness of workers to search for jobs. The intuition is as follows: since there exists costs for a job search, an increase (or decrease) in the relative price of traded intermediate goods may improve (or reduce) employed workers' expected income (See [6]). Thus, unemployed workers in the traded sector would be more likely to accept job offers even if they have lower productivities than their counterparts in import sectors. Consequently, search employment tends to increase, and vice versa. From this perspective, the relationship between changes in the relative price of traded intermediate goods and the determination of employment, predicted by our two-sector model with search unemployment, encompasses not only inter-sectoral employment reallocation effects but also intra-sectoral employment creation (or destruction) effects, which is consistent with Davidson et al (1999). This establishes an important channel for exploring the trade-employment relationship from the perspective of workers' rational responses to expected income.

Proposition 2 *An improvement (deterioration) in the terms of trade reduces (increases) search unemployment in the non- traded sector.*

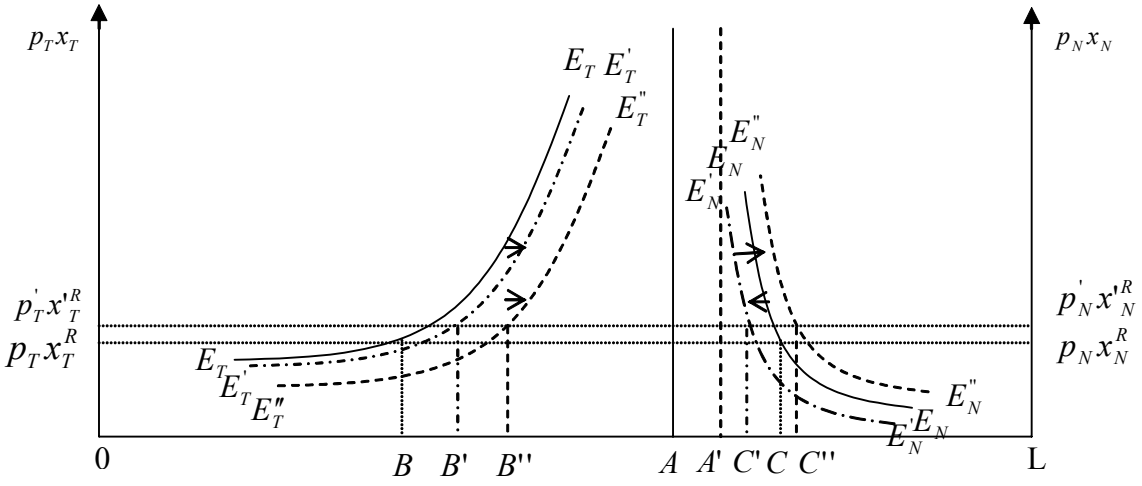
Proof. Given the CES production function (1) for the final consumption goods with fixed output, the relative price of non-traded intermediate goods is positively related to that of traded intermediate goods. That is, $dp_N/dp_T \succ 0$. The reason is that an increase (or decrease) in the relative price of traded intermediate goods increases (or reduces) demand for non-traded intermediate goods, which leads to higher relative prices of non-traded intermediate goods, given the production function of final consumption goods.

From (6), a worker's reservation productivity is negatively related to the relative price of sectoral goods in the non-traded sector. Substituting $dp_N/dp_T \succ 0$ into this condition leads to a worker's reservation productivity being negatively related to the relative price of traded intermediate goods ($dx_N/dp_T \prec 0$). This, combined with $du_N/dx_N^R \succ 0$ (derived from ([7]), shows that the sectoral search unemployment rate in the non-traded sector is negatively related to the relative price of traded intermediate goods (i.e., $du_N/dp_T \prec 0$). That is, changes in search employment in the non-traded sector follow the same direction as that in the traded sector. ■

Proposition 2 establishes the relationship between terms of trade shocks to the traded intermediate goods and the determination of employment in the non-traded sector, and search employment in the non-traded sector tends to go in the same direction as that in the traded sector for given price shocks to traded intermediate goods. The mechanism can be explained as follows: when the relative prices of non-traded intermediate goods increases (reduces) following the increase (decrease) in the relative prices of traded intermediate goods, the expected income of employed workers in the non-traded sector will tend to increase (decrease). Consequently, unemployed workers are more (or less) willing to search for jobs in the non-traded sector and search employ-

ment in the non-traded sector may increase (or decrease). This can be regarded as the 'spill-over' effect of terms of trade shocks on unemployment in the non-traded sector.

Figure 2. Changes in Terms of Trade and Search Unemployment



We illustrate the impact of terms of trade shocks on sectoral search unemployment in Figure 2. Let the horizontal axis denote total labor supply in the economy which has been normalized to 1, with an initial relative scale of the traded and non-traded sectors being μ (or OA/OL) and $1-\mu$ (or AL/OL), respectively. The vertical axis represents the expected value of unemployed workers. From (6), we have that worker's reservation wage $p_i x_i^R$ is decreasing with respect to x_i^R, which together with (7), where sectoral unemployment rate u_i is decreasing with respect to x_i^R, suggests that $p_i x_i^R$ is an increasing function of sectoral search employment, $1-u_i$. Thus, we have $E_T E_T$ and $E_N E_N$ representing the relationship between $p_i x_i^R$ and $1-u_i$ in the traded and non-traded sectors, respectively. Changes in the price of sectoral intermediate goods p_i will result in shifts of both curves, which lead to changes of sectoral search unemployment.

Consider a positive terms of trade shock from p_T to p'_T, where search employment in the traded sector increases from $E_T E_T$ to $E'_T E'_T$, as workers' reservation productivity decreases from x_T^R to $x_T'^R$, with sectoral search unemployment falling from BA to $B'A$. At the same time, an increase in employment in the traded sector will increase the output of traded intermediate goods, and improve the relative price of non-traded intermediate goods, as well as employed workers' expected income in the non-traded sector, both of which tend to reduce search unemployment in the non-traded sector from AC to AC', shifting $E_N E_N$ to $E'_N E'_N$.

Moreover, given the assumption of free mobility of unemployed workers across sectors, a reduction in search unemployment in the traded sector will increase employed workers' expected income in the traded sector, which tends to attract unemployed workers from the non-traded sector flowing into the traded sector. As the traded sector expands, the non-traded sector shrinks, shifting both $E'_T E'_T$ and $E'_N E'_N$ to $E''_T E''_T$ and $E''_N E''_N$ horizontally to the right. In equilibrium, the relative scale of the traded sector increases, from μ (or OA/OL) to μ' (or OA'/OL), and search employments in both the traded and non-traded sectors increase, respectively.

Although both Propositions 1 and 2 are proved to be under the assumption that employed workers' productivities follow a uniform distribution function, it is easy to prove that their validity is independent of this assumption. As long as the distribution of workers' productivity is non-degenerate, most of the foregoing discussion will hold (see Appendix).

IV. Concluding Remarks

In this paper we developed a simple two-sector search model with non-traded goods to explore the impact of changes in terms of trade on search unemployment, a question that has been prominent in discussion among policy makers but has received little attention among international trade theorists, with the exception of, for example, Davidson et al (1988, 1999), among others. To keep the model analytically tractable so that the mechanism through which terms of trade shocks affect unemployment can be crystallized, we have deliberately kept the part on job search theory to a minimal. We extended the inter-temporal job search model of McCall (1970) to a setting of two sectors with non-traded goods and endogenize job search by introducing a worker's reservation productivity, à la Mortensen and Pissarides (1994).

The payoff with such a simple model is powerful results with analytical tractability. We show that changes in terms of trade will not only impact employment by changing the employment reallocation across sectors as in traditional trade models but more importantly, it will affect sectoral search unemployment by changing the expected income of employed workers through affecting their reservation productivity in both the traded and non-traded sectors. Specifically, we show that an improvement (deterioration) of terms of trade reduces (increases) unemployment rates in both traded and non-traded sectors.

Our model can be extended to a full-blown search model along the lines of Diamond-Mortensen-Pissarides' search and matching technology, with two factors, capital and labor. But as with many other models, it comes at a cost. As the model grows more sophisticated, it becomes more and more challenging to arrive at results that

are analytically solvable. Consequently, one has to rely on simulations to discuss the results.

Our model can also be extended along other dimensions. For example, it can be easily extended to discuss the impact of tariff on unemployment. In our model, an increase of tariff would deliver the same result as a negative shock to terms of trade, and will therefore increase unemployment in both traded and non-traded sectors. The effects of unemployment insurance on unemployment can also be addressed in our framework. Finally, we have only focused our analysis on the steady state in this paper and an extension to dynamic adjustment for out-of-steady-state will provide an interesting dimension to the discussion of terms of trade shocks on unemployment. We will leave these for future research.

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Appendix

Some hints for generalizing the assumption of uniform distribution

The existence of general equilibrium of our two-sector search model is independent of the assumption of a worker's productivity taking the form of uniform distribution. As long as we assume that the cumulative distribution function of a worker's productivity is non-degenerative, we have $d\int_{x_i^R}^{\overline{x}}[1-F(x)]dx/dx_i^R \prec 0$ which leads to $dx_T^R/dp_T \prec 0$. Equation (6) and $d\int_{x_i^R}^{\overline{x}}[1-F(x)]dx/dx_i^R \prec 0$ ensure $dx_T^R/dp_T \succ 0$ in (11). We refer readers to a detailed proof in Shimmer (1996).

Proof of equation (13):

Assume that workers' sectoral productivity x follows a uniform distribution function with support on the unit interval [0, 1] (Ljungqvist and Sargent 2005). Substituting $F(x) = x$ into (6), we have: $2x_i^R - \frac{a_i}{r+\lambda_i}(1-x_i^R)^2 = \frac{2b}{p_i}$.

Let $G = 2x_i^R - \frac{a_i}{r+\lambda_i}(1-x_i^R)^2 - \frac{2b}{p_i}$, then $dp_T/dx_T^R = -(\partial G/\partial x_T^R)/(\partial G/\partial p_T)$. Since $\partial G/\partial x_T^R = 2 + 2\cdot\frac{a_T}{r+\lambda_T}(1-x_T^R)$ and $\partial G/\partial p_T = 2b/p_T^2$, we have $dx_T^R/dp_T = -\frac{p_T^2\cdot[1+\frac{a_T}{r+\lambda_T}(1-x_T^R)]}{b} \prec 0$, where $x_T^R \prec 1$. ■

Proof of equation (14):

As workers' sectoral productivity follows a uniform distribution, equation (7) can be written as: $u_i = \frac{\lambda_i}{\lambda_i + a_i(1-x_i^R)}$.

Taking the first derivative of u_i with respect to x_i^R, we have $du_i/dx_i^R = \frac{a_T\lambda_T}{[\lambda_T+a_T(1-x_T^R)]^2} \succ 0$, $\forall i = T, N$. ■