ESSAYS ON INTERNATIONAL ECONOMICS IN PRESENCE OF ECONOMIES OF SCALE AND MONOPOLISTIC COMPETITION

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To Holy Mother,

Sri Sarada Devi

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Chapter 1

Introduction

1.1 The basic concerns-Smith and Ricardo

Trade theorists, have generally been concerned with three basic questions: Why do countries engage in trade? What is the pattern of trade? and What are the gains from trade? These questions have remained the focal point of inquiry from the times of Adam Smith till the present day. The first two questions inquire, respectively about the causes of trade, and if trade indeed takes place, then about the pattern of specialization of each country in the post trade situation. These are thus questions of positive economics. The third point of inquiry is normative. This is because, gains and losses from trade are generally associated with redistribution of income among the various constituent groups of a nation.

David Ricardo explained that countries trade because of comparative advantage. Each nation produces the good that it can produce at a lower *relative* cost. Comparative advantage refers to the ability of a nation, to produce a particular good or service at a lower relative marginal cost over another (nation). Thus as trade opens up, each nation concentrates its resources for production of the good in which it enjoys comparative advantage. This in turn implies that across the nations consumers can avail the goods produced, at the least prices (these models assume markets to be perfectly

competitive and prices are equated to marginal costs). Thus, classical competitive trade theory sought to explain the pattern of trade with models based on some underlying difference among the nations. In standard Ricardian models, a single factor of production is assumed, and it is the difference of technology, that causes trade. Another standard source of explanation of the phenomenon of international trade is the Heckscher-Ohlin model. Developed by Eli Heckscher and Bertil Ohlin, this model also explains trade via comparative advantage, though positing a different source for it. The source of comparative advantage in this genre of models is the difference in relative factor endowments, and it is predicted that each country would export a good which was intensive in usage of the factor that was relatively abundant in the country.

In recent years, another distinct class of models have emerged that explains the phenomenon of international trade invoking the idea, that trade enables more specialized usage of resources which brings efficiency gains to all the trading countries involved, even though they may be similar in terms of their comparative advantage. This idea actually has its origin in the writings of Adam Smith. Adam Smith explained that in all market exchanges, humans have "propensity to truck, barter and exchange one thing for other" (Wealth of Nations I, ii, 1). Interestingly, he also pointed out that exchange brings about gains from specialization by enhancing the division of labour. He illustrated this point with his famous pin factory example, which showed that the division of labour produces an "increase of the quantity of work which the same number of people are capable of performing" (Wealth of Nations, I.i.5). This Smithian argument has been employed in trade models, that seek to explain international trade among similar nations. The argument is as follows: As a country moves from the autarky situation to a trading equilibrium, it no longer needs to produce all the goods and services for itself, but instead can concentrate its labour (or resources) for the production of goods in which it specializes. This division of labour separates production tasks into a series of related operations. Each worker performs one or a few of perhaps hundreds of tasks necessary to produce something. This process makes it possible to assign different tasks to those

individuals who are able to accomplish them most efficiently (that is, at the lowest cost).

Thus, there have been two distinct tradition of models, that seek to answer the central concerns of trade theory. The idea of Smith explains trade among countries on the basis of gains from specialization, and thus does not require them to be different either in terms of technology or relative factor endowment. Contrarily, models based on comparative advantage speak of trade among dissimilar countries. The difference among the nations, that makes them dissimilar, can stem either from resources or from technology, and gives a definite cost advantage of one nation over the other. This in turn also explains the pattern of specialization when countries engage in trade.

However, it was the models based on differences, that traditionally dominated the literature on international trade. It was in $1970's$, that the Smithian notion of gains from specialization as a source of international trade, started to become employed in building trade models.

1.2 Trade with increasing returns and monopolistic competition

Helpman and Krugman (1985) identify few reasons why the traditional models of trade that bases itself on the notion of comparative advantage, seem inadequate for an explanation of the empirical observations regarding the pattern of trade. Firstly, by and large countries should have been exporting goods, whose factor content reflected their comparative advantage in terms of relative factor endowments. Though this remains valid for the overall net exports of the countries, but it does not hold good for the vast volume of intra-industry trade that takes place among the nations. In case of intra-industry trade (as opposed to the classical notion of inter-industry trade), similar goods are being cross-hauled in trade. Secondly, if difference in comparative advantage is the prime motivation of international trade, then we should expect similar countries en-

gaging in trade, to a much lesser extent than countries that are markedly different in terms of technology, or resource endowment. This however does not corroborate either with the reported casual observations or empirical results. Grubel and Llyod (1975) and Krugman (1994) report that the volume of trade between similar countries is substantially higher than countries that differ in terms of either technology or relative factor endowments. Moreover, the Heckscher-Ohlin model of international trade would predict strong distributional conflicts, where a particular factor (which is intensively used in the exporting sector) gains from trade while the factor (which is intensively used in the import competing sector) loses. However, Helpman and Krugman (1985) argue that this is not a general case. Trade can and does sometimes bring gains to all the factors involved, without any significant reallocation of factors.

In the late $1970's$ and the $1980's$ the focus of investigation in the field of international economics has been to build models to account for these observations. Increasing returns to scale and assumptions of market imperfections have been used extensively to explain these unexplained facets of international trade. *The New trade theory*, as it has come to be popularly known, draws liberally from models of industrial organization, to explain international trade on the basis of increasing returns and monopolistic competition. Incorporation of increasing returns, as discussed, was not purely novel. The Smithian idea that trade brings gains, by allowing a greater degree of specialization, makes it clear that the relationship between trade and scale economies was not unknown. However, the problem was related to the assumption of the market structure. Perfect competition is not consistent with scale economies (See Krugman (1980)). Competitive markets require prices to be equated to marginal costs, but for a producer employing a technology that is characterized by increasing returns, this would entail losses. The standard methodology was to assume scale economies external to the firm but internal to the industry, which was compatible with competitive markets. On the contrary, models of *The New trade theory* closely builds on Dixit-Stiglitz (1977) model of monopolistic competition, where each firm has to incur fixed costs to start production. Presence of fixed cost implies that

there are scale economies (internal to the firm) in production, and agents are assumed to have a strong love for variety. Thus no two firms would be producing the same brand, and in equilibrium would be producing a unique variety. Trade in such a set-up, brings about gains to the residents of a country by making available a larger variety of goods for consumption as compared to autarky (where agents are constrained to consume only domestic brands). Moreover, by selling to a larger market, the firms can lower their average costs and take greater benefits from the scale economies as compared to the autarky situation.

Krugman (1979) uses these ideas to develop a model that can explain the phenomenon of intra-industry trade. Increasing returns to scale imply that it is efficient to concentrate production in a single location. Product differentiation would mean that consumers would potentially demand all goods. In this way, the model allows for differentiated brands in the same industry. Identical countries thus engage in trade to derive benefits of scale economies by specializing in production. Importantly, the notion of comparative advantage is not invoked to explain trade.

Krugman (1981), shows that as countries become more and more similar in the factor proportion sense, trade between them increasingly has an intra-industry nature. Moreover, if intra-industry trade is sufficiently dominant, then opening up to trade brings large gains in terms of increased variety. This may outweigh the distributional conflicts which also follow as a consequence of interindustry trade, and benefit both the abundant and the scarce factor (See Krugman (1981)). Ethier (1982) uses the notion of division of labour envisaged by Adam Smith. There are gains in terms of productivity when production is broken down into smaller and smaller specialized activities. The gain in productivity gets translated into a higher output. All these specialized processes are alternatively identified as intermediate goods and production of these are subject to increasing returns to scale (IRS). Thus, trade in intermediate goods is gainful. Ethier (1982) further demonstrates that the basic theorems of neo - classical general equilibrium trade theory holds good, with some modifications, when trade is characterized by mo-

nopolistic competition and increasing returns. If scale economies are not too strong, then the Stolper-Samuelson theorem and Rybczynski theorem remain valid in this set-up.

Krugman and Venables (1990) and Krugman (1991) employ models of monopolistic competition and increasing returns to explain the endogenous emergence of a core-periphery pattern of agglomeration of industry. In these models of *Economic Geography*, trade is subject to transportation costs. Thus it is desirable for the firms to locate its production in a country with a larger market size. Fixed costs further imply that firms would locate only in one point. This is known as the "home market effect" in the literature. The only way a country with a smaller size can attract firms is by offering a lower wage in the equilibrium. Thus presence of scale economies means that a country with a larger size has higher wages. In Markusen (1981) and Markusen and Melvin (1981) a country with a larger size is the net exporter of all goods subject to scale economies.

Introduction of increasing returns and monopolistic competition also have implications for the trade policies pursued by the countries. In an interesting contribution Gros (1987) shows that the optimal tariff for a small country is positive. This is in stark contrast with competitive models of trade, where imposition of tariff by a small country brings about no improvement in terms of trade but expands the import competing (inefficient) sector. In Gros (1987) varieties that are produced in a particular country are produced nowhere else (since there is fixed costs), and thus even a country with a small market share has some monopoly power in the international markets. This allows for possibility of optimal tariff to be positive. Flam and Helpman (1987) argue that imposition of tariff, even if it does not bring about any improvement in terms of trade can increase welfare by causing the domestically under-produced sector to expand. Since there is increasing returns in production, expansion of this sector lowers its average cost of production and brings about welfare gain. Venables (1982), Francois (1992) and Lovely (1997) are other important contributions, that investigate trade policies in context of trade in presence of scale economies and monopolistic competition.

A large number of contributions deal with heterogeneity in productivity, size and

other characteristics of firms within the same industry, using Krugman's (1980) model of product differentiation and trade. Bernard and Jensen (1999) show that this heterogeneity is related to trade participation. Within the same industry, exporting firms are relatively larger in size, more productive and pay higher wages compared to firms which only cater to the domestic markets. Melitz (2003) incorporates a model of industry equilibrium with heterogeneous firm productivity (as in Jovanovic and Rob (1983)), with a model of trade based on love for variety and increasing returns to scale as in Krugman (1980). He develops a model that exhibits firm heterogeneity, steady state entry and exit of firms with steady state job creation and destruction. Due to presence of fixed export costs, and for sufficiently large fixed and variable costs only some firms export. Moreover the firms that export are relatively larger in size. Bernard et al. (2007) discusses the implications of Melitz model for the Factor Price Equalization, Stolper-Samuelson, Rybczynski theorems using an integrated equilibrium approach. Melitz and Ottaviano (2008) model firm heterogeneity, with quasi-linear preferences between a homogeneous and differentiated good and quadratic preferences across varieties within the differentiated sector. Thus the difference between the prices charged and the marginal costs of the firms may vary endogenously with firm productivity, market size and trade integration. Opening up to trade brings welfare gains through lower average prices. It is further shown that unilateral, multilateral and preferential trade liberalisation have distinct effects on welfare, because they have different effects on the entry and production decisions of the firms in the variety sector. Other important contributions are by Chaney (2008) and Arkolakis et al. (2008). Chaney (2008), discusses the relationship between trade volume among nations, and their size and mutual distance (often termed as the "Gravity model") in a model of heterogeneous firms with a Pareto productivity distribution and a fixed measure of varieties. Arkolakis et al. (2008) extends this analysis when there is free entry of firms.

Antras (2003) develops an incomplete contract property rights model of multinational corporations (MNCs) which is then embedded into a model of product differentiation and

IRS. It is shown that firms with higher capital-labour ratio tend to carry out transactions within the boundaries of the MNCs.

An alternative view, that explains why similar countries trade among themselves does not invoke the concept of "love for variety". Instead it is argued, that differences in comparative advantages among nations stems from the fact that factors of production are not completely mobile across countries. Some of these inputs may have world markets, and thus the production patterns in international trade could reflect absolute advantage as the determinant of international trade in these cases. Jones and Kierzkowski (1990) discusses the concept of service link cost i.e. costs of trading various component goods which are used for the production of a final consumption good. They argue that recently, there has been a substantial reduction of trading costs for these intermediary goods, and thus the number of such items involved in the production of the final good that could be transacted through international trade, has increased a lot. In other words, the constraint that inputs in production are produced and traded only within the country gets relaxed. The average costs of producing a final commodity gets reduced, as greater use is made of spreading production of component parts among many countries. These component parts thus enable factors of production, in an indirect fashion to become tradeable. Comparative advantage, continues to explain the pattern of trade, though trade now consists of a longer list of items than if only final goods were traded. Instead of explaining (as discussed in the previous paragraphs) intra-industry trade in terms of love for variety for consumers, Jones and Kierzkowski (1990) argues that intra-industry trade occurs because producers of various component goods, situated across boundaries of different countries, trade their outputs to produce a final consumer good.

1.3 Capital inflow and tariffs

A much debated issue in the literature of international economics, has been the normative implications of factor mobility in presence of trade. Bhagwati (1958) shows that if

growth is biased towards export sector, then the first round welfare gains from growth can be outweighed by an adverse movement in terms of trade for a large country. In a seminal contribution by Johnson (1967), it is demonstrated that growth may be welfare immiserizing for a small open economy when growth is skewed in favour of the tariff protected sector. In Brecher and Diaz-Alejandro (1977) capital inflow into an economy with a tariff protected capital intensive import competing sector is unambiguously welfare immiserizing, when rental income on foreign capital operating in the domestic economy is fully repatriated back to the foreign country. This is because a capital inflow, expands the tariff protected capital intensive import competing sector, which in turn crowds out cheaper available imports. In contrast to these immiserizing results, Grinols (1991) identifies situations when inflow of foreign capital can bring welfare gains to the domestic economy, when there exists an informal sector in the home economy. Chandra and Khan (1993) discusses the implications of factor mobility in an Heckscher-Ohlin set up. The welfare consequences of capital mobility is also analysed by Kemp (1962, 1966) and Jones (1967) when the home country imposes taxes and tariffs. In resolving an apparent paradox in Kemp (1966), Jones (1967) shows that in a two country, two commodity world with goods ranked intensity wise, it can possibly turn out that the optimal commodity import tariff is negative. This is so because a tariff that improves the terms of trade, that is to say reduces the relative international price of importables of the tariff imposing country, will reduce the rental rates of capital abroad if the importables of tariff imposing country is capital intensive. This can potentially lower the welfare of the tariff imposing country, if the country is also a net exporter of capital. Jones (1984) discusses the welfare consequences for a country that has a binding tariff, and is a price taker on world markets while capital is internationally mobile. He shows that in a world characterized by free trade and mobile capital, a small increase in the tariff rate by a small country (a price taker in the world market) would unambiguously reduce welfare.

All these models are based on the assumption of constant returns to scale (CRS)

technology and perfect competition. Sen et al. (1997) builds a model of product differentiation and monopolistic competition and show that capital inflow in presence of tariff protected import competing sector and full repatriation of foreign capital income can be *conditionally* welfare enhancing. This is because capital inflow increases the number of varieties and thus welfare. However, even in this model, the import competing sector expands crowding out cheaper imports, which in turn becomes a potential source of loss of welfare. Chakraborty (2001) also shows that inflow of foreign capital can be welfare enhancing. Interestingly, it is shown that growth caused by an inflow of foreign capital might not crowd out cheaper imports. In this model a final good is produced using labour and intermediate inputs available both domestically and imported. Capital inflow leads to an increase in the number of varieties and thus leads to productivity gains. If this productivity gain is sufficiently strong, the demand for the imported intermediate inputs would rise simultaneously.

Chapter-2 of this thesis builds on Sen et al. (1997) and Chakraborty (2001). It builds a model where capital inflow into a tariff protected sector leads to an unconditional rise in the import volume of the economy. There are two variety producing domestic sectors and production of varieties in each sector involves fixed costs in production and all markets exhibit monopolistic competition. Brands are also imported from the foreign country. An inflow of foreign capital into the protected import competing sector increases the number of varieties produced by that sector. It is shown that the prices of the import competing brands shoot up. Consumers substitute their consumption of domestic brands, by relatively cheaper imported brands and thus import volume rises in the economy. Unlike Marjit and Beladi (1996) and Chakraborty (2001) there is an unconditional rise in the importables. As import volume rises, this in turn means a higher tariff revenue. The net effect on welfare is ambiguous. This is because per brand output of the import competing sector falls. Interestingly, it is shown that under reasonable parametrization, both the import competing sector and the import volume expands simultaneously and there is unambiguous gain in welfare.

1.4 Metzler Paradox and Home market effect

Helpman and Krugman (1985) argues that presence of increasing returns and transportation costs would imply that firms choose its location in a place where most of its output is consumed. This behaviour of firms has become popular in the literature as *home market effect*. Helpman and Krugman (1989) build up a variant of the model that is developed by Venables (1987) and associates home market effect with price lowering effect of tariffs. In the genre of competitive trade theory, price lowering effect of tariffs is known as Metzler paradox (due to Metzler (1949)). The mechanism in Helpman and Krugman (1989) [1] is however novel, and different from what drives the result in Metzler (1949).

They consider an economy in which there are two sectors. A differentiated goods sector using increasing returns to scale technology and a homogeneous good sector, with a constant returns to scale technology. Labour is the only factor of production. The homogeneous good can be traded costlessly, while trade in differentiated products is subject to transportation costs. In this setting, the home country is assumed to impose an ad valorem tariff unilaterally on the differentiated goods sector. There are two implications of this trade policy. Firms relocate themselves from foreign country to the home country (home market effects) and thus the relatively cheaper varieties (home produced varieties are cheaper to the domestic consumers vis-a-vis the foreign varieties, which are subject to transport cost) produced in home rises. This tends to reduce the aggregate price index. On the other hand, imposition of tariff on the foreign varieties makes them relatively dearer to home consumers. This in turn tends to raise the aggregate price index. The first effect dominates the second and thus imposition of tariff actually lowers the price index faced by home consumers. Davis (1998) discusses the crucial role of transportation costs when both the homogeneous and the differentiated good is traded. Krugman and Venables (1990) had argued that when trade in differenti-

[1] Also see Krugman and Venables (1995).

ated goods is subject to transportation costs, the larger country would have a relatively larger differentiated goods sector and the smaller nation would be relatively specialised in the homogeneous good. Davis (1998) points out that once transportation costs are present in both the industries, the differentiated goods sector is distributed across the nations in proportion to their labour force and the homogeneous good is non traded in the equilibrium. Head et al. (2002) analyse three different models featuring increasing returns, firm mobility, and trade costs to assess the robustness of home market effect to alternative modelling assumptions. Crozet and Trionfetti (2008), also discusses home market effect in the context of global agglomeration of the differentiated goods sector vis-a-vis the labour allocation across countries.

In Chapter-3 of this thesis, I investigate how the results of Helpman and Krugman (1989) would be affected when there is a non - traded good and capital is internationally mobile. The analysis is carried out in two alternative models. In the first model, both the differentiated and the homogeneous good is traded. Capital is required to start production of each variety while each additional unit of variety is produced using labour. It is shown that imposition of tariff increases the number of home produced varieties (tariffs attract internationally mobile capital) and thus become a channel of welfare gain. Moreover, the aggregate price index falls. The second model introduces a non traded homogeneous good. The situation becomes more nuanced in this case. A homogeneous non - traded good, along with the mobile capital, makes the effect of tariffs on the price index ambiguous. Also, there can be a Metzler Paradox like situation in terms of quantities. This is because the number of varieties produced by the import competing sector can actually fall and the import competing sector may contract. Thus tariffs may not be able to protect the import competing sector. Davis (1998), Head et al. (2002) and Crozet and Trionfetti (2008) do not discuss the implications of their assumptions on the price depressing effect of tariffs. Thus Chapter - 3 of this thesis also relates to, and supplements these models, by exploring the consequences of having the homogeneous good non-traded.

1.5 Trade and public goods

Public goods are goods that are characterised by non-rivalry in consumption. Public goods are a source of market failure, since efficient allocation of a public good requires the sum of the marginal rates of substitution of the consumers be equated to the marginal rate of transformation of the economy. There have been a substantial research dealing with the the effect of increase in population on the voluntary contribution of the public good. In a seminal contribution by Oslon (1965) it was shown that with increase in the population, provision of public good becomes increasingly difficult through voluntary contribution. Chamberlin (1974) and McGuire (1974), demonstrate that the contribution made by the agents for the provisioning of the public good, is always bounded in a competitive market. In Cornes and Sandler (1989), two goods, one public and another private, are produced with labour. Increase in the labour endowment of each individual increases the contribution made by him to the public good. In the two commodity model developed by Vicary (2004), the effect of an increase of the group size depends on the relative factor intensities of the public and private good produced in the economy.

Similar investigations have been recently carried out in the framework of monopolistic competition, increasing returns and love for variety. Pecorino (2009) builds a model, where labour is allocated between the production of a homogeneous public good and a differentiated private good. Growth of the labour force, causes the variety producing sector to expand and thus the aggregate expenditure on the variety sector rises, as also the marginal utility of the differentiated goods. As a result the aggregate contribution made to the public good falls. Mondal (2013), builds a model where marginal utility of income is inversely related to the aggregate expenditure on the variety sector and thus reverses the result of Pecorino (2009). Pecorino (2013) discusses the implications of these results when there are by-product firms in the economy.

Hatzipanayotou et al. (2011) build a perfectly competitive general-equilibrium model of a small open economy with production of private traded goods and of a public good

which is financed by revenues from trade and domestic taxes. Within this framework they consider the effects of tax reforms on public good provision and on aggregate welfare. However, the literature does not discuss the implications of trade policy in the context of trade, driven by scale economies and monopolistic competition. In chapter 4 of this thesis, I investigate the effects of tariffs in such a set up. To make the analysis simple it is assumed that economy concerned is a small open economy as in Venables (1982) and Sen et al. (1997). There is trade in differentiated products and agents also voluntarily contribute for the provisioning of a public good. Imposition of tariffs, around the free trade equilibrium, increases the voluntary contribution to the public good. Consequently, the volume of public good rises and in the process draws labour from the differentiated sector. The import competing sector contracts and tariffs fail to protect. Thus we have a situation resembling Metzler Paradox, though in terms of quantity.

1.6 Trade and unemployment

Several contributions in trade theory have tried to explain the link between international trade and unemployment. Hoon (1991) embeds the Shapiro and Stiglitz (1984) model of unemployment into a Heckscher Ohlin model of trade and shows that unemployment rises for the capital abundant country but falls for the labour abundant country. Hoon (2001) develops a dynamic Ricardian model of the world economy exhibiting unemployment. In such a set up trade brings gains in terms of employment for both the countries. Matusz (1996) embeds a model of monopolistic competition into a model of unemployment based on shirking behaviour of labourers. Trade increases the number of available varieties and thus increases the real wage. Thus the opportunity cost of unemployment rises (the no shirking condition is relaxed) and thus unemployment falls in both countries due to trade. Helpman and Itskhoki (2010) explores the relationship between trade, unemployment and firm heterogeneity. They discuss the reallocation of resources among the different

sectors due to international trade when the labour market is characterised by search based unemployment. In a related contribution, Felbermayr et al. (2008) discusses the role of productivity gains from trade liberalisation in reducing effective search costs.

In all these models trade always reduces unemployment in at least one country. Chapter-5 of this thesis builds a model where trade can increase unemployment in both countries engaged in trade. It is assumed that fixed costs are falling in the total number of available varieties. Wages are offered by firms on efficiency considerations. As trade opens up, labour required to start production falls and efficiency wage consideration requires that wage remains rigid. Thus total labour demand in each nation falls, without bidding down the wages. If it is assumed that two identical nations engage in mutual trade with sufficiently large labour supply, then unemployment would rise in both countries unambiguously. Moreover, it is shown that the total number of varieties in the world economy after trade is equal to the number of varieties produced by each country individually in autarky. Thus trade reduces the number of varieties produced globally.

1.7 Innovation and labour mobility

A significant part of literature in recent day international economics has been engaged in studying the relation between endogenous growth and trade theory. Grossman and Helpman (1992) develop models of economic growth in terms of expansion in number of available varieties or improvement in quality. Technological progress leads to the introduction of new varieties (or improvement in quality) and this rate of innovation is the growth rate of the economy. They also show how this process of innovation of new varieties, gets enhanced when there is spillover effects of knowledge capital, along with trade in product market, and thus the growth rate of the economy increases.

A related issue is the tendency of countries, identified as the "South" (in contrast to innovating "North") to imitate the innovated products. The developed countries have thus often demanded stronger intellectual property rights (IPR), to protect their

markets from relatively cheaper Southern imitated products. The agreement on Trade Related Intellectual Property Rights (TRIPS) under GATT -1994 requires that developing nations should impose stronger intellectual property rights in their countries. An enormous literature have developed dealing with the issue of intellectual property rights and its welfare consequences. Important contributions have been by Helpman (1993), and Lai (1998). Ludenborg and Segerstrom (2002) discusses labour mobility in a model of quality ladder and growth.

Chapter-6 of this thesis introduces labour mobility in a standard Grossman and Helpman (1992) model of product variety. There are two kinds of factors in the economy, a mobile factor (designated as the skilled labour) which is used for innovation in the North and imitation in South and a country specific immobile factor (designated as the unskilled labour) used for production in each country. Two steady state equilibra are identified - the wide gap equilibrium (where the cost advantage enjoyed by Southern producers are high enough so that they can charge monopoly price) and a narrow gap equilibrium (where the southern producers cannot charge their monopoly price). This model has several interesting features. Firstly, the growth rate of the world economy is same in both the regimes. Unlike standard models of this genre, it is shown that, wide gap steady state equilibrium is not unique. However, one of them is unstable. Moreover, subsidies by either governments have no effect on growth rate in this model. This is important because governments often subsidize the innovating sector to enhance the growth rate of the economy. Interestingly, imposition of subsidy by the North in a narrow gap equilibrium has no effect on the rate of imitation though in the wide gap equilibrium it increases the rate of imitation.

1.8 Plan of the thesis

This thesis has six chapters. Chapter-2 discusses the effects of capital inflow into a tariff protected economy. Capital inflow is considered to be welfare immiserizing, when

the capital intensive import competing sector is tariff protected and earnings of foreign capital are fully repatriated back to the source country. In such models, as the import competing sector expands it crowds out cheaper imports in the process. The present model incorporates features of monopolistic competition and increasing returns to scale and shows that capital inflow might lead to an unconditional rise in the import volume of the economy. This occurs as the price of the import competing brands increase and thus consumers demand more of the internationally available cheaper importables.

In models of monopolistic competition with a single factor of production, imposition of tariff can lead (paradoxically) to a drop in the aggregate price index of the import competing sector. The model in Chapter-3 first introduces an internationally mobile capital in such a set up. It is found that tariff invites capital inflow into the protected sector, which results in a reduction of the price index. Interestingly, the tariff protected import competing sector may not expand, and thus the tariff may fail to protect the import competing sector. However, if there is a homogeneous non-traded good, along with the mobile capital, effect on the price index of the import competing sector becomes ambiguous. Further, the number of varieties produced by the import competing sector can actually fall and the import competing sector may actually contract.

Chapter-4 of this thesis develops a model of small open economy with trade in differentiated goods along with private provisioning of the public good. It is found that around the free trade equilibrium, tariffs may fail to protect the import competing sector. This is because an increase in tariff revenue, which is rebated back to the consumers, increases their voluntary contribution for the public good. Resources are thus drawn away from the variety producing sector to the public goods sector causing it to contract.

Opening up to trade is generally believed to bring gains in terms of employment, for at least one of the trading partners as compared to the autarky situation. The model in Chapter-5 embeds a model of monopolistic competition into an efficiency wage model of unemployment. An increment in the number of varieties makes workers more efficient. As trade opens up between identical nations, labour demand falls but wage

rate remains rigid due to efficiency considerations. Thus, unemployment level may rise for both trading partners.

Chapter-6 introduces labour mobility in an otherwise standard model of innovation and imitation. As in Grossman and Helpman (1992) a wide gap and a narrow gap steady state equilibrium is characterized. It is shown that there can be multiplicity of equilibrium in the wide gap case. Interestingly, free labour mobility causes the growth rate to be identical for both the wide gap and the narrow gap case. Also subsidy by North to innovation, in a narrow gap equilibrium, has no effect on the rate of imitation or on the global growth rate. Subsidy by the Southern government raises the rate of imitation in the wide gape equilibrium, but has no effect on the growth rate. In case, the equilibrium is Narrow gap equilibrium, subsidy cannot affect the rate of imitation also.

Chapter 2

Capital inflow, import volume and immiserizing growth

2.1 Introduction

The [1] welfare consequences of capital inflow into a protected import competing sector have been an issue of a long theoretical debate in the literature of international trade. As Sen et al (1997) observes, this interest was mainly motivated by the policies of the developing nations after the Second World War. These newly independent nations faced a severe scarcity of capital and thus invited foreign capital to meet up the deficiency. Capital inflow occurred mainly into the capital intensive industrial goods sectors which were also the import competing sectors of these economies. Simultaneously, these nations followed a policy of import substitution mainly by imposing a tariff on the imports of industrial goods. Athukorala and Rajapatirana (2003) shows in the post Second World war there has been two major episodes of capital inflow surges to developing countries. The first was during the petro dollar recycling process following oil price increases in the 1970's. It ended with the debt crisis in 1982, associated with Mexican debt moratium.

[1] This chapter is based on Biswas (2013).

The second episode began in the latter half of 1980's till the early 1990's. Malaysia absorbed capital inflows worth 10% of GDP in 1991, 15% in 1992, and more than 20% in 1993. The average annual inflows to Thailand and Phillipines exceeded 10% of GDP in this period. As noted above almost all these developed countries have consistently maintained high tariff rates on their imports. China, even in the 1990's, had a high average tariff rate of about 30%, whereas Vietnam has continued to maintained high tariffs from the mid 1980's (see Chang (2005)). Tariffs have been used by the developing countries not only for protecting their import competing industries, but also to generate high tariff revenue. Chang (2005) shows that the share of total tax revenue attributed to tariffs were as high as 33.7% for Congo DR, 44% for Dominican Republic, 24.1% for India, 54.7% for Swaziland, 50.3% for Uganda as in 2001. In the 1980's protectionist trade policy was quite strong even in the developed countries. As Wong (1997) shows, in the late 1980 s there was a huge inflow of foreign capital, mainly in the automobile industry in USA. In presence of VER Japanese automakers continued to invest in the USA. It started with the investment of Honda (1978), followed by Mazda (1987), Toyota (1988), Fuji Heavy Industries (1989), and Isuzu (1989). Thus a natural curiosity emerged about the welfare implications of changes in factor endowments, under such conditions in the field of international trade.

Bhagwati (1958), had shown that if growth is heavily export biased then the country may actually find its terms of trade moving against it, and in some situations this may outweigh the primary round of welfare gains from growth. This phenomenon has been known as immiserizing growth in the literature of international economics. Immiserizing growth is said to occur when economic growth may actually make the country worse off than before (that is as compared to the pre-growth situation). The possibility of immiserisation shown by Bhagwati (1958) remains valid for a large country that can influence the world prices. Johnson (1967), demonstrated that in case of a small competitive economy factor accumulation may lead to loss of welfare in presence of distortionary tariffs. In both these cases immiserizing growth involves some kind of suboptimality.

A country experiences immiserizing growth only if the growth process occurs subject to some distortion. When growth takes place this distortion may lead to an increased loss as compared to the optimal post growth situation. In Bhagwati (1958) the country has a monopoly power in trade but follows a free trade policy. On the other hand in Johnson (1967) the optimal policy of the small country was free trade policy, but instead it imposes a tariff. This analysis was followed by the contributions of Tan (1968) and Bertrand and Flatters (1971). In a seminal contribution, Brecher and Diaz-Alejandro (1977), argued that if there was a capital inflow into a tariff protected, import competing capital intensive sector and there was full repatriation of capital income by the foreigners back to their home country, welfare would be reduced unambiguously. The mechanism by which welfare was shown to be falling was, that as the capital inflow occurred, the capital intensive import competing sector expanded via the Rybczynski effect, crowding out internationally available cheaper importables in the process. Tariff revenue thus was reduced and the economy was immiserized.

A large portion of the concerned literature is also devoted to the discussion of these types of immiserization results in the context of Harris-Todaro (1970) model. In such models capital inflow with full repatriation of profit in presence of urban unemployment has been found to be welfare immiserizing unambiguously (as in Khan (1982)) and conditionally immiserizing in presence of specific factors (as in Brecher and Findlay, (1983)). Grinols (1991) presents a number of cases where there is a possibility of welfare gains from foreign capital inflow. This happens if the opportunity costs of the labourers are sufficiently low compared to wages earned by the workers who are employed by the new foreign capital. Chandra and Khan (1993) incorporate these results in an Heckscher-Ohlin framework in presence of informal sector. The generally ambiguous welfare implications of capital inflow in these models resulted because of the presence of more than one kind of imperfections (like distortionary tariffs coupled with factor market distortion). However the usual channel of welfare loss remained open, i.e. the expanding import competing sector crowded out cheaper imports in the process.

Sen et al. (1997) departs from the assumptions of competitive framework and constant returns to scale. In a model of increasing returns to scale and monopolistic competition, they find that capital inflow into the protected sector along with full repatriation, can lead to improvement in welfare. They model the import competing sector as exhibiting product differentiation following Dixit and Stiglitz (1977). Capital inflow increases the number of varieties and hence become a channel of welfare gain in this set up. However even in this model, the tariff protected distorted sector expands and this once again opens up the channel of welfare loss through reduction in cheaper imports. The net effect on welfare depends on which effect is stronger. Matsuyama and Takahashi (1998) also discusses the welfare consequences of factor movement in a model of economic agglomeration. The world economy comprises of two regions east and the west. There exists a non tradeable sector in both region, which supplies differentiated goods. Each region has both an absolute and comparative advantage in production of an unique tradeable good respectively. An initial agglomeration in any one region say East would mean higher number of varieties of the non tradeable service. Thus labour (which is the only factor of production) would move from West to East. This in turn reduces the production of the good in which West specializes. A particular parameterization is obtained for which this may reduce the welfare of the migrating workers in the long run.

Marjit and Beladi (1996) and Chakraborty (2001) show an alternative route via which the welfare consequences of capital inflow into the protected sector may get changed. In these models the volume of imports may actually rise thus closing the channel of welfare loss. Marjit and Beladi (1996) build up their model in a competitive framework. In their model, the protected import competing sector produces an intermediate input (which is also imported) that is used in the production of one of the two final goods. An inflow of foreign capital into the protected sector draws labour out of the production of the final goods. The production of the relatively labour intensive final good expands due to Rybczynski effect. This in turn may translate into a higher demand for imports, provided the demand share of the imported input is sufficiently high in production of

the final good that expands. Chakraborty (2001) builds up a model of monopolistic competition and increasing returns to scale that exhibits a similar result but due to different reason. The economy is assumed to produce a single good, with labour and an array of intermediate inputs that are produced domestically and are also imported. There are gains from specialisation in production, which is directly related to input substitutability. Capital inflow increases the varieties of intermediate inputs and hence there are productivity gains. Productivity gains if sufficiently strong may cause both the import competing sector and the volume of importables to expand simultaneously. Both these models show that under certain conditions the volume of imports and the import competing sector may expand simultaneously and thus the conventional intuition of Brecher and Diaz-Alejandro (1977) can get reversed.

The present model closely builds on Sen et al (1997). The production structure is however different from the two sector model of Sen et al (1997) where, one sector produced a differentiated good and the other a homogeneous one. This model assumes two variety producing domestic sectors whose only difference lies in their technology. Production of varieties in each sector is subject to scale economies (due to presence of fixed costs) and monopolistic competition. Foreign brands also are imported. We consider only one of the domestic sectors to be using foreign capital and model it as the import competing sector. The central result of the paper is that though there is an inflow of foreign capital into the import competing sector, import volume rises unambiguously. The intuition of our result is the following. An extra dose of foreign capital into the protected import competing sector increases the number of varieties produced by that sector. As common in the literature of increasing returns and trade, we assume that this sector is Marshall stable (see Ide and Takayama (1990)). Presence of scale economies and Marshall Stability implies that the prices of the import competing brands shoot up. Consumers switch to higher consumption level of relatively cheaper imported brands and thus import volume rises in the economy. Unlike Marjit and Beladi (1996) and Chakraborty (2001) there is an unconditional rise in the importables. In the

competitive model of Marjit and Beladi (1996) import volumes would rise due to the resource reallocation effect only if the share of imported input is sufficiently high in production of the expanding sector. Import levels rise in Chakraborty (2001) only if productivity gains of an inflow of foreign capital is sufficiently strong. The present result is obtained from an altogether different channel, the rise in imports are a direct outcome of the increased prices of the domestic brands coupled with the substitution possibilities faced by the consumers between the imported brands and domestic brands, and thus is unambiguous. Capital inflow in the present model increases the number of varieties produced by the import competing sector. This gets translated into higher return for labourers in the form of a higher wage rate. As import volume rises in the economy this implies a higher tariff revenue. The only source of welfare loss is that the per brand output of the import competing sector falls and welfare results under general circumstances is thus ambiguous. A particular parametrisation is obtained for which both the import competing sector and the import volume rises in the economy.

The chapter is organised as follows: Section 2.2 builds the model, Section 2.3 discusses the effects of capital flows and finally the last section, 2.4 draws upon the conclusions.

2.2 The model

The consumers:

We consider a hypothetical economy with two domestic sectors. One of them is the non-traded sector U which produces n_u number of different brands. The other is the traded sector S and produces n_s number of different brands. Consumers also consume n_f brands from the foreign.

The representative consumers maximises a utility function as in Dixit and Stiglitz (1977) and hence has a love for variety. The utility function is

$$U = \left(\sum_i C_u^{i\theta} + \sum_i C_s^{i\theta} + \sum_i C_f^{i\theta} \right)^{\frac{1}{\theta}}, \ 0 < \theta < 1. \tag{2.1}$$

Here C_j^i is the consumption of the i th brand of the j th sector and let p_j^i be their corresponding prices. Note, that since all consumers are identical hence one can consider these as the aggregate consumptions of the whole economy. The elasticity of substitution between any two brands is given by $\sigma = 1/(1-\theta)$ which is greater than unity. The equilibrium of our model will be a symmetric one, i.e. all firms in a particular sector will charge the same price and produce the same output across all brands. Hence the superscripts are dropped to indicate the symmetry across the varieties. As in Sen et al. (1997) and Venables (1982) we assume that the economy is small and hence the number of foreign brands n_f and the price of the foreign brands p_f^* are exogenously given to the economy. Clearly from the point of view of the consumers all varieties of the domestic and foreign sector enter the utility function symmetrically. Balanced trade, as we will assume, would imply exports in value terms must equal to the value of the imports. Thus the non-traded sector is considered to be the import competing sector in this model. The S sector is the exporting sector in the economy.

The first order condition of utility maximisation will be given by

$$\frac{C_u}{C_f} = (\frac{p_u}{p_f})^{-\sigma}. \tag{2.2}$$

As it is clear from equation (2.2) consumers can always substitute the importables with the brands from the non-trading sector. The economy is tariff ridden. The domestic price of the importables faced by the consumers p_f is above the world price of the importables. That is $p_f = p_f^*(1+t)$ where t is the tariff rate. We assume that entire capital is owned by foreign residents. All returns to capital is repatriated by the foreigners back to their country and the tariff revenue is rebated back to domestic consumers. This is in keeping with the Brecher and Diaz - Alejandro (1977) assumption. The national income is given by

$$I = wL + tn_f p_f^* C_f \tag{2.3}$$

where I is the national income, w is the wage rate of the economy, L is the aggregate labour and C_f is the per brand demand for imports.

Finally we can write the demand functions for the different varieties:

$$C_f = \frac{p_f^{-\sigma}(wL + tn_f p_f^* C_f)}{(n_u p_u^{1-\sigma} + n_s p_s^{1-\sigma} + n_f p_f^{1-\sigma})} \tag{2.4}$$

$$C_u = \frac{p_u^{-\sigma}(wL + tn_f p_f^* C_f)}{(n_u p_u^{1-\sigma} + n_s p_s^{1-\sigma} + n_f p_f^{1-\sigma})} \tag{2.5}$$

$$C_s = \frac{p_s^{-\sigma}(wL + tn_f p_f^* C_f)}{(n_u p_u^{1-\sigma} + n_s p_s^{1-\sigma} + n_f p_f^{1-\sigma})}. \tag{2.6}$$

The producers:

The U and the S sector differs in their usage of technology. Capital is the only component of fixed cost in the U sector and the rent earned by capital is r. We choose units in such a way that one unit of foreign capital is required to begin production in U sector. Moreover, the per unit production of each brand of the non-trading sector require β units of labour. Production is thus subject to increasing returns to scale (due to presence of fixed costs) and all markets are monopolistically competitive. Profit maximisation for each brand implies that producers in the U sector would equate marginal revenue with marginal cost

$$p_u(1 - \frac{1}{\sigma}) = \beta w \tag{2.7}$$

where p_u is the price of the import competing brands. Hence

$$p_u = \frac{\beta w}{\theta}. \tag{2.8}$$

Equation (2.8) implies that prices are a constant mark up over the marginal cost. The Chamberlinian set up of this model ensures that free entry into differentiated goods sector drives supernormal profits down to zero. This in turn would imply that for each firm the surplus would be equal to the fixed cost of production. x_u represents the firm output. So

$$\frac{p_u x_u}{\sigma} = (1)r. \tag{2.9}$$

The return to capital is taken to be unity, as capital is chosen to be the numeraire in this model [2]. Thus the per firm output can be solved from using equation (2.9) and is given by

$$x_u = \frac{\theta}{\beta w(1-\theta)}. \tag{2.10}$$

Production in the S sector requires α^* units of labour to begin production and β^* units of labour are required for each additional unit of output. x_s represents each firms output of this sector. Profit maximisation by the producers would imply that

$$p_s(1-\frac{1}{\sigma}) = \beta^* w. \tag{2.11}$$

Hence,

$$p_s = \frac{\beta^* w}{\theta}. \tag{2.12}$$

We assume that free entry in the S sector drives profits down to zero. Thus

$$\frac{p_s x_s}{\sigma} = \alpha^* w \tag{2.13}$$

which in turn would imply that

$$x_s = \frac{\alpha^* \theta}{\beta^*(1-\theta)}. \tag{2.14}$$

Note that the per firm output in the U sector is falling in wages, while the per firm output in the S sector is a constant. Any increase (decrease) in the wage rate implies that per brand output of the non traded sector declines (increases).

Factor markets: The labour market clears by equating the total demand equal to the total supply (L)

$$n_u \beta x_u + n_s(\alpha^* + \beta^* x_s) = L. \tag{2.15}$$

The number of brands in the U sector is equal to the units of foreign capital employed i.e.

$$n_u = K \tag{2.16}$$

[2] We could have alternatively chosen $p_u = 1$. However, as we would require to discuss the stability of the market for the import competing brands p_u is kept free to adjust.

where K is the total foreign capital employed. The labour market clearing condition (2.15) along with the demand relations (2.4), (2.5), (2.6) determine the wage rate in the equilibrium.

2.3 Capital Inflow

We want to study the effect of an inflow of foreign capital on our hypothetical economy. We use the following notation. For any arbitrary variable, s,

$$\hat{s} \equiv \frac{ds}{s}.$$

Clearly since one unit of foreign capital is required to produce each new brand of the U sector so n_u would increase. That is we have $\hat{n_u} = \hat{K}$. However whether the import competing sector expands or not would also depend on the per brand output which again depends on the wage rate. To solve for the effect of an inflow of foreign capital on the wage rate explicitly total differentiation of equation (2.15) and using equation (2.10) yields

$$\lambda_u(\hat{n_u} - \hat{w}) + (1 - \lambda_u)\hat{n_s} = 0,$$

which after rearrangement gives

$$-\lambda_u\hat{w} + (1 - \lambda_u)\hat{n_s} = \lambda_u\hat{K} \tag{2.17}$$

where $\lambda_u = \frac{n_u\beta x_u}{L}$ is the share of total labour allocated in the U sector. Equation (2.17) involves two variables $\hat{w}$ and $\hat{n_s}$. To obtain a solution in terms of change in capital stock, another such equation is required. This is obtained by differentiating the demand function for imports.

Differentiating the demand function for the importables given in equation (2.4) we obtain the following equation.

$$\hat{C_f} = \gamma\hat{w} + (1 - \gamma)\hat{C_f} - s_u[\hat{n_u} + (1 - \sigma)\hat{p_u}] - s_s[\hat{n_s} + (1 - \sigma)\hat{p_s}]$$

where $\gamma = wL/I$ represents the ratio of labour income to total income and $s_u = n_u p_u C_u/I$ and $s_s = n_s p_s C_s/I$ represents the expenditure shares accruing to the U sector and S sector respectively. From the pricing equations (2.8) and (2.12) $\hat{p_u} = \hat{p_s} = \hat{w}$. Combining this with the capital market equilibrium condition (2.16) the change in demand for imports can be expressed as

$$\gamma \hat{C_f} = (\gamma + (\sigma - 1)[s_u + s_s])\hat{w} - s_u \hat{K} - s_s \hat{n_s}. \tag{2.18}$$

Now from the first order condition of utility maximization:

$$\frac{C_f}{C_u} = (\frac{p_f}{p_u})^{-\sigma}. \tag{2.19}$$

Differentiating (2.19) we get

$$\begin{aligned} \hat{C_f} - \hat{C_u} &= -\sigma(\hat{p_f} - \hat{p_u}) \\ \Rightarrow \hat{C_f} &= \sigma \hat{p_u} + \hat{x_u} \\ \Rightarrow \hat{C_f} = \sigma\hat{w} - \hat{w} &= (\sigma - 1)\hat{w}. \end{aligned} \tag{2.20}$$

Substituting equation (2.20) into equation (2.18) we get another equation involving the two variables $\hat{n_s}$ and $\hat{w}$

$$\big(\gamma[\sigma - 2] - (\sigma - 1)(s_u + s_s)\big)\hat{w} + s_s \hat{n_s} = -s_u \hat{K}. \tag{2.21}$$

Equations (2.17) and (2.21) are two equations in the variables $\hat{n_s}$ and $\hat{w}$. Solving for these variables we can express the change in wage rate and the number of varieties produced by the S sector, in terms of change in total capital stock.

$$\hat{w} = \frac{-s_u(1 - \lambda_u) + s_s \lambda_u}{D} \hat{K} \tag{2.22}$$

$$\hat{n_s} = \frac{-\lambda_u[\gamma(\sigma - 2) - (\sigma - 1)(s_u + s_s)] + s_u}{D} \hat{K} \tag{2.23}$$

where

$$D = [\gamma(\sigma - 2) - (\sigma - 1)(s_u + s_s)](1 - \lambda_u) + s_s \lambda_u. \tag{2.24}$$

As common in the literature of scale economies we assume the market of the U sector adjusts according to Marshall's quantity adjustment concept. Marshall stability of the U sector implies that D is negative (see Appendix A.2).
From equation (2.22) we get

$$\frac{\hat{w}}{\hat{K}} = \frac{-s_u(1-\lambda_u) + s_s\lambda_u}{D}. \tag{2.25}$$

Since S is the exporting sector, so domestic consumption must be less than total production. Hence $C_s \leq x_s$

$$C_s \leq \frac{\alpha^*}{\beta^*} + x_s$$

which in turn would mean that $\frac{\beta^* C_s}{C_u} \leq \frac{\alpha^* + \beta^* x_s}{x_u}$
$\Rightarrow \frac{n_s p_s C_s}{n_u p_u C_U} \leq \frac{n_s(\alpha^* + \beta^* x_s)}{n_u \beta x_u}$
$\Rightarrow \frac{s_s}{s_u} \leq \frac{1-\lambda_u}{\lambda_u}$
which after rearranging means $-s_u(1-\lambda_u) + s_s\lambda_u \leq 0$. Thus the effect of capital inflow on the wage rate is given by the following proposition.

Proposition 2.1 *Capital inflow into the non traded import competing sector causes the wage rate to rise in the economy i.e.* $\frac{\hat{w}}{K} > 0$.

Since prices are a mark-up over the wage rate, prices of the import competing brands also rises. The increased price of the domestic brands in both the sectors (which is reflected as higher wages) causes the consumers to switch from the domestic brands to cheaper imports. Thus in the present model the demand for the importables rises unambiguously. This can be seen also from equation (2.20).

It is to be noted that this is in complete contrast to the standard Brecher and Diaz-Alejandro (1977) model where the import competing sector expanded, simultaneously reducing the internationally available cheaper imports. The total output produced by the import competing sector in the model is $n_u x_u$. As wages rise due to the inflow of capital, x_u falls (see equation (2.10)) and n_u rises. The net effect on the non traded sector is ambiguous. From the labour market equilibrium condition given in equation (2.15),

an expanding (contracting) U sector would imply a fall (rise) in the number of varieties produced by the S sector. In the present model since there is no restriction on the change in the number of varieties of the S sector, it may very well be the situation that both the import competing sector and the volume of imports expand simultaneously. From equations (2.8) and (2.10) we have

$$\frac{\hat{x_u}}{\hat{p_u}} = -1. \tag{2.26}$$

We can use equation (2.4) to get the demand curve for the import competing brands (shown in Appendix A.2)

$$\hat{C_u} = \frac{1}{\gamma(1-\lambda_u)}[(\sigma-1)[-\gamma+(s_u+s_s)](1-\lambda_u) - s_s\lambda_u]\hat{p_u} + \frac{\hat{K}}{\gamma(1-\lambda_u)}. \tag{2.27}$$

It can be shown that $\gamma > s_u + s_s$ (See Appendix A.1), which implies that the first term in the RHS is negative. This would in turn mean a negatively sloped demand curve. The second term in the RHS acts as a shift parameter, i.e. it measures the change in demand for the import competing brands when prices are held constant and capital inflow occurs. Trade situation guarantees that this term is negative when $\hat{K} > 0$. The situation is depicted in figure 2.1.

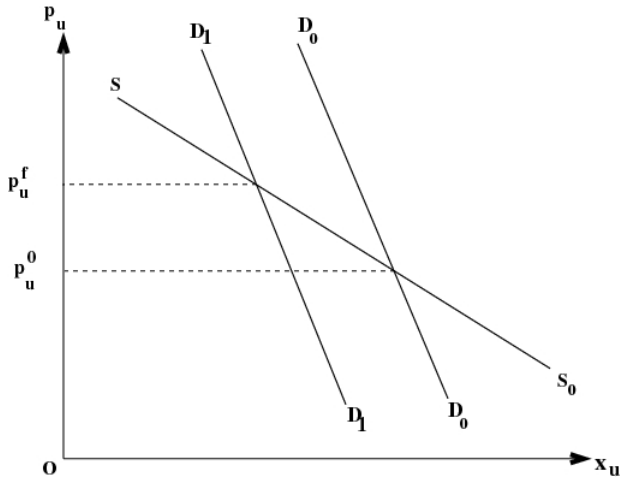

Figure 2.1 Capital inflow into the U sector

Capital inflow causes the demand for x_u to shift from D_0D_0 to D_1D_1 and prices rise (and hence wages). Marshall stability requires that the negatively sloped demand curve is steeper than the negatively sloped supply curve (a negatively sloped supply relation is the manifestation of the scale economies present in the model). It is this stability assumption that causes the price to rise from p_u^0 to p_u^f. Since capital inflow increases the number of brands available to the consumers,the consumers per brand demand falls (as shown in the figure 2.1). This increase in wages itself becomes a channel of welfare gain. Moreover from equation (2.20), the higher wages gets translated into a higher demand for imports.

The increased price of the domestic brands in both the sectors (which is reflected as higher wages) causes the consumers to switch from the domestic brands and substitute by a higher consumption of importables. This result is completely opposite to that exhibited in standard Brecher and Diaz-Alejandro (1977) type models. Thus in the present model the demand for the importables rises unambiguously.

Finally we consider the welfare consequences of capital inflow in our model. The welfare consequences of an inflow of foreign capital are given in the following proposition.

Proposition 2.2 *The welfare of the economy may rise or fall depending upon suitable parameter values. There is one case at least where welfare of the economy rises unambiguously and the import competing sector also expands.*

Proof. The change in welfare is given by:

$$\hat{U} = \Big(- s_u(1-\lambda_u) + s_s\lambda_u \Big) \Big(- \gamma(\sigma-2) + \theta(\sigma-1) \Big) \frac{\hat{K}}{D}. \tag{2.28}$$

(See Appendix A.3 for derivation). Note that the first and the third term is negative for any inflow of foreign capital ($\hat{K} > 0$). However, there is no restriction on the sign of the second term and hence a sufficient condition for welfare to rise in this economy is given by

$$-\gamma(\sigma-2) + \theta(\sigma-1) > 0.$$

We consider a special case when $\sigma \in (1, 2)$. In that case welfare of the economy rises unambiguously even when the import competing sector of the economy expands. To see this fact first note the expression for $\hat{n_s}$ as given in equation (2.23). Clearly $\sigma < 2$ would mean the number of varieties in the S sector falls. This would mean that since there is full employment of labour the U sector of the economy expands. In this special case both demand for importables rises in the economy and also the import competing sector expands simultaneously. Note that such a result is contrary to what one sees in standard Brecher and Diaz- Alejandro (1977) set up. Also in Sen et al. (1997) the import competing sector expanded crowding out the importable. The welfare gain in that model was coming from an increased number of varieties. We find a different channel via which welfare rises. For suitable restriction on σ an inflow of capital not only causes the demand for importables to rise but also the import competing sector expands and there is an additional channel for welfare gain. ■

2.4 Conclusion

Brecher and Diaz-Alejandro in their seminal paper (1977) showed that capital inflow into the capital intensive import competing sector leads to welfare immiserization. This occurs as the import competing sector expands by the Rybczynski effect and the volume of cheaper imports is crowded out. Moreover the lower volume of the imports led to fall in national income as the tariff revenue decreases. The present model forgoes the assumption of competitive markets and constant returns to scale. In our model an increase in the number of varieties of the import competing sector causes the wage rate to rise in the economy. Since all domestic brands have prices which are a mark up above the wage rate, consumers find the domestic brands dearer and switches to cheaper importable and thus contrary to what happens in standard Brecher and Diaz-Alejandro (1977) model import volumes expands. Thus three major channels of welfare gain are identified in this model. Firstly the import volume rises. Secondly the wage rate rises and

hence the national income. Finally the import competing sector may also expand. Hence if one incorporates features of increasing returns to scale and monopolistic competition the standard Brecher and Diaz-Alejandro (1977) result may no longer hold.

2.5 Appendices

2.5.1 Appendix-1

In this section we show that $\gamma > s_u + s_s$.

Proof: Balanced trade implies that total income should be equal to the total expenditure

$$wL + tn_f p_f^* C_f = n_u p_u C_u + n_s p_s C_s + n_f p_f C_f \tag{2.29}$$

$$or, wL = n_u p_u C_u + n_s p_s C_s + n_f p_f^* C_f \tag{2.30}$$

$$\gamma = s_u + s_s + B \tag{2.31}$$

$B > 0$ and hence $\gamma > s_u + s_s$.

2.5.2 Appendix-2

As shown in the main text

$$\hat{C_f} - \hat{C_u} = -\sigma(\hat{p_f} - \hat{p_u}).$$

Substituting equation (2.18) we get

$$\hat{C_u} = 1/\gamma([\gamma + (\sigma - 1)(s_u + s_s)]\hat{w} - s_u\hat{K} - s_s\hat{n_s}) - \sigma\hat{p_u}. \tag{2.32}$$

Now using equations (2.22) and (2.23)

$$\hat{C_u} = \frac{1}{\gamma(1-\lambda_u)}\big((\sigma-1)[-\gamma+s_u+s_s](1-\lambda_u-s_s\lambda_u)\hat{p_u} + \frac{K}{\gamma(1-\lambda_u)}\big(-s_u(1-\lambda_u+s_s\lambda_u)\big). \tag{2.33}$$

In this section we want to study the stability analysis of the market for U goods. Putting $\hat{K} = 0$ in equation (2.33),

$$\frac{\hat{C}_u}{\hat{p}_u} = \frac{1}{\gamma(1-\lambda_u)}\big((\sigma-1)[-\gamma+s_u+s_s](1-\lambda_u-s_s\lambda_u\big). \tag{2.34}$$

We consider in all markets except that of the U sector, output adjusts instantaneously. It is assumed that output in the U market adjusts according to the following output adjustment rule (See Ide and Takayama (1991) and the discussion in Wong (1997))

$$\dot{x_u} = a\left(\frac{p_u^d}{p_u^s} - 1\right). \tag{2.35}$$

Linearizing around the equilibrium value of x_u, stability in the U market requires $R^{'}(x_u) < 0$. Also noting the fact that equation (2.33) gives the change in demand price of the importing brands, the price-quantity adjustment mechanism in the U market requires: $\frac{\hat{p_u^d}}{\hat{x_u}} - \frac{\hat{p_u^s}}{\hat{x_u}} < 0$ (evaluated at equilibrium) where $\hat{p_u^d}$ is the change in demand price and $\hat{p_u^s}$ is the change in the supply price. Using relations (2.33) and (2.26)

$$\begin{aligned} &\gamma(1-\lambda_u) > [\gamma(\sigma-1)-(\sigma-1)(s_u+s_s)](1-\lambda_u)+s_s\lambda_u \\ &\implies [\gamma(\sigma-2)-(\sigma-1)(s_u+s_s)](1-\lambda_u)+s_s\lambda_u < 0 \end{aligned} \tag{2.36}$$

which means $D < 0$.

2.5.3 Appendix 3

Finally the expression for welfare in the economy is derived. Taking logarithms of both sides of (2.1) and differentiating we get

$$\begin{aligned} \theta\hat{U} &= s_u(\hat{n_u}+\theta\hat{C_u}+s_s(\hat{n_s}+\theta\hat{C_s})+s_f(\hat{n_f}+\theta\hat{C_f}) \\ &= s_u\hat{K}+\theta s_u(-\hat{w})+\theta s_f\hat{C_f}+\theta s_s(-\hat{w})+s_s\hat{n_s} \\ &= s_u\hat{K}+\theta\hat{w}(s_f\sigma-1)+s_s\hat{n_s}. \end{aligned} \tag{2.37}$$

Substituting the values of $\hat{w}$ and $\hat{n_s}$ from equations (2.22) and (2.23) into equation (2.37) we get equation (2.28) in the main text.

Chapter 3

Metzler paradox in presence of mobile capital and non traded goods

3.1 Introduction

Traditional trade theory has an extensive literature that deals with the effects of imposition of tariffs. In general, imposition of tariff has two effects, firstly, it improves the terms of trade for the tariff imposing country by lowering the international price of the imports, and secondly, it causes the import competing sector to expand (and thus crowd out cheaper importables). Competitive trade theory identifies a situation where imposition of tariff can lower domestic price of the imports (that is when the first effect dominates the second effect). Better known as the Metzler Paradox (see Metzler (1949)), this can happen when the improvement in terms of trade, for the tariff imposing nation is so large that it actually lowers the domestic price of the output of the import competing sector and thus fails to protect it. Neary (1995) develops a model where capital is used as a specific factor in one of the industries, but is sluggishly mobile across countries. Imposition of tariff, in the short run (that is when capital stocks of the two countries do not respond to price changes), may under certain conditions lead to a Metzler Paradox type effect. A somewhat similar result is shown by Marjit (1993). It is shown that in a

production structure exhibiting both Heckscher-Ohlin and specific factor features (this production structure is similar to that of Gruen and Corden (1970)), uniform tariffs may fail to protect some of the import competing sectors. This is due to the resource allocation between the Heckscher-Ohlin and specific factor production structures. Choi and Yu (1987) incorporates variable returns to scale [1] in a two country, two commodity and two factor general equilibrium model and establishes sufficient conditions, for which tariffs may fail to protect the domestic import competing sector.

All these models are based on the assumptions of perfect competition and/or constant returns to scale. Departing from this tradition, trade in differentiated products have been modelled in the literature of international trade theory by a fairly extensive number of contributors [2]. Helpman and Krugman (1985) argues that increasing returns to scale and transportation costs would mean, the industry would tend to concentrate in a single country where most of its output is consumed so as to take advantage of the scale economies and also to reduce transportation costs. This came to be known as *home market effect* in the literature of international trade.

Helpman and Krugman (1989) build up a variant of the model that is developed by Venables (1987) and associates home market effects with price lowering effect of tariffs. They consider a two country world in which there is both a homogeneous good and a differentiated goods sector, produced by a constant returns to scale technology and increasing returns to scale technology respectively by a single factor of production, namely labour. While the homogeneous good can be traded in a costless manner, there are transportation costs for trading the differentiated goods. The home country imposes an ad valorem tariff unilaterally on the differentiated goods sector. Since the relatively cheaper varieties produced in home rises (the home varieties are cheaper be-

[1] The scale economies in this model are external to the firm and internal to the industry.

[2] Krugman (1979, 1980, 1981), Ethier (1982), Helpman (1981) and Venables (1982, 1987), builds models of intra industry trade where markets are monopolistically competitive, and trade in differentiated products occur due to scale economies and love for variety exhibited by the agents (See Dixit and Stiglitz (1977)).

cause consumers don't have to pay transportation costs for them), this tends to reduce the aggregate price index. On the other hand, imposition of tariff on the foreign varieties makes them dearer and tends to raise the aggregate price index. The first effect dominates and thus imposition of tariff actually lowers the price index faced by home consumers. The strength of the result lies in the fact that such price reducing effect of the tariffs does not remain a mere theoretical curiosum like Metzler Paradox, which requires severe restrictions on the import elasticities.

The present model builds closely on Helpman and Krugman (1989), by introducing an internationally mobile factor (capital) and a non-traded homogeneous good. Two distinct but related issues are addressed in the process. Firstly, the assumption of a traded homogeneous good is retained but only the single factor assumption of Venables (1987) and Helpman and Krugman (1989) is changed. Secondly, we assume the homogeneous good is non traded. The first variant of the model discusses the implications of capital mobility in presence of tariffs. Capital is used to start production of the varieties, while the homogeneous good is produced by labour alone. All goods are traded and capital is fully mobile across nations [3]. This in turn ensures complete factor price equalization between the home country and the foreign country. Even in such a situation home market effect is observed to be operative and the aggregate price index falls. Imposition of tariff by the home country increases the number of varieties produced in Home and this gets manifested as a lower price index in the home economy. Thus, capital inflow is induced by imposition of tariff, (reflected by a rise in the number of home varieties) and it becomes a channel of improvement welfare. However, it is shown that the per-firm output falls. This is in contrast to the model developed by Helpman and Krugman (1989), where it is held constant. Thus though the total number of varieties produced by the import competing sector rises, the total volume of the import competing sector *may* actually contract.

Welfare consequences of factor mobility has been discussed extensively in the literature

[3]Thus capital is "footloose" as in Martin and Rogers (1995).

of international economics. Kemp (1962, 1966) and Jones (1967) discusses the implications of factor mobility in presence of taxes and tariffs. In Johnson (1967) it is shown that factor accumulation may lead to welfare immiserization in presence of distortionary tariffs. Brecher and Diaz-Alejandro (1977) shows that capital inflow into a tariff protected import competing sector, reduces the welfare of the economy unambiguously by crowding out cheaper imports. Other important contributions have been by Tan (1968), Bertrand and Flatters (1971), Khan (1982), Jones (1984) and Grinols (1991). Sen et al. (1997) discusses the issue of factor mobility in a set-up characterized by monopolistic competition and increasing returns to scale. Capital inflow into the differentiated sector increases the number of varieties and becomes a potential source of welfare gain. In our model also, capital inflow raises the number of home produced varieties. This is a potential channel of welfare gain because consumers now pay transportation costs for a lesser number of varieties (as in Helpman and Krugman (1989)). However, imported brands fall, as a larger number of firms relocate their production in the Home country. The possibility that tariffs can cause the import competing sector to contract, implies that tariffs may fail to provide protection to the import competing sector.

In a variant of the same model, it is assumed that the homogeneous good is non-traded, while retaining the assumption of a mobile capital [4]. The non traded good is produced using only labour and a constant returns to scale technology, while the differentiated good requires fixed units of capital to start the production (this accounts for the fixed costs). Production of each additional unit of output requires only labour. Since the non traded good is both produced and consumed within each country, there is no channel through which the wage rates are equalized. Capital is allowed to be fully mobile and this equalizes the rental (the return to capital) across countries (See Kind et al (2000)). Trade in differentiated good is subject to transportation costs. In such a set up, imposition of tariff by the home country may not lead to a drop in the price

[4]Haufler and Pfluger (2003) compares source based taxation and destination based taxation, when markets are monopolisticaly competitive, in a similar model.

index via the home market effect. In general the effect of tariff on the wage rate, the number of varieties produced and the price index for the differentiated good becomes ambiguous. This is because in Helpman and Krugman (1989), when the home country imposes tariff, only thing that adjusts to maintain the equilibrium is the number of varieties produced in each country. However in the present model, the channels through which the adjustment takes place is not only the number of varieties but also the wage rate (which in turn implies that the rental and the per firm output adjusts). Imposition of tariff by the home country, cetiris paribus, increases the tariff revenue. Increase in this tariff revenue positively affects the consumer's income (as we assume that the entire tariff revenue is rebated back to the consumers), whose demand for the non traded good rises pushing up its price in the home country. This in turn causes the wage rate to rise in the economy relative to the foreign wage rate. The difference lies in the assumption of the non traded good. Since labour is the only factor of production that is used in the production of non traded good, wage rate is free to adjust. Interestingly, no unambiguous result can be predicted for the number of varieties produced by the import competing sector. This is important from the view point of trade policy. Imposition of tariff may actually fail to protect the import competing sector not only in terms of price (since the aggregate price index may fall) but also in terms of the varieties produced.

This model is also closely related to Davis (1998). Davis (1998) introduces uniform transportation costs in an identical Helpman and Krugman (1985) model to arrive at the conclusion that manufacturing is spread across countries in proportion to their labour size when the homogeneous good is non traded in the equilibrium. The present model follows Davis (1998) in assuming the existence of trading costs in the homogeneous good, in fact it is assumed that these costs are prohibitive in nature. However, unlike Davis (1998), this model extends the analysis to two factors of production (one of them being mobile internationally), and focusses on the price depressing effects of tariffs. Thus, this chapter can be considered to link the price depressing effects of tariffs with models where the homogeneous good is subject to transportation costs. Head et al. (2002), builds on

Krugman's (1980) model of trade that predicts that the country with the relatively large number of consumers is the net exporter and has a larger share of firms in the increasing returns sector. They consider three models featuring increasing returns, firm mobility, and trade costs to analyze the robustness of home market effects to alternative modelling assumptions. Crozet and Trionfetti (2008), discusses home market effects in the context of global agglomeration of the differentiated goods sector vis-a-vis the labour allocation across countries. The present model, is related to these papers as tariffs are used to relocate production, and thus depress the price index of the differentiated goods. Presence of a non traded good does however generates income effects that may prevent the price index to fall.

Section 3.2 discusses the first model with mobile capital. Section 3.3 then proceeds by introducing the non traded good in this set up. Finally Section 3.4 concludes and discusses the implications for policy.

3.2 Basic model with mobile capital

We consider an economy (Home) where agents have a utility function given by

$$U = logD + C \tag{3.1}$$

where the good C is homogeneous good and the good D is a composite good which compromises of varieties produced both by Home and Foreign. These varieties are denoted by n_h and n_f respectively.

$$D = (\sum_{1}^{n_h} D_h^{\rho} + \sum_{1}^{n_f} D_f^{\rho})^{\frac{1}{\rho}}. \tag{3.2}$$

The D good is modelled as in Dixit-Stiglitz (1977). D can be alternatively interpreted as a final good which is produced by intermediaries n_h and n_f that are produced in the home and foreign economies respectively (see Ethier (1982)). $\sigma = \frac{1}{1-\rho} > 1$ is the elasticity of substitution, and is greater than unity, as $\rho \in (0, 1)$. Since all agents

are identical one can consider equation (3.1) and equation (3.2) indicating aggregate variables. Maximizing equation (3.1) subject to the budget constraint $Y = P_C C + P_D D$ yields [5]

$$D = \frac{P_C}{P_D} \tag{3.3}$$

$$C = \frac{Y}{P_C} - 1 \tag{3.4}$$

where P_C, P_D and Y represents the price of goods C, price of good D and the national income at home respectively. All goods are traded.

The good C is produced using only labour, while the sector D requires both capital and labour for production. One unit of capital is required to set up production and production of each additional unit of output requires one unit of labour.

This homogeneous good sector is assumed to be competitive and requires one unit of labour for production of each unit of output. Thus zero-profit condition of this sector, can be written as

$$P_C = w \tag{3.5}$$

where w is the wage earned by the labourers. We choose the varieties produced in the home as the numeraire and thus price of each domestic brand, p_h is normalized to unity. The D sector is monopolistically competitive and profit maximization by each producer implies,

$$p_h(1 - \frac{1}{\sigma}) = w. \tag{3.6}$$

Equation (3.5) and equation (3.6) implies that

$$P_C = w = \rho. \tag{3.7}$$

[5] Assuming an interior solution both $D, C > 0$.

To understand the home market effects it is assumed that Home imposes a tariff on the foreign varieties. On the other hand, the good C can be traded costlessly across the world. Trade in the differentiated products is subject to transportation cost. Specifically, if one unit of good is shipped from a country, then only $\frac{1}{\tau}$ units of the good reaches its destination, where $\tau > 1$ (See Helpman and Krugman (1989)). The foreign country is identical to the home, except for the fact that it does not impose any tariffs on the varieties produced in the home good. All variables of the foreign country are represented by asterisk. Price of the composite good in the home and foreign are respectively given as

$$P_D^{1-\sigma} = n_h p_h^{1-\sigma} + n_f(\tau p_f(1+t))^{1-\sigma} = n_h + n_f(\tau p_f(1+t))^{1-\sigma} \tag{3.8}$$

$$P_D^{*1-\sigma} = n_h(\tau p_h)^{1-\sigma} + n_f p_f^{1-\sigma} = n_h(\tau)^{1-\sigma} + n_f p_f^{1-\sigma} \tag{3.9}$$

where p_f represents the prices of the foreign brands and t is the tariff rate imposed by the home country on the varieties of the foreign country.
Uninhibited trade equalizes the price of good C in both countries. Thus,

$$P_c = w = \rho = P_C^* = w^*. \tag{3.10}$$

However, the composite price indices for the differentiated goods do not get equalized (see equation (3.8) and equation (3.9)) even in vicinity of free trade because of presence of transportation cost. Equation (3.10) also implies

$$p_f = p_h = 1 \tag{3.11}$$

x_h and x_f are the outputs produced by the home and foreign firm while r is the rental rate of capital. Free-entry in the differentiated goods sector implies that firms would break even and earn no supernormal profits. Thus

$$\begin{aligned} \frac{p_h x_h}{\sigma} &= \frac{p_f x_f}{\sigma} = r \\ x_h &= x_f = \sigma r. \end{aligned} \tag{3.12}$$

Perfect mobility of capital across countries guarantees that the rental is equal both in home and foreign.

Market clearing for a typical domestic firm would imply that (See Krugman (1979) for the derivation of the demand functions) [6]

$$x_h = D_h + \tau D_h^* = \frac{p_h^{-\sigma}}{P_D^{1-\sigma}}\rho + \tau(\tau p_h)^{-\sigma}\frac{\rho}{P_D^{*1-\sigma}}.$$

Similarly for the foreign firm

$$x_f = \frac{\tau^{1-\sigma}}{P_D^{1-\sigma}}[1+t]^{-\sigma}p_f^{-\sigma}\rho + \frac{p_f^{-\sigma}\rho}{P_D^{*1-\sigma}}.$$

Using equation (3.11) and equating the per firm output of the home and foreign country, as can be done observing equation (3.12), the ratio of price indices for the differentiated goods sector can be expressed in terms of tariff and transportation cost.

$$(\frac{P_D}{P_D^*})^{\sigma-1} = \frac{1-\tau^{1-\sigma}}{1-\tau^{1-\sigma}[1+t]^{-\sigma}}. \tag{3.13}$$

It is to be noted that the number of varieties produced in each country are not independent variables. The above relation can thus be used to solve for the number of varieties produced in each country. It is assumed that K^H and K^F are the capital stocks owned by the Home and Foreign economies respectively. Thus,

$$n_h + n_f = K^H + K^F. \tag{3.14}$$

Solving equations (3.8), (3.9), (3.13), (3.14) we obtain the number of varieties produced in each country (See Appendix 1 for derivation),

$$n_h = \frac{(K^H + K^F)[\{\tau(1+t)\}^{1-\sigma} - B]}{\tau^{1-\sigma}B - (B+1) + [\tau(1+t)]^{1-\sigma}}, \tag{3.15}$$

$$n_f = \frac{(K^H + K^F)[\tau^{1-\sigma}B - 1]}{\tau^{1-\sigma}B - (B+1) + [\tau(1+t)]^{1-\sigma}} \tag{3.16}$$

[6] Substituting equation (3.7) into equation (3.3) we find that total expenditure on differentiated goods by the domestic residents is ρ.

where $B = \frac{1-\tau^{1-\sigma}[1+t]^{-\sigma}}{1-\tau^{1-\sigma}}$.

The two countries are completely symmetric, in terms of number of varieties when there is free trade. This becomes clear, from equation (3.15) as it implies that in the vicinity of free trade $n_h = n_f = (K^H + K^F)\frac{1}{2}$. As in Venables (1987), it is interesting to find out the effect of tariff on the aggregate price index of the differentiated good. The difference between that model and the present model is that unlike Venables (1987) the per firm output is not constant. To understand the effect on the price index, the effect of tariff on the number of varieties produced in Home is analysed. Differentiating equation (3.15) with respect to t, in the vicinity of free trade, $(t = 0)$ we get (See Appendix-1)

$$\hat{n}_h = \frac{dt}{2(1-\tau^{1-\sigma})}[\tau^{1-\sigma}(\sigma-1) + \frac{\sigma\tau^{1-\sigma}(1+\tau^{1-\sigma})}{(1-\tau^{1-\sigma})}] \tag{3.17}$$

(since evaluated at free trade, $n_h = (K^H + K^F)/2$).

Equation (3.17) clearly indicates that number of varieties produced by the home country rises unambiguously. Since capital is required to begin production of each variety, a higher number of home produced varieties would mean that a larger share of the global capital stock is now employed in the Home country. This is fairly intuitive, as the domestic sector receives protection, imported brands are crowded out of the economy, and thus domestic sector expands in terms of total number of varieties. Capital inflow, does conditionally increase welfare in Sen et al. (1997) through increasing the available number of varieties in the home economy. In the present model, imposition of tariff actually makes it profitable for firms to relocate their production in Home rather than in the foreign country. This in turn reduces the aggregate price index faced by the consumers. The only factor that can raise the price index is the relatively higher price of the tariff ridden imports. To determine the magnitude of theses changes, we differentiate (3.8) in the vicinity of free trade. (See Appendix-1)

$$\frac{\hat{P}_D(\sigma-1)}{dt} = -\frac{\tau^{1-\sigma}[2\sigma\tau^{1-\sigma}+1-\tau^{1-\sigma}]}{2(1-\tau^{2(1-\sigma)})} < 0. \tag{3.18}$$

The RHS of equation (3.18) is negative. Thus home market effects lowers the aggregate price index faced by domestic consumers in this model. This, in turn becomes a channel for welfare improvement. Hence tariffs, make the Home country attractive to mobile capital and though it reduces the number of import competing foreign brands, consumers are finally better off in terms of the differentiated good. It is shown in the Appendix-1, that imposition of tariff causes a decline in the per firm output, the overall rental rate, and the total volume of the import competing sector ($n_h x_h$). This is also in contrast to Helpman and Krugman (1989) where the per firm output is constant and the total number of varieties increase. Hence, in our model there is a possibility of a situation akin to Metzler Paradox, not only in terms of prices but also in terms of output. Tariffs thus may fail to protect the import competing sector by causing the import volume ($n_h x_h$) to contract.

3.3 Home market effects and non traded goods

We next consider a variant of the above model. The only point of departure being that now the good C is assumed to be a non-traded good. Davis (1998) argues that when the homogeneous good is subject to trade costs, market size does not play a decisive role in the global distribution of the manufacturing sector. In the present analysis also home market effects get weakened when the homogeneous good sector is non traded (to keep matters simple, these trade costs are assumed to be prohibitive). Unlike Davis (1998), we concentrate on the aggregate price index. This has implications for the price depressing effects of tariffs found in Helpman and Krugman (1989) and in the mobile capital model discussed above. We assume (as in the previous section) that agents have a quasilinear utility given by

$$U = logD + C \tag{3.19}$$

where the good C is homogeneous good produced using only labour and the good D is a composite good which compromises of varieties produced both by Home and Foreign. Capital and labour both are employed in its production. C is assumed to be non traded.

$$D = (\sum_{1}^{n_h} D_h^{\rho} + \sum_{1}^{n_f} D_f^{\rho})^{\frac{1}{\rho}} \tag{3.20}$$

Since C is a non-traded good, equalization of wages in the two countries is no longer guaranteed. Thus in the Home and Foreign we have respectively

$$P_C = w = \rho \tag{3.21}$$

$$P_C^* = w^*. \tag{3.22}$$

The second equality in equation (3.21) follows from assuming an identical production structure of the traded sector D as in the previous model. That is to start production of each variety one unit of capital is required, while after that, each additional unit of output is produced by employing one unit of labour. Unlike equation (3.10), however, foreign wages are not equal to the wage rate in the home market. This in turn would imply that in general, prices of domestic and foreign brands would not converge. Prices of home brands are normalized to unity. Prices of foreign brands are a constant markup over the foreign wages.

$$p_f = \frac{w^*}{\rho} \tag{3.23}$$

Moreover the per firm output of the home and foreign firms will be different and can be obtained from the zero profit conditions (equations (3.12)) and the pricing equations (3.11) and (3.23)

$$x_h = \frac{r}{1-\rho} \tag{3.24}$$

$$x_f = \frac{r\rho}{w^*(1-\rho)}. \tag{3.25}$$

Now market clearing of the non traded good in Home implies that the total supply of output produced $(\bar{L} - n_h x_h)$ must be equal to the demand of good C, given by equation (3.4).

$$\bar{L} - n_h x_h = \frac{Y}{P_C} - 1$$

Using equation (3.24), (3.21) and substituting for Y we can write this as

$$\bar{L} - n_h \frac{r}{1-\rho} = \frac{\rho\bar{L} + rK^H + T}{\rho} - 1.$$

K^H is the capital owned by the Home country, while $\bar{L}$ is the labour force. It is assumed that the home country imposes a tariff on the imports of the foreign varieties, T is the tariff revenue generated by the imports and $T = tn_f \tau p_f D_f$. Solving for r we get

$$r = \frac{\rho - T}{n_h \frac{\rho}{1-\rho} + K^H}. \tag{3.26}$$

Similarly for the foreign country we have,

$$r = \frac{w^*}{n_f \frac{\rho}{1-\rho} + K^F} \tag{3.27}$$

where K^F is the foreign capital stock. Free mobility of capital ensures that rental rate of capital are equalised across nations. Noting that $n_f = K^H + K^F - n_h$ equations (3.26) and (3.27) therefore relates the foreign wage rate with varieties produced in Home.

$$w^* = \frac{(\rho - T)(n_f \frac{\rho}{1-\rho} + K^F)}{(n_h \frac{\rho}{1-\rho} + K^H)} \tag{3.28}$$

Capital market clearing across the world implies that

$$n_h + n_f = K^H + K^F. \tag{3.29}$$

Differentiating equation (3.29) yields

$$\delta_h \hat{n}_h + (1-\delta_h)\hat{n}_f = 0 \tag{3.30}$$

where $\delta_h = n_h/(n^h + n^f)$, is the relative number of home varieties with respect to total number of varieties produced in the world.

To understand the effect of tariffs on the varieties produced in the home market, total differentiation of equation (3.28) and using equation (3.30) gives

$$\begin{aligned}
\hat{w^*} &= \frac{-T}{\rho - T}\hat{T} + \{\frac{-n_h\rho\sigma}{n_f\rho\sigma + K^F} + \frac{n_f(\frac{-\delta_h}{1-\delta_h})\rho\sigma}{n_h\rho\sigma + K^H}\}\hat{n}_h \\
&= \frac{-T}{\rho - T}\hat{T} - [\frac{(K^H + K^F)(\rho\sigma + 1)n_h\rho\sigma}{(n_f\rho\sigma + K^H)(n_h\rho\sigma + K^H)}]\hat{n_h} \\
&= -B_1\hat{t} + \{\frac{B_1 s_h}{1-\delta_h} - \frac{(K^H + K^F)(\rho\sigma + 1)n_h\rho\sigma}{(n_f\rho\sigma + K^F)(n_h\rho\sigma + K^H)}\}\hat{n}_h + B_1 s_h(\sigma - 1)\hat{w^*} \\
&\quad + \frac{B_1 dt}{1+t}(\sigma + s_f(1-\sigma)).
\end{aligned}$$

This, on rearranging terms and after some manipulations yields,

$$\hat{w^*}\{1 - B_1(\sigma - 1)s_h\} - \{\frac{B_1 s_h}{1-\delta_h} - \frac{(K^H + K^F)(\rho\sigma + 1)n_h\rho\sigma}{(n_f\rho\sigma + K^F)(n_h\rho\sigma + K^H)}\}\hat{n}_h$$

$$= -\frac{B_1\hat{t}}{1+t}[1 + t(1-\sigma) + s_f t(\sigma - 1)] \tag{3.31}$$

where, $B_1 = \frac{T}{\rho - T}$.

Imposition of the tariff by the home country increases the tariff revenue that accrues to the nation. Given the number of varieties ($\hat{n}_h = 0$), an increase in the tariff revenue gets translated into a higher national income, since the entire tariff income is rebated to the consumers. The increased income raises the price of the non traded good and in turn the wages of the home labourers *relative to the foreign workers*. This is reflected in equation (3.31) where keeping the number of varieties constant, an imposition of tariff lowers the foreign wage. Our choice of numeraire implies this can be interpreted as a decline in the relative wage of foreign workers vis-a-vis the wage rate of home workers

Equation (3.31) involves two variables, the change in wage rate of the foreign country and the change in the varieties produced in the home economy. To solve them explicitly we would require another equation involving these two terms. This is obtained from the zero profit condition involving the home firm and foreign firm. Free entry implies that in equilibrium, these firms would just break even. Consider the case of the home firm,

$$\frac{p_h x_h}{\sigma} - r = \frac{D_h + \tau D_h^*}{\sigma} - r = 0$$

where the second equality follows from the market clearing condition for the output produced by the home firm. Substituting the demand functions (See Krugman (1979)) we get the following equations for the home and the foreign firm.

$$\rho P_d^{\sigma-1} + \tau^{1-\sigma} w^* P_d^{*\sigma-1} = \sigma r \tag{3.32}$$

Proceeding in a similar manner for the foreign firm, we get,[7]

$$\tau^{1-\sigma} w^{*1-\sigma} P_d^{\sigma-1} \rho^\sigma (1+t)^{-\sigma} + w^{*2-\sigma} \rho^{\sigma-1} P_d^{*\sigma-1} = \sigma r. \tag{3.33}$$

These two equations yields

$$(\frac{P_d}{P_d^*})^{\sigma-1} = \frac{w^{*2-\sigma}\rho^{\sigma-1} - \tau^{1-\sigma} w^*}{\rho - \tau^{1-\sigma} w^{*1-\sigma} \rho^\sigma (1+t)^{-\sigma}}. \tag{3.34}$$

Differentiating equation (3.34) and some algebraic manipulations yields

$$\hat{w^*}\{(\sigma-1)(s_h^* - s_h) + (\sigma-2) + (\sigma-1)(\mu_1+\mu_2)\} + \hat{n}_h(\frac{s_h^* - s_h}{1-\delta_h})$$

$$= -[\mu_2\sigma + s_f(\sigma-1)\frac{dt}{1+t}] \tag{3.35}$$

$s_h \equiv \frac{n_h p_h D_h}{Y}$ and $s_f \equiv \frac{n_f p_f D_f}{Y}$ are the total expenditure shares incident on home and foreign varieties of the residents in the home economy. s_h^* and s_f^* are the analogous counterparts for the foreign economy. $\mu_1 \equiv \frac{\tau^{1-\sigma} w^*}{w^{*2-\sigma}\rho^{\sigma-1} - w^* \tau^{1-\sigma}}$ and $\mu_2 \equiv \frac{\tau^{1-\sigma} w^{*1-\sigma} \rho^\sigma (1+t)^{-\sigma}}{\rho - \tau^{1-\sigma} w^{*1-\sigma} \rho^\sigma (1+t)^{-\sigma}}$. Simultaneously solving equations (3.31) and (3.35) leads us to the following proposition.

[7] Note that the expenditure on the differentiated goods, by the foreigners is w^*.

Proposition 3.1 *The effect of imposition of tariff by the home country can either increase or decrease the foreign wage. Moreover the number of varieties produced in home may either increase or fall.*

Proof. Solving equations (3.31) and (3.35) around zero tariffs i.e. by assuming that $t = 0$ we obtain

$$\hat{w}^* = \frac{-A(\mu_2\sigma + s_f(\sigma-1)) + (\frac{s_h^* - s_h}{1-\delta_h})\frac{n_f \tau p_f D_f}{\rho}}{\vartheta} dt \tag{3.36}$$

$$\hat{n}_h = \frac{-[(\sigma-1)(s_h^* - s_h) + (\sigma-2)(\mu_1+\mu_2)]n_f \frac{\tau p_f D_f}{\alpha\rho} + (\mu_2\sigma + s_f(\sigma-1))}{\vartheta} dt \tag{3.37}$$

where $A = \frac{(K^H+K^F)(\rho\sigma+1)n_h\rho\sigma}{(n_f\rho\sigma+K^F)(n_h\rho\sigma+K^H)}$. The above two equations shows the effects of imposing tariff on the foreign wage rate and number of varieties produced in the home market. As shown in the Appendix-2, stability analysis implies that the denominator of the above expressions is positive. However in general the sign of the numerator in either case cannot be determined. In contrast to the model of section-3.1, no unambiguous result is seen. More specifically unlike Venables (1987) varieties produced by the home may actually fall. ■

We concentrate on a specific situation, where around free trade, the two countries are identical (i.e. they are endowed with equal amount of capital and labour). The following proposition discusses the equilibrium.

Proposition 3.2 *If both home and foreign have an equal endowment of capital and labour then imposition of tariff by the home leads to an unambiguous fall in the wages of the foreign country, while the effect on home produced number of varieties remains ambiguous.*

Proof. Consider equation (3.34), substituting the value of the price indices we can solve for n_h in terms of the foreign wage rate at the vicinity of free trade ($t = 0$) and assuming

that $K^H = K^F = K$

$$n_h = \frac{2K[G\tau^{1-\sigma}w^{*^{1-\sigma}}\rho^{\sigma-1} - w^{*^{1-\sigma}}\rho^{\sigma-1}]}{\tau^{1-\sigma} - w^{*^{1-\sigma}}\rho^{\sigma-1} + G\tau^{1-\sigma}w^{*^{1-\sigma}}\rho^{\sigma-1} - G} \tag{3.38}$$

where G is the RHS of equation (3.34). Substituting $w^* = \rho$, in equation (3.38) and $n_h = K$, in equation (3.28) we can focus on a particular equilibrium situation which is completely symmetric around free trade, where $n_h = n_f = K$, and $w^* = \rho$. It is to be noted that in Appendix -2 we have assumed that as firms enter into the market profits fall while as they exit, per firm profits rise. Thus, there is only one possible equilibrium consistent with zero profits. Hence this is an unique equilibrium .

It is relatively straightforward, to check that $s_h^* = \tau^{1-\sigma}/(1+\tau^{1-\sigma}) < s_h = 1/(1+\tau^{1-\sigma})$ In this situation, wage rate in the foreign economy falls (see equation (3.36)), while the number of varieties produced in home can either increase or decrease. ■

Proposition 3.3 *Imposition of tariff by the home country has an ambiguous effect on the price index. Interestingly total volume of output produced by the import competing sector may actually contract.*

Proof. The price index of the differentiated goods sector is given by equation (3.8).Thus one can express the change in the aggregate price index in terms of change in number of varieties produced in home and the change in the foreign wage rate.

$$(1-\sigma)\hat{P}_D = s_h\hat{n}_h + (1-s_h)(\hat{n}_f + (1-\sigma)\hat{w}^*)$$

which after simplification and using equations (3.30) and (3.37) yields

$$\begin{aligned}\vartheta\frac{\hat{P}_D}{dt} &= -\frac{(\delta_h - s_h)}{(1-\delta_h)(\sigma-1)}\Big\{[(\sigma-1)(s_h^* - s_h) + (\sigma-2)(\mu_1+\mu_2)]n_f\frac{\tau p_f D_f}{\rho} \\ &+ (\mu_2\sigma + s_f(\sigma-1))\Big\} + (1-s_h)\Big\{ - A(\mu_2\sigma + s_f(\sigma-1)) + (\frac{s_h^* - s_h}{1-\delta_h})\frac{n_f\tau p_f D_f}{\rho}\Big\}.\end{aligned} \tag{3.39}$$

Thus the aggregate price index can either increase or fall depending on specific parameter values. Moreover the total output produced by the import competing sector ($n_h x_h$) may also go either way. (See Appendix-3 for derivation) ■

3.4 Conclusion

Metzler (1949) had shown that imposition of a tariff can paradoxically fail to protect the import competing sector. This can happen when the offer curve of the country may be so inelastic that the tariff lowers the international price of the importables by a very large extent, thereby offsetting the increase in price caused due to the imposition of the tariff itself. Thus tariffs fail to protect the import competing sector in this situation. However, neo-classical trade theory considers this Metzler Paradox as a case of mere theoretical interest (See Marjit (1993) and Caves and Jones (1985)). Helpman and Krugman (1989) shows, price reducing effect of tariffs becomes more relevant, in a setting characterized by monopolistic competition and increasing returns to scale. In such a situation imposition of tariff is clearly desirable from the point of view of the policy maker. This is because the aggregate price index of the differentiated goods sector falls and the number of varieties produced in the home market also rises (which are relatively cheaper than their foreign counterpart, due to the presence of transportation costs). Imposition of tariff by the home economy causes a global shift in the distribution of production of the differentiated varieties across the world. This benefits the consumers of the home economy as they have to bear an additional transportation cost for a lesser number of varieties. The present model makes two important departure from the Helpman and Krugman (1989) model. In the first departure, a mobile capital is introduced into the model. Imposition of tariff, in presence of transportation costs, gives incentives to firms to locate their production in the home economy rather than in the foreign. This benefits consumers by lowering the price index, just as in Helpman and Krugman (1979). However, the per firm output falls, and the effect on the import competing sector becomes

ambiguous.

The model is further extended to show that the situation may become more nuanced when we relax the assumptions of single factor of production and introduce a homogeneous non traded good. Imposition of the tariff has an ambiguous effect on the aggregate price index. Also important from the policy perspective, is the fact that number of varieties produced by the home may actually fall. Policy makers, if they are interested in protecting the import competing sector may not thus be able to achieve it, when home market effects are present. This is in contrast to Venables (1987) and Helpman and Krugman (1989). Though our model shows that tariff may increase the aggregate price index of the differentiated goods industry, it also opens upon the channel that the industry may actually contract in terms of varieties and total output produced by the tariff protected import competing sector (one can consider this as an example of Metzler Paradox in terms of quantities). This is quite paradoxical, since tariff protection is often sought to expand the import competing sector. Clearly, the effect on welfare is ambiguous and will depend on particular parametrization.

3.5 Appendices

3.5.1 Appendix 1

From equation (3.11) equations (3.8) and (3.9) can be expressed as

$$P_D^{1-\sigma} = n_h + n_f(\tau(1+t))^{1-\sigma}$$

$$P_D^{*1-\sigma} = n_h(\tau)^{1-\sigma} + n_f.$$

Substituting these into equation (3.13) and also using the fact that $n_h = K^H + K^F - n_f$, equation (3.15) in the main text is obtained.

Now consider equation (3.15),

$$\begin{aligned}\frac{dn_h}{dt} &= \frac{K^H+K^F}{[\tau^{1-\sigma}B-(B+1)+\{\tau(1+t)\}^{1-\sigma}]^2}\Bigg[\Bigg\{\tau^{1-\sigma}B-(B+1)\\ &+\{\tau(1+t)\}^{1-\sigma}\Bigg\}\Bigg\{\tau^{1-\sigma}(1+t)^{-\sigma}(1-\sigma)-\frac{\sigma\tau^{1-\sigma}(1+t)^{-\sigma-1}}{1-\tau^{1-\sigma}}\Bigg\}\\ &-\{\{\tau(1+t)\}^{1-\sigma}-B\}\Bigg\{\frac{\tau^{2-2\sigma}\sigma(1+t)^{-1-\sigma}}{1-\tau^{1-\sigma}}-\frac{\tau^{1-\sigma}\sigma(1+t)^{-1-\sigma}}{1-\tau^{1-\sigma}}\\ &+\tau^{1-\sigma}(1-\sigma)(1+t)^{-\sigma}\Bigg\}\Bigg]. \qquad (3.40)\end{aligned}$$

Now at the vicinity of free trade, we put $t=0$, thus

$$\begin{aligned}\frac{dn_h}{dt} &= \frac{K^H+K^F}{(2\tau^{1-\sigma}-2)^2}\Bigg[\Bigg\{\tau^{1-\sigma}(1-\sigma)-\frac{\sigma\tau^{1-\sigma}}{1-\tau^{1-\sigma}}\Bigg\}(2\tau^{1-\sigma}-2)\\ &-(\tau^{1-\sigma}-1)\Bigg\{\frac{\tau^{2(1-\sigma)}\sigma}{1-\tau^{1-\sigma}}-\frac{\sigma\tau^{1-\sigma}}{1-\tau^{1-\sigma}}+\tau^{1-\sigma}(1-\sigma)\Bigg\}\Bigg]\\ &= \frac{K^H+K^F}{4(\tau^{1-\sigma}-1)^2}\Bigg[2(\tau^{1-\sigma}-1)\Bigg\{\tau^{1-\sigma}(1-\sigma)-\frac{\sigma\tau^{1-\sigma}}{1-\tau^{1-\sigma}}\Bigg\}\\ &-(\tau^{1-\sigma}-1)\Bigg\{\frac{\tau^{2(1-\sigma)}\sigma}{1-\tau^{1-\sigma}}-\frac{\sigma\tau^{1-\sigma}}{1-\tau^{1-\sigma}}+\tau^{1-\sigma}(1-\sigma)\Bigg\}\Bigg]\\ &= \frac{K^H+K^F}{4(1-\tau^{1-\sigma})}\Bigg[\tau^{1-\sigma}(\sigma-1)+\frac{\sigma\tau^{1-\sigma}(1+\tau^{1-\sigma})}{1-\tau^{1-\sigma}}\Bigg]. \qquad (3.41)\end{aligned}$$

Near the free trade equilibrium, $n_h=(K^H+K^F)/2$ and also $n_f=(K^H+K^F)/2$. Substituting this in equation (3.41) will give equation (3.17). Total differentiation of equation (3.9) near free trade ($t=0$) yields

$$\widehat{P_d}(1-\sigma)=s_h\widehat{n_h}+(1-s_h)(\widehat{n_f}+(1-\sigma)dt) \qquad (3.42)$$

where $s_h=\frac{n_h p_h^{1-\sigma}}{n_h p_h^{1-\sigma}+n_f(\tau p_f(1+t))^{1-\sigma}}=\frac{1}{1+\tau^{1-\sigma}}$. After some manipulations this can be ex-

pressed as

$$\begin{aligned}\frac{(\sigma-1)\widehat{P_d}}{dt} &= (1-2s_h)\frac{\widehat{n_h}}{dt}+(\sigma-1)(1-s_h)\\ &= \left(\frac{\tau^{1-\sigma}-1}{\tau^{1-\sigma}+1}\right)\frac{\widehat{n_h}}{dt}+(\sigma-1)\frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}}\\ &= \frac{-1}{2(1+\tau^{1-\sigma})}\left[\tau^{1-\sigma}(\sigma-1)+\frac{\sigma\tau^{1-\sigma}(1+\tau^{1-\sigma})}{1-\tau^{1-\sigma}}\right]+(\sigma-1)\frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}}.\end{aligned} \tag{3.43}$$

Rearranging the terms we get equation (3.18) in the text.

We now proceed to analyse the effect of the tariffs on per-firm output. As shown in the main text the per firm domestic output can be expressed as

$$x_h = \rho P_d^{\sigma-1}+\tau^{1-\sigma}\rho P_d^{*\sigma-1}. \tag{3.44}$$

Differentiating both sides we get

$$dx_h = \rho P_d^{\sigma-1}[(\sigma-1)\hat{P}_d]+\tau^{1-\sigma}\rho P_d^{*\sigma-1}[(\sigma-1)\hat{P}_d^*]. \tag{3.45}$$

Differentiating equation (3.13) from the main text,

$$(\sigma-1)\hat{P}_d = (\sigma-1)\hat{P}_d^*-\frac{\sigma\tau^{1-\sigma}(1+t)^{-(\sigma+1)}dt}{1-\tau^{1-\sigma}(1+t)^{-\sigma}}. \tag{3.46}$$

From equation (3.9)

$$(\sigma-1)\hat{P}_d^* = \frac{1-\tau^{1-\sigma}}{1+\tau^{1-\sigma}}\hat{n_h} \tag{3.47}$$

when all the terms are evaluated around free trade. Substituting (3.46) and (3.47) into

(3.45) we get

$$\begin{aligned} dx_h &= \rho P_d^{\sigma-1}[(\sigma-1)\hat{P}_d + \tau^{1-\sigma}(\sigma-1)\hat{P}_d^*] \\ &= \rho P_d^{\sigma-1}\left[\frac{1-\tau^{1-\sigma}}{1+\tau^{1-\sigma}}\hat{n_h} - \frac{\sigma\tau^{1-\sigma}}{1-\tau^{1-\sigma}}dt + \frac{\tau^{1-\sigma}(1-\tau^{1-\sigma})}{1+\tau^{1-\sigma}}\hat{n_h}\right] \\ &= \rho P_d^{\sigma-1}\left[\frac{1-\tau^{2(1-\sigma)}}{1+\tau^{1-\sigma}}\hat{n_h} - \frac{\sigma\tau^{1-\sigma}}{1-\tau^{1-\sigma}}dt\right] \\ &= dt\rho P_d^{\sigma-1}\left[\frac{1}{2}\left(\tau^{1-\sigma}(\sigma-1) + \frac{\sigma\tau^{1-\sigma}(1+\tau^{1-\sigma})}{1-\tau^{1-\sigma}}\right) - \frac{\sigma\tau^{1-\sigma}}{1-\tau^{1-\sigma}}\right] \\ &= dt\rho P_d^{\sigma-1}\left[\frac{\tau^{1-\sigma}(\sigma-1)}{2} - \frac{\sigma\tau^{1-\sigma}}{2}\right] \\ &= \frac{-dt\rho P_d^{\sigma-1}\tau^{1-\sigma}}{2} < 0. \end{aligned} \tag{3.48}$$

The effect of tariffs on the import competing sector is as follows. Tariffs makes it more profitable, for firms to locate their production in the Home market. The per firm output declines. Thus the volume of the import competing sector may not expand and the net effect is ambiguous. Moreover, the overall impact of tariffs on welfare is also ambiguous. It is to be noted that even if the import competing sector expand in terms of volume, the tariff revenue may still fall worsening the welfare.

3.5.2 Appendix 2

For purpose of stability, it is assumed that firms enter into the market when existing firms earn supernormal profits and in turn diminishes profits earned by each firm. On the other losses cause exit of firms from the industry and this reduces the losses made by existing firms in the industry. Thus profits earned by each of the firms are a decreasing function of the total number of firms operating in the market.

Consider the profit earned by the home firm

$$\begin{aligned} \pi^h &= \frac{D_h + \tau D_h^*}{\sigma} - r \\ &= \frac{\alpha\rho P_d^{\sigma-1} + \tau^{1-\sigma}\alpha w^* P_d^{*^{1-\sigma}} - \sigma r}{\sigma}. \end{aligned} \tag{3.49}$$

Total differentiation of the above expression yields

$$\frac{1}{\sigma}d\pi^h = \rho P_d^{\sigma-1}(\sigma-1)\widehat{P_d} + \tau^{1-\sigma}w^*P_d^{*^{1-\sigma}}(w^*+(\sigma-1)P^*) - \sigma r\hat{r}. \tag{3.50}$$

After a little manipulation this yields

$$\begin{aligned}
&= \rho P_d^{\sigma-1}\left[(\sigma-1)\widehat{P_d^*} + \frac{(s_h^*-s_h)}{1-\delta_h}\widehat{n_h} + \widehat{w^*}(\sigma-1)(s_h^*-s_h)\right] + \tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}\widehat{P_d^*} \\
&\quad +\tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}\widehat{w^*} - \frac{\sigma}{\alpha}r\hat{r} \\
&= \sigma r\left[((\sigma-1)\widehat{P_d^*}-\hat{r}) + \rho P_d^{\sigma-1}\left[\frac{(s_h^*-s_h)}{1-\delta_h}\widehat{n_h} + \widehat{w^*}(\sigma-1)(s_h^*-s_h)\right]\right] \\
&= \sigma r[\mu_2+(\sigma-2)](-A)\widehat{n_h} + \tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}(-A)\widehat{n_h} + \rho P_d^{\sigma-1}\left[\frac{(s_h^*-s_h)}{1-\delta_h}\widehat{n_h}\right. \\
&\quad \left.+(\sigma-1)(s_h^*-s_h)(-A)\widehat{n_h}\right].
\end{aligned} \tag{3.51}$$

Dividing both sides by $\hat{n_h}$ we get

$$\begin{aligned}
\frac{\frac{1}{\sigma}d\pi^h}{\widehat{n_h}} &= \sigma r[\mu_2+(\sigma-2)](-A) + \tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}(-A) + \rho P_d^{\sigma-1}\left[\frac{(s_h^*-s_h)}{1-\delta_h}\right. \\
&\quad \left.+(\sigma-1)(s_h^*-s_h)(-A)\right].
\end{aligned} \tag{3.52}$$

Now our assumption implies that LHS must be negative, which in turn means

$$\begin{aligned}
&[\rho P_d^{\sigma-1} + \tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}]\left[[(\sigma-1)\mu_2+(\sigma-2)](-A) + \tau^{1-\sigma}w^*P_d^{*^{\sigma-1}} + \rho P_d^{\sigma-1}\left[\frac{(s_h^*-s_h)}{1-\delta_h}\right.\right. \\
&\left.\left.+(\sigma-1)(s_h^*-s_h)(-A)\right]\right] < 0 \\
\text{or,}\quad &\rho P_d^{\sigma-1}\left[A\left\{(\sigma-1)\mu_2+(\sigma-1)(s_h^*-s_h)+(\sigma-2)\right\} - \frac{s_h^*-s_h}{1-\delta_h}\right] \\
&+\tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}A((\sigma-1)(\mu_2+1)) > 0 \\
\text{or,}\quad &\left[A\left\{(\sigma-1)\mu_2+(\sigma-1)(s_h^*-s_h)+(\sigma-2)\right\} - \frac{s_h^*-s_h}{1-\delta_h}\right] \\
&+\frac{\tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}A((\sigma-1)(\mu_2+1))}{\rho P_d^{\sigma-1}} > 0.
\end{aligned}$$

Now consider the last term in the left hand side of the inequality,

$$\begin{aligned}\frac{\tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}A(\sigma-1)(\mu_2+1)}{\rho P_d^{\sigma-1}} &= \frac{\tau^{1-\sigma}w^*P_d^{*^{\sigma-1}}A(\sigma-1)}{\rho P_d^{\sigma-1}}\left[\frac{\tau^{1-\sigma}w^{*^{1-\sigma}}\rho^\sigma}{\rho-\tau^{1-\sigma}w^{*^{1-\sigma}}\rho^\sigma}+1\right]\\ &= \frac{A(\sigma-1)\tau^{1-\sigma}w^*}{w^{*^{2-\sigma}}\rho^{\sigma-1}-\tau^{1-\sigma}w^*}\\ &= A(\sigma-1)\mu_1. \end{aligned} \tag{3.53}$$

So,

$$A[(\sigma-1)(\mu_1+\mu_2)+(\sigma-1)(s_h^*-s_h)+(\sigma-2)]-\frac{s_h^*-s_h}{1-\delta_h}>0$$

$$i.e.\quad \vartheta>0. \tag{3.54}$$

3.5.3 Appendix 3

From equation (3.24),

$$\hat{x}_h=\hat{r}. \tag{3.55}$$

Now, using equation (3.26)

$$\hat{r}=\frac{-T}{\alpha\rho-T}\hat{T}+\frac{\hat{n}_h}{n_h\rho\sigma+K^H} \tag{3.56}$$

$$=-B_1\{\hat{t}-\frac{s_h}{1-\delta_h}\hat{n}_h-(\sigma-1)s_h\hat{w}^*+\frac{dt}{1+t}[s_f(\sigma-1)-\sigma]\}. \tag{3.57}$$

So,

$$\hat{x}_h=\hat{r}=-B_1\hat{t}+\{B_1\frac{s_h}{1-\delta_h}-\frac{1}{n_h\rho\sigma+K^H}\}\hat{n}_h+B_1(\sigma-1)s_h\hat{w}^*+\frac{B_1dt}{1+t}[s_f(1-\sigma)+\sigma].$$

Total output produced by the import competing sector in Home is given by n_hx_h

$$\begin{aligned}\widehat{n_hx_h} &= [1+\frac{B_1s_h}{1-\delta_h}-\frac{1}{n_h\rho\sigma+K^H}]\hat{n}_h+\frac{B_1dt}{1+t}[s_f(1-\sigma)+\sigma]-B_1\hat{t}+B_1(\sigma-1)\hat{w}^*\\ &= [1+\frac{B_1s_h}{1-\delta_h}-\frac{1}{n_h\rho\sigma+K^H}]\frac{dt}{\vartheta}\Big\{-[(\sigma-1)(s_h^*-s_h)+(\sigma-2)(\mu_1+\mu_2)]n_f\\ &\quad \frac{\tau p_fD_f}{\alpha\rho}+(\mu_2\sigma+s_f(\sigma-1))\Big\}+\frac{B_1dt}{1+t}[s_f(1-\sigma)+\sigma]-B_1\hat{t}+\frac{B_1(\sigma-1)dt}{\vartheta}\\ &\quad \Big\{-A(\mu_2\sigma+s_f(\sigma-1))+(\frac{s_h^*-s_h}{1-\delta_h})\frac{n_f\tau p_fD_f}{\alpha\rho}\Big\}\end{aligned} \tag{3.58}$$

which is indeterminate in its sign.

Chapter 4

Metzler Paradox and voluntary contribution to public goods

4.1 Introduction

A good or a service is considered to be public, if it is non-rival in consumption. Thus, these goods are potentially for collective consumptions. In general, markets fail to allocate public goods efficiently and thus the issue of providing and financing public goods through collective action has become an important issue in the literature. Oslon (1965) had argued that in a society with competing political groups, provision of public good becomes increasingly difficult through voluntary contribution, as the group size increases. Chamberlin (1974) and McGuire (1974), show that in a competitive set-up, if the public good provided is a normal good, then contribution by each member increases and reaches a finite value with an increasing group size. Cornes and Sandler (1989) builds a model, with both a public good and private good. Both these goods are produced with labour. Increase in labour endowment, increases the contribution of each individual to the public good. In the two factor model developed by Vicary (2004) the effect of group size become ambiguous and depends on the relative factor intensities of the public good and the private good.

Pecorino (2009) builds a model, where labour is employed between a differentiated private goods sector and a public good sector. As labour increases, the variety sector expands which in turns implies a higher expenditure on the differentiated goods sector. This increases the marginal utility of income and thus the aggregate contribution made to the public good falls. In Mondal (2013), marginal utility of income is inversely related to the aggregate expenditure on the variety sector and thus increasing group size, in contrast to Pecorino (2009) increases the aggregate contribution to the public good.

The present model, extends Mondal (2013) and incorporates trade in the differentiated goods sector. The economy is assumed to be small, in a sense that the prices of the foreign brands and the number of foreign varieties are exogenously given (See Venables (1982) and Sen et al. (1997)). Imposition of tariff, by the home country in such a set up has interesting implications. An increase in tariff, cetirus paribus (that is at the level of constant import demand), increases the income of the individuals through the tariff income rebated to the agents. This generates an "income effect" by which agents would contribute more to the public good and thus increase the aggregate expenditure on public goods. Market clearing implies that an expanding public goods sector draws labour out of the differentiated goods sector and thus this sector may contract. Tariffs then would fail to protect the import competing sector. Such a result is reminiscent of the famous Metzler Paradox result in classical trade theory (See Metzler (1949)).

Competitive trade theory has an extensive literature that deals with the effects of imposition of tariffs. In general, imposition of tariff has two opposing effects on the domestic price of imports. Tariffs improves the terms of trade for the tariff imposing country, which in turn reduces the domestic price of the imports. It also increases the domestic price of imports directly, which causes the import competing sector to expand (and thus crowd out cheaper importables). Competitive trade theory identifies a situation known as the Metzler Paradox (see Metzler (1949)), when large improvement in terms of trade, actually lowers the domestic price of the output of the import competing sector and thus fail to protect it. Helpman and Krugman (1989) builds a model of trade

with monopolistic competition and scale economies. They show that in such set up, the price lowering effect of the tariffs can become more pronounced since it requires much lesser restrictive conditions than Metzler (1949). A single factor of production, labour is allocated between a differentiated goods sector and a homogeneous goods sector. Differentiated goods sector is traded but is subject to transportation costs while trading of the homogeneous good is costless. Imposition of tariffs in a two country world leads to re-allocation of firms in the tariff imposing country. Since the relatively cheaper home varieties increases; the aggregate price index faced by the domestic consumers fall. Home market effects can thus lower the domestic price of the import competing sector.[1]

Our model is also related to this class of literature. However, the possibility that tariffs may fail to protect the import competing sector comes through a completely different channel (not through home market effects) and in a different manner. Increase in the tariff, increases the revenue earned from the imports directly. As this tariff income is rebated back to the agents, it reduces the marginal utility of income and thus agents increase their contribution to the public good. On the other hand, increase in the tariff rate causes the import demand to fall, which may reverse the effect. The net effect thus is ambiguous. To focus on the intuition, we study the equilibrium in the neighbourhood of free trade. Near the free trade equilibrium, the first effect dominates the second and tariffs fail to protect the import competing sector unambiguously. The number of domestic (import competing) brands falls and the total volume of the import competing sector contracts.

The next section outlines the basic model, and section 4.3 develops the comparative statics. The last section concludes the model.

[1]Davis (1998) builds another model that discusses the implications of home market effects and trade policy.

4.2 The Model

Consider a hypothetical small open economy which produces n_h number of varieties domestically and imports n_f number of varieties from foreign. "Smallness" implies that the number and prices of the foreign varieties are exogenously given to this economy as in Venables (1982) and Sen et al. (1997). Moreover, the agents also consume a (non-traded) public good, which is financed by voluntary contribution of the agents. All the agents supply one unit of labour inelastically and total number of residents is assumed to be L. Government imposes a tariff on the import of the foreign varieties and it is assumed that the entire tariff revenue is rebated back to the consumers. The utility function of the agents is given by

$$U = \log\left(\sum_{i}^{n_h} C_h^{\rho} + \sum_{j}^{n_f} C_f^{\rho}\right)^{\frac{1}{\rho}} + f(G/w) \tag{4.1}$$

where $f' > 0$ and $f'' < 0$. C_h indicates the representative consumption of the home variety while C_f is the consumption of any foreign variety. σ $(= \frac{1}{1-\rho})$ is the elasticity of substitution and $\sigma > 1$ as $\rho \in (0, 1)$. G and w are the total expenditure on the public good and the wage rate in the economy respectively. For simplicity, it is assumed that one unit of labour is used for producing one unit of public good. Thus $\frac{G}{w}$ is the total labour employed for the production of public good. Suppose the voluntary contribution made by each individual, k is given by g_k. Then, $G = \sum_k g_k = gL$, where the second equality follows from the fact that all agents are symmetric and thus their voluntary contribution in the Nash equilibrium will be identical, i.e. g (See equation (4.4)). Then the demand functions can be obtained by maximising (4.1) when the income of each consumer is

$$M = w + T/L \tag{4.2}$$

where M is the individual income. T is the aggregate tariff revenue earned by the government which we assume to be rebated equally among the agents, and thus each

consumer gets T/L share of the total revenue. Utility maximisation implies

$$\frac{C_h}{C_f} = \left(\frac{p_h}{p_f(1+t)}\right)^{-\sigma}. \tag{4.3}$$

p_h, p_f and t represents the prices of the home produced brand, imported brand and the tariff rate respectively. The first order condition of utility maximisation also implies

$$\frac{1}{w}f'(G/w) - \lambda = \frac{1}{C} - \lambda P = 0$$

where C and P represents the aggregate consumption index [2] and the aggregate price index respectively for the variety sector. Suitably rearranging terms, and substituting into the budget constraint we get the symmetric voluntary contribution made by each agent in Nash equilibrium.

$$g = g_k = w + T/L - \frac{w}{f'(G/w)} \ \forall k \tag{4.4}$$

Total amount of public good thus produced in the economy is

$$G = wL + T - \frac{wL}{f'(G/w)}. \tag{4.5}$$

Domestic production of each variety requires α units of labourers to start production and β units of labourers for each additional unit of output produced. Producers maximise profits by equating the marginal revenue with the marginal cost

$$p_h(1 - \frac{1}{\sigma}) = \beta w \tag{4.6}$$

which implies,

$$p_h = \frac{\beta w}{\rho}. \tag{4.7}$$

Free entry in the variety sector, means that in the equilibrium, firms would equate the surplus with the fixed costs of production,

$$\frac{p_h x_h}{\sigma} = \alpha w \implies x_h = \frac{\alpha\rho}{\beta(1-\rho)}, \tag{4.8}$$

[2] $C = \left(\sum_i^{n_h} C_h^\rho + \sum_j^{n_f} C_f^\rho\right)^{\frac{1}{\rho}}$

when x_h is the output of the domestic firm. Total value of exports made by this small open economy is $n_h p_h(x_h - LC_h)$ and the aggregate value of imports is given by $n_f p_f LC_f$. Balance of payments would require that value of imports should be equal to the value of exports.

$$n_h p_h(x_h - LC_h) = n_f p_f LC_f. \tag{4.9}$$

The tariff revenue earned by the government is given by

$$T = t n_f p_f C_f L. \tag{4.10}$$

Labour is required for production both by the public good and the variety sector. Labour is assumed to be the numeraire and thus $w = 1$. Then it follows that the labour market clearing condition is

$$n_h(\alpha + \beta x_h) + G = L. \tag{4.11}$$

Equations (4.1) to (4.11) completes the description of the model.

4.3 Comparitive statics

To understand the effect of tariffs in this model, we totally differentiate equation (4.9) to get

$$\hat{n_h} - s\hat{C_h} = \hat{C_f}, \tag{4.12}$$

where $s = \frac{LC_h}{x_h - LC_h}$, and $s > 0$ the ratio of aggregate domestic consumption of each brand to its imports. Utility maximisation implies that $\hat{C_h} = \hat{C_f} + \sigma\frac{dt}{1+t}$ (See equation (4.3)). Substituting this into equation (4.12), we obtain an equation involving $\hat{n_h}$ and $\hat{C_f}$.

$$\hat{n_h} - (1+s)\hat{C_f} = \frac{\sigma s dt}{1+t}. \tag{4.13}$$

From equation (4.5),

$$dG = t n_f p_f C_f L(\hat{C_f} + \hat{t}) + \frac{Lf''}{f'^2} dG,$$

which would in turn imply

$$\hat{G} = \frac{tn_f p_f LC_f(\hat{t} + \hat{C}_f)}{G[1 - L\frac{f''}{f'^2}]}. \tag{4.14}$$

Using the labour market clearing condition (4.11) equation (4.14) can be written as

$$-[1 - L\frac{f''}{f'^2}](\alpha + \beta x_h)n_h\hat{n_h} - tn_f p_f LC_f\hat{C}_f = n_f p_f LC_f dt. \tag{4.15}$$

Solving equations (4.13) and (4.15) the change in total number of home produced varieties and the import demand due to a change in tariffs can be expressed as:

$$\hat{n_h} = \frac{-(1+s)n_f p_f LC_f + \frac{tn_f p_f LC_f \sigma s}{1+t}}{D}dt \tag{4.16}$$

$$\hat{C}_f = -\frac{[1 - L\frac{f''}{f'^2}](\alpha + \beta x_h)n_h\sigma s/(1+t) + n_f p_f LC_f}{D}dt \tag{4.17}$$

where $D = n_h(1+s)(1 - \frac{Lf''}{f'^2})(\alpha + \beta x_h) + tn_f p_f LC_f > 0$.

Equations (4.16) and (4.17) can be used to derive the following propositions.

Proposition 4.1 *Tariffs may fail to protect the import competing sector. Moreover, around the free trade equilibrium an increase in tariffs cause an unambiguous contraction of the import competing sector.*

Proof. Consider equation (4.16). The number of brands produced by the import competing sector will decline if the parametrisation $\frac{\sigma t}{1+t} - \frac{1+s}{s} < 0$ holds. It is straightforward to check that around the free trade equilibrium, $(t = 0)$, imposition of tariffs reduce the total number of varieties produced by the home economy (this is seen by putting $t = 0$, in the RHS of equation (4.16)). This implies that tariffs fail to protect the import competing sector in the presence of public good. we can conclude, that in case the total number of domestic brands decline ($\hat{n_h} < 0$) and since the per firm output produced by the import competing sector is constant, the volume of import competing sector's output ($n_h x_h$) contracts unambiguously. ■

Clearly, a sufficiently high elasticity of substitution rules out the Metzler Paradox like situation (in terms of import volume) in this economy. A high value of σ ($\sigma > \frac{(1+s)(1+t)}{st}$) means that the domestic brands and foreign brands are very close substitutes to each other. Imposition of tariff on the foreign varieties makes them dearer to the domestic residents, who switch to the home produced varieties. This makes it profitable for new entry into the home sector, and thus n_h may rise.

Imposition of tariff increases the total income accruing to the consumers, which thus reduces the opportunity cost of contributing to the public good. Thus the voluntary contribution to the public good increases, which draws labour out of the production of the home produced varieties. As the per firm output is constant, the total number of home produced varieties gets reduced, which in turn implies that the total volume of the import competing sector ($n_h x_h$) contracts. This can be summarized as the following proposition.

Proposition 4.2 *In the neighbourhood of the free trade equilibrium, imposition of tariffs increases the tariff revenue.*

Proof. Differentiating equation (4.10) we get

$$\frac{dT}{dt} = tn_f p_f \frac{dC_f}{dt} + n_f p f C_f. \tag{4.18}$$

Assuming free trade (that is, $t = 0$), $\frac{dT}{dt} > 0$. ■

The next proposition brings into focus the main intuition of the model.

Proposition 4.3 *Near the free trade equilibrium, an increase in the tariff rate increases the voluntary contribution of each individual to the public good, and reduces the domestic varieties produced in the economy.*

Proof. Equation (4.4) can be re-written as

$$w + T/L = g + w/f'.$$

Total differentiation of the above equation gives,

$$\frac{dT}{L} = d(g + \frac{1}{f'})$$

and from equation (4.10) this can be written as

$$\frac{1}{L}[n_f p_f C_f L dt + t n_f p_f dC_f] = d(g + 1/f'). \tag{4.19}$$

The LHS of the above equation is positive near free trade (the second term in the LHS vanishes). Moreover, with increase in tariffs (that is as dt rises), the LHS of the equation rises. To maintain equality, the RHS of the equation can rise only when g rises. Thus the voluntary contribution of each individual rises in the economy, which in turn increases the aggregate expenditure on the public good. Thus labour is drawn out of the differentiated sector, causing it to contract (n_h falls). ■

Equation (4.17) shows the usual effect of tariffs on the import demand. The volume of import falls, because imposition of tariffs makes it dearer to the consumers. From the labour market clearing condition (4.11), near the free trade equilibrium a fall in the number of varieties implies higher output of the public good.

4.4 Conclusion

Imposition of tariff can be due to various reasons. One of the persuasive arguments in favour of tariffs is that it protects the import competing sector. Since domestic prices of the import competing sector is expected to rise above the international prices, it would expand crowding out imports from the domestic market. However, tariffs also improves welfare by bringing the terms of trade in favour of the tariff imposing nation. This happens because tariffs cause a reduction in the international price of the imports. Metzler (1949) had argued that if the improvement in terms of trade is very large, the domestic prices may actually fall for the import competing sector. Helpman

and Krugman (1989) builds a model of monopolistic competition and love for variety and shows that home market effects can lead to a result akin to Metzler Paradox. The present model generates a somewhat similar result, though through a completely different channel. Presence of a public good implies, that around the free trade equilibrium the differentiated goods sector (which is the import competing sector) would contract. Thus, tariffs may fail to protect, though in general, the effect of tariffs on public good and the total volume of the import competing sector remains ambiguous. This is interesting because tariffs are often invoked to protect the domestic import competing industry. If the elasticity of substitution is sufficiently high, then tariffs are able to protect the import competing sector. As tariffs make the domestic brands relatively cheaper than the foreign varieties, a high elasticity of substitution implies that consumers substitute readily among the two type varieties. Thus, we can get back the usual protective effects of tariffs, since increase in demand for domestic varieties implies that there is potential for new entry into the import competing sector. Interestingly, an increase in the tariffs, increase the voluntary contribution to a public good and thus the total amount of public good allocated in the equilibrium rises.

Chapter 5

A trade induced model of unemployment

5.1 Introduction

The issue of unemployment has been one of the central concerns in the literature of macroeconomics. In a competitive labour market, characterized by a Walrasian adjustment mechanism, presence of workers who are willing to work at a wage rate lower than the prevailing one, would evidently bid down the wages. In such models, presence of unemployment can never be a feature of the long run equilibrium of the economy. The central theme among the various theories of unemployment has been to assume a labour market with an adjustment mechanism that departs from the paradigm of perfect competition (see Romer (2001)). It is generally believed that the only possible way unemployment may arise at all in a competitive labour market is when the free operation of market forces are hindered (for example due to presence of minimum wage laws). There have been a large number of contributions that have tried to explain the presence of unemployment by assuming some kind of departure from the competitive model of the labour market. Calvo (1979) develops some "quasi-Walrasian" type of models. Agents are not necessarily price takers or/and markets are incomplete in such models.

These models are essentially of two kinds. They either rely on costly labour mobility, or presence of some kind of imperfect information (regarding workers, institutions or legal contracts), to generate unemployment in the labour market. Shapiro and Stiglitz (1984) build a model where workers can potentially shirk in their jobs. Firms can monitor their workers imperfectly and hence have to provide incentives (in form of higher wages) so that they exert effort. The penalty facing a shirker is increasing in both wages and unemployment rate. This is because a higher unemployment rate implies a lengthier spell of remaining unemployed. This in turns acts as disincentive for shirking. Evidently there will always exist some unemployed workers in the equilibrium. Even if there are workers who are willing to work at a lower wage in the equilibrium, firms would not bid down the wages since they are also interested in preventing shirking. In Diamond (1981, 1982), workers and jobs are highly heterogeneous and both are engaged in a costly process of matching with each other. Thus the labour market is no more frictionless and the process of matching is not instantaneous. This in turn leads to some workers remaining unemployed. Another class of literature that tries to provide a rationale for presence of involuntary unemployment bases itself on the efficiency wage hypothesis (see Yellen (1984)). According to the efficiency wage hypothesis labour productivity depends on the real wage paid. Higher wages would imply not only a higher labour cost for the firms but also more productive workers. In the equilibrium firms may not have incentive to lower wages (due to efficiency considerations) even in presence of workers who are willing to work at lower wages.

A related series of contributions have tried to explain the link between international trade and unemployment. Hoon (1991) incorporates the unemployment model of Shapiro and Stiglitz (1984) into a Heckscher - Ohlin model of trade. The effect of trade on unemployment depends on the relative factor abundance of the trading nations. The labour abundant country experiences a lower unemployment rate in the post trade situation compared to its autarky state. This is due to the expansion of the labour intensive sector in the post trade situation compared to autarky. However, unemployment

increases for the capital abundant country, as the labour intensive sector becomes the import competing sector and thus shrinks compared to autarky. Hoon (2001) develops a dynamic Ricardian model of the world economy exhibiting unemployment due to labour shirking. International trade increases the stake in job holding, enhances the real earnings of the labourers and in equilibrium lowers unemployment. Economic shocks in one country affect the other country by shifting the terms of trade. This is true unless one of the countries is so large that it faces the same terms of trade in autarky as in the post trade situation. Matusz (1996) embeds a model of monopolistic competition into a shirking model of unemployment. A single consumer good is produced using a variety of intermediate inputs. Production of each of these inputs is subject to scale economies and markets are monopolistically competitive. Monitoring work effort is imperfect and hence unemployment enters as a worker disciplining device. Trade increases the varieties of intermediary inputs available through imports and thus causes an expansion of the final good produced. The rise in the value of total output gets translated into a higher wage bill for the workers. At constant employment this would mean higher wages. The increased wage relaxes the efficiency wage constraint and causes an unambiguous rise in employment. The gains from trade results due to a greater division of labour, which in turn is due to the increase in the number of intermediate inputs. The resulting productivity increases the real wages and hence employment. Helpman and Itskhoki (2010) builds a model of search based unemployment and firm heterogeneity. They discuss the reallocation of resources among the different sectors due to international trade. In Felbermayr et al. (2008) trade liberalisation reduces the search costs and hence unemployment.

All these models seem to suggest that either trade always reduces unemployment in both countries engaged (this is especially true in Ricardian type models) or one country gains in terms of employment while the other loses (this is the case for trading partners with difference in relative factor abundance). The present chapter builds a model of monopolistic competition as in Krugman (1980) and Dixit and Stiglitz (1977) and

incorporates a model of labour market with efficiency wages into it. It is shown that trade can increase unemployment for both (identical) trading partners. There are a large number of potential varieties. Production of each variety is subject to fixed and variable costs. Labour is the single factor of production. It is assumed that the fixed cost incurred by the firms decreases as the number of available varieties in the economy rises. The variable costs depend on the wage offered to the workers by the producers. That is by offering a higher wage workers become more productive and the per unit labour costs of production falls. One may view the fixed costs as payments to managerial activities while variable costs are incurred by the producers as payments to carry out routine production process. The efficiency of the managers rises if the available varieties increase but that does not affect the routine production. Markets are monopolistically competitive and presence of love for variety implies that each brand is produced by a single producer. The assumption of the efficiency wage implies that for a sufficiently large labour supply the economy can exhibit unemployment. As the economy opens up to trade, the integrated world equilibrium completely replicates the autarky equilibrium of the home country. As a result the number of varieties produced in the integrated equilibrium is equal to the number of varieties produced by the home economy in the autarky. The number of varieties produced in the home country gets reduced unambiguously from autarky to trade. The aggregate labour demand thereby gets reduced. However efficiency considerations entail that producers would not lower the wages. For an economy that exhibits unemployment in the autarky this would mean a further increase in the unemployment level. Moreover for an identical trading partner the effect of trade on employment will be exactly alike. Thus trade can increase unemployment in both the countries as compared to autarky. Trade thus causes loss to either countries both in terms of varieties produced and employment.

Section 5.2 builds up the basic model in an autarky situation and shows the possible presence of unemployment, while Section 5.3 discusses the trading equilibrium and

Section 5.4 concludes the chapter.

5.2 The basic model

5.2.1 The consumers:

We consider an economy with agents exhibiting love for variety. Following Dixit and Stiglitz (1977), we assume that the utility function of the economy is given by

$$U = \left(\sum_{i}^{n} C_i^{\rho} \right)^{\frac{1}{\rho}}. \tag{5.1}$$

C_i indicates the consumption of the i^{th} variety and the total number of varieties available is n. σ $(= \frac{1}{1-\rho})$ is the elasticity of substitution and $\sigma > 1$ as $\rho \in (0, 1)$. Note that a higher value of ρ indicates higher substitutability among the different varieties. The demand function for any particular brand is the following

$$C_i = \frac{p_i^{-\sigma} M}{P^{1-\sigma}} \tag{5.2}$$

where, $P^{1-\sigma} = \sum p_i^{1-\sigma}$.

M represents the income of the representative consumer and P is the aggregate price index. Since all consumers are identical in this model we would interpret C_i and M as the aggregate demand for the i^{th} variety and the total national income of the economy respectively. Moreover our specification of the production technology would entail symmetric pricing by all variety producing firms. Thus in equilibrium the aggregate price index is given as

$$P^{1-\sigma} = np^{1-\sigma} \tag{5.3}$$

where $p_i = p \ \forall i$.

5.2.2 The technology:

Producers carry out production using a single factor namely labour. We make a special assumption regarding the production technology. To start production each firm has to

incur some fixed costs. One may view these fixed costs as payments to managerial activities. It is assumed that there is strong learning by doing effects in these activities. At any given point in time the available varieties can be considered to be a measure of such learning activities [1]. This means that a higher number of available brands would make each worker employed as a manager more efficient i.e. labour requirement for such managerial activities would be a decreasing function of the available number of brands. Suppose $\alpha(n)$ be the labour required to start production then $\alpha'(n) < 0$. We also assume that $\alpha(n)$ cannot fall to zero. That is, as varieties increase, $\alpha(n)$ falls until a certain critical value α^c is reached, beyond which a further increase in the number of varieties brings no efficiency gains and $\alpha(n)$ becomes a constant.

Once the set up costs has been incurred, β units of labourers are required to produce each unit of output. It is assumed that this production process is somewhat routine and does not have much scope for learning. However β depends on the wage offered by the producers. Higher wage makes workers in the production process more efficient and reduces the unit labour requirement of production. That is $\beta = \beta(w)$ and $\beta^{'}(w) < 0$, and $\beta^{''}(w) > 0$. Once again we impose a restriction on the efficiency gains coming from higher wages to prevent $\beta(w)$ fall to zero. As w rises $\beta(w)$ reaches a lower bound β^c and becomes a constant. By offering higher wages the total variable cost of the producers may rise or fall depending upon the elasticity of the $\beta(w)$ schedule. This situation is identical to all models that have an efficiency wage assumption. Efficiency enhancing effects of higher wages are ultimately translated into a rigid wage that may become completely independent of the total labour supply. Putting it differently, even if there are workers who may offer to work at lower wages, producers may not be interested to bid down wages as that would mean a lower value of $\beta(w)$. Evidently, such workers would then become unemployed. This would have been averted if wages were flexible

[1] This way of modelling the knowledge base of the economy is similar to that of Grossman and Helpman (1992).

and labour market would have always cleared.

5.2.3 The producers:

Since there are fixed costs in the production process, no two producers would produce the same variety. From the demand function given by equation (5.2), each producer producing a specific variety faces a downward sloping demand curve. This implies, each of them enjoys some monopoly power in the market. The producers would maximize profits by chosing appropriately the prices of their products and the wage they would offer to the workers. We consider each producer to be an atomistic one with the belief that their actions have no effect on the aggregate price index and the total income of the economy. Moreover each producer takes the number of brands as exogenously given. The profit function of the producer is given by

$$\pi = px - [\alpha(n) + \beta(w)x]w \tag{5.4}$$

where x is the output of each brand. Market clearing for each variety implies the equality of x and C_i. From (5.2) and (5.3) one can express the per firm profits as

$$\pi = \frac{p^{1-\sigma}}{P^{1-\sigma}}M - \left[\alpha(n) + \beta(w)\frac{p^{-\sigma}M}{P^{1-\sigma}}\right]w. \tag{5.5}$$

Profit maximization implies,

$$\frac{\delta\pi}{\delta p} = (1-\sigma)\frac{p^{-\sigma}M}{P^{(1-\sigma)}} - w\beta(w)(-\sigma)\frac{p^{-1-\sigma}}{P^{1-\sigma}}M = 0 \tag{5.6}$$

$$\frac{\delta\pi}{\delta w} = -[\alpha(n) + \beta(w)x] - w\beta'(w)x = 0. \tag{5.7}$$

Solving (5.6) and (5.7) we get,

$$p = \frac{\beta(w)w}{\rho} \tag{5.8}$$

$$w = -\frac{\alpha(n) + \beta(w)x}{\beta'(w)x}. \tag{5.9}$$

Equation (5.8) and (5.9) gives the prices charged and wage offered by each firm respectively. Markup pricing by each firm reflects their monopoly power in the markets. As

the varieties become closer substitutes (indicated by a higher ρ) market power for each firm diminishes. Rearranging equation (5.9) we get

$$w\beta'(w)x = -[\alpha(n) + \beta(w)x]$$

which after some manipulations yields

$$x^{s.r.} = \frac{\alpha(n)}{\beta(w)(\theta - 1)} \tag{5.10}$$

where $\theta = \frac{-w\beta'(w)}{\beta(w)}$ is the elasticity of the efficiency wage schedule of the workers. We term the per firm output $x^{s.r.}$ as the "short run" output of each firm. By short run, it is meant that the per firm output in equation (5.10) is consistent for any given number of varieties (That is, it is solved taking the number of varieties as exogenously given). However, the number of varieties are determined from the zero profit conditions and the per firm output has to be consistent with it.

To characterize the "long run" equilibrium we assume that presence of profit opportunities would cause entry whereas losses would imply that firms would exit from the industry. This would in turn mean that in the equilibrium firms earn zero profits. The surplus earned by each firm is $\frac{px}{\sigma}$ and the fixed costs incurred is $\alpha(n)w$. At the equilibrium

$$\frac{px}{\sigma} = \alpha(n)w \tag{5.11}$$

or,

$$x = \frac{\alpha(n)\rho}{\beta(w)(1 - \rho)} \tag{5.12}$$

where x is the long run output. It is to be noted that equations (5.11) and (5.12) are true only when the number of firms are determined by the zero profit condition. Comparing equations (5.10) and (5.12) the long run value of θ is $\frac{1}{\rho}$, which is greater than unity. Thus, the requirement of positive per firm output restricts the value of θ to be greater than unity.

The total number of varieties available in the economy determines the wage rate. This is seen from equations (5.9) and (5.12). The profit maximizing wage offered by

each producer at the equilibrium is independent of the labour supply in the economy. Even if there is an excess supply of labour, wages (as in equation (5.9)) would not be lowered. It is this feature of the model that has the potential to generate unemployment.

5.2.4 Determination of the wage rate

We normalize the aggregate price index to unity. Thus equation (5.3) becomes

$$1 = np^{1-\sigma} = n\left(\frac{\beta(w)w}{\rho}\right)^{1-\sigma}. \tag{5.13}$$

We define for any arbitrary variable, z, $\hat{z} \equiv \frac{dz}{z}$. Total differentiation of equation (5.13) gives,

$$\hat{n} = (\sigma - 1)\hat{w}(1 - \theta). \tag{5.14}$$

Equation (5.14) shows that in the autarky situation there exists a negative relationship between the number of varieties and the wage rate. As the number of varieties increase in the economy, a normalised price index implies that price of each variety rises. From the pricing equation (5.8) this in turn would mean that $\beta(w)w$ would have to increase. Falling wages directly reduces this term, but increases $\beta(w)$. The restriction on the efficiency schedule of the workers ($\theta > 1$) implies that wages would have to fall to increase the price of each brand.

Equation (5.13) and equation (5.10) determines the wage rate and the per firm output for any given number of varieties. For any fixed number of varieties, the wage rate is determined uniquely from equation (5.13). (Note that equation (5.14) shows that wages are a monotonically decreasing function of the number of varieties). Equation (5.10) then determines output. We term this situation as the short run situation, as the number of firms are taken exogenously given. In the long run situation the zero profit conditions determine the number of firms and the per firm output is given by equation (5.12).

5.2.5 Determination of number of firms in autarky (long run equilibrium):

Stability in the present model requires that suitable restrictions be imposed on the behaviour of firms as regards to their entry and exit decisions. We assume that existence of profit opportunities attracts new entrants into the industry whereas losses would cause firms to exit. Any stable equilibrium demands that as new firms enter, profits should fall, while exit should cause the per firm profits to rise. That is $\frac{px}{\sigma} - \alpha(n)w$ (see equation (5.11) and the discussion above it) should be a decreasing function of n. Suppose we start from a situation where positive profits are earned by the firms. Then

$$\begin{aligned} \frac{px}{\sigma} - \alpha(n)w &\geq 0 \\ or, \frac{px}{\sigma} &\geq \alpha(n)w \\ or, \frac{\beta wx}{\rho\sigma} &\geq \alpha(n)w \\ or, \frac{\beta x}{\alpha(n)} &\geq \rho\sigma \end{aligned} \tag{5.15}$$

where the third step is obtained from equation (5.8). The stability condition thus requires that $\beta x/\alpha(n)$ is a decreasing function of n and is indicated by the downward sloping DD curve in figure 5.1. The horizontal CC curve represents the value of $\rho\sigma$. The determination of the number of firms is shown in figure 5.1.

The DD curve intersects the CC curve at E. The equilibrium number of firms is denoted by n^*. As seen from the figure the equilibrium is stable. If the total number of firm is lesser than that at n^*, firms enjoy supernormal profits and hence there will be entry. On the other hand if the numbers of firms are more than n^* firms would make losses and hence there will be exit. At the equilibrium $\frac{\beta x}{\alpha(n)} = \rho\sigma$; this in turn implies that value of per firm output is given by equation (5.12). Also the LHS of the inequality (5.15) can be expressed in terms of elasticity of the efficiency schedule of the workers,

$$\frac{\beta(w)x}{\alpha(n)} = \frac{\beta(w)\frac{\alpha(n)}{\beta(w)(\theta-1)}}{\alpha(n)} = \frac{1}{(\theta-1)}. \tag{5.16}$$

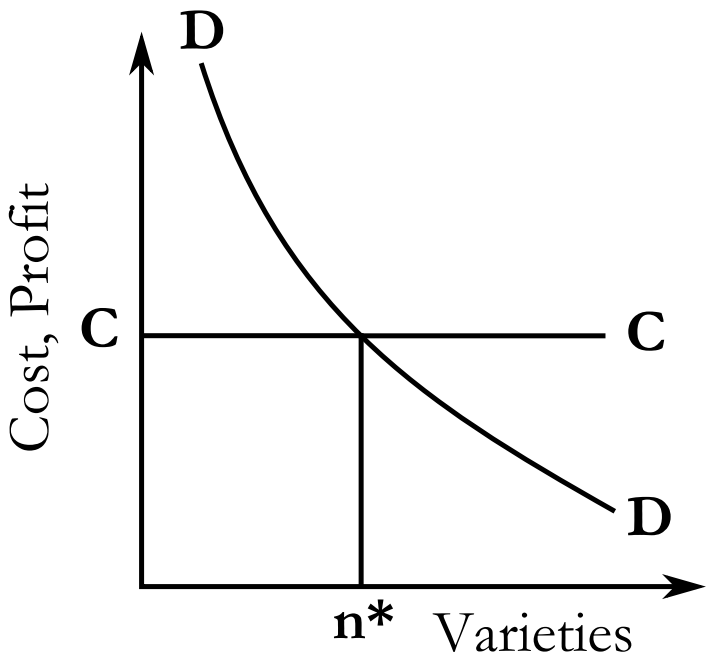

Figure 5.1 Equilibrium determination of varieties

The first equality follows from equation (5.10).

Let $g(\theta) = 1/(\theta - 1)$. Total differentiation of $g(\theta)$ yields,

$$\frac{\hat{g}}{\hat{n}} = \frac{-\theta}{\theta - 1}\frac{\hat{\theta}}{\hat{w}}\frac{\hat{w}}{\hat{n}}. \tag{5.17}$$

Stability implies that the sign of the LHS of equation (5.17) is negative. We also know, that since $\theta > 1$, the first term is negative. From equation (5.14), the third term is also negative. So to ensure a stable equilibrium the second term must be unambiguously negative.

Now, $\theta = -w\beta'(w)/\beta(w)$. Total differentiation of both sides gives,

$$\hat{\theta} = -[\hat{w} + (w\beta''(w))/(\beta'(w))\hat{w} + \theta\hat{w}]. \tag{5.18}$$

Dividing both sides of equation (5.18) by $\hat{w}$ the stability condition becomes

$$\frac{\hat{\theta}}{\hat{w}} = -[1 + \theta + \frac{w\beta''(w)}{\beta'(w)}] < 0. \tag{5.19}$$

Suppose free entry restricts the number of firms to n^*. The aggregate labour demand is $n^*(\alpha(n^*) + \beta(w^*)x)$. Suppose, from equation (5.9), the wage rate consistent with n^*, is w^*. Efficiency requirements demands that wages are fixed at w^* whereas zero profit conditions along with stability requirements fix the number of firms at n^*. There is no mechanism in the model which would guarantee the clearance of the labour market. The unemployment that may exist in our model is clearly due to efficiency wages. In general

$$n^*(\alpha(n^*) + \beta(w^*)x) \leq L^S, \tag{5.20}$$

where strict inequality means the labour market exhibits equilibrium unemployment.

5.3 Trading Equilibrium

Suppose there is another economy which is completely identical to that analyzed in Section 5.1. As in Krugman (1980), we now consider trade between these identical nations. From the first order condition of utility function maximisation of the consumers

$$\frac{C^h}{C^f} = (\frac{p_h}{p_f})^{-\sigma} \tag{5.21}$$

where, C^h and C^f represents the consumptions of the representative home and foreign brands and p_h and p_f represents their respective prices. Market clearing for each brand would mean that

$$\frac{x^h}{x^f} = (\frac{p_h}{p_f})^{-\sigma} \tag{5.22}$$

where x^h and x^f are the outputs of the home and foreign firm respectively. Using equation (5.10) and the pricing equation (5.8) this can be written as

$$\frac{\frac{\beta(w_h)^{\sigma-1}w_h^{\sigma}}{\theta_h - 1}}{\frac{\beta(w_f)^{\sigma-1}w_f^{\sigma}}{\theta_f - 1}} = 1 \tag{5.23}$$

where w_h and w_f represents the wages in the home and foreign country, and θ_h, θ_f represents their respective elasticity of their efficiency schedule. The numerator and the denominator of the LHS and the RHS are only functions of wages in the home and the foreign country. Thus we can write equation (5.23) as

$$\frac{\phi(w_h)}{\phi(w_f)} = 1. \tag{5.24}$$

Assuming the function $\phi(w)$ to be a monotonic function of wage rate, equation (5.24) would imply factor price equalisation (See Appendix 2).

We assume that there is complete knowledge spillovers, and thus $\alpha(n^T)$ is common for both the nations when n^T is the post trade total number of varieties across the world. Thus trade (from equation (5.24) and our assumption of monotonicity) equalises wages, prices (see equation (5.8)), elasticity of the labour schedules and the per firm output (see equation (5.12)) in both the countries. It is more interesting to note the effect trade has on the total number of varieties produced in the world and also on the number of varieties produced in home and foreign. This can be derived as follows. In the equilibrium, the zero profit condition must hold both in the autarky and the post trade situation. So the operating profits in both these situations would be equal to the fixed costs of operation. From equation (5.16) the zero profit conditions can be expressed in terms of elasticities. So

$$\frac{1}{\theta_A - 1} = \frac{1}{\theta_T - 1} = \rho\sigma \tag{5.25}$$

where θ_A and θ_T represent the elasticity terms in the pre-trade and post trade situations respectively. Equation (5.25) along with figure 5.1 implies that the number of varieties produced in the home country in the autarky situation would be equal to the total varieties produced in the world after trade opens up, also the varieties produced in the home country falls as trade opens up, as compared to the autarky situation. This is because n^T is determined uniquely, though n_h^T and n_f^T, i.e. the post trade varieties produced in home and foreign, are not determined uniquely from figure 5.1 in the post

trade situation. The post trade situation can be thus summarised as

$$\theta_A = \theta_T, \tag{5.26}$$

$$n_A = n_T. \tag{5.27}$$

Consider the home economy. Trade with an identical nation leads to a post-trade equilibrium situation with number of varieties identical to the number of varieties produced in the autarky. Thus, it can be concluded that in the post trade situation the number of varieties produced in the home economy actually falls. This has interesting implication for the equilibrium rate of unemployment in the economy. Using equations (5.12) and equation (5.27) aggregate labour demand in the economy in the autarky situation can be compared with that of the post trade situation,

$$n^A(\alpha(n^A) + \beta(w^*)x) = n^A[\alpha(n^A) + \alpha(n^A)\frac{\rho}{(1-\rho)}] = n^A\frac{\alpha(n^A)}{1-\rho} = n^T\frac{\alpha(n^T)}{1-\rho}. \tag{5.28}$$

As the country opens up to trade aggregate demand for labour becomes $n_h^T\frac{\alpha(n^T)}{(1-\rho)}$ which is less than $n^T\frac{\alpha(n^T)}{1-\rho}$, where n_h^T represents the number of varieties produced in the home country after trade. If we assume that inequality (5.20) holds, then this would mean that the unemployment level of the economy rises after trade compared to autarky. Thus labour demand falls and unemployment rises due to trade. Moreover as we assume that both nations are symmetric; unemployment rises in the foreign country as well. Thus trade can cause both countries to face a higher unemployment rate after opening up. This very special result is obtained due to the presence of wage rigidities (which are in turn generated due to the efficiency considerations of the producers) and the strong learning effects assumed in the managerial tasks (which are again the fixed costs of productions).

5.4 Conclusion

The present model incorporates features of a monopolistically competitive market into a efficiency wage model of unemployment. It is found that for a large enough labour

supply of an economy there is unemployment in the autarky. Opening up to trade brings efficiency gains by reducing the fixed costs of production. Since wage is rigid a further lower demand for workers implies higher unemployment. Moreover the effect is exactly similar for an identical trading partner. Thus trade can reduce employment for both countries compared to the autarky situation.

5.5 Appendices

5.5.1 Appendix 1

In this appendix we would discuss the relevant second order conditions related to the maximisation of profits by the individual firms. Profit maximisation implies that the principle minors of the determinant $\begin{vmatrix} \pi_{pp} & \pi_{pw} \\ \pi_{wp} & \pi_{ww} \end{vmatrix}$ should alternate in sign beginning from negative.

$$\pi_{pp} = \frac{-\rho\sigma p^{-(\sigma+1)}}{P^{1-\sigma}} M < 0 \tag{5.29}$$

$$\begin{aligned} \pi_{pp}\pi_{ww} - \pi_{wp}\pi_{pw} &= \frac{\rho\sigma p^{-(\sigma+1)}}{P^{1-\sigma}} Mx(2\beta^{'}(w) + w\beta^{''}(w)) \\ &= \frac{\rho\sigma p^{-(\sigma+1)}}{P^{1-\sigma}} Mx\beta^{'}(w)(2 + \frac{w\beta^{''}(w)}{\beta^{'}(w)}) \end{aligned} \tag{5.30}$$

Equation (5.29) is obtained by differentiating equation (5.7) and using equation (5.8). Note that our assumption of a convex efficiency wage schedule i.e. $\beta^{''}(w) > 0$ is a necessary condition for the inequality (5.30) to hold.

5.5.2 Appendix 2

We identify the condition required for factor price equalisation in our model. As discussed in the main text factor price equalisation would occur due to trade only if the function $\phi(w)$ is a monotonic function of wages. Now from the main text,

$$\phi(w) = \frac{\beta(w)^{\sigma-1} w^{\sigma}}{\theta - 1}. \tag{5.31}$$

Total differentiation of both sides of equation (5.31) gives,

$$\hat{\phi(w)} = -[\sigma - 1]\theta\hat{w} + \sigma\hat{w} - \frac{\theta}{\theta - 1}\hat{\theta} = [-(\sigma - 1)\theta + \sigma - \frac{\theta}{\theta - 1})A]\hat{w} \tag{5.32}$$

where the last step follows from equation (5.19). The RHS of (5.19) is represented as A in the above expression. Monotonicity of the required function requires that $[-(\sigma - 1)\theta + \sigma - \theta/(\theta - 1)A] > 0$ everywhere or else < 0 everywhere .

Chapter 6

Innovation and labour mobility

6.1 Introduction

Endogenous growth theory identifies technological progress to be one of the major determinant of economic growth. Existing literature based on product-variety framework of Grossman and Helpman (1992), identifies economic growth as a process of expansion of the number of varieties available to the consumers in the market, or alternatively as an increase in the average quality of a fixed set of varieties. Technological progress, as understood in standard endogenous growth models, is modelled as a process of innovation that leads to the discovery of new varieties, or continuous improvement in the quality of a given set of varieties. This rate of innovation itself becomes the growth rate of the economy. Grossman and Helpman (1991a, 1992b, and 1992) shows how this process of innovation of new varieties, gets enhanced when trade in product market is coupled with spillover effects of knowledge capital. This in turn gets translated into a higher growth rate of the economy. The argument is as follows: Countries that engage in trade, learn more about newly innovated products and thus the knowledge stocks of these economies are enhanced. This is modelled in this genre of literature as a decline in the costs of innovation, which in turn causes the growth rate to shoot up.

All these models comprise of an innovating country designated as "North" and an im-

itating "South". Krugman (1979a) comprises of an innovating North and non-innovating South. In this paper, North innovates new products, but the technology of production later becomes available to South. Thus North imports old goods from South, and exports new products. It is shown that technological progress raises the marginal productivity of capital, wherever it occurs. This opens a channel of foreign investment. Also free movement of capital across nations, equalizes the income of the factors in both regions, while increasing the inequality of income of immobile factors. Grossman and Helpman (1992) builds a dynamic model of a small open economy with full capital mobility. The economy trades two consumer goods and also there is a possibility of trade in financial assets. There is a manufacturing sector which employs labour and capital for production of an intermediary good (which is used in the production of the final goods) and the two final goods. The intermediary good is non-traded. It is shown that inflow of foreign capital may cause the rate of innovation to decline (which is also the growth rate of the economy). For a sufficiently high interest rate, households choose to reallocate some of their savings from local research to initially higher yielding foreign bonds. However, the result may get reversed if inflow of knowledge capital is also incorporated. Grossman and Helpman (1992) stresses the importance of knowledge capital in long run growth performance of the economy. It is shown that, in case of a large economy international transmission of knowledge along with trade in consumer goods raises the growth rate in comparison to only trade in goods.

With the enhancement of the process of globalization, many developing nations have entered into the world trading system. One of the major features of these countries is a tendency to copy the varieties produced by the innovating North by a costly process of imitation. Lower manufacturing costs in the developing countries, often gets them an advantage over the Northern products and thus they can capture a larger share of the global markets. Consequently, the developed countries have often called for stronger intellectual property rights (IPR) to protect their markets from relatively cheaper Southern products. The agreement on Trade Related Intellectual Property Rights (TRIPS)

under GATT -1994 requires that developing nations should impose stronger intellectual property rights in their countries. An enormous literature have developed dealing with the issue of intellectual property rights and its welfare consequences. (See Helpman (1993), Lai (1998) and Grossman and Helpman (1991a))

All these models consider an innovating North and an imitating South and the existence of a steady state equilibrium is assumed. Schumpeter (1947) and Romer (1991) argue that stronger protection of the fruits of R&D should enhance the rate of product development. However, in models based on product differentiation, the effect of strengthening of IPR becomes more nuanced. In general the effect of strengthening of IPR is ambiguous. Lai (1998) compares two vehicles of technology transfer, between North and South. These are foreign direct investment (FDI) and the imitation of Northern products by Southern firms. Building a model closely on Grossman and Helpman (1991b) and Helpman (1993) it is shown that if multi-nationalisation is the channel of technology transfer, then rate of innovation increases in a world with stronger property rights. However, in Grossman and Helpman (1992) and Helpman (1993), stronger IPR lowers the rate of innovation in North.

Lundborg and Segerstrom (2000, 2002) analyses the effect of labour mobility in these set up. Lundborg and Segerstrom (2000) uses a two country quality ladder model, and shows that free international migration increases world growth rate if it is caused due to labour supply imbalances, while it can lower the global growth rate if it is induced by policy measures. Lundborg and Segerstrom (2002) analyses the effects of immigration quotas on the growth rate and welfare, in a North-South trade model with quality ladders.

The present model closely builds on Grossman and Helpman (1992). Two kinds of labour force are available in each country, "skilled" and "unskilled". Skilled labour is used for innovation in North and for imitation purposes in South. Moreover, it is assumed that skilled labour is perfectly mobile across the countries which in turn equalises the skilled wage rate across the world. Unskilled labour is immobile across the countries

and used only for routine production. Thus their wages may not converge across the countries. This basically is an international specific factor model. Product development, as in Grossman and Helpman (1992) determines the global growth rate in this economy. Free trade occurs between the regions. Since the same mobile factor is used for innovation and imitation, a steady state equilibrium is characterised by a constant and common growth rate of both regions, that depends solely on the endowment of skilled labour across the world and technological parameters. As common in literature, the steady state equilibrium can be consistent with a wide gap or a narrow gap equilibrium. In a wide gap equilibrium, the cost advantage of Southern producers (reflected as relatively lower wages of unskilled workers in South vis-a-vis that in North) is sufficiently high to enable them to charge their monopoly price. In a narrow gap equilibrium, the cost advantage enjoyed by the Southern producers is not sufficiently high and thus Northern producers can undercut them profitably if they charge a monopoly price. In contrast to Grossman and Helpman (1992), the growth rate of the global economy is same in both the regimes. This is because the growth rate depends only on the endowment of skilled labour (besides the technological parameters). Moreover, the wide gap equilibrium is not unique, though a unique stable equilibrium is identified. Strengthening of intellectual property rights lowers the growth rate in the world economy. As IPR becomes stronger per unit skilled labour requirement for imitation rises, which draws from the fixed global pool of skilled labour reducing the growth rate of the economy.

Governments often go for subsidisation of innovation or imitation ventures respectively in North and South. Subsidies have no effect on growth rate in this model. Interestingly, imposition of subsidy by the North in a narrow gap equilibrium has no effect on the rate of imitation though in the wide gap equilibrium it increases the rate of imitation.

Section 6.2 discusses the basic set up. Section 6.3 and Section 6.4 characterizes the wide gap and narrow gap equilibrium and analyses the effects of subsidies respectively. Section 6.5 concludes the model.

6.2 Basic set-up

6.2.1 Consumers

There are two countries North (N) and South (S) inhabited by consumers who are identical with respect to their preferences. The representative consumer maximises lifetime utility given by

$$U = \int_t^{\infty} e^{-\rho(\tau - t)} \log C(\tau) d\tau \tag{6.1}$$

subject to the inter temporal budget constraint

$$\int_t^{\infty} e^{-r^i(\tau - t)} E^i(\tau) d\tau = \int_t^{\infty} e^{-r^i(\tau - t)} I^i(\tau) d\tau + A^i(t) \ \forall t, \ i = N, S \tag{6.2}$$

where $E^i(\tau)$, and $I^i(\tau)$, represents aggregate expenditure, and aggregate income in any given period of time. $A^i(t)$ is the total assets at the beginning of each period. ρ and r^i represents the rate of discount of the consumers and the interest rate in the i th country respectively. It is further assumed that the consumption index $C(\tau)$ is an aggregation of differentiated varieties produced by firms operating both in North and South. The specification of the consumption index (or the instantaneous utility) is given by

$$C(\tau) = \left[\int_0^n x_j^{\alpha} dj \right]^{\frac{1}{\alpha}} \tag{6.3}$$

where, $0 < \alpha < 1$.

Utility maximisation yields

$$\frac{\dot{E}^i}{E^i} = r^i - \rho. \tag{6.4}$$

Aggregate spending in the world economy equals $E(\tau) = E^N(\tau) + E^S(\tau)$. $E(\tau)$ is normalized to unity, at every moment of time. This guarantees a nominal interest rate of ρ in each country in steady state. (See Grossman and Helpman (1992)). Thus $r = r^N = r^S = \rho$.

6.2.2 Producers in North

It is assumed that there are two types of labour forces available in the world. The first kind of labour is called "skilled" labour and they are perfectly mobile across the nations. Skilled labour is used for innovation in North and imitation in South. Free mobility ensures that their wages are equalised across the world and they earn a wage equal to w^{skill}. The other type of labour termed as "Unskilled" is fixed across countries (i.e. immobile) and is used for carrying out production of innovated or imitated varieties respectively in North and South. It is assumed that one unit of unskilled labour is used for per-unit production in North, hence profit maximisation leads to

$$p_N = \frac{w_N^U}{\alpha} \tag{6.5}$$

where w_N^U is the Northern wage rate of unskilled labourers. As in Grossman and Helpman (1992), $\frac{a}{n}$ units of labour are required for innovation. $a > 0$, is technologically given and n represents the total number of varieties. Further, $n = n_N + n_S$ where n_N and n_S are the varieties produced by North and South respectively. A higher number of varieties reduces the cost of innovation, reflecting the fact that there are increasing returns to knowledge. It is this specification of the technology that generates endogenous growth in these models (See Romer (1991)). Suppose that each innovated blueprint has a market value v_N. Allowing free entry in the Northern innovation sector implies that firms earn zero-profits from innovation

$$v_N = \frac{w^{skill} a}{n}. \tag{6.6}$$

A Northern firm owning a blueprint that has not yet been imitated by southern producers earns profits $\pi_N dt$ for the time interval dt. In any particular time interval, $\dot{n_S}$ [1] products are copied. If the blueprint is copied by Southern producers, the northern firm owning the blueprint suffer a loss equal to v_N with a probability $\frac{\dot{n_S}}{n_N} dt$, otherwise they gain or loose $\dot{v_N}$ with a probability $(1 - \frac{\dot{n_S}}{n_N} dt)$. Hence the net expected return of a Northern firm

[1] For a variable x, $\dot{x}$ represents its derivative with respect to time.

from a newly innovated product, is $\pi_N dt - \frac{\dot{n_S}}{n_N} dt v_N + (1 - \frac{\dot{n_S}}{n_N} dt)\dot{v_N} dt$. Taking dt to be very small, the no-arbitrage condition of the Northern firms can be found by equating this expected return with a consumption loan of v_N as

$$\frac{\pi_N}{v_N} + \frac{\dot{v_N}}{v_N} - \frac{\dot{n_S}}{n_N} = r^N = \rho. \tag{6.7}$$

Finally the Northern unskilled labour market clears,

$$n_N x_N = L_N^U. \tag{6.8}$$

6.2.3 Producers in South

Grossman and Helpman (1992) characterizes two kinds of steady state equilibrium. "Narrow gap equilibrium" is a situation where the cost advantage enjoyed by the Southern producers is relatively small. In this situation if the Southern producers charge a monopoly price w_S^U/α, Northern producers can always undercut them profitably. In an equilibrium Southern firms would charge a price equal to the cost of the Northern firm. Thus the narrow gap equilibrium is characterised by

$$p_S = w_N^U \tag{6.9}$$

$$\pi_S = (p_S - w_S^U)x_S = p_S x_S(1 - \frac{w_S^U}{p_S}) = (1 - \frac{w_S^U}{w_N^U})p_S x_S \tag{6.10}$$

$$v_S = \frac{w^{skill} a_m}{n_S} \tag{6.11}$$

where, a_m/n_S is the labour required for imitation and the last equality follows from the fact that free entry into the Southern imitation sector causes firms to break even.

In a "wide gap equilibrium", the cost differential in North and South is sufficiently large enabling the Southern firms to charge a monopoly price. The wide gap equilibrium can be thus characterized by

$$p_S = \frac{w_S^U}{\alpha} \tag{6.12}$$

$$\pi_S = (1 - \alpha)p_S x_S \tag{6.13}$$

and the value of the Southern firm given by equation (6.11). Finally Southern unskilled labour market clears

$$n_S x_S = L_S^U. \tag{6.14}$$

6.2.4 Steady state with Narrow gap equilibrium

A narrow gap equilibrium will be consistent with a steady state of the economy, if and only if the cost advantage experienced by the Southern producers is small enough. Using equations (6.5) to (6.9), and the no arbitrage condition of North (see equation (6.33) in Appendix 1) can be expressed as

$$\frac{1-\alpha}{\alpha}\left(\frac{w_N^U}{w^{skill}}\right)\left(\frac{L_N^U}{a}\right)\left(\frac{m+g}{g}\right) = \rho + g + m \tag{6.15}$$

(See Appendix 1 for detailed derivation) where $m = \frac{\dot{n_S}}{n_N}$ is the rate of imitation by the Southern producers and $g = \frac{\dot{n}}{n}$ is the growth rate of the world economy [2]. The no-arbitrage condition of the Southern producers can be written as

$$\frac{\pi_S}{v_S} = \rho + g. \tag{6.16}$$

This can be expressed as:

$$\frac{\pi_S}{v_S} = \frac{x_s(w_N^U - w_S^U)}{a_m \frac{w^{skill}}{n_S}} = \frac{L_S^U(w_N^U - w_S^U)}{a_m w^{skill}} = \rho + g. \tag{6.17}$$

The first equality follows from equations (6.6) and (6.9) and from the expression of profits given in equation (6.10). The second equality follows from the market clearing condition of the unskilled labourers in South given by equation (6.14). Dividing equation (6.15) by (6.17) we get

$$\left(\frac{a_m}{a}\right)\left(\frac{\omega}{\omega-1}\right)\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{L_N^U}{L_S^U}\right)\left(\frac{m+g}{g}\right) = \frac{\rho+g+m}{\rho+g}. \tag{6.18}$$

[2] In the steady state, there is a convergence of growth rates of the number of varieties in each region. Thus if $g^i = \frac{\dot{n^i}}{n^i}$ is the growth rate of the i th region, then in the steady state, $g = g^N = g^S$.

Here $\omega = \frac{w_N^U}{w_S^U}$ is the ratio of unskilled wages across the two nations. It is to be noted that since the RHS of the above equation is unambiguously positive, it is guaranteed that the wages earned by the unskilled workers in North would be higher than that of Southern unskilled workers (i.e. $\omega > 1$). Skilled labour required for innovation and imitation are $\frac{a}{n}$ and $\frac{a_m}{n_S}$ respectively. Market clearing for skilled labour would imply,

$$\begin{aligned} \frac{a}{n}\dot{n} + \frac{a_m}{n_S}\dot{n_S} &= L^{skill} \\ g &= \frac{L^{skill}}{a + a_m}. \end{aligned} \tag{6.19}$$

Equation (6.19) conveys one of the most interesting messages of this model. In a world which allows free mobility of the specific factor that is used for innovation and imitation purposes in North and South respectively, *the growth rate becomes a constant*. Moreover, this growth rate is independent of the choice of regime, i.e. in a steady state equilibrium consistent with a wide gap or with a narrow gap, the growth rate remains the same. Strengthening of IPR (reflected as a increase in a_m) lowers the growth rate of the economy.

First order condition of utility maximisation implies

$$\frac{C_N}{C_S} = \frac{x_N}{x_S} = (\frac{p_N}{p_S})^{-\sigma}. \tag{6.20}$$

C_N and C_S are the consumptions of a Northern and Southern variety across the world. Multiplying both sides of equation (6.20) by $\frac{n_N}{n_S}$, and using the pricing equations (6.5) and (6.9) we get

$$\frac{n_N x_N}{n_S x_S} = \alpha^\sigma \frac{1-\iota}{\iota}$$

where ι is the share of southern varieties to the total number of varieties globally produced. Using the fact that labour market for unskilled labour (see equations (6.8) and (6.14)) clears we get

$$\frac{L_N^U}{L_S^U} = \alpha^\sigma \frac{g}{m}. \tag{6.21}$$

This determines the steady state rate of imitation m. Once the growth rate and the rate of invitation is determined, equation (6.18) determines ω. The only variables that remains to be determined are the wage rates of unskilled labour in both the countries and the wage rate of skilled labour. For the determination of these wage rates, we substitute the demand for a typical northern variety [3] in equation (6.8) and this yields

$$\frac{(\frac{n_N}{n_S})(\frac{p_N}{p_S})^{-\sigma}p_S^{-1}}{(\frac{n_N}{n_S})(\frac{p_N}{p_S})^{1-\sigma}+1} = L_N^U.$$

Using equations (6.5), (6.9), and (6.20) this can be expressed as

$$\frac{\frac{L_N^U}{L_S^U}\frac{1}{w_N^U}}{\frac{L_N^U}{L_S^U}\frac{1}{\alpha}+1} = L_N^U. \tag{6.22}$$

Equation (6.22) along with equation (6.18) and equation (6.15) completes the description for the narrow gap equilibrium by determining w_S^U and w^{skill}.

6.2.5 Steady state with Wide gap equilibrium

In case of a steady state equilibrium, consistent with a wide gap, the cost advantage experienced by the Southern producers is sufficiently large, so that they can charge their monopoly price.

$$p_S = \frac{w_S^U}{\alpha} \tag{6.23}$$

which implies that the profits enjoyed by them are

$$\pi_S = (1-\alpha)p_S x_S. \tag{6.24}$$

The growth rate will be identical to that of the narrow gap case as given by the equations (6.19). This is because contrary to Grossman and Helpman (1992) the growth rate is determined by labour mobility independent of the fact whether the equilibrium is a

[3] For demand functions, see Krugman (1979).

narrow gap or a wide gap equilibrium. The no arbitrage condition for the Southern producers can be written as

$$\frac{\pi_S}{v_S} + \frac{\dot{v_S}}{v_S} = \rho. \tag{6.25}$$

This equation can be manipulated as follows:

$$\frac{\pi_S}{v_S} + \frac{\dot{v_S}}{v_S} = \frac{(1-\alpha)p_S x_S}{v_S} - g = \rho \implies (\frac{1-\alpha}{\alpha})(\frac{w_S^U}{w^{skill}})(\frac{L_S^U}{a_m}) = \rho + g$$

where the second equality follows from the labour market clearing condition of southern unskilled labour given by equation (6.14). Dividing the no arbitrage condition of Northern producers (as in equation (6.15)) with this relation, and after some manipulations (See Appendix 2) we get

$$(\frac{m}{g})^{\frac{-1}{\sigma}}(\frac{m}{g}+1) = \frac{a}{a_m}(\frac{L_N^U}{L_S^U})^{\frac{1-\sigma}{\sigma}}(\frac{\rho+g+m}{\rho+g}). \tag{6.26}$$

Equation (6.26) is represented by figure-6.1.

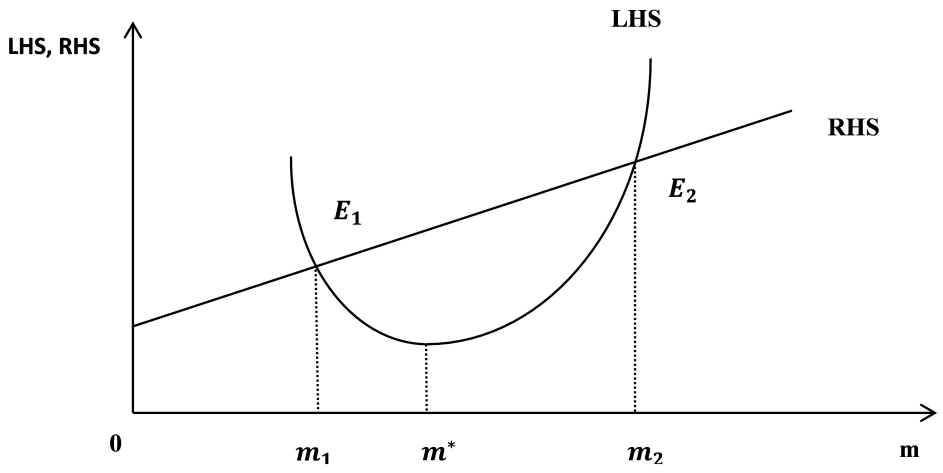

Figure 6.1 Steady state wide gap equilibrium

The LHS and RHS of this equation is plotted with respect to m, the rate of imitation. The RHS is a positively sloped straight line with a positive intercept. Total differentiation of the LHS gives

$$\hat{LHS} = \frac{-1}{\sigma}\hat{m} + \frac{m}{m+g}\hat{m}. \tag{6.27}$$

For, $m < \frac{g}{\sigma-1}$ this curve is falling and this curve is rising for all other positive values of m. This implies that there are two possible equilibrium, designated E_1 and E_2 in the figure. Contrary to Grossman and Helpman (1992), both these equilibriums are consistent with a wide gap situation. However, for any rate of imitation, m within the range $(0, m_1)$ the LHS lies above the RHS. LHS of equation (6.26) is obtained by taking the ratio of returns to capital in North and South and thus can be viewed as relative rate of return to capital operating in North. The RHS of the equation is obtained by taking a ratio of the user cost of capital in North vis-a- vis South and thus can be viewed as relative user cost of capital in North. Thus in the range $(0, m_1)$ since the relative return to capital operating in North is higher than the relative user cost, there would be a tendency of "capital flight" from South to North, and the rate of imitation would fall. In other words, as innovation becomes relatively profitable to imitation, mobile firms will relocate themselves in North. Similarly for all possible rates of imitation in the range (m_1, m_2) it is more profitable to imitate than innovate, so rate of imitation would have a tendency to rise. In this sense m_1 is an unstable equilibrium. A similar reasoning establishes m_2 as a stable equilibrium. In the rest of the paper it is assumed that the economy, if it is indeed in a wide gap steady state equilibrium, then that equilibrium must be the stable one.

The determination of the unskilled wages and the skilled wage is similar to that of the narrow gap equilibrium. Equations (6.15) and (6.25) along with labour market clearing conditions (given by (6.8) and (6.14)) can be manipulated (as in the previous section) to obtain w_N^U, w_S^U, and w^{skill}.

6.3 Role of Subsidies

Grossman and Helpman (1992) discusses the effects of subsidies as a policy tool to affect the rate of innovation. It is instructive to compare the effects of subsidy in the present model, when the specific factor used for innovation and imitation is perfectly mobile.

Suppose ϕ^N is the fraction of product development costs that is borne by the government as subsidy in the North. The cost of innovation in North falls to $\frac{w^{skill}(1-\phi^N)a}{n}$. The value of the firm in this case becomes

$$v_N = \frac{w^{skill}(1-\phi^N)a}{n}. \tag{6.28}$$

To fix ideas, first the wide gap equilibrium is considered. As it is clear from equation (6.19), a subsidy has no effect on the growth rate in the steady state equilibrium. Equation (6.26) can be re-written, by incorporating the effect of subsidy, as:

$$(\frac{m}{g})^{\frac{-1}{\sigma}}(\frac{m}{g}+1) = \frac{a(1-\phi_N)}{a_m}(\frac{L_N^U}{L_S^U})^{\frac{1-\sigma}{\sigma}}(\frac{\rho+g+m}{\rho+g}). \tag{6.29}$$

From equation (6.29), starting from a stable equilibrium, the rate of imitation falls, as the RHS of the equation shifts downwards and also becomes flatter. The effect of subsidy is shown in figure 6.2. Dividing the no arbitrage conditions of North and South given

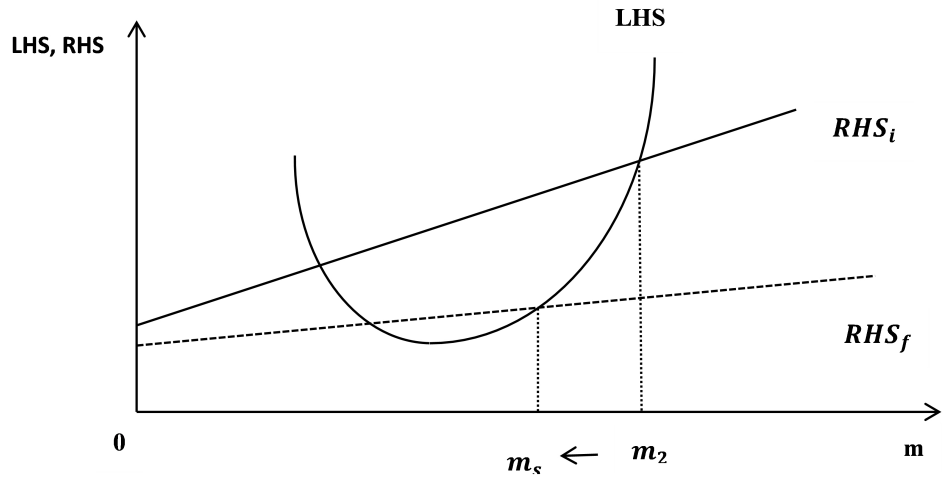

Figure 6.2 Subsidy by Northern Government in a wide gap steady state equilibrium

by equations (6.15) and (6.25) respectively, we get

$$\omega(\frac{L_N^U}{L_S^U})\frac{a_m}{a(1-\phi_N)} = (1+\frac{m}{\rho+g})(\frac{g}{m+g}). \tag{6.30}$$

The effect on relative wages of the unskilled workers, as seen from the above equation is ambiguous. Subsidy, for a given rate of imitation decreases the ω, which is seen from the LHS of the above equation. However, the rate of imitation itself falls, which increases the RHS and thus the overall effect is ambiguous.

Now consider the narrow gap equilibrium, both the rate of imitation and the growth rate remains unchanged as a result of the subsidy. This is because the skilled labour market clearing condition determines the growth rate, in equation (6.19) which then determines the rate of imitation of South from equation (6.21). Both of these equations are independent of the subsidy. However, the relative unskilled wage rate between North and South changes and moves in favour of the Northern unskilled workers. This can be seen from equation (6.18) which now becomes

$$\frac{1-\alpha}{\alpha}\left(\frac{1}{1-\frac{1}{\omega}}\right)\frac{L_N^U}{L_S^U}\left(\frac{a_m}{a(1-\phi_N)}\right)=\frac{\rho+g+m}{\rho+g}. \tag{6.31}$$

In Grossman and Helpman (1992) imposition of subsidy in a narrow gap equilibrium increases both growth rates and the rate of imitation.

Table 6.1 compares the effects of subsidy by the Northern government in the two models (G-H indicates the model developed by Grossman and Helpman (1992)).

Table 6.1 Subsidy by Northern government

	Present model	G-H model
Wide gap equilibrium	m falls, g unchanged	m falls, g unchanged
Narrow gap equilibrium	m & g unchanged	m & g rises

Southern government may also give a subsidy to facilitate imitation by the Southern producers. Let ϕ_S be the subsidy given by the Southern government to the southern producers. In case the equilibrium is a wide gap equilibrium, the RHS of equation (6.26) shifts upwards and becomes steeper. This is shown by equation (6.32)

$$\left(\frac{m}{g}\right)^{\frac{-1}{\sigma}}\left(\frac{m}{g}+1\right)=\frac{a}{a_m(1-\phi_S)}\left(\frac{L_N^U}{L_S^U}\right)^{\frac{1-\sigma}{\sigma}}\left(\frac{\rho+g+m}{\rho+g}\right). \tag{6.32}$$

Proceeding as in the case of Northern subsidy, the effect on relative wages of unskilled workers in the two regions is ambiguous.

Thus if the focus is on the stable equilibrium, then the rate of imitation increases while the growth rate remains constant (See Figure 6.3).

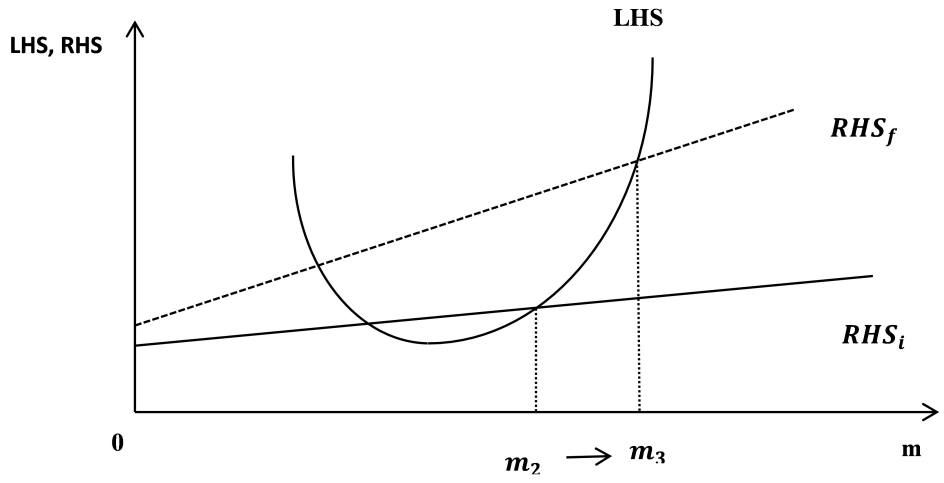

Figure 6.3 Subsidy by the Southern government in a wide gap equilibrium

If the equilibrium is a narrow gap equilibrium, then there is no effect of the subsidy on the rates of innovation or on imitation (see equation (6.19) and (6.21)), however the effect on the relative wages of the unskilled workers is just the reverse of what happens when the Northern government gives subsidy.

In case of Grossman and Helpman (1992) in a wide gap equilibrium, subsidy by the Southern government increases both the rates of imitation and the growth rate. In case of Narrow gap equilibrium, the subsidy by the Southern government has no effect either on the rate of imitation or on the rate of innovation.

Table 6.2 compares the effects of subsidies by the Southern government on the two models.

Table 6.2 Subsidy by Southern government

	Present model	G-H model
Wide gap equilibrium	m rises, g unchanged	m & g rises
Narrow gap equilibrium	m & g unchanged	m & g unchanged

6.4 Conclusion

The present model introduces two major changes in a standard model of innovation and imitation of Grossman and Helpman (1992). Firstly a specific factor (namely skilled labour) is used for innovation and imitation purposes. Secondly, this factor is mobile across nations. Strengthening of IPR reflected as an increase in the unit labour requirement for imitation reduces the steady state growth rate. This is similar to Helpman (1993) but different from Lai (1998). Moreover, unlike standard models of innovation and imitation, the wide gap equilibrium in this model is not unique. Two possible wide gap equilibriums are seen to be consistent with a steady state, only one of them is stable. This model, has interesting implications for the subsidy policies of the governments. In a standard Grossman and Helpman (1992) model subsidies can alter the rate of innovation of new products (and thus the growth rate). The free mobility of skilled labour across the world implies the growth rate is determined and independent of the fact that whether the equilibrium is a narrow gap or a wide gap equilibrium. Moreover, in case the subsidy is given by the northern government, in a narrow gap equilibrium both the rates of innovation and imitation rises in the standard model. However, in the present model, both these variables remain unchanged. This is because once the rate of innovation is determined the relative unskilled labour in the two nations determine the rate of imitation uniquely (see equation (6.21)). In case the subsidy is given by the southern government, though the rate of imitation increases in the wide gap equilibrium, no effect takes place on innovation. All these results seem to suggest that free mobility of the specific factor seriously limits the scope of increasing the global growth rate as it is shown

that a fixed growth rate, makes all growth-enhancing effects of subsidy redundant.

6.5 Appendices

6.5.1 Appendix 1

Consider the no arbitrage condition of North given in equation (6.7)

$$\frac{\pi_N}{v_N} + \frac{\dot{v_N}}{v_N} - \frac{\dot{n_S}}{n_N} = \rho. \tag{6.33}$$

This equation can be written as

$$\frac{\pi_N}{v_N} = \rho + g + m.$$

This follows from the fact that in the steady state $V = \frac{1}{n_N v_N}$ is a constant. (For discussion see Grossman and Helpman (1992)). Now, using equation (6.6) and equation (6.8) from the main text,

$$\frac{\pi_N}{v_N} = \frac{(1-\alpha)p_N x_N n}{a w^{Skill}} = \frac{1-\alpha}{a\alpha}\frac{w_N^U L_N}{w^{skill}}\frac{1}{1-\iota} \tag{6.34}$$

where $\iota = \frac{n_S}{n}$ is the share of southern imitated varieties among the total varieties produced. This can be written as

$$\iota = \frac{m}{m+g}. \tag{6.35}$$

Substituting equations (6.34) and (6.35) into (6.33) we get equation (6.15) of the main text.

For the Narrow gap equilibrium to be consistent the following condition should also hold $w_N^U > w_S^U > \alpha w_N^U$. From equation (6.15) $\omega > 1$, thus for the existence of a narrow gap equilibrium $\alpha < \frac{1}{\omega}$.

So rearranging equation (6.18) a necessary and sufficient condition for narrow gap equilibrium becomes $1 - \frac{1}{(1+\frac{m}{\rho+g})(\frac{\alpha}{1-\alpha})(\frac{L_S^U}{L_N^U})(\frac{g}{m+g})} > \alpha$, where m and g are given by equations (6.19) and (6.21) in the text.

6.5.2 Appendix 2

In case of a wide gap equilibrium, dividing the no-arbitrage condition of the North by the no arbitrage condition of the South we get

$$(\frac{w_N^U}{w_S^U})(\frac{L_N^U}{L_S^U})(1+\frac{m}{g}) = \frac{a}{a_m}(\frac{\rho+g+m}{\rho+g}). \tag{6.36}$$

Now,

$$\frac{w_N^U}{w_S^U} = \frac{p_N}{p_S} = (\frac{C_N}{C_S})^{\frac{-1}{\sigma}} \tag{6.37}$$

where the last equality follows from the first order condition of utility maximisation of the consumers. Using the product market clearing conditions along with the labour market clearing conditions (given by equations (6.8) and (6.14))

$$(\frac{C_N}{C_S})^{\frac{-1}{\sigma}} = (\frac{x_N}{x_S})^{\frac{-1}{\sigma}} = (\frac{n_S}{n_N})^{\frac{-1}{\sigma}}(\frac{L_N}{L_S})^{\frac{-1}{\sigma}} = (\frac{m}{g})^{-\frac{1}{\sigma}}(\frac{L_N}{L_S})^{\frac{-1}{\sigma}}. \tag{6.38}$$

Substituting equation (6.37) and (6.38) into (6.36) and we get equation (6.26) in the text.

For the wide gap equilibrium to be consistent, $\alpha w_N^U > w_S^U$.

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