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ALAN KIRMAN
and
LOUIS PHLIPS

European University Institute, Florence

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Italy

Exchange Rate Pass–Through and Market Structure

Alan Kirman and Louis Phlips

Department of Economics
EUROPEAN UNIVERSITY INSTITUTE
Badia Fiesolana
I-50016 S. Domenico di Fiesole (Fi)
ITALY
Tel.: +39-55-50921
Fax: +39-55-5092.202

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Abstract

n firms located in market 1 and m firms located in market 2 each sell a homogeneous commodity in both markets. Each market has its own currency. The market demand functions differ. When these markets are independent on the cost side (constant marginal costs) and demands are linear, a merger in market 1 increases the pass-through (of an appreciation of currency 2) in market 1 and decreases the pass-through in market 2. A merger in market 2 has the opposite effect. With identical economies of scope linking the markets, the sign of the price changes may be reversed when the number of foreign firms is small enough compared to the number of local firms. However, the sign reversals cannot occur in the two markets simultaneously.

1 Introduction

Empirical evidence (see Feinberg (1986) and Fisher (1989a)) suggests that the pass-through of exchange rate changes (into export prices) is smaller when the exporting country is more concentrated. In particular, more concentrated industries lower their export price markup more than less concentrated industries, when there is an appreciation of their domestic market's currency. The econometric results obtained by Feinberg (1986, 1989, 1991) also indicate that domestic prices react more to exchange rate changes in industries with a larger import share. These findings are in accordance with the theoretical results on the relationship between exchange rate changes and domestic prices in oligopolistic "home" markets obtained by Dornbusch (1987) and Fisher (1989b).

This paper presents a model which allows one to simultaneously trace down the effects of an exchange rate change on the prices in two oligopolistic markets for the same commodity and to study the effect of mergers, i.e. increased concentration, on the pass-through in both directions. It is a generalization of Hens, Kirman and Phlips (1991), in which there is one firm in one market and one firm in the other market, each selling in the two markets considered. Here there are n firms in market 1 and m firms in market 2, so that the impact of mergers in one of the markets (or between markets) can be studied without losing the oligopolistic structure.

Studying the consequences of a merger and the resultant Cournot-Nash equilibrium is complicated, as Salant, Switzer and Reynolds (1983) pointed out. The essential problem is that a merger corresponds to the formation of a two-player coalition. As is well known in Game Theory, Nash equilibria are vulnerable to objections by coalitions of more than one player. Hence the coalition may lose as a result of forming, not since the previous outcome is not attainable but because their strategy would no longer be a best response to their opponents. Thus any analysis of a merger has to take account of the fact that the new equilibrium may be very different from the previous one. The route to positive results lies in limiting, by assumption, some of the possible changes in the equilibrium.

The model is presented in Section 2. A comparative statics analysis is then carried out, first under the standard assumption of constant marginal costs (Section 3). The impact of strategic complementarity and substitutability on individual quantity responses in the two markets to exchange rate changes is examined in some detail. Then the effects of mergers on the extent of the pass-through is traced out. Section 4 allows for economies and diseconomies of scope linking the two markets. When the firms benefit from identical economies of scope, the sign of the price changes may be reversed: the price may go up in the market whose currency appreciates, <u>or</u> the price may go down in the market whose currency depreciates, depending on the relative number of firms located in the two markets. Under the assumptions made, the two market prices may go up or the two market prices may go down. But the perverse situation where the price goes up in the country that appreciates and goes down in the country that depreciates cannot occur.

2 The Model

Let there be two markets for a homogeneous commodity, market 1 and market 2, separated by barriers other than tariffs and transportation costs. Market structure is oligopolistic in each: there are n firms located in market 1, selling $(x_{i1} + x_{i2})$ each $(i = 1, \ldots, n)$; there are m firms located in market 2, selling $(z_{k1} + z_{k2})$ each $(k = 1, \ldots, m)$.

The profit function of a firm located in market 1, expressed in market 1 currency, is

$$\Pi_i = p_1(X)\, x_{i1} + e\, p_2(Z)\, x_{i2} - c_i(x_{i1},\, x_{i2}) \tag{1}$$

where

$$X = \sum_{i=1}^{n} x_{i1} + \sum_{k=1}^{m} z_{k1} = X_1 + Z_1 \tag{2.1}$$

$$Z = \sum_{i=1}^{n} x_{i2} + \sum_{k=1}^{m} z_{k2} = X_2 + Z_2. \tag{2.2}$$

x_{i1} represents the sales of firm i in market 1 and x_{i2} represents its sales in market 2. And similarly for z_{k1} and z_{k2}. The inverse market demand functions are $p_1(X)$ and $p_2(Z)$, respectively. The exchange rate, e, is the worth in market 1 currency of the currency used in market 2. The cost functions are $c_i\,(x_{i1},\, x_{i2})$ and $c_k\,(z_{k1},\, z_{k2})$, with marginal costs c_i^1, c_i^2, c_k^1 and c_k^2. Superscripts denote derivatives with respect to the first, respectively second, argument. Firms located in market 2 have profit functions

$$\Pi_k = p_1(X)\, z_{k1} + e\, p_2(Z)\, z_{k2} - e\, c_k(z_{k1},\, z_{k2}) \tag{3}$$

also expressed in market 1 currency.

The demand, cost and profit functions obey the following assumptions. The inverse demand functions $p_j(X)$ and $p_j(Z)$, $j = 1, 2$, are continuous for all $X > 0$, $Z > 0$. For each market there exists $\bar{X} > 0$ and $\bar{Z} > 0$ such that $p_1(X) = 0$ for all $X \geq \bar{X}$, $p_2(Z) = 0$ for all $Z \geq \bar{Z}$ and $p_1(X) > 0$ for $X < \bar{X}$, $p_2(Z) > 0$ for $Z < \bar{Z}$. Furthermore, $p_j(0) = \bar{p}_j < \infty$ $(j = 1, 2)$ and for all X and Z such that $0 < X < \bar{X}$ and $0 < Z < \bar{Z}$ respectively, $p_1(X)$ and $p_2(Z)$ have a continuous second derivative p_j'' with $p_1'(X) < 0$ and $p_2'(Z) < 0$ for all X and Z. The cost functions $c_i(x_{i1},\, x_{i2})$ and $c_k(z_{k1},\, z_{k2})$ are defined and continuous for all output levels $x_{i1} \geq 0$, $x_{i2} \geq 0$, $z_{k1} \geq 0$ and $z_{k2} \geq 0$. $c_1(0,0) \geq 0$, $c_k(0,0) \geq 0$. c_i and c_k have continuous first and second partial derivations for all x_{i1}, x_{i2}, z_{k1}, $z_{k2} \geq 0$. Furthermore, c_i^1, c_i^2, c_k^1, $c_k^2 > 0$ for all x_{i1}, x_{i2}, z_{k1}, $z_{k2} \geq 0$. Finally, for all x_{i1}, x_{i2}, z_{k1}, $z_{k2} > 0$, $X < \bar{X}$ and $Z < \bar{Z}$. $\Pi_i(x_{i1},\, x_{i2},\, X,\, Z)$ and $\Pi_k(z_{k1},\, z_{k2},\, X,\, Z)$ are concave.

Let us derive the first-order conditions of a Cournot–Nash equilibrium. Differentiating Π_i and Π_k, the marginal profits are

$$\Pi_i^1(x_{i1},\, x_{i2},\, X,\, Z) = p_1'(X)\, x_{i1} + p_1(X) - c_i^1(x_{i1},\, x_{i2}) \tag{4.1}$$

$$\Pi_i^2(x_{i1},\, x_{i2},\, X,\, Z) = e(p_2'(Z)\, x_{i2} + p_2(Z)) - c_i^2(x_{i1},\, x_{i2}) \tag{4.2}$$

for firms i and

$$\Pi_k^1(z_{k1},\, z_{k2},\, X,\, Z) = p_1'(X)\, z_{k1} + p_1(X) - e\, c_k^1(z_{k1},\, z_{k2}) \tag{4.3}$$

$$\Pi_k^2(z_{k1},\, z_{k2},\, X,\, Z) = e(p_2'(Z)\, z_{k2} + p_2(Z) - c_k^2(z_{k1},\, z_{k2})) \tag{4.4}$$

for firms k. The system of $2(n+m)$ equations

$$\begin{aligned} \Pi_i^j(x_{i1}^*,\, x_{i2}^*,\, X^*,\, Z^*) &= 0 \qquad j=1,2;\; i=1,\ldots,n \\ \Pi_k^j(z_{k1}^*,\, z_{k2}^*,\, X^*,\, Z^*) &= 0 \qquad j=1,2;\; k=1,\ldots,m \end{aligned} \tag{5}$$

describes the first–order equilibrium conditions, where stars denote equilibrium values of the relevant variables.[1] These conditions allow one to divide (4.2) and (4.3) by e. A change in the exchange rate can therefore be interpreted alternatively as a rotation of a firm's foreign marginal revenue curve or as a change in the opposite direction of its marginal cost.

The second–order conditions imply

$$a_{i1} = p_1''(X^*)\, x_{i1}^* + 2p_1'(X^*) - c_i^{11}(x_{i1}^*,\, x_{i2}^*) < 0 \tag{6.1}$$

$$a_{i2} = e(p_2''(Z^*)\, x_{i2}^* + 2p_2'(Z^*)) - c_i^{22}(x_{i1}^*,\, x_{i2}^*) < 0 \tag{6.2}$$

$$a_{k1} = p_1''(X^*)\, z_{k1}^* + 2p_1'(X^*) - e\, c_k^{11}(z_{k1}^*,\, z_{k2}^*) < 0 \tag{6.3}$$

$$a_{k2} = e(p_2''(Z^*)\, z_{k2}^* + 2p_2'(Z^*) - c_k^{22}(z_{k1}^*,\, z_{k2}^*)) < 0. \tag{6.4}$$

We now introduce the following derivatives:

$$b_{i1} = p_1''(X^*)\, x_{i1}^* + p_1'(X^*) \tag{7.1}$$

$$b_{i2} = p_2''(Z^*)\, x_{i2}^* + p_2'(Z^*) \tag{7.2}$$

$$b_{k1} = p_1''(X^*)\, z_{k1}^* + p_1'(X^*) \tag{7.3}$$

$$b_{k2} = p_2''(Z^*)\, z_{k2}^* + p_2'(Z^*). \tag{7.4}$$

[1]Equilibrium exists under the assumptions made (Friedman (1977)). These assumptions are satisfied if $p_j' < 0$, $p_j'' < 0$ for both countries and c_i'', $c_k'' > 0$ for all i and k. They may still hold under economies of scale and $p_j'' > 0$ if p_j' is large enough.

An interesting interpretation was suggested by Bulow, Geanakoplos and Klemperer (1985). Think of b_{i1} as $\partial(\partial \Pi_i/\partial x^*_{i1})/\partial x^*_{j1}$ where j represents firms other than i selling in market 1: b_{i1} represents the change in the marginal profitability to firm i of being more aggressive (selling more) when competitor j becomes more aggressive (sells more) in market 1. Note that b_{i1} takes the same value with respect to $x^*_{j1}(j \neq i)$ and z^*_{k1} for all $j \neq i$ and k, b_{k1} takes the same value with respect to $z^*_{l1}(l \neq k)$ and x^*_{i1} for all $l \neq k$ and i, and similarly for b_{i2} and b_{k2}. When $b_{i1} > 0$, firm i regards its product as a "strategic complement" to the product of its competitors in market 1. When $b_{i1} < 0$, firm i regards its product as a "strategic substitute" to the product of its competitors in market 1. These signs clearly depend on the shape of the market demand functions and may therefore differ between markets although the commodity is homogeneous. Since demand in one market is independent of the price in the other market, there is no room for strategic substitutability or complementarity between markets. When demands are linear ($p''_1 = p''_2 = 0$), then $b_{i1} = b_{k1} = p'_1(X^*) < 0$ and $b_{i2} = b_{k2} = p'_2(Z^*) < 0$, so that strategic complementarity is eliminated.

3 Constant Marginal Costs

To gain first insights, we start with the standard assumption that all firms have constant marginal costs of production. There are no economies or diseconomies of scale: $c_i^{11} = c_i^{22} = c_k^{11} = c_k^{22} = 0$; there are no economies or diseconomies of scope between markets: $c_i^{12} = c_i^{21} = c_k^{12} = c_k^{21} = 0$, for all i and k. Consequently the two markets are independent on the cost side, in the sense that quantities sold in one market do not affect the marginal cost of quantities sold in the other market, and each market's equilibrium can be determined separately.

3.1 Exchange Rate Pass–Through

Stability conditions can also be imposed on each market separately. Such conditions are needed to establish the consequences of an exchange rate change. A natural adjustment process is to suppose that a firm will increase its sales if it obtains a positive marginal profit from so doing. For market 1, the adjustment process is

$$\dot{x}_{i1} = \Pi_i^1(x_{11}, \ldots, x_{n1}, z_{11}, \ldots, z_{m1}, e) \quad (8.1)$$

$$\dot{z}_{k1} = \Pi_k^1(x_{11}, \ldots, x_{n1}, z_{11}, \ldots, z_{m1}, e). \quad (8.2)$$

Linearising around the equilibrium point $x^*_{11}, \ldots, x^*_{1n}, z^*_{11}, \ldots, z^*_{m1}$, i.e. taking a first-order Taylor expansion, one obtains

$$\begin{bmatrix} \dot{x}_{11} \\ \dot{x}_{21} \\ \vdots \\ \dot{z}_{m1} \end{bmatrix} = \begin{bmatrix} a_{11} & b_{11} & \cdots & \cdots & b_{11} \\ b_{21} & a_{21} & b_{21} & \cdots & b_{21} \\ & & & & \\ b_{m1} & b_{m1} & b_{m1} & \cdots & a_{m1} \end{bmatrix} \begin{bmatrix} x_{11} - x^*_{11} \\ x_{21} - x^*_{21} \\ \\ z_{m1} - z^*_{m1} \end{bmatrix} \quad (9)$$

and similarly for market 1.

We have

$$\begin{aligned} a_{i1} &= \Pi_i^{11} = b_{i1} + p_1'(X^*) < 0 \quad \text{for all } i \\ a_{k1} &= \Pi_k^{11} = b_{k1} + p_1'(X^*) < 0 \quad \text{for all } k, \end{aligned}$$

a necessary condition for stability. Another necessary condition is that the determinant of the coefficient matrix in (9) should have the same sign as $(-1)^{n+m}$. This determinant can be written as

$$\left[\prod_{j=1}^{n+m} (a_{j1} - b_{j1})\right] \left[1 + \sum_{j=1}^{n+m} (\frac{b_{j1}}{a_{j1} - b_{j1}})\right].$$

Therefore

$$(-1)^{n+m} \left[\prod_{j=1}^{n+m} (a_{j1} - b_{j1})\right] \left[1 + \sum_{j=1}^{n+m} (\frac{b_{j1}}{a_{j1} - b_{j1}})\right] > 0. \tag{10}$$

Sufficient conditions are obtained by requiring that the coefficient matrix in (9) has the "dominant diagonal" property

$$|a_{j1}| > (n + m - 1)\,|b_{j1}| \tag{11}$$

for $j = 1, \ldots, n + m$. In conjunction with the second-order conditions, this implies

$$\begin{aligned} a_{j1} + (n + m - 1)\, b_{j1} &< 0 \qquad \text{if} \quad b_{j1} > 0 \\ a_{j1} - (n + m - 1)\, b_{j1} &< 0 \qquad \text{if} \quad b_{j1} < 0. \end{aligned} \tag{12}$$

These inequalities in turn imply

$$a_{j1} - b_{j1} < 0 \qquad\qquad j = 1, \ldots, n + m. \tag{13}$$

Therefore

$$(-1)^{n+m} \prod_{j=1}^{n+m} (a_{j1} - b_{j1}) > 0$$

and (10) implies

$$\beta_1 = 1 + \sum_{j=1}^{n+m} \left(\frac{b_{j1}}{a_{j1} - b_{j1}}\right) > 0. \tag{14}$$

Similar conditions apply to market 2. Since $a_{i1} - b_{i1} = p_1' - c_i^{11}$, $i = 1, \ldots, n$, and $a_{k1} - b_{k1} = p_1' - e\,c_k^{11}$, $k = 1, \ldots, m$, conditions (13) impose that the slope of the inverse market demand curve (expressed in home currency) be smaller than the slope of the marginal cost curve. When, as here, marginal cost is constant, condition (14) simplifies to

$$\beta_1 = 1 + n + m + \left(\frac{p_1''}{p_1'}\right) X > 0, \tag{14.1}$$

which restricts complementarity (occurring when p_1'' is positive). Condition (14) ceases to be restrictive when, in addition, market demand is linear ($p_1'' = p_2'' = 0$), since then

$$\beta_1 = \beta_2 = 1 + n + m, \tag{14.2}$$

strategic complementarity being eliminated altogether as noticed above.

We are now ready for comparative statics. Let $y_i = X - x_{i1}$, $y_k = X - z_{k1}$, $g_i = Z - x_{i2}$, $g_k = Z - z_{k2}$. Total differentiation of the first-order conditions (5) gives

$$a_{i1}\,dx_{i1} + b_{i1}\,dy_1 = 0 \tag{15.1}$$

$$a_{k1}\,dz_{k1} + b_{k1}\,dy_k = \delta_{k1}\,de \tag{15.2}$$

$$a_{i2}\,dx_{i2} + b_{i2}\,dg_i = \delta_{i2}\,de \tag{15.3}$$

$$a_{k2}\,dz_{k2} + b_{k2}\,dg_k = 0 \tag{15.4}$$

where $\delta_{k1} = -\Pi_k^{1e}$ and $\delta_{i2} = -\Pi_i^{2e}$. In particular,

$$\delta_{k1} = c_k^1 > 0$$

is the cost increase (in market 1 currency) resulting from an appreciation of market 2 currency for firms located in market 2. Similarly,

$$\delta_{i2} = -\left(\frac{1}{e}\right) c_i^2 < 0$$

is the cost reduction (in market 2 currency) resulting from an appreciation of market 2 currency for firms located in market 1.

Rewrite (15.1) as

$$a_{i1}\,d\,x_{i1} + b_{i1}\,(d\,X - d\,x_{i1}) = 0$$

or

$$d\,x_{i1} + \frac{b_{i1}}{a_{i1} - b_{i1}}\, d\,X = 0.$$

Summing over i,

$$d\,X_1 + \left[\sum_{i=1}^{n} \left(\frac{b_{i1}}{a_{i1} - b_{i1}}\right)\right] d\,X = 0. \tag{16.1}$$

Rewrite (15.2) as

$$a_{k1}\, d\,z_{k1} + b_{k1}\,(d\,X - d\,z_{k1}) = \delta_{k1}\, de$$

or

$$d\,z_{k1} + \frac{b_{k1}}{(a_{k1} - b_{k1})}\, d\,X = \left(\frac{\delta_{k1}}{a_{k1} - b_{k1}}\right) de.$$

Summing over k,

$$d\,Z_1 + \left[\sum_{k=1}^{m} \left(\frac{b_{k1}}{a_{k1} - b_{k1}}\right)\right] d\,X = \left[\sum_{k=1}^{m} \left(\frac{\delta_{k1}}{a_{k1} - b_{k1}}\right)\right] de. \tag{16.2}$$

The sum of (16.1) and (16.2) in turn gives

$$d\,X = \frac{1}{\beta_1} \left[\sum_{k=1}^{m} \left(\frac{\delta_{k1}}{a_{k1} - b_{k1}}\right)\right] de, \tag{17}$$

so that

$$d\,x_{i1} = -\frac{b_{i1}}{\beta_1 (a_{i1} - b_{i1})} \left[\sum_{k=1}^{m} \left(\frac{\delta_{k1}}{a_{k1} - b_{k1}}\right)\right] de \tag{18}$$

and

$$d\,z_{k1} = \left[\frac{\delta_{k1}}{(a_{k1} - b_{k1})} - \frac{b_{k1}}{\beta_1 (a_{k1} - b_{k1})} \left[\sum_{k=1}^{m} \left(\frac{\delta_{k1}}{a_{k1} - b_{k1}}\right)\right]\right] de. \tag{19}$$

A similar aggregation procedure applied to market 2 gives

$$d\,Z = \frac{1}{\beta_2} \left[\sum_{i=1}^{n} \left(\frac{\delta_{i2}}{a_{i2} - b_{i2}}\right)\right] de \tag{20}$$

$$d\,x_{i2} = \left[\frac{\delta_{i2}}{(a_{i2} - b_{i2})} - \frac{b_{i2}}{\beta_2 (a_{i2} - b_{i2})} \left(\sum_{i=1}^{n} \frac{\delta_{i2}}{a_{i2} - b_{i2}}\right)\right] de \tag{21}$$

$$d\,z_{k2} = -\frac{b_{k2}}{\beta_2(a_{k2}-b_{k2})}\left[\sum_{i=1}^{n}\left(\frac{\delta_{i2}}{a_{i2}-b_{i2}}\right)\right] de. \tag{22}$$

Since $\delta_{k1} > 0$ and $\delta_{i2} < 0$, we have

$$\frac{dX}{de} < 0 \qquad \text{and} \qquad \frac{dZ}{de} > 0. \tag{23}$$

The sum appearing in dX is over the m firms located in market 2, whereas the sum appearing in dZ is over the n firms located in market 1: the price change in a market is due to the quantity response of the foreign firms to the exchange rate shift. This response is related to the fact that an appreciation of market 2 currency amounts to a cost increase for foreign firms selling in market 1 (reflected in δ_{k1}) and a cost decrease for firms i selling in market 2 (reflected in δ_{i2}). These cost effects are weighted by the degree of aggressiveness encountered in the foreign market ($1/\beta_1$ in market 1, $1/\beta_2$ in market 2). The sign of the response, however, is independent of the sign of b_{i1}, b_{k1}, b_{i2} and b_{k2}, that is, of the strategic nature of the commodity, since $\beta_1 > 0$ and $\beta_2 > 0$.

Proposition 1: An appreciation of the currency of market 2 decreases p^2 and increases p^1, when markets are independent.

This is the standard proposition in the (static) literature on the subject.

As for individual sales, we find

$$\frac{\partial x_{i1}}{\partial e} < 0 \qquad \text{and} \qquad \frac{\partial z_{k1}}{\partial e} < 0 \tag{24}$$

for all i and k in the case of strategic complementarity ($b_{i1} > 0$ and $b_{k1} > 0$). However, in case of strategic substitutability

$$\frac{\partial x_{i1}}{\partial e} > 0 \qquad \text{and} \qquad \frac{\partial z_{k1}}{\partial e} < 0. \tag{25}$$

Indeed, since $dX/de < 0$, the positive quantity response of the firms located in market 1, which take advantage of the local price increase, must be over–compensated by a negative response of the foreign firms whose currency appreciates. This negative response results from (19) and the fact that

$$\sum_{i=1}^{n}\frac{\partial x_{i1}}{\partial e} + \sum_{k=1}^{m}\frac{\partial z_{k1}}{\partial e} < 0$$

or

$$-\sum_{k=1}^{m}\frac{\partial z_{k1}}{\partial e} > \sum_{i=1}^{n}\frac{\partial x_{i1}}{\partial e}$$

can be written as

$$1+\sum_{i=1}^{n}\frac{b_{i1}}{a_{i1}-b_{i1}}>\sum_{i=1}^{n}\frac{b_{i1}}{a_{i1}-b_{i1}}.$$

In market 2,

$$\frac{\partial x_{i2}}{\partial e}>0 \qquad \text{and} \qquad \frac{\partial z_{k2}}{\partial e}>0 \tag{26}$$

when there is strategic complementarity, and

$$\frac{\partial x_{i2}}{\partial e}>0 \qquad \text{and} \qquad \frac{\partial z_{k2}}{\partial e}<0 \tag{27}$$

when there is strategic substitutability. The negative quantity response of the firms located in the market whose currency is over–compensated by the increased sales, in market 2, of the foreign firms.

Proposition 2: Individual quantity responses to exchange rate changes depend on the strategic effect on marginal profits. In the case of strategic complementarity in both markets, all firms increase sales in the market whose currency appreciates and reduce sales in the other market. In the case of strategic substitutability in both markets, firms located in the market whose currency appreciates sell less in both markets, whereas firms located in the other market sell more in both markets. If there is strategic complementarity in the market whose currency appreciates and strategic substitutability in the other market, then firms located in the former sell more at home and less abroad, while firms located in the latter sell more in both markets. In the opposite case, the reverse is true.

It does not seem possible to derive a general result about the incomplete pass–through of exchange rate changes into prices in oligopolistic markets. The elasticities of prices with respect to e are

$$\varepsilon_1 = -\frac{e\,p_1'}{\beta_1\,p_1}\sum_{h=1}^{m}\frac{\delta_{k1}}{a_{k1}-b_{k1}}>0 \tag{28.1}$$

$$\varepsilon_2 = -\frac{e\,p_2'}{\beta_2\,p_2}\sum_{i=1}^{n}\frac{\delta_{i2}}{a_{i2}-b_{i2}}<0 \tag{28.2}$$

respectively. However, when market demands are linear, these elasticities simplify to

$$\varepsilon_1=\frac{1}{1+n+m}\left(\frac{p_1'}{p_1}Z_1+m\right)<\frac{m}{1+n+m}<1$$

and

$$\varepsilon_2 = -\frac{1}{1+n+m}\left(\frac{p_2'}{p_2}X_2 + n\right) > -\frac{n}{1+n+m} > -1$$

using (14.2). Consequently

$$0 < \varepsilon_1 < 1 \qquad \text{and} \qquad -1 < \varepsilon_2 < 0. \tag{29}$$

With constant marginal costs and linear market demands, the pass-through is incomplete in both directions.

3.2 Mergers

In this section, we adopt the two assumptions of constant marginal costs and linear demands. This puts us in the framework adopted by Salant, Switzer and Reynolds (1983): merged firms are treated as a collection of plants under the control of a particular player in a noncooperative game. We shall also adopt their simplifying assumption that all firms have equal marginal costs ($\bar{c}$), since nothing essential is lost in doing so once marginal costs are constant. Note that the linearity of market demands implies that all firms regard their product as a "strategic substitute" to their competitors' in both markets.

We first consider a merger of two firms in market 1. To see its effect on the pass-through, in market 1, of an appreciation of country 2, we use equation (17), which becomes

$$\frac{dX^M}{de} = \frac{1}{\beta_1^M}\left(\sum_{k=1}^{m}\frac{\delta_{k1}}{a_{k1}-b_{k1}}\right) < 0 \tag{30}$$

where the superscript M indicates post-merger values. We have

$$\beta_1^M = n + m < \beta_1.$$

The sum between brackets remains unchanged since $\delta_{k1} = c_k^1$ and $a_{k1} - b_{k1} = p_1'$ are constant under the assumptions made. $\beta_1^M < \beta_1$ implies that the degree of aggressiveness is increased in market 1 ($\frac{1}{\beta_1^M} > \frac{1}{\beta_1}$), so that X^M decreases more than X: the post-merger price p_1^M increases more than p_1 as market 2 currency appreciates.

How does the same merger (in market 1) affect the pass-through in market 2? Equation (20) becomes

$$\frac{dZ^M}{de} = \frac{1}{\beta_2^M}\left(\sum_{i=1}^{n-1}\frac{\delta_{i2}}{a_{i2}-b_{i2}}\right) > 0. \tag{31}$$

Here $\beta_2^M = \beta_1^M < \beta_2$, while the sum between brackets is reduced. Remember, indeed, that $a_{i2} - b_{i2} = p_2'$ and $\delta_{i2} = -\bar{c}^2/e$ for all i. We thus have

$$\frac{dZ}{de} = \frac{-1}{1+n+m}\left(\frac{n\bar{c}^2/e}{p_2'}\right) > \frac{dZ^M}{de} = \frac{-1}{n+m}\left(\frac{(n-1)\,\bar{c}^2/e}{p_2'}\right) \tag{32}$$

since this can be written as $\frac{n}{n-1} > \frac{1+n+m}{n+m}$ which is always true. Z^M increases less than Z and p_2^M decreases less than p_2.

<u>**Proposition 3**</u>: A merger in market 1 increases the pass–through of an appreciation of currency 2 in market 1, where the post–merger equilibrium price increases more than the pre–merger price, and decreases the pass–through in market 2, where the post–merger equilibrium price decreases less than the pre–merger price, when the products are strategic substitutes in two separate markets.

We next consider the effects of a merger of two firms in market 2, using equations (17) and (20) again, when the currency of market 2 appreciates. A similar argument gives

$$\frac{dX}{de} < \frac{dX^M}{de} < 0$$

since $\frac{m}{m-1} > \frac{1+n+m}{n+m}$. In market 1, X^M decreases <u>less</u> than X and p_1^M increases <u>less</u> than p_1. However, in market 2, in which the merger occurs, Z^M increases more simply because of the reduction in β_2^M.

<u>**Proposition 4**</u>: A merger in market 2 decreases the pass–through of an appreciation of currency 2 in market 1, where the post–merger equilibrium price increases less than the pre–merger price, and increases the pass–through in market 2, where the post–merger equilibrium price decreases more than the pre–merger price, when the products are strategic substitutes in two separate markets.

In terms of the empirical results summarized in the introduction, Propositions 3 and 4 are compatible with the finding that the pass–though into export prices is smaller when the exporting industry is more concentrated, in the sense that such industries lower their export price markup more than less concentrated industries, when there is an appreciation of their domestic currency.

What about the indication that domestic prices react more to exchange rate changes in industries with a larger import share? This would be compatible with our Propositions 3 and 4, to the extent that mergers occurring in a market increase the import share of that market. Under the Salant–Switzer–Reynolds assumptions made here, such an increase in import shares indeed occurs. In post–merger equilibrium, each surviving firm sells more in each of our two markets since the total number of firms is reduced. Each surviving firm also sells the same quantity in each market, since the equilibrium is symmetric in each market. However, the two merged firms contract their aggregate output after the merger, for any given output of the other firms, because they internalize the inframarginal loss that they impart to each other. Consequently, $X^M < X^*$, $Z_1^M > Z_1^*$ and $X_1^M < X_1^*$ according to (2.1), when two firms merge in market 1, and the post–merger import share Z_1^M/X^M is larger than the pre–merger share. And similarly if the merger occurs in the other market.

Finally, we note that if a firm located in market 1 takes over a firm located in market 2, the effect on $\frac{dX}{de}$ and on $\frac{dZ}{de}$ is the same, under the assumptions made, as if the merger had been between firms located in market 2 (and vice–versa). All that matters is the reduction in the number of players.

4 Economies and Diseconomies of Scope Across Markets

We now take account of the fact that each firm's cost function may have non-zero cross partial derivatives: selling abroad may lead to economies or diseconomies of scope. Economies of scope contribute positively to marginal profits, whereas diseconomies do the opposite. Since

$$\begin{aligned}
\Pi_i^{12} &= -\frac{\partial^2 c_i}{\partial x_{i1}\, \partial x_{i2}} = -c_i^{12} \\
\Pi_k^{12} &= -\frac{\partial^2 c_k}{\partial z_{k1}\, \partial z_{k2}} = -e\, c_k^{12} \\
\Pi_i^{21} &= -\frac{\partial^2 c_i}{\partial x_{i2}\, \partial x_{i1}} = -c_i^{21} \\
\Pi_k^{21} &= -\frac{\partial^2 c_k}{\partial z_{k2}\, \partial z_{k1}} = -e\, c_k^{21}
\end{aligned}$$

there are diseconomies of scope across markets if $c_i^{12} > 0$, $c_k^{12} > 0$, $c_i^{21} > 0$ and $c_k^{21} > 0$. There are economies of scope across markets when these derivatives are negative.

4.1 Exchange Rate Pass–Through

Total differentiation of equations (5) gives

$$\begin{aligned}
a_{i1}\, dx_{i1} + b_{i1}\, dy_i - c_i^{12}\, dx_{i2} &= 0 \\
a_{k1}\, dz_{k1} + b_{k1}\, dy_k - e\, c_k^{12}\, dz_{k2} &= \delta_{k1}\, de \\
a_{i2}\, dx_{i2} + b_{i2}\, dg_i - c_i^{21}\, dx_{i1} &= \delta_{i2}\, de \\
a_{k2}\, dz_{k2} + b_{k2}\, dg_k - e\, c_k^{21}\, dz_{k1} &= 0.
\end{aligned}$$

These equations can be rewritten as

$$dx_{i1} + \left(\frac{b_{i1}}{a_{i1} - b_{i1}}\right) dX - \frac{c_i^{12}}{a_{i1} - b_{i1}} dx_{i2} = 0 \tag{33.1}$$

$$dz_{k1} + \left(\frac{b_{k1}}{a_{k1} - b_{k1}}\right) dX - \frac{e\,c_k^{12}}{a_{k1} - b_{k1}} dz_{k2} = \frac{\delta_{k1}}{a_{k1} - b_{k1}} de \tag{33.2}$$

$$dx_{i2} + \left(\frac{b_{i2}}{a_{i2} - b_{i2}}\right) dZ - \frac{c_i^{21}}{a_{i2} - b_{i2}} dx_{i1} = \frac{\delta_{i2}}{a_{i2} - b_{i2}} de \tag{33.3}$$

$$dz_{k2} + \left(\frac{b_{k2}}{a_{k2} - b_{k2}}\right) dZ - \frac{e\,c_k^{21}}{a_{k2} - b_{k2}} dz_{k1} = 0. \tag{33.4}$$

To solve this system for dX and dZ we have to simplify matters. We suppose that all firms are alike, in the following sense. First we assume that $c_i^{12} = c_k^{12} = c^{12}$ and $c_i^{21} = c_k^{21} = c^{21}$ for all i and k, and that

$$e\,c_k^{12} = c_i^{12} = c^{12},\ c_i^{21} = e\,c_k^{21} = c^{21} \text{ and } c^{12} = e\,c^{21}.$$

The last assumption can be justified if we do local analysis of a situation in which the exchange rate is normalized to $e = 1$. Increased sales in market 2 have the same effect on the marginal cost of sales in market 1 for firms located in market 1 as for firms located in market 2, and similarly for increased sales in market 1.

Second, we assume that $b_{i1} = b_{k1} = b_1$ and $b_{i2} = b_{k2} = b_2$, that is, all firms selling in a particular market consider their product either as a strategic substitute or as a strategic complement.

Third, $a_{i1} = a_{k1} = a_1$ and $a_{i2} = a_{k2} = a_2$, that is, the effect of increased sales on marginal profit is the same for all firms selling in a particular market.

Fourth, $\delta_{k1} = \delta_1$ and $\delta_{i2} = \delta_2$. The cost disadvantage (advantage) resulting from an appreciation (depreciation) of home currency is the same for all firms in a given market.

Summing (33.1)-(33.4) over i and k under these assumptions, we obtain

$$\begin{bmatrix} \gamma & -\beta \\ -\theta & \alpha \end{bmatrix} \begin{bmatrix} dX \\ dZ \end{bmatrix} = \begin{bmatrix} \varepsilon\, de \\ \eta\, de \end{bmatrix}$$

and

$$\begin{bmatrix} dX \\ dZ \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} \alpha & \beta \\ \theta & \gamma \end{bmatrix} \begin{bmatrix} \varepsilon\, de \\ \eta\, de \end{bmatrix} \tag{34}$$

where

$$
\begin{aligned}
\alpha &= 1+\frac{(n+m)\,b_2}{a_2-b_2}; & \gamma &= 1+\frac{(n+m)\,b_1}{a_1-b_1}; \\
\beta &= \frac{c^{12}}{a_1-b_1}; & \theta &= \frac{c^{21}}{a_2-b_2}; \\
\varepsilon &= \frac{m\,\delta_1}{a_1-b_1}; & \eta &= \frac{n\,\delta_2}{a_2-b_2}; \\
\Delta &= \alpha\gamma-\theta\beta.
\end{aligned}
$$

To interpret (34) we need stability conditions. We can use the stability conditions for each market separately derived in Section 3.1. In addition we now need to take the two markets together and consider the profit adjustment process described by the system of $2(n+m)$ differential equations

$$
\begin{aligned}
\dot{x}_{i1} &= \Pi_i^1\,(x_{i1},\, y_i,\, x_{i2},\, e) \\
\dot{z}_{k1} &= \Pi_k^1\,(z_{k1},\, y_k,\, z_{k2},\, e) \\
\dot{x}_{i2} &= \Pi_i^2\,(x_{i2},\, g_i,\, x_{i1},\, e) \\
\dot{z}_{k2} &= \Pi_k^2\,(z_{k2},\, g_k,\, z_{k1},\, e).
\end{aligned}
\tag{35}
$$

(increasing around the equilibrium point $(x_{11}^* \ldots z_{m1}^*,\, x_{12}^* \ldots z_{m2}^*)$, we obtain

$$
\begin{bmatrix} \dot{x}_{11} \\ \dot{x}_{21} \\ \cdot \\ \cdot \\ \cdot \\ \dot{z}_{m1} \\ \dot{x}_{12} \\ \dot{x}_{22} \\ \cdot \\ \cdot \\ \cdot \\ \dot{z}_{m2} \end{bmatrix}
=
\begin{bmatrix}
a_1 & b_1 & b_1 & \ldots & b_1 & -c_{12} & 0 & 0 & \ldots & 0 \\
b_1 & a_1 & b_1 & \ldots & b_1 & 0 & -c_{12} & 0 & \ldots & 0 \\
\ldots & & & & & & & & & \\
 & & & & & & & & & \\
 & & & & & & & & & \\
b_1 & b_1 & b_1 & \ldots & a_1 & 0 & 0 & 0 & \ldots & -c_{12} \\
-c_{21} & 0 & 0 & \ldots & 0 & a_2 & b_2 & b_2 & \ldots & b_2 \\
0 & -c_{21} & 0 & \ldots & 0 & b_2 & a_2 & b_2 & \ldots & b_2 \\
\ldots & & & & & & & & & \\
 & & & & & & & & & \\
 & & & & & & & & & \\
0 & 0 & 0 & \ldots & -c_{21} & b_2 & b_2 & b_2 & \ldots & a_2
\end{bmatrix}
\begin{bmatrix} x_{11}-x_{11}^* \\ x_{21}-x_{21}^* \\ \cdot \\ \cdot \\ \cdot \\ z_{m1}-z_{m1}^* \\ x_{12}-x_{12}^* \\ x_{22}-x_{22}^* \\ \cdot \\ \cdot \\ \cdot \\ z_{m2}-z_{m2}^* \end{bmatrix}
\tag{36}
$$

The $2(n+m)\times 2(n+m)$ coefficient matrix satisfies a necessary condition for stability that the trace be negative. We will add a condition which is sufficient for uniqueness and stability and therefore justifies the use of comparative statics, namely that the coefficient matrix (36) has the "dominant diagonal" property, or

$$
\begin{aligned}
|a_1| &> (n+m-1)\,|b_1|+|c^{12}| \\
|a_2| &> (n+m-1)\,|b_2|+|c^{21}|
\end{aligned}
\tag{37}
$$

which, together with $a_1 < 0$ and $a_2 < 0$, implies $\alpha > 0$, $\gamma > 0$, $a_1 - b_1 < 0$, $a_2 - b_2 < 0$ and

$$\begin{aligned} a_1 - b_1 &< c^{12} \\ a_2 - b_2 &< c^{21}. \end{aligned} \tag{38}$$

The decrease in marginal profit, corrected for strategic complementarity or substitutability, must remain larger than the cost decrease due to economies of scope. From

$$\Delta = \frac{1}{(a_1 - b_1)(a_2 - b_2)} \left[(a_2 + (n+m-1) b_2)\, (a_1 + (n+m-1) b_1) - c^{21} c^{12} \right]$$

and (37) it follows that $\Delta > 0$. Indeed, $a_2 + (b_2 + c^{21}) < 0$ implies $-(a_2 + b_2) > c^{21}$ and $a_1 + (b_1 + c^{12}) < 0$ implies $-(a_1 + b_1) > c^{12}$.

We are now in a position to interpret equations (34). We have

$$\begin{aligned} \frac{dX}{de} = \frac{1}{\Delta}(\alpha\varepsilon + \beta\eta) &< 0 \qquad \text{if} \quad c^{12} > 0 \\ &\lesseqgtr 0 \qquad \text{if} \quad c^{12} < 0, \end{aligned} \tag{39.1}$$

since $\alpha > 0$, $\varepsilon < 0$, $\eta > 0$, $\beta < 0$ if $c^{12} > 0$ and $\beta > 0$ if $c^{12} < 0$. On the other hand,

$$\begin{aligned} \frac{dZ}{de} = \frac{1}{\Delta}(\theta\varepsilon + \gamma\eta) &> 0 \qquad \text{if} \quad c^{21} > 0 \\ &\lesseqgtr 0 \qquad \text{if} \quad c^{21} < 0, \end{aligned} \tag{39.2}$$

since $\gamma > 0$, $\varepsilon < 0$, $\eta > 0$, $\theta < 0$ if $c^{21} > 0$ and $\theta > 0$ if $c^{21} < 0$. The coefficient ε reflects the fact that an appreciation of country 2 currency represents a cost increase for firms from country 2 when exporting to market 1, whereas η reflects the cost reduction for firms from country 1 when exporting to market 2. Note that both ε and η appear in dX and dZ: both affect total sales in each market. β and θ are proportional to the economies or diseconomies of scope resulting from exports to the other market. α and γ reflect the aggregate degree of aggressiveness due to strategic substitutability or complementarity and correspond to the coefficients β_2 and β_1 defined in (14). When $c^{11} = c^{22} = 0$ and $p_1'' = p_2'' = 0$, $\alpha = \gamma = 1 + n + m$.

The standard conclusion that $dX/de > 0$ and $dZ/de > 0$ reappears when exports lead to diseconomies of scope (for all firms). It is the end result of a series of reactions. First, the appreciation creates cost (dis)advantages which make market 2 firms export less and market 1 firms export more to the other market. However, this is only a first explanation of the reduction in X. Because of the diseconomies, increased exporting increases the cost of production for local producers in market 1. This is another reason for reducing their local sales. Reduced exports to market 1 decrease the cost of production of market 2 firms, which therefore increase their local sales. The effects on local sales, in this second round, are reinforced, in a third round, when the commodities are strategic complements: the reduction of local sales by firms i further reduces the exports by firms k; the increase in local sales by firms k is reinforced by a strategic increase in the exports of firms i. Strategic substitutability implies reactions in the opposite direction, which are not strong enough to prevent X from decreasing and Z from increasing.

These changes in X and Z may go in the opposite direction when all firms benefit from economies of scope. This sign reversal clearly depends on the impact of the economies on local sales, which in turn depends (all firms being alike) on the number of local firms. The role of n and m in this respect will be analysed in the next section.

Proposition 5: On the assumption of identical diseconomies of scope for all firms, an appreciation of the currency of market 2 increases p_1 and decreases p_2 if exporting leads to diseconomies of scope. However, p_1 may decrease and p_2 may increase if all firms benefit from economies of scope.

4.2 Market Structure

We now examine the impact on exchange rate pass-through of changes in the number of firms. Changes in n or m affect the equilibrium quantities X^* and Z^*, which in turn affect the parameters appearing in dX/de and dZ/de. Given the comparative statics approach followed, it would be an impossible task to trace out these effects. What can be done is to make the parameters, other than n and m, constant with respect to X^* and Z^*. To that effect, we suppose that the demand functions are linear ($b_1 < 0$, $b_2 < 0$) and that the second derivatives of the cost functions are constant. As a consequence, $a_1 - b_1 = p_1' - c^{11}$ and $a_2 - b_2 = p_2' - c^{22}$ are constant. These are restrictive assumptions, indeed. In a world with economies or diseconomies of scale and scope, they are equivalent, though, to the assumptions of linearity and constant marginal costs made in Section 3.2: effects of changes in market concentration are reduced to effects of changes in the number of players.

Of course, the plausibility of these assumptions depends very much on the technologies of the firms. If each firm prior to a merger had increasing costs but with constant second derivatives once the merge is made and the firm can utilise two plants, the second derivative of its cost will change. However, in the case which is most interesting, that is, where there are decreasing marginal costs, the firm will concentrate its entire production in one of the plants and the second derivative of its costs will therefore by assumption be unchanged.

The second part of Proposition 5 noted that the sign of the pass-through may be reversed in the case of economies of scope. We now examine how such sign reversals are related to differences in market structure.

Notice first that the sign of the determinant in equations (39) does not change with n or m. The sign of dX/de depends on the sum $\alpha\varepsilon + \beta\eta$ and the sign of dZ/de on the sum $\theta\varepsilon + \gamma\eta$. We have

$$\alpha\varepsilon < 0, \qquad \beta\eta > 0, \qquad \text{if} \quad c^{12} < 0;$$

and

$$\alpha\varepsilon < 0, \qquad \gamma\eta > 0, \qquad \text{if} \quad c^{21} < 0.$$

dX/de turns positive when $\beta\eta$ dominates $\alpha\varepsilon$ in absolute value. However, α increases with both m and n, while η increases with n and $|\varepsilon|$ increases with m. Similarly, dZ/de turns negative when $\theta\varepsilon$ dominates $\gamma\eta$ in absolute value. Here, γ increases with m or n. In both markets, the sign of the effect of an appreciation therefore depends on the ratio m/n.

For market 1, we find $(\alpha\varepsilon + \beta\eta) > 0$ if

$$\frac{m}{n} < \left[\frac{c^{12}}{a_2 + (n+m-1)\,b_2}\right]\left(\frac{c^2}{c^1}\right). \tag{40}$$

The economic rationale is as follows. Increased exporting to market 2, as a result of the appreciation of currency 2, reduces the cost of production for firms located in market 1, which therefore increase their local sales. Strategic substitutability ($b_1 < 0$) reduces imports into market 1. Nevertheless, total sales increase in market 1 if the number of local firms (n) is large enough compared to the number of foreign firms (m). In the aggregate, the effect of economies of scope then dominates the strategic effect.

The critical ratio m/n decreases with $|c^{12}|$ and c^2: the smaller the economies of scope or the relative cost disadvantage of foreign firms, the larger n must be compared to m. Mergers in market 2 make a sign reversal in market 1 more likely.

Note that (40) does not imply that market 2 must be more concentrated than market 1. With $c^2 = c^1$, m must be smaller than n only if $|c^{12}| < |a_2 + (n+m-1)\,b_2|$.

In market 2, a sign reversal occurs, that is, $dZ/de < 0$ or $(\theta\varepsilon + \gamma\eta) < 0$, if

$$\frac{m}{n} > \left[\frac{a_1 + (n+m-1)\,b_1}{c^{21}}\right]\left[\frac{c^2}{c^1}\right]. \tag{41}$$

Reduced exporting to market 1, as a result of the appreciation of their currency, increases the cost of production of firms located in market 2. They reduce their local sales, which increases imports into market 2 through the strategic substitution effect. Nevertheless, total sales decrease in market 2 if the number of local firms (m) is large enough compared to the number of foreign firms. In the aggregate, the effect of economies of scope then dominates the strategic effect.

The smaller the economies of scope resulting from exports to market 1, and the larger the cost disadvantage for firms located in market 2 resulting from the appreciation of their currency, the larger the number of these firms must be for a sign reversal to occur. Now mergers in market 1 make this reversal more likely. With $c^2 = c^1$, m must be larger than n only if $|c^{21}| < |a_1 + (n+m-1)\, b_1|$.

Can a sign reversal occur in both markets simultaneously? In other words, can (40) and (41) be satisfied simultaneously? The answer is: no. Indeed, if they were, then

$$c^{12}\, c^{21} > (a_1 + (n+m-1)\, b_1)\,(a_2 + (n+m-1)\, b_2)$$

which is not compatible with the dominant diagonal property (37). Whatever the number of firms in the two markets, it cannot happen that p_1 decreases and p_2 increases, when all firms are identical in the sense defined above. To find such a perverse result, one has to look for differences in production technology.[2] We thus have

Proposition 6: The price in market 1, p_1, may decrease as the result of an appreciation of currency 2, if the number of local firms is large enough compared to the number of foreign firms, when all firms benefit from the same economies of scope and the commodities are strategic substitutes. The price in market 2, p_2, may increase under the same assumptions, if the number of firms located in market 2 is large enough. Such price changes cannot occur simultaneously, however.

We noted that mergers in market 2 make a sign reversal more likely in market 1 and that mergers in market 1 make such a reversal more likely in market 2. We can now add that, in the event of a sign reversal, these mergers accentuate the pass–through (in the "wrong" direction). Reductions in n or m make the determinant appearing in (39) smaller. A smaller m gives a smaller $|\alpha\varepsilon|$, so that $\frac{dX^M}{de} > \frac{dX}{de} > 0$, where the superscript M again designates post–merger values. A smaller n makes $\gamma\eta$ smaller, with the result that $\frac{dZ^M}{de} < \frac{dZ}{de} < 0$.

Proposition 7: The pass–through in the market where the price change, resulting from an appreciation, goes in the "wrong" direction, is accentuated by a reduction in the number of players in the other market.

What about the impact of mergers on the extent of the pass–through, when prices move in the "correct" direction? In the case of constant marginal costs (3.2), clearcut impacts could be detected. With economies or diseconomies of scope, this does not seem possible in the framework of our model: the extent of the pass–through may be reduced as well as accentuated.

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[2]This conclusion corresponds to Proposition 6 of Hens, Kirman and Phlips (1991) where the case $m = n = 1$ is considered.

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