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International factor movements and trade: The basic issues

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International Factor Movements and Trade
The Basic Issues

by Andreas Kopp

December 1994



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Introduction

A central hypothesis of the locational competition (cf. SIEBERT 1994; SIEBERT/KOOP 1993) is that countries or regions, or rather their immobile factors compete for internationally mobile factors. To analyse systematically the determinants of locational competition a natural first question is what are the basic determinants of factor mobility and how do they depend on the determinants of trade? An elementary starting point in this respect appears to be the Heckscher-Ohlin-Samuelson model of international trade, relaxing the assumption that factors of production are internationally immobile and introducing some mobile factors. This model is meant to serve as a benchmark which allows to systematically study the determinants of locational competition by variation of the assumptions of the basic model.

Although there exists a literature on various aspects of factor mobility and the pattern of trade (cf. SIEBERT 1994), the interdependencies have for long not figured prominently in the theory of international trade. This appears to be mainly due to the importance of the Heckscher-Ohlin-Samuelson model explaining international trade as caused by differences in (relative) national factor endowments and the corresponding factor price equalization theorem stating that international trade as a consequence of differences in factor endowments would lead to factor price equalization if the national factor endowments were not too dissimilar. Naturally, within such a model world factor mobility has only a limited role to play as free trade would normally remove any incentive to migrate. International trade and factor mobility were simply considered as substitutes (cf. MUNDALL 1957).

In the real world, however, there is movement not only of goods but migration of workers and professionals, as well as of direct foreign investment (cf. e. g. OBSTFELD 1986, STRAUBHAAR 1988 and for the problems of empirical assessment e.g. SINN 1991). While several individual aspects of factor mobility had been analysed (e.g. JONES/RUFFIN 1975, MARKUSEN 1983) a general and systematic account of how intercountry differences in factor endowments determine both goods trade and factor mobility has only been given recently (SVENSSON 1984, ETHIER/SVENSSON 1986). MARKUSEN (1985) has pointed out that even if goods trade and factor trade are substitutes when international trade is caused by differences in (relative) factor endowments they may be complements for other causes of trade. The purpose of this paper is to address the question of whether goods trade and factor mobility may be complements even in the classical Heckscher-Ohlin case. The general M goods and N factor model is employed as the $2 \times 2 \times 2$ model conceals the incompatibility between the "Jones chain proposition" and factor price equalization (JONES 1956 and BHAGWATI 1972). The opening up of trade in an autarky situation where countries differ only in relative factor endowments would then result not only in the export of the goods which use the abundant factors intensively¹, but also in the "export" of that factor. Events that change the national allocation of resources would then result not only in a change in

¹ This remains true "on average" in the general case (cf. DEARDORFF 1982; DIXIT/WOODLAND 1982 and SIEBERT 1994).

trade flows but in factor movements as well with consequences for national welfare and the income of the immobile factors of production.

To isolate the effect of factor endowment differences it is assumed that in the initial situation the two countries considered, called home and foreign country, are identical, i.e. they have the same aggregate preferences, technology and factor endowments. Both countries will consequently have identical autarky equilibria which are assumed to be unique. If trade were opened up between these countries the "trade equilibrium" would be one of zero trade with prices for goods and factors identical to the autarky situation. In the *local analysis* of the effects of factor endowment differences on trade and factor movements (DIXIT/ WOODLAND 1982) the endowment vector of the home country is marginally changed. At unchanged prices there will be excess demand and/or supply of goods, then home country prices will adjust and a new equilibrium will be established with zero trade. If after the change in home country endowments international trade and factor movements are allowed we will have a new international equilibrium with generally non-zero trade in both goods and factors. The effects of factor mobility on the pattern of international trade is identified by comparing this result with the outcome of the same procedure under the assumption of internationally completely immobile factors. As a matter of fact, as the influence of differences in (relative) factor endowments are analysed by a marginal change of the endowment vector of the home country we obtain preliminary insights on the effects of technical change as well.

The model

To be able to treat goods trade and factor trade symmetrically the analysis proceeds from the assumption that factor owners remain in their home countries, employ the factors of production abroad and consume the factor income in the home country.² First the effects of factor endowment differences are derived under the standard assumptions that all goods are traded and all factors are immobile. This result is then compared to the situation when some factors are mobile.

An open economy is considered which produces M goods, indexed $i = 1, \dots, M$. $p = (p_i)$ denotes the goods price vector. Demand is described in terms of the minimum aggregate expenditure function

$$E(p, u) \equiv \min \{pc : U(c) \geq u\}, \quad (1)$$

where U is the ordinary or direct utility function, and $c = (c_1, \dots, c_M)$ is the aggregate consumption vector.

The direct utility function $U(c)$ is defined for all $c \geq 0$. It is required to be non-negative $c \geq 0$, positive for $c > 0$, continuous, quasi-concave, weakly increasing in the sense that

² The distinction between the movement of factor owners and the movement of factor services is often referred to as the analytical dividing line between labour and capital mobility (cf. e.g. WOODLAND 1982, pp 409-410 and pp. 421-423).

$c_1 > c_0$ implies $U(c_1) > U(c_0)$, and is defined such that for any $u \geq 0$ there exists a c such that $U(c) \geq u$. These properties of the direct utility function imply that the expenditure function $E(p,u)$ is a non-negative continuous function defined over $p > 0$ and $u \geq 0$. It is (a) homogeneous of degree one in p , (b) non-decreasing in p , (c) concave in p , and (d) non-decreasing in u .

Let $E(p,u)$ be differentiable with respect to p at p^0, u^0 and let c^0 be the solution if p^0 occurs. Then for $p > 0$ the definition of $E(p,u)$ as the minimum of pc for $U(c) \geq 0$ implies that $E(p,u) \geq p c^0$, with equality if $p = p^0$. Thus a function $h(p) \equiv E(p,u) - p c^0 \geq 0$ for $p > 0$ and it attains a minimum value of zero for $p = p^0$, which must satisfy the first order conditions for a minimum namely $\partial h(p^0)/\partial p_i = \partial E(p^0, u)/\partial p_i - c_i^0 = 0$ for $i = 1, \dots, M$. This shows that the partial derivatives give the compensated (Hicks-) demand functions (Shephard's lemma)

$$c_i(p,u) = \partial E(p,u)/\partial p_i \quad i = 1, \dots, M \quad (2)$$

or $c(p,u) = E_p(p,u)$ in vector notation.

The production sector of the economy is described by a production possibility set $Y(v)$, where $v = (v_1, \dots, v_N)$ is the vector of factor endowments and $Y(v)$ consists of all (net) production vectors $y = (y_1, \dots, y_M)$ which are technically feasible. The production sector is assumed to behave as if to maximise the gross national product. The GNP is then given by

$$G(p,v) = \max \{ p y : y \in Y(v) \}, \quad (3)$$

$$\text{where } Y(v) \equiv \{ y : y_i \leq f^i(v_i); v_i \geq 0, i = 1, \dots, M; \sum v_i \leq v \} \quad (4)$$

$p = (p_1, \dots, p_M)$ is the vector of commodity prices. The boundary of the set $Y(v)$ represents the production possibility or transformation frontier. $f^i(v_i)$ denote the production functions for the individual goods. The production functions are defined and assumed to be non-negative for all non-negative input vectors. They are assumed to be positive for all strictly positive input vectors, quasi-concave, weakly increasing in the sense that $v^1 > v^0$ implies $f^i(v^1) > f^i(v^0)$, and are defined such that for any y_i there exists a vector v_i such that $f^i(v_i) \geq y_i$. If the production functions satisfy these conditions the production possibility set $Y(v)$ is non-empty, convex and compact for all $v \geq 0$.³ Assuming that G is differentiable, the supply functions, invoking Shephard's lemma, are given by

$$y_i(p,v) = \partial G(p,v)/\partial p_i \quad i = 1, \dots, M \quad (5)$$

³ That is, the set is closed, containing its boundary, and bounded. $Y(v)$ is bounded below since $y \geq 0$ is required and bounded above since $y_i \leq f^i(v_i)$. That is to say, if all resources are put into one industry, a finite production of that good would occur, and if production of another good was required some resources would have to be released from the former industry. Closedness follows from the continuity of the production functions.

or $y(p, v) = G_p(p, v)$ in vector notation. The equilibrium factor prices are given by

$$w_j(p, v) = \partial G(p, v) / \partial v_j \quad j = 1, \dots, N \quad (6)$$

or $w(p, v) = G_v(p, v)$ for short.

Assuming non-satiation, all income will be spent, and u of equation (1) can be obtained as the solution to

$$S(p, v, u) \equiv G(p, v) - E(p, u) = 0. \quad (7)$$

This solution is the indirect utility function, i.e. the maximum utility that a country with endowments v and given the prices p can obtain by arranging production and trade patterns optimally. This can be expressed as $u = H(p, v)$. Referring to (2), (5) and (7) the net export function $x \equiv y - c$ can be derived by differentiating S with respect to p :

$$\bar{x}(p, v) = S_p(p, v, H(p, v)) \quad (8)$$

In the local analysis two countries are considered whose factor proportions differ only slightly. This allows sharper than the "average" results of the general analysis and excludes problems resulting from factor intensity reversals, which could occur even in the two-by-two case.

Initially, the home and the foreign country are assumed to have identical factor intensities. The home country's endowment vector is v , and the foreign country has $v^* = bv$ with b being a positive scalar. As we have assumed constant returns to scale in production and identical homothetic preferences both countries will have identical net export functions. The two countries' autarky price vectors p^a and p^{*a} are given by

$$x(p^a, v) = 0, \text{ and} \quad (9)$$

$$x(p^{*a}, v^*) = 0. \quad (10)$$

The free trade price vector p^f for the two countries follows from

$$x(p^f, v) + x(p^f, v^*) = 0. \quad (11)$$

The last three equations imply that the autarky price vectors and the free trade world price vector will be identical (assuming uniqueness). This is a restatement of the result that with identical factor proportions the two countries will have the same relative prices for goods, and trade will not take place even in the absence of any impediments to trade. Now the endowment vector of the home country is changed by a small amount dv . As a preliminary, the excess supply vector of the home country due to the marginal change of the endowment vector at $p^a = p^f$ is considered

$$dx^S = x_v dv, \quad (12)$$

where the derivative is understood to be evaluated at (p^a, v) . To establish a free trade

equilibrium the (new) autarky prices have to change. Differentiating (11), we have

$$[x_p(p^f, v) + x_p(p^f, v^*)] dp^f + x_v(p, v) dv = 0 \quad (13)$$

Because of the GNP function and the expenditure function being linear homogeneous the production and demands of the foreign country will, for any fixed p , be b times those of the home country. Therefore, the same will be true of excess demands and their price derivatives, i.e. for all p :

$$x(p, v^*) = bx(p, v), \quad (14)$$

$$x_p(p, v^*) = bx_p(p, v) \quad (15)$$

Using this equation and (12), (13) becomes

$$(1+b)x_p dp^f + dx^s = 0^4 \quad (16)$$

Since no trade occurred at the initial free trade point, the new net export vector of the home country is simply the change in the excess supply vector taking into account the effect of the accompanying price change. The total change in the excess supply vector is labelled dx^f . Then we have

$$\begin{aligned} dx^f &= x_p dp^f + dx^s, \text{ and using (16)} \\ &= [-1/(1+b)+1] dx^s \\ &= [b/(1+b)] dx^s \end{aligned} \quad (17)$$

This result says that the pattern of free trade is determined by the sign structure of dx^s . $[b/(1+b)]$ is simply a scaling factor for the endowment effects on excess supply without any price changes but doesn't change their sign. That is to say, if at the initial prices a change in the endowment vector causes a good to be in excess supply, then it will end up being exported even after the free trade price vector has changed to re-establish equilibrium. Without any factor mobility, the relationship between endowments and the pattern of commodity trade is therefore determined by the dependence of dx^s on dv or rather by the matrix x_v . We will come back to this result after the modifications encountered by introducing some mobile factors have been considered.

The home country's endowment vector v is now decomposed into two subvectors $v = (k, l)$ with k denoting the non-negative N_k -vector of mobile factors while the non-negative N_l -vector l denotes the immobile factor endowments, $N = N_k + N_l$. The factor price vectors corresponding to k and l are r and w respectively. Let the non-negative N_k -vector k^o represent the input of mobile factors in domestic production, and let the N_k -vector z , given by $z = k - k^o$ denote "net exports" of mobile factors, i.e. the difference between domestic endowments and input of mobile factors. Positive amounts of z refer to domestic inputs employed abroad and negative elements of foreign factors used in domestic production.

⁴ Explicit solutions for dp^f can be obtained choosing a rule for normalization of prices.

Taking into account international factor movements we have to distinguish a *domestic* product function and a *national* product function. The domestic product function is defined in complete analogy to the case with immobile factors with the only difference that factor inputs rather than factor endowments are arguments of that function:

$$G(p, k^o, l) \equiv \max \{ p y : y \in Y(k^o, l) \} \quad (18)$$

The gross national function instead is defined, with goods prices p and prices of mobile factors r given, as

$$G^o(p, r, k, l) \equiv \max \{ G(p, k^o, l) + r(k - k^o) : k^o \geq 0 \}. \quad (19)$$

The gross national product function is twice differentiable and indicates the maximum over the sum of domestic product, $G(p, k^o, l)$ where k^o is the input of mobile factors at home, and $r(k - k^o)$ the net factor payments from abroad. The optimal domestic input of mobile factors will be a function $k^o(p, r, l)$ of goods prices, prices of the mobile factors and the endowments with immobile factors. This mobile-input-function is determined from the first order optimality condition (Shephard's lemma)

$$G_k(p, k^o(p, r, l), l) \equiv r, \quad (20)$$

where G_k is the N_k -vector of partial derivatives $\partial G / \partial k_j$. (20) indicates that the marginal value product of the mobile factors must equal the factor prices (assuming an interior solution). The equation shows that the domestic input of mobile inputs is independent of the national endowments.

The net output M -vector $y = (y_i)$ will be given by the function

$$y^o(p, r, k, l) \equiv G^o_p(p, r, k, l), \quad (21)$$

that is, production possibilities will depend i. a. on the domestic availability of mobile factors, differing possibly from the factor endowments.

The consumption M -vector $c = (c_i)$ will be given by $c(p, G^o(p, r, v))$ where c is the Marshallian demand, corresponding to the direct utility function, depending on goods prices and national income. Net exports of goods denoted by the M -vector $x = (x_i)$, the difference between output and consumption, is given by the net export function

$$x^o(p, r, v) \equiv y^o(p, r, v) - c(p, G^o(p, r, v)) \quad (22)$$

The movements of mobile factors are given by the "net export functions" for mobile factors which satisfy according to Shephard's lemma:

$$z(p, r, v) \equiv G^o_r(p, r, v) \equiv k - k^o(p, r, l) \quad (23)$$

It is assumed that the net export functions (22) and (23) are single-valued and differentiable, which is equivalent to the assumption that the national product and the national

expenditure function are twice differentiable.⁵

Now the foreign country is introduced with net export functions $x^{o*}(p, r, v^*)$ and $z^*(p, r, v^*)$ where v^* denotes the factor endowments of the foreign country.

The international equilibrium where all goods are traded and some factors mobile is given by the condition that the two countries' net exports of goods and movements of factors must add up to zero, i.e.

$$x^o(p, r, v) + x^{o*}(p, r, v^*) = 0, \quad (24)$$

$$z(p, r, v) + z^*(p, r, v^*) = 0 \quad (25)$$

From these equations we can solve for price vectors for goods and mobile factors (up to a multiplicative factor). In the completely symmetric case where the two countries have identical preferences and identical technologies they will have identical net export functions. If additionally the factor endowments are identical, i.e. $v = v^*$, it is clear that the goods and factor prices will be identical to autarky prices for the two countries, and that there is no trade between them in equilibrium: $x^o = x^{o*} = 0$ and $z = z^* = 0$.

To see how differences in factor endowments determine the pattern of trade and simultaneously the movement of factors we let again change the home country's endowment vector by the n -vector dv . The home country is then defined to be relatively abundant in factor j ($j = 1, \dots, N$) if dv_j is positive and relatively scarce in factor j if dv_j is negative. The change of endowments will, at constant prices for goods and mobile factors, give rise to an excess supply of $x^o_v dv$ and $z_v dv$ respectively. x^o_v denotes the $(M \times N)$ -matrix $[\partial x^o / \partial v_j]$ and z_v the $(N_k \times N)$ -matrix $[\partial z / \partial v_j]$ representing endowment effects on net exports and factor movements at constant prices. From the assumed symmetry of the two countries follows that the prices of goods and mobile factors will adjust such that each country absorbs half of the initial excess supply. Hence the domestic net export of goods and the movement of factors will be half the initial effect at constant prices:

$$dx^o = x^o_v dv / 2 \text{ and } dz = z_v dv / 2. \quad (26)$$

Next it is examined what determines the initial excess supply of goods and mobile factors. It is first looked at the excess supply of mobile factors $z_v dv$. From (19), (20) and (23) we have

$$dz = G^o_{TV} dv / 2 \equiv (dk - k^o_l dl) / 2 \quad (27)$$

where the $(N_k \times N_l)$ -matrix $k^o_l \equiv [\partial k_l / \partial l_j]$ denotes the derivatives of the mobile input function with respect to labour endowments at constant prices for goods and mobile

⁵ With constant returns to scale and in absence of joint production, this amounts to assuming more factors than goods (to give single-valued and differentiable output functions for given inputs of factors) and to assume that the $(N_k \times N_k)$ -matrix $G_k^o k^o$ of second order partial derivatives of the domestic product function with respect to the mobile factors is negative definite. The latter assumption excludes the possibility of factor movements when factor prices are equalized and (locally) independent of factor endowments.

factors. The initial excess supply of the mobile factors consists of the change in endowments of the mobile factors, dk , minus the change in domestic input of mobile factors due to a change in the endowments of immobile factors (whose prices may vary) $k^0 dl$. As will be shown below, the properties of k^0 will be crucial in determining movements of factors to the foreign country.

With respect to the initial excess supply of goods, we have from (22)

$$x^0_v dv \equiv y^0_v dv - c_Y G^0_v dv \equiv y^0_v dv - c_Y (r dk + w dl) \quad (28)$$

Here the $(M \times N)$ -matrix $y^0_v \equiv [\partial y^0_i / \partial v_j]$ is the matrix of endowment effects on output at constant prices for goods and mobile factors. The column M -vector c_Y is the vector of income derivatives $[\partial c_i / \partial Y]$ of the Marshallian demand functions $[c_i(p, Y)]$. The expression $G^0_v dv$ denotes, by the above discussed properties of the national product function the inner product $r dk + w dl \equiv \sum_h r_h dk_h + \sum_j w_j dl_j$ of factor prices and the change in factor endowments.

The first term on the right hand side of (28) is the endowment effect on production, the second term is the effect on consumption of the change in income due to the change in endowments. To isolate the mere production effect, it is assumed that there are only compensated changes in the factor endowments, i.e.

$$r dk + w dl = 0, \quad (29)$$

such that there is no direct effect on the income of the home country. That is, there will be some elements of dv positive and others negative such that the income of the home country will remain constant. This means that we keep the countries at the same size in terms of income despite the change of the endowment vector in the home country. The endowment effect on production can be decomposed further. Differentiating (21) and using (19) and (20), we obtain

$$dx^0 = y^0_v dv / 2 \equiv y^0_l dl / 2 \equiv (G_{pk} k^0 dl + G_{pl} dl) / 2, \quad (30)$$

where $y^0_k = 0$, since output will depend on prices of mobile factors and not directly on endowments with mobile factors. Recalling (17) and the fact that we have set k equal to one for the mobile factor case we have the following corresponding production endowment effect in case all factors are immobile

$$dx = x_v dv / 2 \equiv y_v dv / 2 \equiv G_{pv} dv / 2 \equiv (G_{pk} dk + G_{pl} dl) / 2 \quad (31)$$

Here the $(M \times N)$ -matrix $y_v \equiv [\partial y_i / \partial v_j] \equiv G_{pv} \equiv [\partial^2 G / \partial p_j \partial v_i]$ is the matrix of Rybczynski derivatives, i.e. the effect on output of changes in factor inputs at constant prices. Then, we can summarise (31): With *no* factor trade, for compensated factor endowment changes, the net export of goods is simply half the Rybczynski effect on production.⁶

⁶ The definition of factor intensities in the general model is controversial. The above definition presupposes that all factors are used in the production of all goods. Otherwise it cannot be ruled

Following DIXIT/NORMAN (1982), we can interpret (31) by taking the elements of the Rybczynski matrix G_{pv} to represent generalised factor intensities: good i is said to be intensive (non-intensive) in its use of factor j if and only if $\partial^2 G / \partial p_i \partial v_j$ is positive (negative). With this interpretation of the Rybczynski matrix, we may interpret (31) as expressing that the home country tends to export goods that are intensive in its abundant factors.

Now the trade patterns with and without international factor movements shall be compared. We consider the situation that the home country is abundant in mobile factors and scarce in immobile factors:

$$dk > 0 \text{ and } dl < 0, \text{rdk} + \text{wdl} = 0, \quad (32)$$

that is, all components of the vector dk are assumed to be non-negative (and not all zero) and all components of the vector dl are non-positive (and not all zero). From (31) it follows that in the absence of factor movements the home country will export k -intensive goods in the sense discussed above and import l -intensive goods.

When factor movements are allowed, the trade pattern in goods is given by (30). Subtracting (31) from (30), using (27) we have

$$dx^0 - dx = G_{pk}(-dz)/2. \quad (33)$$

If we cannot observe any factor movements in equilibrium, $dz = 0$, the goods trade pattern is of course the same whether factor movements are allowed or not. If the home country has an outmigration of mobile factors ($dz > 0$), the production and export of the goods which are intensive in the mobile factors are lower with factor trade. In this case factor trade and goods trade are substitutes. If the home country has an immigration of mobile factors, in spite of being relative abundant in mobile factors, than factor movements and goods trade are complements.

Clearly, all these cases, dz positive, negative or equal to zero are conceivable. From (27) and (32) we see that a sufficient condition for the outmigration of factors is that mobile factors and immobile factors are *cooperative* in the sense that the matrix $k^0_1 = [\partial k^0_H / \partial l_j]$ is positive, i.e. its entries are non-negative and not all zero. If mobile and immobile factors are only weakly non-cooperative (k^0_1 negative) both immigration and outmigration of mobile factors may occur, i.e. mobile and immobile factors being non-cooperative is only a necessary condition for an immigration of foreign mobile factors. A sufficient condition for the import of foreign factor services is that mobile and immobile factors are strongly non-cooperative, i.e. that the home country's increase in mobile factors k^0_1 dominates the increase in endowment abundance of mobile factors dk .

out that the Rybczynski effect indicates a peculiar good as intensive in a particular factor which is not used at all in production of that good. Cf. SVENSSON (1984), p. 371.

Summary and concluding remarks

Using DIXIT/WOODLAND's (1982) method of local analysis around a zero trade equilibrium and considering compensated changes of factor endowments only it could be shown how goods trade and factor movements are interrelated when trade is caused by factor endowment differences. We obtained results that are sharper than those which hold "on average" for a global analysis (ETHIER/WOODLAND 1986).

With the home and the foreign country being identical in the initial situation we saw that when all factors of production are immobile, the net export of goods due to a marginal variation of the endowment vector is half of the initial excess supply of goods, i.e. half the Rybczynski effect on production of the endowment change. If we identify the Rybczynski effects with generalised factor intensities, the result can be interpreted as confirming the Heckscher-Ohlin theorem for the general case of many goods and many factors.

When movements of some factors are introduced, it could be shown that differences in endowments of mobile factors have a direct effect on net factor movements but no effect on the net exports of goods. Differences in the endowments of immobile factors have an indirect effect on trade in factors, via their effect on the domestic input of traded factors, and a direct impact on the net export of goods, via the Rybczynski effect. Hence, the relation between goods trade and differences in factor endowments is weakened by the existence of factor movements.

Comparing explicitly the goods trade pattern with and without factor trade, we found that if mobile and immobile factors are cooperative, a country that is abundant in mobile factors will directly export factors and export goods which are less intensive in mobile factors than when all factors are immobile. Hence, factor movements and goods trade can be considered substitutes, as stated by MUNDELL (1957).

If mobile and immobile factors are strongly non-cooperative, a country that is abundant in mobile factors will nevertheless import factors, contributing to even larger exports in goods which are intensive in mobile factors.

The results, however, strictly applying only within a neighbourhood of the initial zero trade equilibrium, and for factor endowment differences that are compensated. This disadvantage of the local analysis has to be measured against the drawback of the global analysis, namely that its results can only be expressed as correlations.

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