Kiel Institute of World Economics
Duesternbrooker Weg 120
24105 Kiel (Germany)

Kiel Working Paper No. 964

Do We Have to Consider International Capital Mobility in Trade Models?

by

Katrin Springer

January 2000

The responsibility for the contents of the working papers rests with the author, not the Institute. Since working papers are of a preliminary nature, it may be useful to contact the author of a particular working paper about results or caveats before referring to, or quoting, a paper. Any comments on working papers should be sent directly to the author.

Do We Have to Consider International Capital Mobility in Trade Models?

Abstract:
The traditional trade theory predicts that trade in goods perfectly substitutes for direct movement of factors. This equivalence between goods trade and factor movements, however, depends crucially on assumptions about the production. This paper establishes necessary and sufficient conditions which describe the relationship between goods trade and capital mobility in a 2x2x2 trade model with internationally mobile capital. It identifies possible ways of incorporating capital mobility into a multi-regional, multi-sectoral Computable General Equilibrium framework. The consideration of capital mobility leads to other allocational and distributional outcomes of policy scenarios if there exists differences in production technologies across regions, trade impediments, or distortions in product or factor markets.

Keywords: Capital Mobility, International Trade, Computable General Equilibrium Model

JEL classification: F1, F21 ,D58

Katrin Springer*
Kiel Institute of World Economics
24100 Kiel, Germany
Telephone: 0049-(0)431-8814-471
Fax: 0049-(0)431-8814-502
E-mail: kspringer@ifw.uni-kiel.de.

*This paper has been produced as part of the research project on 'Greenhouse Effect and Economic Development: A Disaggregated Climate-Economy -Model'. Financial support from the Volkswagen Foundation is gratefully acknowledged. I am grateful to Wilfred Ethier, Gernot Klepper, Michael Koop, Warwick McKibbin and Daniel Piazolo for many useful comments and suggestions. The paper has also benefited from discussions with participants of the Second Annual Conference on Global Economic Analysis 1999, Denmark, June 1999. The usual disclaimer applies.

1 Introduction

One of the modeling issues arising in open economy general equilibrium analysis for assessing different policy measures concerns the consideration and specification of international capital mobility. Having in mind the increased importance of international capital flows and international cross-holdings of capital in the last decades, the consideration of capital mobility[1] as an additional channel for spill-overs among countries besides trade in goods seems especially important for analyzing policies which affect international prices. An example is the international climate policy, i.e. the Kyoto Protocol (UN, 1997). The Kyoto Protocol imposes different greenhouse gas emission reduction objectives on industrial and developing countries. The emission reduction measures taken by the abating countries lead to a change in the terms-of-trade, and thus, to a change in international competitiveness which in turn results in a change in welfare of countries depending on the amount of international spill-overs. The interaction of international capital mobility and trade in goods may completely change the pattern of trade compared to the case where only trade in goods occurs. Hence, the effects of a policy may differ depending on the existence of international capital mobility.

Being rich on regional or sectoral detail, most multi-regional models analyzing the impact of climate change policies neglect the explicit analysis of international mobility of physical capital. Prominent examples of such multi-regional models are the RICE model (Nordhaus and Yang, 1996), the GREEN model used by the OECD (Burniaux et al., 1992), or models designed for the European Union region, such as the LEAN model, the EIREM model, and the NEWAGE model

[1] In this paper the term ‘capital’ stands for physical capital, i.e. all capital goods used as a factor in the production of other goods. Financial capital, in contrast, is the amount of money necessary to accumulate a certain stock of physical capital. International mobility of physical capital disconnect the locality of capital accumulation through savings from the locality of capital use in the production. (Lorz ,1997, p. 7) The models considered in this paper only analyze real markets. Hence, the possible impacts of financial markets on the real sphere of economies are neglected.

(Hoster et al., 1997). An exception is the G-Cubed Model by McKibbin and Wilcoxen (1998) which is a multi-country, multi-sectoral intertemporal general equilibrium model. The G-Cubed Model distinguishes between physical and financial capital. It assumes that financial capital is almost perfectly mobile among countries while the physical capital remains sector- and region-specific.

One reason for neglecting international movements of productive factors in most trade models lies in traditional trade theory. Indeed, the classical theory and its modern descendants see international factor immobility as the basic cause of international trade. International differences in factor endowments induce trade in goods. This was formalized by the Heckscher-Ohlin model, where trade is tracked back to different relative factor endowments. Mundell (1957) was the first who formally examined the consequences of capital mobility in the Heckscher-Ohlin model. By applying the factor price equalization theorem (Samuelson, 1948, 1949; Lerner, 1952), Mundell shows that the commodity price equalization is brought about by international factor mobility without trade in goods as in the reverse case the factor price equalization results from trade in goods without capital mobility. The model predicts that trade in goods perfectly substitutes for the direct movement of factors if relative factor endowments are not too different between countries. Therefore, gains from trade can be realized either through the movement of goods or of factors.

If trade in goods and capital mobility are completely equivalent, this raises the question whether it is necessary to model international capital mobility explicitly and not just restrict the international linkages to trade in goods in a multi-regional computable general equilibrium (CGE) framework. However, several authors have shown that factor movements and trade in goods augment each other if trade is not induced by a difference in relative factor endowments, but different production technologies, distortions in product and factor markets, external economies of scale, or imperfect markets (e.g. Markusen, 1983; Wong, 1986,

1995; Melvin, 1995; Neary, 1995). Hence, the substitutive relationship between trade in goods and capital mobility is a rather special case. In these models the world equilibrium depends on whether international trade in goods alone or international factor mobility or both are allowed.

The omission of international capital mobility in trade models can also be attributed to the minor importance of capital flows before the 1980s. International capital mobility has become empirically relevant only in the past decades. While the world's real GNP grew by 2.5 percent annually between 1980 and 1994, average annual growth of the volume of world exports was 3.4 percent. Thus world trade grew much faster then world production (Siebert, 1999). However, total real outward direct investment grew by an annual rate of 13.4 percent from 1981 to 1990. In this period, the growth of direct investment for any region (industrial countries, developing countries) was higher than that of export, which in turn was higher than that of GDP (Wong, 1995). While the worldwide trend of opening up financial markets has restored a degree of international capital mobility not seen since this century's beginning (Obstfeld, 1998), the labor markets remain mainly segmented along national borders (Siebert, 1999). Therefore, this paper focuses on international capital mobility while labor is assumed to remain internationally immobile.

This paper addresses the question, whether and under which circumstances the prevailing practice of abstracting from international capital mobility in CGE trade models is a reasonable simplification or rather a source of misleading predictions. In order to answer this question the interaction of trade in goods and international capital mobility is analyzed in a 2x2x2 general equilibrium framework. For the whole analysis we stay in a perfectly competitive world with constant returns to scale. This may be justified by the highly aggregated level at which global CGE models work. First, necessary and sufficient conditions for a substitutive or complementary relationship between trade in goods and capital mobility are

derived while the existence of international trade in goods and capital flows are exogenously assumed. Secondly, the paper looks at the interaction of trade in goods and capital mobility by explicitly specifying three different causes for trade in goods and international capital flows—different factor endowments, different production technologies, and distortions in domestic product and factor markets. Because of the increasing importance of foreign cross-holdings of capital the paper touches on sector-specific factor models which belong to the group of models that view market distortions as the basis for trade, but allow to model the cross-hauling of capital in a perfectly competitive world.

The discussion of consequences of incorporating international capital mobility distinguishes two cases: In the first case physical capital can be relocated to an other country, but the owner of that capital remains at home and the consumption associated with the returns to capital continues to take place in the country of origin. In the other case, the capital owner actually moves when capital flows take place. However, the more policy-relevant scenario is the first case where the capital owner does not move and repatriates his capital earnings back to the home country. This is, therefore, the only case considered in this paper.

The paper is organized as follows. Section 2 analyzes under which circumstances trade in goods and international capital mobility are no perfect substitutes, i.e. in which cases it is necessary to consider capital movements in addition to international trade in goods. For the analysis, a 2x2x2 trade model with international capital mobility is established. In this section the existence and direction of trade in goods and capital flows is not explicitly derived. It is shown that factor abundance, technologies as well as preferences of the countries determine the relationship between goods trade and capital mobility. Therefore, section 3 discusses two different bases for trade in goods and capital—different production technologies between countries, and goods and factor market distortions. The interaction of capital mobility and trade in goods is examined.

The last part of section 3 focuses on a variant of market distortions, i.e. specific factor models which allow the modeling of two-way capital flows. Against this background, section 4 derives some conclusions for the implementation of international capital mobility into a multi-regional, multi-sectoral CGE model for analyzing climate policy.

2. International goods and capital markets interdependencies in an integrated world

Trade theory continues to be heavily influenced by the important work of Mundell (1957). The Samuelson-Mundell analysis postulates a substitutive relationship between international trade in goods and factor flows in two ways: Each of them leads to the same world equilibrium, and an increase of the volume of one reduces the volume of the other. Therefore, the Samuelson-Mundell analysis demonstrates the full equivalence of trade in goods and international factor mobility with regard to equilibrium in prices and welfare.[2]

Many economists, especially Purvis (1972), Markusen (1983), Svensson (1984), Markusen and Svensson (1985), Wong (1986), and Ethier (1996), have, however, demonstrated that this equivalence crucially depends on the basic production assumptions made in the models. Therefore, the relationship between trade in goods and international capital mobility is systematically reviewed here. The necessary and sufficient conditions pertaining to the question as to when substitution or complementarity will be obtained are derived. Thus, this chapter answers the question under which circumstances the simultaneous modeling of goods trade and capital movement is appropriate. In this section, the existence of

[2] Within the Heckscher-Ohlin framework, Ethier and Svensson (1986) analyze goods trade and factor mobility in a higher dimensional context. The basic theorems of international trade are shown to hold in their strong versions if the number of international markets for goods and factors is at least as large as the number of factors.

trade in goods and international capital mobility is simply assumed and not endogenously deduced.

First, different concepts of the relationship between trade in goods and capital mobility are reviewed. According to Wong (1986, p. 41) four such concepts of substitutability and complementarity between goods trade and factor mobility can be distinguished. Secondly, the model for the analysis of the interrelation of capital flows and goods trade is introduced.

(1) Quantitative-relationship sense:

Goods trade and international factor movements are said to be substitutes (complements) in the quantitative-relationship sense if an increase in the volume of trade will decrease (increase) the level of factor movements and/or if an increase in the level of factor movements will decrease (increase) the volume of trade. Strong complementarity is fulfilled if goods trade and capital movements increase *each other*. For weak complementarity it is sufficient, that either goods trade increases factor movements or factor movement leads to an increase in goods trade. Hence, only one direction of the relationship has to be fulfilled.[3] Some examples for analyzing goods trade and factor movement in the quantitative relationship sense are Ohlin (1933), Markusen (1983), Svensson (1984), Markusen and Svensson (1985), Jones and Neary (1984), Thompson (1994), Melvin (1995) and Markusen (1997).

(2) Price-equalization sense

The substitutability concept in the price-equalization sense is ascribed to Mundell (1957, p. 321) who stated it in the following way:

> ‘Commodity movements and factor movements are substitutes. The absence of trade impediments implies commodity-price equalization and, even when

[3] The distinction between strong and weak complementary or substitutability indicates that the influence of goods trade on capital mobility and the influence of capital mobility on trade in goods may not be symmetric. We will elaborate on this asymmetric behavior in the subsequent analysis.

factors are immobile, a tendency toward factor-price equalization. It is equally true that perfect factor mobility results in factor-price equalization and, even when commodity movements cannot take place, in a tendency toward commodity-price equalization.'

(3) World-efficiency sense

This concept relates to the impact of goods trade and/or factor movements on world efficiency. Trade in goods and factors are substitutes in the world-efficiency sense when either one is sufficient to establish efficiency in world production, and hence maximize potential world welfare. They are complements if both of them are required to establish world production efficiency. This concept was used by Meade (1955), and Purvis (1972).

(4) National-welfare sense

The national-welfare sense of the relationship between goods trade and factor mobility is used in a wide range of papers dealing with the effects of trade, factor mobility or both on the welfare of an individual country. Here, trade and factor mobility are substitutes if either one of them is sufficient to bring about maximum welfare for the domestic economy, and complements if both of them are required. Examples are Bhagwati (1973), Brecher and Diaz-Alejandro (1977), Markusen and Melvin (1979), Bhagwati and Brecher (1980), Wong (1983), Suzuki (1989), and Saavedra-Rivano and Wooton (1983) in a dynamic context.

Despite these differences in the definitions, these concepts are closely related. If trade in goods and factor mobility are substitutes in the price-equalization sense, for example, then they must be also substitutes in the world-efficiency and national-welfare sense. In the Heckscher-Ohlin framework with diversification, they are substitutes in all four concepts (cf. Markusen, 1983, p. 342).

The analysis in this paper concentrates on the interrelation between goods trade and capital mobility in the quantitative-relationship and the price-equalization

sense. It starts from a two country general equilibrium model with goods trade and capital mobility.[4] In a first step, we examine the relationship from a single country view and derive the effects of capital mobility on trade in goods for that country in partial equilibrium, i.e. holding the terms-of-trade constant. Secondly, the general equilibrium for both countries is determined by deriving the equilibrium of the world commodity market and the equilibrium of the world capital market and the simultaneous equilibrium of all markets. Given these equilibria, thirdly, the necessary and sufficient conditions for a complementary or a substitutive relationship are established.

2.1 The Model

Suppose that the world consists of two countries *h* and *f,* each of which is initially endowed with fixed amounts of two homogeneous factors, labor (*L*) and capital (*K*). Let the endowments of labor and capital be $\overline{L}$ and $\overline{K}$. In each country two sectors produce homogeneous goods, labeled good 1 and 2. The production function of sector *i, i=1,2*, is

$$Q_i = F_i(K_i, L_i), \tag{1}$$

where Q_i is the output of sector *i*, and K_i and L_i are the amounts of capital and labor employed in the sector. Each production function is increasing, concave, linearly homogeneous, and differentiable up to the necessary order in inputs. By exploiting the linear homogeneity, the sectoral production function can be written as $f_i(k_i) \equiv F_i(k_i,1)$, where $k_i \equiv K_i / L_i$ is the capital-labor ratio.

Let us further assume that:

(a) countries have identical relative factor endowments;
(b) countries have identical technologies;

[4] The model and the analysis is based on Wong (1986, 1995).

(c) countries have identical homothetic demand;

(d) production is characterized by constant returns to scale;

(e) production is characterized by perfect competition;

(f) there are no domestic distortions in either economy.

Perfect competition (e) and constant returns to scale (d) are assumed throughout the paper. If all assumptions hold, the two countries have no incentive to trade. If assumption (a) is relaxed, we have the Heckscher-Ohlin model with different factor endowments as the cause of trade. Then the substitutive property found by Mundell (1957) holds. In this chapter capital mobility and trade exists regardless of possible causes given by relaxing assumption (a), (b), (c), or (f). In chapter 3, the trade-capital mobility relationship is analyzed by relaxing assumption (b) and (f). There, the pattern of capital movements and trade in goods becomes endogenous.

2.1.1 Single country equilibrium

Let us first describe the economy of the home country *h*. Choosing good 2 as the numeraire, define p as the relative price of good 1. Suppose further that an amount of foreign capital κ works in the home country (negative κ for an outflow of domestic capital). The economy of the home country can be described by the Gross Domestic Product (GDP) function, which is also called revenue function. Without joint production, the GDP function denoted by $g\left(p, \overline{K}+\kappa, \overline{L}\right)$ can be written as:

$$g\left(p, \overline{K}+\kappa, \overline{L}\right) = \max_{Q_i, \{\overline{K}+\kappa, \overline{L}\}} \left\{ \begin{array}{l} p \cdot Q: \quad Q_i \le F_i\left(K_i+\kappa_i, L_i\right), \\ \qquad \text{and } \sum_i K_i+\kappa_i \le \overline{K}+\kappa, \sum_i L_i \le \overline{L}, i=1,2 \end{array} \right\} \tag{2}$$

or in an alternative way:

$$g\left(p, \overline{K}+\kappa, \overline{L}\right) = \min_{r, w} \left\{ r \cdot (K+\kappa) + w \cdot L: p_i \le c_i(r, w), i=1,2 \right\} \tag{2'}$$

with r and w denoting the factor prices for capital and labor paid in the home country. The unit cost function of sector i is denoted by $c_i(r, w)$. The constraint $p_i \leq c_i$ in (2') comes from the zero-profit condition of a firm under perfect competition. To simplify the notation, the fixed factor endowments are dropped from the GDP function which becomes $g(p, \kappa)$.

The supply of good 1 is given by $Q_1(p, \kappa) = \partial g / \partial p$, and the rental rate of capital is equal to $r(p, \kappa) = \partial g / \partial \kappa$. The foreign capital earns r per unit, which is repatriated to the foreign country.

The demand side of the economy is described by a social utility function u(C), which is increasing, differentiable, and quasi-concave. The simplest way to represent national welfare is to assume that there is only one household in the economy. Instead of assuming the existence of only one household for each country one could also assume that all households of the economy have identical preferences and endowments. If they have identical preferences and endowments, they must make the same consumption choices, and in equilibrium they have the same utility level. This means that the utility level of each household is sufficient to represent the welfare level of the economy, i.e. the utility of any household represents the welfare of the economy.[5] Hence, in the absence of any distortions in consumption, the representative household, taking prices as given, chooses the consumption bundle, which maximizes his (hence, the social) utility function.

The utility function $u(C)$ is assumed to be non-negative, continuous, quasi-concave and increasing. The social indirect utility function, $\tilde{V}(p, I)$, can be defined as the maximum social welfare level by choosing the consumption bundle C subject to the budget constraint: $\tilde{V}(p, I) = \max_{C} \{u(C) : p \cdot C \leq I\}$, where I denotes the income of the home economy. The social utility function $u(C)$ is the

[5] For the different concepts of the social welfare function see Mas-Colell et al. (1995).

maximum social welfare function when the economy is given the aggregate consumption C. Hence, $\widetilde{V}(p, I)$ is interpreted as the dual to $u(C)$.

For considering international linkages of the home country, the social indirect utility function $\widetilde{V}(p, I)$ can be transformed into the indirect trade utility (ITU) function $V(p, \kappa, b)$ by replacing the national income with $g(p, \kappa) + b$, that is, $V(p, \kappa, b) \equiv \widetilde{V}\big(p, g(p, \kappa) + b\big)$. Assuming the existence of a social utility function, the indirect trade utility function (ITU) of the home country is defined as:

$$V(p, \kappa, b) = \max_{C} \{u(C): \quad p \cdot C \leq g(p, \kappa) + b\}, \tag{3}$$

where b is the amount of transfers the country receives from the rest of the world (Woodland, 1980). The solution of equation (3), $C(p, \kappa, b)$, gives the optimal consumption bundle for the economy. Again, for simplicity the fixed factor endowments are dropped from the function. The ITU function gives the maximum utility level of the economy when it faces commodity prices p, capital inflows or outflows κ, and receives a transfer of b, and is, thus, a compact way of summarizing the preferences and technologies of the economy.

With repatriation of the earnings of foreign capital and no other transfers, b is given by: $b = -r\kappa$ and the ITU function changes to $V(p, \kappa, -r\kappa)$. The national income level of the country is defined as $I \equiv g(p, \kappa) - r\kappa$. Note that if we have an outflow of domestic capital, i.e. when κ is negative, capital earns and repatriates the foreign rental rate r^*. In absence of any foreign income tax the national income is then given by $g(p, \kappa) - r^*\kappa$ with $\kappa < 0$. For simplicity and because rental rates are equalized in the equilibrium with free capital movements, this case is not explicitly considered.

Denote the export of good 1 by $E_1 = E_1(p,\kappa, b)$ with $E_1>0$ for exports and $E_1<0$ for imports of good 1. The export of good 1 can be derived from the ITU function:

$$E_1(p,\kappa, b) = \frac{1}{\lambda}\frac{\partial V}{\partial p}, \tag{4}$$

where λ is the marginal utility of income.[6] Alternatively, the export of good 1 is given by:

$$E_1(p,\kappa, b) = Q_1(p,\kappa) - C_1(p, I), \tag{5}$$

where $Q_1(p,\kappa)$ denotes domestic production, and $C_1(p, I)$ is domestic consumption, i.e. the Marshallian demand for good 1. Define m_1 as the marginal propensity to consume good 1, that is, $m_1 = p\partial C_1 / \partial I$. With no inferior goods, $0<m_1<1$. Using the transfer equation $b = -r\kappa$, the reduced form of the export function for good 1 can be derived from condition (4) or (5):

$$\varepsilon_1(p,\kappa) \equiv E_1\left(p,\kappa, -r(p,\kappa)\kappa\right). \tag{6}$$

Effects of capital movement on the volume of trade:

At this stage we can analyze the effects of capital flows on the volume of trade at constant commodity prices from a single country perspective, i.e. the weak version of the quantitative relationship between capital mobility and trade in goods.

---

[6] Starting from the ITU function, define the Lagrangian function $\mathcal{L} \equiv u(C) + \lambda\left[g(p,\kappa) + b - p\cdot C\right]$ and assume differentiability. By using the envelope theorem, the derivative of the ITU function with respect p and to b gives: $\frac{\partial V}{\partial p} = \lambda\left[Q_1(p,\kappa) - C_1\right] = \lambda E_1(p,\kappa, b)$, and $\frac{\partial V}{\partial b} = \lambda$, where $\lambda = \lambda(p,\kappa, b)$ is the Lagrangian multiplier and can be interpreted as the marginal utility of income. Without satiation, $\lambda>0$. Combining and rearranging gives: $E_1(p,\kappa, b) = \frac{\partial V/\partial p}{\partial V/\partial b} = \frac{1}{\lambda}\frac{\partial V}{\partial p}$.

The effect of capital inflow on the home country's export can be obtained by differentiating equation (5) with respect to κ :

$$\varepsilon_{1\kappa} = \frac{\partial Q_1}{\partial \kappa} - \frac{\partial C_1}{\partial \kappa} = \frac{\partial Q_1}{\partial \kappa} - \frac{m_1}{p}\frac{\partial I}{\partial \kappa}.^{7} \qquad (7)$$

Hence, the effect of capital inflow on exports depends on the pattern of production. Three cases can be distinguished: diversification in production, specialization in good 1, specialization in good 2.

In the first case, *the production of the home economy is diversified.* According to the Rybczynski theorem, the effect of capital inflow on production of good 1 is $\partial Q_1 / \partial \kappa > 0$ if and only if sector 1 is capital-intensive. The effect of capital inflow on national income is

$$\frac{\partial I}{\partial \kappa} = \frac{\partial g}{\partial \kappa} - r - \kappa \frac{\partial r}{\partial \kappa} = 0 \qquad (8)$$

because $\partial g / \partial \kappa = r$, and with diversification r depends only on p, that is $\partial r / \partial \kappa = 0$. Combining these results, (7) reduces to :

$$\varepsilon_{1\kappa} = \frac{\partial Q_1}{\partial \kappa} = \frac{\partial r}{\partial p}, \qquad (9)$$

where the last equality is due to the reciprocity relation, which shows the symmetry between the output effect of capital endowment and the input effect of commodity prices[8]. The capital effect on exports of good 1 is positive if and only if sector 1 is capital-intensive, or more generally, an increase in capital inflows leads to an increase of the exports of the capital-intensive good.

---

[7] To minimize the use of notation, denote partial derivatives by subscripts, e.g. $\varepsilon_{i\kappa} \equiv \partial e_1(p,\kappa)/\partial \kappa$.

[8] The reciprocity relation links the Stolper-Samuelson theorem with the Rybczynski theorem. For derivation of the reciprocity relation see Ethier (1995, p. A-23).

If the economy is completely specialized in good 1, the output of good 1 is given by the production function: $Q_1 = F_1(\overline{K} + \kappa, \overline{L})$. Assume for the first and second derivatives of the production function the usual properties to hold, especially $F_{1K} > 0$ and $F_{1KK} < 0$. The rental rate of capital is $r = pF_{1K}(\kappa)$ which depends on κ and p. Then, the derivatives of the rental rate are $r_p = F_{1K} > 0$ and $r_\kappa = pF_{1KK} < 0$. Using the partial derivatives, the effect of capital inflow on national income is:

$$\frac{\partial I}{\partial \kappa} = \frac{\partial g}{\partial \kappa} - r - \kappa \frac{\partial r}{\partial \kappa} = -\kappa \frac{\partial r}{\partial \kappa} = -p\kappa F_{1KK} > 0. \tag{10}$$

Using the income definition, the capital effect on consumption is equal to:

$$\frac{\partial C_1}{\partial \kappa} = \frac{\partial C_1}{\partial I}\frac{\partial I}{\partial \kappa} = \frac{m_1}{p}\frac{\partial I}{\partial \kappa} = -\frac{m_1 \kappa}{p}\frac{\partial r}{\partial \kappa} \tag{11}$$

Substituting these results in equation (7) gives the effect of capital inflow on export of good 1:

$$\varepsilon_{1\kappa} = F_{1K} + \frac{m_1 \kappa}{p}\frac{\partial r}{\partial \kappa} = \frac{1}{p}\left(r + m_1 \kappa \frac{\partial r}{\partial \kappa}\right). \tag{12}$$

Using the product rule, $r + \kappa \partial r / \partial \kappa = \partial(r\kappa)/\partial \kappa$ which gives the rate of change in the total payment of foreign capital with respect to capital inflow. Assume that it is positive (which is fulfilled by a constant elasticity of substitution (CES) production function). Furthermore, assume that $0<m_1<1$, i.e. no inferior goods exist. Under these conditions $\varepsilon_{1\kappa} > 0$, meaning that there is a complementary relationship between capital inflow and export of good 1 in the weak quantitative relationship sense.

If the economy is specialized in good 2, the export function of good 1 reduces to $E_1 = -C_1$. The output of good 2 is again given by its production function

$Q_2 = F_2(\overline{K} + \kappa, \overline{L})$ with its first and second order derivatives $F_{2K} > 0$ and $F_{2KK} < 0$. The rental rate of capital is equal to the marginal product of capital in sector 2: $r = F_{2K}$. Hence, similar to the case with complete specialization in good 1 (cf. equation (10)) the capital effect on national income is:

$$\frac{\partial I}{\partial \kappa} = \frac{\partial g}{\partial \kappa} - r - \kappa \frac{\partial r}{\partial \kappa} = -\kappa \frac{\partial r}{\partial \kappa} = -\kappa F_{2KK} > 0. \qquad (13)$$

The capital effect on consumption can easily be derived from this equation giving the capital effect on export if the economy is completely specialized in good 2:

$$\varepsilon_{1\kappa} = -\frac{m_1}{p}\frac{\partial I}{\partial \kappa} = \frac{m_1 \kappa}{p}\frac{\partial r}{\partial \kappa} < 0. \qquad (14)$$

Hence, an increase in capital inflow ($d\kappa > 0$) leads to decreasing imports of good 1, i.e. a substitutional relationship between capital inflow and trade in good 1. However, if the economy is a capital-exporting country ($\kappa < 0$), $\varepsilon_{1\kappa} > 0$ implying a complementary relationship between capital outflows and imports of good 1.

Having analyzed the effects of an increased capital inflow on the volume of trade at constant commodity prices, these results can be summarized as:

Proposition 1: *If (i) the economy is diversified, or (ii) completely specialized in the capital-intensive good (good 1), or (iii) in the labor-intensive good (good 2) while being a capital-exporting country, an increase in capital flows, i.e. inflows for case (i) and (ii) and outflows for case (iii), will, under constant terms of trade, lead to a greater export of good 1, i.e. the capital-intensive good.*

Proposition 1 also implies that in all three cases above, $\varepsilon_{1\kappa}$ is negative if and only if good 1 is labor-intensive.[9] Note, that the sign of the effects of capital flows on the volume of trade depends not just on the factor intensity of good 1 but also on

[9] This case was shown in Wong (1986).

technology, preferences, and factor endowments of the economy which are exogenous in this section. This influence will be analyzed in the next section.

2.1.2 Two Countries Equilibrium

Up to now we have analyzed the weak relationship between commodity trade and international factor movements in a quantitative-sense under constant terms of trade. Next, we will determine the world general equilibrium for the two country model with trade and capital movement and analyze the results.

The foreign country can be modeled in a similar way as the home country. Foreign variables are distinguished by asterisks. For example, the export function of good 1 for the foreign country is given by $E_1^* = e_1^*\left(p^*, k^*\right)$, where p^* is the foreign relative price of good 1, and $k^*(=-k)$ denotes the capital inflow into the foreign country.

The general equilibrium of the two countries with free goods trade and capital movement is described by the following conditions:

$$e_1(p,k) + e_1^*\left(p^*, k^*\right) = 0 \qquad (15a)$$

$$k + k^* = 0 \qquad (15b)$$

$$p = p^* \qquad (15c)$$

$$r(p,k) = r^*\left(p^*, k^*\right)^{10} \qquad (15d)$$

Condition (15a) is the market clearing condition for good 1. Condition (15b) assures the world equilibrium of capital flows. The other two conditions state price equalization due to the free market, perfect competition assumptions. Due to Walras' law no equation describing the equilibrium of the good 2 market is

[10] Recall that $r = r(p,k)$ and $r^* = r^*\left(p^*, k^*\right)$ are the derivatives with respect to capital endowment of the respective GDP function of country *h* and *f*. Depending on the pattern of production the rental rate may only be a function of the relative price of good 1, *p*.

needed. The four conditions can be solved for the four unknown variables: *p, p**, κ , κ *.

The current account balance of the home country, and thus, that of the foreign country in this two country case is given by:

$$pE_1 + E_2 = r\kappa . \qquad (16)$$

For analyzing international goods trade and capital movement in a general equilibrium framework, we will use the graphical technique developed in Wong (1986). This approach depicts the four equilibrium conditions (15a) to (15d) in two curves, labeled GT and KM (see Figure 1). Curve GT describes the equilibrium of the world good-1 market, whereas curve KM shows the equilibrium of the international capital market.

2.1.2.1 Equilibrium of the world s commodity market

The equilibrium of the world's good 1 market in the presence of capital movements is described by the equations (15a) to (15c). Substitute conditions (15b) and (15c) into (15a) gives:

$$e_1(p,\kappa) + e_1^*(p,-\kappa) = 0 \qquad (17)$$

This export function states that at any pre-chosen price level, there may be one or more combinations of home's export of good 1, $e_1\left(=-e_1^*\right)$, and the amount of capital inflow from abroad, $\kappa\left(=-\kappa^*\right)$, which equilibrate the world market for good 1. This does not necessarily imply that the capital market is in equilibrium. Hence, rental rates of capital may not be equalized among countries while goods markets clear.

The home export supply function for good 1 can be further transformed[11] into a function where the export supply is solely dependent on capital movement κ :

$$E_1 = e_1(f(\kappa),\kappa) \equiv \Theta^G(\kappa). \tag{18}$$

Function $f(\kappa) = \tilde{p}$ shows the relative price of good 1 in the world free-trade equilibrium, as κ is given as a parameter. Then, the function $\Theta^G(\kappa)$ gives the free-trade export level of good 1 of the home country when κ is treated as a parameter. The world market equilibrium for good 1 depending on parameter κ is described by curve GT in Figure 1. The vertical intercept of GT gives the level of home country's export of good 1, E_1^0, if capital is internationally immobile. E_1^0 can be positive or negative, depending on the comparative advantage of the home country before capital moves. The slope of the GT curve is given by:

$$\left.\frac{dE_1}{d\kappa}\right|_{GT} = \frac{e_{1p}e^*_{1\kappa^*} + e_{1\kappa}e^*_{1p^*}}{e_{1p} + e^*_{1p^*}} \tag{19}$$

For Walrasian stability[12] in the good 1 market it is assumed that $e_{1p} + e^*_{1p^*} > 0$ at any given level of κ .[13] Thus if both of the partial derivatives are positive, then GT is positively (negatively) sloped if $e_{1\kappa}$ and $e^*_{1\kappa^*}$ are both positive (negative). As shown above (proposition 1), $e_{1\kappa}$ is positive (negative) if the home country is diversified and if good 1 is capital- (labor-) intensive, or if the home country is specialized in good 1 (good 2). The same conditions apply to the foreign country.

---

[11] Assume that the partial derivative of the sum of export functions with respect to p does not vanish. Equation (17) is inverted to give p as a function of κ , $\tilde{p} = f(\kappa)$.

[12] Walrasian stability implies price adjustment (whereas Marshallian stability refers to the quantity adjustment).

[13] This assumption is made so that given the same factor intensities in good 1 in both countries is sufficient to know the sign of the slope of curve GT. Thus, if goods in both countries have the same factor intensity ranking at all factor prices, curve GT is monotonically rising or falling.

2.1.2.2 Equilibrium of the international capital market

The equilibrium of the world's capital market is described by conditions (15a), (15b), and (15d), which does not imply equilibrium in the good 1 market. Graphically, the equilibria of the international capital market at different values of E_1 when commodity prices are not equalized are depicted by curve *KM* in Figure 1.

Recall that the dependence of $r = r(p,\kappa)$ on p and κ relies on the pattern of production in the home country, namely (i) diversification, (ii) specialization in good 1, or (iii) specialization in good 2. Here, only case (i) is explicitly considered. If the home country is diversified in production, the rental rate r depends on p but is independent of κ. The domestic price ratio can be expressed as $p = \rho(r,\kappa)$. Under diversification $\rho_r > 0$ if and only if good 1 is capital-intensive, and $\rho_\kappa = 0$. The foreign price ratio can similarly be defined as $p^* = \rho^*(r^*,\kappa^*)$ with $\rho^*_{r^*} > 0$ if and only if good 1 is capital-intensive, and $\rho^*_{\kappa^*} = 0$ if the foreign country is diversified, too.

Substitute equation (15b) and (15d) and the price equations into condition (15a) to give:

$$e_1(\rho(r,\kappa),\kappa) + e_i^*(\rho^*(r,-\kappa),-\kappa) = 0. \qquad (20)$$

Equation (20) is inverted to give the equilibrium rental rate, $\tilde{r}$, in terms of capital movement, $\tilde{r} = \varphi(\kappa)$, while assuming that $e_{1p}\rho_r + e^*_{1p^*}\rho^*_{r^*}$ does not vanish. This equilibrium rental rate function is substituted into the export supply function of the home country which becomes:

$$E_1 = \varepsilon_1(\rho(\theta(\kappa),\kappa),\kappa) \equiv \Theta^K(\kappa). \qquad (21)$$

Function $\Theta^K(\kappa)$, represented by curve KM, gives the equilibrium value of κ under free capital movement for different values of the export level of good 1, E_1. The horizontal intercept of curve KM at κ^0 represents the equilibrium amount of free capital movement with autarky in goods trade. The slope of curve KM is given by:

$$\left.\frac{dE_1}{d\kappa}\right|_{KM} = \frac{e_{1p}r_r e^*_{1\kappa^*} + e_{1\kappa} r^*_{r^*} e^*_{1p^*} + e_{1p} e^*_{1p^*}\left(r_r r^*_{\kappa^*} + r^*_{r^*} r_\kappa\right)}{e_{1p} r_r + e^*_{1p^*} r^*_{r^*}}. \qquad (22)$$

Remember that when both countries are diversified $r_\kappa = r^*_{\kappa^*} = 0$, and $e_{1\kappa}$ and r_r, as well as $e^*_{1\kappa^*}$ and $r^*_{r^*}$ always have the same sign.[14] Again, Walrasian stability for the world capital market is assumed with $e_{1p} + e^*_{1p^*} > 0$. Thus, both e_{1p} and $e^*_{1p^*}$ have to be positive or if one of them is negative it has to be of insignificant magnitude. Hence, under diversification a sufficient condition for KM to be positively (negatively) sloped is that both $e_{1\kappa}$ and $e^*_{1\kappa^*}$ are positive (negative).[15]

Thus, having described the equilibrium of the international capital market and the world equilibrium of the good markets, the simultaneous equilibrium where all four conditions of the equation system (15) are fulfilled is represented by the point of intersection between the two curves GT and KM (W in Figure 1). This

[14] For example, according to equation (9) $e_{1\kappa} > 0$ if and only if good 1 is capital-intensive when the economy is diversified. But if good 1 is capital-intensive then $r_r > 0$ pursuant to the Stolper-Samuelson theorem.

[15] The same condition applies if the home country is specialized in good 1 and the foreign country is diversified or specialized in good 1. Then $r = pF_{1K}(\kappa)$, and $r_r = 1/F_{1K} > 0$ and $r_\kappa = -pF_{1KK}/F_{1K} > 0$.
If the home country is specialized in good 2 , curve KM is positively sloped if the foreign country is specialized in good 1, or if good 1 is capital-intensive when the foreign country is diversified.

point of intersection gives an equilibrium with free goods trade and capital movement.[16]

2.2 The relationship between international trade in goods and capital mobility in a general equilibrium

Now the interaction between capital mobility and trade in goods is analyzed in a general equilibrium framework. Starting from the equilibrium framework above, Figure 1 is used to derive necessary and sufficient conditions for the substitutability and complementarity between trade in goods and capital mobility in the quantitative-sense. The analysis is based on Wong (1986).

Three situations can be distinguished:

(i) free trade but internationally immobile capital, i.e. the vertical intercept of GT, $E_1^0\left(=-E_1^{*0}\right)$,

(ii) free capital mobility but autarky in goods trade, i.e. the horizontal intercept of KM, $k^0=\left(-k^{*0}\right)$, and

(iii) free trade and capital mobility, represented by point W which gives E_1^w, the export level of good 1 by the home country, and k^w, the level of capital inflow.

[16] Whether an equilibrium exists in which both countries are diversified in production was a question long discussed in the literature. Whereas Jones (1967) argues that countries tend to specialize in production if goods trade and international capital movement occur, Kemp and Inada (1969), Chipman (1971), Uekawa (1972), and Brecher and Feenstra (1983) show that there are some general conditions that are sufficient for the existence of an equilibrium under diversification. A somewhat weaker question is whether an efficient production point exists with diversification in both countries. Chipman (1971) has shown that the world production possibility frontier (PPF — concave to the origin given convex technologies in both countries) under goods trade and capital mobility has a flat segment, called the Chipman flat, when there is diversification in production. The existence of a Chipman flat implies the existence of an efficient production point with diversification. However, one can not conclude from the existence of a Chipman flat that at world equilibrium according to equations (15) both countries are diversified. This requires that the equilibrium must be a point on the Chipman flat. If both countries have identical technologies and if factor price equalization exists, the Chipman flat degenerates to a point.

By comparing E_1^0 with E_1^w and k^0 with k^w, the following definitions of the relationship between goods trade and capital mobility in a general equilibrium framework can be stated:[17]

Definition 1

A) Capital mobility diminishes (augments) goods trade if and only if the volume of trade under free goods trade and capital mobility is smaller (greater) than the volume of trade under free trade but no capital mobility, i.e. if and only if $E_1^w < (>) E_1^0$.

B) Goods trade diminishes (augments) capital mobility if and only if capital flows under goods trade and capital mobility are smaller (greater) than the amount of capital under capital mobility but autarky in trade, i.e. if and only if $k^w < (>) k^0$.

In definition 1, the effects of goods trade and capital mobility on each other are measured by comparing their levels under goods trade or capital mobility with their levels at the world equilibrium with goods trade and capital mobility simultaneously. Definition 1 corresponds with the weak version of substitutability and complementarity in the quantitative sense because it only looks at a unidirectional relationship, allowing non-symmetrical effects of capital mobility and goods trade on each other. This means that situations may occur in which goods trade increases capital mobility but capital mobility decreases trade in goods and vice versa.

[17] These are very broad definitions of the relationship between international capital mobility and trade in goods. There are other definitions of defining the relationship in the quantitative-sense, each with some constraints imposed on the markets. For example, Markusen (1983) analyses the relationship under constant terms of trade (cf. the analysis above on the effects of capital flows on the volume of trade). Furthermore, he considers only one direction, i.e. the effect of capital mobility on goods trade. Another way would be to analyze the effects of an exogenous change in either the volume of trade or the level of capital movement on each other, i.e. to examine the slopes of the curves GT and KM.

Definition 2 is equivalent to the strong version of the interrelation between capital mobility and goods trade. Thus, according to definition 2, goods trade and capital flows must behave symmetrically. Both definitions allow that E_1^w and/or k^w are negative.

Definition 2

A) Goods trade and capital mobility are substitutes if and only if they diminish each other.

B) Goods trade and capital mobility are complements if and only if they augment each other.

Using definitions 1 and 2, the necessary and sufficient conditions for substitutability and complementarity can now be derived. To do so, we compare the levels of exports of goods in absence of international capital mobility with the level in the world equilibrium of goods trade and capital mobility, and the level of capital flows in autarky with the level in the world equilibrium. Then the necessary and sufficient conditions for substitutability and complementarity are deduced from comparing the slope of the goods market and capital market equilibrium curves with (a) the signs of capital and goods flows or (b) with the capital rental price differential in autarky and the price differential for good 1 with internationally immobile capital, respectively.

Denote the slope of the line linking points E_1^0 and W by S_{GT}, with $S_{GT} = \left(E_1^w - E_1^0\right)/\mathsf{k}^w$, and the slope of the line linking k^0 and W by S_{KM} with $S_{KM} = \left(\mathsf{k}^w - \mathsf{k}^0\right)/E_1^w$. The conditions for the change in the export levels of good 1 between the equilibrium with capital mobility but autarky in trade and the equilibrium with capital and goods trade flows are:

$$E_1^w \begin{cases} > \\ = E_1^0, \\ < \end{cases} \quad \text{if} \quad S_{GT} \cdot \mathsf{k}^w \begin{cases} > \\ = 0, \\ < \end{cases}$$

$$\text{or iff} \quad \begin{cases} S_{GT} \text{ and } \mathsf{k}^w \text{ have the same sign,} \\ \text{either } S_{GT} \text{ or } \mathsf{k}^w \text{ is zero,} \\ S_{GT} \text{ and } \mathsf{k}^w \text{ have different signs.} \end{cases}$$

The conditions for the change in the equilibrium levels of capital flows are:

$$\mathsf{k}^w \begin{cases} > \\ = \mathsf{k}^0, \text{if} \\ < \end{cases} \quad S_{KM} \cdot E_1^w \begin{cases} > \\ = 0, \\ < \end{cases}$$

$$\text{or iff} \quad \begin{cases} S_{KM} \text{ and } E_1^w \text{ have the same sign,} \\ \text{either } S_{KM} \text{ or } E_1^w \text{ is zero,} \\ S_{KM} \text{ and } E_1^w \text{ have different signs.} \end{cases}$$

Due to the assumed Walrasian stability, the slope of curves GT and KM have the same sign as S_{GT} and S_{KM}. Denote r_0 and r_0^* as the domestic and the foreign rental rate on capital under free trade but internationally immobile capital. Thus, if and only if $r_0 > r_0^*$, foreign capital tends to flow to the domestic country under free trade and in equilibrium $\mathsf{k}^w > 0$, i.e. $\text{sign}\left(r_0 - r_0^*\right)$ is equal to $\text{sign}\left(\mathsf{k}^w\right)$. Furthermore, if p_0 and p_0^* are the autarky prices of good 1 in the home and foreign country under free capital mobility, then the level of exports of good 1 from the home country, E_1^w, is positive (negative) if and only if $p_0 < (>) p_0^*$, i.e. the home country has a comparative advantage in good 1. Combining these results, the necessary and sufficient conditions for substitutability and complementarity between goods trade and international capital mobility are:

Proposition 2:

(i) Capital mobility diminishes {augments} goods trade if and only if

$$sign(\text{slope of curve } GT) \;\{=\}\; sign\left(\mathsf{k}^{w}\right) = sign\left(r_0 - r_0^*\right);$$

(ii) goods trade diminishes {augments} capital mobility if and only if

$$sign(\text{slope of curve } KM) \;\{=\}\; sign\left(E_1^w\right) \;sign\left(p_0 - p_0^*\right);$$

(iii) goods trade and capital mobility are substitutes if and only if

(a) $sign(\text{slope of curve } GT) \;sign\left(\mathsf{k}^{w}\right) = sign\left(r_0 - r_0^*\right)$; ***and***

(b) $sign(\text{slope of curve } KM) \;sign\left(E_1^w\right) \;sign\left(p_0 - p_0^*\right)$;

(iv) goods trade and capital mobility are complements if and only if

(a) $sign(\text{slope of curve } GT) = sign\left(\mathsf{k}^{w}\right) = sign\left(r_0 - r_0^*\right)$; ***and***

(b) $sign(\text{slope of curve } KM) = sign\left(E_1^w\right) \;sign\left(p_0 - p_0^*\right)$.

Here again, proposition 2 (i) and (ii) correspond to weak complementarity or substitutability between capital mobility and trade in goods (cf. Definition 1) while 2 (iii) and (iv) is equivalent to the strong version of the interrelation (cf. Definition 2). From Proposition 2 (iii) and (iv) follows: If both countries have the same factor-intensity ranking and if the factor and goods price differentials, $\left(r_0 - r_0^*\right)$ and $\left(p_0 - p_0^*\right)$, have the opposite sign, then goods trade and capital mobility are either substitutes or complements.

In Proposition 2, the slopes of curves GT and KM, and the direction of capital flows and goods trade are considered as given. As shown above the slopes of GT and KM are affected by the factor intensities of goods in both countries, and by the production technologies used. One important conclusion is that both the technologies and preferences of the two countries have to be considered simultaneously to determine the relationship between goods trade and capital mobility. Factor intensities are not sufficient for determining the relationship. The

influence of factor intensities and of differences in production technologies between countries on patterns of trade and capital flows are analyzed in the following section. Hence, in the next section the shape of GT and KM curves are endogenously derived rather than exogenously assumed.

3. The interrelation between trade in goods and capital movements with endogenous goods and capital flows

In chapter 2 a simple 2x2x2 trade model with international capital mobility was established to analyze the relationship between trade in goods and international capital movements. There, it was exogenous which factors and goods are tradable (good 1 and 2 and capital) and which are non-tradable (labor) without giving any explanation what causes these flows in goods and capital. It was found that factor intensities, technologies as well as preferences of the two countries determine the relationship between goods trade and capital movement. For constant terms of trade it was shown that capital mobility must lead to an inflow (outflow) of capital if capital is used intensively in the production of the export (import) good. Now we look at the interaction of capital mobility and goods trade by considering different bases for trade and capital mobility, e.g. different factor endowments, different technologies or market distortions.

If all assumptions (a) - (f) stated in section 2.1 hold, factor and goods prices are equalized and there is no incentive to trade. If the assumption (a) of identical relative factor endowments is relaxed, we have the Heckscher-Ohlin model with commodity movements and factor movements as substitutes in the strong and weak price as well as quantitative-relationship sense. Hence, in the following sections assumption (b) — identical technologies, and assumption (f) — no domestic distortions in either economy are subsequently relaxed. The last part of this section looks at factor endowment trade, i.e. a Heckscher-Ohlin model with international mobility of sector-specific capital.

3.1 Different technologies

In this section differences in technologies across countries are considered as the basis for trade. This means that factor price equalization is generally not possible and that goods trade and capital mobility are no substitutes in the price-equalization sense.[18] Additional to the technology differences there may be other causes for trade such as different factor endowments and/or differences in preferences among countries. It is assumed that both countries are diversified and always have the same factor-intensity ranking, meaning that in both countries the same sector (1 or 2) is capital-intensive relative to labor and vice versa. What patterns of goods and capital flows result from a trade model with internationally mobile capital?

Suppose that the home country is more productive in sector 1 compared to the foreign country, but equally or less productive in sector 2. Hence:

$$F_1(L_1, K_1) > F_1^*(L_1, K_1) \qquad \text{for all} \qquad L_1, K_1 > 0,$$

$$F_2(L_2, K_2) \leq F_2^*(L_2, K_2) \qquad \text{for all} \qquad L_2, K_2 > 0.$$

The differences in technology can be of any type (i.e. Hicks-neutral, labor-augmenting, capital-augmenting), but it is assumed that they do not cause different factor-intensity rankings in both countries.

To assure stability, assume that $\varepsilon_{1p} + \varepsilon^*_{1p^*} > 0$. This implies, that if both countries are diversified, GT and KM are positively (negatively) sloped if sector 1 is capital- (labor-) intensive in both countries (see equations (19) and (22)). Furthermore, for a Marshallian stable world equilibrium under free goods trade and capital movement the sufficient conditions are:

[18] Purvis (1972) extended the Heckscher-Ohlin model by considering different production functions among countries. He showed that trade and factor flows were complements in the sense that both were required to establish world production efficiency.

(i) sector 1 is capital-intensive in both countries and slope of KM > slope of GT > 0; or

(ii) sector 1 is labor-intensive in both countries and slope of KM < slope of GT < 0.

Based on these conditions for stable equilibria, three possible cases can be derived. The three cases are shown in panel (a) to (c) in Figure 2.

<u>*Case 1.*</u> Both curves are positively sloped and the home country receives capital under free goods trade. Result: $E_1^w > E_1^0$ and $\mathsf{k}^w > \mathsf{k}^0$. Hence, *goods trade and capital mobility are complements in both directions.*

<u>*Case 2.*</u> Both curves are negatively sloped and the home country exports capital under free goods trade. Result: $E_1^w > E_1^0$ (i.e. *capital mobility augments goods trade*), and $\mathsf{k}^w < \mathsf{k}^0$ (i.e. *goods trade diminishes capital mobility*).

<u>*Case 3.*</u> Both curves are negatively sloped and the home country receives capital under free goods trade. Result: $E_1^w < E_1^0$ (i.e. *capital mobility diminishes goods trade*), and $\mathsf{k}^w > \mathsf{k}^0$ (i.e. *goods trade augments capital mobility*).

As examples, cases 1 and 2 are explained.

<u>Case 1:</u>

In *case 1* (panel (a)) both curves are positively sloped. Thus, sector 1 is capital-intensive in both countries. First, the impact of capital mobility on goods trade is considered. Following from proposition 2 (i) with (sign(slope of GT)>0) = = sign$\left(\mathsf{k}^w\right)$ = sign$\left(r_0 - r_0^*\right)$, in *case 1* capital mobility augments goods trade. The following lemma which is stated and proofed in Findlay and Grubert (1958) and Kemp (1969) is used for deriving this effect of capital mobility on goods trade.

Lemma: If the economy remains diversified, technological progress in the capital- (labor-) intensive sector will raise (lower) the rental rate under constant terms of trade.

As stated above, the home country is more productive in sector 1 compared to the foreign country. Then, according to the lemma, the rental rate in the home country must be higher than in the foreign country under free trade which leads to a capital inflow into the home country. The imported capital is employed in sector 1 which uses capital more intensively then sector 2. This leads to an increase in production of good 1, i.e. the Rybczynski effect, and thus to an increase of home country's export of good 1. To summarize, if a country is superior in the production of the export good but equally or less productive in the other good, then capital mobility augments goods trade.

Secondly, the impact of goods trade on capital mobility is analyzed. With (sign(slope of KM)>0) = sign$\left(E_1^w\right)$ = sign$\left(p_0^* - p_0\right)$ proposition 2 (ii) states that goods trade augments capital movement. The last equality holds because the unit costs in sector 1 are lower in the home country due to its productivity advantage. Following from the zero profit condition with perfect competition $p_0^* > p_0$. The lower unit costs in production of the home country's capital-intensive good induces its export and in turn raises capital inflows because of the increased demand in capital in the capital-intensive export sector. Therefore, if the home country is more productive in the capital-intensive good but equally or less productive in the labor-intensive good, then goods trade augments capital movement.

Putting all effects together, in case 1 where the home country is superior in the production of the export good and the export good is capital-intensive, goods trade and capital mobility are complements in the quantitative-relationship sense.

Case 2:

In *case 2* (Figure 2, panel (b)) both curves are negatively sloped, implying that sector 1 is now labor-intensive in both countries. With technical progress in sector 1 in the home country the rental rate in the home country must be lower

than the foreign rental rate under free trade according to the lemma. This leads to capital flowing out of the home country.

First, we look again at the impact of capital mobility on trade in goods. According to proposition 2 (i) with (sign(slope of GT)<0) = sign$\left(\mathsf{k}^{w}\right)$ = = sign$\left(r_0 - r_0^*\right)$ it follows that capital mobility augments goods trade. Hence, if the home country is superior in the production of the labor-intensive export good, i.e. $E_1^0 > 0$, but equally or less productive in the other good, and if the home country is a capital exporter, then capital mobility augments goods trade.

Secondly, the impact of goods trade on capital mobility is derived. Using proposition 2 (ii) with (sign(slope of KM)<0) ≠ (sign$\left(p_0^* - p_0\right)$>0) = = (sign$\left(E_1^w\right)$>0) gives that goods trade diminishes capital movement. Again, $\left(p_0^* - p_0\right)$>0 holds because of the technological superiority of the home country versus the foreign country in the labor-intensive sector 1. The rise in exports of the labor-intensive good 1 entails also an increase in demand for capital, what leads to a reduction of home country's capital export. Thus goods trade diminishes capital movement if the country is superior in the production of the labor-intensive good.

The second case is an example for an asymmetric relationship between trade in goods and capital mobility: while capital movements augment trade in goods, trade in goods diminishes capital movements.

Case 3:

The third case can be derived in the same way. There, the home country is more productive in sector 2 relative to the foreign country, but equally or less productive in sector 1, and good 1 is the labor-intensive good which is initially, i.e. without capital mobility, exported. For case 3 we also get an asymmetric impact of goods trade and capital mobility on each other as in case 2 but in the opposite direction.

It can be concluded that the relationship between capital mobility and trade in goods depends on the assumed technological differences across countries. The analysis is summarized in the following proposition (cf. Wong, 1986) which describes the general relationship between goods trade and capital mobility for the cases in which one country is more productive in one sector but equally or less productive in the other sector:

Proposition 3:

(i) If the home country is superior in the production of the exportable (importable) good but equally or less productive in the other good, then capital mobility augments (diminishes) goods trade.

(ii) If the home country is superior in the production of the capital- (labor-) intensive good but equally or less productive in the labor- (capital-) intensive good, then goods trade augments (diminishes) capital mobility.

(iii) If the home country is superior in the production of the exportable good but equally or less productive in the other good and if the exportable good is capital-intensive, then goods trade and capital mobility are complements.

Proposition 3 (i) corresponds to Proposition 1 and confirms the results found by Markusen (1983). In his analysis, Markusen also considers a two country, two factor model and shows that if the basis for trade are production and factor taxes, differences in production technologies, returns to scale, or imperfect competition

rather than differences in relative factor endowments, then factor mobility must lead to an inflow (outflow) of the factor used intensively in the production of the export (import) good.

Furthermore, Markusen points out that the augmenting effect of capital mobility on trade in goods is a self-reinforcing process in situations where the home country is more productive in the export good and is a capital receiving country. Assuming that initially both countries are equally endowed with both factors, the factor flows induced by different production technologies in turn add a factor-proportion base for trade which complements the other basis for trade, i.e. different production technologies. Here, the difference in factor endowments is not the cause of goods trade, but is the result of international factor movements. Markusen shows by means of the Rybczynski argument that factor mobility caused by technology differences, trade impediments, imperfect competition or increasing returns to scale must lead to an increase in the volume of trade. He concludes that trade in goods and factors as substitutes is a rather special result which is a general characteristic only of the factor proportion models.

However, Markusen has not studied the effects of goods trade on capital flows. As stated in Proposition 3 (ii), these effects depend on the factor-intensity of the home country's more productive sector. Thus, it may be possible that capital mobility has an augmenting effect on goods trade while goods trade leads to diminished capital flows, the total effect being unclear.

It should be noted that in the complementarity case the expansions of trade and capital mobility are limited. Capital moves from one country to the other until at least one country has specialized in the production of one good. Taking again case 1 as an example, the home country experiences an increase in capital inflows and an increase in exports of good 1 because of its technological superiority in its

capital-intensive export sector 1. Capital inflows stop after the home country has specialized in the production of good 1 or/and the foreign country has specialized in the production of good 2. Only after such specialization has occurred the rental-wage ratio of the home country can begin to fall relative to the foreign ratio with capital movements continuing until factor prices are equalized among countries. With equalized factor prices there is no incentive for capital flows anymore. Hence, the final equilibrium point requires complete specialization in at least one country (cf. Uekawa, 1972; Markusen, 1983; Wong, 1986). That means if both countries are diversified at the beginning, trade flows and capital mobility induced by technological differences lead to specialization in at least one country.

One may argue that this specialization result can not be observed empirically in a world with high intra-industry trade flows in goods and increasing capital movements. There are several reasons for the discrepancy between theory and the empirical facts. In a higher than 2x2x2 dimensional world with *n* different countries producing *m* different goods and experiencing a series of overlapping technology shocks specialization in goods production is unlikely to occur. Additionally, trade in goods and capital movements are not mono-causally induced by technological differences among countries but result also from differences in relative factor endowments and distortions in factor and production markets etc. Hence, imperfections in trade and capital movements may prevent the countries from an instantaneous adjustment to the knew equilibrium as depicted in Figure 2, and thus, from specialization. The total effect of all interactions is hard to predict. This leads us to the relationship of trade in goods and capital mobility induced by distortions on production and factor markets.

3.2 Production and factor market distortions

Now the assumption (f) — no domestic distortions in either economy — is relaxed and the resulting trade and factor flows are considered.

Mundell (1957) analyzes the effects of trade impediments, i.e. import tariffs, on capital movements, and the effects of impediments of factor movements on trade in goods. He starts from a Heckscher-Ohlin type of trade model, where different relative factor endowments are the basis for trade in goods. Hence, the Mundell-Samuelson-result applies, i.e. initially free trade in goods prevails with factor price equalization and there is no incentive for factor movements. Then, he introduces trade impediments in terms of an import tariff. The import tariff leads to a change in the domestic relative price and thus via the Stolper-Samuelson effect to factor price differentials encouraging factor movements between countries. As a result, free capital movement in response to factor price differentials suppresses goods trade. Capital movements stop when factor prices, and thus commodity prices, are equalized. The tariff eliminates trade, but after the capital has moved there is no longer a need for trade since marginal products and prices are again equalized. This analysis shows that trade impediments in a Heckscher-Ohlin framework discourage goods trade, but encourage factor movements.

Starting from a free factor movement equilibrium, impediments to factor movement encourage trade in goods until commodity prices are equalized. With identical technologies among countries commodity price equalization implies factor price equalization and no factor movements in the end.

Hence in a Heckscher-Ohlin framework with trade and factor impediments, factor movements diminish goods trade, and goods trade also diminish factor movements, i.e. they are substitutes.

Notwithstanding, Markusen (1983) shows for a competitive two-good, two-factor production model with constant returns to scale, identical production technologies, and identical factor endowments across countries, that trade in goods and capital mobility resulting from production taxes are complements. He introduces a price wedge in terms of a production tax between foreign producer and consumer prices, resulting in a change in relative production prices between the home and the foreign country.

Assume that the foreign country levies a tax, T, with $0<T<1$, on the production of good 1. Denote the producer price of good 1 relative to good 2 in the home country as p, in the foreign country as p^*, and the consumer prices of good 1 in terms of good 2 as q and q^*. The price relationships are then given by:

$$p^*/(1-T) = q^* = p^W, \qquad p = q = p^W, \qquad p>p^*.$$

With identical technologies across countries this leads to different relative production quantities of good 1 and 2 across countries. Combined with homothetic demand and identical consumer prices, production taxes can form a basis for trade. If an economy is diversified, the relative price p equals the marginal rate of transformation (MRT) between both goods, i.e. the amount of good 1 that must be forgone in order to produce one unit of good 2. Then if both goods are produced at home and abroad, $p>p^*$ means that the world can produce more of either or both goods, if the home country switches recourses from good 2 towards exports of good 1, if the foreign country does the opposite, and if the two countries trade more. Hence, the home country exports good 1 while the foreign country exports good 2 in this setting.

According to the Stolper-Samuelson theorem the real price of the factor used intensively in the production of good 1 is higher in the home country than in the foreign country and vice versa for the other factor. Hence, the home country will be receiving more capital that is used intensively in the production of its export

good 1. This induced capital movement adds a Heckscher-Ohlin basis for trade, i.e. different relative factor endowments between countries, which reinforce the direction of trade induced by the production tax in one country. Following from the Rybczynski theorem and from the assumption of homothetic demand, this must lead to increased trade at the existing terms of trade.

Therefore, trade in goods caused by a production tax augments capital movements which in return augment goods trade. Similar to the case with different production technologies, factor prices will not equalize until the home country is specialized in its export good, i.e. the good taxed in the foreign country, and/or the foreign country is specialized in good 2, i.e. the good without the production tax. When a country is diversified, factor prices depend on producer prices only. This results in the factor price equalization theorem when producer prices are equalized by trade. With a tax on the production of good 1 in the foreign country, the relative producer price of good 1 in the home country is always higher compared to the foreign country, and consequently the factor price of that factor used intensively for the production of good 1. Factor prices only begin to converge once the home country is specialized in its export good 1 and/or the foreign country is specialized in good 2.

Similar results can be obtained for a wide variety of situations involving factor market distortions (Markusen, 1983). One example for factor market distortions, the specific factor model, will be analyzed in the next section.

Norman and Venables (1995) consider a Heckscher-Ohlin model in which goods and factors can be traded, but trade involves transaction costs. These trade costs could also include a tariff.[19] With transaction costs, goods trade alone will not

[19] Transaction costs on international trade have two effects. First, they prevent international equalization of goods prices. Second, if they are real costs, not taxes or other transfer payments, they create a demand for production factors. Norman and Venables (1995) concentrate on the first effect and, therefore, have a simple treatment of the real transaction costs. They assume that transactions use primary factors in the same proportion as does consumption. They model the transaction costs in

equalize factor prices, so there is an incentive for factor mobility. In contrast to other studies which assume exogenously what is traded internationally, Norman and Venables ask which goods and factors are traded under which circumstances. They characterize equilibria in which there is no trade, goods trade only, factor movement only, and both goods trade and factor movement. Whether or not trade occurs depends on the value of the transaction costs, on preferences, technology, and endowments.

They find that trade in goods and factor movements interrelate in a non-trivial way. For some parameter configurations, factor flows reverse the pattern of trade predicted by the Heckscher-Ohlin framework. The relationship also means that changes in relative transactions costs could have unexpected effects on the pattern of trade. For instance, economic liberalization which reduces transaction costs for both goods and factors can result in either more or less international trade.

Summarizing this section, distortions in production and factor markets such as production taxes or transaction costs create an additional base for trade in goods and capital movements which interrelate in a non-trivial way depending on the value of distortions, preferences, technologies, and the distribution of factor endowments.

3.3 International capital movements with sector-specific capital

So far the neoclassical framework was considered with perfect inter-sectoral capital mobility. However, in the short-run capital is sector-specific. Therefore, this factor market distortion can be analyzed in the specific-factor (SF) model introduced by Jones (1971) and extended by Caves (1971). Caves (1971) also provided an explanation for modeling internationally mobile capital as sector-

---

analogy to ‘iceberg’ transactions costs. Hence, it is as if transactions costs absorb utility rather than using primary factors directly. For their results the form of transaction costs (taxes or not) is irrelevant.

specific. He argued that capital should be seen as a composite factor embodying managerial and technical skills as well as more tangible factors of production. This composite factor is not easily transferable between sectors within a given country but may be much more easily transferable between countries within the same sector.

Neary (1995) establishes a SF model in an explicit two-country framework. One important feature of the SF model is that it can explain the phenomenon of two-way foreign investment, or 'cross-hauling' of capital, an empirically relevant characteristic of capital flows.[20]

Two concepts of 'cross-hauling' of capital can be distinguished. In the first concept, the initial situation of internationally immobile capital with or without trade in goods is compared with the situation when sector-specific capital becomes internationally mobile. Two cases may emerge in the equilibrium of trade in goods and capital mobility: First, foreign capital from one sector is employed in the same sector in the domestic country while domestic capital from the other sector is employed in the same sector in the foreign country in a free trade plus capital movement equilibrium (e.g. Neary, 1995). Secondly, both types of sector-specific capital flow from the foreign to the home country or vice versa, i.e. there is no "cross-hauling" of foreign investment.

The second concept of 'cross-hauling' uses an initial equilibrium with free trade and capital mobility as a reference point and then examines the movements of the two types of capital after a shock. Wong (1995) illustrates the latter concept by means of technological progress or a decrease in the amount of capital in one sector of the home country, and by an increase in labor endowment.

[20] In the neoclassical framework with homogeneity of capital and certainty, it is not possible to have 'cross-hauling' of capital. Other ways of explaining 'cross-hauling' is to assume uncertainty, or the presence of product differentiation or intra-industry investment of oligopolistic firms in two countries (see e.g. Koop, 1997).

Similarly, Neary (1995) looks at the effects of a number of shocks on the equilibrium in a SF model such as international transfers, international barriers to trade in goods and international factor movements. In his model, labor and land are immobile between countries. Concerning the relationship between trade in goods and capital mobility he finds that goods and factors are likely to be substitutes given that internationally mobile capital is used in the import-competing sector. If capital was used in the export sector, however, trade in goods and capital mobility encourage each other. The last finding reconciles with Markusen (1983) who argues that with sector-specific capital goods and factor trade are necessarily complements. He states that capital mobility would for each country result in an inflow of capital specific to the production of the export good. These findings of Neary or Markusen correspond with Proposition 1 in the previous section.

In conclusion, the specific factor model is a convenient way of modeling the phenomenon of „cross-hauling“ of international capital flows in a perfectly competitive world. In these SF models two-way capital flows may be induced through international transfers, international barriers to trade, labor migration, or asymmetric technological progress among countries. Concerning the relationship between capital mobility and trade in goods in a quantitative sense, they are complements (substitutes) if internationally mobile capital is used in the export (import) sector.

4. Implementation of capital mobility into a CGE Framework - Some Conclusions

The purpose of this paper was to investigate whether and under which circumstances international capital mobility has to be explicitly considered in a multi-regional CGE model with trade in goods. According to the goods and factor price equalization theorem goods trade and factor mobility are perfect substitutes

with regard to prices and welfare, and therefore, the incorporation of international capital mobility would not add further insights to the analysis of policies which affect international prices.

However, as this paper shows, there are many cases in which the substitutability between trade in goods and factor mobility stated by Mundell (1957) does not hold. Hence, the world equilibrium depends on whether only international trade in goods or international factor mobility, or both are allowed. Therefore, it is incorrect in the context of complementarity between goods trade and capital mobility to subsume international capital mobility under the theory of international trade in goods. The impact of capital movements should be analyzed carefully. Only by taking into account the non-trivial interactions between goods trade and factor mobility can the effect on production and trade be predicted. Furthermore, as Norman and Venables (1995) have found, it is crucial for policy analysis whether capital earnings are repatriated back to the home country or not.

The analysis of the relationship between goods trade and international capital mobility suggests that in cases where a complementary relationship exists the distribution of factors matters very much. Thus, beginning with equal relative endowments, capital moves internationally because production technologies differ across countries, because distortions in production or factor markets exists, because of changes in preferences, or because of changes in government policies which make endowments unequal, i.e. make each country relatively abundant (scarce) in the factor used intensively in the production of domestically advantaged (disadvantaged) goods. The resulting pattern of goods trade and capital flows are affected by production technologies, preferences, the distribution of factor endowments among countries, the value of production and factor market distortions, factor intensities of sectors, and the amount of capital flows. All these factors of influence may have partly offsetting effects on the resulting trade pattern leaving the sum of all effects unclear.

This paper concludes that the incorporation of international capital mobility is very important in a multi-regional, multi-sectoral trade model. The modeling of international capital mobility seems essential if there are differences in production technologies across regions, if trade impediments such as import or export tariffs exist, if there are distortions in product or factor markets. For modeling the phenomenon of 'cross-hauling' of capital flows one may consider the specification of sector-specific capital flows.

From the analysis done so far one can expect that the incorporation of international capital mobility will considerably change the allocational and distributional outcomes of climate policy scenarios. Furthermore, aggregate regional welfare, and hence, the outcome of policy scenarios are affected by the reallocation of capital across regions. In order to obtain valid policy results one has to keep track of capital ownership by extending the accounting framework of the model to accommodate foreign capital ownership, foreign investment, and foreign income receipts and payments.

Besides the modeling of foreign capital ownership and repatriation of capital earnings it is important to consider that there is no perfect capital mobility in the real world. Gordon and Bovenberg (1996) provide a good overview of the causes of imperfect capital mobility. For modeling imperfection in capital movements it may be worthwhile to combine the international trade literature with the extensive growth literature dealing with imperfect capital mobility. One promising approach to capture imperfect capital mobility seems to be the incorporation of transaction costs as 'iceberg' transaction costs on capital movements as in Norman and Venables (1995).

References

Bhagwati, J. N. (1973). The theory of immiserizing growth: Further applications. In: M. B. Connolly and A. K. Swoboda, eds., *International Trade and Money*. Toronto: University of Toronto Press: 45-54.

Bhagwati, J. N.; Brecher, R. A. (1980). National welfare in an open economy in the presence of foreign owned factors of production. *Journal of International Economics* 10: 103-115.

Brecher, R. A.; Diaz-Alejandro (1977). Tariffs, foreign capital, and immiserizing growth. *Journal of International Economics* 7: 321-339.

Brecher, R. A.; Feenstra, R. C. (1983). International trade and capital mobility between diversified economies. *Journal of International Economics* 14: 321-339.

Burniaux, J.-M., Martin, J. P., Nicoletti, G. and Martins, J. O. (1992). GREEN - A Multi-Sector, Multi-Region General Equilibrium Model for Quantifying the Cost of Curbing CO_2 Emissions: A Technical Manual. *Economics Department Working Papers No. 116*. Paris: OECD

Caves, R. E. (1971). International corporations: The industrial economics of foreign investment. *Economica* 28: 1-27.

Chipman, J. S. (1971). International trade with capital mobility: A substitution theorem. In: J. N. Bhagwati et al., eds., *Trade, Balance of Payment and Growth*. Amsterdam: North-Holland: 201-237.

Ethier, W. J. (1995). *Modern International Economics*. 3rd. edition. New York: W. W. Norton & Company.

Ethier, W. J. (1996). Theories about Trade Liberalization and Migration: Substitutes or Complements? In: P. J. Lloyd and L. Williams (eds.), *International Trade and Migration in the Asia Pacific Region.* Oxford: Oxford University Press: 50-68.

Ethier, W. J.; Svensson, L. E. O. (1986). the Theorems of International Trade with Factor Mobility. *Journal of International Economics* 20: 21-41.

Findlay, R.; Grubert, H. (1958). Factor intensities, technological progress and terms of trade. *Oxford Economic Papers*: 111-121.

Gordon, R. H.; Bovenberg, A. L. (1996). Why is capital so immobile internationally? Possible explanations and implications for capital income taxation. *American Economic Review* 86: 1057-1075.

Hoster, F.; Welsch, H.; Böhringer, C. (1997). *CO2 abatement and economic structural change in the European internal market*. Heidelberg: Physica-Verlag.

Jones, R. W. (1967). International capital movements and the theory of tariffs and trade. *Quarterly Journal of Economics* 81: 1-38.

Jones, R. W. (1971). A three factor model in theory, trade and history. In: J. N. Bhagwati et al., eds., *Trade, Balance of Payment and Growth*. Amsterdam: North-Holland: 3-21.

Jones, R. W.; Neary, J. P. (1984). The positive theory of international trade. In: R. W. Jones and P. B. Kenen, eds., *Handbook of International Economics.* Amsterdam: North-Holland.

Kemp, M. C. (1969). *The pure theory of international trade and investment*. Englewood Cliffs: Prentice-Hall International Inc..

Kemp, M. C.; Inada, K. (1969). International capital movements and the theory of tariffs and trade: Comment. *Quarterly Journal of Economics* 77: 524-528.

Koop, M. (1997). Trade, Foreign Direct Investment, and Multinational Enterprises in a General Equilibrium Model. *Kiel Working Paper No. 833*, September 1997, Kiel.

Lerner, A. P. (1952). Factor Prices and International Trade. *Economica* 19: 1-15.

Lorz, O. (1997). *Standortwettbewerb bei internationaler Kapitalmobilität: eine modelltheoretische Untersuchung.* Tübingen: Mohr.

Markusen, J. R. (1983). Factor Movements and Commodity Trade as Complements. *Journal of International Economics* 14: 25-43.

Markusen, J. R. (1997). Trade Versus Investment Liberalisation. *Nota Di Lavoro 75.97*. Milano: FEEM.

Markusen, J. R.; Melvin, J. R. (1979). Tariffs, capital mobility and foreign ownership. *Journal of International Economics* 9: 395-410.

Markusen, J. R.; Svensson, L. E. O. (1985). Trade in goods and factors with international differences in technology. *International Economic Review* 26: 175-192.

Mas-Colell, A.; Whinston, M. D.; Green, J. R. (1995). *Microeconomic Theory*. New York: Oxford University Press.

McKibbin, W.; Wilcoxen, P. (1998). The Theoretical and Empirical Structure of the G-Cubed Model. *Economic Modelling* (forthcoming).

Meade, J. E. (1955). *Trade and Welfare.* Oxford: Oxford University Press.

Melvin, J. R. (1995). Trade and investment with constant and increasing returns to scale. *Canadian Journal of Economics* 28: S24-S45.

Mundell, R. (1957). International Trade and Factor Mobility. *American Economic Review* 67: 321-335.

Neary, P. (1995). Factor mobility and international trade. *Canadian Journal of Economics* 28: S4-S23.

Nordhaus, W. D. and Yang, Z. (1996). A Regional Dynamic General Equilibrium Model of Alternative Climate-Change Strategies. *American Economic Review* 86: 741-65.

Norman V. D.; Venables, A. J. (1995). International trade, factor mobility, and trade costs. *Economic Journal* 105: 1488-1504.

Obstfeld, M. (1998). The global capital market: Benefactor or menace? *Journal of Economic Perspectives* 12: 9-30.

Ohlin, B. (1933). *Interregional and international trade.* Cambridge: Harvard University Press.

Purvis, D. D. (1972). Technology, trade and factor mobility. *Economic Journal* 82: 979-999.

Saavedra-Rivano, N., Wooton, I. (1983). The Choice of International Labour and Capital Mobility in a Dynamic Model of North-South Trade. *Journal of International Economics* 14: 251-261.

Samuelson, P. A. (1948). International Trade and the equalization of Factor Prices. *Economic Journal* 58: 163-184.

Samuelson, P. A. (1949). International Factor-Price Equalization Once Again. *Economic Journal* 59: 181-197.

Siebert, H. (1999). *World Economics*. London: Routledge.

Suzuki, K. (1989). Choice between International Capital and Labor Mobility for Diversified Economies. *Journal of International Economics* 27: 347-361.

Svensson, L. E. O. (1984). Factor Trade and Goods Trade. *Journal of International Economics* 16: 365-378.

Thompson, H. (1994). An investigation into the quantitative properties of the specific factors model of international trade. *Japan and the World Economy* 6: 375-388.

Uekawa, Y. (1972). On the existence of incomplete specialization in international trade with capital mobility. *Journal of International Economics* 2: 1-23.

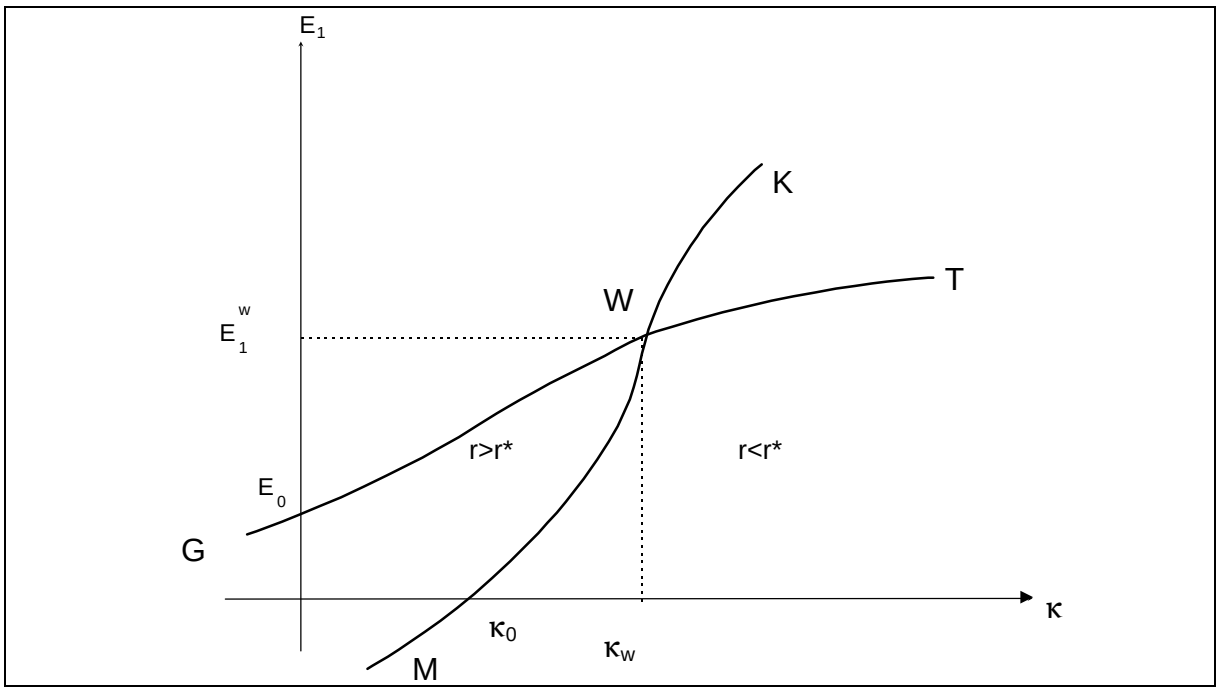
United Nations (UN) (1997), *Kyoto Protocol*. FCCC/CP/1997/L.7/Add.1 (Bonn: United Nations 1997).

Wong, K.-Y. (1983). On Choosing Among Trade in Goods and International Capital and Labor Mobility. *Journal of International Economics* 14: 223-250.

Wong, K.-Y. (1986). Are International Trade and Factor Mobility Substitutes? *Journal of International Economics* 21: 341-356.

Wong, K.-Y. (1995). *International Trade in Goods and Factor Mobility*. Cambridge, MA: MIT Press.

Figure 1

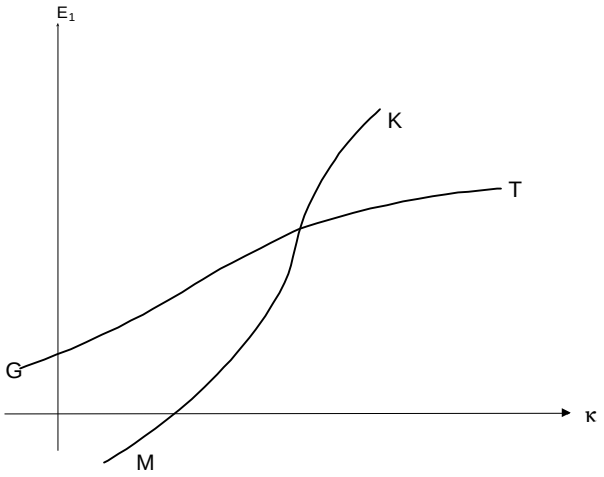


Source: Wong (1995, p.151)

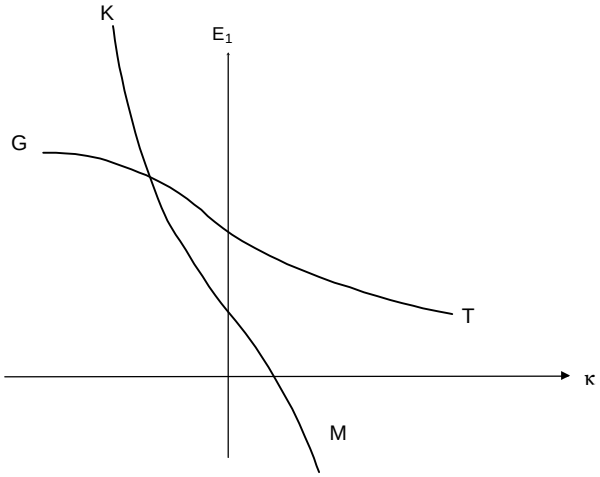
Figure 1 describes the equilibrium for the world goods market and the world capital market. Curve GT gives the world market equilibrium for good 1 in dependence of capital movement κ, whereas curve KM gives the equilibrium of the world capital market for different values of exports of good 1 from the home country, E_1. The vertical intercept of curve GT at E_1^0 represents the level of home country's export of good 1 if capital is immobile. The horizontal intercept of curve KM at κ^0 gives the equilibrium amount of free capital movement, but autarky in goods trade. Starting from κ^0, since an increase in the home country's capital stock tends to lower the rental rate the space in right (left) of curve KM in Figure 1 represents a home rental rate lower (higher) then the foreign rental rate.

The intersection of curve GT and curve KM, point *W*, gives the equilibrium where we have free trade in goods and free capital movements simultaneously. Then, κ^W and E_1^W are the levels of capital inflows to the home country and home country's export of good 1, respectively, occurring in the general equilibrium.

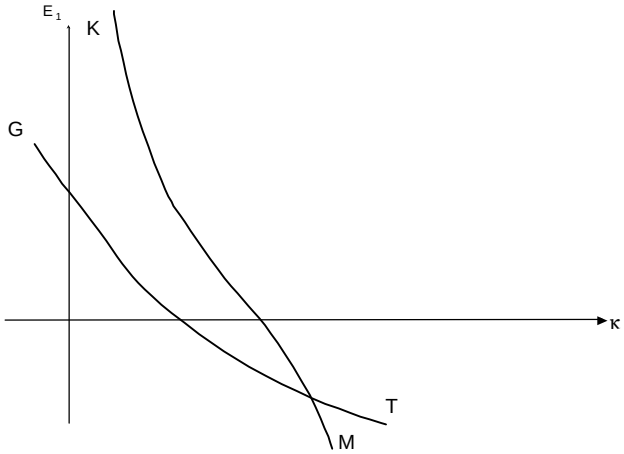
Figure 2



(a)



(b)



(c)

Source: Wong (1995, pp. 174-175)

Figure 2 shows three possible cases of a stable general equilibrium with free trade in goods and internationally mobile capital. In panel (a) trade in goods and capital mobility are complements in both directions. Panel (b) gives the situation where capital mobility augments goods trade, but goods trade diminishes capital mobility. In panel (c) capital mobility diminishes goods trade whereas goods trade augments capital mobility.