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Short-Run Trade Surplus Creation

Makoto Yano*

Abstract

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* Professor, Department of Economics, Keio University

Faculty of Economics and Faculty of Business and Commerce, Keio University
2-15-45 Mita, Minato-ku, Tokyo 108-8345, Japan

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Makoto Yano

Department of Economics, Keio University
Mita, Minato, Tokyo, Japan 108-8345
myano@econ.keio.ac.jp

Abstract

This study constructs a generalized version of quasi-stationarys dynamic equilibrium models and derives a set of conditions under which a uniform suppression of present and future consumptions results in what Yano (2001) calls a short-run trade surplus creation effect. This result reveals a common mechanism that underlies in a number of existing results that independently obtain similar effects in different model settings.
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1 Introduction

It has been recognized by a number of studies that an exogenous change that suppresses a country's present and future demands tends to increase the country's present trade surplus at the same time as to decrease its trade surpluses in future periods (see Sen and Turnovsky, 1989, Ono and Shibata, 1992, Yano, 2001, and Ota, 2002). Because those results have been derived in completely different contexts, their close similarity has not yet been appreciated in the literature.

Towards filling this void, the present study constructs a generalized version of quasi-stationary dynamic equilibrium models, which are adopted in the existing studies, and characterizes what Yano (2001) calls a short-run trade surplus creation, i.e., the phenomenon that an exogenous change that suppresses present and future consumptions uniformly over time increases the present trade surplus and, at the same time, decreases the trade surplus in each future period as much as the interest accruing to the increase in the present trade surplus. This result reveals that short-run trade surplus creation is a phenomenon that can be observed in a broad range of quasi-stationary models on trade balance dynamics, including the existing studies.

Yano (2001) attributes a short-run trade surplus creation to the fact that the supply of tradables at the initial point of time is assumed to be inelasitic in a dynamic equilibrium model of trade balances (the short-run specificity of a supply of tradables). In Section 2, simplifying Yano's argument, I will prove a preliminary theorem, relating short-run trade surplus creation to the short-run specificity of a supply of tradables. In Section 3, I will present a generalized version of the quasi-stationary models on which the existing studies are based and characterize short-run trade surplus creation in that model. Section 4 explains that result in a simple example.

2 A Preliminary Theorem

The goods and services (including both production factors and consumption goods) that exist in an economy consist of tradables (i.e., those traded between countries) and non-tradables (those traded only within a country). Let Y_t and X_t, respectively, be the total value of the home country's supplies of tradables and that of its demands for tradables at time t in current value. A surplus on trade account in period t, s_t, can be defined as a difference between them, i.e.,

$$s_t = Y_t - X_t. \tag{1}$$

Let $t = 0$ be the present time. Let C_0 be the exogenously given value of foreign credits that the country holds at $t = 0$. Then, the intertemporal budget constraint that the country faces implies that the sum of present values of present and future trade surpluses must be equal to the foreign credit held at $t = 0$. That is to say, it must hold that

$$\sum_{t=0}^{\infty} \left(\prod_{\tau=1}^{t} \frac{1}{1+i_t} \right) s_t = -C_0, \tag{2}$$

where $\Pi_{t=1}^{0} x_t = 1$, and where i_t is the interest rate in the period between $t-1$ and t (period t).

Assumption 1 (small country): The country is small in that any parametric change taking place in that country does not affect the present-value prices of all tradables, including the sequence of interest rates, i_t $(t = 1, 2, ...)$.

Assumption 2 (short-run specificity in supply): $Y_0 = \bar{Y}$.

The next theorem follows from these assumptions.

Theorem 1 *Suppose $dX_0 = \xi_0 d\mu$. Under the assumption that a country is small, it holds that*

$$ds_0 = -\xi_0 d\mu \tag{3}$$

and

$$\sum_{t=1}^{\infty} \left(\prod_{\tau=1}^{t} \frac{1}{1+i_t} \right) ds_t = -ds_0. \tag{4}$$

Proof. Under the small-country assumption (Assumption 1), (2) implies (4). By Assumption 2 and (1), (3) holds. ■

This theorem implies that any exogenous change that suppresses consumption in the initial period, $t = 0$, increases the trade surplus in period 0 (i.e., $\xi_0 d\mu < 0$ implies $ds_0 > 0$) and that the future trade surpluses (s_t, $t = 1, 2, ...$) must decrease so as to offset the increase in period-0 trade balance. This is a direct consequence of the following conditions:

1. A country's tradable endowment, $\bar{Y}$, in the initial period is fixed (Assumption 2);
2. A country is subject to its intertemporal budget constraint, which implies (4);
3. A country is small so that an exogenous change within the country does not affect relative prices of present and future tradables, which are presented by interest rates i_t, $t = 1, 2, ...$

3 Fundamental Theorem on Short-Run Trade Surplus Creation

Straight-forward as it is, Theorem 1 captures the fundamental feature of adjustments in trade balance that underlies the results of Sen and Turnovsky (1989), Ono and Shibata (1992), and Yano (2001). In this section, I will explain this fact by using a generalized version of their models.

Towards this end, let $\mathbf{q}_t$ be the vector of prices of tradables in current value in period t and $\mathbf{x}_t$ and $\mathbf{y}_t$, respectively, be the vectors of demands for and supplies of tradables in period t. Then, X_t and Y_t can be written as follows:

$$X_t = \mathbf{q}_t\mathbf{x}_t;\ Y_t = \mathbf{q}_t\mathbf{y}_t. \tag{5}$$

Assume that the country is endowed with fix amounts of tradables at $t = 0$, i.e.,

$$\mathbf{y}_0 = \bar{\mathbf{y}}, \tag{6}$$

which the country, inelastically, supplies at time 0.

Denote by $\mathbf{p}_t$ the vector of current-value prices of non-tradables in period t. The behavior of consumers in a country is described by the maximization problem of a representative agent. Denote by $\mathbf{c}_t$ the country's aggregate consumption vector. Because consumers may consume non-tradables as well as tradables, the elements of $\mathbf{c}_t$ consist of both tradables and non-tradables. The total value of consumption in period t is $\mathbf{r}_t\mathbf{c}_t$ in current value, where $\mathbf{r}_t = (\mathbf{q}_t, \mathbf{p}_t)$.

A country's intertemporal consumption is constrained by its wealth constraint, i.e., which can be expressed as

$$\sum_{t=0}^{\infty}\left(\prod_{\tau=1}^{t}\frac{1}{1+i_t}\right)\mathbf{r}_t\mathbf{c}_t = W_0, \tag{7}$$

where W_0 is the value of the country's wealth. A country's present and future consumptions, $\mathbf{c}_t$ $(t = 0, 1, 2, ...)$, are determined so as to maximize the discounted utility sum of the representative agent,

$$U_0 = \sum_{t=0}^{\infty}\rho^t f(\mathbf{c}_t), \tag{8}$$

subject to the wealth constraint, (7), where ρ is the discount factor of future utilities satisfying

$$0 < \rho < 1. \tag{9}$$

In a dynamic general equilibrium model, like those of Sen and Turnovsky (1989), Ono and Shibata (1992) and Yano (2001), the initial wealth, W_0, cannot be determined unless the production process of the model is specified; once a complete model with a production side is set up, it may be demonstrated that the wealth constraint, (7), and the intertemporal constraint on trade surplus, (2), are equivalent. Because the following argument is not model specific, I will not spell out the complete structure of production in this section.

In the class of quasi-stationary models, in general, the demand and supply vectors at time t, $\mathbf{x}_t$ and $\mathbf{y}_t$, can be written as time-independent functions of current value prices time t and $t-1$, $\mathbf{q}_t$, $\mathbf{p}_t$, $\mathbf{q}_{t-1}$ and $\mathbf{p}_{t-1}$, and interest rates at t and $t-1$, i_t and i_{t-1}, as well as the implicit price of utility U_0, which is equal to the inverse of the Lagrangean multiplier associated with the consumer's maximization problem. Denote by λ this Lagrangean multiplier. In a quasi-stationary model, for $t = 1, 2, ...$,

$$\mathbf{x}_t = \mathbf{x}\left(\mathbf{q}_t, \mathbf{p}_t, \mathbf{q}_{t-1}, \mathbf{p}_{t-1}, i_{t-1}, i_t, \lambda; \mu\right) \tag{10}$$

and

$$\mathbf{y}_t = \mathbf{y}\left(\mathbf{q}_t, \mathbf{p}_t, \mathbf{q}_{t-1}, \mathbf{p}_{t-1}, i_{t-1}, i_t, \lambda; \mu\right), \tag{11}$$

where μ is the exogenous parameter.

Sen and Turnovsky (1989), Ono and Shibata (1992) and Yano (2001) focus on the case in which the value of an exogenously determined parameter changes once and for all at time 0 and compare the post-parameter change equilibrium path with the pre-parameter change equilibrium path. Their results hinge on the two basic assumptions: the assumptions of a stationary pre-change equilibrium and the "price-pegging property."

Assumption 3 (stationary pre-parameter-change equilibrium): The equilibrium that holds before the value of parameter μ changes is stationary; i.e., $\mathbf{q}_t = \mathbf{q}$, $\mathbf{p}_t = \mathbf{p}$, $i_{t+1} = i$, $\mathbf{x}_t = \mathbf{x}$ and $\mathbf{y}_t = \mathbf{y}$ for $t = 0, 1, ...$

Under this assumption, given (10) and (11), the stationarity of prices and interest rates implies that of $\mathbf{x}_t$ and $\mathbf{y}_{t+1}$ but does not imply $\mathbf{y}_t = \mathbf{y}_0$, which Assumption 3 intends to guarantee as well. Let $\tilde{\mathbf{q}}$, $\tilde{\mathbf{p}}$, and $\tilde{\imath}$ be the sequences of tradable prices and non-tradable prices, $\mathbf{q}_t$ and $\mathbf{p}_t$ $(t = 0, 1, ...)$, and interest rates, i_t $(t = 1, 2, ...)$.

Assumption 4 (price-pegging property): There is a function $\tilde{\mathbf{p}}$ such that

$$\tilde{\mathbf{p}} = \tilde{\mathbf{p}}(\tilde{\mathbf{q}}, \tilde{\imath}) \tag{12}$$

around the pre-parameter-change equilibrium.[1]

This assumption implies that the prices of tradables determine those of non-tradables. Under the small-country assumption (Assumption 1), therefore, any parametric change that takes place within a country does not affect the prices of non-tradables. This is a generalization of the standard assumption in the international economic literature. In the standard trade literature, which assumes that only the production factors are non-tradables, the result deriving Assumption 4 from a fundamental structure of a model is called a factor price equalization theorem.

Denote by $\nabla_\lambda \mathbf{y}$ ($\nabla_\lambda \mathbf{x}$) and $\nabla_\mu \mathbf{y}$ ($\nabla_\mu \mathbf{x}$), respectively, the vectors of partial derivatives of function $\mathbf{y}$ ($\mathbf{x}$) with respect to λ and μ. The next theorem generalizes Yano's result (2001).

Theorem 2 *Suppose that* $\frac{\mathbf{q}\nabla_\lambda \mathbf{y}}{1+i} \neq \mathbf{q}\nabla_\lambda \mathbf{x}$. *There is* σ *such that* $\mathbf{q}d\mathbf{x}_t = \sigma d\mu$ *for* $t = 0, 1, 2, ...$ *and that* $ds_t = -ids_0 = i\sigma d\mu$ *for all* $t = 1, 2, ...$

Proof. Given Assumptions 3 and 4, it holds that

$$d\mathbf{x}_t = (\nabla_\lambda \mathbf{x})d\lambda + (\nabla_\mu \mathbf{x})d\mu \tag{13}$$

and

$$d\mathbf{y}_{t+1} = (\nabla_\lambda \mathbf{y})d\lambda + (\nabla_\mu \mathbf{y})d\mu \tag{14}$$

for all $t = 0, 1, 2, ...$ These equations imply that it is possible to set $d\mathbf{x} = d\mathbf{x}_t$ and $d\mathbf{y} = d\mathbf{y}_{t+1}$. By eliminating $d\lambda$, it holds that

$$\mathbf{q}d\mathbf{y} = \frac{\mathbf{q}\nabla_\lambda \mathbf{y}}{\mathbf{q}\nabla_\lambda \mathbf{x}}\mathbf{q}d\mathbf{x} + \left[(\mathbf{q}\nabla_\mu \mathbf{y}) - \frac{\mathbf{q}\nabla_\lambda \mathbf{y}}{\mathbf{q}\nabla_\lambda \mathbf{x}}(\mathbf{q}\nabla_\mu \mathbf{x})\right] d\mu. \tag{15}$$

Under Assumption 3, (5) implies

$$ds_t = \mathbf{q}d\mathbf{y} - \mathbf{q}d\mathbf{x} \tag{16}$$

for $t = 1, 2, ...$ Moreover, by (6),

$$ds_0 = -\mathbf{q}d\mathbf{x}. \tag{17}$$

Thus, by (4),

$$\mathbf{q}d\mathbf{y} = (1+i)\mathbf{q}d\mathbf{x}. \tag{18}$$

[1] See Ota (2002), who demonstrates that this price-pegging property is crucial in order to a short-run trade surplus creation to emerge unambiguously.

Thus, by (15) and (18),

$$\mathbf{q}d\mathbf{x} = \frac{(\mathbf{q}\nabla_\lambda \mathbf{y})(\mathbf{q}\nabla_\mu \mathbf{x}) - (\mathbf{q}\nabla_\mu \mathbf{y})(\mathbf{q}\nabla_\lambda \mathbf{x})}{\mathbf{q}\nabla_\lambda \mathbf{y} - (1+i)\mathbf{q}\nabla_\lambda \mathbf{x}} d\mu. \tag{19}$$

This implies the theorem. ■

This theorem demonstrates that a short-run trade surplus creation can occur in a broad range of quasi-stationary equilibrium models. As it shows, if the pre-parameter change equilibrium is stationary, a once-and-for-all change in parameter μ affects uniformly the present and future demands for tradables ($\mathbf{q}d\mathbf{x}_t = \sigma d\mu$ for $t = 0, 1, 2, ...$). If this change is to suppress the demands for tradables ($\sigma d\mu < 0$), the present trade surplus increases as much as the reduction in the value of the tradables demand in each period ($ds_0 = -\sigma d\mu$). This increase in present trade surplus is matched by uniform reductions in trade surplus over the future periods, which are equal to the interest accruing to the increase in present trade surplus ($ds_t = i\sigma d\mu$ for $t = 1, 2, ...$). The quasi-stationary model of this study is consistent with many dynamic equilibrium models in the existing literature. Theorem 2 shows that a short-run trade surplus creation occurs in those models.

In a dynamic equilibrium, in general, it follows from the equilibrium conditions that

$$\frac{\mathbf{q}\nabla_\lambda \mathbf{y}}{1+i} > \mathbf{q}\nabla_\lambda \mathbf{x}, \tag{20}$$

which guarantees the hypothesis of Theorem 2. In order to check if this inequality actually holds, it is necessary complete to spell out the structure of a dynamic model, which I do not provide in order to simplify the presentation. Instead, in the next section, I will demonstrate that (20) holds in a specific example of the model.

4 A Simple Example

In this section, I construct a simple example in which Theorem 2 is applicable. In the example, the representative consumer consumes the aggregate product c_t and leisure l_t in period t. Let q_t and w_t be the current-value price of the product and the wage rate in period t. the representative consumer's optimization problem is

$$\max_{c_t, l_t,\, t=0,1,2,...} \sum_{t=0}^{\infty} \rho^t (u(c_t, \mu) + v(l_t))$$
$$\text{s.t.} \quad \sum_{t=0}^{\infty} \left(\prod_{\tau=1}^{t} \frac{1}{1+i_\tau} \right) (q_t c_t + w_t l_t) = W_0, \tag{21}$$

where $\Pi_{t=1}^{0} x_t = 1$. Assume that u and v are strictly concave and increasing in c_t and l_t, respectively. Wealth W_0 is

$$W_0 = q_0 \bar{y} + \sum_{t=0}^{\infty} \left(\prod_{\tau=1}^{t} \frac{1}{1+i_\tau} \right) w_t \bar{l} + C_0. \tag{22}$$

On the production side, in period t, aggregate output y_{t+1} is produced by using produced input z_t and labor l_t. The product, y_{t+1}, is used for both consumption and production in period $t+1$. At each time, the produced input, z_t, the product, y_t, and the consumable, c_t, are perfect substitutes of one another. The behavior of the country's producers is described as the maximization problem of the sum of present values of profits over time, i.e.,

$$\max_{y_t, z_{t-1}, h_t,\, t=1,2,..} \sum_{t=0}^{\infty} \left(\prod_{\tau=1}^{t} \frac{1}{1+i_\tau} \right) \left(\frac{1}{1+i_{t+1}} q_{t+1} y_{t+1} - q_t z_t - w_t h_t \right)$$
$$\text{s.t.} \quad y_{t+1} = F(z_t, h_t),\ t = 0, 1, 2, ... \quad , \tag{23}$$

where $F(z,h)$ is a concave and linearly homogenous production function.

There are two markets in period $t = 0, 1, 2, ...$: the product market and the labor market. The market clearing condition in the labor market is

$$\bar{l} = l_t + h_t, \tag{24}$$

which implies that labor is a non-tradable. In the small-country case, a country can purchase as much as it wants at the international price of the product (exogenously determined). The demand for the product is

$$x_t = z_t + c_t. \tag{25}$$

In equilibrium, in the small-country case, the sequences of products y_{t+1}, inputs of the produced goods z_t, labor inputs h_t, aggregate consumptions of the product and leisure, c_t and l_t must satisfy conditions (21)-(25).

In order to relate this example, described by conditions (21)-(25), to the general model developed in the previous section, it is important first to show that the wealth constraint in (21) implies the trade balance constraint, (2). Towards this end, note that the production plan, (y_{t+1}, z_t, h_t) where $t = 0, 1, 2, ...$, must satisfy, in equilibrium,

$$z_t = a_K(q_t, w_t) y_{t+1}, \tag{26}$$

$$h_t = a_L(q_t, w_t) y_{t+1}, \tag{27}$$

and

$$a_Z(q_t, w_t) q_t + a_L(q_t, w_t) w_t = \frac{1}{1 + i_{t+1}} q_{t+1}, \tag{28}$$

where $(a_Z(q_t, w_t), a_L(q_t, w_t))$ is the input vector that minimizes the unit cost of production, i.e., solves the following minimization problem

$$\min_{a_Z, a_L} \; q_t a_Z + w_t a_L \text{ s.t. } F(a_Z, a_L) = 1. \tag{29}$$

The wealth constraint in (21) can be transformed into (2) by using (24) through (28).

Next, I will demonstrate that the model is quasi-stationary in the sense of the previous section. To this end, take the first order condition of optimization for (21), which implies that there is $\lambda > 0$ such that

$$\rho^t u_c(c_t, \mu) = \lambda \left(\prod_{\tau=1}^{t} \frac{1}{1 + i_\tau} \right) q_t, \tag{30}$$

where u_c is the partial derivative of $u(c, \mu)$ with respect to c, and

$$\rho^t v'(l_t) = \lambda \left(\prod_{\tau=1}^{t} \frac{1}{1 + i_\tau} \right) w_t. \tag{31}$$

Since the pre-parameter change equilibrium is assumed to be stationary, in that equilibrium, (30) and (31) must hold for $q_t = q$, $i_t = i$, $w_t = w$, $c_t = c$ and $l_t = l$ for $t = 1, 2, ...$ This implies that

$$\frac{1}{1 + i} = \rho. \tag{32}$$

This implies

$$u_c(c_t, \mu) = \lambda q_t \tag{33}$$

and

$$v'(l_t) = \lambda w_t. \tag{34}$$

In order to express the equilibrium system described by (21)-(25) in the form of (10) and (11), by solving (34), express l_t as a function of λw_t, $l_t = l(\lambda w_t)$. By using this function and (24), (27) can be transformed as

$$y_t = \frac{\bar{l} - l(\lambda w_{t-1})}{a_L(q_{t-1}, w_{t-1})} = y(q_{t-1}, w_{t-1}, \lambda). \tag{35}$$

Moreover, by solving (33), express c_t as a function of λq_t and μ, $c_t = c(\lambda q_t, \mu)$. Then, by using (26) and (35), (25) can be transformed as

$$x_t = a_Z(q_t, w_t)\frac{\bar{l} - l(\lambda w_t)}{a_L(q_t, w_t)} + c(\lambda q_t, \mu) = x(q_t, w_t, \lambda, \mu). \tag{36}$$

Equations (35) and (36) are the counterparts of (10) and (11). Thus, the example here is quasi-stationary in the sense of the previous section.

That this example has the price-pegging property (Assumption 4) follows from the fact that (28) can be solved for w_t, which can be expressed as a function of q_t, q_{t+1}, and i_{t+1}. In the example, the aggregate product and labor are assumed to be a tradable good and a non-tradable good. This implies that the prices of present and future non-tradable goods (labor) are pegged by the prices of present and future aggregate products and interest rates.

In order to apply Theorem 2, next check if condition (20) is in fact satisfied. To this end, by using (35) and (36), obtain

$$\frac{1}{1+i}\frac{\partial y}{\partial \lambda} - \frac{\partial x}{\partial \lambda} = -\left(\frac{1}{1+i} - a_Z\right)\frac{wl'}{a_L} - qc^1 > 0, \tag{37}$$

where c^i is the partial derivative of $c(\lambda q, \mu)$ with respect to the i-th coordinate. By the strict concavity of u and v, $l' < 0$ and $c^1 < 0$. Since (28) implies

$$\frac{1}{1+i} - a_Z = wa_L/q > 0 \tag{38}$$

in the pre-parameter change equilibrium, the last inequality follows. This inequality implies condition (20).

Finally, I will derive the counterpart of (19) in the example. To this end, by totally differentiating $c_t = c(\lambda q, \mu)$, obtain

$$dc_t = qc^1 d\lambda + c^2 d\mu. \tag{39}$$

Moreover, by totally differentiating (25), (26), and (35), obtain

$$dx_t = a_Z dy_{t+1} + qc^1 d\lambda + c^2 d\mu \tag{40}$$

and

$$dy_{t+1} = -\frac{wl'}{a_L} d\lambda. \tag{41}$$

Since these equations imply that dy_{t+1} and dx_t are time independent for $t = 0, 1, 2, ...$, set $dy_{t+1} = dy$ and $dx_t = dx$ for $t = 0, 1, 2, ...$ Since $ds_0 = -qdx$ and $ds_t = q(dy - dx)$, by (40) and (41), (4) implies

$$dx = \frac{\frac{wl'}{a_L}\frac{c^2}{1+i}}{\left(\frac{1}{1+i} - a_Z\right)\frac{wl'}{a_L} + qc^1} d\mu. \tag{42}$$

Since $wl'/a_L < 0$, by (37), this equation shows that if $c^2 d\mu < 0$, $qdx_t = qdx < 0$ for all $t = 0, 1, ...$ That $c^2 d\mu < 0$ implies that a change in parameter μ suppresses consumption uniformly over time. Thus, (42) implies that a once-and-for-all suppression of consumption leads to a uniform reduction in a country's demands for tradables over time. In that case, by Theorem 2, a trade surplus creation effect emerges, i.e., the country's present trade surplus increases, and the increases is met by uniform reductions in that country's future trade surpluses that are equal to the interest accruing to the increase in present surplus.

This result is a simplified version of Yano's result (2001), in which a once-and-for-all suppression of consumption is attributed to an exogenous reduction in the degree of competition in the market for consumption goods. In obtaining similar results, Sen and Turnovsky (1989) focus on a once-and-for-all increase of a tariff rate, whereas Ono and Shibata (1992) analyze the effect of a corporate tax. Because those studies adopt more complicated models than this section's example, it is necessary in each model to check how Theorem 2 can be applied. While the present study is based on a discrete time model, Sen and Turnovsky adopt a continuous time model. Whether or not their result can be explained by a continuous-time model version of Theorem 2 is an interesting subject, which is left for a future investigation.

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