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The application of trade and growth theories to agriculture: a survey[†]

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This article reviews a broad range of theoretical concepts available to explain international trade in agricultural and food products. For many years agricultural trade analyses were largely based on traditional perceptions of comparative advantage following neoclassical theory. Observations of agricultural trade suggest, however, that concepts from modern trade and growth theories are increasingly relevant. This survey demonstrates that many opportunities exist for applying these new theories to the modern food economy.

1. Introduction

Many different answers have been offered for the questions, 'why do countries trade and what are the gains from trade?' Differences between countries, for instance, in factor endowments and technology, may lead to trade. Countries trade in order to take advantage of these differences. This concept of trade is based on the theory of comparative advantage, first introduced by Ricardo (1817). More recent theories state that countries may also trade because there are inherent advantages in specialisation arising from the existence of economies of scale (Helpman and Krugman 1985). Some models in modern trade theories emphasise imperfect competition, product differentiation and technology gaps (innovation) among firms and countries as major sources of international trade. Finally, the 'new' growth theories emphasise the endogenous generation of technological change, which can be interpreted as having important implications for international trade (Grossman and Helpman 1991b).

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This article surveys the recent contribution of trade theories and growth theories in evaluating and explaining agricultural specialisation and trade patterns. The purpose of this article is, first, to review the main determinants of international trade as identified by the major trade theories, and second, to identify the empirical relevance of various theories of trade or growth for explaining trade in agricultural and food products.

We conclude that recent developments in trade theory and growth theory have enlarged the toolbox of agricultural economists studying trade and growth issues, and have significantly increased opportunities to link empirical agricultural trade observations with explanatory theoretical concepts. There no longer exists *one* general theory of international trade. Instead, an eclectic approach based on a match of the most important characteristics of agricultural and food products with various trade theories seems more appropriate.

The next section gives a brief overview of international trade theories, supplemented by a review of the trade implications of new growth theories. Then some major characteristics of international agricultural and food markets are presented. Recent empirical work explaining and projecting international trade patterns in agricultural and processed food products is reviewed. The final section highlights the principal conclusions and implications for future research.

2. An overview of international trade theory and growth theory

An overview of the main theories addressing international trade is presented in figure 1. Three major streams (depicted as the three columns in figure 1) are identified. First, there are the classical and neoclassical theories of international trade, referred to as 'traditional trade theories'. The most prominent model of this stream is the neoclassical Heckscher–Ohlin model. Despite its theoretical dominance in the field for more than a half a century, some of its implications were not supported by empirical evidence. This prompted economists to search for other, more appropriate theories to explain trade. These approaches were developed primarily in the late 1970s and early 1980s, and draw on developments in industrial organisation and game theory (Krugman 1995). These more recent theoretical frameworks are presented as a second major stream, the 'modern trade theories' in figure 1. In the late 1980s the so-called 'new growth' theory emerged from progress in the fields of industrial organisation and economic dynamics, which had previously been the preoccupation of macroeconomists (Blanchard and Fisher 1989). Growth theorists set the modern trade theories in a dynamic context and shed light upon the evolution of comparative advantage. The trade implications of these growth theories are also taken into account and captured in the third main stream, referred to as 'trade implications of growth theories'.

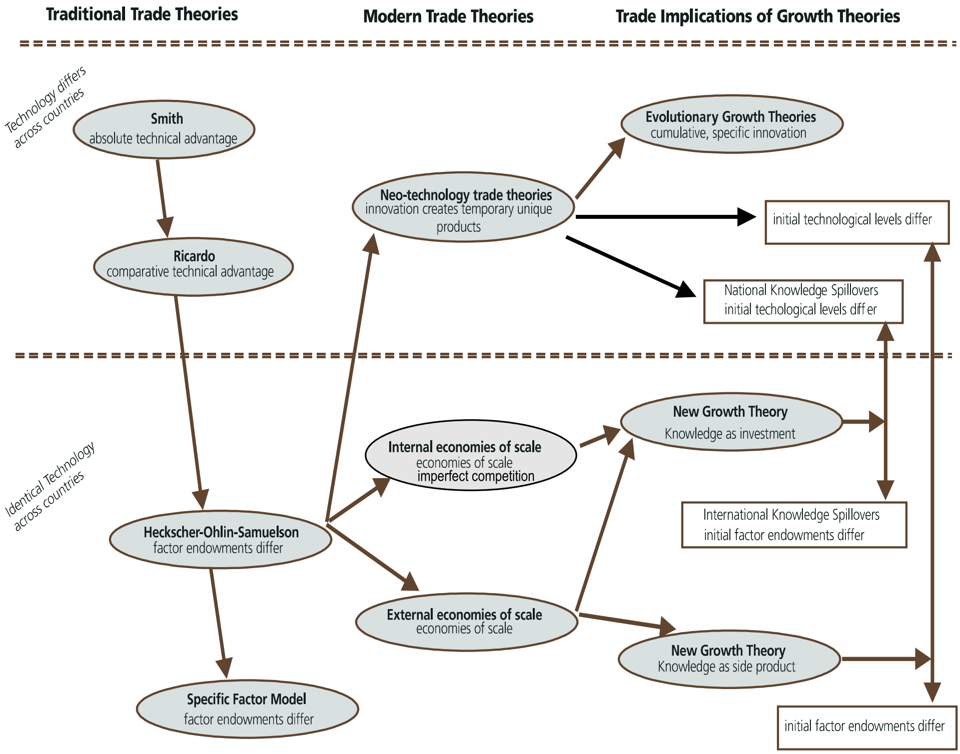


Figure 1 Main trade theories

Within each major stream, a further classification of schools of thought is illustrated in figure 1, according to the key assumptions and the main mechanism of trade emphasised. An important aspect differentiating the various approaches is whether or not technology differs between countries, with the horizontal line in the middle of figure 1 representing this distinction. Following Smith and Ricardo, differences in technology are the main reason for international trade. However, beginning with Heckscher–Ohlin, mainstream trade theory, including the new trade theories that focused on economies of scale and imperfect competition, assumed identical technologies across countries. The focus on dynamics and the endogenous generation of technical change within the new growth theories restored technological differences between countries as a rationale for trade within mainstream trade theory in the late 1980s.[1] The revival of interest in differences in technology among countries induced some important advances in empirical work on

[1] Because in both of the schools based on the new growth theories technology can be either different or identical across countries, we identified two directions within these schools. Each direction is illustrated as a white box in figure 1.

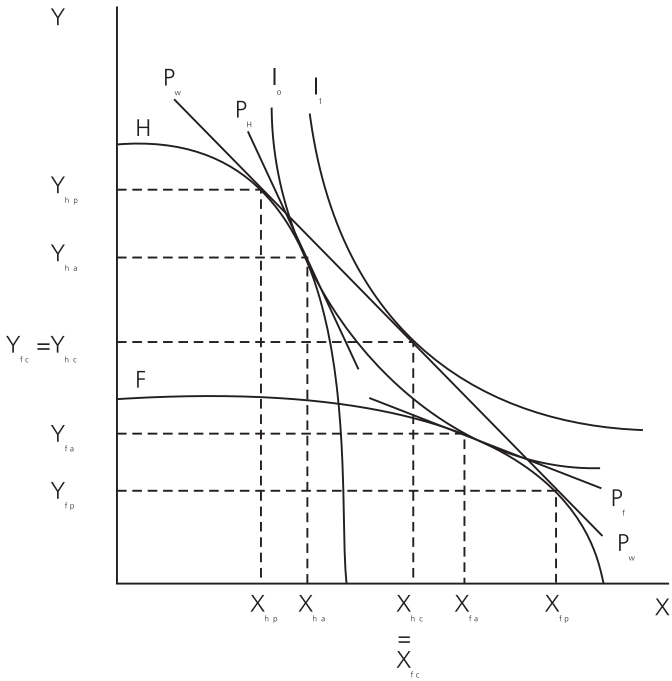
factor content theory in the late 1990s. This latter work combines, in fact, ingredients from both the Heckscher–Ohlin and the Ricardian models of trade, by assuming that trade is driven by differences both in technology and in relative factor endowments. We include these recent empirical advances in the overview of the theoretical developments.

2.1 Traditional theories

As do many other theories, trade theories find some of their roots in Adam Smith's *The Wealth of Nations* (1776). Smith showed that trade is possible when there are absolute cost differences between countries. This means that trade may occur when one country can produce a certain good with less labour than another country, while this second country can produce another good more efficiently. Ricardo (1817) also showed that trade is possible, and beneficial, to both countries when one country produces all goods more efficiently than another country, as long as the relative costs of production of goods differ between countries. In that case each country has a comparative advantage in the good for which the highest efficiency gap holds. This 'principle of comparative advantage' is still one of the most important concepts in trade theory. In the Ricardian model, labour is the only factor of production, and differences in labour productivity are the main explanation for trade, under the assumption of differences in technology level and/or natural circumstances between countries (natural resources, climate, soil, geographical position). However, this model does not explain what causes technology levels, and thus labour productivity, to differ between countries.

Differences in the use of capital per worker are an important explanation of differences in labour productivity. Therefore, the Heckscher–Ohlin–Samuelson (H–O–S) model elaborated on the theory of Ricardo by introducing another factor of production (capital), but then assumed identical production techniques across countries (Ohlin 1933; Samuelson 1948). Furthermore, the standard, neoclassical H–O–S model assumes homogeneous goods, constant returns-to-scale in production, identical, homothetic consumer preferences across countries, and perfect competition in markets. These assumptions imply that differences in factor endowments (leading to different factor prices and prices of goods between countries) are the only determinant of trade patterns between countries. Because of its theoretical dominance in the field, we elaborate on the main mechanisms and principles of the H–O–S model with the following illustration.

Assume a standard H–O–S model with two goods (X and Y) and two countries (H for home, and F for foreign). Country H is relatively capital-abundant while country F is relatively labour-abundant. Production of good Y is capital-intensive while that of good X is labour-intensive. The



H = production possibility curve of country H
F = production possibility curve of country F

I_o = indifference curve in autarky
I_1 = indifference curve with trade

P_h = Px /Py for country H, pre-trade relative price of X to Y
P_f = Px /Py for country F, pre-trade relative price of X to Y
P_w = Px /Py in the trade equilibrium

Figure 2 Production possibility curves and indifference curves for H and F

production possibility curves for H and F and their indifference curves are depicted in figure 2.

With autarky, factor prices differ between the two countries. The rental rate of capital relative to the wage rate is lower in the capital-abundant country H, which will, therefore, use more capital per worker than country F for the production of both goods. This implies that the relative price of the capital-intensive good Y is lower in H than in F (Lerner 1952). This is reflected in the steeper price line of good X relative to Y for H (P_h) than for F (P_f) in figure 2.[2] Under trade, H will export good Y, and F will export

[2] Given these relative prices, country H produces and consumes Y_{ha} and X_{ha} while F produces and consumes Y_{fa} and X_{fa}.

good X, following the principle of comparative advantage. When trade occurs, each country's (now) exporting sector grows and its (now) import-competing sector contracts. Factors of production move accordingly, resulting in income distribution effects. Because the export sector uses relatively more of the abundant factor of production, the relative price of this factor increases and the relative price of the export good increases. This process continues until the relative prices in both countries are the same (world price P_w in figure 2).

In equilibrium, H produces Y_{hp} and consumes Y_{hc} and, therefore, exports $Y_{hp} - Y_{hc}$ to F. F produces Y_{fp} and consumes Y_{fc}, importing $Y_{fc} - Y_{fp}$. For good X, the situation is reversed. It is important to note that trade enables each country to reach a higher indifference curve (I_1 instead of I_0).

From the above illustration of the H–O–S model several conclusions can be drawn.

1. The Heckscher–Ohlin theorem: given the assumptions of the model, each country exports the good that uses most intensively its relatively abundant factor of production. In our example, the capital-(labour-) abundant country H (F), will export the capital-(labour-)intensive good Y (X), and will import the labour-(capital-)intensive good X (Y).
2. The factor price-equalisation theorem: given a certain set of assumptions, the equalisation of commodity prices through trade will result in the equalisation of relative factor returns.[3] In our example, the equilibrium relative prices between goods are the same in both countries. With the same production technology and constant returns to scale, this is only possible when factor prices are identical.
3. The Stolper–Samuelson theorem: an increase in the relative price of a good increases the real reward to the factor of production that is used intensively, and decreases the real reward to the other factor (Stolper and Samuelson 1941).
4. A combination of the Heckscher–Ohlin theorem and the Stolper–Samuelson theorem implies that the scarce production factor in a country will lose from trade and the abundant production factor will gain from trade.
5. The Rybczynski theorem: an exogenous increase in the supply of one factor of production leads to an increase in the production of the good that uses this factor intensively, and to a decrease in the production of

[3] In addition to the assumptions of the standard Heckscher–Ohlin model, there may be no distortions and no impediments to trade, such as tariffs, quotas or transportation costs. Furthermore, both commodities have to be produced in both countries in the equilibrium and there may be no factor intensity reversals.

the other good. If the increase is in the abundant factor this will cause more trade, while an increase in the scarce factor will reduce trade.

6. Trade results in an increase in welfare for both countries: in our example, both countries reach a higher indifference curve in the trade equilibrium. This is caused by a more rational allocation of productive resources and lower relative prices for the import-competing product. Trade is beneficial and occurs due to differences between countries. The larger the differences, the more trade occurs between countries, with all this trade consisting of inter-industry trade.[4] Furthermore, policies that impede trade will decrease welfare. Free trade is therefore the best policy. But, as the Stolper–Samuelson theorem indicates, the gains will not accrue to everyone; income distribution effects may be large.

With respect to the effects of trade on income distribution, it is important to recognise that the standard H–O model assumes that all production factors can move freely between sectors, which is clearly a long-run assumption. The specific factor (short-term Heckscher–Ohlin or so-called Ricardo–Viner) model assumes that one factor is specific to the production of one good. Trade patterns and income distribution implications are both different from the standard H–O–S model, depending on the allocation of the specific factors across sectors (Jones 1971; Samuelson 1971). Trade is beneficial to the specific factor that is necessary to produce the export good, and reduces the return to the factor specific to the import good, while having an ambiguous effect on the real return to the mobile factor.[5]

The trade implications of the H–O–S-model were not always supported by empirical evidence. The most famous example of a result that contradicts the expected model outcomes is the one by Leontief (1953), who found that the imports of the United States — a capital-abundant country — were more capital-intensive than its exports. Not surprisingly, a major stream of research has been concerned with the explanation, within the factor-proportions framework, of the 'Leontief paradox'. The difficulty is that the generalisation of the simple H–O model beyond two factors and two goods does not generalise the Heckscher–Ohlin theorem. For example, it is not the case that the most labour-abundant country will export the most labour-

[4] According to the H–O theory, trade in goods produced in similar industries should not exist. Davis (1995) has proposed, however, that small differences in individual product-related technologies can produce such overlaps even in a Heckscher–Ohlin framework.

[5] With trade, the mobile factor labour moves into the export sector. The marginal product of (= real return to) labour falls in the export sector while real returns to labour increase in the import sector. The welfare effect to labour depends on the consumers' preferences between the export good (whose price has increased) and the import good (whose price has declined). See Ruffin and Jones (1977) for more details.

intensive good. Furthermore, when there are more goods than factors, production levels are indeterminate, so obviously the theory cannot predict the commodity composition of trade. This point was made by Leamer and Bowen (1981) and led to a shift in the empirical work from explaining the commodity composition of trade to explaining the factor content of trade. Recent empirical work on international trade revitalised the factor content model of trade, and some of its major contributions are briefly reviewed below.

The simplest version of the factor content theory is the Heckscher–Ohlin–Vanek model with factor price equalisation (Vanek 1968). Important assumptions are similar technologies and identical homothetic preferences across countries. The model predicts that countries are net exporters of the services of their abundant factors. In the Vanek model, the measure of factor content of net exports should be equal to the country's measure of factor abundance. The *factor content* of net exports is calculated by multiplying the quantity of net exports of each good with the factor input coefficient and summing over all goods. The assumptions of identical technologies and factor prices across countries imply that these input coefficients are identical across countries. *Factor abundance* is calculated as the economy's factor endowment minus the factor content of consumption. The latter is equal to the country's share of world spending multiplied by the world's factor endowment because identical homothetic preferences across countries imply that the composition of consumption is the same everywhere.

Bowen, Leamer and Sveikauskus (1987) tested this model for 12 inputs and 27 countries. The US technology matrix was used to calculate the factor content of net exports for all countries. They found no correlation between factor contents and factor abundance. Studies by Trefler (1993) and Davis and Weinstein (1998) confirmed this dismal result, suggesting that Leontief was right: trade just does not run in the direction that the Heckscher–Ohlin theory predicts (Krugman and Obstfeld 1994).

But Trefler (1995) took a step forward by documenting not just that the H–O–V model performed poorly, but also *how* it performed poorly. First, he found that the measures of factor content of net exports are small relative to the factor abundance measures. He called this 'the mystery of the missing trade'. Second, Trefler calculated that poor countries export too little of their abundant factors while rich countries export too much. Trefler (1995) addressed the latter observation by assuming that absolute levels of technology differ between rich and poor countries. Absolute differences in technology influence national incomes, and hence the volume of trade, but as comparative advantage does not change, they do not affect the pattern of trade in factor services. Trefler's amended H–O–V model fits the data much better than the simple H–O–V model: the correlation between predicted and actual factor content of trade is 0.67, with the sign of factor abundance predicting the sign of factor services trade 93 per cent of the time.[6] However, the predicted size of the factor content of trade was still an order of magnitude larger than the actual level of the factor content of trade, leaving the mystery of the missing trade unsolved.

Very recently, some work has been done to unravel this mystery. Davis and Weinstein (1998) looked very carefully at the trade data as collected and categorised by statistical agencies and observed that goods grouped in the same classification almost certainly include goods produced with varying technology and factor intensities. Capital-abundant countries will produce the capital-intensive goods within a category, while labour-abundant countries will produce the labour-intensive ones. Therefore, if the capital-abundant country's measured average input coefficients are used to calculate the factor content of trade, the capital intensity of its exports will be understated and the capital intensity of its imports will also be overstated. Davis and Weinstein estimate their model empirically and find that a part of the mystery disappears. They conclude that the factor content of trade is drastically underestimated when average factor intensities are used, which indicates that trade is not truly missing but is under-recorded.

Next, the gap between theory and data can be closed by modelling cross-country differences in techniques of production that are driven by both technological differences and differences in factor rewards (Helpman 1999). Hakura (1997) and Davis and Weinstein (1998) show that the fit of the factor content equations improves significantly when each country's production technology is used instead of a common technology.

It may be said that recent studies have revitalised the factor content theory of trade by allowing technology levels to differ across countries. However, the same difficulty remains as with the Ricardian theory: why technology levels differ across countries is not explained. This is where the new theories of trade and growth seem more accommodating.

2.2 Modern trade theories

In the 1970s and 1980s, prior to the recent empirical advances on the factor content of trade discussed above, economists looked for new explanations for international trade in order to find answers for the poor empirical

[6] Regarding 'the missing trade', Trefler introduced a home bias in consumption, which amounts to a prediction that countries prefer to consume services of their own factors. Helpman (1999) finds this amendment less appealing because there is plenty of evidence that technologies differ across countries (for example, Harrigan 1997) while there is no such evidence for demand patterns (except for biases that are related to income levels).

evidence of the factor proportions theory. Empirical studies showed that — contrary to what would be expected according to the standard H–O theory — a major part of trade between industrial countries is of an intra-industry nature,[7] and that the income distribution effects of trade are small. The 'new' trade theories that emerged in the 1980s elaborated on the neoclassical framework by relaxing the assumptions of constant returns-to-scale and perfect competition, and emphasised economies of scale and product differentiation. A second stream, the 'neotechnology theories', stressed the central role of technology as had the classical theories and thus proposed a radical departure from the neoclassical framework.

Where there are economies of scale, doubling the inputs to an industry will more than double the industry's production. Imagine a world with many goods subject to economies of scale. If each country produces only a limited number of goods, each good can be produced on a larger scale than would be the case if each country tried to produce all goods, and the world economy can therefore produce more of each good. International trade plays a crucial role: it makes it possible for each country to produce a restricted range of goods and to take advantage of economies of scale, while consumption of all goods is possible through trade.

The new trade theories assume increasing returns to scale, which implies imperfect competition unless economies of scale are assumed to be entirely external to individual firms. An industry where economies of scale are purely external (that is, where there are no advantages to large firms) will typically consist of many small firms and be perfectly competitive (Ethier 1979, 1982). Economies of scale at the industry level may arise because a larger industry enables a greater variety of specialised services that support the industry's operations or support a larger and more flexible market for specialised kinds of labour. But when external economies are significant, a country starting with large production in a particular industry has a cost advantage in that industry, which induces further specialisation in that industry and leads to inter-industry trade. The process is self-reinforcing and a country may retain an advantage even if another country could potentially produce the same goods more cheaply. In these theories, history and economies of scale explain trade patterns. Furthermore, countries may lose from trade when external economies of scale in their specialisation pattern are relatively small and/or the income elasticity of the products in which they specialise is low. Trade policy (subsidies/tariffs) can be used to reverse the trade and specialisation pattern.

[7] Following some 'documentary work' in the 1960s by other authors, the publication by Grubel and Lloyd (1975) was the first providing detailed evidence of intra-industry trade at the SITC 3-digit level for all major industrialised countries.

A second approach assumes internal economies of scale, which lead to imperfect competition. Within this approach two directions are identified. The first direction concentrates on modelling economies of scale and treats market imperfections as simply as possible by assuming monopolistic competition (Helpman and Krugman 1985). A second direction characterises market structure as oligopolistic, by modelling 'Cournot' or 'Bertrand' competition (Brander and Spencer 1985; Helpman and Krugman 1989).

Under monopolistic competition, an industry contains a sufficiently large number of 'similar' firms producing differentiated 'unique' products. In the market equilibrium, there are zero profits for all firms, while the number of firms depends on the size of the market, the amount of fixed costs and the degree of product differentiation. Underlying the application of this model to trade is the idea that trade increases market size, which may expand the scale of production and may enlarge the variety of goods available to consumers. The main mechanisms of trade are (internal) economies of scale and product differentiation, which cause the production of each product variety to be concentrated in a particular country. Each country produces a different set of varieties of a certain product. Because consumers display a 'love of variety', all varieties are in demand which implies that a country imports each of the varieties produced in other countries and exports each of the varieties domestically produced. So, there will be intra-industry trade. However, it is ambiguous which country produces which variety. Again, the exact specialisation pattern is dependent on history and accidental factors.

In an oligopolistic market, firms are mutually dependent on each other's decisions. If trade is opened, each firm will become part of a larger, more competitive market. Each firm will find itself facing a higher elasticity of demand, leading it to expand output, and as the industry's output expands, the price will fall. This is the so-called pro-competitive effect.[8] However, if market segmentation and price discrimination are possible, there can be trade even without economies of scale and comparative advantage (Brander 1981; Brander and Krugman 1983). Trade occurs because oligopolists perceive a higher elasticity of demand on exports than on domestic sales — they have a smaller share on the foreign market than on the domestic market — and interpenetrate each other's market (reciprocal dumping).

[8] Assuming economies of scale causing the oligopolistic market structure, the effect of opening of trade in a Cournot market structure is a world industry with larger firms, but fewer in number than the sum of the firms in the national industries before trade. Competition nonetheless increases production and lowers output price levels. Thus, the opening of trade leads not only to a reduction in the monopoly distortion, but also to increased efficiency.

Gains from trade in the new trade theories appear in the form of the pro-competitive effect, the exit of firms which are unable to cover their fixed costs, and lower average costs if the production scale of a firm increases. The welfare and trade implications of trade policies depend on the assumption of perfect or imperfect market competition (Helpman and Krugman 1989). For example, the equivalence of a tariff and a quota disappears when markets are imperfect because a quota creates more monopoly power than a tariff.[9] Furthermore, export subsidies may seem attractive for shifting profits from foreign to domestic firms in a situation where an oligopolistic industry can earn excessive profits. In the simplest case, a subsidy to domestic firms, by deterring investment and production by foreign competitors, can increase the profits of domestic firms by more than the subsidy. This is the so-called 'strategic' trade policy argument, which emerged from the separate role of industrial organisation in the strategic trade literature (Brander 1995).[10] An argument that justifies export subsidies is in contradiction with the traditional theories and extremely useful for lobbyists. However, all justifications for an active trade policy are dependent on very specific assumptions (for instance, Cournot competition) and disappear with foreign retaliation. Therefore, Krugman (1987) concludes that although free trade is almost never optimal under imperfect competition, it is a good rule of thumb.

While these new trade theories assume identical production technologies across countries, the neotechnology trade theories emphasise (endogenous) technological innovation and technology gaps across firms and countries as a major reason for international trade (Kravis 1956; Posner 1961). In these theories, trade patterns are explained in terms of technological progress. Technological differences or gaps across countries are an endogenous outcome of firm-level product and process innovation that reduces costs of production and generates new products. The flow of technological developments and innovation is assumed to be not free and instantaneous, implying that a firm/country has at least a temporary comparative advantage in production and exports. The difference with the Ricardian trade models is that in the latter, differences in technology (productivity) for some *given* goods cause trade, whereas in the neotechnology trade models trade is induced because the innovating country generates some new products that other countries are unable to produce, at least temporarily.

[9] When monopolistic industries are protected by tariffs, domestic firms know that if they raise their prices too high, they may still be undercut by imports. An import quota, on the other hand, provides absolute protection: no matter how high the domestic price, imports cannot exceed the quota level (see Helpman and Krugman 1989).

[10] Strategic because it is not profitable when viewed in isolation but it alters competition in the future.

2.3 Trade implications of growth theories

While all trade theories are mainly static in nature and focus on allocation issues, an interesting development has taken place in the growth literature. The 'new' growth theories, which emerged from progress in economic dynamics and industrial organisation, build on the static 'new' trade models by putting them in a dynamic context. Like the neotechnology theories, the new growth theories stress the role of technological change. By emphasising dynamics, growth theories deal with the evolution of comparative advantage. Trade implications of new growth theories are that trade and trade policy can influence the long-run growth rate of a country.

The new growth theories found several ways to endogenise technological change in a general equilibrium model. Two approaches can be distinguished. The first approach assumes that externalities (like knowledge spillovers) or 'learning-by-doing' effects, which are both by-products of other activities, cause growth. The external economies of scale approach is used to model these effects (Romer 1986; Lucas 1988). The second approach assumes that technological change is the intended outcome of economic behaviour and firms have to 'invest' in knowledge creation to obtain technological change (Romer 1990; Grossman and Helpman 1991b; Aghion and Howitt 1998). Investments in knowledge can be seen as fixed costs and monopolistic competition makes it possible to cover these fixed costs. Most studies that follow the second approach also assume that knowledge generates some externalities, and are thus a mixture of both approaches.

In models in which external economies of scale determine the evolution of the specialisation pattern (the first approach), the central mechanism is that a firm creates knowledge as a by-product of other activities. This knowledge flows directly to all other firms, where it increases the productivity level of the production factor that can be accumulated. In principle, the initial specialisation and trade pattern are determined by comparative advantage (initial factor endowments, see the second model in Lucas (1988)) or the initial knowledge stock (technological capabilities, see Young (1991)). The dynamic implications of these growth theories based on external economies of scale are that a country will build up knowledge or expertise in goods in which it specialises, therefore reinforcing its comparative advantage in these goods. Because the technological opportunities differ between goods, the specialisation pattern determines the welfare level and long-term growth of a country. Trade or trade policy can influence the specialisation pattern and, subsequently, the long-term growth rate of an economy.

Models that concentrate on investment in knowledge (human capital) combine imperfect competition with externalities. Through investments in R&D, an explicit R&D sector produces new goods by expanding product variety (Romer 1990) or improving product quality (Grossman and Helpman 1991a). Furthermore, there are also some spillovers on the aggregate stock of knowledge. A larger stock of knowledge, in turn, reduces the costs of producing blueprints for new intermediate or final products (i.e. stimulates technological progress).[11] This leads to a constant incentive to invest in R&D and, therefore, to growth in the knowledge stock. The general knowledge stock also increases the productivity of inputs in other sectors or the quality of consumer products. The economy will therefore also be growing at a constant rate. The growth performance dynamics of a country depend on the amount of resources devoted to R&D investments. The R&D investments are dependent on the specialisation pattern, which is determined by the principle of comparative advantage (factor endowments), history, the initial stock of knowledge, the scale of a country's market, and the demand structure. These factors determine the amount of resources devoted to the R&D sector relative to other sectors.

Opening up to trade can, therefore, also influence the growth rate in these endogenous growth models.[12] For instance, Rivera-Batiz and Romer (1991a, 1991b) identify three effects of trade on growth. First, there is the redundancy effect; by eliminating duplication of innovation activities in different countries, trade increases the efficiency of R&D investments and boosts growth. Second, there is the integration effect; if the R&D sector is subject to external economies of scale and spillovers are international in scope, trade can boost productivity by increasing the extent of the market. Third, there is the reallocation effect; as usual, opening to trade alters the equilibrium allocation of resources across sectors. The growth rate increases (decreases) if the trading equilibrium involves more (less) resources in R&D investments. The first two effects are essentially a shift in the efficiency of investment spending. The third effect reflects the amount of resources devoted to R&D investments, which is the result of all kinds of effects that change the allocation of resources. The welfare and growth implications of trade are therefore

[11] Many of the new products that arise due to innovation are intermediate goods. Crucial in modelling the different varieties of intermediate goods is the Ethier (1982) specification, which implies that an increase in the number of varieties increases productivity of all production factors. The intuition behind this result is that more specialised intermediate goods increase the productivity level of all factors.

[12] In the old neoclassical growth models the long-term growth rate was assumed to be exogenous. Trade had therefore no influence on the long-run growth rate of an economy, see Smith (1984) for a survey.

dependent on the specialisation pattern and on shifts in the efficiency of investment spending. Furthermore, whether knowledge spillovers are national or international in scope is important (Grossman and Helpman 1991b).

When there are international knowledge spillovers, all innovators will have the same knowledge and national advantages in R&D arise only from differences in relative factor prices (which are dependent on resource endowments). Factors such as the size of a country's market and the history of its production play no role in long-term trade patterns; the only thing that matters is factor endowments.

With only national knowledge spillovers, the initial conditions govern long-run outcomes. In many situations the country with the greater initial stock of knowledge has an advantage in R&D and accumulates knowledge more quickly than its trading partner. This sustains and adds to its productivity lead. History alone determines long-run trade patterns and growth rates. Government policy aimed at changing the amount of resources devoted to the R&D sector may have long-lasting effects.

Evolutionary growth theories assume that technology plays the fundamental role in economic life (Dosi, Pavitt and Soete 1988; Dosi *et al.* 1990). Technological change and innovation are a cumulative, specific and irreversible process. The main trade mechanism is the absolute technological differences that determine the world market position of all sectors. Relative technological gaps play a minor role. They determine the specialisation pattern between sectors according to the mechanism of comparative advantage. Future growth and technological developments are determined by the current specialisation pattern. The current specialisation pattern of a country has, therefore, a dynamic effect because this pattern determines in which sectors technical skills will be accumulated, innovations will occur, economies of scale will be realised, etc. Sectors differ in their growth opportunities such that the present specialisation pattern is extremely important for the countries' future economic performance. A specialisation pattern according to the traditional mechanism of comparative advantage can lead a country to specialise in those industries (sectors) and activities in which the opportunities for growth and technological development are smallest. A specialisation pattern, which is statically efficient can therefore be dynamically inefficient and vice versa. If this trade-off occurs, a country can try to change the specialisation pattern and future growth path through industrial or trade policy.

2.4 Summarising the key issues

The key issues of the theories described above are summarised in table 1 in

Table 1 Overview of the most important assumptions, determinants and implications of trade theories

Trade theories	Important assumptions	Determinants of trade	Implications
Traditional trade theories			
Ricardo	– natural resources (climate, soil, geographical position) differ between countries – technology differs between countries – homogeneous goods, perfect competition, constant returns to scale	– countries differ in labour productivity (caused by different levels of natural resources and technology)	– trade patterns determined by comparative advantage – inter-industry trade – the more countries differ, the more they trade – severe income distribution effects
Heckscher–Ohlin–Samuelson	– initial labour and capital endowments differ – technology identical across countries – homogeneous goods, perfect competition, constant returns to scale	– countries differ in factor endowments	
Modern trade theories and trade implications of new growth theories			
New trade theories	– (internal or external) economies of scale – imperfect competition – differentiated goods – technology identical across countries	– economies of scale and product differentiation – market segmentation and price discrimination	– history and chance factors determine trade patterns – precise patterns of trade indeterminate – inter-industry and/or intra-industry trade – income distribution effects small
Trade implications of 'new' growth theories	– growth by knowledge creation – (a) factor endowments (human capital, unskilled) differ between countries *or* – (b) initial technological level differs between countries – homogeneous, unskilled labour-intensive, low tech goods and differentiated, human capital-intensive, high tech goods. Technological opportunities are higher for differentiated high tech goods. – national or international knowledge spillovers	– initial specialisation pattern determined by initial factor endowments (a) or technological level (b). This specialisation pattern determines growth rate and the specialisation pattern in future because technological opportunities differ between sectors.	– inter-industry specialisation for homogeneous goods – intra-industry specialisation for differentiated goods (precise pattern of trade indeterminate) – countries may lose from trade especially when knowledge spillovers are national in scale. However, most models assume international knowledge spillovers.
Neotechnology trade theories and trade implications of evolutionary growth theories	– technological level differs between countries (i.e. there are technology gaps) – newly developed knowledge does not flow immediately between countries as it is country- and firm-specific – newly developed knowledge is cumulative and path-dependent – product differentiation by product innovation	– technology gaps, which grow with process and/or product innovation and close with imitation, give countries at least a temporary comparative advantage	– trade patterns determined by technology gaps – inter-industry and/or intra-industry trade – leading countries have to innovate to maintain income levels – countries may lose from trade (if trade-off exists between static and dynamic efficiency). Chances of this occurring are higher because knowledge is cumulative and firm-/country-specific.

which a condensed overview of their most important assumptions, determinants and consequences is presented. Traditional theories suggest that trade is determined by country differences in (a) natural resources; (b) technology levels; and (c) factor endowments. These theories assume homogeneous products and predict inter-industry trade between countries. Modern trade theories and the trade implications of new growth theories identify imperfect competition, economies of scale, product differentiation, and process and product innovations as the main determinants of trade patterns. Based on these theories, intra-industry trade and specialisation in differentiated products can be explained. Overall, recent theoretical and empirical developments point to an increasing role for technology in explaining trade patterns.

Regarding government interventions, the new trade theories have shown that the expected trade and welfare implications of a certain policy are dependent on the underlying assumptions, such as imperfect competition and economies of scale. Furthermore, these theories provide, in principle and under very strict conditions, some justification for interventionist policies, calling into question any blanket rejection of government intervention by the traditional trade theories. The use of the 'right' theory under the 'right' description of the circumstances is, therefore, very important in assessing the impact of government intervention.

Table 1 shows that various determinants can create international trade. However, almost all trade and growth theories state that it is still the principle of comparative advantage rather than absolute advantage that is the important determinant of trade patterns at the industry level. This means that the relative (cost or uniqueness) advantage of a certain domestic product over a foreign product has to be compared with the relative advantage of another domestically produced product over its foreign competitor; the country specialises in the product for which it has the highest efficiency gap. International competitiveness studies that focus on a specific sector (product) should therefore also take into account other sectors (products) in the domestic as well as in the foreign economy. Indeed, a sector can perform well in comparison to its direct foreign competitor but other domestic sectors can perform even better. When such economy-wide effects are ignored, the sector that is thought to be competitive performs less successfully in the future than predicted by such competitiveness studies, as these compare only the domestic sector with the direct foreign competitor. Studies concentrating on one specific sector, say, agriculture, while abstracting from the remainder of the economy are fundamentally deficient in comparison to those covering the whole economy. This implies that a general equilibrium analysis permits a better insight into competitive positions than a partial equilibrium analysis.

3. Characteristics of agricultural products, markets and trade

We now ask to what extent these theories are applicable in explaining trade patterns in the agrifood sector. In so doing, it is important to note the major characteristics of agrifood products, market structures and trade. These characteristics can then be matched to appropriate features of the various theories of international trade to help determine the best theoretical approach to explaining trade patterns. Several general and interrelated observations of agricultural trade characteristics are presented below.

1. *A large part of agricultural and food trade is between similar countries*
   A large share of the trade of developed countries in agricultural and food products (69 per cent and 76 per cent, respectively) is with other developed countries. Furthermore, trade among developing countries is becoming more important (Hertel *et al.* 1999). Intra-developing country trade increased from 23 per cent to 36 per cent for agricultural products and from 24 per cent to 46 per cent for food processing products in the 1965–95 period (GTAP version 4 data). These percentages indicate that the amount of trade among countries that may be considered similar in terms of their relative factor endowments is substantial.
2. *The importance of trade in processed agricultural products increases at the expense of trade in basic products*
   McCorriston and Sheldon (1991) reported on the development of trade in bulk and processed products since 1960. They show that since the mid-1970s the value of world trade in processed products has been growing at a faster rate than that of bulk commodities. This trend continued in the 1980s. In 1988 — the last year considered by the authors — processed products accounted for 60 per cent of world agricultural trade with bulk and intermediate products accounting for equal shares of the remainder. Traill (1996) recorded a 9.4 per cent annual growth rate for trade in processed products between 1961 and 1990 compared with a 2.1 per cent growth for agricultural bulk commodities over the same period. Traill also noted a striking difference between the EU and the United States in this respect: the processed 'high-value' products account for 85 per cent of EU food and agricultural exports but only 60 per cent of US exports. Coyle *et al.* (1998) reported a continuation of the trends towards increased trade in processed food products through the 1990s.
3. *Trade in processed food products is concentrated among a few countries*
   Dayton and Henderson (1992) claim that 30 developed and newly-industrialised countries (NICs) account for 90 per cent of processed food imports, of which the NICs' share was only 6 per cent. McCorriston and Sheldon (1998) emphasise the dominance of the EU as a trader of processed food products in the world trade in food and agricultural

products. Referring to 1990 data from ERS/USDA, the authors report that the EU countries are among the leading exporters of processed food products, with France and the Netherlands together accounting for around 20 per cent of total world trade in manufactured foods.

4. *Market concentration in food processing industries and retailing is increasing*
   There is a general tendency towards increased concentration in the US and EU food processing sectors (Oustapassides *et al.* 1995; Henderson, Sheldon and Pick 1998; McCorriston and Sheldon 1998). This indicates that these industries seek to exploit the gains from economies of scale, and are able to influence supply and prices on the markets. McCorriston and Sheldon (1998) observed a relatively high concentration in each of the sub-sectors of food manufacturing and retailing across the EU.
5. *Trade in processed products between developed countries is increasingly intra-industry trade (IIT)*
   Even at more disaggregated product levels, countries simultaneously export and import processed products that are close substitutes for each other. Traill (1996) refers to a study by Gomes da Silva who found that levels of intra-industry trade, as measured by the Grubel and Lloyd index, in the EU food, drinks and tobacco industries increased between 1980 and 1992 from 0.38 to 0.45 on average.[13] Based on 1994 four-digit SIC data, Henderson *et al.* (1998) report an average IIT level of 0.57 for the US processed food sector, suggesting a significantly higher level of trade overlap than McCorriston and Sheldon (1991) calculated for the US food industries for 1986.

The observations indicate that agricultural trade is concentrated mainly among countries having more or less similar factor endowments and that products traded are increasingly of a processed (highly differentiated) and intra-industry nature. These observations have important implications for the application of trade theories in analysing international trade in agricultural and food products. The observations suggest that (a) the standard Heckscher–Ohlin–Samuelson model is not always suitable to explain agricultural trade; and (b) the relevance of modern trade and growth theories

[13] The common measure of intra-industry trade is the Grubel and Lloyd index, see Greenaway and Milner (1986) for a review of pros and cons of this measurement. This index measures the degree of the absolute amount of commodity exports that is offset by commodity imports of the same grouping, and expresses this intra-industry trade as a proportion of the total trade in this commodity group. In formula: $GL = 1 - |X - M|/(X + M)$, where X is exports and M is imports. The index ranges between zero (no IIT) and 1 (where exports equal imports for each sub-sector of the industry in question).

increases relative to traditional theories in the area of agricultural trade. The study by Coyle *et al.* (1998) underlines these points as it found that the factors stressed by the traditional trade theories, such as increasing income per capita, factor endowments, transport costs and policies, only partly explain the shift in the composition of food trade towards more processed food products. According to the authors, the large, unexplained residual is due to variety effects and differential rates of technology growth among various food and agricultural sectors, thereby presenting a case for the application of elements from the new trade and growth theories in agricultural trade analyses.

4. New trade and growth theories and their application to agriculture

For many years, the mainstream of empirical agricultural trade analysis has been based on the traditional theory of comparative advantage following the neoclassical approach.[14] For instance, empirical research on the impact of trade liberalisation due to the recent GATT round was largely based on this theoretical framework, although the limitations of the most commonly used trade models are recognised (see Peterson, Hertel and Stout 1994).[15] Yet agricultural trade research has progressed to include trade determinants identified by the more recently developed theories. In the following sections, empirical work is reviewed to illustrate the contribution of those studies from applying the recent theoretical developments to gain a better understanding of trade in agricultural commodities and food products.

4.1 Measuring and explaining intra-industry trade

In general, differences in countries lead to inter-industry trade and cannot explain intra-industry trade, while economies of scale can explain intra-industry trade. The study of intra-industry trade in agricultural and food

[14] For overviews of traditional agricultural trade models, see Sarris (1981) and MacLaren (1990). McCalla (1966) introduced imperfect competition in agricultural modelling. In his analysis of price formation in the international wheat market, he suggested that grain trade may be oligopolistic. Several researchers followed McCalla in his approach. These models were, however, criticised as being essentially theoretical models, providing no empirical support and trying to model dynamic price competition in a static framework. A more acceptable inclusion of strategic interaction in modelling requires the introduction of game theoretic analysis. This approach is covered in the section on strategic trade theory.

[15] Studies that have used elements of the new trade theory in analyses of the Uruguay Round are described by Martin and Winters (1996).

products can, therefore, be seen as a way of testing the importance of scale economies in agricultural trade.[16]

Empirical studies of intra-industry trade (IIT) can be classified into three groups. The first group measures levels of IIT to obtain an indication of the importance of non-comparative advantage specialisation. The second group examines whether levels measured confirm predictions of the theory. The third group investigates whether industries for which IIT is measured have the characteristics assumed by the models.

Levels of intra-industry trade

Early studies that measured the level of IIT in agriculture found that agricultural trade was largely of an inter-industry nature (see, for example, Greenaway and Milner 1986). However, as agricultural production was defined as generally as 'food and live animals', it was suggested that these outcomes were mainly due to the high levels of product aggregation in the data. McCorriston and Sheldon (1991) examined IIT levels in a sample of ten high-value processed food and agricultural products for the United States and the EU. The results indicate that in 1986 a large part of this trade was of an intra-industry trade nature and this part was of a similar order of magnitude to other industrial goods. Furthermore, the EU exhibited more intra-industry trade across the sample than the United States, although much of this was due to trade between EU countries. The high levels of IIT for the EU (with values of the Grubel and Lloyd index exceeding 0.70) appear to be influenced by its integrated nature. Focusing on the external trade of the EU, the results showed lower levels of IIT for all product groups, while for seven product groups trade tended to be of an inter-industry, rather than of an intra-industry nature. The results indicated that changes in EU specialisation were largely intra-industry in nature, particularly with respect to intra-EU trade and trade with other European countries, while for the United States it was predominantly inter-industry in nature (with the exception of exports to Canada which indicated a trend to intra-industry specialisation).

Testing hypotheses on intra-industry trade and factor endowments

Hirschberg, Sheldon and Dayton (1994) investigated some predictions of the basic intra-industry trade model of Helpman and Krugman (1985). They

[16] However, the concept of intra-industry trade is an imperfect measure for economies of scale. On the one hand, it may overstate the importance of economies of scale because industries within one industrial classification group may have different factor proportions, and trade within one group is still due to factor proportions. On the other hand, an intra-industry measure may understate the importance of economies of scale because economies of scale may lead to inter-industry trade when there are not many differentiated products within an industry (e.g. aeroplanes).

studied three hypotheses with respect to the relation between IIT and factor endowments. First, the level of IIT will be higher (lower), the smaller (greater) the difference in relative factor endowments between the countries. Second, the level of IIT will be higher (lower), the smaller (greater) the size of the capital-rich country relative to the capital-poor country. And, third, the degree of IIT for a specific country will be positively associated with endowments of capital per worker. The study covered the food processing sector for a sample of 30 countries over the period 1964–85. The results of the analysis by Hirschberg *et al.* provide support for two predictions of the Helpman-Krugman model, indicating that IIT in food processing is a positive function of a country's GDP per capita and relates positively to equality of GDP per capita between countries. In addition, it was found that such trade is strongly influenced by distance between trading partners, membership of customs unions and free trade blocs. Distance between countries has a negative impact on IIT (indicating that the greater the distance between two countries, the lower the IIT level) while membership of either a customs union or a free trade area has a positive effect on intra-industry trade.

Determinants of intra-industry trade

The third group of studies on IIT does not test a specific model, but instead tests a set of hypotheses on causal relationships linked to the theoretical assumptions of the various new trade theories that can explain IIT. Christodoulou (1992), examining red meat markets in the EU, found that product differentiation, taste overlap and market proximity have a positive influence on IIT. Scale economies had a negative influence on IIT.[17] Pieri, Rama and Venturini (1996) examined the determinants of IIT in the EU dairy industry for the period 1988 to 1992, and also found a positive influence of product differentiation, taste overlap and market proximity on the level of IIT. In contradiction to the findings of Christodoulou, market concentration and economies of scale also had a positive influence on IIT. Furthermore, Pieri *et al.* found that more concentrated retailing structures contribute to IIT by reinforcing the taste for variety among final consumers and by reducing the transaction costs in international trade.

[17] Theories assume that economies of scale (together with product differentiation) induce intra-industry trade (a low, minimum efficient size relative to the size of the total market would favour product differentiation). However, when economies of scale are high, production may be located in a few locations, which may lead to inter-industry trade. The relation between economies of scale and intra-industry trade may therefore be positive or negative (Greenaway *et al.* 1995).

One important distinction in the theoretical literature is between horizontal and vertical product differentiation (e.g. Greenaway and Torstensson 1997). Horizontal differentiation is associated with preference diversity: 'love of variety' approach (Dixit and Stiglitz 1977) or the 'favourite variety' approach (Lancaster 1979) and decreasing costs (Helpman and Krugman 1985). Vertical differentiation is represented as differences in quality between similar products and may be related more to comparative advantage, as IIT in vertically differentiated products may be driven by differences in relative factor endowments (Falvey 1981; Falvey and Kierzkowski 1987) or in R&D investments (Shaked and Sutton 1984). Since theoretical models point to different determinants of the two types of IIT with different adjustment implications for a trade expansion, empirical investigations attempt to separate trade flows in horizontally differentiated products (horizontal IIT) and vertically differentiated products (vertical IIT). For the food and agricultural sector, such attempts are to date quite scarce. Following some studies that focus on non-agricultural products,[18] De Frahan and Tharakan (1998) were among the first to analyse horizontal IIT and vertical IIT in the processed food sector. The authors separated total IIT into horizontal and vertical IIT to test separately the importance of country (e.g. differences in per capita income, GDP levels) and industry-specific (e.g. minimum efficient plant size reflecting scale economies) determinants. The empirical investigation was applied to the bilateral trade of EU countries with their major partner countries for 18 food, drink and tobacco sub-sectors for 1980 and 1990. The study used unit values as an indicator for product quality to identify trade flows of products that are vertically differentiated versus products that are horizontally differentiated. The econometric results confirmed most country and industry-specific determinants as proposed by the theoretical models for explaining horizontal and vertical IIT,[19] with the exception of per capita income differences taken as a proxy variable for relative capital endowments in explaining vertical IIT. The latter implies that the authors found no support for either the hypothesis that IIT in vertically differentiated products results from differences in factor endowments, or that

[18] For example, Abd-el-Rahman (1991); Greenaway, Hine and Milner (1994 and 1995).

[19] The authors' results are consistent with the theoretical models explaining horizontal IIT. They found that the average market size and the average level of economic development of the two partner countries, trade preferences, location advantage and horizontal differentiation of the sub-sector all have a significant positive effect on the level of horizontal IIT. Further, factor endowment and market size differences between pairs of countries and scale economies of sub-sectors have a significant negative effect. With respect to vertical IIT, the authors show a positive effect on its level for the average size of the two partner countries, their location advantage and vertical product differentiation of the sub-sector, while scale economies of the sub-sector have a negative effect.

vertical IIT is driven by scale economies. The authors suggested that the definition and measurement of proxy variables could be an important reason for these (unexpected) results. De Frahan and Tharakan conclude from their attempt that 'although the need to test separately determinants of horizontal and vertical IIT is well justified in the new trade theory, this is yet to be confirmed empirically' (1998: 13).

4.2 External economies of scale

The review of the literature indicates that there are two main approaches within the new trade theories for dealing with increasing returns to scale. One approach assumes internal economies of scale, which may explain intra-industry trade. The empirical evidence on intra-industry trade is therefore mostly linked to this approach. The other approach assumes external economies of scale at the industry or regional level (i.e. agglomeration externalities). In a recent article Morrison-Paul and Siegel (1999) estimated internal economies of scale and agglomeration externalities with a dynamic cost function approach. For overall US manufacturing they find that both internal economies of scale and agglomeration externalities are important for the 1959–89 period. The long-run scale elasticity is equal to 0.77; 6 per cent of the difference from an elasticity of 1.00 (implying constant returns to scale) can be attributed to internal economies of scale and 17 per cent to agglomeration externalities. For food and related products they also found evidence for economies of scale (the long-run scale elasticity is equal to 0.90). However, in contrast to overall manufacturing, most of the scale effects can be attributed to agglomeration externalities. This indicates that external economies of scale are important for the food and agricultural sector (for empirical evidence on dynamic externalities in knowledge development in agriculture, see section 4.4).

4.3 Imperfect competition

Price discrimination and market segmentation

Next to comparative advantage and increasing returns to scale, a combination of price discrimination and market segmentation could be a third, but minor cause of trade (see Brander 1981; Brander and Krugman 1983). An example of this approach to trade in agricultural commodities is the study by Pick and Park (1991). Exporters may exercise market power by adjusting prices to different export destinations, resulting in a form of price discrimination. Pick and Park apply a pricing-to-market model to US exports of wheat, corn, cotton, soybean, and soybean meal and oil. In the 1970s and 1980s, the United States was a major exporter of these commodities. The results of this analysis reject the hypothesis that the export pricing decisions by US firms are consistent with price discrimination across destination markets, except for international trade in wheat, where the United States is a major exporter discriminating heavily across destination markets. However, China and the former Soviet Union, the two largest importers of wheat, obtain lower prices for their imports, which suggests both countries exercise some mono- or oligopsony power in international wheat trade, or it may be an example of dumping.

Strategic trade policy

A third direction within the new trade theories focuses on oligopolistic market structures and deals with the strategic interactions of firms and governments. In such models, 'strategic' trade policy may improve the welfare of countries. It is true that production in agriculture may comprise a larger number of similar farmers, but international marketing of agricultural and food products may occur through a small number of private firms, or through a monopoly marketing board or state trading agency. Given the increasing concentration in food processing and retailing, and the presence of agricultural marketing boards or state trading agencies in several countries, it may be important to consider strategic interaction between a small number of buyers/sellers in agricultural and food products.[20]

Strategic trade arguments in this strand of the literature are based on rent-shifting from foreign to domestic firms through government intervention.[21] Much of the literature on strategic trade theory shows how details of market and trade policy regimes affect outcomes. Some papers are briefly summarised to illustrate this.

Thursby and Thursby (1990) evaluated the nature of exporter competition in international wheat trade. In their model, two countries export wheat: one of them (Canada) through a marketing board while in the other (the United States), the export industry is composed of large private firms. The authors used conjectural variation parameters to allow for a range of competitive assumptions, including Cournot and Bertrand behaviour, which

[20] Some notable studies that applied strategic trade analysis to agriculture are those of Thursby (1988), Thursby and Thursby (1990), Krishna and Thursby (1990) and McCorriston and Sheldon (1992). The last study focuses on private firms in the food industry while the other studies concentrate on the role of marketing boards and trade in agricultural commodities.

[21] Other strategic trade arguments are linked to the desirability of a certain industry because it creates (dynamic) external economies. In this section we deal with the first argument concerning rent-shifting. Section 4.4 deals partly with the (dynamic) external economies argument (i.e. spillovers).

means that the exporters of wheat can compete either on the basis of prices or outputs.[22] According to the study, the interactions of both competitors in wheat exports can be characterised as a Bertrand game (= imperfectly competitive firms set their own prices given the price decision of the competitive firm). Thus, price is the strategic variable and determines the optimal policy. If the exporters compete on price and play a Bertrand game, as this model suggests, then an export tax (instead of the 'strategic' export subsidy usually sought by lobby groups) is the optimal policy (see also Eaton and Grossman 1986).

McCorriston and Sheldon (1992) applied a strategic trade model to the US–EC cheese processing sector and evaluated the benefits of the US import quota regime in a strategic trade context. The authors demonstrated that, under imperfect competitive market structures such as those of the cheese processing industries in both the United States and the EU, overall welfare effects of the imposition of a quantitative import restriction are positive. However, important redistribution effects occur as domestic firms (through higher domestic prices) and the government (through selling quota licences) gain, while consumers lose (through higher prices). Interestingly, McCorriston and Sheldon showed that overall welfare effects of the actual (1980) quota regime could increase if import quotas were expanded. Relative to the free trade case, the optimal quotas could increase welfare, albeit marginally, indicating that there is a case for import quotas in the US cheese processing sector. In more recent papers, both authors further elaborated on the distribution consequences of the imposition of import quota by adding details of the import regime, and on the imperfect competitive market structure and export retaliation, to their analysis (McCorriston and Sheldon 1994; McCorriston 1996).

Strategic trade theory has also been used in some studies searching for the rationality behind the agreement on agriculture in the GATT by taking an explicitly game theoretic approach (e.g. Johnson, Mahé and Roe 1993; Abbott and Kallio 1996). For instance, Abbott and Kallio used a stylised model of world wheat trade to illustrate, under differing institutional arrangements (game structures), the levels of export subsidies (or taxes — the strategies), net exports and the political payoffs for four regions or players: the United States, the EU, the CAIRNS Group Countries and importers. Their simulations of alternative GATT arrangements show that, given political payoffs, the US–EU co-operative solution in which export subsidies persist is optimal relative to free trade and unilateral reform. Game

[22] See Dixit (1988) for the calibration technique developed to quantify strategic trade models.

theory may be useful in understanding the nature of market outcomes when policies of export subsidies matter. But although, as Abbott and Kallio (1996) state, issues of imperfect competition and strategic trade policy interaction lay at the heart of the GATT Uruguay Round negotiations, incorporating game theoretic approaches into trade policy analysis is not common, because of its complexity. Most models used to assess trade liberalisation impacts assumed competitive world markets without explicitly examining the game theoretic aspects of market outcome.

These examples show that strategic trade theory does have some relevance for agricultural trade policy research when markets can be characterised as imperfectly competitive. However, caution is recommended in the application of these theories as the specific details of market and trade regimes can have a considerable impact on the outcomes. The empirically-measured overall benefits of strategic trade policy are small and may be negated by inappropriate policy selection, foreign government retaliation and general equilibrium effects that divert resources away from other sectors (Dixit and Grossman 1986).

Imperfect competition and Computable General Equilibrium (CGE) modelling

Yet, as some of the work cited above shows, empirical modelling of agricultural trade policy under imperfect competition has developed recently together with the growth in the theoretical literature. Furthermore, monopolistic competition models have formed the basis for imperfect competition CGE models, which have also had some practical importance in quantifying the outcome of the GATT Uruguay Round (Martin and Winters 1996) and *ex ante* assessments of the Millennium WTO Round (Nagarajan 1999).[23] A relevant paper is also the one by Lanclos and Hertel (1995) who assessed the effects of tariffs on intermediate inputs and final goods in monopolistic competitive food processing industries. They show, for example, that input tariffs reduce output per firm and the number of firms, and indicate that monopolistic competition strengthens the response to input tariffs compared to perfect competition. Considering the joint effects of input and output tariffs, the direction of change in total output may even differ between monopolistic and perfect competition. Their results show that market structure has important implications for the outcome of policy measures.

[23] However, the empirical basis is weak. In particular, cross-country econometric evidence on key parameters that measure scale economies are not yet available: measurement of cost disadvantage ratios is lacking.

4.4 Relevance of neotechnology trade theory and the new growth theory for agricultural trade

Investigating the influence of innovation on trade and growth, Dosi *et al.* (1990) found that export performance is positively associated with differences in innovative products per capita (confirming the hypothesis of neotechnology trade theories) and differences in labour productivity (as Ricardian models predict). However, another result is that changes in trade performance were more strongly associated with changes in innovative activities than with changes in relative labour costs. Regarding growth, they found that international differences in the rate of growth of per capita income are associated with similar differences in the rate of investment and in the rate of growth of innovative activities. This study thus confirms the importance of innovative activities for trade and growth performance, as maintained by the neotechnology trade theories and the new growth theories. However, with respect to the food processing sector, this study did not find a positive influence of innovative activities on trade performance. This may be due to the aggregation level (as one sector) and the use of data from the mid-1970s. There are hardly any empirical studies that have tested the link between knowledge creation and innovation in the agricultural and food sector, on the one hand, and trade in agricultural and food products, on the other. For a more balanced evaluation of the relevance of innovative activities for agricultural trade, studies are needed which investigate the relation between innovation and trade at a more detailed product level and for a more recent period.

Empirical work based on new growth theories has recently begun to appear.[24] These studies focus, on the one hand, on predictions (implications) on the steady-state rate of economic growth and, on the other hand, on two crucial assumptions of these theories, namely, whether spillovers do exist and, if so, whether they are national or international in scope. Jones (1995) tested the relationship between changes in R&D spending and changes in macroeconomic growth implied by these models. The knife-edge assumption

[24] There are, however, numerous studies focusing on an important assumption in the technology trade and new growth theories: the link between innovative activities and productivity growth. Huffman and Evenson (1994) concluded after a survey of the empirical literature that there are high positive returns to public research, extension and schooling for US agriculture. Craig, Pardey and Rosenboom (1997) found a significant positive influence of public R&D expenditures on the labour productivity in agriculture for a group of 98 developed and developing countries. In another recent study Shane, Roe and Gopinath (1998) found that public investments in agricultural R&D and public infrastructure account for 75 per cent of US agricultural productivity growth. The authors stress the importance of productivity growth for agricultural growth in sustaining the returns to its sector-specific resources and maintaining its comparative advantage.

of constant returns to R&D investments in the 'knowledge as investment approach' is crucial for endogenous growth: with decreasing returns to R&D investments there is no endogenous positive long-run growth rate. The constant returns assumption implies that when resources devoted to R&D are doubled, the growth rate of output should also double. Jones showed that this prediction receives little empirical support. The number of scientists engaged in R&D in advanced countries has grown dramatically over the last 40 years, while growth rates either exhibited a constant mean or even declined on average. This indicates that there are decreasing returns to scale to R&D, so that the influence of both policy and opening to trade on the long-run growth rate vanishes. But, how long is the long run? Policies can still have an influence on the period of growth along the transition path to the new steady state. Whether policies are still worthwhile depends on the length of the transition path and the magnitude by which policies can shorten this path.

Several authors have investigated whether spillovers exist and whether they are national or international in scope. The existence of spillovers is important because they cause increasing returns in production, which is necessary for endogenous growth. The (inter-)national scope is important because in models with only national spillovers, government policy can have long-lasting effects. Griliches' (1958, 1960) study on the diffusion of hybrid corn across the United States was the first to show how differences in local climate conditions affect the use and diffusion of new agricultural technology (see also Huffman and Evenson 1994). Griliches (1992) concluded after a survey of the empirical literature that spillovers in agriculture and industry exist and that their magnitude may be large. Recent studies by Gopinath, Roe and Shane (1996) and Gopinath and Roe (1999) confirm these results. In the latter, the authors found empirical evidence for substantial inter-industry spillovers from farm machinery to both primary agriculture and food processing in the United States for the period 1961–1991. With regard to the nature of spillovers, for example, Coe and Helpman (1995) and Bernstein and Mohnen (1994) found some evidence for international spillovers for the economy as a whole.[25] Thirtle *et al.* (1995) also found evidence for the existence of international spillovers in agriculture within Europe. However, Branstetter (1996), in an investigation of both intra-national and international spillovers, concluded that intra-national spillovers are stronger than international ones. There is also some evidence that spillovers are geographically localised (Griliches 1957, 1960; Jaffe 1986; Acs, Audretsch and Feldman 1992). In summary, there is evidence that some spillovers are international in nature, but local or intra-national knowledge

[25] See Mohnen (1998) for a survey on international knowledge spillovers.

spillovers exist as well. This gives some support to models in which government policy can have long-lasting effects.

In another strand of the empirical literature, elements of the new growth literature are embedded in applied general equilibrium models. For example, Diao and Roe (1997) explored the properties of an empirical endogenous growth model of the US economy whose analytical underpinnings are the R&D-based growth models of Romer (1990) and Grossman and Helpman (1991b). In addition to an independent R&D sector, agriculture and food processing is one of the four final output production sectors distinguished in the model. Knowledge spillovers from R&D activities increase the general national knowledge pool, which increases the productivity of factors used in both R&D and other sectors, thus enabling sustainable long-run growth. Two groups of policies — trade policies and R&D-inducing policies — are evaluated to explore how selected economic instruments affect growth through their effects on the accumulation of technological knowledge. R&D subsidies have a substantial positive impact on growth, protecting agriculture causes the growth rate to increase slightly, and protecting the manufacturing sector causes it to fall. The relative factor proportions devoted to the R&D sector are important for these results, due to Stolper–Samuelson-type effects. The R&D sector is most labour-intensive. Among the four final goods-producing sectors, agriculture is relatively capital-intensive, while manufacturing is labour-intensive. Protection raises a sector's output and induces a relative price increase in the factor used intensively in this sector. Protecting manufacturing negatively affects the R&D sector by bidding up the wage rate; the opposite is true for agriculture. The effects of trade on growth turn out to be small. One reason for this result could be that this model does not take into account international knowledge spillovers. Van Meijl and van Tongeren (1998, 1999) investigated the impact of international knowledge spillovers in agriculture on production in a multi-sectoral, multi-region applied general equilibrium model, but did not focus on growth issues. Technological change in the innovating country is exogenous. The question in their paper is how this technological change is transmitted to other countries. They assumed that knowledge is 'embodied' in traded intermediate inputs, such as chemicals and machinery, which increase the productivity in the primary agricultural sector. Enhanced chemicals lead to land-saving technical change while improved machinery induces labour-saving technical change. The amount of knowledge transmitted depends on the volume of trade flows between the innovating and receiving country. The impact of foreign knowledge depends on the absorptive capacity (human capital) of the receiving country and the similarity of production structures (land/labour ratios) between countries. If knowledge is embodied in traded commodities, protective measures preclude countries not only from enjoying cheaper imports but also from using foreign technologies. The potential gains from trade liberalisation under embodied technology spillovers are illustrated by reducing Chinese import barriers against North American chemical or machinery exports as a case study. It is shown that negative welfare effects of unilateral trade liberalisation (mainly due to terms-of-trade effects under the Armington product differentiation assumption) may be more than compensated for by the productivity advantages, which are achieved in the Chinese grain sector. This holds especially in the case of chemical innovations, which improve the productivity of land, the relatively scarce production factor in China: lower import barriers on enhanced chemicals from the United States induce more chemical imports and a higher use of these inputs in the production of grain.

5. Conclusion

The landscape of agricultural trade is changing. An examination of trade trends indicates that processed agricultural and manufactured food products and other high-value products are gaining in importance at the expense of basic, bulky agricultural products. Furthermore, trade is increasingly of an intra-industry nature. These observations point to the increasing importance of elements of the new trade and growth theories, such as market imperfections, product differentiation, increasing economies of scale and innovation. Recent empirical evidence shows that theoretical developments in the new trade theories, and to a lesser extent the new growth theories, are of significant practical importance for agricultural trade analysis and that trade policy with imperfect competition is not confined to theoretical abstraction.

This does not mean that traditional trade theories are no longer useful for agricultural trade. First of all, they are helpful in explaining trade in homogeneous goods. Furthermore, the Ricardian model remains relevant when thinking about issues such as the effects of technological progress on the pattern of specialisation and the distribution of gains from trade. The focus on factor endowments in the H–O–S model, which assumes identical technologies across countries, remains relevant when thinking, for example, about income distribution effects. Recent empirical evidence provides support for hybrid trade models that combine ingredients from the Ricardian and Heckscher–Ohlin models. More specifically, when technologies are allowed to differ among countries, empirical evidence supports the factor content theory of trade. However, the main difficulty is that this theory does not explain why technology levels differ across countries. There seems to be a role here for the new trade and growth theories, which focus on the generation of technology differences across countries.

In general, we can say that *technology* as a determinant of trade is becoming increasingly important in both empirical and theoretical work. Technological progress can create comparative advantage. However, to understand the drivers of technological change and the impact of these changes on trade requires more emphasis on the *dynamics* involved. Some analytical concepts have been developed within growth theories, but so far these concepts have rarely been tested empirically. Using these concepts more extensively seems to be a potentially fruitful area for empirical research because what is really needed is a more technology-oriented trade theory incorporating a dynamic perspective.

Along these lines, there is indeed considerable scope for future work. For instance, empirical research should aim to formally test the predictions of these technology-oriented trade and growth theories. This implies further efforts to measure the relation between knowledge creation/innovation and trade, to investigate whether knowledge spillovers are national and/or international, and to endogenise technological change and growth in applied trade and growth models.

With respect to economies of scale and imperfect competition, further empirical research is needed on the measurement and explanation of horizontal and vertical intra-industry trade, the quantification of the influence of imperfect competition on (strategic) trade policy, and the measurement of external economies of scale. With respect to the latter, there are interesting theoretical developments in the so-called 'new economic geography' (Krugman 1991; Krugman and Venables 1995). These theories focus on where economic activity occurs and why. Cumulative processes, involving some form of increasing returns, are crucial elements in explaining geographical concentration. Using the same tools that have been developed in industrial organisation, the new trade theories and the new growth theories have transformed a once inhospitable field into fertile ground for theorists (Fujita, Krugman and Venables 1999). Another interesting area closely linked to international trade is the theory of foreign direct investment (Markusen 1995; Markusen and Venables 1998). Multinationals are becoming increasingly important in agriculture and they affect the pattern of trade. McCorriston (1999) discussed the relation between theories of multinational firms and agricultural trade, but empirical testing in this area also lags behind theoretical development.

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