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Tariffs, Unemployment, and the Current Account: An Intertemporal Equilibrium Model

Shouyong Shi

Department of Economics
Queen’s University
94 University Avenue
Kingston, Ontario, Canada
K7L 3N6

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Shouyong Shi
Department of Economics
Queen's University
Kingston, Ontario, Canada, K7L 3N6
e-mail: shi@qed.econ.queensu.ca
phone: (613) 545-6660

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Abstract

This paper integrates labor market search into an intertemporal equilibrium model to analyze the dynamic macroeconomic effects of a tariff. The search friction creates a wedge between the marginal product of labor and the product wage, although wages are perfectly flexible. The model captures the intuitive argument in the earlier literature that a permanent increase in the tariff improves the country's terms of trade, which tends to reduce the product wage and stimulates labor demand. However, the tariff also increases the price of the consumption goods bundle and reduces the marginal utility of wealth measured by imports. This consumption bundle effect raises the reservation wage and the product wage. When the consumption smoothing motive is realistically strong, the consumption bundle effect of the tariff dominates the direct product effect, reducing employment in both the short-run and the long-run. Thus, even with the presence of the search friction and unemployment, raising tariffs is not the means in which a government in a small open economy can increase employment.

Keywords: tariffs, employment, search, vacancy, terms of trade, current account.

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1. Introduction

The idea that raising tariffs can raise employment and output has often been publicly debated and sometimes proposed as a policy prescription to reduce unemployment (Cripps and Godley (1978)). This positive "employment effect" of tariffs found support in the earlier literature that assumed *ad hoc* savings functions and rigid nominal wages. The argument is straightforward. A tariff shifts demand from the import to the domestic good and so improves the country's terms of trade. When the nominal wage is rigid, the terms-of-trade improvement reduces the wage measured in the domestic good – the product wage. Labor demand thus increases to absorb some of the unemployed workers, resulting in higher employment.

This argument depends on the controversial assumption of nominal wage rigidity. If wages are instead fully indexed to a consumer price index, the nominal wage must rise in the same proportion as the price index does in response to a tariff. Since the price index typically increases in response to a tariff by more than the terms of trade do and since the product wage is measured in the domestic good only, the product wage rises and so employment falls (see van Wijnbergen (1987)). The negative employment response is even stronger when the labor supply is elastic, in which case the rise in the price index induces the substitution from consumption goods to leisure (Sen and Turnovsky (1989)).

Even if nominal wages are somehow rigid, the employment effect of tariffs through the product wage is limited, provided that the product wage equals the marginal product of labor. When agents optimally accumulate wealth and preferences are time-additive, the long-run marginal product of capital is equal to the exogenous subject discount rate and so the long-run capital ratio is exogenous. If the product wage is equal to the marginal product of labor, its long-run level must then be exogenous, irrespective of the tariff.[1] For these reasons, the later literature with intertemporal maximizing agents has found very little support for tariffs as a macroeconomic stimulus.[2]

[1] If preferences are not time-additive but instead recursive in the Uzawa-Epstein fashion, a tariff produces a negative effect on employment that is even stronger than in a time-additive model. See Obstfeld (1982) and Shi (1994) for applications of the Uzawa-Epstein preference in open economies.

[2] There are two other objections to the positive employment effect. One is the possibility of retaliation (see section 5). The other is Mundell's (1961) result that an improvement in the terms of trade induced by tariffs increases savings via the Laursen-Metzler effect, reduces aggregate demand and output (see Eichengreen (1981) for more discussions

Both the earlier literature and the later one have left open an important question: Can tariffs increase employment when some labor market friction other than nominal wage rigidity enables the product wage to deviate permanently from the marginal product of labor? This is the question which the current paper intends to answer. The question is interesting because, when the product wage deviates from the marginal product of labor, tariffs may have a permanent effect on the product wage. If a positive employment effect of tariffs is rejected in such an economy, the rejection is more robust than in an economy without such frictions.

This paper constructs an intertemporal maximizing model where unemployment is generated by a search friction in the labor market, as formulated by Mortensen (1982a, b) and Pissarides (1990). That is, firms must maintain vacancies in order to hire workers and unemployed workers must search in order to find a job. The search friction generates a gap between the marginal productivity of labor and the product wage. The difference between the two is the firm's surplus from hiring, which must be positive in order to compensate for the firm's hiring (vacancy) cost. The product wage, determined by Nash bargaining between the firms and the worker, is a weighted sum of the marginal product of labor and a reservation wage which equals the marginal rate of substitution between consumption and leisure. Although wages are perfectly flexible and agents optimally accumulate wealth, tariffs can permanently affect the product wage by changing the reservation wage.

There are two ways in which a tariff affects the reservation wage in the current model. One corresponds to the above mentioned channel through the terms of trade, which will be referred to as the *direct product wage effect* of tariffs. That is, a tariff increases the price of the domestic good and so reduces the product wage. The second corresponds to a reduction in the marginal value of wealth, which will be referred to as the *consumption bundle effect* of tariffs. That is, a tariff increases the price of the goods bundle, both directly through the import price and indirectly through the terms-of-trade improvement, which reduces the marginal value of wealth measured in the import and raises the marginal rate of substitution between leisure and consumption (i.e., the reservation wage).

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and references.)

The two effects of the tariff are opposite to each other and the relative strength depends on the elasticity of intertemporal substitution. The consumption bundle effect dominates the direct product wage effect when the elasticity of intertemporal substitution is small, in which case consumption varies very little in response to the higher price, leaving the marginal value of wealth to fall significantly and the product wage to rise. With realistic values of the elasticity of intertemporal substitution, the overall effect of the tariff is to raise the product wage in both the long run and the short-run. Thus, the presence of the search friction and unemployment is insufficient for supporting a predominant, positive employment effect for the tariff.

The search approach to unemployment is chosen here because it matches the statistical definition of unemployment as agents who are searching but have not found a job. It is also tractable in a dynamic optimization environment that involves a long horizon. In contrast to the search models of Pissarides (1990) and Mortensen (1982a,b), this paper integrates labor market search with agents' savings and investment decisions, following recent attempts by Merz (1995), Andolfatto (1996), and Shi and Wen (1994, 1997). The intertemporal framework is necessary for the current examination because, as discussed above, optimal wealth accumulation yields restrictions on the long-run product wage. More importantly, the intertemporal framework endogenizes the reservation wage as the marginal rate of substitution between leisure and consumption. It is through this reservation wage that tariffs affect the product wage and employment.

To emphasize the importance of the search friction, a small open economy is adopted so that the product wage effect of the tariff would be absent in the long run if the friction were eliminated. Without the friction, the model reduces to the one analyzed by Sen and Turnovsky (1989). The intertemporal analysis is related to the voluminous literature on the Laursen-Metzler effect. Since this literature does not directly examine the effect of tariffs, I omit the comparison (see Obstfeld (1982) and Persson and Svensson (1985)). Some trade models also examine unemployment, e.g., Matusz (1986), Fernandez (1992), Brecher (1992), and Neary (1982). The current paper differs from those models in two aspects. First, the current paper focuses on the macroeconomic effects of tariffs. Second, the current paper employs an intertemporal structure, while those models are typically either static or very restrictive on agents' intertemporal decisions.

The remainder of this paper is organized as follows. Section 2 constructs an intertemporal maximization model with labor market search. Section 3 isolates the consumption bundle effect by assuming that the economy faces exogenous terms of trade. Section 4 examines the dynamic effects of tariffs when the terms of trade are endogenous. Section 5 concludes the paper and the appendices provide necessary proofs.

2. Labor Market Search in a Small Open Economy

2.1. Goods and Assets

Consider a small open country that imports a good whose price in the world market is normalized to one. The country imposes a tariff rate τ on imports and the country's residents face an import price $(1+\tau)$. The country produces a single good, called the *domestic good*, which can be consumed and exported. The relative price of the domestic good to the import in the world market is q, which is the country's terms of trade. The assumption of complete specialization in production places the focus of this paper on the aggregate effect of the tariff rather than its sectorial allocative effects. As in Sen and Turnovsky (1989), the country can influence the terms of trade so that tariffs can affect employment through the terms of trade. This influence is captured by an export function, $x(q)$, which satisfies:

$$x'(q) < 0; \quad qx'(q) + x(q) \leq 0. \tag{2.1}$$

The property $x' < 0$ requires that the foreign demand for the country's good is a decreasing function of the price of the good. The property $qx' + x < 0$ states that such demand has an elasticity greater than unity, since the small country's influence on the terms of trade is limited. A special case is $x'(q) = -\infty$, in which case the country faces exogenous terms of trade.

The country consists of many identical households whose size is normalized to one. Households have an unrestricted access to the world good and asset markets. In particular, capital is perfectly mobile across countries and so households can borrow and lend at a constant world interest rate $\rho > 0$. A household's portfolio consists of domestic capital K, measured in terms of domestic goods, and foreign assets F, measured in terms of the import before the tariff. The rental rate of capital is r. Because the terms of trade can vary over time, holding domestic capital yields a capital gain (or loss) $\dot{q}/q$ relative to holding foreign assets. Therefore, the arbitrage between domestic capital and foreign assets yields

$$r + \frac{\dot{q}}{q} = \rho. \tag{2.2}$$

In contrast to capital mobility, labor is immobile across countries.

For the demand for goods, denote a representative household's consumption of the domestic good by d and the consumption of the import by f. To simplify analysis, assume that d and f enter the household's utility function through a linearly homogeneous aggregator $H(d, f)$ that is increasing and concave in each argument.[3] In this case, a household's optimal consumption can be chosen in two stages. First, for any given c (> 0), it is optimal to choose the bundle (d, f) to solve:

$$c \cdot p(q, \tau) \equiv \min_{(d,f)} \{qd + (1+\tau)f : H(d, f) \geq c\}.$$

The function $p(q, \tau)$ defined above is the unit cost (or expenditure) function dual to H, which will be referred to as the price index of the consumption bundle. In the second stage of the consumption choice, c is chosen to maximize intertemporal utility, as described in the next subsection. I will also refer to c as the level of the consumption bundle.

It is well known that $p(q, \tau)$ is increasing and concave in each argument and is linearly homogeneous in $(q, 1+\tau)$. For given c, the demand for goods is:

$$d = c \cdot p_1(p, \tau), \quad f = c \cdot p_2(p, \tau). \tag{2.3}$$

It is reasonable to require that the share of consumption on the domestic good, qp_1/p, be a non-decreasing function of the tariff and a non-increasing function of the terms of trade. That is, $pp_{12} \geq p_1 p_2$ and $pp_1 \leq q(p_1^2 - pp_{11})$. These requirements can be easily satisfied if, for example, H is a Cobb-Douglas aggregator.

2.2. Households

Each household consists of many agents, who are infinitely-lived and each endowed with a fixed flow of time, T. At any given point in time, an agent can choose only one of the following activities:

[3] Linear homogeneity of H implies that the two goods are complementary in the sense $H_{12} > 0$. This implication is plausible and is used by Sen and Turnovsky (1989).

working for wages, searching for a job or enjoying leisure. Agents who are searching for jobs are called unemployed agents. Each unemployed agent is randomly matched with job vacancies according to a matching function described later. Since the timing of a match is random, agents face idiosyncratic risks in income and leisure. This randomness can complicate the analysis by generating distributions of wealth and consumption across agents. To focus on the aggregate behavior, I will assume that each household consists of a continuum of agents with measure T and that all members care only about the household's utility. In this case, individual risks in consumption and leisure are completely smoothed within each household. A similar approach is adopted in the literature of indivisible labor, where employment lotteries are used to smooth the risk across states of employment (see Hansen (1985), Rogerson (1988), and Rogerson and Wright (1988)).[4]

The utility function of a household is

$$U = \int_0^\infty \{u(c) - \beta[n + l(s)]\}e^{-\rho t}dt, \quad \beta > 0, \tag{2.4}$$

where $c = H(d, f)$ is the household's consumption of the bundle, n the size of household members in work, and s the size of unemployed members. The fraction of members in work is n/T and the fraction of members in unemployment is s/T. The labor force participation rate is $(n+s)/T$ and the unemployment rate is $s/(n+s)$. The function $l(s)$ measures the efficiency units of time in search relative to working. Note that the utility function is linear in the hours of work, as implied by the above cited literature on indivisible labor with employment lottery. Also, the rate of time preference equals the international interest rate, which is necessary for consumption to converge to a steady state in a small open economy with a constant rate of time preference.

The function $u(\cdot)$ is assumed to be increasing and concave, with an intertemporal elasticity of substitution $\sigma \equiv -u'(c)/[cu''(c)]$. Hall (1988) and Epstein and Zin (1991) have found that the intertemporal elasticity of substitution is empirically small and below unity. I thus assume $\sigma \leq 1$. I also assume that the search effort is inelastically supplied so that s is fixed at a level s_0 which is normalized to one. The assumption is made for analytical tractability: The model

[4]The approach is also common in other well-known macroeconomic models. For example, in a monetary model, Lucas (1990) assumes that household members go to different markets and pool the receipts.

cannot be analytically solved without this assumption. The assumption should be interpreted as an approximation for the reality that the search effort is indeed much less elastic than vacancy (Layard, et al. (1991)). Accordingly, the qualitative results obtained herein should hold more generally for such economies.[5]

As in other search models, employment in the current model is predetermined at each given time; it changes only gradually as workers quit or unemployed agents find jobs:

$$\dot{n} = ms_0 - \theta n. \tag{2.5}$$

θ is the (constant) rate of job separation and m the rate at which each unemployed agent finds a job. As discussed later, m depends on the ratio of aggregate vacancy to unemployment. However, an individual household takes m as given. With an inelastic search effort, the above description of employment is exogenous to the household, which will be determined by the firm's hiring decision and a wage equation.

A representative household's maximization problem is

$$(PH) \qquad \max_{(c,\dot{F})} U$$

subject to:

$$(2.5) \text{ holds;}$$

$$\dot{F} = \rho F + q(wn + \pi) - pc + L; \tag{2.6}$$

$$F(0) = F_0 \text{ given.}$$

Here π is the dividend to capital (defined later), measured in terms of the domestic good, w is the product wage, and L is the lump-sum rebate of the tariff revenue. The household takes (m, w, π, q, p, L) as given in this maximization problem.

Let ϕ be the current-value shadow price of wealth measured in terms of imports before tariffs. Standard optimization techniques generate:

$$\dot{\phi} = 0 \tag{2.7}$$

[5]Pissarides (1987) makes a similar assumption that $s = 1 - n$ is predetermined. In a search model without tariffs (an earlier version of Shi and Wen (1997)), it is shown that, if the search effort is much more elastic than job vacancy, a permanent productivity increase generates the counter-factual result that the ratio of job vacancy to the number of unemployed agents immediately falls.

$$u'(c) = p\phi. \tag{2.8}$$

The constancy of the rate of time preference requires the shadow value of wealth to be constant over time, as is typical in a small open economy. The marginal utility of consumption of the goods bundle is equal to the value of wealth, evaluated with the price index p. Once c is determined, the demand for each good is given by (2.3).

2.3. Firms

There are many identical firms in the economy. The production function is $G(K, n)$ which is increasing and concave in each argument, and linearly homogeneous. Each firm maintains vacancies in order to hire workers. The cost of maintaining a number v of job vacancies is $B(v)$, assumed to be increasing and convex, with a *vacancy elasticity* $\epsilon = B'(v)/[vB''(v)]$. Let μ be the rate at which a vacancy is matched with an unemployed agent. Like m, the rate μ depends on aggregate vacancy and unemployment, but an individual firm takes μ as given. A firm's employment evolves as follows:

$$\dot{n} = \mu v - \theta n. \tag{2.9}$$

Investment in physical capital incurs adjustment costs, as in Hayashi (1982). For an investment of an amount i, the total cost of investment is $Q(i)$, which has the following properties:

$$Q'(i) > 0,\ Q''(i) > 0,\ Q(0) = 0,\ Q'(0) = 1.$$

An individual firm takes as given the wage rate w offered by other firms. The firm also takes (μ, q, r) as given and maximizes the present value:

$$(PF) \quad \max_{(v,i,n,K)} \quad \int_0^{\infty} \pi(t) e^{-\int_0^{\tau} r(\tau) d\tau}\, dt$$

subject to (2.9) and the following constraints:

$$\pi = G(K, n) - wn - B(v) - Q(i); \tag{2.10}$$

$$\dot{K} = i;$$

$$n(0) = n_0,\ K(0) = K_0 \text{ given.}$$

Let Ψ be the current-value shadow price of an additional worker to the firm and Ω the marginal value of capital. The optimal conditions for (PF) are

$$\Psi = B'(v)/\mu; \tag{2.11}$$

$$\dot{\Psi} = (\theta + r)\Psi - (G_2 - w); \tag{2.12}$$

$$\Omega = Q'(i); \tag{2.13}$$

$$\dot{\Omega} = r\Omega - G_1. \tag{2.14}$$

(2.11) characterizes the firm's optimal decision for vacancy – the investment in employment. It requires the marginal cost of a vacancy, $B'(v)$, to be equal to the marginal benefit, $\mu\Psi$. (2.12) requires the "return" to employment $(\theta+r)\Psi$ to be equal to the sum of the "cash flow" from hiring, $(G_2 - w)$, and the capital gain, $\dot{\Psi}$. (2.13) and (2.14) are similar conditions for the investment in physical capital.

I will refer to the difference $(G_2 - w)$ as the firm's surplus from hiring. In contrast to a typical neoclassical model, the marginal product of labor here must exceed the wage rate in order to give firms a positive surplus from hiring that compensates for the hiring cost. If $G_2 = w$, the shadow price of an additional worker to the firm would be zero in the steady state so that vacancies and employment would be zero in the steady state (see (2.12)).

2.4. Matching and Wage Determination

Vacancies and unemployed agents are randomly matched with each other. However, aggregate job matches are deterministic and given by a matching function. To economize on notation, let us use the same symbols v and s_0 $(= 1)$ to represent aggregate vacancies and unemployment. The flow of job matches is:

$$M(v, s) = M_0 v^\alpha s_0^{1-\alpha}, \qquad \alpha \in (0, 1), \tag{2.15}$$

where M_0 is a positive constant. The matching technology exhibits constant returns-to-scale. Besides its apparent similarity to the usual production technology, such matching technology is empirically supported (see Pissarides (1986) and Blanchard and Diamond (1989)). The Cobb-Douglas form is adopted for analytical simplicity. With the normalization $s_0 = 1$, we have:

$$m \equiv M/s_0 = M_0 v^{\alpha}, \qquad \mu \equiv M/v = m/v. \tag{2.16}$$

Note that the matching rate for vacancy, μ, is a decreasing function of v. Also, $\mu v = m$ so that the two laws of motion for n, (2.5) and (2.9), coincide in equilibrium.

Once an unemployed agent is matched with a vacancy, the agent and the firm negotiate the agent's current and future wage rates. The outcome is determined by Nash bargaining which maximizes the weighted surpluses of the household and firm. To be precise, let t_0 be the time when a match is created. Denote by $\{\hat{w}(t)\}_{t \geq t_0}$ the path of wage rates to be determined for the new worker, conditional on the continuation of the agent's employment. Having an additional member working at the wages increases the household's utility for each time $t \geq t_0$ by $[\hat{w}(t)q\phi - \beta]dn$. Hiring an additional worker dn with the wages increases the firm's current-valued surplus at time t by $[G_2(t) - \hat{w}(t)]dn$. With normalization, the Nash bargaining solution solves

$$\max_{\hat{w}(t)} [G_2(t) - \hat{w}(t)]^{1-\lambda} [\hat{w}(t) - \frac{\beta}{q\phi}]^{\lambda}, \quad for\ t \geq t_0.$$

The parameter $\lambda \in (0, 1)$ can be interpreted as the worker's bargaining power.[6] Solving this bargaining problem yields

$$\hat{w}(t) = \lambda G_2(t) + (1 - \lambda)\frac{\beta}{q\phi}. \tag{2.17}$$

Since all firms are identical, they must offer the same wage in any symmetric equilibrium. Since the wage formula is independent of when the match is formed (i.e., independent of t_0), two workers who are hired by the same firm at different times must be paid the same wage at any given time. Thus, $\hat{w}(t) = w(t)$ for all t.

The product wage rate is a weighted sum of the marginal product of labor, G_2, and the reservation wage, $\beta/(q\phi)$, with the weights being the bargaining powers of the worker and the firm. Since $G_2 > w$, as argued before, $G_2 > \beta/(q\phi)$. The product wage lies between the marginal rate of

[6]The Nash formulation maintains tractability. In a stationary environment, the solution to the Nash bargaining problem coincides with the solution to some non-cooperative sequential bargaining games (Wolinsky (1987)). Coles and Wright (1994) discuss the relationship between the two solutions in a nonstationary environment.

substitution $\beta/(q\phi)$ and the marginal product of labor G_2, in contrast to a standard neoclassical model where $w = \beta/(q\phi) = G_2$. Even if the marginal product of labor is constant, a tariff can still affect the product wage through the terms of trade and the marginal value of wealth. These induced responses of q and ϕ will be the two channels through which a tariff affects employment, as analyzed later.

2.5. Equilibrium Definition

For a finitely elastic export function $x(q)$, the terms of trade are determined by the market clearing condition for the domestic good:

$$d + x(q) + B(v) + Q(i) = G. \tag{2.18}$$

An equilibrium can be defined as follows:

Definition 2.1. *A search equilibrium is a converging sequence of* $\{c(t), d(t), f(t), n(t), F(t), a(t), K(t), v(t), i(t)\}_{t\geq 0}$, *good price* $\{q(t)\}_{t\geq 0}$, *factor returns* $\{r(t), w(t)\}_{t\geq 0}$, *dividend* $\{\pi(t)\}_{t\geq 0}$, *matching rates* $\{m(t), \mu(t)\}_{t\geq 0}$ *and rebate* $\{L(t)\}_{t\geq 0}$ *such that*

(i) given $\{q, r, w, \pi, m, \mu, L\}$, $\{c, F\}$ *solve* (PH) *and* $\{d, f\}$ *satisfy (2.3);*

(ii) given $\{q, r, w, m, \mu, L\}$, $\{n, K, v, i\}$ *solve the firm's problem* (PF)*;*

(iii) $\{r, \pi, w\}$ *satisfy (2.2), (2.10), and (2.17);*

(iv) $\{m, \mu\}$ *are given by (2.16);*

(v) $L = \tau f$ *and* q *satisfies (2.18).*

Let us sketch the dynamics in employment. Employment is driven by the firm's decision on vacancy. The dynamics of vacancy can be obtained from (2.11) and (2.12) by eliminating Ψ and substituting the wage equation (2.17):

$$\dot{v} = \gamma \left[(\theta + r)v - \frac{(1-\lambda)m(v)}{B'(v)}(G_2 - \frac{\beta}{q\phi})\right], \tag{2.19}$$

where $\gamma \equiv \epsilon/[1+(1-\alpha)\epsilon] > 0$. Vacancy increases if and only if the return to vacancy, $(\theta+r)vB'/m$, exceeds the firm's surplus from hiring. In the steady state, the two are equal and so steady state vacancy, denoted v^*, is given by

$$(\theta+\rho)\frac{v^*B'(v^*)}{m(v^*)} = (1-\lambda)(G_2 - \frac{\beta}{q^*\phi}). \tag{2.20}$$

We have use the fact that $r = \rho$ in the steady state.

The marginal product of labor in the steady state is exogenous, as the steady state capital-labor ratio is pinned down exogenously by $G_1 = \rho$. Therefore, a tariff can affect steady state job vacancy and employment only through the reservation wage $\beta/(q^*\phi)$. This effect can be channeled either through a change in the terms of trade – the *direct product wage effect* of tariffs, or through a change in the marginal value of wealth – the *consumption bundle effect* of tariffs.

(2.20) implicitly characterizes the long-run supply of the goods market. It gives a positive relation between steady state vacancy (and hence output) and the marginal utility of wealth (ϕ), depicted by the upward sloping curve VV in Figure 1. The VV curve will be called the long-run "aggregate supply curve", with the marginal utility of wealth being the "price". A high marginal utility of wealth lowers the reservation wage, increases the firm's surplus from hiring and so stimulates hiring (and output).

3. The Case of Exogenous Terms of Trade

In this section I isolate the consumption bundle effect of the tariff. This is achieved in a special case where the country faces an infinitely elastic foreign demand for its goods, i.e., $x'(q) = -\infty$. In this case the terms of trade are constant, eliminating the possible direct product wage effect of the tariff. With constant terms of trade, the rental rate of capital must be equal to the world interest rate at each point of time, i.e., $r = \rho$. To ease exposition in this section, I also assume that the marginal adjustment cost in investment is flat, i.e., $Q'' = 0$. In this case the marginal value of capital is unity and $G_1 = r = \rho$ at each point of time. Therefore, the capital-labor ratio is constant, denoted $\kappa = K/n$. The variable K can be replaced by κn and $\dot{K}$ by $\kappa\dot{n}$.

3.1. The Dynamic System and the Solution

The dynamic system for this special case consists of differential equations for (v, n, F). The dynamic equation for v is given by (2.19) with $r = \rho$. The dynamic equation for n is given by (2.5). To obtain the dynamic equation for F, substitute π from (2.10) and $L = \tau f$ into the dynamic equation for F in (2.6):

$$\dot{F} = \rho F + q[G - B - \kappa(m - \theta n)] - (p - \tau p_2)c. \tag{3.1}$$

The initial conditions for the dynamic system of (v, n, F) are $n(0) = n_0$ and $F(0) = F_0$.

Vacancy is constant along the transition path in this special. To see this, notice that (q, r, G_2, ϕ) are all constant along the transition path and so the equation (2.19) is an autonomous equation for vacancy. Since the right-hand side of (2.19) is an increasing function of vacancy, the return to vacancy exceeds the firm's surplus from hiring if and only if vacancy exceeds its steady state level v^* defined by (2.20). Thus, vacancy increases over time if and only if vacancy exceeds the steady state level. The steady state level can be reached only when $v(t) = v^*$ for all t. That is, when responding to disturbances like the tariff, vacancy jumps immediately to the steady state level and stays there afterward.

With constant vacancy, the dynamic equations for n and F are linear differential equations that can be solved to generate the following proposition (see Appendix A).

Proposition 3.1. *When the terms of trade are constant, the stable paths of (n, F) are characterized as follows for any given (n_0, F_0):*

$$n(t) = \frac{m(v^*)}{\theta} + \left[n_0 - \frac{m(v^*)}{\theta}\right] e^{-\theta t}, \tag{3.2}$$

$$F(t) = F^* - \frac{q^*}{\theta + \rho}(\frac{G}{n} + \theta\kappa)[n(t) - \frac{m(v^*)}{\theta}], \tag{3.3}$$

where F^* is the steady-state value of F and is given by

$$F^* = \frac{1}{\rho}\left\{(p - \tau p_2)c - q^*[G - B(v^*)]\right\}. \tag{3.4}$$

Proposition 3.1 states that claims on foreign assets are negatively related to employment and hence to output along the stable path. This is because an increase in employment raises the marginal product of capital, which in turn induces agents to switch investment from foreign assets to domestic capital. As a result, the current account, $\dot{F}$, is negatively related to changes in employment.

Figure 1 here.

Proposition 3.1 also implies that the steady state depends on the initial conditions (n_0, F_0), as is typical in a small open economy model with a constant rate of time preference. The equation (3.3) at $t = 0$ helps to determine the marginal utility of wealth ϕ. Substituting (3.4) into (3.3), setting $t = 0$ and noticing $c = u'^{-1}(p\phi)$ yields:

$$\frac{G_2}{\theta+\rho} m(v^*) - B(v^*) + \rho(\kappa + \frac{G_2}{\theta+\rho}) n_0 = \frac{1}{q^*}\left[(p - \tau p_2) u'^{-1}(p\phi) - \rho F_0\right]. \tag{3.5}$$

This steady state equation gives a negative relationship between steady state vacancy and the marginal utility of wealth that is depicted by the downward sloping curve FF in Figure 1. The left-hand side is an increasing function of v^*, measuring the supply of goods available for consumption and export.[7] The right-hand side of the equation is a decreasing function of ϕ, measuring the expenditure on goods and foreign debt service. The FF will be called the long-run "aggregate demand curve".

The intersection of the two curves VV and FF in Figure 1 determines steady state vacancy and the marginal utility of wealth. Once (v^*, ϕ) are determined, other steady state values (n^*, K^*, F^*, c) can be recovered accordingly.

3.2. A Permanent Increase in the Tariff

Suppose that the economy is in a steady state at time 0, with $\tau = 0$ and $(n(0), K(0), F(0)) = (n_0, \kappa n_0, F_0)$. Then the tariff rate has a once-and-for-all, unexpected increase to a new level $d\tau > 0$ which is sufficiently small.[8] Since the terms of trade are fixed, the tariff affects the product wage only through its effect on the marginal value of wealth, ϕ. This consumption bundle effect arises because the tariff makes the consumption bundle more expensive, i.e., increases p. Since the marginal value of wealth is $\phi = u'(c)/p$, it falls and the reservation wage rises. The product wage rises, which reduces the firm's surplus from hiring and reduces vacancy. Depicted in Figure 1, the long-run aggregate demand curve FF shifts to the left, as consumers can afford to buy a small quantity of

[7]The condition required for the left-hand side of (3.5) to be increasing in v^* is $\alpha/(1-\lambda) > 1 - \beta/(q\phi G_2)$, which is satisfied if the firm's bargaining power in the wage determination $(1-\lambda)$ does not exceed its contribution to the match formation (measured by α) by too much a margin. Such condition is maintained here (see Hosios (1990) for more discussions on the difference between $1-\lambda$ and α).

[8]Throughout this paper, I will examine only permanent changes in tariff. Transitory changes can also be examined but omitted here.

the consumption bundle for any given ϕ. The VV curve does not shift and so job vacancy is lower in the new steady state (point E) than in the original steady state (point A). Consequently, steady state employment and capital stock are lower in the new steady state.

The employment response to the tariff clearly relies on the reservation wage being endogenous. It also depends critically on the non-Walrasian feature of the labor market. In particular, the bargaining power of the firm in the wage determination $(1-\lambda)$ plays a key role. If the firm has a very low bargaining power, for example, changes in the product wage induced by the tariff will have only a small effect on the firm's surplus of hiring, in which case the responses of vacancy and employment to the tariff will be small. In terms of Figure 1, a lower bargaining power of the firm corresponds to a steeper long-run aggregate supply curve VV, in which case the shift in the FF curve generates a large change in ϕ but only a small change in v.

The importance of the labor market friction sets the current analysis apart from the Sen-Turnovsky (1989) model, where the labor market is Walrasian. In a Walrasian labor market, the marginal product of labor equals the marginal rate of substitution between consumption and leisure. In this case the VV curve is horizontal and an increase in the tariff generates the *largest* (negative) consumption bundle effect. Thus, the search friction in the labor market attenuates the consumption bundle effect which a tariff has on employment.

The transitional dynamics after the tariff increase can be analyzed as follows. Since $(n^*, K^*) < (n_0, K_0)$, (3.2) implies that employment and the capital stock monotonically decrease along the stable path. Thus, raising the tariff reduces employment and output, both in the long-run and in the short-run — there is no trade-off between the short run and the long run effects of a tariff in this special case. The tariff also raises the long-run level of claims on foreign assets, which can be verified from (3.4). The country experiences current account surpluses along the entire transition path (see (3.3)), as investors switch investment from domestic capital to foreign assets.

Figure 2 here.

The dynamic adjustments in the labor market can be expressed in Figure 2 in the subspace of the vacancy rate $\hat{v} \equiv \frac{v}{n+1}$ and the unemployment rate $\hat{s} \equiv \frac{1}{n+1}$. The long-run relationship between these two variables is given by $\dot{n} = 0$, i.e., by $m(v^*) = \theta n^*$, which is depicted by the downward sloping Beveridge curve, BEV. The increase in the tariff moves the economy from one steady state (point A) to another (point E). The transition of $(\hat{v}, \hat{s})$ traces a stylized counter-clockwise trajectory around the Beveridge curve (see Layard et al. (1991)), as depicted by the path ABE. First, since job vacancy immediately falls to the new long-run level after the increase in the tariff and since n is pre-determined, the vacancy rate $\hat{v}$ must immediately fall below its new long-run level, while $\hat{s}$ is predetermined. That is, the immediate response of the economy is a discontinuous drop from point A to point B. After this immediate response, $\hat{v}$ and $\hat{s}$ gradually rise to reach point E as employment falls to the new long-run level.

As analyzed above, the tariff increases the product wage, w. However, the tariff reduces the wage rate measured by the goods bundle, qw/p, because it increases the price index of the consumption bundle by more than increasing the terms of trade. Finally, the tariff reduces welfare if it has a small effect on employment. To see this, note first that the tariff reduces consumption by increasing the marginal utility of consumption measured in terms of the goods bundle, $p\phi$ (although the tariff reduces ϕ). Second, the tariff reduces employment and hence increases leisure. When employment responds only slightly to the tariff (for example, as a result of a low bargaining power of firms), the reduction in consumption outweighs the increase in leisure and so utility falls.

3.3. A Permanent Improvement in the Terms of Trade

In this subsection I examine the effect of an exogenous improvement in the terms of trade, which generates an exogenous direct product wage effect. The purpose of the exercise is to highlight the conflict between the consumption bundle effect illustrated in the last subsection and the direct product wage effect.

Suppose that the economy is in a steady state at time 0, with $q = q_0$ and $(n(0), K(0), F(0)) = (n_0, \kappa n_0, F_0)$. The terms of trade then have an unanticipated, once-and-for-all (marginal) increase to q^*. Like the tariff in the last section, the terms-of-trade improvement makes the consumption bundle more expensive. This generates the consumption bundle effect that increases the product wage for any given q. The terms-of-trade improvement also directly reduces the product wage for any given ϕ. This direct product wage effect increases vacancy. The product wage falls and so vacancy rises if and only if the direct product wage effect outweighs the consumption bundle effect.

The conflict between the two effects can be illustrated with Figure 1 (where the corresponding shifts of the curves for the current case are not drawn). The direct product wage effect shifts the aggregate supply curve VV down to the right. That is, for given marginal value of wealth ϕ, a higher value of q increases the firm's surplus from hiring and increases vacancy. The consumption bundle effect corresponds to a downward shift of the aggregate demand curve FF to the left.[9] Overall, the marginal value of wealth is unambiguously lower in the new steady state than in the old one, but vacancy can be either higher or lower in the new steady state. Graphically, the product wage falls if the aggregate supply VV curve shifts downward by more than the aggregate demand curve FF does.

Whether the direct product wage effect dominates the consumption bundle effect depends on the elasticity of intertemporal substitution, σ. The larger the elasticity of intertemporal substitution, the weaker the consumption bundle effect (i.e., the smaller the reduction in ϕ), in which case it is more likely that the direct product wage effect dominates the consumption bundle effect. The explanation is as follows. When the elasticity of intertemporal substitution is large, the consumption smoothing motive is weak. In this case consumption on the goods bundle falls a lot in response to the increase in the goods price. The resulted increase in the marginal utility of consumption mitigates the rise in price and so the marginal utility of wealth $\phi = u'(c)/p$ falls very little. In contrast, when the elasticity of intertemporal substitution is small, consumption on the goods bundle falls very little in response to the price increase, leaving the marginal utility of wealth to fall significantly. This explanation can be supported by showing that the terms-of-trade improvement raises job vacancy if and only if

$$\sigma > qx/f. \tag{3.6}$$

Whether this condition is satisfied clearly depends on the nature of the economy. It suffices

[9]Precisely, the FF curve shifts downward to the left if and only if $G^* - B(v^*) > (1-\sigma)d^*$, or equivalently, $x + \sigma d > 0$, which is easily satisfied if the country exports a positive quantity of goods.

to say that the requirement imposed by (3.6) is not entirely unrealistic. For example, if the value of the export is seventy percent of the import, (3.6) would require the elasticity of intertemporal substitution to exceed 0.7, which is possible with some of the estimates in Epstein and Zin (1992). Nevertheless, a tariff increase may not be able to induce sufficient improvement in the terms of trade that produces a dominating direct product wage effect, as shown in the next section.

Figure 3 here.

The dynamic responses of (n, F) to the terms-of-trade improvement can be analyzed using Figure 3. The lines STP and STP' depict the stable path (3.3) before and after the terms-of-trade improvement. Since the slope of the stable path depends positively on q, the terms-of-trade improvement increases the slope of the stable path. The initial steady state is at point A. The dynamics depend on whether (3.6) is satisfied. If (3.6) is satisfied, the new steady state is at point $B1$, in which case employment increases and the current account is in a deficit along the adjustment path. If (3.6) is violated, the new steady state is at point $B2$, in which case employment falls and the current account is in a surplus along the adjustment path.

Regardless of how steady state employment responds to the terms-of-trade improvement, it can be verified that the marginal utility of consumption in terms of the goods bundle, $p\phi$, falls. Consumption and the real wage rate (qw/p) rise. Utility is higher in both cases if the response of employment is small. The dynamic responses of $(\hat{v}, \hat{s})$ can also be analyzed using Figure 2 but omitted here.

4. The Case of Endogenous Terms of Trade

I now examine the dynamic effects of a tariff when the terms of trade are endogenous. Only local dynamics are considered. As in the last section, let the tariff change be a marginal, permanent and unanticipated increase from the initial value 0. The economy is in a steady state prior to the tariff change, with $(n(0), K(0), F(0)) = (n_0, K_0, n_0)$.

4.1. Characterization of the Stable Dynamic Path

With endogenous terms of trade, the dynamic system consists of seven variables, $(r, \Omega, q, v, n, K, F)$. Solving equilibrium dynamics is analytically possible only when $\alpha = 1 - \lambda$. Since the values of α and $1 - \lambda$ are indeed close to each other in calibration exercises (see Merz (1995) and Andolfatto (1996)), I will assume $\alpha = 1 - \lambda$ in the remainder of this paper. This condition requires that the firm's power in wage bargaining, $1 - \lambda$, exactly compensates for the contribution of the vacancy to the match formation, measured by α (see Hosios (1990)). The analytical conclusions reached thereafter should be valid more generally for α to be in the neighborhood of $1 - \lambda$.

Without losing the essence of the analysis, I will consider only the case where the marginal adjustment cost of investment is small around the steady state, i.e., $Q''(0) \approx 0$. In this case the marginal value of capital, Ω, is close to 1 and so the rental rate of capital is close to the marginal product of capital. The dynamics of the other five variables (q, v, n, K, F) can be approximated by the following system:[10]

$$(E) \quad \begin{cases} \dot{q} = q(\rho - G_1) \\ \dot{v} = \gamma \left[(\theta + G_1) v - \frac{(1-\lambda) m(v)}{B'(v)} (G_2 - \frac{\beta}{q\phi}) \right] \\ \dot{n} = m(v) - \theta n \\ \dot{K} = G - [d + x(q)] - B(v) \\ \dot{F} = \rho F + q x(q) - f. \end{cases}$$

The initial conditions are $(n(0), K(0), F(0)) = (n_0, K_0, F_0)$. The condition for $\dot{q}$ is derived from (2.2) by replacing r with its proxy G_1. The condition for $\dot{v}$ comes from replacing r with G_1 in (2.19). The conditions for $\dot{n}$ is a copy of (2.5). The condition for $\dot{K}$ comes from the goods market clearing condition (2.18) using the approximation $Q(i) \approx i$. The condition for F is derived by substituting $(L, \pi, \dot{K})$ into (2.6). Since the variables (d, f) are functions of (q, τ, ϕ) (see (2.3)), the system (E) is a complete dynamic system of the five variables (q, v, n, K, F) once ϕ is determined. According to (2.7), ϕ is constant along the equilibrium dynamic path. Its value is determined through a stability

[10] A formal proof for the approximation is straightforward but tedious and hence is omitted. The procedure involves linearizing the dynamics of $(r, \Omega, q, v, n, K, F)$ and showing that the stable path of (q, v, n, K, F) in this dynamic system approaches that of system (E) when $Q'' \to 0$.

requirement described later.

Denote world-wide consumption of the country's good by $D(q, \phi, \tau) \equiv d + x(q)$, where $d = p_1 u'^{-1}(p\phi)$. The earlier assumptions on x and p imply $D_1 < 0$. Appendix B shows that the dynamic system is saddle-path stable if the demand for the domestic good is sufficiently elastic (i.e., if D_1 is sufficiently negative). This result is not surprising since the dynamic system is stable when $D_1 = -\infty$, as demonstrated in the previous section. In particular, the dynamic system has two real, negative roots $\omega_2 < \omega_1 < 0$. Denote $Y = (q, v, n, K)$ and Y^* the steady state value of Y. The stable path is characterized as follows (see Appendix B).

Proposition 4.1. *The stable path of (E) is:*

$$Y(t) - Y^* = (Z_1, Z_2) \begin{pmatrix} b_1 e^{\omega_1 t} \\ \\ b_2 e^{\omega_2 t} \end{pmatrix}, \tag{4.1}$$

$$F(t) - F^* = (n^* - n_0)(\Gamma_1 e^{\omega_1 t} - \Gamma_2 e^{\omega_2 t}), \tag{4.2}$$

where Z_1 and Z_2 are 4×1 vectors and (b, Γ) are constants, both given in Appendix B, with $\Gamma_1 > \Gamma_2 > 0$ and $\omega_1 \Gamma_1 < \omega_2 \Gamma_2$.

4.2. Long-Run Effects of the Tariff

Let us first determine the steady state. Use the notation κ to denote the steady state capital labor ratio κ, given by $G_1(\kappa) = \rho$. Since the capital labor ratio is κ in both steady states before and after the tariff, steady state capital stock and employment always respond to the tariff in the same direction:

$$K^* - K_0 = \kappa(n^* - n_0). \tag{4.3}$$

Steady state employment is $n^* = m(v^*)/\theta$, which depends on steady state vacancy. Steady state vacancy in turn is determined by the terms of trade and the marginal value of wealth. In particular, (2.20) holds in the steady state, which can be used to solve v^* as an increasing function of (ϕ, q^*). Denote this function as $v(\phi, q^*)$. Steady state terms of trade and the marginal utility of consumption are determined by the market clearing conditions for the domestic good and the condition for the country's balance of payments.

The domestic good market clearing condition is given by the $\dot{K}$ equation in (E). Setting $\dot{K}=0$ and substituting the function $v(\phi,q^*)$ yields the following equation for (ϕ,q^*):

$$(\frac{G}{n})\cdot\frac{m(v(\phi,q^*))}{\theta}-B(v(\phi,q^*))-p_1u'^{-1}(p\phi)-x(q^*)=0. \tag{4.4}$$

The left-hand side of this equation is the excess supply of the domestic good. Note that G/n is an exogenous constant in the steady state. (4.4) gives a negative relation between steady state terms of trade and the marginal utility of wealth, depicted by the DD curve in Figure 4. A higher marginal utility ϕ decreases the reservation wage, increases vacancy and the supply of the domestic good. To clear the market for the domestic good, the price of the domestic good must fall.

The condition for the country's balance of payments is given by the $\dot{F}$ equation in the system (E). Setting $\dot{F}=0$ and substituting F^* from the version of (4.2) at $t=0$ gives the following equation for (ϕ,q^*):

$$\rho\delta\left[\frac{m(v(\phi,q^*))}{\theta}-n_0\right]+p_2u'^{-1}(p\phi)-\rho F_0-q^*x(q^*)=0, \tag{4.5}$$

where $\delta\equiv\Gamma_1-\Gamma_2>0$. The left-hand side of this equation is the country's current account deficit in the steady state. (4.5) gives an ambiguous relationship between steady state terms of trade and the marginal utility of consumption. To see the ambiguity, note first that a higher ϕ increases the supply of the country's export through increased vacancy and output, which must be absorbed by a fall in the relative price of the country's goods – the terms of trade. However, since the demand for the import is $f=p_2u'^{-1}(p\phi)$, a higher ϕ also reduces the demand for the foreign good and its relative price $1/q^*$. When the intertemporal elasticity σ is small, the second effect is small and dominated by the first effect so that (4.5) gives a positive relationship between q^* and ϕ. Otherwise the relationship is negative, as depicted in Figure 4 by the FF curve.

Figure 4 here.

Regardless of the nature of the slope of the FF curve, however, there is a unique solution for (ϕ,q^*). In particular, when the FF curve is negatively sloped, Appendix C shows that the DD curve is steeper than the FF curve, as depicted by Figure 4. Since the analytical result with a positively sloped FF curve is similar to that with a negatively sloped FF curve, I will analyze only the case of a negatively sloped FF curve. Figure 4 also draws a reference curve $dv = 0$, along which the reservation wage is fixed at the level of the original steady state. That is, $q\phi = constant$ along the curve $dv = 0$. The steady state values of (q, ϕ) before the increase in the tariff is given by point A. Points above the $dv = 0$ curve have more vacancies than in the initial steady state and points below the $dv = 0$ curve have fewer vacancies.

Now the long-run effect of the tariff increase can be analyzed. The increase in the tariff shifts the FF curve up because, for any given ϕ, the tariff reduces the demand for the import. The resulted current account surplus must be eliminated in the steady state by a terms of trade improvement, which increases the demand for the import and reduces the export. The tariff shifts the DD curve up because, for any given ϕ, the tariff increases the demand for the domestic good. The resulted excess demand for the domestic good must be eliminated in the steady state by a terms of trade improvement, which stimulates domestic production and curtails the country's demand for the domestic good. The new levels of (q^*, ϕ) are given by point E. Appendix C shows that the upward shift of the FF curve is more than the upward shift of the DD curve and so the new steady state is below the curve $dv = 0$. Thus, although the terms of trade improve as a result of the increase in the tariff, the improvement is proportionally less than the fall in the marginal utility of wealth. The consumption bundle effect of the tariff through the marginal utility of wealth dominates the direct product wage effect through the terms of trade. The product wage rises and so the tariff reduces steady state vacancy and employment.

The explanation for why the consumption bundle effect dominates the direct product wage effect is that wealth is smoother than output when the consumption smoothing motive is relatively strong ($\sigma < 1$). As explained above, the tariff directly increases the current account surplus and the excess demand for the domestic goods, both of which must be eliminated in the steady state by a terms-of-trade improvement. Since wealth is smoother than output, to eliminate the current account surplus requires a larger terms-of-trade improvement than to eliminate the excess demand for the domestic good. The upward shift in the FF curve is thus larger than in the DD curve, as depicted in Figure 4.

The above explanation can be made precise by the following corollary, which can be shown through direct computation and using (C.2) in Appendix C:

Corollary 4.2. *For any given marginal utility of wealth ϕ, the following inequalities hold:*

$$0 < \partial(f^* - q^*x^* - \rho F^*)/\partial q^* < q^*\partial(G^* - d^* - x^* - B^*)/\partial q^*, \tag{4.6}$$

$$\frac{-\partial(f^* - q^*x^* - \rho F^*)/\partial\tau}{\partial(f^* - q^*x^* - \rho F^*)/\partial q^*} > \frac{-\partial(G^* - d^* - x^* - B^*)/\partial\tau}{\partial(G^* - d^* - x^* - B^*)/\partial q^*}. \tag{4.7}$$

(4.6) states that, in response to a terms-of-trade improvement, the current account deficit increases by less than the excess supply of the domestic good does. (4.7) states that to eliminate the current account surplus generated by the tariff requires a larger terms-of-trade improvement than to eliminate the excess demand for the domestic good.

4.3. Dynamic Effects

The dynamic effect of the tariff on employment and capital can be obtained by differentiating with respect to time the stable path in (4.1) for these variables. The dynamics are illustrated in Figure 5, where the long-run capital-labor ratio lies along the line $G_1 = \rho$. The explicit expressions for the $\dot{n} = 0$ and the $\dot{K} = 0$ schedules are provided in Appendix C, which establishes the following features: (i) both the $\dot{n} = 0$ schedule and the $\dot{K} = 0$ schedule are positively sloped; (ii) the $\dot{n} = 0$ schedule is steeper than the line $G_1 = \rho$ and steeper than the $\dot{K} = 0$ schedule; (iii) the $\dot{K} = 0$ schedule can be either steeper or flatter than the line $G_1 = \rho$. To avoid repetition, I discuss only the case where the $\dot{K} = 0$ schedule is flatter than the line $G_1 = \rho$.

Figure 5 here.

The initial steady state is point A and the new steady state is point E; both lie on the line $G_1 = \rho$. The tariff induces the capital stock and employment to fall monotonically toward the steady state E. Output also falls monotonically. The dynamics of the job vacancy rate and the unemployment rate can be analyzed using Figure 2 and are omitted here. It is clear that the unemployment rate increases monotonically along the transition path so that the tariff has qualitatively the same effect on the unemployment rate both in the short run and in the long run.

Since the domestic capital stock monotonically falls, investment is re-directed toward foreign assets during the transition. That is, the current account is in surplus along the transitional path and reaches zero in the new steady state. This can be verified by differentiating (4.2) with respect to time to obtain the following expression for the current account:

$$\dot{F}(t) = (n^* - n_0)(\Gamma_1 \omega_1 e^{\omega_1 t} - \Gamma_2 \omega_2 e^{\omega_2 t}). \tag{4.8}$$

Since $\omega_2 < \omega_1 < 0$, $\omega_1 \Gamma_1 < \omega_2 \Gamma_2 < 0$ and $n^* < n_0$, we have $\dot{F}(t) > 0$ for all t.

An interesting feature of the dynamics is that the terms of trade respond to the tariff in a non-monotonic fashion. To see this non-monotonic adjustment, notice first that $q(0) < q^*$ (see Appendix C). That is, the immediate improvement in the terms of trade after the increase in the tariff is less than in the long run. After this immediate improvement, the terms of trade continue to improve in order to maintain the arbitrage condition (2.2), since the rising capital labor ratio (see Figure 5) pushes down the domestic interest rate. In this process the terms of trade overshoot its new long-run level. In the middle of the transition, the capital labor ratio begins to fall, which pushes up the domestic interest rate and induces the terms of trade to deteriorate toward the new long-run level. The complete adjustment of the terms of trade is characterized by an immediate jump which is followed by a continuous, hump-shaped path.

This particular adjustment path of the terms of trade implies overshooting product wage and job vacancy. Since the terms of trade rise immediately by less than in the long-run, and since the marginal value of wealth ϕ falls immediately to the new long-run level, the reservation wage, $\beta/(q\phi)$, must immediately overshoot its new steady state level. Since both the capital stock and employment are predetermined, the marginal product of labor is predetermined and so the product wage must immediately overshoot its new steady state level. After this overshooting, the product wage rate falls toward its new steady state level. As the product wage overshoots, job vacancy immediately falls below its long-run level.

5. Conclusion

This paper integrates labor market search into an intertemporal equilibrium model to analyze the dynamic macroeconomic effects of a tariff. The search friction creates a wedge between the marginal product of labor and the product wage, although wages are perfectly flexible. The model captures the intuitive argument in the earlier literature that a permanent increase in the tariff improves the country's terms of trade, which tends to reduce the product wage and stimulates labor demand. However, the tariff also increases the price of the consumption goods bundle, reduces the marginal utility of wealth and increases the product wage through the reservation wage. With a realistically strong consumption smoothing motive, this consumption bundle effect of the tariff dominates the direct product wage effect, causing vacancy and employment to fall both in the long run and in the short run. Thus, even with the presence of the search friction and unemployment, raising tariffs is not the means in which a government in a small open economy can increase employment. International finance theorists who argue for a predominant positive employment role for tariffs must look for other labor market frictions to support their arguments.

There might be *ad hoc* rationales for a government to increase tariffs (in practice). The current paper indicates two. One is redistributional: The government might want to boost the product wage. An increase in the tariff achieves this purpose and does so in a larger scale in the short-run than in the long-run. The second reason might be current account management: An increase in the tariff produces a current account surplus along the entire transition path. However, neither rationale has a clear justification. For the first purpose, in particular, the wage rate measured in terms of the consumption bundle falls with the tariff and workers are worse off.

For tractability, the paper has abstracted from the possible strategic responses by the rest of the world to the increase in the tariff. This omission is not as serious as it appears. Although the tariff deteriorates the terms of trade of the rest of the world, it also increases the capital flow into the rest of the world. Since it is not clear whether the rest of the world stands to lose or gain from the tariff, it is not clear whether it has the incentive to retaliate. Addressing the strategic interaction requires a two-country model and is likely to be intractable given the dynamic setting.

As far as the small country is concerned, a possible short-cut to modelling the response of the rest of the world would be to assume that the export function, $x(q)$, depends on the tariff. In particular, one can view that a tariff may trigger responses that make the export function more elastic. The analytical results remain valid after this modification.

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Appendix

A. Proof of Proposition 3.1

Proof. Since v is constant along the transition path, $n(t)$ can be solved directly by integrating the equation for n in (E). The result is given by (3.2). Substitute this solution into (3.1) and notice that G/n depends only on the capital-labor ratio and hence is constant along the transition path. Integrating (3.1) generates:

$$\begin{aligned} F(t) &= F^* - \frac{q}{\theta+\rho}(\frac{G}{n}+\theta\kappa)[n(t)-\frac{m}{\theta}] \\ &\quad +[F_0 - F^* + \frac{q}{\theta+\rho}(\frac{G}{n}+\theta\kappa)(n_0-\frac{m}{\theta})]e^{\rho t}, \end{aligned}$$

For F to converge to a steady state, it is necessary and sufficient that

$$F_0 - F^* = -\frac{q}{\theta+\rho}(\frac{G}{n}+\theta\kappa)(n_0-\frac{m}{\theta}).$$

Under this condition, the solution for $F(t)$ given above becomes (3.3). ■

B. Proofs of Proposition 4.1

Since the dynamics of $Y=(q,v,n,K)^T$ are autonomous for any given ϕ, let us examine them first. Linearizing the dynamic equations for Y in (E) yields:

$$\dot{Y} = J(Y-Y^*), \tag{B.1}$$

where Y^* is the steady state value of Y and J is the following matrix:

$$J = \begin{bmatrix} 0 & 0 & -qG_{12} & -qG_{11} \\ -\frac{\gamma A\beta}{\phi q^2} & \theta+\rho & \gamma G_{12}(v+A\kappa) & \gamma G_{11}(v+A\kappa) \\ 0 & m' & -\theta & 0 \\ -D_1 & -B' & G_2 & \rho \end{bmatrix}.$$

Here $A=\alpha m/B'>0$ and all elements in the matrix are evaluated at the steady state with $\tau=0$.

Denote a typical eigenvalue of matrix J by ω and let $\xi=\omega(\omega-\rho)$. The determinant of matrix J can be expressed as the following quadratic function of ξ:

$$g(\xi) \equiv \xi^2 - [\theta(\theta+\rho)+qD_1G_{11}-\gamma G_{11}(v+A\kappa)(B'+\kappa m')]\xi$$

$$+\theta(\theta+\rho)qD_1G_{11} - \gamma G_{11}\frac{A\beta}{q\phi}[m'(G_2+\rho\kappa) - \theta B'].$$

Denote the two solutions to the equation $g(\xi) = 0$ by ξ_1 and ξ_2. These roots are real numbers if and only if

$$\begin{aligned} 0 \quad < \quad & [\theta(\theta+\rho) + qD_1G_{11} - \gamma G_{11}(v+A\kappa)(B'+\kappa m')]^2 \\ & -4\theta(\theta+\rho)qD_1G_{11} + 4\gamma G_{11}\frac{A\beta}{q\phi}[m'(G_2+\rho\kappa) - \theta B']. \end{aligned}$$

The right-hand side of the above inequality can be equivalently written as:

$$\begin{aligned} & [\theta(\theta+\rho) - qD_1G_{11} - \gamma G_{11}(v+A\kappa)(B'+\kappa m')]^2 \\ & -4\gamma G_{11}[qD_1G_{11}(v+A\kappa)(B'+\kappa m') - \frac{A\beta}{q\phi}(m'(G_2+\rho\kappa) - \theta B')]. \end{aligned}$$

This condition is satisfied if

$$qD_1G_{11} > \frac{A\beta}{\phi q}\cdot\frac{m'(G_2+\rho\kappa) - \theta B'}{(v+A\kappa)(B'+\kappa m')}. \tag{B.2}$$

Assume (B.2). Then (ξ_1, ξ_2) are positive and distinct. Let $\xi_1 < \xi_2$. Moreover, $g(qD_1G_{11}) < 0$ and so $qD_1G_{11} \in (\xi_1, \xi_2)$.

Since ξ_1 and ξ_2 are positive, matrix J has two positive real eigenvalues and two negative real eigenvalues, calculated through the equations $\omega(\omega-\rho) = \xi_i$ $(i = 1, 2)$. The two negative real eigenvalues are $\omega_i \equiv [\rho - (\rho^2 + 4\xi_i)^{1/2}]/2$, $i = 1, 2$. Clearly, $\omega_2 < \omega_1 < 0$. The property $qD_1G_{11} \in (\xi_1, \xi_2)$ can then be written as

$$\omega_1(\omega_1 - \rho) < qD_1G_{11} < \omega_2(\omega_2 - \rho). \tag{B.3}$$

The number of negative eigenvalues of J (two) falls short of the number of pre-determined variables (n, K, F) in the system (E) by one, leaving the stable path of the equilibrium dependent on the initial conditions.

The stable manifold of Y is given by (4.1), where Z_i is the eigenvector of J corresponding to ω_i and is given as follows:

$$Z_i = \begin{pmatrix} z_{i1} \\ z_{i2} \\ z_{i3} \\ z_{i4} \end{pmatrix} = \begin{pmatrix} \frac{-qG_{11}}{\xi_i - qD_1G_{11}}[\frac{\beta}{q\phi} + (\kappa + \frac{B'}{m'})(\rho - \omega_i)] \\ (\omega_i + \theta)/m' \\ 1 \\ \frac{1}{\xi_i - qD_1G_{11}}[qD_1G_{12} - \frac{B'}{m'}\xi_i + \frac{\beta}{q\phi}\omega_i] \end{pmatrix}. \tag{B.4}$$

To determine (b_1, b_2) in (4.1), set $t = 0$ and use (4.3). We have

$$\begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \frac{(n_0 - n^*)}{z_{14} - z_{24}} \begin{pmatrix} \kappa - z_{24} \\ \\ z_{14} - \kappa \end{pmatrix}. \tag{B.5}$$

Thus, (b_1, b_2) are uniquely determined for any given ϕ if and only if $z_{14} \neq z_{24}$. Compute:

$$\begin{aligned} z_{14} - z_{24} &= -\frac{(\omega_1 - \omega_2)}{(\xi_1 - qD_1G_{11})(\xi_2 - qD_1G_{11})} \\ &\quad \times \left\{ [(\kappa + \frac{B'}{m'})(\rho - \omega_1 - \omega_2) + \frac{\beta}{q\phi}]qD_1G_{11} + \omega_1\omega_2\frac{\beta}{q\phi} \right\}. \end{aligned}$$

This is positive, because $qD_1G_{11} \in (\xi_1, \xi_2)$ and $\omega_1 > \omega_2$. Therefore, the system (B.1) is stable for any given ϕ.

To find the stable path for F, linearize the $\dot{F}$ equation in (E), substitute the stable manifold (4.1), and integrate. Imposing the condition $\lim_{t\to\infty} F(t) = F^* < \infty$ yields (4.2), where

$$\begin{aligned} \Gamma_1 &= \frac{(z_{24} - \kappa)z_{11}}{(z_{14} - z_{24})(\rho - \omega_1)}[c(p_{12} - \frac{\sigma p_1 p_2}{p}) - (x + qx')], \\ \Gamma_2 &= \frac{(z_{14} - \kappa)z_{21}}{(z_{14} - z_{24})(\rho - \omega_2)}[c(p_{12} - \frac{\sigma p_1 p_2}{p}) - (x + qx')]. \end{aligned}$$

The path (4.2) at $t = 0$ also provides a condition which helps to determine ϕ.

To verify the features of $(\delta, \Gamma_1, \Gamma_2)$, note that $z_{11} < 0$, $z_{21} > 0$ and $z_{14} > \kappa > 0 > z_{24}$. Then, $\Gamma_1 > 0$ and $\Gamma_2 > 0$. Substituting $(z_{11}, z_{21}, z_{14}, z_{24})$ and using the notation $\delta = \Gamma_1 - \Gamma_2$ yields:

$$\begin{aligned} \delta &= \frac{[c(p_{12} - \sigma p_1 p_2/p) - (x + qx')]}{(-D_1)[\kappa + \frac{B'}{m'} + \frac{\beta}{q\phi}(1 + \frac{\omega_1\omega_2}{qD_1G_{11}})/(\rho - \omega_1 - \omega_2)]} \\ &\quad \times [\frac{\beta}{q\phi} + (\kappa + \frac{B'}{m'})/(\rho - \omega_1)][\frac{\beta}{q\phi} + (\kappa + \frac{B'}{m'})/(\rho - \omega_2)]. \end{aligned} \tag{B.6}$$

Since $p_{12} > p_1p_2/p$, $\sigma \leq 1$, $x + qx' < 0$, and $D_1 < 0$, we have $\delta > 0$. Similarly one can verify $\omega_1\Gamma_1 < \omega_2\Gamma_2$. This completes the proof for Proposition 4.1. ■

C. Other Statements in Section 4

In this appendix, we verify the following results used in Section 4: (i) The DD schedule is negatively sloped, while the FF schedule may be either positively or negatively sloped; (ii) The DD schedule is steeper than the FF schedule when the latter is negatively sloped; (iii) The long-run terms of trade improve and the long-run marginal utility of wealth falls in response to the tariff; (iv) The long-run job vacancy falls when the tariff increases; (v) $q(0) < q^*$; (vi) The dynamics of (n, K) are as described in the text and illustrated in Figure 5.

To show (i) – (v), differentiate (2.20) and suppress the asterisk associated with the steady state:

$$\frac{dv}{v} = \frac{\gamma}{G_2 q\phi/\beta - 1}\left(\frac{dq}{q} + \frac{d\phi}{\phi}\right). \tag{C.1}$$

Denote

$$E_1 = \frac{v\gamma[Gm'/(n\theta) - B']}{G_2 q\phi/\beta - 1}, \quad E_2 = \frac{v\gamma\rho\delta m'/\theta}{G_2 q\phi/\beta - 1}.$$

Differentiating (4.4) and (4.5), substituting (C.1), we have:

$$\begin{bmatrix} E_1 - q[x' + c(p_{11} - \frac{\sigma p_1^2}{p})], & E_1 + \sigma c p_1 \\ E_2 + q[c(p_{12} - \frac{\sigma p_1 p_2}{p}) - (x + qx')], & E_2 - \sigma c p_2 \end{bmatrix} \begin{pmatrix} dq/q \\ d\phi/\phi \end{pmatrix} = c \begin{bmatrix} p_{12} - \frac{\sigma p_1 p_2}{p} \\ \frac{\sigma p_2^2}{p} - p_{22} \end{bmatrix} d\tau.$$

Since $p_{12} > p_1 p_2/p$, $\sigma \leq 1$ and $x + qx' < 0$, it is clear that the elements of the above 2×2 coefficient matrix are positive, with the only possible exception for the element $E_2 - \sigma c p_2$. Thus the DD schedule is negatively sloped. The FF schedule is also negatively sloped if and only if $E_2 > \sigma c p_2$.

Denote the determinant of the above 2×2 coefficient matrix by DT. When the FF schedule is negatively sloped, the DD schedule is steeper than the FF schedule if and only if $DT < 0$. To verify $DT < 0$, notice $qp_1 + p_2 = p$, $qp_{11} = -p_{12}$ and $qp_{12} = -p_{22}$. Using these relations, we can compute

$$\begin{aligned} DT &= -\sigma c[cpp_{12} - q(px' + p_1 x)] + \frac{v\gamma}{G_2 q\phi/\beta - 1}\Delta \\ \Delta &= \rho\delta\frac{m'}{\theta}[c(p_{12} - \frac{\sigma p_1 p_2}{p}) - qx'] - (\frac{Gm'}{n\theta} - B')[c(qp_{12} + \frac{\sigma p_2^2}{p}) - q(x + qx')]. \end{aligned}$$

A sufficient condition for $DT < 0$ is $\Delta < 0$, which can be verified using the following relations:

$$D_1 = x' - \frac{c}{q}(p_{12} + \frac{\sigma p_1^2}{p}q); \quad \frac{Gm'}{n\theta} - B' = \frac{\rho m'}{\theta}(\kappa + \frac{B'}{m'} + \frac{\beta}{q\phi}\rho^{-1});$$

$$\delta < \frac{1}{(-D_1)}[c(p_{12} - \frac{\sigma p_1 p_2}{p}) - (x + qx')][\frac{\beta}{q\phi} + (\kappa + \frac{B'}{m'})/(\rho - \omega_1)]. \tag{C.2}$$

With (C.2), one can also show that $dq/d\tau > 0$, $d\phi/d\tau < 0$ and $dv/d\tau < 0$. The inequality $q(0) < q^*$ can be verified directly using the equation for q in (4.1). This completes the proof for (i) – (v).

For part (vi), differentiate the equations for (n, K) in (4.1) with respect to time yields

$$\begin{pmatrix} \dot{n} \\ \dot{K} \end{pmatrix} = \frac{1}{z_{14} - z_{24}} \begin{pmatrix} \omega_2 z_{14} - \omega_1 z_{24} & \omega_1 - \omega_2 \\ -(\omega_1 - \omega_2) z_{14} z_{24} & \omega_1 z_{14} - \omega_2 z_{24} \end{pmatrix} \begin{pmatrix} n - n^* \\ K - K^* \end{pmatrix}.$$

Notice that $z_{14} > 0$ and $z_{24} < 0$. It is then evident that the $\dot{n} = 0$ and $\dot{K} = 0$ schedules are both positively sloped. Since the coefficient matrix has two negative eigenvalues (ω_1 and ω_2), its determinant is positive and so the $\dot{n} = 0$ schedule is steeper than the $\dot{K} = 0$ schedule. The $\dot{n} = 0$ schedule is steeper than the line $G_1 = \rho$ if and only if

$$-\frac{\omega_2 z_{14} - \omega_1 z_{24}}{\omega_1 - \omega_2} > -\frac{G_{12}}{G_{11}} = \kappa,$$

which can be verified after substituting z_{14} and z_{24}. However, the $\dot{K} = 0$ schedule may or may not be steeper than the line $G_1 = \rho$.

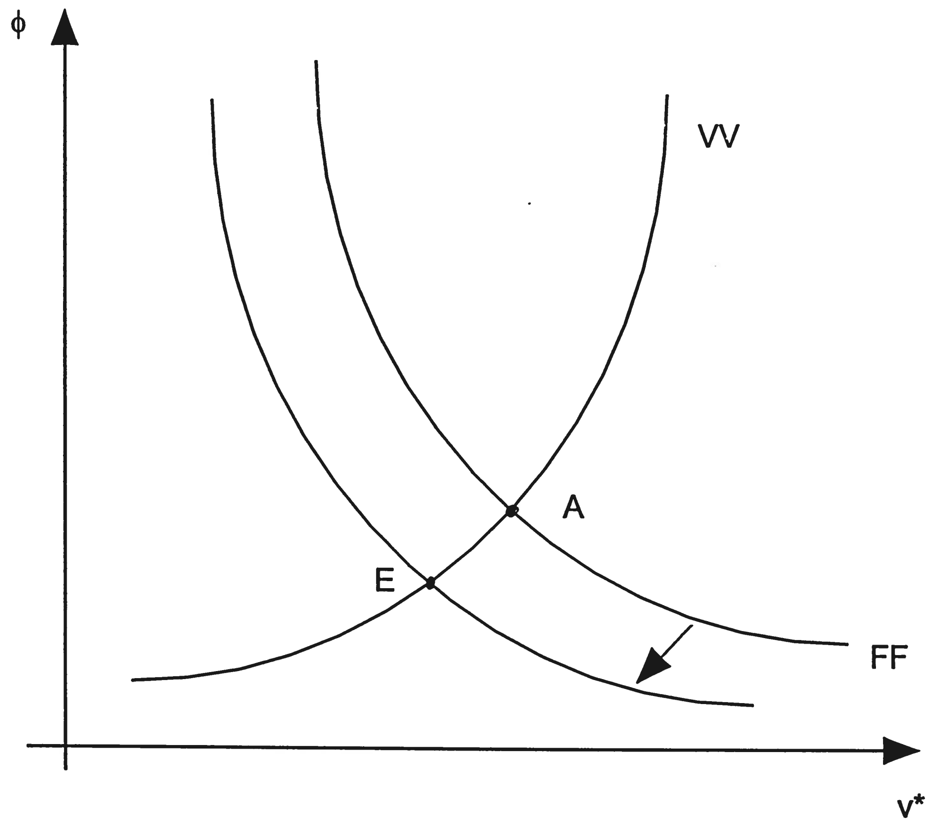

Figure 1

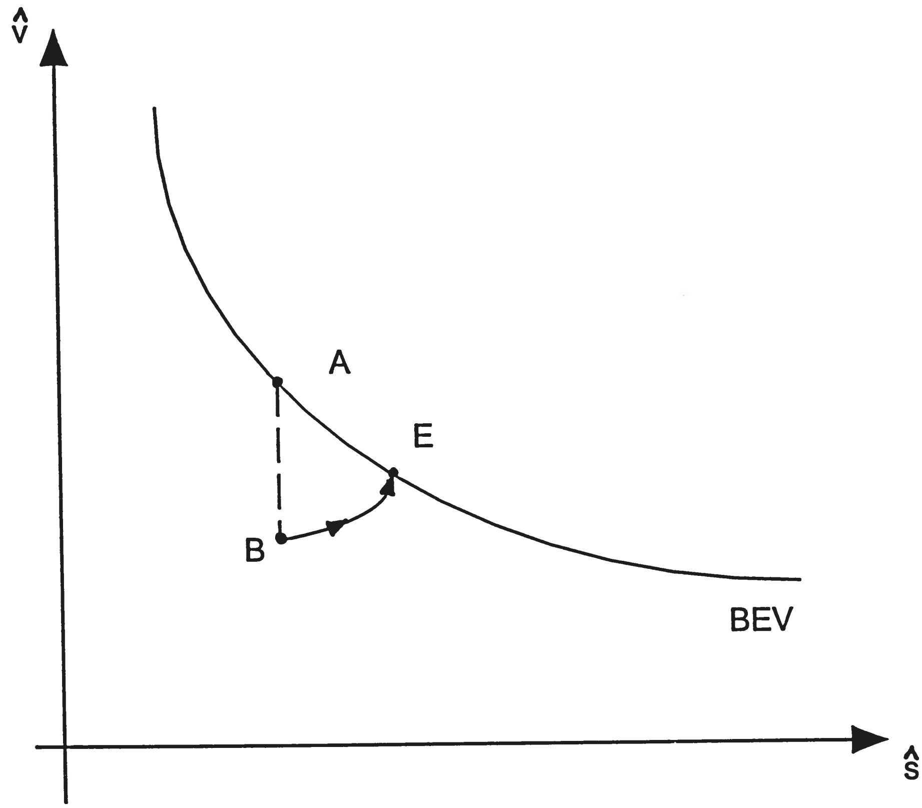

Figure 2

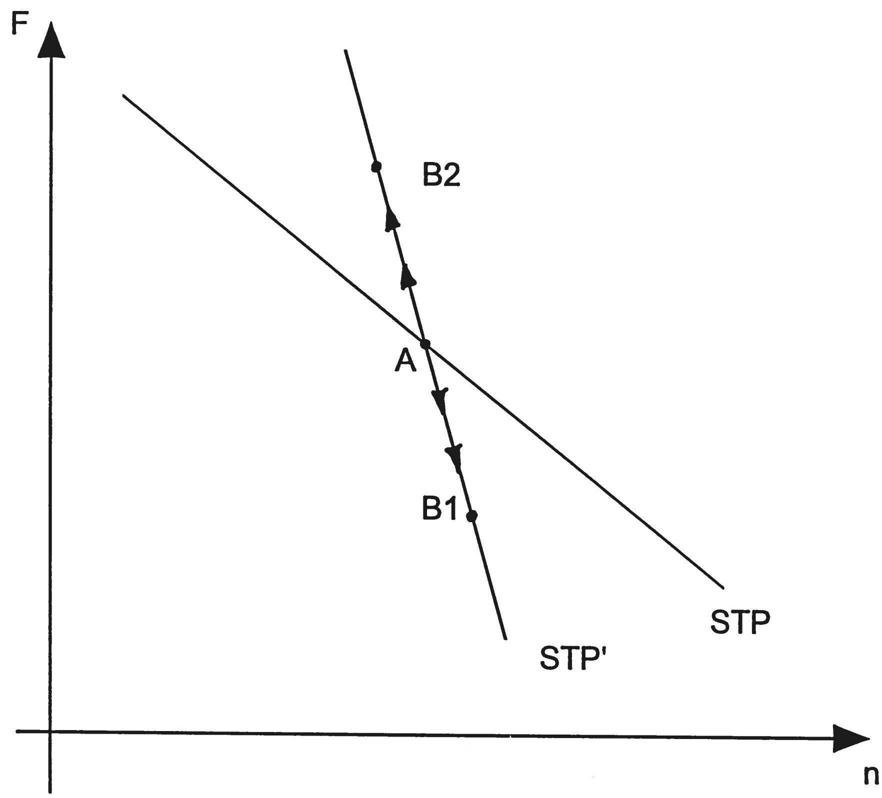

Figure 3

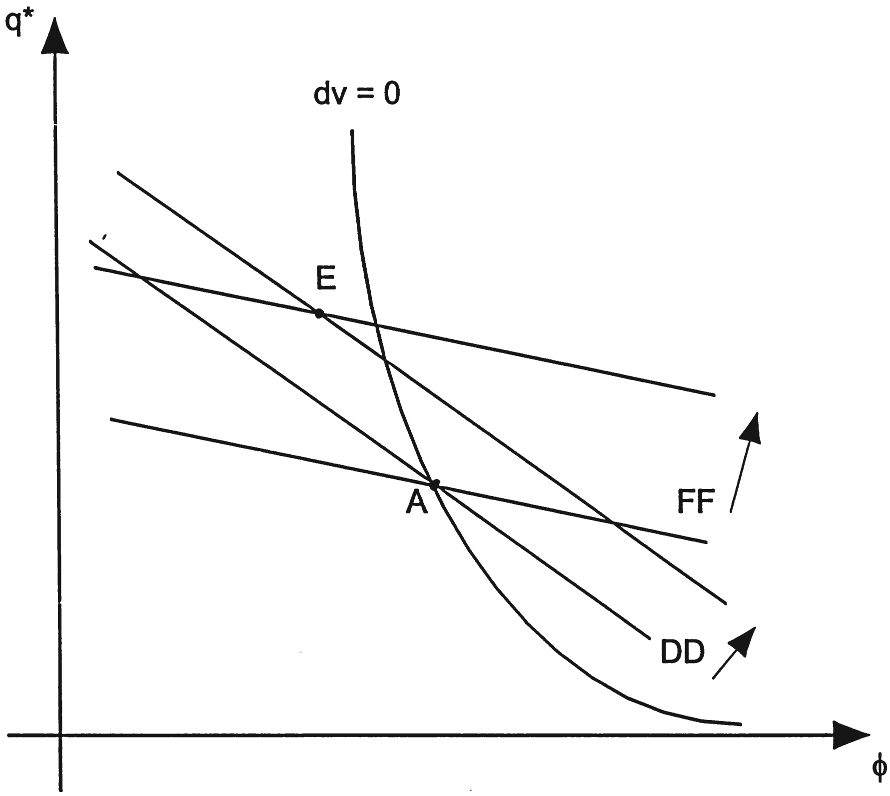

Figure 4

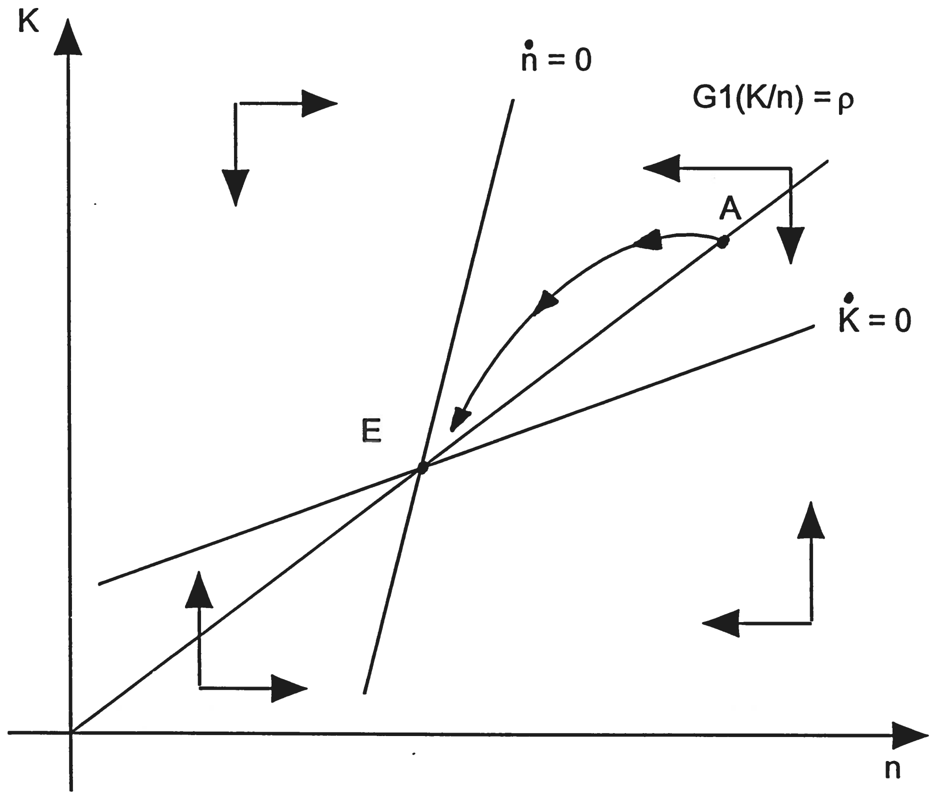

Figure 5