

Foreign Direct Investment in Services and the Domestic Market for Expertise

James Markusen
Thomas F. Rutherford
David Tarr

James R. Markusen
Department of Economics
University of Colorado
Boulder, CO 80309-0256
and NBER
james.markusen@colorado.edu

Thomas F. Rutherford
Department of Economics
University of Colorado
Boulder, CO 80309-0256
thomas.rutherford@colorado.edu

David Tarr
The World Bank #N-5037
1818 H Street NW
Washington DC 20433-0002
dtarr@worldbank.org

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Non-Technical Summary

A growing body of evidence and economic theory suggests that the close availability of a diverse set of business services is important for economic growth. Producer services such as managerial and engineering consulting can provide domestic firms with the substantial benefits of specialized knowledge that would be costly in terms of both time and money for domestic firms to develop on their own. The key idea in the literature is that a diverse set (or higher quality set) of business services allows downstream users to purchase a quality adjusted unit of business services at lower cost.

These intermediate services, however, are often non-traded, or costly to trade. Consequently, many authors regard non-tradable intermediate goods (primarily producer services produced under conditions of increasing returns to scale) as an important source of agglomeration externalities which account for the formation of cities and industrial complexes, and explanations of the difference in economic performance across regions.

Since the services are very costly to trade, foreign services are best transferred through foreign direct investment. This has important implications for public policy since policies that impact on foreign direct investment are often quite different from those that impact on trade in goods.

We develop a model of these services in this paper. Results show that: (1) liberalization of restraints on inward foreign direct investment in the service sector has a very powerful positive impact on the income and welfare of the FDI importing country. The impact is much stronger than in traditional competitive models of goods trade; (2) the increase in the variety of imported services leads to increased total factor productivity in downstream industries. But the relative impact on the downstream industries depends on how intensively they use intermediate services. The differential productivity effects in final goods production could be sufficiently strong so that which final good is exported or imported can reverse when FDI is permitted; and (3) policies that aim to protect domestic skilled labor against competition from imported services can have the perverse effect of lowering the returns to domestic skilled labor. This is because even when imported services economize on the use of domestic skilled labor (compared to domestic service industries), the positive productivity and scale effects on the downstream industry can be sufficiently powerful that the real wage of skilled labor increases after the liberalization of FDI in service industries. That is, domestic skilled labor and imported services are partial-equilibrium substitutes in our model, but are typically general-equilibrium complements.

1. **Scope of the Paper**

How important are restraints on foreign providers of producer services for welfare and growth in developing countries? With the General Agreement on Trade in Services (GATS) having been incorporated into the World Trade Organization and the agreement to discuss these issues after the Uruguay Round (possibly as part of a New Round), this question has taken on an important policy dimension.

A growing body of evidence and economic theory suggests that the close availability of a diverse set of business services is important for economic growth. The key idea in the literature is that a diverse set (or higher quality set) of business services allows downstream users to purchase a quality adjusted unit of business services at lower cost. As early as the 1960s, the urban and regional economics literature (e.g., Greenfield, 1966; Jacobs, 1969, 1984; Chinitz 1961; Vernon 1960; Stanback, 1979) recognized the importance of non-tradable intermediate goods (primarily producer services produced under conditions of increasing returns to scale) as an important source of agglomeration externalities which account for the formation of cities and industrial complexes, and explanations of the difference in economic performance across regions.

The more recent economic geography literature (e.g., Krugman, 1991; Porter, 1992; Fujita, Krugman and Venables, 1999) has also focused on the fact that related economic activity is economically concentrated due to agglomeration externalities (e.g., computer businesses in Silicon Valley, ceramic tiles in Sassuolo, Italy). Evidence comes from a variety of sources. Ciccone and Hall (1996) show that firms operating in economically dense areas are more productive than firms operating in relative isolation. Caballero and Lyons (1992) show that productivity increases in industries when output of its input supplying industries increases. Hummels (1995) shows that most of the richest countries in the world are clustered in relatively small regions of Europe, North America and East Asia, while the poor

countries are spread around the rest of the world. He argues this is partly explained by transportation costs for inputs since it is more expensive to buy specialized inputs in countries that are far away for the countries where a large variety of such inputs are located.

As the urban economics literature suggested, we believe that the most natural place to look for the source of agglomeration economies is producer services. Intermediate goods with low transportation costs can not play the role required by the urban economics or economic geography theories, since if transportation costs are low there is little advantage to being close to these input suppliers. But many business services are either non-traded internationally or provided at much higher costs from a distance so that there are significant disadvantages to a user of these services from being far from the core location of these activities.¹ Marshall (1988) shows that in three regions in the United Kingdom (Birmingham, Leeds and Manchester) almost 80 percent of the services purchased by manufacturers were bought from suppliers within the same region. He cites studies which show that firm performance is enhanced by the local availability of producer services. In developing countries, McKee (1988) argues that the local availability of producer services is very important for the development of leading industrial sectors.

In this paper we develop a theoretical model that we numerically simulate to quantitatively assess the importance of liberalization of restraints on foreign providers of producer services. Based on the evidence we have mentioned, we make three key assumptions in our model: (1) producer services are non-traded internationally; (2) a larger variety of producer services lower the quality adjusted costs of these services for downstream industries;² and (3) producer services are produced under conditions of increasing returns to scale. We have already discussed the evidence for

¹Empirical work has traditionally treated producer services as non-traded. See Kravis and Lipsey (1988). Daniels (1985) found that service providers charge higher prices when the service is provided at a distance.

²Business services enhance the productivity of final goods production which expand and in turn demand more business services. This is a virtuous cycle of forward and backward externalities.

stylized facts (1) and (2). Faini (1984) surveys the evidence on increasing returns to scale in producer services. As emphasized by Romer (1990), many professional services are information intensive which in itself suggests increasing returns to scale given the non-rival property of information as an input in production.

We prefer to remain somewhat vague regarding a generic definition of producer services.³ We shall, however, provide some elaboration since it explains some of the nuances of our model. The types of activities we are interested in include: (1) managerial services, which improve organizational and decision-making efficiency. (2) engineering services, which improve technical efficiency and product quality. (3) financial services (not actual trade in capital) which provide expertise in financial management and decision making. (4) marketing services which improve firms' abilities to sell or purchase other goods and services. (5) information services in which the buyer receives some type of information or knowledge not just listed.

We believe these types of services represent a substantial share of the GDP of modern economies. Based on national income statistics, all services are about 60 percent of GDP in OECD countries, and are about 50 to 55 percent of GDP in middle income countries. Business services (which is perhaps the best indicator of the types of services on which we focus in this paper) are about one-third of the total of all services. See UNCTAD (1994, tables A.1 and B.1).

Many routine services, such as cleaning services have been left off this list quite deliberately. While unskilled-labor-intensive services might be quantitatively important, they are not generally traded internationally. Firms incur costs of doing business abroad, and as such must have advantages over domestic firms. Thus we will disregard a wide range of routine services, and concentrate on the list just presented.

³Intermediate goods with high transportation costs could also be a source of agglomeration economies, since clearly with sufficiently high transportation costs goods can become non-traded also.

Several concepts emerge from this list. First, as emphasized above, our services are intermediate inputs. Second, the services we are interested in generally involve an exchange of knowledge, which has been accumulated by the seller through previous investments. This implies two separate characteristics: the services of interest here are (a) intensive in skilled labor and other knowledge-based assets, and (b) involve some sort of scale economies: once painfully or slowly learned, knowledge can be supplied at low marginal cost.

Third, these services are generally customized to some extent, solving particular problems of the buyer, and they are not generally good substitutes for the services of other firms. Thus there is firm-level product differentiation. There may also be differentiation by firm nationality: two US management consulting firms may be better substitutes for one another than a US firm is for a Russian firm.

Finally, our services generally require a personal presence in a country or at least personal contact and discussions between the service provider and the client. In particular, restrictions on goods trade only affect service trade indirectly, while restrictions on foreign investment and the movement of business personnel have major, direct impacts. Note in particular that insofar as many services of interest are intensive in knowledge capital or knowledge-based assets, firms may insist on proprietary control of these assets to prevent their dissipation. Laws and regulations prohibiting foreign investment may thus rule out "trade" in many services; i.e., firms may only be willing to provide their services internally within the firm, not through arm's length contractual arrangements.

In summary then, we are interested in services have the following general characteristics.

- (a) intermediate goods
- (b) intensive in skilled labor and other knowledge capital
- (c) produced with increasing returns.
- (d) differentiated by firm and possibly by firm nationality
- (e) subject to high or prohibitive transactions costs from barriers to foreign ownership, movement of business personnel, etc.

"Imported" services with these characteristics offer a number of important advantages to developing or transition economies. First, they may complement rather than substitute for domestic producer services, the differentiated-product characteristic just mentioned. Second, they economize on scarce domestic skilled labor which is then freed for other uses, the factor-intensity property noted above. This second property suggests that imported producer services might harm domestic skilled labor and its accumulation in the long run. But combined with the first "complements" property, this is far from obvious as we shall show below.

Third, imported services allow countries to obtain in the present expertise that is not otherwise available and would take considerable time and/or resources to develop, the scale economies property. In a static model, this could be captured by simple scale economies with fixed costs in terms of skilled labor, or in a dynamic model by a learning-by-doing or investment process which requires a time lag between skilled-labor inputs and service output.

Fourth, imported services may provide crucial missing inputs which allow a country to produce and export goods in which the country has a natural comparative advantage except for the missing input. This has the potential for huge surplus value. The Arabian gulf may have had huge oil supplies, but expertise was required to bring it to market. A few hundred million dollars worth of foreign expertise likely had a return of many billions of dollars.

The purpose of this paper is to take several steps toward incorporating the types of producer services just discussed into applied general equilibrium models. The first step in this process is to adopt a formal theoretical approach. Our formulation will build on existing work, including Markusen (1989), Francois (1990a,b), and Stibora and de Vaal (1995). The second, and more original, step of this paper will be to obtain a quantitative assessment of the impact of this approach by embedding it in *both* static and dynamic applied general-equilibrium models. The static model considers the implications of FDI in

a model where the supply of domestic skilled labor is fixed. There have been some prior numerical efforts to quantitatively assess the implications of international liberalization against foreign service providers (Brown et al., 1996; Robinson and Wang, 1999). But these studies have not required a domestic presence by foreign service providers. Rather they treated service sectors as tradable and assumed that there were tariffs or the tariff equivalent of non-tariff barriers against foreign services that acted to restrain imported services in a manner similar to tariffs on goods trade. In our approach, liberalization of the restraints on the *inputs* to foreign service providers will expand the domestic provision of foreign services, but will have no impact in the prior approaches.

Our dynamic model provides a means of assessing the time and disruption involved in moving from an initial equilibrium to a new steady-state equilibrium by modeling the transition under consistent expectations by firms and consumers. There are two reasons that the transitional dynamics are of interest. First, given an assumption of imperfect intersectoral immobility of existing workers, there are potentially important equity consequences of reform. Second, if there are wage rigidities or other distortions in the economy that slow the adjustment of labor, FDI liberalization may generate transitional unemployment losses which could offset some fraction of the efficiency gains offered by the reform. For these reasons, in our dynamic extension we focus on adjustment in the stock of skilled labor within the economy, assuming that existing workers may be unable to move directly into the FDI enclave.

We believe these template models should provide a useful starting point for the analysis of these issues in future applications with real data. Before proceeding, we will mention of a couple of interesting results which may induce the reader to continue. First, we use a static model to show that liberalization of rules to permit inward FDI in producer services may imply that these services are general-equilibrium complements to domestic skilled labor, even though they appear to substitute for domestic skilled labor in a partial-equilibrium sense. Thus, it is likely that FDI may foster the accumulation of skilled workers. Second, allowing inward FDI in producer services may significantly affect the pattern of trade in goods.

As in the "key input" argument above, these services may reverse the direction of trade, permitting the host country to successfully export advanced products. Third, we find that the transitional process may involve substantial changes in the market for skilled labor, particularly if we assume that workers in FDI enterprises require specialized education. These effects depend on assumptions regarding the productivity of older skilled workers in the new market for services. If all workers in the new services sector must be new graduates, the reform imposes a significant burden on older workers, and the transition process could take a number of years to complete.

The order of the paper is as follows. In the next section we lay out the basic theoretical model and some simplifying assumptions. The following section describes the dynamic extension of the model which is used to examine the economic transition following liberalization. Section 4 presents a number of implementational issues involved in the analysis, and section 5 describes some of the results of numerical simulations. Section 6 concludes. Three appendices, available separately, present GAMS source code for the models employed in this paper.

2. **Modelling Trade and FDI in Producer Services**

Our basic approach will be to model producer services as intermediate inputs. These intermediate inputs will be differentiated from one another and may also be differentiated according to whether or not they are produced domestically or by foreign firms. Both types of services are produced with increasing returns to scale due to fixed costs.

There will be two final goods, X and Y , and two primary factors available on the domestic market, S and L .⁴ S will denote skilled labor and L will denote all other factors, aggregated into a composite factor to simplify the model. S and L are in fixed aggregate supply and immobile between

⁴Below we introduce a composite input that must be imported for FDI to occur; this input may be partly primary factors.

countries. The production function for Y is written in Cobb-Douglas form to facilitate comparison with X , but in the numerical model we allow the more general CES production function.

$$(1) \quad Y = S_y^{\alpha_y} L_y^{(1-\alpha_y)}$$

Services are an intermediate input into X production. The composite of all services inputs Z enters into the production of X :

$$(2) \quad X = S_x^{\alpha_x} L_x^{\beta_x} Z_x^{(1-\alpha_x-\beta_x)}$$

Later, in some illustrative simulations, we will assume that in direct S and L requirements, X is skilled-labor intensive relative to Y , in the sense that $\alpha_x/\beta_x > \alpha_y/\beta_y$.

Services are produced by imperfectly competitive firms. There is a one to one correspondence between the firm and their differentiated service varieties. There are both domestic and foreign firms producing services inputs. Z_x is a CES function of ZD and ZM , each of which is in turn a CES function of the individual ZD and ZM varieties, zd_i and zm_j respectively.

$$(3) \quad Z_x = (ZD^\gamma + ZM^\gamma)^{1/\gamma}$$

$$(4) \quad ZD = \left[\sum_i^{n_d} zd_i^\delta \right]^{1/\delta} \quad ZM = \left[\sum_j^{n_m} zm_j^\varepsilon \right]^{1/\varepsilon}$$

where n_d and n_m are the number of domestic and imported service varieties, respectively. The elasticities of substitution within product groups are: $\sigma_d=1/(1-\delta)$ and $\sigma_m=1/(1-\varepsilon)$. We require that δ and ε are between 0 and 1, which implies that the elasticities of substitution within product groups exceed unity.

Domestic intermediate inputs ZD are produced using domestic skilled labor and the composite factor. Imported services ZM are produced from domestic skilled labor the composite domestic factor and a composite imported factor. Examples of these imported inputs, which will be denoted V , are:

specialized technical expertise, advanced technology, management expertise and marketing expertise. The variable V is thus quite general and denotes a key difference between foreign and domestic production structures. zd_i and zm_i are produced with a fixed and a variable cost.

Because of the two components of cost, it is normal to express technologies for these differentiated goods by a cost function rather than by a production function. Let CD and CM be the cost function for producing individual domestic and foreign varieties. We impose a symmetry assumption within firm types, i.e., all foreign firms have identical cost structures, and all domestic firms that operate have cost structures identical to other domestic firms. cd and cm represent unit variable cost functions and fd and fm represent the fixed costs functions for domestic and foreign varieties respectively. Let r be the price of S , w be the price of L , and p_v be the price of V . Cost functions for domestic and foreign intermediates are thus:

$$(5) \quad C^D(r, w, zd) = cd(r, w)zd + fd(r, w)$$

$$(6) \quad C^M(r, w, p_v, zm) = cm(r, w, p_v)zm + fm(r, w, p_v)$$

Let n_d and n_m as variables refer to the number of domestic and foreign service firms active in equilibrium. Recalling that the derivatives of cost function with respect to the price of factor i is the input demand for factor i , the market clearing equations for S and L can then be written as:

$$(7) \quad L = L_y + L_x + n_d C_w^D + n_m C_w^M$$

$$(8) \quad S = S_y + S_x + n_d C_r^D + n_m C_r^M$$

in which C_w^j and C_r^j represents the partial derivatives of unit cost for firm type $j \in \{D, M\}$ with respect to the unskilled wage rate and the rental price of skilled labor, respectively. (By Shephard's lemma, these are the compensated demand functions.)

The demand side of the economy consists of a representative consumer, who derives income from factor supplies and possibly from tax revenues (net of subsidies). Let subscripts c and p distinguish consumption and production of X and Y . Preferences of the representative consumer are given by

$$(9) \quad U = U(X_c, Y_c)$$

The model is closed with a trade balance condition that requires that net exports of X and Y equal net payments for foreign services. Let p_x^* and p_y^* denote the world prices of X and Y (which may differ from domestic prices if there are taxes or subsidies). Trade balance is given by:

$$(10) \quad p_x^*(X_p - X_c) + p_y^*(Y_p - Y_c) - p_v^*V = 0$$

where the demand for foreign services is given by the number of foreign services times the derivative of the cost function for a given foreign service with respect to the cost of imports::

$$(11) \quad V = n_m C_{p_v}^M$$

Figure 1 presents a schematic diagram of real flows within the economy. Domestic factors S and L are supplied to four production activities. One of these, foreign producer services uses imported inputs from abroad, V . Services are inputs to production of X along with S and L . Domestic production of X or Y may then be supplied to export markets in exchange for the other good and/or as payments for V . A portion of X and Y will be supplied to the domestic market where it is consumed with imports.

To simplify the interpretation of results, we assume "large-group monopolistic competition." That is, individual firms believe they are too small to influence the composite price of their group. As we will show, it implies that the ratio of the price of services to marginal cost is constant. Consider first the

marginal product of an individual service zm_i in the aggregate output of the service sector Z_x .⁵ From the chain rule:

$$(12) \quad \frac{\partial X}{\partial zm_i} = \frac{\partial X}{\partial Z_x} \frac{\partial Z_x}{\partial ZM} \frac{\partial ZM}{\partial zm_i}$$

From equations 2, 3 and 4 the partial derivatives on the right hand side are:

$$(13) \quad \frac{\partial X}{\partial Z_x} = (1 - \alpha_x - \beta_x) S_x^{\alpha_x} L_x^{\beta_x} Z_x^{-\alpha_x - \beta_x}$$

$$(14) \quad \frac{\partial Z_x}{\partial ZM} = (ZD^\gamma + ZM^\gamma)^{\frac{1}{\gamma} - 1} ZM^{\gamma - 1} \quad \text{and}$$

$$(15) \quad \frac{\partial ZM}{\partial zm_i} = \left| \sum_j^{nm} zm_j^\varepsilon \right|^{\frac{1}{\varepsilon} - 1} zm_i^\varepsilon = ZM^{1 - \varepsilon} zm_i^{\varepsilon - 1}$$

Therefore,

$$(16) \quad \frac{\partial X}{\partial zm_i} = (1 - \alpha_x - \beta_x) S_x^{\alpha_x} L_x^{\beta_x} Z_x^{-\alpha_x - \beta_x} \left[ZD^\gamma + ZM^\gamma \right]^{\frac{1}{\gamma} - 1} ZM^{\gamma - \varepsilon} zm_i^{\varepsilon - 1}$$

Let p_x denote the domestic price of X and p_{zmi} denote the price received by the producer of a representative zm_i . Since final X production is assumed competitive, p_{zmi} is the value of the marginal product of zm_i in producing X .

$$(17) \quad p_{zmi} = p_x (1 - \alpha_x - \beta_x) S_x^{\alpha_x} L_x^{\beta_x} Z_x^{-\alpha_x - \beta_x} \left[ZD^\gamma + ZM^\gamma \right]^{\frac{1}{\gamma} - 1} ZM^{\gamma - \varepsilon} zm_i^{\varepsilon - 1}$$

Revenue of an individual zm_i producer is price times quantity.

$$(18) \quad zm_i p_{zmi} = p_x (1 - \alpha_x - \beta_x) S_x^{\alpha_x} L_x^{\beta_x} Z_x^{-\alpha_x - \beta_x} \left[ZD^\gamma + ZM^\gamma \right]^{\frac{1}{\gamma} - 1} ZM^{\gamma - \varepsilon} zm_i^\varepsilon$$

Large-group monopolistic competition is the assumption that an individual firm views Z_x as fixed or parametric, and here by extension views ZM and ZD as fixed. Thus, the individual firm views all

⁵ Symmetric results apply to the marginal product of a domestic service.

variables on the right hand side of equation (18) as fixed except for its own output zm_i . This implies that marginal revenue takes on a very simple form.

(19)

Setting marginal revenue equal to

$$MR_{zm_i} = p_x (1 - \alpha_x - \beta_x) S_x^{\alpha_x} L_x^{\beta_x} Z_x^{-\alpha_x - \beta_x} [ZD^\gamma + ZM^\gamma]^{\frac{1}{\gamma} - 1} ZM^{\gamma - \varepsilon} \varepsilon z m_i^{\varepsilon - 1} = \varepsilon p_{zm_i}$$

marginal cost implies that the ratio of price to marginal cost is simply $1/\varepsilon$. We have assumed that all foreign varieties have an identical cost structure and the demand for all foreign varieties is identical. These “symmetry” assumptions imply that the output and price of all foreign firms that operate will be identical. We can thus write $zm_i = zm$ and $p_{zmi} = p_{zm}$ for all i . Similar conclusions follow for domestic firms.

Then equilibrium for a symmetric group of service firms (zm or zd) is found as the solution to two equations and two unknowns. One equation is the individual firm's optimization condition, marginal revenue equals marginal cost. A second condition arising from the free-entry condition is that price equals average cost. This condition determines the number of firms in equilibrium. For our type- zm firms, these two conditions are given as follows (with corresponding equations for the type- zd firms).

$$(20) \quad MR = MC: \quad p_{zm} \varepsilon = cm(r, w, p_v)$$

$$(21) \quad p_{zm} = AC: \quad p_{zm} = cm(r, w, p_v) + fm(r, w, p_v)/zm$$

Solving these equations to find zm , output per firm, we get:

$$(22) \quad \frac{1}{\varepsilon} = 1 + \frac{fm}{cm} \frac{1}{zm} \quad \frac{1}{\varepsilon} - 1 = \frac{1 - \varepsilon}{\varepsilon} = \frac{fm}{cm} \frac{1}{zm}$$

and finally

$$(23) \quad z_m = \frac{\varepsilon}{1 - \varepsilon} \frac{f_m(r, w, p_v)}{c_m(r, w, p_v)} = (\sigma_m - 1) \frac{f_m(r, w, p_v)}{c_m(r, w, p_v)}$$

The output of a given variety is larger when fixed costs are larger relative to marginal costs (scale economies are larger) and when the varieties are better substitutes. Similar results apply for domestic type firms.

Dual to the output indices in equation 4 are cost functions. When firms minimize the cost of purchasing foreign (domestic) varieties, a cost of a unit of the composite foreign (domestic) input ZM (ZD) is:

$$(24) \quad CM = \left[\sum_i^{n_m} p_{zm_i}^{1 - \sigma_m} \right]^{\frac{1}{1 - \sigma_m}} \quad \sigma_m = \frac{1}{1 - \varepsilon}$$

$$(25) \quad CD = \left[\sum_i^{n_m} p_{zd_i}^{1 - \sigma_d} \right]^{\frac{1}{1 - \sigma_d}} \quad \sigma_d = \frac{1}{1 - \delta}$$

where p_{zdi} is the price of the output of a domestic firm and n_d and n_m are the number of domestic and foreign firms.

Substituting the symmetry of the equilibrium into the cost functions for a unit of ZM or ZD , implies that CM and CD can be written as:

$$(26) \quad CM = \frac{p_{zm}}{n_m^{\sigma_m - 1}} \quad \text{and} \quad CD = \frac{p_{zd}}{n_d^{\sigma_d - 1}}$$

Since the elasticities of substitution exceed unity, the cost of obtaining an aggregate unit of foreign or domestic services decreases as the number of varieties increases. That is, additional varieties convey an externality on the final goods sector X by lowering its costs of obtaining a unit of composite services. The elasticity of the cost of a composite unit of foreign services with respect to the number of foreign varieties is $(1 - \sigma_m)$. Thus, an additional foreign variety conveys a larger externality on the final goods sector the better foreign varieties substitute for each other. A similar argument applies for domestic varieties.

Alternatively, the externality can be viewed from the primal (equation 4). Symmetry implies that

$$(27) \quad ZD = n_d^{1/\delta} z d \quad ZM = n_m^{1/\varepsilon} z m$$

The cost of purchasing the output of domestic firms is $n_d z d p_{zd}$, which increases in proportion to the number of firms. But, since $\delta < 1$, the effective supply to the firm increases more than proportionately with the number of firms.

Note in the special case in which $\gamma = \delta = \varepsilon$ and $z m = z d$, that Z_x can be written as:

$$(28) \quad Z_x = (n_d + n_m)^{1/\gamma} z \quad z = z m = z d$$

in which case domestic and imported firms, while differentiated, are perfect substitutes at the margin.

A final set of assumptions needed to complete the model formulation relate to the specification of the external sector, and in particular the endogeneity of prices. For our purposes, we will begin with a "small country assumption", that prices to our country are fixed. It is clear what this means with respect to X and Y , but less clear with respect to foreign producer services. We assume that there are a large number of potential foreign firms in production in the rest of the world. A fixed cost is needed to enter the domestic market (fm). Foreign firms will enter up to the point where the local markup revenues cover this fixed cost. In other words, the domestic market has no "world" effect on the number of multinationals. In terms of Figure 1, the "World Markets" block exchanges X , Y and V at fixed prices. This assumption would generally not hold in a "large-country case", with firm level scale economies. In such a model, excess markup revenues contribute to firm-level fixed costs, and the number of multinational firms becomes endogenous to policy changes in one country (Markusen and Venables, 1998, 2000).

3. Modeling Transitional Dynamics

In this section we present an extension of the static model above which we employ in the dynamic simulations. In this analysis we assume that liberalization of FDI in services is an unanticipated policy reform and the economy is initially on a steady-state growth path with FDI prohibited.⁶ We calibrate the dynamic model to precisely the same dataset employed to illustrate the static model. The model assumes a growth in new vintage labor and a utility discount factor consistent with a balanced baseline GDP growth rate of 2% per annum and an interest rate of 5% per annum.

Savings and investment are determined implicitly by the consumption decisions of a forward-looking representative agent who allocates wealth to maximize intertemporal welfare:

$$(29) \quad W = \Delta^t U_t(X_{c_t}, Y_{c_t})$$

Consistent with a labor market in which workers enter the workforce at age 20 and retire at age 70, we assume an exogenous retirement rate of 2% per year. Along the dynamic growth path new vintage workers enter the labor market in each period, and they must choose whether to enter school or the unskilled workforce. School graduates subsequently choose either to work in the domestic or FDI service industry. The new-vintage labor market clearance condition, where n is the number of new workers, is:

$$(30) \quad \ell_t + s_t^\beta = n_t$$

in which $\beta > 1$ reflects diminishing returns in the production of skilled workers, i.e. marginal graduates are less productive than the earlier participants.⁷ New skilled workers (new graduates) may subsequently choose to enter the domestic or FDI (multinational) skilled labor markets:

$$(31) \quad s_t^D + s_t^M = s_t$$

⁶ Unlike Tarr and Rutherford [1998], this model is based on an exogenous growth rate in the workforce. Product variety effects are defined on a per-capita basis.

⁷ In this model unskilled workers are measured in units proportional to population, but skilled workers are measured in efficiency units. For our reference calculations we take $\beta=10/7$.

while the unskilled workforce likewise evolves:

$$(32) \quad L_{t+1} = \lambda L_t + \ell_t$$

We assume in the dynamic model that the cost of producing a new skilled worker for the domestic or FDI markets is identical.

Given a dynamic model, we have the capacity to assess the adjustment costs of workers. Cross-country evidence on the adjustment costs of labor indicates that the *social* adjustment costs of trade and FDI liberalization are typically rather low relative to the fears of policy-makers, unless there are significant labor market distortions present. Moreover, even the private costs of adjustment are low for workers who were not earning rents (Matusz and Tarr, forthcoming). Restrictions on the ability of firms to terminate labor and other labor market distortions that limit mobility, as well as a poor climate for investment (due to macroeconomic instability or lack of the rule of law) can, however, lead to prolonged periods of adjustment to trade and FDI liberalization for labor.

In this paper we take a proxy for these various distortions that can lead to large adjustment costs of workers. We assume that some fraction of *existing* skilled workers have human capital that is specific to the firm type in which they work and cannot be trained for the other type firms, i.e., a fraction of the workforce is unable to gain employment in foreign firms. (All new workers can freely choose between domestic and multinational firms.) The base year supply of skilled workers is then divided between those working in the domestic and multinational firms:

$$(33) \quad \bar{S}_0 = S_0^D + S_0^M$$

and there is an upper bound on the share working in the multinational sector:

$$(34) \quad S_0^M \leq \phi \bar{S}_0$$

In the central scenarios, we take $\phi=0.5$. Subsequent to the initial reallocation of skilled workers across the two sectors, these human capital stocks evolve according to the standard capital accounting relationship:

$$(35) \quad S_{t+1}^k = \lambda S_t^k + s_t^k \quad k \in \{D, M\}$$

When skilled workers are immobile (φ is small), there may be an initial disparity in real wages between workers in different types of firms during the adjustment process.⁸ As new skilled workers enter the workforce, they move into the sector paying the highest return, and wage differences between foreign and domestic firms disappear. The model formulation in a complementarity format does not rule out “bang-bang” adjustment paths, so that during a transition period where (34) is binding, all new graduates adopt jobs in the FDI service sector.

In differentiating domestic and multinational skilled workers, we replace equation (8) by two equations, one for domestic workers:

$$(36) \quad S_t^D = S_{yt} + S_{xt}^D + n_{dt} C_{rt}^D$$

and a second for skilled workers employed in multinational firms:

$$(37) \quad S_t^M = S_{xt}^M + n_{mt} C_{rt}^M$$

Prior to liberalization, skill-intensive services (Z) and skill-intensive goods (X) are produced using only domestic inputs. In the long-run, following reform, both are produced using both domestic and multinational inputs (see equation 3). During the transition, however, the relative cost of new- versus old production techniques determines how these goods are supplied. During the transition, the supply of X is therefore the sum of production from *conventional* domestic sources and new multinational firms:

$$(38) \quad X_t = (S_{xt}^D)^{\alpha_x} (L_{xt}^D)^{\beta_x} (Z_t^D)^{1-\alpha_x-\beta_x} + (S_{xt}^M)^{\alpha_x} (L_{xt}^M)^{\beta_x} (Z_t^M)^{1-\alpha_x-\beta_x}$$

⁸ Since the skilled workers remain employed during the transition, the adjustment costs are private not social.

4. **Implementation Issues**

Before illustrating how the model described above can be coded into an applied general-equilibrium model, we present a brief discussion of some important practical issues.

(a) Initially - inactive activities Often AGE models avoid initial calibrations in which there are no initially-inactive production activities or trade links. Or, if there is an initially inactive trade link (aircraft exports from Sri Lanka to the US), the link is omitted from the model: i.e., an inactive link is always inactive.

In our case, this is not an appropriate procedure. We very much want to consider initial situations in which FDI is prohibited in a sector, and liberalization opens the closed sector. In a complementarity framework this is not a technical difficulty. The difficulty is economic. We would like to know how profitable the excluded activity would be if the barrier were removed. This will obviously be very quantitatively important to the results, which can range from zero in a perfectly competitive model (the barrier was redundant, the activity is not profitable with no barrier) to extremely high values. But there are no easily obtainable data for the "shadow price" of these restrictions. Survey evidence from multinational firms might be one source of information.

(b) Firm-level production differentiation We have no good estimates of the extent to which the outputs of firms in a given sector are good or poor substitutes for one another. Note that in the large-group monopolistic-competition model, the degree of production differentiation is closely related to scale economies, or more precisely the ratio of fixed costs to average costs. Thus if one were to take the model seriously, one could use possible data on scale economies to estimate the elasticity of substitution among different firms. This estimate will of course be of considerable importance to the results: a lower elasticity of substitution implies lower externalities to the final good sector, as explained above.

(c) Differentiation by region of origin If we really believe that the essence of production differentiation is firm-level only, and that firms are symmetric but imperfect substitutes for one another,

then the three parameters γ , δ , and ε in (3) and (4) should be identical. But is it really believable that the elasticity of substitution between two Russian management consulting firms is the same as the elasticity of substitution between one Russian and one American firm? In the model presented here we will assume that $\delta = \varepsilon$, but that this number is greater than or equal to γ . Substitution across firm type (domestic and foreign) is less than or equal to substitution within a type.

(d) Bang-Bang Solutions We have chosen a structure of production that provides for firm-type product differentiation with national differences (see equation (3)). When the elasticities of substitution are equal at all levels, i.e., $\gamma = \delta = \varepsilon$, the CES function reduces to strictly firm-level product differentiation. In this case, the final good sector is completely indifferent between a domestic or foreign variety. Decreasing n_m by one is perfectly matched in final sector productivity by increasing n_d by one; only the total number of varieties matters. If the costs of producing domestic or foreign services are not that different, and they are collectively a small part of total GDP, then we can get bang-bang solutions in which a small change in relative costs shift us from only domestic services being produced to only foreign services. This has indeed occurred in our simulations.

On the other hand, we have set γ less than $\delta = \varepsilon$ (which may be justified by economic arguments as noted above). In this case, domestic and foreign varieties have different impacts on the productivity of the final goods sector. The total number of varieties is not all that is important, but also the share of foreign and domestic varieties. In particular, the marginal productivity of either the domestic or foreign aggregate ZD and ZM goes to infinity as its share goes to zero. Then, as long as either foreign or domestic varieties are permitted to be produced and sold, they will both exist in the market and we will not have bang-bang solutions.

5. Simulation Results

Table 1 shows some simulation results from the static model. In these calculations, the elasticity of substitution among services of one firm type (domestic or multinational) is set at 5 while the elasticity of substitution between firm types is set at 3.

The model is benchmarked such that key variables have the values of one or zero initially. The first column of Table 1 shows results when imports of V are banned and hence ZM is zero. The country exports Y and imports X , and there is no trade in V (trade balance requires that the last three entries in a column sum to zero). The prices for skilled and unskilled labor are real prices, the nominal price divided by the consumer price index.

Columns 2-6 of Table 1 gives results for counterfactuals with alternative values of p_v . Some explanation of this exercise is required and we begin first with the interpretation of alternative values of p_v . One interpretation of p_v is the international “term-of-trade” for V . A lower p_v denotes better terms of trade insofar as how much X and/or Y the country must pay for the imported input V . Alternatively, p_v can be interpreted as a domestic price that must be paid for imported V , with this price above the foreign supply price due to a regulatory barrier or red tape. The difference between p_v and the foreign supply price is captured by the foreign supplier or is dissipated on regulatory procedures or red tape. That is, p_v is the real resource cost to the domestic economy of an imported unit of V . From the point of view of the *domestic* economy, either interpretation is the same: real resources are sacrificed in the differences between p_v and a lower foreign supply price. Note however that this way of modeling the barrier is not equivalent to a tax or a bribe. In those case, the difference between p_v and the foreign supply price is capture by domestic agents, either the government or the domestic bribe taker.

Column 2 of Table 1 in which $p_v = 1$ is a very important special case and requires some explanation. Let w_0 and r_0 be the initial equilibrium values of w and r in column 1, where foreign FDI is

banned. For $zd = zm$ (domestic and imported varieties produced in the same quantity), $p_v = 1$ is the value of p_v that satisfies the equality

$$(39) \quad cd(r_0, w_0)zd + fd(r_0, w_0) = cm(r_0, w_0, p_v)zm + fm(r_0, w_0, p_v) .$$

That is, at the initial prices with FDI-banned, $p_v = 1$ means that cost of one unit of output from a representative foreign firm is equal to cost of a unit of output from a domestic firm. This is an interesting case because, in traditional competitive models, no entry would occur and the initial no-FDI equilibrium would continue to be an equilibrium once entry is permitted. However, as explained above, when foreign and domestic varieties are differentiated, the marginal productivity of foreign varieties is unbounded in the initial no-FDI situation. Therefore, we must have some entry by foreign firms to reduce the value of their marginal product to their marginal costs. Given the initial high marginal productivity of the banned FDI, it can be expected to convey a large productivity boost.

Column 2 of Table 1 confirms that there is a strong productivity and welfare boost even at this price of V . An entering zm producer confers an “externality” effect on zd producers raising the price received by an individual producer of zd for a given demand for aggregate ZD (symmetric equation to (17)). Entry of more zd and/or zm firms occurs until factor prices adjust to reach a new equilibrium. The result in column 2 (100%) is a pure variety or productivity effect; i.e., in a competitive model without scale economies this second column would be identical to the first. The second column in fact shows a welfare increase of 2.5%.

One of the most interesting results is that the real wage of skilled labor rises by 7.0%. This is an effects suggested earlier, in which the substitution effect away from domestic skilled labor (V economizes on domestic skilled labor in producing ZM) is outweighed by a scale effect. Imported services produce a sort of productivity effect that lowers the cost of final output and increases the X -sector's direct demand for skilled labor. A final interesting result in the second column is change in the trade pattern. Imports of

X are eliminated due to the economy's increased ability to produce it domestically, and trade consists of a small export of Y to pay for imported V .

As the price of V falls, these results are amplified. This lower price for V may be economically reasonable, insofar as foreign multinationals have made large sunk investments and are willing to supply V at a low marginal cost when competing with one another. The number of domestic service firms continues to fall as the price of V falls, but this fall in demand for domestic skilled labor is outweighed by the scale effect in X production so that the real wage of skilled labor continues to rise. In the right-hand column of Table 1, the skilled-labor wage has risen by 40% while the real wage of the composite factor has fallen by 4%. These results are particularly dramatic if we want to think of V as largely consisting of imported skilled workers: they are clearly a general-equilibrium complement to domestic skilled labor.

Note the reversal of the pattern of trade in goods in the right-hand two columns of Table 1. When V is sufficiently cheap, the country imports Y and exports X . Finally, we might draw attention to the very large changes in welfare in Table 1. The model is calibrated so that imported services ZM have only a 10% value share in X production at the initial price of 1.0 for V , and V has only a 40% value share in producing ZM . Thus V has a 4.0% value share in X initially. Yet a fall in the cost of V to 20% of its initial value produces a 14.6% increase in welfare, a result that is due to scale/variety effect.

Earlier, we noted that the entry of a new service producer confers a positive productivity boost or “externality” on existing producers. To put it somewhat differently, a well-known result in this type of model is that the number of firms in market equilibrium is below the optimal number. In Figure 2, we therefore present results when we impose a tax/subsidy on imported V . Figure 2 uses column five of Table 1 (Price of V is 40%), and welfare changes are measured relative to the no-tax reference point (i.e., 1.07 in Table 1 is the basis for equivalent variations in income depicted in Figure 2). Figure 2 shows that the optimal tax on V is in fact negative, the optimum is a subsidy of about 25%.

There are two opposing effects of a tax on V (the same would apply to a tax on zm). Domestic service “varieties” are produced with increasing returns, imperfect competition, and sell for a price in excess of marginal cost. A tax on imported services or intermediate goods induces a substitution effect in favor of domestic “varieties”. Each sells for a price in excess of marginal cost and so the domestic economy captures a surplus on the extra varieties. This effect shows up in models of differentiated final goods and leads to a positive optimal tax.

However, in addition to this “substitution” effect there is a “scale” effect. Imported varieties have an “externality” effect on domestic producers at constant prices (prices do not stay constant). Alternatively, the extra imported varieties could be thought of as having a productivity-enhancing effect on final production: final production exhibits increasing returns in the range of intermediates. There is no general theoretical result as to which effect will dominate, the latter does in this model. But the effect is clear in column 5 of Table 1 ($p_v = 0.4$), the value which is used in Figure 2. The sum of the indices for the domestic and foreign firms is 1.53 (0.11 + 1.42), greater than the value of one in the benchmark. The productivity or scale effect is reflected in the fact that the real prices of *both* factors increase relative to the benchmark. A related result is found in Lopez-de-Silanes, Markusen, and Rutherford (1994), where the authors find that the optimal tariff on auto parts imported into Mexico is negative. For theoretical foundations of this problem, see Markusen (1989, 1990).

The dynamic transition could require significant changes in the labor market, as illustrated in Figure 3. In this simulation, based on parameter values as described above, the transition to a new steady state takes roughly 5 years. These calculations assume $\phi=0.5$, so that half of the existing skilled workforce can enter the multinational sector in year 0. During much of this time, new entrants to the skilled labor market choose to work in the FDI sector.

The reason for this corner solution is indicated in Figure 4. In the long run, the wages for skilled workers in domestic firms (w_t^D) and wages in FDI firms (w_t^M) are equalized, but during the transitional

process, our assumption of imperfect mobility results in substantial differences in these wages. As indicated in the figure, liberalization raises the return to skilled workers in the FDI sector by nearly 15% while the return to skilled workers in the domestic sector falls monotonically over two year period before beginning to recover. During this time the unskilled wage (w_t^U) rises by over 10%.

Figure 5 indicates that immediately following reform, the number of domestic firms (n_{dt}) falls by 60%, and thereafter this number declines to 20% of the original number. The number of multinational firms (n_{mt}) more than compensates however, as the total number of firms in the economy increases to 20% higher than the baseline number after 5 years.

Figure 6 indicates how trade in goods (X and Y) and imported services (V) adjust through the transition process. The initial impact on service-intensive trade is to produce substantial imports in X . As the number of FDI service firms rises, however, imports of these goods decline until, after 5 years, the economy becomes a net exporter of X . On the new steady-state, both X and Y are exported, and only V is imported.

The rate of transition depends crucially on parameter φ , the assumed mobility of skilled workers between domestic and multinational firms as shown in Figure 7. This figure reports the percentage change in the wage of skilled workers in the domestic services sector. When the mobile fraction of skilled workers in the initial workforce (φ) increase to 0.6, the return to these workers increases almost immediately. When the fraction is smaller, the wage of skilled workers falls and remains low for a number of years. Our formulation does not incorporate retraining activities, so that in the case of low mobility, our results overstate the transition costs. These results, however, could be expected in an economy with significant labor market distortions or an especially poor climate for investment.

6. **Conclusions**

Although there is a clear trend among developing countries to liberalize their policies with respect to inward foreign direct investment (UNCTAD, 1995, 272-275), many developing countries continue to impose restraints on FDI in general and in services in particular. These policies may be motivated by the fear that foreign service providers will harm the domestic skilled workers that provide these services in domestic firms. For example, examination of the commitments on services of WTO members in their GATS schedules reveals that 32 countries (mainly in Africa and Latin America) have scheduled “horizontal restrictions” that require foreign firms to use and train domestic skilled workers. In many cases these restraints may impede the foreign firm from importing the specialized people it would desire.

In this paper we have examined the impact of the liberalization of policies to allow the formation of foreign firms that provide intermediate services. The foreign service providers import an input (which we interpret as a composite of foreign skilled labor and specialized technology), and economize on the use of domestic skilled labor compared to domestic firms that provide the substitute service.

We first examined this issue with a comparative static model and showed that liberalization could lead to gains between 3 and 15 percent of GDP, depending on parameter assumptions. These are very large gains relative to what we might expect from a comparative static model. The source of these large gains is that additional intermediate service firms increase the productivity of the final goods sector that uses these firms services as intermediate inputs. More service firms allow final goods producers to use more specialized expertise, in the same way that larger markets allow for more specialized machine tools.

We have also constructed a dynamic model, which allows us to assess the transition path to a new steady state growth path and the adjustment costs. In our model, while the total number of firms and total factor productivity in the economy increases steadily from the first period, for the first 5 years the domestic industry progressively declines. Consequently, all new domestic entrants to the skilled labor

force enter foreign firms, where real wages are higher for the first 5 years. Eventually the domestic industry stabilizes (the marginal product of domestic firms increases as the number of domestic firms declines). The potential losers during the transition are skilled workers in the domestic industry. These workers incur losses only when we make rather strong assumptions regarding the immobility of skilled workers and we assume that their human capital is specific to domestic firms and that only new entrants to the workforce can be trained to work in the foreign owned firms. When we assume that 50% of the workforce is immobile, after 5 years real wages of skilled workers are equalized across foreign and domestic owned service firms and are higher as a result of the liberalization of FDI in the service sector.

One of the more interesting results of the comparative static model is that the real wage of domestic skilled labor increases with liberalization of policies against foreign service providers, and the more foreign firms there are in the domestic market the more the real wage of domestic skilled workers increases. Thus, despite the fact that foreign firms import an input (V) and thereby use domestic skilled labor less intensively than domestic firms, additional foreign firms benefit domestic skilled labor. The reason is that additional foreign firms lower the cost of the intermediate service product in final goods production and thereby increase the relative importance of the final good sector (X), which uses services relatively intensively. Thus, in a general equilibrium sense, domestic skilled labor and the specialized foreign input V are complements. One possible interpretation of this result is that the policies of certain developing countries discussed above that restrain the import of foreign inputs or force foreign multinationals to use domestic skilled factors in place of foreign inputs may not only result in lost national income, but may hurt the factor of production they are designed to assist.

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**Table 1: Simulations for various prices of V, the imported input for FDI
in services (skilled labor, blueprints, patents, etc.)**

| VARIABLES | PRICE OF V (units of foreign exchange)* | | | | | |
|-------------------------------|---|-------|-------|-------|-------|-------|
| | +INF | 1.00 | 0.80 | 0.60 | 0.40 | 0.20 |
| Welfare | 1.00 | 1.03 | 1.03 | 1.05 | 1.07 | 1.15 |
| Real wage of skilled labor | 1.00 | 1.07 | 1.07 | 1.11 | 1.14 | 1.40 |
| Real wage of composite factor | 1.00 | 0.99 | 1.01 | 1.00 | 1.02 | 0.96 |
| No. of domestic service firms | 1.00 | 0.45 | 0.35 | 0.24 | 0.11 | 0.03 |
| No. of foreign service firms | 0.00 | 0.51 | 0.67 | 0.98 | 1.42 | 2.80 |
| Net imports of X | 1.00 | 0.00 | 0.00 | -0.41 | -0.63 | -3.01 |
| Net imports of Y | -1.00 | -0.26 | -0.31 | 0.00 | 0.11 | 2.18 |
| Net imports of V | 0.00 | 0.26 | 0.31 | 0.41 | 0.52 | 0.83 |

*To interpret the price of V, the export of one unit of Y earns one unit of foreign exchange, and the export of X earns 0.95 units of foreign exchange.

Figure 1: Real Flows in the Economy

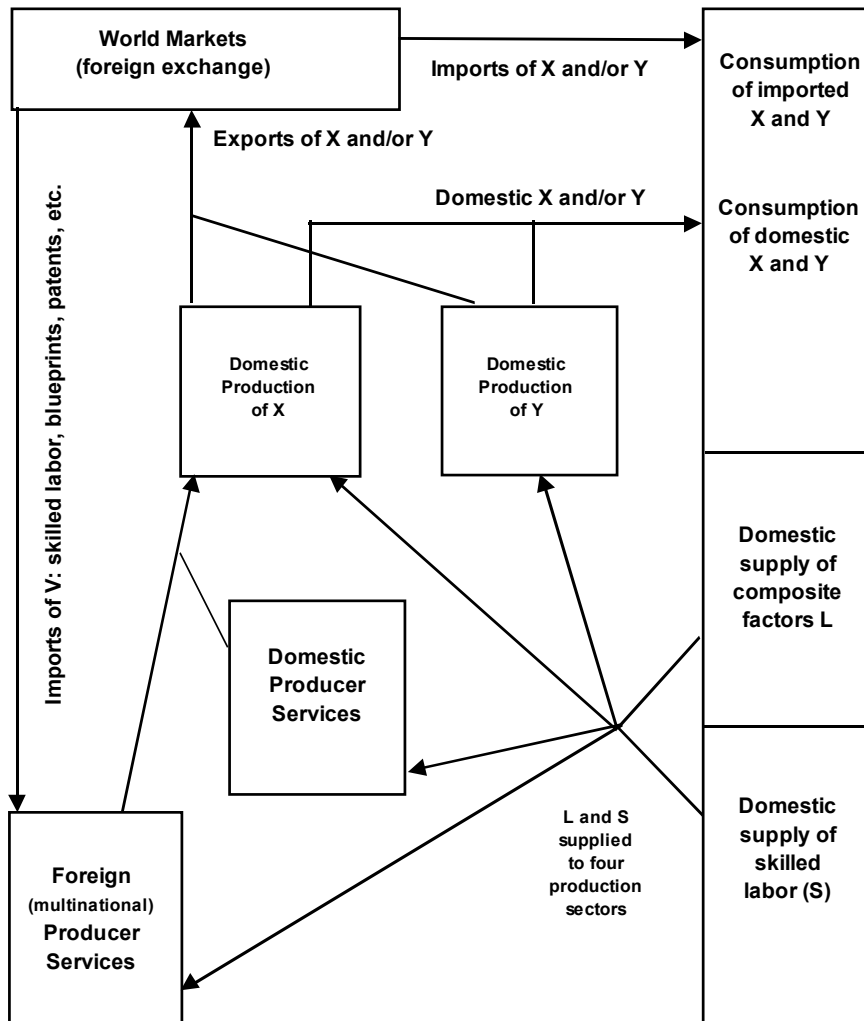


Figure 2: Welfare Effects of a Tax on FDI Imports

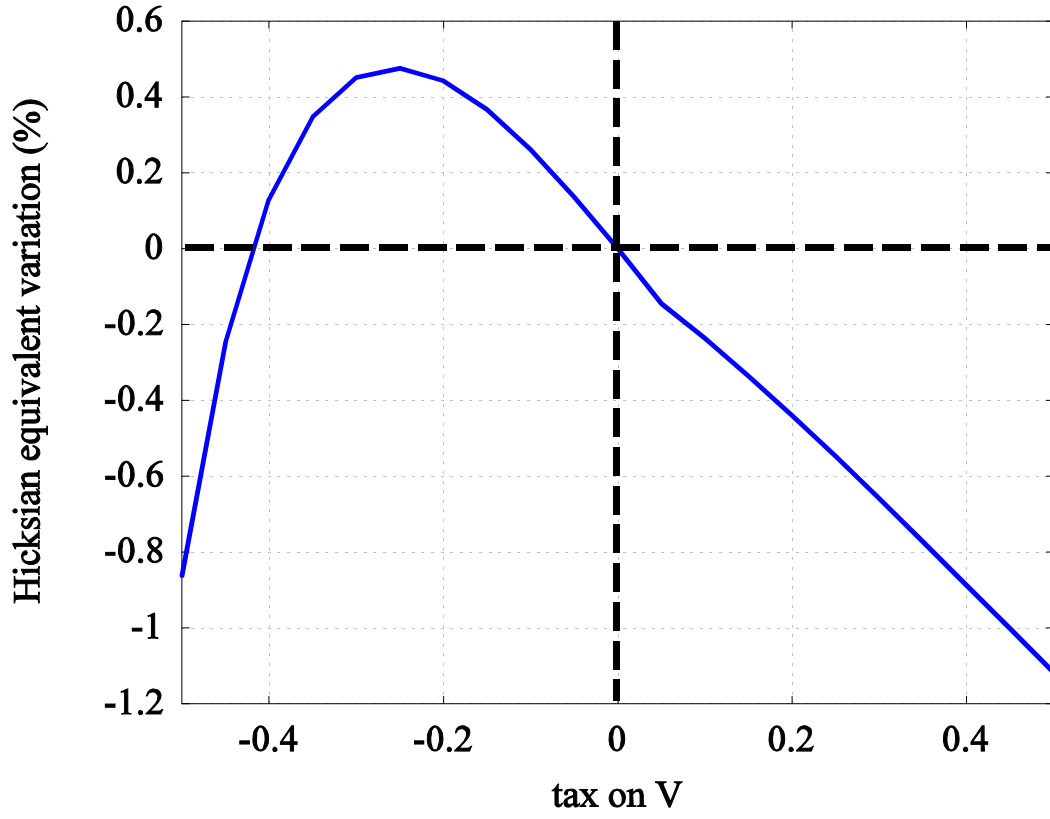


Figure 3: Labor Market Adjustment

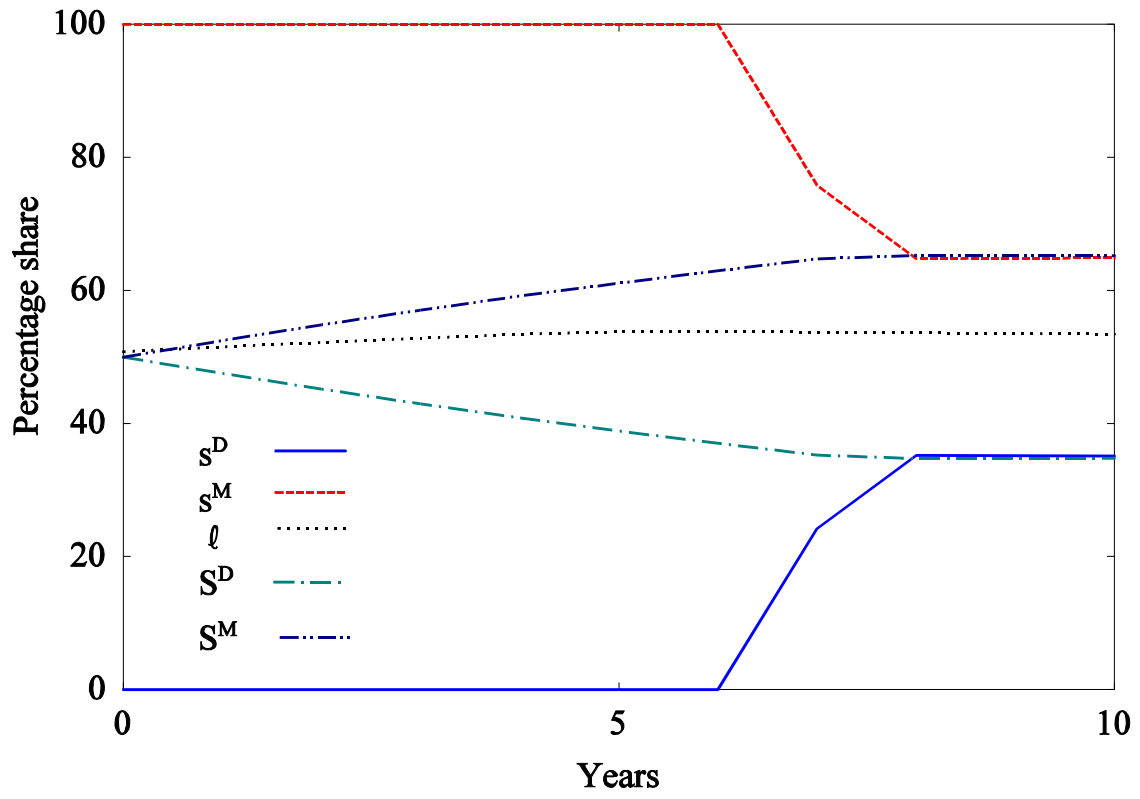


Figure 4: Wages in Transition

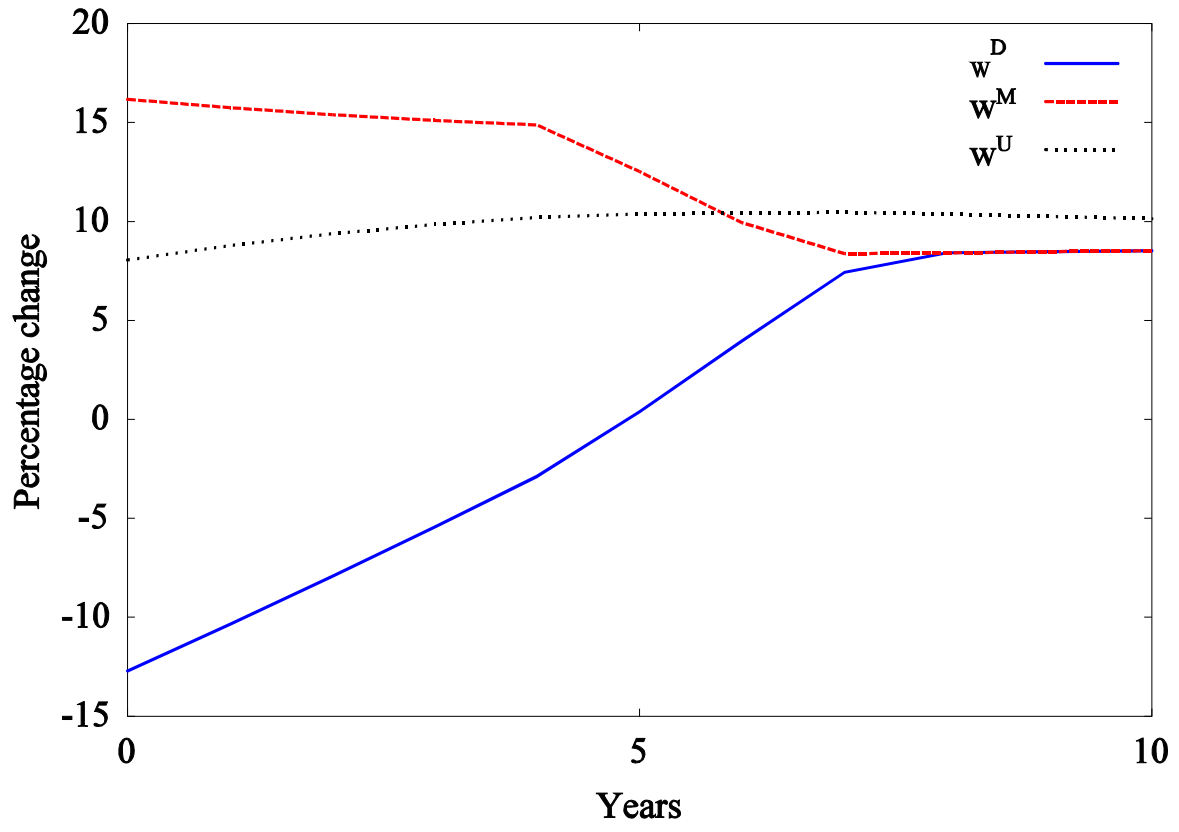


Figure 5: Number of Firms

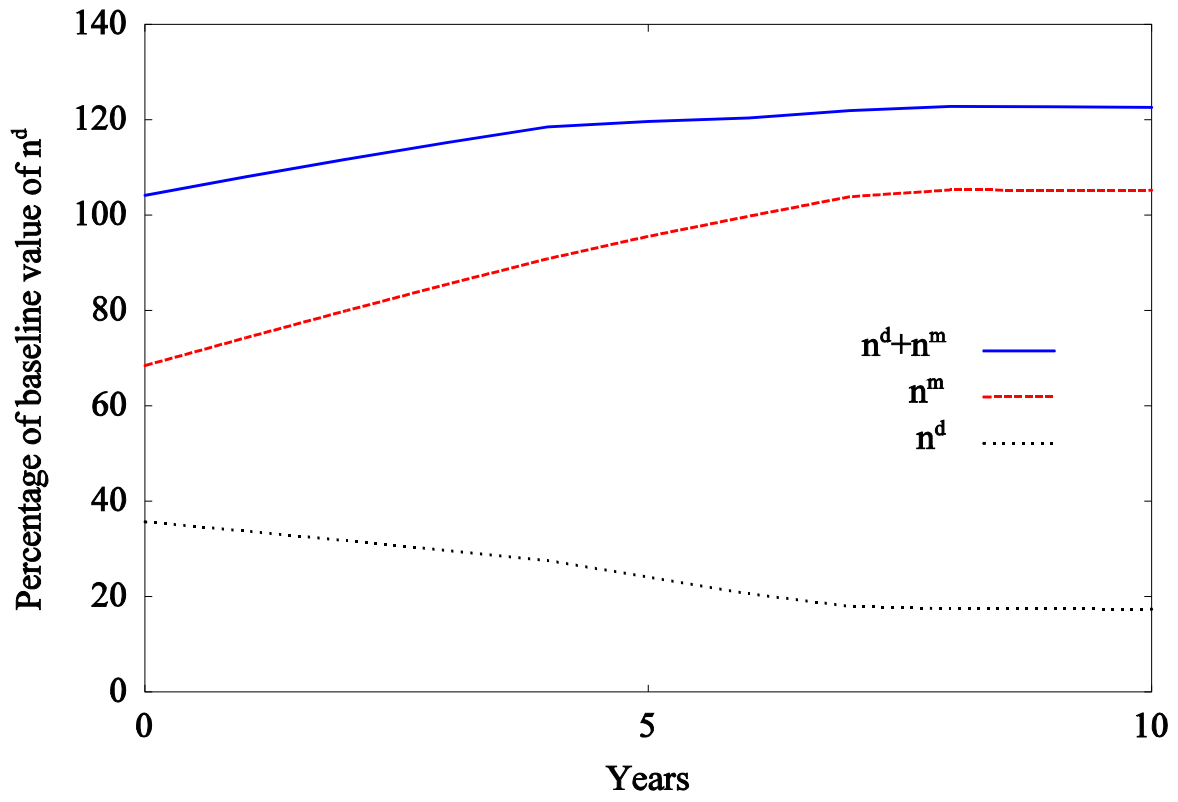


Figure 6: Net Exports

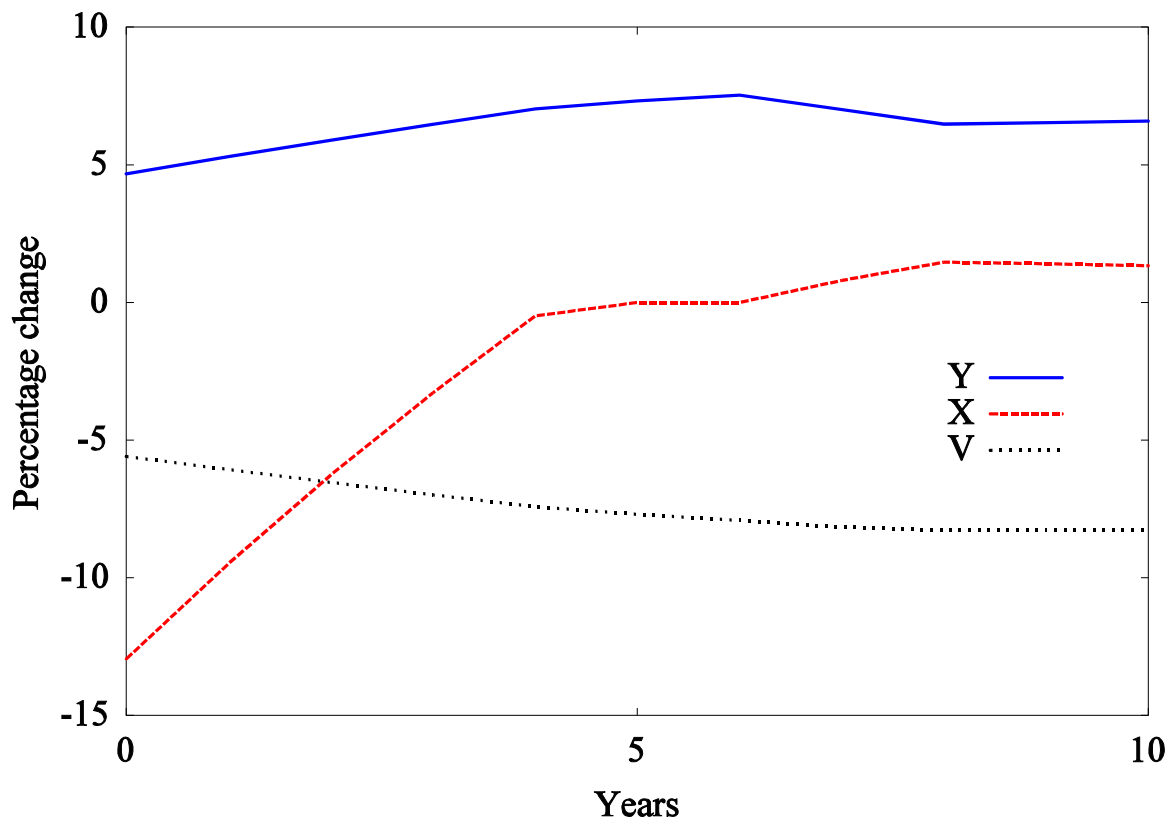
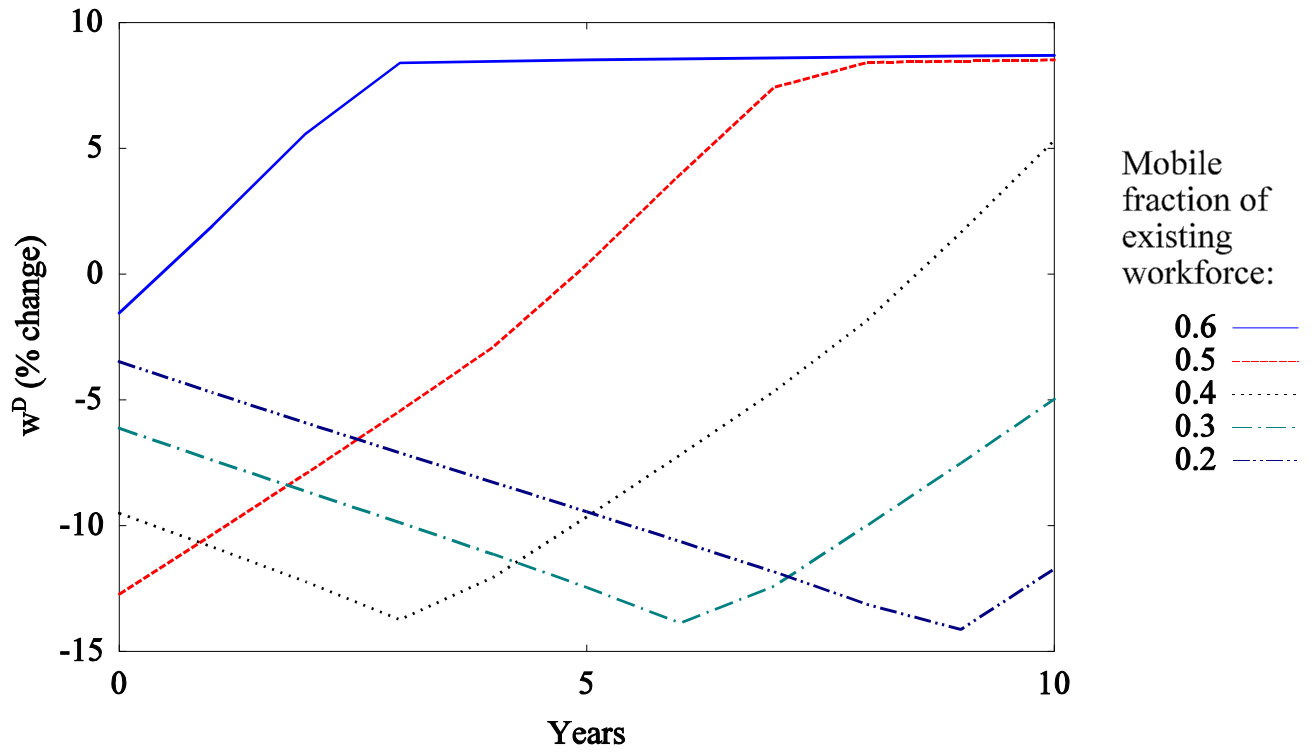


Figure 7: Mobility and the Wages of Skilled Workers in Domestic Sector



Appendix A: Formulating the Static Model in GAMS/MPSGE

In this first appendix we will describe and implement a numerical model using MPSGE (Rutherford, 1999). As we will see, there is one cumbersome feature about using MPSGE in this framework, but we believe that is outweighed in more complicated models with real data due to its immense advantages in data handling and savings in coding.

The model follows the formulation in Figure 1, and the GAMS file is given at the end of this appendix. Because the variable associated with a commodity in MPSGE is its price, we will follow a convention of beginning each commodity name with the letter "P". This also prevents a confusion between a production sector or activity and the good(s) it produces.

Primary factors are skilled labor (PS) and a second composite factor (PL). These are supplied to four "industries", the Y sector (producing only output PY), the X sector (producing only output PX), the domestic service sector ZD (producing PZD) and the foreign service sector ZM (producing PZM). Services are only used in the production of PX and not in the production of PY. Because of a technical problem involving the slope of a CES isoquant near zero of one input, we actually specify two X activities: XD for producing PX when foreign services are not available and XM for producing PX when they are. This is summarized as follows:

Final Production Activities

| | |
|----|--|
| Y | Competitive industry that produces PY using PS and PL. Assumed to be PL intensive. |
| XD | Produces PX using PS, PL, and PZD (active when foreign services are not available). Assumed to be PS intensive in primary factors. |
| XM | Produces PX using PS, PL, PZD, and PZM (active when foreign services are available). Assumed to be PS intensive in primary factors. Initially inactive in our benchmark. |
| W | Welfare activity produces "utility good" PW using PX and PY (the activity level W is the true welfare index for the economy) |

Turning to trade activities, there is a dummy good called "foreign exchange", PFX. For activities permit the exchange of goods for one another.

Trade Activities for Goods

| | |
|-----|--|
| TEY | Exports of PY: PY produces PFX. Initially active in our benchmark. |
| TMX | Imports of PX: PFX produces PX. Initially active in our benchmark. |
| TEX | Exports of PX: PX produces PFX. Initially inactive in our benchmark. |

TMY Imports of PY: PFX produces PY. Initially inactive in our benchmark.

The intermediate services are more complicated due to scale economies and imperfect competition. For domestic services, there are two activities, ZD and ND. ND is an activity for producing the fixed costs needed by a single ZD firm (good PFD). In addition, there is an agent called ENTRED (entrepreneur domestic, corresponding to no real agent), who receives markup revenue and demands fixed costs (PZD) produced by activity ND. The budget balance condition for ENTRED generates a free-entry equilibrium.

Because MPSGE requires production sectors (activities) to have constant returns to scale, a trick is needed to incorporate product variety into the model. This is done by an auxiliary quantity adjustment variable, ZDQADJ and a price adjustment variable, ZDPADJ. We will describe this more in a minute, but first let us summarize the activities, agents and auxiliary variables associated with the production of domestic services, PZD.

Production Activities, Agents, and Auxiliary Variables for PZD

| | |
|--------|--|
| ZD | Produces PZD using units of RL and RS. The price adjustment variable ZDPADJ is applied on this activity. The production of Z is assumed to be skilled-labor intensive relative to both PX and PY. Markup is applied on this activity's inputs (the markup derived in the text is defined on a <i>gross basis</i> , but in the model this is converted to a <i>net basis</i> to apply to inputs.) |
| ND | Produces PFD, the fixed costs for each domestic variety. The activity level ND is an index of the degree of product differentiation (number of firms n_d in equilibrium). Same factor intensity as ZD. |
| ENTRED | Dummy agent who receives markup revenues and demands fixed costs. |
| ZDQADJ | Auxiliary variable which accounts for product variety effects. |
| ZDPADJ | Tax/subsidy adjustment that ensures that the value of sector ZD output equals the value of true output. |

Exactly the same activities, agents, and auxiliary variables apply to production of foreign services, switch the letter M for the letter D, with two exceptions:

Activities for Foreign Services that Differ from Domestic Services

| | |
|----|---|
| ZM | Produces PZM using inputs of PS, PL, and PV (imported inputs). ZM economizes on skilled labor (implicitly using foreign skilled labor and knowledge-based assets) relative to ZD. The markup is applied on inputs to this activity. |
|----|---|

NM Produces PFM, the fixed costs for each foreign variety. The activity level NM is an index of the degree of product differentiation (number of firms n_m in equilibrium). Same factor intensity as ZM.

Figure 8 explains the coding of the services sectors in more detail (it applies to both ZD and ZM so for economy the distinction is dropped in this diagram). Beginning in the top center, there is a sector producing "pseudo" Z, defined as $Z^* = nz$, and therefore having constant returns to scale, as opposed to "true" Z, $Z = n^{1/\epsilon}z$. The fixed markup produces revenues assigned to an agent ENTRE. ENTRE takes these revenues and demand fixed costs. The equilibrium activity level N, for production of fixed costs, is an index of the number of firms active in equilibrium.

So now we know Z^* and n , and can therefore find Z. Units in the numerical model are chosen such that $z = 1$ (z_d and z_m) which is a constant, so $Z = Z^{*(1/\epsilon)}$. ZQADJ is then the difference between these two values, $ZQADJ = Z^{*(1/\epsilon)} - Z^*$. This amount is then "given" to the representative consumer, CONS, in an endowment field in the demand block, CONS (the consumer does not consume this amount, he/she sells it for X and Y). Thus the total amount of Z in the economy is the true amount $Z = Z^* + ZQADJ$.

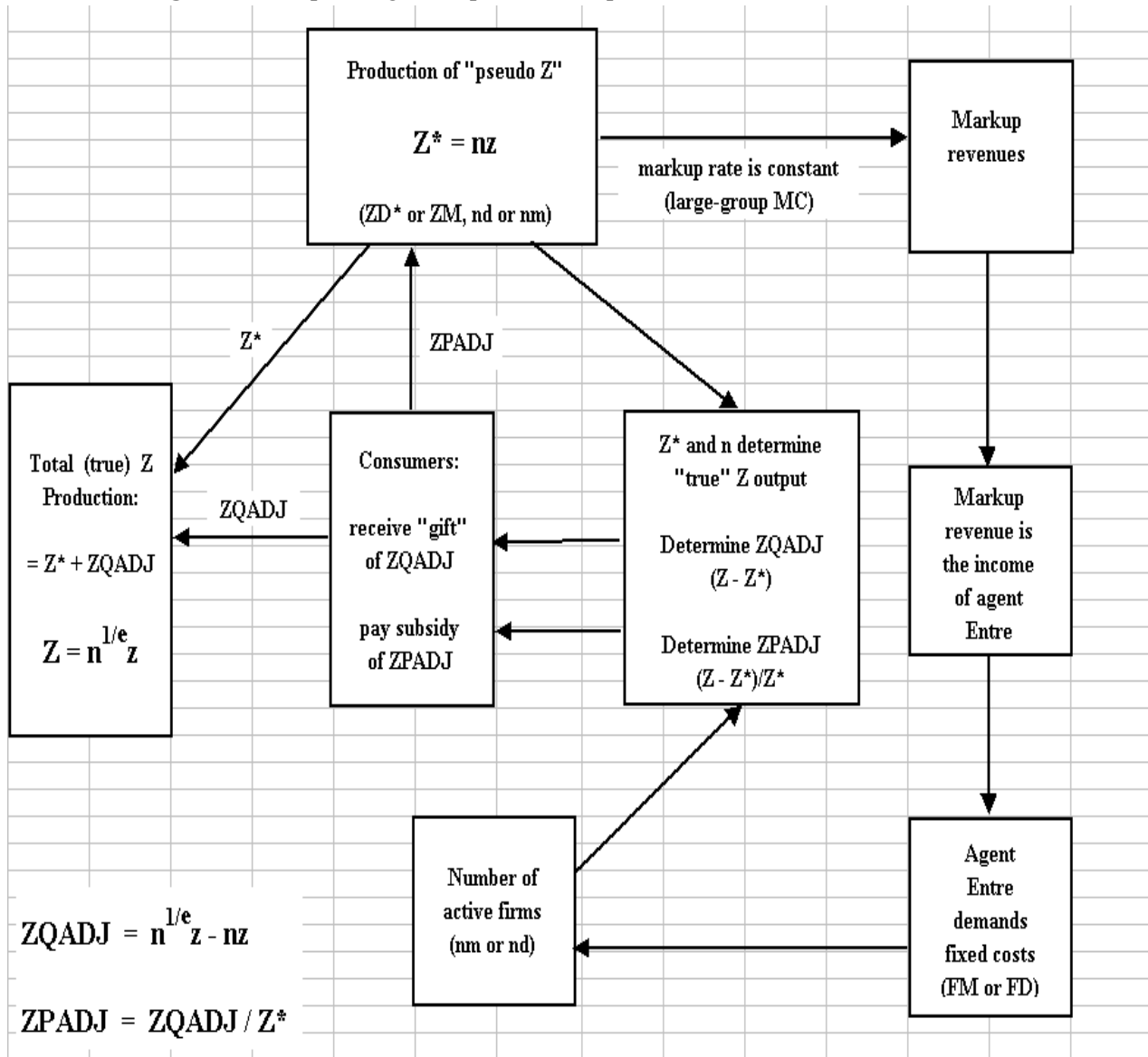
But now we have a problem, in that the value of payments for Z received by producers is not equal to the value of Z to consumers. We correct this by an ad valorem subsidy rate, ZPADJ. This is set so that the value of Z to consumers equals the payments for Z^* receive by producers.

$$(40) \quad p_z Z = p_z Z^{*1/\epsilon} = p_z (1 + ZPADJ) Z^*$$

$$(41) \quad ZPADJ = (Z^{*1/\epsilon} - Z^*)/Z^* = ZQADJ/Z^*$$

One final mystery needs to be explained (well, at least one). Note that the reference quantities in the Q fields in the production block for XM, 7.07 for PZD and PZM. These were arrived at by using the production in (3). If 20 units of ZD (used in production block XD) yield a given amount of Z_x with ZM =

Figure 8 Incorporating Monopolistic Competition into a GAMS/MPSGE Model



0, how much ZD and ZM (equal amounts of each) could deliver the same amount of Z_x given $\gamma = 2/3$ (elasticity of substitution = 3) in (3)? The answer is $ZD = ZM = 7.07$. This amount is of course less than half of 20 due to ZD and ZM being imperfect substitutes.

This completes the discussion of the model. Scalar parameter ZDI is a logical flag used to turn on and turn off activities XM, ZM, and NM. In the first solution to the model, $FDI=0$, corresponding to the

prohibition of imported services. Subsequently, FDI is set to a positive value and FDICOST is used to set the cost of foreign services in the new equilibrium.

The computer code follows:

```

$TITLE Basic FDI in services model

* Monopolistic-Competition:
* Elasticity of sub among firms of one type: 5
* Elasticity of substitution between firm types: 3

$ONTEXT
-----
Mkts |      X      | Production Sectors | Consumers
      |             | ZD ND ZM NM  Y  TEY TMX TEX TEY W | CONS ED EM
-----|-----|-----|-----
PX   |      80      |                   |
PZD  |     -25     |      25           |
PFD  |             |      5           |
PZM  |             |                   |
PFM  |             |                   |
PY   |             |             120 -20 |
PW   |             |                   |
RL   |     -20     |     -4 -1         |
RS   |     -35     |     -16 -4        |
PFX  |             |             20 -20 |
-----|-----|-----|-----
MKDREV |           |     -5           |
MKMREV |           |                   |
-----|-----|-----|-----

$OFFTEXT

SCALAR

* -----
FDI          Control parameter for FDI          /0/,
FDICOST FDI cost index                          /1/,

EDELTA       Domestic firm demand elasticity    /5/,
EEPSILON     FDI firm demand elasticity         /5/,
EGAMMA       Armington elasticity               /3/,

R0           Baseline interest rate             /0.05/,
G0           Baseline GDP growth rate           /0.01/,
D0           Depreciation rate for labor        /0.05/,

ALPHA        Fixed-factor value share in schooling /0.2/

GAMMA        Armington elasticity parameter
DELTA        Domestic firm elasticity paraemter
EPSILON FDI firm elasticity paraemter

MKD          Markup by domestic firms
MKM          Markup by foreign firms;

* Elasticity exponents and markups:

GAMMA = 1 - 1/EGAMMA;
DELTA = 1 - 1/EDELTA;
EPSILON = 1 - 1/EEPSILON;
DISPLAY EPSILON, DELTA, GAMMA;

MKD = 1 - DELTA;
MKM = 1 - EPSILON;

$ONTEXT

$MODEL: BASIC

$SECTORS:
C          ! Consumption (static welfare) level
X          ! Activity level for sector X
Y          ! Activity level for sector Y

```

```

ZD          ! Activity level for sector Z domestic services
ZM$FDI     ! Activity level for sector Z MNE services

ND          ! Number of domestic service firms
NM$FDI     ! Number of MNE service firms
V$FDI      ! MNE import level

TMX        ! Activity level for imports of X
TEY        ! Activity level for exports of Y
TMY        ! Activity level for imports of Y
TEX        ! Activity level for imports of X

$COMMODITIES:
PC          ! Price index for consumption

PX          ! Price index for commodity X
PY          ! Price index for commodity Y

RL          ! Return to unskilled labor L (composite)
RS          ! Return to skilled labor S (skilled labor)

PZD        ! Price index for commodity Z domestic
PFD        ! Price of fixed costs for domestic services

PZM$FDI    ! Price index for commodity Z MNE
PFM$FDI    ! Price of fixed costs for MNE services

PV$FDI     ! Price of MNE import
PFX        ! Price index for foreign exchange

$CONSUMERS:
CONS       ! Income level for consumer CONS
ENTRED     ! Dummy agent for domestic services (receives markups)
ENTREM$FDI ! Dummy agent for MNE services (receives markups)

$AUXILIARY:
ZDQADJ    ! X Quantity adjustment (positive when X>1)
ZDPADJ    ! X output subsidy rate (positive when X>1)

ZMQADJ$FDI ! Z Quantity adjustment (positive when Z>1)
ZMPADJ$FDI ! Z output subsidy rate (positive when Z>1)

ZDT       ! Variable to prevent divide by zero when ZD = 0
ZMT$FDI   ! Variable to prevent divide by zero when ZM = 0

*-----
$PROD:C s:1
O:PC      Q:200
I:PX      Q:100
I:PY      Q:100

$PROD:Y s:1
O:PY      Q:120
I:RL      Q:90
I:RS      Q:30

•         MKD is the markup defined on a gross basis. It is
•         converted to a net basis when it applies to inputs:

$PROD:ZD s:1
O:PZD     Q: 20   A:CONS  N:ZDPADJ M:-1
I:RL      Q: 4    A:ENTRED T:(MKD/(1-MKD))
I:RS      Q: 16   A:ENTRED T:(MKD/(1-MKD))

$PROD:ND s:1
O:PFD     Q: 5
I:RL      Q: 1
I:RS      Q: 4

$PROD:X$(NOT FDI) s:1
O:PX      Q:80
I:RL      Q:20
I:RS      Q:35
I:PZD     Q:20   P:(1/DELTA)

*-----
$PROD:X$FDI s:1 a:EGAMMA
O:PX      Q:80
I:RL      Q:20
I:RS      Q:35
I:PZD     Q:7.07 P:(1/DELTA) a:

```

```

I:PZM Q:7.07 P:(1/EPSILON) a:
$PROD:ZM$FDI s:1
O:PZM Q:20 A:CONS N:ZMPADJ M:-1
I:RL Q:4 A:ENTREM T:(MKM/(1-MKM))
I:RS Q:8 A:ENTREM T:(MKM/(1-MKM))
I:PV Q:(8*FDICOST) A:ENTREM T:(MKM/(1-MKM)) P:(1/FDICOST)

$PROD:NM$FDI s:1
O:PFM Q:5
I:RL Q:1
I:RS Q:2
I:PV Q:(2*FDICOST) P:(1/FDICOST)

$PROD:V$FDI
O:PV
I:PFX

```

*-----

```

$DEMAND:CONS
D:PC Q:200
E:RL Q:115
E:RS Q:85
E:PZD Q:20 R:ZDQADJ
E:PZM$FDI Q:20 R:ZMQADJ

```

```

$PROD:TEY
O:PFX Q:20
I:PY Q:20

```

```

$PROD:TMX
O:PX Q:20
I:PFX Q:20

```

```

$PROD:TEX
O:PFX Q:19
I:PX Q:20

```

```

$PROD:TMY
O:PY Q:19
I:PFX Q:20

```

```

$DEMAND:ENTRED
D:PFD Q:5

```

```

$CONSTRAINT:ZDQADJ
ZDQADJ =E= ZD * (ND**(1/DELTA-1) - 1);

```

```

$CONSTRAINT:ZDPADJ
ZDPADJ * ZDT =E= ZDQADJ;

```

```

$CONSTRAINT:ZDT
ZDT =G= ZD;

```

*-----

```

$DEMAND:ENTREM$FDI
D:PFM Q:5

```

```

$CONSTRAINT:ZMQADJ$FDI
ZMQADJ =E= ZM * (NM**(1/EPSILON-1) - 1);

```

```

$CONSTRAINT:ZMPADJ$FDI
ZMPADJ * ZMT =E= ZMQADJ;

```

```

$CONSTRAINT:ZMT$FDI
ZMT =G= ZM;

```

*-----

```

$OFFTEXT
$SYSINCLUDE mpsgeset BASIC

```

```

V.L = 0;

```

```

* Adjust bounds so that the auxiliary variables can take on
* negative values:

```

```

ZMQADJ.LO = -1; ZMPADJ.LO = -1;
ZDQADJ.LO = -1; ZDPADJ.LO = -1;

```

```

ZMT.LO = 0.01;   ZDT.LO = 0.01;
ZMT.L = 0.01;   ZDT.L = 1;
TEX.L = 0;      TMY.L = 0;
PZD.L = 1.25;   PZM.L = .8777;

$INCLUDE BASIC.GEN
SOLVE BASIC USING MCP;

PARAMETER          RESULTS          Static Equilibria for Alternative FDICOST;

SET COST /"inf","100","80","60","40","20"/;

FDI = 0;
FDICOST = 1.2;
LOOP(COST,

$INCLUDE BASIC.GEN
SOLVE BASIC USING MCP;

    FDI = 1;
    FDICOST = FDICOST - 0.2;

    RESULTS("welfare",COST) = C.L;
    RESULTS("rs",COST) = RS.L/PC.L;
    RESULTS("rl",COST) = RL.L/PC.L;
    RESULTS("nd",COST) = ND.L;
    RESULTS("nm",COST) = NM.L;
    RESULTS("m_x",COST) = 20 * TMX.L - 19 * TEX.L;
    RESULTS("m_y",COST) = 20 * TMY.L - 20 * TEY.L;
    RESULTS("m_v",COST) = V.L;

);
RESULTS("nm","INF") = 0;

DISPLAY results;

```

Appendix B: Formulating The Static Model with GAMS/MCP

In this second appendix we describe an alternative implementation of our model in GAMS. We begin with the static model as it is implemented in GAMS algebra. This implementation follows the basic structure of the GAMS/MPSGE model (Rutherford, 1999), but in place of the MPSGE function evaluator, this implementation uses the new GAMS-F function preprocessor (Ferris, Rutherford and Starkweather, 1998) to define cost indices and simplify the structure of the model equation. The disadvantage of this approach is that we must define all cost and demand functions explicitly. An advantage of the algebraic formulation is that we can directly endogenize the Z-sector output coefficients to account for product variety effects, so there is not need for price- and quantity adjustment variables, ZDQADJ, ZDPADJ etc.

The top of the GAMS program defines the program title, and then it invokes the preprocessor. Following the invocation of the preprocessor, it is possible to define functions within the GAMS code, as will be illustrated below.

```
$TITLE Basic FDI in services model

*      Run the preprocessor to substitute function definitions:

$sysinclude gams-f
```

The program begins with a large comment block which provides the reader with a summary of the benchmark equilibrium dataset. The values in this table correspond to demands and supplies in the base year.

| \$ONTEXT | | | | | | | | | | | | | | |
|-----------------|-----|--------------------|----|----|-----|-----|-----|-----|-----|-----|---|-----------|------|------|
| Mkts | X | Production Sectors | | | | | | | | | | Consumers | | |
| | | ZD | ND | ZM | NM | Y | TEY | TMX | TEX | TEY | W | CONS | ED | EM |
| PX | 80 | | | | | | | 20 | | | | | | -100 |
| PZD | -25 | 25 | | | | | | | | | | | | |
| PFD | | | 5 | | | | | | | | | | | |
| PZM | | | | | | | | | | | | | | |
| PFM | | | | | | | | | | | | | | |
| PY | | | | | 120 | -20 | | | | | | | -100 | |
| PW | | | | | | | | | | | | | 200 | -200 |
| RL | -20 | -4 | -1 | | | -90 | | | | | | | | 115 |
| RS | -35 | -16 | -4 | | | -30 | | | | | | | | 85 |
| PFX | | | | | | | 20 | -20 | | | | | | |
| MKDREV | | -5 | | | | | | | | | | | | 5 |
| MKMREV | | | | | | | | | | | | | | |

\$OFFTEXT

In an MPSGE model the variable associated with a commodity is its price, and in setting up the data and model we will follow a convention of beginning each commodity name with the letter "P". This also prevents a confusion between a production sector or activity and the good(s) it produces.

Primary factors are skilled labor (PS) and a second composite factor (PL). These are supplied to four "industries", the Y sector (producing only output PY), the X sector (producing only output PX), the domestic service sector ZD (producing PZD) and the foreign service sector ZM (producing PZM). Services are only used in the production of PX and not in the production of PY.

The data appearing in the comment block are not read directly into the GAMS program. Instead, we simply specify the model using numerical values taken from this table. Setting up the program in this manner suppresses a number of GAMS programming details. There are a few additional model inputs in addition to the table of base year values. These data are declared as scalars within the GAMS program, and following their declaration, we then assign elasticity exponents and base year markups.

```

SCALAR

FDI          Control parameter for FDI          /0/,
FDICOST      FDI cost index                    /1/,

EDELTA      Domestic firm demand elasticity    /5/,
EEPSILON    FDI firm demand elasticity        /5/,
EGAMMA      Armington elasticity              /3/,

GAMMA      Armington elasticity parameter
DELTA      Domestic firm elasticity parameter
EPSILON    FDI firm elasticity parameter

MKD        Markup by domestic firms
MKM        Markup by foreign firms;

GAMMA = 1 - 1/EGAMMA;      DELTA = 1 - 1/EDELTA;      EPSILON = 1 - 1/EEPSILON;
DISPLAY EPSILON, DELTA, GAMMA;

MKD = 1 - DELTA;      MKM = 1 - EPSILON;

```

A significant advantage of the MPSGE representation of a general equilibrium model is that there is no need to declare share and scale parameters for the underlying cost and expenditure function. When we use conventional GAMS algebra to specify the equilibrium structure, the declaration and assignment of share parameters is unavoidable. The program therefore includes share parameter declarations:

```

PARAMETER
THETAD      Benchmark value shares for the XD activity
THETAZM     Benchmark value shares for the ZM activity
THETANM     Benchmark value shares for the NM activity
THETAM      Value shares for the XM activity
THETAZ      Values shares for Z aggregate in ZM activity;

```

The specific interpretation of these share parameters will become apparent as we go through the benchmarking of the individual functional forms. This section of the program employs extended GAMS syntax in which the symbol “==” signifies the definition of a function. Functions simplify to the specification of model equations. The first function declared in the program is the cost function for sector

Y, the competitive industry that produces PY using RL and PL. According to benchmark value shares, Y is assumed to be PL-intensive. Furthermore, we assume that the underlying functional form is Cobb-Douglas, with shares parameters 3/4 and 1/4 following from the benchmark inputs of 90 and 30 for unskilled and skilled labor.

```
COSTY == RL**(3/4) * RS**(1/4);
```

Sector X represents the provision of services to the domestic economy. When foreign services are not available (FDI=0), this sector produces PX using PS, PL, and PZD. The benchmark dataset reflects and assumption that sector X is PS-intensive in primary factors.

```
THETAD("L") = 20 / (20 + 35 + 20/DELTA);
THETAD("S") = 35 / (20 + 35 + 20/DELTA);
THETAD("ZD") = (20/DELTA) / (20 + 35 + 20/DELTA);
COSTXD == RL**THETAD("L") * RS**THETAD("S") * (DELTA*PZD)**THETAD("ZD");

*      Unit cost for ZD:

COSTZD == RL**(1/5) * RS**(4/5);

*      Unit cost for ND:

COSTND == RL**(1/5) * RS**(4/5);
```

When foreign services are available (FDI=1), the X sector produces PX using PS, PL, PZD, and PZM, assuming a full transition from the initial static equilibrium to a new equilibrium in which services are provided by both domestic and FDI firms:

```

*      Unit cost function for the Z aggregate in the ZM
*      activity:

THETAZ("D") = 1/DELTA / (1/DELTA + 1/EPSILON);
THETAZ("M") = 1/EPSILON / (1/DELTA + 1/EPSILON);
COSTZ == ( THETAZ("D") * (DELTA*PZD)**(1-EGAMMA) +
           THETAZ("M") * (EPSILON*PZM)**(1-EGAMMA) )**(1/(1-EGAMMA));

THETAM("L") = 20 / (20 + 35 + 7.07*(1/DELTA+1/EPSILON));
THETAM("S") = 35 / (20 + 35 + 7.07*(1/DELTA+1/EPSILON));
THETAM("Z") = 7.07*(1/DELTA+1/EPSILON)
             / (20 + 35 + 7.07*(1/DELTA+1/EPSILON));
COSTXM == RL**THETAM("L") * RS**THETAM("S") * COSTZ**THETAM("Z");

*      Define a price index for the cost of X, depending on
*      whether or not there is FDI:

COSTX == ( (55+20/DELTA)/80 * COSTXD$(NOT FDI) +
           ((55+7.07*(1/DELTA+1/EPSILON))/80) * COSTXM$FDI);

*      The following is an index of the cost of production, taking
*      the benchmark point equal to unity:

COST_X == (COSTXD$(NOT FDI) + COSTXM$FDI);

THETAZM("L") = 4 / (4 + 8 + 8);
THETAZM("S") = 8 / (4 + 8 + 8);
THETAZM("FX") = 8 / (4 + 8 + 8);
COSTZM == RL**THETAZM("L") * RS**THETAZM("S") * (FDICOST*PV)**THETAZM("FX");

THETANM("L") = 1/(1+2+2);
THETANM("S") = 2/(1+2+2);
THETANM("FX") = 2/(1+2+2);
COSTNM == RL**THETANM("L") * RS**THETANM("S") * (FDICOST*PV)**THETANM("FX");

```

At this point in the program we have defined nearly all the functions required to express the equilibrium conditions in a compact format. As in a conventional GAMS program, the model declaration begins with VARIABLE and EQUATION statements and performs the identical calculations as the model presented earlier. The GAMS code for this portion of the program follows.

```

POSITIVE
VARIABLES
  C      ! Activity level for consumption
  X      ! Activity level for sector X
  Y      ! Activity level for sector Y
  V      ! Activity level for FDI imports

  ZD     ! Activity level for sector Z domestic services
  ZM     ! Activity level for sector Z MNE services

  ND     ! Number of domestic service firms
  NM     ! Number of MNE service firms

  TMX    ! Activity level for imports of X
  TEY    ! Activity level for exports of Y
  TMY    ! Activity level for imports of Y
  TEX    ! Activity level for imports of X

  PX     ! Price index for commodity X
  PY     ! Price index for commodity Y
  PV     ! Price index for FDI imports

```

RL ! Price index for primary factor L (composite)
 RS ! Price index for primary factor S (skilled labor)

PZD ! Price index for commodity Z domestic
 PZM ! Price index for commodity Z MNE
 PFX ! Price index for foreign exchange

CONS ! Income level for consumer CONS

EQUATIONS E_C, E_X, E_Y, E_V, E_ZD, E_ZM, E_ND, E_NM, E_TMX, E_TFY, E_TMY,
 E_PV, E_TFX, E_PX, E_PY, E_RL, E_RS, E_PZD, E_PZM, E_CONS;

* (1) Market clearance conditions:

$$E_C.. \quad \text{SQRT}(PX*PY) * C * 200 = E = \text{CONS};$$

$$E_PX.. \quad 80*X + 20*TMX = E = 0.5*CONS/PX + 20*TEY;$$

$$E_PY.. \quad 120*Y + 19*TMX = E = 0.5*CONS/PY + 20*TEY;$$

$$E_RL.. \quad \begin{aligned} RL*115 = E = & 90 * COSTY * Y \\ & + 20 * COST_X * X \\ & + 4 * COSTZD * ZD \\ & + 1 * COSTND * ND \\ & + (4 * COSTZM * ZM \\ & + 1 * COSTNM * NM)\$FDI; \end{aligned}$$

$$E_PV\$FDL.. PV * V = E = 2 * NM * COSTNM + 8 * ZM * COSTZM;$$

$$E_RS.. \quad \begin{aligned} RS*85 = E = & 30 * COSTY * Y \\ & + 35 * COST_X * X \\ & + 16 * COSTZD * ZD \\ & + 4 * COSTND * ND \\ & + (8 * COSTZM * ZM \\ & + 2 * COSTNM * NM)\$FDI; \end{aligned}$$

$$E_PZD.. \quad \begin{aligned} 20 * ZD * ND**(1/DELTA-1) = E = & \\ (20 * COSTXD/(DELTA*PZD) & * X)\$(NOT FDI) \\ + (7.07 * (COSTZ/(DELTA*PZD))**EGAMMA * & (COSTXM/COSTZ) * X)\$FDI; \end{aligned}$$

$$E_PZM\$FDL.. \quad \begin{aligned} 20 * ZM * NM**(1/EPSILON-1) = E = & \\ 7.07 * (COSTZ/(EPSILON*PZM))**EGAMMA * & (COSTXM/COSTZ) * X; \end{aligned}$$

* (2) Zero profit conditions:

$$E_X.. \quad \text{COSTX} = E = \text{PX};$$

$$E_Y.. \quad \text{COSTY} = E = \text{PY};$$

$$E_V\$FDL.. \quad \text{PFX} = E = \text{PV};$$

$$E_ZD.. \quad \text{COSTZD} * (1 + \text{MKD}/(1-\text{MKD})) = E = \text{PZD} * \text{ND}**(1/DELTA-1);$$

$$E_ZM\$FDL.. \quad \text{COSTZM} * (1 + \text{MKM}/(1-\text{MKM})) = E = \text{PZM} * \text{NM}**(1/EPSILON-1);$$

$$E_TFY.. \quad \text{PY} = G = \text{PFX};$$

$$E_TMX.. \quad \text{PFX} = G = \text{PX};$$

$$E_TFX.. \quad \text{PX} = G = \text{PFX} * (19/20);$$

$$E_TMY.. \quad \text{PFX} = E = \text{PY} * (19/20);$$

$$E_ND.. \quad 5 * \text{COSTND} * \text{ND} = E = (\text{MKD}/(1-\text{MKD})) * 20 * \text{COSTZD} * \text{ZD};$$

$$E_NM\$FDL.. \quad 5 * \text{COSTNM} * \text{NM} = E = (\text{MKM}/(1-\text{MKM})) * 20 * \text{COSTZM} * \text{ZM};$$

* (3) Income balance conditions:

$$E_CONS.. \quad \text{CONS} = E = \text{RL} * 115 + \text{RS} * 85;$$

MODEL BASICMCP /

E_C.C, E_X.X, E_Y.Y, E_ZD.ZD, E_ZM.ZM, E_ND.ND, E_NM.NM, E_TMX.TMX,

```

E_V.V, E_PV.PV,
E_TY.TY, E_TMY.TMY, E_TEX.TEX, E_PX.PX, E_PY.PY, E_RL.RL,
E_RS.RS, E_PZD.PZD, E_PZM.PZM, E_CONS.CONS /;

V.L = 1; C.L = 1; X.L = 1; Y.L = 1; ZD.L = 1; ZM.L = 1; ND.L = 1; NM.L = 1; TMX.L = 1; TEY.L = 1;
PV.L = 1; PX.L = 1; PY.L = 1; RL.L = 1; RS.L = 1; PZD.L = 1.25; PZM.L = 0.8777;
CONS.L = 200;

PFX.FX = 1;

BASICMCP.ITERLIM = 0;
SOLVE BASICMCP USING MCP;
BASICMCP.ITERLIM = 8000;

*           Define a price index for consumption:

PC == SQRT(PX.L*PY.L);

PARAMETER           RESULTS           Static Equilibria for Alternative FDICOST;

SET COST /"inf", "1.0", "0.8", "0.6", "0.4", "0.2"/;

FDI = 0;
FDICOST = 1.2;
LOOP(COST,

        SOLVE BASICMCP USING MCP;

        RESULTS("Welfare", COST) = C.L;
        RESULTS("RS", COST) = RS.L/PC;
        RESULTS("RL", COST) = RL.L/PC;
        RESULTS("N.D", COST) = ND.L;
        RESULTS("N.F", COST)$FDI = NM.L;
        RESULTS("M.X", COST) = 20 * TMX.L - 19 * TEX.L;
        RESULTS("M.Y", COST) = 20 * TMY.L - 20 * TEY.L;
        RESULTS("M.V", COST)$FDI = V.L;

        FDI = 1;
        FDICOST = FDICOST - 0.2;

);
RESULTS("N.F", "INF") = 0;

DISPLAY RESULTS;

```