Effective Protection, Domestic Resource Costs, and Shadow Prices

A General Equilibrium Perspective

Edward Tower

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ABSTRACT

Simple general equilibrium models are built, linearized about their initial equilibrium, and then used to analyze the economic effects of various changes in policy. In the process, the models are used to elucidate effective protection, shadow prices, and domestic resource cost and the relationships among them. In particular, the paper discusses applications to simple approaches to second-best tariffs, including second-best optimum tariffs on imported capital goods; alternative definitions of nominal and effective rates of protection; the symmetry between effective protection and value added subsidies; the relation between effective protection and shadow prices, and the relationship between the effective rate of protection and domestic resource cost.
Se construyen modelos de equilibrio general simples, linearizados en torno a su equilibrio inicial, y luego se usan para analizar los efectos económicos de diversas modificaciones de política. En el análisis los modelos se usan para explicar la protección efectiva, los precios sombra y el costo de los recursos internos, así como las relaciones entre ellos. En particular, en este trabajo se examinan: la aplicación de métodos sencillos para estimar los aranceles que siguen a los mejores, incluidos los aranceles que siguen a los óptimos sobre los bienes de capital importados; distintas tasas de protección nominales y efectivas; la simetría entre la protección efectiva y las subvenciones al valor agregado; la relación entre protección efectiva y precios sombra, y la relación entre las tasas efectivas de protección y el costo de los recursos internos.
Pour analyser les conséquences économiques qu'entraînent certains changements de politique, l'auteur construit des modèles simples d'équilibre général et les linéarise autour de leur position d'équilibre initiale. Ces modèles servent à évaluer la protection effective, les prix de référence et les coûts en ressources intérieures, ainsi qu'à mettre en lumière les relations qui existent entre ces éléments. Le document porte en particulier sur les points suivants : application des modèles à des méthodes simples d'estimation des droits de douane à appliquer, et notamment du niveau optimal des droits applicables aux biens d'investissement importés, à défaut de pouvoir modifier d'autres droits; analyse critique des définitions du taux nominal et du taux effectif de protection; symétrie existant entre la protection effective et les subventions à la valeur ajoutée; relation entre la protection effective et les prix de référence, et relations existant entre les taux effectifs de protection et des coûts en ressources intérieures.
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CHAPTER I

INTRODUCTION AND SUMMARY

I.1 INTRODUCTION

In many developed and developing countries effective rates of protection (ERPs) shadow prices and domestic resource cost ratios (DRCs) are very commonly estimated and used to analyse a variety of trade policy questions. In this paper we survey some of the theoretical literature on these subjects with the purpose of elucidating the relationship between these concepts and how they might be used for making inferences for economic policy. This is done by building simple general equilibrium models, linearising them about the initial equilibrium and then solving them to discover the economic effects of various changes in policy. By so doing one can gain insights into optimum policies with regard to taxes, subsidies and direct controls on production, consumption and trade. The paper is divided into this introduction and five subsequent chapters which we now summarize.
Chapter II, entitled "A Framework for Calculating Shadow Prices of Goods, Factors and Parameters of Economic Policy," builds a prototype model for calculating the effects on economic welfare of small changes in government sales of factors, goods and foreign exchange so that the private sector gains their services, and of increases in policy parameters like tariffs, quotas, taxes and subsidies, where economic welfare is assumed to depend on the real income of two groups and its distribution between them. It also shows how to calculate the effects of these changed autonomous variables on other endogenous variables of concern to policy makers.

The model is not designed to be innovative. Rather, it is intended to describe a simple full-employment specific factor model with interindustry relationships and variable world prices.

In particular, we assume that each good is produced using intermediate inputs and a value added aggregate in fixed proportions and with constant returns to scale. Then we let the value-added aggregate be a constant returns
to scale function of one factor which is specific to the industry (i.e. used only by the industry) and one factor which is mobile between industries. In the simplest interpretation of our model we interpret the specific factor as a combination of capital and land which in the short run is difficult to move from industry to industry and we interpret the mobile factor as labor which is mobile between industries, although in the longer run one might wish to think of most capital and labor being mobile between industries, with only a small fraction of the capital stock being sector specific. The model has several purposes.

First and most important, it is designed to present an introduction to the shadow pricing of goods and policy parameters as a complement to the Little-Mirrlees (1974) and Squire and Van der Tak (1975) discussions which are partial equilibrium in exposition. The approach is to recognize that a hypothetical economy can be described as a collection of many relatively simple relationships or equations, then to linearize the system, and solve it to find the amount by which welfare changes in response to small increases in policy parameters and government sales of goods, factors, and foreign exchange. Then the shadow price of any commodity, factor, or parameter is simply the fall in welfare which results from a unit increase in the government purchases of that commodity or factor or an increase in that parameter. To look at the problem more generally, we can define the policy maker's utility as a function of various aspects of how the economy performs, e.g. real incomes to various groups, real government revenues, prices and unemployment rates; and the shadow price of any parameter, good or factor is simply the ratio of the increase in the policy maker's utility to the increase in the parameter or

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1For more on the specific factor model, see Neary (1978).
government sales of the good or factor in question. To explain the concept of shadow prices in this way is important, because practical guides to shadow pricing sometimes fail to distinguish between the particular technique used to calculate a shadow price and the meaning of a shadow price.

Secondly, this chapter is intended to be an introduction to the art of model building, and to encourage people working in the area to think in terms of general equilibrium.\textsuperscript{2}

Third, this chapter is intended to encourage use of this sort of linear model for calculating shadow prices. This is because such a model is just as good as a computable general equilibrium (CGE) model for this purpose, since what is required is an analysis of only a small perturbation of the system from its initial equilibrium.\textsuperscript{3}

Fourth, this chapter is designed to encourage readers to recognize that this kind of model can also be useful as an approximation to the effects of a set of finite changes in endowments and policy parameters. While it offers only an approximation to the correct solution for finite changes, it is simpler than a CGE model in three senses: (A) to solve it requires only matrix

\textsuperscript{2}In this regard it performs the same function as chapter 2 of Dixon, Parmeter, Sutton and Vincent (1982), henceforth DPSV (1982), which presents a skeletal version of their general model in order to give readers a rapid understanding of their approach.

\textsuperscript{3}The strength of a CGE model is that it enables one to calculate to any desired degree of accuracy the effects of a set of finite changes in parameters and endowments. But the role of the shadow pricing authority should be to calculate the loss of welfare from small adjustments in government purchases and parameters from some base, for that is the definition of a shadow price. If the base is the observed status quo, both a CGE and a linear model will perform equally well. However, if it is believed that the economy is about to jump or has already jumped from the equilibrium which was used to calibrate the model to a new one, a finite distance away, one would wish to use a CGE model or else a linear model along with the numerical integration referred to in the next footnote to calculate the full description of the new equilibrium. Then to find shadow prices at this new equilibrium a linear model, calibrated about the new equilibrium, would be appropriate.
multiplication instead of an iterative computer algorithm; (B) such solutions require knowledge of only first derivatives of the functions, rather than complete specification of them, and (C) it offers an analytic solution which recommends its use when a quick answer is required or an analytic solution is needed in order to better intuit the essence of an analytical problem.  

I.3 CHAPTER III

III.1

Chapter III uses special cases of the general model developed in the first chapter to approach particular problems. It consists of several related essays. The first entitled "On a Quick and Simple Approach to Estimating Second Best Tariffs" lays out the concept that the welfare gain associated with the reduction of a particular distortion is equal to the sum of the induced flows of goods across each of the economy's distortions, each multiplied by the size of the distortion attached to that flow. It then shows how, even when we do not have more than a rough idea of how to model an economy and for some reason all tariffs but one are frozen, perhaps by political constraints, we can get an estimate of what the remaining tariff should be.

This is an example of the use of a very simple model to reach policy conclusions using information from policy makers as a major direct input into the analysis. I believe it is also a good way to introduce the classic problem of

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4 For the state of the art in CGE modeling see Dervis, DeMelo and Robinson (1982), DPSV (1982) and Harris (1982). For more on the advantages of a linear approach over a CGE formulation see DPSV (1982, pp. 5, 6 and 47). DPSV (1982, pp. 51-54) also discuss how to use conventional numerical integration techniques in conjunction with a linear model with the same mathematical properties as the one presented here to obtain exact solutions for finite changes. Thus the basic framework suggested here is not limited to the consideration of infinitesimal changes.
the general theory of the second best because the solution is at a level that should be comprehensible to those with a basic mastery of undergraduate economics.

III.2

The next essay, written jointly with Harold O. Fried, "On Using a Single Tariff to Exploit Market Power on Many Traded Goods," considers the same problem in the context of variable world prices. Thus, in this model, unlike the previous one, there is an externality from the viewpoint of the home economy, namely variable terms of trade, which needs internalizing through the use of tariffs. In this paper, we explain more fully the logic behind the optimum use of a policy instrument in one market to maximize welfare, when (using Bhagwati's (1971) terminology) there are both autonomous policy imposed distortions in other markets (e.g. tariffs we can't do anything about) and endogenous non-policy imposed distortions (e.g. monopoly power) in all markets.

The particular policy conclusions which emerge from this essay are that any policy which increases (reduces) imports of any good with an import tariff which is above (below) the traditional optimum import tariff (when foreign excess supply functions are independent of one another this is \(1/\sigma_i\), where \(\sigma_i\) is the elasticity of foreign excess supply) is beneficial in that regard. Similarly, any policy which reduces exports of goods subject to export subsidies or inadequate export taxes is beneficial. Thus one can assess the desirability of any particular policy by summing up its effects on all imports and exports. More specifically, the change in domestic real income is given by the policy-induced increased net imports (in physical terms) multiplied by the amount by which the wedge between domestic and world prices exceeds what
it ought to be based on traditional optimum tariff calculations, summed over all traded commodities.

We then illustrate this general principle by showing how this problem relates to the case of a less developed economy which imports both a capital intensive good and foreign capital services and faces fixed prices for traded commodities, an upward sloping supply of foreign capital services and a fixed corporation income tax. Our conclusion is that the introduction of a small import tariff is welfare increasing if and only if the corporation income tax exceeds the traditional optimum corporation income tax rate. Then the optimum import tariff can be determined by recognizing that raising the import tariff will be beneficial if and only if the capital attracted times the difference between the marginal product of capital and the marginal expenditure on it exceeds the quantity of the import repelled times the difference between its unit value to domestic consumers and its world price.

III.3

The third essay in this chapter, "Some Thoughts on The Optimum Tax on Imported Capital Goods in The Presence of Other Taxes and Tariffs," goes beyond the other essays by building a specific model of interactions within the economy of a hypothetical primary-producing less developed country to determine the optimum level for one tariff when others are frozen. This essay is more directly relevant to World Bank problems than the other two as it is based on an actual problem confronted by a World Bank mission. The analytical results obtained here are neat, and initially surprising, but are understandable intuitively. Thus, this essay both clarifies the forces at work in the problem and provides some ball-park estimates. It also indicates how one can simplify a complex problem to manageable proportions.
The particular story we tell is of a country which faces fixed world prices and uses labor and imported capital goods to produce a single good, some of which is consumed and some of which is exported, with exports subsidized. Moreover, the earnings from this export are used to import both the capital good and a consumption good subject to a fixed tariff. One result of our analysis is that the import tariff on the consumption good is not a determinant of the optimum tariff on imported capital. This is because all consumption goods are traded with world prices and their border taxes fixed, so that their domestic prices are fixed. Thus consumption expands or contracts along a given income-consumption line. Therefore (holding savings constant), domestic utility derived from consumption in any period will be maximized by maximizing the value at world prices of domestic production net of capital stock depreciation in each period. Other results are that when there is no domestic corporation income tax to distort savings behavior, the optimum tax on imported capital goods will just offset the export subsidy, and hence will be equal to it. However, when we are forced to reckon with a positive corporation income tax which discourages savings, it is necessary to subsidize imported capital goods to offset it. When there is no depreciation or export subsidy the optimum policy is to subsidize the import of capital goods at the same rate at which the corporation income tax is levied. Thus with a corporation income tax of 20% and an export subsidy of 15% we should levy something between an import subsidy on capital goods of 20% and an import tariff of 15% on them. Taking the real before tax rate of return on investment to equal the rate at which capital goods depreciate, we come up with an optimum import tax on capital goods of 3.5%.
III.4

The fourth essay, "Optimum Taxes on Imported Capital Goods and Intermediate Goods" is a further analysis of the problem posed in the previous essay. The problem was to provide a more detailed analysis which captures more elements of the problem posed there and allows for the simultaneous determination of two second best tariffs. In the process it explores some of the ways of making the analysis tractable, and discovers some of the difficulties associated with making the models more complex. The reader may wish to skip quickly through much of this essay as it involves some tedious manipulation.

What this paper tries to describe is a less developed economy which produces both agricultural goods and manufactured goods where the manufacturing activity uses labor, imported inputs, agricultural goods and capital to produce processed agricultural output. We then recognize that some luxury consumer goods are solely imported, and that the country consumes both the processed agricultural goods and the non-competitive import. The distortions are a 20% corporation income tax, a 20% export subsidy on processed agricultural goods and an 80% import tariff on luxury consumer goods. While this is a very simple economy, it is complex enough to illustrate the principles of how one would go about analyzing a more complex model. Holding all of our distortions fixed, but letting the elasticity of supply of domestic savings\(^5\) and the elasticity of substitution between land and labor in agriculture vary between zero and infinity, we find that the optimum import tariff on imported capital goods varies from \(-7.7\%\) to \(34.2\%\), while the optimum import tariff on

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\(^5\)We are defining the elasticity of supply of domestic savings as the proportional change in the quantity of capital goods that individuals are willing to hold per percentage increase in the after-tax rate of return on capital.
non-capital inputs varies from 7.5% to 40.5%. Finally, if we are constrained to impose a common tariff on all imported inputs it should lie between .74% and 34.2%. These are of course polar cases; in practice, with realistic elasticity values, the second best optimal tariffs would fall within a fairly narrow range between these broad limits.

III.5

Conclusions, implications and extensions of the work contained in chapters two and three are presented in the final essay of Chapter III. These are the following:

A. The optimum tariffs on intermediate inputs and imported capital goods are very dependent on the particular parameter values assumed. Thus, attempting to find second-best tariffs, while simple in theory is likely to be quite troublesome in practice, both because our knowledge of parameters is uncertain and because parameters are likely to change from time to time. Therefore, it is hard to escape the view that the role of the policy adviser should be, whenever possible, to correct distortions at their source and move the economy back toward first-best equilibria.

B. This view is reinforced by the fact that comparative static analysis is a fiction. In truth each market (goods, capital, labor, savings) adjusts at different speeds, and by convention when we do comparative static analysis we pick a length of run where some markets have adjusted totally and others not at all. In fact, in the very short run unemployment should be permitted. In the long run it is reasonable to assume that most types of unemployment will disappear, but some capital and some labor is still tied to particular sectors. In the still longer run a Heckscher-Ohlin model with both capital and labor internally mobile but with total domestic supplies of labor and
capital fixed may be reasonable. Finally, in the very long run both labor and capital in the aggregate will be variable. In calculating optimal tariffs which length of run is reasonable? The answer is none of these. This is because (1) the policy makers must always trade off short versus long run costs and benefits and (2) if everyone knows that the economy is going to move through successive equilibria, it is obvious that the optimum time path of the vector of tariffs will be complex, and individual decision makers will wish to reckon with the dynamic path in making their decisions.

C. We can, actually, be somewhat more optimistic than one would expect from a quick look at the numerical results of section III.4. It is not too surprising, since we have let two parameters vary between 0 and \infty, that we got a wide range of results. In actual fact, the policy adviser is likely to have a somewhat better idea of what parameter values are likely to be, and should be able to narrow the range of estimated optimum tariffs accordingly.

D. One important point, which is illustrated by the preceding section and elsewhere in the paper, is that one can calculate the welfare impact of a tariff change as the sum of a set of distortions multiplied each by a corresponding change in flows of goods induced by a change in the tariff. It is my belief that this is the natural way to deal with problems of the second best, because (1) it focuses on the logical structure of the welfare calculus, (2) it is also a decomposition that facilitates the process of calculation and (3) the source of variance in the estimates of second best values is the estimates of differential flows, not the distortions, so it is convenient to have the two parts of the calculation separated.

E. Typically, one can estimate the changes in the flows only by inverting a large matrix, which must be done on a computer. We have avoided this problem by choosing our parameter values judiciously. However, given the importance
of specifying the parameters correctly and doing sensitivity analysis to make this kind of analysis truly useful for policy, it makes sense to specify the model precisely and use the computer to solve it for different parameter values. In so doing, it may be necessary to constrain tariff rates not to fall out of certain ranges, in order to try to achieve greater uniformity of import tariffs and export subsidies, and gradually to move towards a first best solution. Moreover, since our approach rests on a first order approximation we cannot have much confidence about the veracity of the model's optima when they lie too far from the initial equilibria. Once the policy maker decides on a politically acceptable range of tariffs he could use this approach to determine whether particular tariffs should be at the top or bottom of that range.

F. This approach can also be usefully applied to determine the optimum structure of tariffs to achieve various domestic objectives, such as raising revenue, redistributing income or increasing employment of a particular group at minimum cost. In other words, it is a tractable first approximation to a more sophisticated use of cost benefit analysis to optimize the tariff structure. However, it is still my guess, and that of many others, that in general there will be better instruments for accomplishing the government's goals than tariffs, even in less developed countries, and that in actual fact the use of tariffs will be detrimental. Even so, using this calculus can indicate the costs of failing to use the optimum policies.

G. As mentioned in point E, the optimizing approach has the fault that the optima so calculated may lie outside the range for which the approximation is valid. Even if this is the case, it is still possible to use the linear approach developed here in order to assess the cost benefit ratio for using small changes in the tariff structure to accomplish various goals, which
should modestly contribute to optimum economic policy.

I.4 CHAPTER IV

The fourth chapter, "On The Symmetry Between Effective Tariffs and Value Added Subsidies," is the first of three chapters dealing specifically with the meaning of the concepts of the effective rate of protection (ERP) and domestic resource cost (DRC) which have been used so extensively in the World Bank. The problem posed here is: How do these concepts relate to a full-fledged general equilibrium model, and how should ERP and DRC calculations be used to make inferences about appropriate economic policy?

We note that the standard definition of the ERP as the proportion by which value added at domestic prices exceeds value added at world prices implies an alternative more intuitive definition. Value added in an activity can be thought of as the price of the commodity basket produced by an activity where we think of an activity's intermediate inputs as being goods which are present in the basket in negative quantities. Then the standard definition means that the ERP for an activity is simply the proportion by which the domestic price of that activity's basket exceeds its world price. Therefore, in this regard, it can be thought of as the tariff on that basket or the subsidy to domestic production of that basket.

The chapter then goes on to show that we can best think of ERPs as impli-

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6The effective rate of protection of a good is a weighted average of the tariff on the good and the tariffs on its inputs, and it is designed to reflect the extent to which the tariff structure protects domestic production of the good. A precise definition is provided in section IV.4.

The domestic resource cost of a good is a measure of the cost/benefit ratio associated with government or private production of that good. Thus production of the good is desirable if and only if the DRC is less than unity. A precise definition is provided in section VI.2.
cit nominal rates of subsidy to value added. In it we establish the following proposition. Consider an economy which uses intermediate inputs in fixed proportions along with primary factors to produce outputs. In such an economy, there is an equivalence between two fiscal structures. One is the levy of a vector of tariffs on net imports, where these tariffs are expressed as fractions of world prices. The other is the levy of a set of consumption taxes equal to that set of nominal tariffs combined with a set of subsidies to value added equal to the ERPs. While this proposition is implicit in much of the work on effective protection, to my knowledge it has never been stated previously and it provides a useful way of looking at the ERP. Moreover, it has an important corollary which is: a vector of tariffs on net imports combined with the same vector of consumption subsidies and taxes on value added equal to the implied ERPs will be equivalent to free trade. Thus in the absence of non-traded goods, all of the production costs of tariffs can be eliminated by matching the ERP for each industry with an equal tax on value added. These propositions are important primarily because they clarify the conceptual relationship between tariff structures and the structure of domestic excise and value added taxation and secondarily because they indicate in the presence of a fixed set of tariffs which value added taxes are the best candidates for upward or downward adjustment.

Related to this analysis is the conclusion that any set of taxes on trade, value added and domestic sales can be thought of as consisting of one set of taxes on consumption in combination with another set on value added plus free trade, and this equivalence proposition can be used to greatly simplify analysis of incentives in less developed countries. This chapter also explores two other equivalence theorems which clarify the nature of the ERP and it demonstrates that what matters for resource allocation is
differential rates of taxation and subsidization, not absolute levels, because producers and consumers response to relative, not absolute prices. Of course to the extent that there are minimum nominal wages and/or a fixed money stock in the presence of a fixed exchange rate absolute prices for value added and hence absolute levels of value added do matter.

In this chapter we also consider four alternative ways for treating non-traded goods and show that no matter how non-traded goods are dealt with, the equivalence between the alternative fiscal structures holds. In the two Corden methods, industries are integrated with the non-traded goods which feed directly and indirectly into them, so the Corden ERPs refer to the extent to which the value-added of these integrated industries is implicitly taxed. In the Balassa method, industries are also integrated backward in the same way, but the vector of Balassa ERPs is the vector of taxes on value added in tradeable industries and on those non-tradeables which are directly consumed which (when combined with consumption taxes equal to the nominal tariffs and zero value added taxes on non-tradeables used as intermediate inputs) is equivalent to the existing structure of tariffs. Finally, we suggest use of the simple Balassa method, a fourth alternative which does not involve vertical integration of industries with their non-traded inputs, and hence is simpler to calculate. This approach simply involves calculating a different ERP for each traded and non-traded good.

This chapter also explores the desirability of taxing each firm's value added at its rate of ERP calculated from the firm-specific data on the tradeable goods it uses as inputs and concludes that this is superior to the same policy using industry wide data if there is some scope for substitution between inputs, because under the former system the firm's after-tax prices for tradeables are world prices, so that it will have an incentive to use
efficient mixes of tradeable inputs. Still, of course, the best policy is to adjust tax laws so that all firms make their decisions on the basis of the appropriate shadow prices for inputs and outputs.

Next we explore how these symmetry theorems suggest a strategy for trade liberalization: namely eliminate all tariffs, and institute value-added subsidies equal to ERPs. Then gradually bring the value added subsidies into line with one another. Such a scheme would have the advantage of immediately eliminating the consumption distortion associated with a tariff system while leaving the implicit production subsidies intact temporarily while entrepreneurs figure out new ways to use their resources in light of anticipated trade liberalization. Finally, we relate our discussion to other concepts of the ERP used by other authors. We note that the other definitions considered by Bhagwati and Srinivasan (1983) are of interest only in that they provide an index of how the tariff structure affects variables of concern to policy makers. Thus it is better to be concerned with the effects of protection than effective protection per se, when defined in these ways, and the latter will typically give only limited information about the former.

In brief, the major conclusion of this chapter is that whereas many like Ethier (1977) have searched for analogies between effective and nominal tariffs, the more appropriate analogy is between the effective tariff and the value added subsidy. Perhaps then we should rename the effective tariff the implicit value added subsidy.
The previous chapter developed the concepts of the effective value added subsidy, \(z\), and the implicit rate of final demand taxation, \(\tau\), which summarize the effects of taxes and tariffs on production and consumption incentives. Now we turn to the problem of assessing the normative significance of these tools. Bertrand (1972) derives a simple expression for the effects of shifts in consumption and production between sectors on economic welfare in which the tariff and the effective rate of protection play important and symmetric roles. This chapter accomplishes several things. (1) We rewrite Bertrand's formula in a way that is easier to understand and interpret. (2) We permit the existence of explicit value-added and sales taxes so that our \(z\) replaces the ERP and our \(\tau\) replaces the tariff in Bertrand's formula. (3) We show that the existence of non-traded goods and variable world prices leaves Bertrand's formula unchanged if we replace the \(\tau\) and \(z\) with \(\tilde{\tau}\) and \(\tilde{z}\) where \(\tilde{\tau}\) is defined as \((p^C_1 - \tilde{p}_1)/\tilde{p}_1\) where \(p^C_1\) is the price to domestic consumers and \(\tilde{p}_1\) is marginal revenue or marginal expenditure on world markets if the good is traded or else price to the producer of the good if it is non-traded, and \(\tilde{z}_i\) is the proportion by which disposable value added in sector \(i\) exceeds value added at the \(\tilde{p}_i\)'s. (4) We extend the formula so that it can be used to derive shadow prices of goods, factors and policy parameters and call it our fundamental equation. (5) We show how this equation can be used in the Little-Mirrlees procedure of shadow pricing everything as the amount of foreign exchange it saves, holding real income constant. (6) We show how similar forms emerge for the fundamental equation when the reference prices are calculated in several different ways and thereby generalize the concept of effective protection. (7) We use the equation to calculate the welfare benefit of removing all of the economy's
distortions, thereby extending a formula of Harry G. Johnson's. (8) We show how to use the equation to assess the welfare impact of making a number of simultaneous small adjustments in each of various distortions. (9) We interpret the logic of our analysis geometrically. (10) Finally, we assess the normative significance of different ways of treating non-traded goods and devise some alternative ways of dealing with the problem.

I.6 CHAPTER VI

The final chapter, co-authored with Barbara L. Rollinson, attempts to explain the idea of domestic resource cost, assess its usefulness and extend work on the relationship between ERPs and DRCs by Srinivasan and Bhagwati (1978) and Bhagwati and Srinivasan (1980). Our contribution is to show how to combine information on ERPs and resource flows generated by a proposed project in order to calculate the DRC associated with the project. Srinivasan and Bhagwati conclude that in the presence of distortions the ERP is inappropriate to the task of project selection and the correct criterion is DRC. In this essay, we argue that either tool is appropriate, so long as relative prices to consumers are fixed. The only difficulty is that if one uses ERPs, one must know and use data on the ERPs for each of the sectors whose production is affected by the expansion of the sector in question as well as the extent of resource movements in and out of those sectors.

In particular, we demonstrate that the DRC for sector zero can be written as

\[
DRC = \left[1 + \text{ERP}_0\right] \sum_{i=1}^{N} \frac{\lambda_i}{1 + \text{ERP}_i}
\]
where $\lambda_i$ is the value of resources drained from sector $i$ per unit of resources attracted to sector zero, and ERP$_i$ is the ERP for the $i$th sector. Thus, contrary to the implications of these two articles both the DRC approach and the ERP approach to project evaluation are logically sound. In fact they are conceptually equivalent and Bhagwati-Srinivasan are wrong to appraise them as fundamentally different approaches to project evaluation.

We also make several additional points about DRCs. First if there is only one mobile factor of production, assuming competition, the correlation between ERPs and DRCs across sectors will be perfect. Second, we consider various ways to deal with non-traded goods. Third, we note that the DRC is simply the cost benefit ratio of performing the activity in question and therefore can be used to describe the desirability of activities involving the production and/or use of non-traded goods as well as those activities which deal solely with tradeables. Fourth, except under extraordinary circumstances the DRC is a cost benefit ratio only for marginal changes, and all we can say with precision is that a small expansion (contraction) of any industry with a DRC which is less than (exceeds) unity is a good thing. Fifth, the DRC for an industry will depend on the adjustment mechanism used. For example the industry in question may be operated by the government, encouraged by a subsidy to value added, a subsidy to its use of particular factors or the use of import tariffs. There is no reason why the DRC should be the same in these differing circumstances.

Sixth and finally, the DRC is not generally the best cost benefit ratio. The kind of ratio that is most likely to interest a policy maker is the economic cost at the margin of doing something the policy maker wishes to accomplish but to which he has trouble attaching a specific economic value, such as increasing employment or redistributing income or fostering economic
activity in a region. This argues for calculating the economic costs of achieving a unit of non-economic benefits through the expansion of particular economic instruments along the lines of the kind of linear models proposed in chapter II.

I.7 SUMMARY

In sum, the purpose of this working paper is to clarify some issues in project selection and policy reform. More specifically, the goal is to make the following points:

1. The shadow price of any good or parameter is the derivative of the policy maker's utility with respect to government sales of that item.

2. The change in welfare from a unit alteration in a policy parameter (e.g. a tax, tariff or quota) is the shadow price of that parameter.

3. A model and its associated computer algorithm designed to calculate shadow prices for project evaluation can at the same time be efficiently used to calculate shadow prices for policy parameters since the two problems are both logically and computationally similar.

4. It is neither conceptually nor practically difficult or costly to build fairly highly aggregated linear general equilibrium models to calculate these shadow prices. Moreover, linearity makes possible the building of highly disaggregated general equilibrium models.

5. Once one understands the basic principles of how these models are constructed, it is not very difficult to visualize how one could modify the model to describe a particular economy with a set of elements different from the one presented in the prototype built here.

6. Building very simple highly aggregated models along the lines
suggested, the policy maker can gain useful insights into appropriate policy making.

7. The effective rate of protection of a sector can be thought of as the implicit rate of subsidization of value added in that sector, and the effects of a set of trade barriers on production can be completely offset by taxes on value added at the corresponding ERPs. This clarifies the logical relationship between explicit value added taxation and effective protection.

8. ERPs can be used as inputs into calculation of the welfare gain from reallocating resources between sectors even when there are domestic distortions and also as inputs into calculating shadow prices. To perform these calculations is conceptually simple in that one need know only four things: the ERPs associated with each of the affected sectors and the resource movements which will occur plus changes in the consumption of various goods and the tariffs attached to them. But such changes in consumption and resource allocation may best be determined by differentiating a general equilibrium model. So again, such a model can be a helpful adjunct to ERP calculations in evaluating projects and policies.7

9. The domestic resource cost for sector i (DRC_i) is the ratio of the incremental increase in primary inputs valued at their shadow prices to the incremental increase in net output valued at its shadow price in industry i. Thus, it is a social cost/benefit ratio although it is not the best ratio. To calculate it, one must know the shadow prices of primary factors. Since the ways of defining distortions and modeling the economy discussed here are useful in determining shadow prices, this analysis can be thought of as a handmaiden to DRC calculations.

7Tower and Pursell (1984) uses simple linear general equilibrium models that are variants of the ones developed here to derive simple analytic expressions for shadow prices of goods, factors, foreign exchange and policy parameters.
Chapter II

A FRAMEWORK FOR CALCULATING SHADOW PRICES OF GOODS, FACTORS, AND PARAMETERS OF ECONOMIC POLICY

II.1 INTRODUCTION

In this chapter we build a simple linear model of a multisectoral economy in order to calculate the shadow prices of goods, factors, foreign exchange, taxes, tariffs and quotas. This model is designed to describe a standard trading economy in short-run full employment equilibrium: short run in the sense that in each sector output is produced with one variable factor, labor, and one fixed factor, which can be interpreted as land, natural resources or sector specific capital. For convenience, we will refer to it as capital. We allow the world prices of tradeables to be variable. Some imports are protected with tariffs, others with quotas; some goods are traded and others are not; output is produced with a first degree homogeneous production function using intermediate inputs and the capital-labor aggregate in fixed proportions, with substitution between capital and labor. Labor is homogeneous and perfectly mobile between sectors. Perfectly flexible wages and prices maintain both full employment and balance of payments equilibrium. Two types of domestic distortions are permitted: differential excise taxes on goods

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1The alternative is to let all factors be mobile between industries. The difficulty with this assumption combined with fixed world prices is that if the number of factors, F, is less than the number of tradeable goods produced the economy will specialize in the production of no more than F tradeable goods, or else the pattern of production will be indeterminate. Hartigan and Tower (1982) present a model which explores the impact of factor mobility on specialization. For other references on this problem, see Bertrand (1979) and Bhagwati and Wan (1979).
which are consumed at home, and a proportional differential in each sector between the standard wage rate and the value of the marginal product of labor. Finally, we recognize that the government attaches a positive value to government revenue.

II.2 THE MODEL

We now write down the equations of the model, defining terms and developing explanations as we go. The model consists of the numbered equations (1) through (12), with non-numbered equations used to derive the numbered equations. Since most of these are matrix equations, we indicate the number of rows next to the equation number. Each good is subject to an excise tax $\tau_{e_i}$ so that the $(N \times 1)$ column vector of consumer prices, $p^c$, is related to the $(N \times 1)$ column vector of producer prices, $p^p$, by

$$p^c = (1 + \tau_e)D p^p$$

where $(1 + \tau_e)D$ is an $N \times N$ diagonal matrix of $1 + \tau_{e_i}$, and $N$ is the number of domestically consumed commodities. Differentiating yields

$$dp^c = p^{D}dt_e + (1 + \tau_e)D dp^p$$

where a $D$ superscript denotes a diagonal matrix, so $p^{D}$ is a diagonal matrix constructed out of the $N$ $p^p$'s.

There are $T$ traded goods, $T_Q$ of which are subject to import quotas and $T_T$ of which are not. $M_i$ is net imports of the $i$th good. Thus $M_i$ is positive or negative depending on whether the $i$th good is imported or exported. $M_i$, $M_Q$, and
MT are respectively the column vectors of net imports, net imports subject to binding quotas, and net imports not subject to quotas. p* is the column vector of the T world prices for traded goods. The elasticity of excess supply of the ith good from the rest of the world is given by $\sigma_i^* > 0$, so $\Delta M_i = \sigma_i^* p^*$ where a "\(^\wedge\)" denotes a proportional change. Putting this in absolute form: $dM_i = s_i dp^*$, where $s_i = \sigma_i^* M_i / p^*_i$ and is the slope of the foreign excess supply curve for good i. In matrix form this becomes:

$$dM = [\ldots, s_i dp^*, \ldots] = s dp^*.$$  \hspace{1cm} (2 - T)

For each of the TQ goods covered by binding import quotas, $dM_i = \bar{M} Q_i$ where $\bar{M}_{Q_i}$ is the autonomous increase in the licences to import the ith good. Thus

$$dM_Q = \bar{M} Q$$  \hspace{1cm} (3a - T_Q)

where $\bar{M}_Q$ is a (TQx1) column vector.

For each of the 'T' traded goods which are not subject to import quotas domestic producer prices are related to world prices, p*, by

$$p_i^D = (1 + t_i) p_i^*$$

where $t_i$ is the import tariff or export subsidy on the ith good (depending on whether it is imported or exported in the initial equilibrium) expressed as a fraction of its world price. Thus, we are measuring domestic prices in foreign currency which in effect amounts to assuming that the exchange rate is fixed at a value of one. This equation can be rewritten in matrix form as
\[ dp^P = (1 + t) dp^* + p^D dt \]  \hfill (3b - T_T)

where \( dt \) has dimensions \( T_T \times 1 \).

The balance of payments equilibrium is defined by

\[ p^* \ dM + M' \ dp^* = \bar{F} \]  \hfill (4 - 1)

where "'" denotes a transpose, so \( p^* \) is \( 1 \times T \); \( dM \) is a \( (T \times 1) \) column vector of changes in net imports, \( M' \) is a \( (1 \times T) \) row vector of net imports (so the \( i \)th term is positive or negative depending on whether the \( i \)th element is initially imported or exported), and \( \bar{F} \) is the autonomous increase in the sales of foreign exchange by the government. In each case when we discuss government sales of an item we assume that it is initially kept idle, so that the effect of government sales of foreign exchange or anything else is to permit it to be used by the private sector, as well as to set up certain price changes and welfare redistributions as a consequence.

Let \( A \) be the \( (N \times N) \) input-output coefficient matrix defined in physical units, so that the \( (N \times 1) \) vector of net outputs, \( Y \), is given by \( Y = [I - A] X \) where \( X \) is the \( (N \times 1) \) vector of gross outputs, and the net output of any good is its domestic production net of its use as an intermediate input.

Denote \( \tilde{Q}_i \) as the autonomous increase in sales of good \( i \) by the government, due say to a new project, so that the \( \tilde{Q} \)'s will be positive for those goods produced by a project and negative for those goods used up by the project.

Then commodity balance is described by

\[ dC = [I - A] \ dX + [\tilde{Q}_M] + \tilde{Q} \]  \hfill (5 - N)
where \( C \) is an \((N \times 1)\) vector of domestic consumption of the \( N \) goods, \( \bar{Q} \) is the \((N \times 1)\) vector of \( \bar{Q}_i \)'s, and \( 0 \) is a column vector of zeros, one for each of the non-tradeables.

Each good \( i \) is produced using each of its intermediate inputs and a value added composite in fixed proportions.

We define a value-added composite, \( Z \), as a first degree homogeneous function of labor and capital employed in producing value added. Since each factor is paid its marginal product, for movements along the production function it must be true that 
\[
 p_{vi} dz_i = w_i dL_i + r_i dK_i
\]
where \( p_{vi} \) is the price of value added, \( w_i \) is the wage, \( r_i \) is the rental rate, \( dz_i \) is the increase in the production of value added and \( dK_i \) and \( dL_i \) are the increases in labor and capital inputs in industry \( i \). Rewriting this relationship we have

\[
 Z_i = v_{Li} L_i + v_{Ki} K_i
\]

where \( v_{Li} = w_i L_i / p_{vi} \); \( v_{Ki} = r_i K_i / p_{vi} \). \(^2\) Thus \( v_{Li} \) and \( v_{Ki} \) can be interpreted as shares of capital and labor in value added in industry \( i \). Moreover, since all value added must accrue to either labor or capital, \( v_{Li} + v_{Ki} = 1 \).

Since the value added composite is combined with other factors in fixed proportions to produce \( X_i \) we have

\[^2\]This equation is a special case of the relationship that states that when a good is produced under competition with a first degree homogeneous production function, the percentage change in its output is equal to the weighted sum the percentage changes in inputs, with each weight being the appropriate factor share, i.e. 
\[
 \hat{x} = \sum_i \theta_{ix} \hat{v}_i
\]
x, \( \hat{x} \) is the proportional change in the input of the ith factor into the production of \( x \) and \( \theta_{ix} \) is the share of the value of \( x \) produced which is paid to the ith factor. For further discussion see Caves and Jones (1981, p. 513).
where $X_i$ is the number of units of good $i$ produced.

Holding the capital stock fixed (but allowing intermediate inputs to vary) means that we can combine these two equations to yield:

$$dX_i = \lambda_i dL_i \quad \text{where} \quad \lambda_i = \frac{X_i v_i}{L_i}.$$  

The $N$th good can be thought of as a non-competitive import which is not produced at home. Thus, $X_N$ and hence $\lambda_N$ is zero.

In matrix notation

$$dX = \lambda^D dL$$

where $dX$, $dL$ and $X$ are $N \times 1$ and $\lambda^D$ is an $(N \times N)$ diagonal matrix with the $i$, $i$th element equal to $\lambda_i$.

To relate prices of inputs and outputs we have from Caves and Jones (1981, p. 509)

$$p = \sum_{ij} \theta_{ij} p_i + \theta_i w + \theta_{kj} r_l$$(6 - N)

where $\theta_{ij}$ is the share of $i$ in the production of $j$ in the initial equilibrium, $\sum_{ij} \theta_{ij} + \theta_i + \theta_{kj} = 1$, $w_j$ is the wage rate, and $r_l$ is the user cost of capital in industry $j$. Due to our fixed proportions assumption:

$$X_j = Z_j = v_j L_j.$$
Thus the percentage change in output is equal to the percentage change in labor input weighted by its share in value added.

By definition, with a fixed capital stock

\[ L_j^\prime = \sigma_j (r - \hat{\omega}_j) \]

where \( \sigma_j \) is the elasticity of substitution between labor and capital in industry \( j \). Combining these last three equations yields

\[ p_j^\prime = \sum_{i} \theta_{ij} p_i^\prime + \theta_j \hat{\omega}_j + \frac{\theta_j}{e_j} X_j \] \hspace{1cm} (6')

where \( \theta_{ij} \) is the share of value added in the production of \( j \) and \( e_j = \sigma_j \lambda_j / \theta_j \) is the elasticity of supply of output (\( X \) or \( Z \)) with respect to the wage rate (holding the capital stock and all other prices except for the rental rate constant, and while allowing the total quantities used of all intermediate inputs to vary). Since \( \sum_{i} \theta_{ij} \hat{\omega}_j = 1 \), this equation implies that if the wage rate and all intermediate goods prices rise by some proportion, the supply curve of \( X_j \) will rise by the same proportion.

Furthermore, the coefficient of \( X_j \) implies that the supply curve of \( X_j \) will be flatter the higher is the elasticity of substitution between labor and capital, the smaller is the share of value added in output, and the higher is the ratio of the share of labor to that of capital. Finally, a one percent increase in the price of an intermediate input will cause the supply curve of output to shift upward by the share of that intermediate input in output.

We follow de Melo (1978b) in recognizing the possibilities of distortions in labor markets by assuming that relative wages are unchanged so that each \( \hat{\omega}_j \) is identical, but do not require all wages to be identical.
Putting this into matrix form with \( w \) being the standard wage we have

\[
[I - \theta'] \left[ \frac{1}{\text{p}^D} \right]^D \text{dp}^P - \left[ \frac{\theta_v}{\text{w}} \right]^D \text{dw} - \left[ \frac{\theta_{v_i}}{\text{eX}^D} \right] \text{dX} = 0 \quad (7 - N)
\]

where \( \theta' \) is the \((N \times N)\) transpose of the matrix of goods shares \( \theta_{ij} \) in output.

Let \( \bar{L} \) be an autonomous increase in government sales of labor services. Then, full employment dictates that

\[
\text{ UdL } = \bar{L} \quad (8 - 1)
\]

where \( U \) is a \( 1 \times N \) row vector of 1's and \( dL \) as before is a \( N \times 1 \) column vector.

We will pretend that there are two types of consumer in our model, one which earns its income from the private sector, and one which spends government revenue from taxes and tariffs. To keep the analysis simple, we will pretend that both types of consumers have identical and homothetic demand functions. This assumption means that at given relative prices goods will be demanded in the same proportions regardless of the distribution of income between consuming groups or the level of aggregate income. Moreover, we will assume that the policy maker attaches 1 util to each additional dollar's worth of real income which accrues to the former and attaches \( 1 + \alpha \) utils to each dollar's worth of real income that accrues to the latter where \( \alpha > 0 \). Thus the change in economic welfare, i.e. the policy maker's utility, is given by

\[
\text{dW} = \text{pc}^' \text{dC}_p + (1 + \alpha) \text{pc}^' \text{dC}_g
\]

where \( \text{dC}_p \) and \( \text{dC}_g \) are the \( N \times 1 \) vectors of consumption by the two groups.
Thus we are assuming that the policy maker trusts each consumer to allocate his own budget to maximize utility and that the policy maker attaches a premium of 100·α% to expenditure out of government revenue. Alternatively we could have assumed that the government spends its revenue directly on public goods and that the policy maker's welfare is the sum of utility accruing to consumers, if we further assume that all consumers attach 1 util to a marginal dollar spent on any private good and 1 + α utils to a marginal dollar spent on any public good, where $C_p$ and $C_g$ are the vectors of consumption of private and public goods. Either interpretation fits our mathematics. This equation can be rewritten as

$$dW = p^C dC + \alpha p^C dC_g.$$

Thus if all expenditure is weighted equally in the policy maker's utility function, $\alpha = 0$ and the change in welfare is equal to the change in aggregate consumption evaluated at the initial set of prices.³

Define $R$ as government revenue, and $g$ as the ratio of government revenue to total final demand in the initial equilibrium. Then recognizing that the two consumers spend their incomes in the same ratios, and that all government revenue is spent, $dR = d[C_g p^C]/g$, so $p^C dC_g = dR - C_g d[p^C]$ and we can rewrite the

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³Harberger (1974, ch. 1) argues that attitudes toward income distribution are likely to vary from observer to observer, so that policies should be evaluated first on grounds of efficiency without regard to income distribution, and then with regard to implications for income distribution. In our model this would involve performing the analysis first for $\alpha$'s corresponding to expenditure by all groups set equal to 1 and then setting the $\alpha$'s to different values to reflect different attitudes toward income distribution. Moreover, Harberger (1978a; 1978b) also argues that assigning different $\alpha$'s to consumption by different individuals may be inferior to assigning high $\alpha$'s to consumption of certain commodities by certain individuals which meet basic needs as perceived by society (e.g. a child's first drink of milk or visit to the doctor).
previous equation as

\[ dW = dy + \alpha [dR - \sum g dp^c] \quad (9 - 1) \]

where the expression in the brackets is the change in real government revenue or the purchasing power of government revenue and

\[ dy = p^c' dC \quad (10 - 1) \]

which is simply the change in real income, or the change in aggregate utility if we postulate the marginal utility of real income to all spenders is 1.

Since government revenue is simply equal to taxes collected plus the value of any governmental sales of foreign exchange, labor or goods we have

\[ dR = \sum_i \sum_{i,e} \left[ \frac{C^i_{t, p^d}}{1} + t p_*^m \right] + F + wL + p^c \quad (11 - 1) \]

Finally we write the demand relationship as

\[ dC = Bdp^c + (m/p^c)dy \quad (12 - N) \]

where \( B \) is the \( N \times N \) matrix of pure substitution terms, with the \( i, j \)th being

\[ \frac{C^i_{t, p^d}}{p^j} \]

where \( \eta_{ij} \) is the compensated elasticity of demand for the \( i \)th good with respect to the \( j \)th price, \( m/p^c \) is the \( N \times 1 \) column vector of marginal propen-

---

We have pretended that initially the government is not engaged in any net purchases of foreign exchange, labor or goods just so we won't have to reckon with its monopsony or monopoly power. This is a simplification just for purposes of exposition, for if the government is large relative to the private sector in its impact on any activity, such monopoly-monopsony power would be important.
sities to consume out of real income and \( dy \) is the change in real income. Since all output is consumed, and there is no money illusion, \( \sum_{j}^{\eta_{ij}} = 0 \) for all \( i \).

II.3 SUMMARY

For convenience, we summarize the equations below.

SUMMARY OF EQUATIONS

<table>
<thead>
<tr>
<th>PRICES</th>
<th>EQUATION NUMBER AND NUMBER OF SCALAR EQUATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{d\rho}{c} = \rho^{D}<em>{e} \cdot ^{D}</em>{e} + \left(1 + t_{e}\right)^{D}_{e} \cdot \rho^{p} )</td>
<td>1 - ( N )</td>
</tr>
<tr>
<td>FOREIGN TRADE</td>
<td></td>
</tr>
<tr>
<td>( \frac{dM}{dQ} = ^{D}<em>{Q} \cdot ^{D}</em>{Q} \rho^{*} )</td>
<td>2 - ( T )</td>
</tr>
<tr>
<td>( \frac{dM}{T} = ^{M}_{Q} )</td>
<td>3a - ( T_{Q} )</td>
</tr>
<tr>
<td>( \frac{dp^{P}}{} = \left(1 + t\right)^{D}<em>{e} \rho^{*} + \rho^{P}</em>{D} \cdot dt )</td>
<td>3b - ( T_{T} )</td>
</tr>
<tr>
<td>( \rho^{<em>} \cdot \frac{dM}{M} + \frac{dp^{</em>}}{t} = F )</td>
<td>4 - 1</td>
</tr>
</tbody>
</table>
PRODUCTION AND MARKET CLEARING

\[ dC = [I - A] \, dX + \left[ \frac{dM}{dL} \right] + Q \quad 5 - N \]

\[ dX = \lambda^D \, dL \quad 6 - N \]

\[ [I - \theta'] \left( \frac{1}{p^P} \right)^D \, dp^P - \left[ \frac{\theta}{p^P} \right]^D \, dw - \left[ \frac{\vartheta}{p^P} \right]^D \, dX = 0 \quad 7 - N \]

LABOR MARKET CLEARING

\[ UdL = L \quad 8 - 1 \]

WELFARE, REAL INCOME AND GOVERNMENT REVENUE

\[ dW = dy + a[dr - C'dp^C] \quad 9 - 1 \]

\[ dy = p^C' \, dC \quad 10 - 1 \]

\[ dr = \sum d\left[ C_t \, p^t + t \, p^* M \right] + F + wL + p^C' Q \quad 11 - 1 \]

\[ = \sum \left[ t^p \, dC + C_t \, p^t \, dt + C_t \, dp^P + p^* M \, dt + t \, M \, dp^* \right. \]
\[ + t^p \, p^* dM_t \left| + F + wL + p^C' Q \right. \]

CONSUMPTION

\[ dC = Bdp^C + (m/p^C)dy \quad 12 - N \]
Number of scalar equations: \( 5N + 2T + 5 \)

There are

5 endogenous variables with \( N \) components: \( dp^P, dp^C, dC, dX, dL \)

2 endogenous variables with \( T \) components: \( dM, dp^* \)

4 endogenous variables with 1 component: \( dw, dy, dR, dW \)

2 exogenous variables with \( N \) components: \( dte, \dot{Q} \)

1 exogenous variable with \( T_T \) components: \( d \)

1 exogenous variable with \( T_Q \) components: \( \bar{M} \)

2 exogenous variables with 1 component: \( \bar{F}, \bar{L} \)

Note that there is one less endogenous variable than there are equations, so in the solution of the model one equation must be dropped. We chose to drop equation (10). Note that we have arbitrarily fixed the exchange rate at one, and therefore have made a flexible wage the vehicle which clears the labor market, although we could have equally well fixed the wage and made the exchange rate variable.

\[ \text{II.4 SOLUTION AND INTERPRETATION OF RESULTS} \]

To solve the model we write it in matrix form with the dependent variables on the left hand side and the independent variables on the right-hand side, where each matrix's dimensions are in parentheses underneath it:
The solution is obtained as

\[
\begin{bmatrix}
\frac{dp^p}{dt}
\frac{dp^c}{dt}
\cdot
\cdot
\cdot
\cdot
\cdot
\frac{dW}{dt}
\end{bmatrix} = \begin{bmatrix}
\Omega_1
\cdot
\cdot
\cdot
\cdot
\cdot
\frac{dt_e}{dt}
\end{bmatrix} (13)
\]

\[
\begin{bmatrix}
\cdot
\cdot
\cdot
\cdot
\cdot
\cdot
\frac{dW}{dt}
\end{bmatrix} = \begin{bmatrix}
\cdot
\cdot
\cdot
\cdot
\cdot
\frac{dt_e}{dt}
\end{bmatrix} (14)
\]

where \(\Omega_3 = \Omega_1^{-1} \Omega_2\).

The \(i, j\)th element of \(\Omega_3\) is simply the multiplier showing the impact on the \(i\)th endogenous variable of a unit increase in the \(j\)th exogenous variable, holding constant all of the other exogenous variables, but letting all of the
endogenous variables vary. Each multiplier may be of interest to policy makers. But of particular interest is the last row of the matrix, for it shows the impact of a unit increase in each of the exogenous variables on welfare. This means that, by definition, these elements are simply the shadow prices of each of the exogenous variables or constraints. Thus for example \( dW/F \), which is the element in the last row and next to the last column of \( \Omega \), is the shadow price of foreign exchange; \( dW/Q_i \) is the shadow price of the \( i \)th good, \( dW/dt_i \) is the shadow price of the \( i \)th tariff and \( dW/M_{Qi} \) is the shadow price of the \( i \)th quota.

Note that the specification of (9) means that the numeraire of these shadow prices is domestic currency in the hands of the private sector. In other words a shadow price of 3 for a bushel of rice means that a project consisting of securing a gift from foreigners of a bushel of rice would bring as much increased economic welfare as giving private consumers goods which they value at 3 units of domestic currency with the understanding that their expenditure on each good remains unchanged.\(^5\) If it is desired to express shadow prices in terms of border domestic currency in the hands of the government, all that is needed is to divide each coefficient by \( dW/F \), the shadow price of foreign exchange.

Another way to approach the problem is to follow Gordon Hughes' suggestion to me and interpret shadow prices as the amount of foreign exchange which

\(^{5}\)Note that in this definition I have not said that the rice is worth three units of domestic currency, for to give three units of domestic currency to consumers, in some models of the world would just cause inflation. Moreover it is necessary to add the proviso that expenditure on each good remains unchanged, because without it a gift would alter expenditure patterns and hence resource allocation which in a distorted economy or one where income distribution matters is fraught with externalities which are difficult to evaluate. Shadow prices defined in this way are what Sieper (1981) calls uncompensated shadow prices.
the government would have to buy back from the economy in return for government sale of one unit of the commodity or factor in question in order to leave welfare unchanged. This is the Little-Mirrlees approach which consists of measuring the shadow price of anything by its "foreign exchange equivalent." Mathematically, the natural way to solve this system is to treat $-\bar{F}$ as an endogenous variable on the left-hand side of equations (13) and (14) and to either constrain $dW$ equal to zero or treat it as an exogenous variable on the right-hand side. This means that (14) is replaced by

$$\begin{bmatrix}
dp^p \\
dp^c \\
\vdots \\
\vdots \\
\vdots \\
-\bar{F}
\end{bmatrix} = \Omega_4 
\begin{bmatrix}
dte \\
\vdots \\
\vdots \\
\vdots \\
-dW \\
\vdots \\
\bar{L}
\end{bmatrix}$$

(15)

where $\Omega_4$ is a coefficient matrix. Then we can interpret $-\bar{F}/\bar{L}$ in (15) i.e. the element in the south-east corner of $\Omega_4$, as the shadow price of $\bar{L}$ in the sense of the foreign exchange equivalent of a unit of $L$ or the amount of foreign exchange the policy maker would have to buy back from the private sector in return for releasing one more unit of $L$ from a project if it wished to leave welfare unchanged. Similarly, $\bar{F}/dW = (-\bar{F})/(-dW)$ is the shadow price.

\footnote{This is a different interpretation of Little-Mirrlees from that of Warr (1980) but it is the same as that of Sieper (1981). It is what Sieper calls a compensated shadow price. This notion is precisely what McKenzie (1983) defines as the "Money Metric measure of welfare change," except that we are applying it to a whole economy and keeping the policy maker on a Bergsonian welfare contour instead of one individual on a given indifference curve.}
of economic welfare, in the sense that it indicates how much foreign exchange in the hands of the private sector would be needed to generate one more unit of economic welfare. The reciprocal of this term is what Warr (1980, p. 34) refers to as "the shadow price of foreign exchange in utility numeraire" and what Bacha and Taylor (1971) refer to as the second best shadow price of foreign exchange.

One of the nice aspects of this approach is that it brings out the logical relationship between determining the desirability of a particular policy reform (e.g. a package of adjustments in tariffs, quotas and excise taxes) and a particular project (e.g. a package of positive excess supplies of certain goods [outputs] and negative excess supplies of certain others [inputs]). In both cases the desirability of the package is evaluated by multiplying the package of changes by the shadow price attached to each change.

Moreover, in some circumstances it may be important to have consistent estimates of both shadow prices of policy parameters and goods. For example, suppose that a particular project involves the production of certain goods along with the use of certain inputs and the relaxation of certain import quotas, but the raising of certain tariffs in order to leave government revenue unchanged. Evaluation of the desirability of this project will involve evaluating the change in all of these variables by multiplying the various changes by the appropriate shadow prices. Such an exercise would be facilitated by the approach laid out here, both because our matrix can be used to calculate the shadow price of each constraint and good, and because the revenue row can be used to determine the contribution of each change in inputs, outputs and constraints to revenue, thereby enabling one to calculate the change in the tariff or tariffs that would just offset the negative revenue effects of the project itself.
A few more additional points are worth making:

A. Suppose we wish to know how free trade will affect equilibrium. We can express all quantitative constraints on trade as a tariff equivalent, and then solve the model for a small equiproportional cut in all tariffs. The model should give very accurate estimates for a uniform tariff reduction as small as 1%. Then all we need to do to have a measure of the impact of free trade is to multiply the multipliers for a 1% uniform cut in tariffs by 100. Such a measure will be an imperfect estimate, but it should give a reasonably accurate ranking of industries from most hurt to least hurt. For a more precise figure one could apply the n step procedure described in DPSV (1982, sec. 8, ch. 5 and sec. 47).

B. Suppose we wish to calculate net effective protection or domestic resource cost. Once a general equilibrium program is set up, it would be a small additional programming problem to pull out of it standard measures of net ERPs and DRCs. Moreover if one wishes to use the effective rate of protection as a measure of the effect of the tariff structure on resource allocation, it seems to me that neither the Corden nor the Balassa way of handling non-traded goods nor the Balassa method for handling exchange rate change is as good as the following: Use the linearized general equilibrium model as described above to estimate changes in wage rates, exchange rates and non-traded goods prices, and then use these to calculate net effective protection. Similarly use the model to calculate shadow prices for inputs into a project and outputs from it. Then combining input and output flows from a hypothetical project enables us to calculate its DRC.

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7 For definitions of these methods and the formulas see Balassa and Associates (1982, pp. 352-354). This way of dealing with non-traded goods is what Ray (1973) proposes and labels the Scott method after Little, Scitovsky and Scott (1970, p. 432).
Also, as Garry Pursell has suggested, one may want net effective protection statistics on a more disaggregated basis than could be estimated using a general equilibrium model. In this case, one could use the linearized general equilibrium model to calculate price changes for various input aggregates, and use these in order to calculate more disaggregated net effective protection measures.

C. The kind of analysis proposed here is not at conflict with the partial equilibrium analyses provided by Corden (1974) and others. Their studies can be interpreted as describing various aspects of a general equilibrium system in isolation. It is the role of a model of the sort described here to provide a framework for putting together the ideas Corden discussed separately in various chapters, and treating them all together in a general framework.

Moreover, the techniques proposed here are well known and have been implemented with varying degrees of complexity and disaggregation and to focus on various issues.\(^8\)

D. Now let us provide a measure of the welfare cost of all the distortions taken together to a quadratic approximation. In order to avoid the problem of varying marginal utility of income, we will interpret the welfare cost of an existing set of distortions as the amount of foreign exchange which could be taxed away from the economy, simultaneously with the distortion elimination so as to leave domestic welfare unchanged. Thus, we are adopting the Little-Mirrlees numeraire, and as our measure of welfare change, we are taking the compensating variation in foreign exchange. To measure the welfare cost of

\(^8\)See for example Taylor and Black (1974), the ORANI model described in DPSV (1982), Stoeckel (1978) which also deals with Australia and Baade and Richardson (1973), which deals with the United States and permits labor to acquire new skills in response to changed relative wages, as well as the early work by Johansen (1960).
all of the distortions taken together to a quadratic approximation, one need only calculate the foreign exchange equivalent of say a 1% proportional reduction of all distortions, multiply this figure by 100 and divide by 2. To see why this is true, write the size of the ith distortion ($T_i$) as the product of its initial observed value $\bar{T}_i$ and an index, $I$, which varies from zero to 1. Let us approximate the compensating variation in official foreign exchange sales per unit increase in the index ($F'$) as a linear function of the index as in figure 1, where $F'$ is given from the solution of our model as $\frac{dW/dI}{dF} > 0$, at the point where $I = 1$.

We know that $F'(I) = 0$ when $I = 0$, (a result which simply states that the marginal welfare cost of a small distortion increase is zero when the distortion is initially zero). Also, $F'(I)$ when $I = 1$ is given by our model as $F'(1)$, so the welfare cost of the entire set of distortions is given by the shaded area in figure 1, and its value is just

![Figure 1](image-url)
\[
\frac{F'(1) + F'(0)}{2} = \frac{F'(1) + 0}{2} = \frac{F'(1)}{2}.
\]

Thus, if we discovered that a 1% cut in the initial level of each distortion would increase national income by 1 million dollars, a complete elimination of them should increase national income by 50 million dollars.

E. Now let us make explicit the mathematics that we are using in part D, since this mathematics is also applied implicitly by Johnson (1971) in his chapters involving consumers' surplus. Implicitly, we have expressed the compensating variation in foreign exchange per unit change in the index as a Taylor's series:

\[
\frac{dF}{dI} = F'(1) + (I-1)F''(1) + \frac{(I-1)^2F'''(1)}{2} + \ldots.
\]

We assume that third and higher order terms are small relative to the first and second order terms so that we can drop third and higher order terms.

Then, recognizing that solution of our model gives us \( F'(1) \) we solve for \( F''(1) \) as

\[
F'(0) = 0 = F'(1) + (0-1)F''(1)
\]

to yield

\[
\Delta F = \int_1^0 \frac{dF}{dI} \, dI = \int_1^0 [F'(1) + (I-1)F'(1)] \, dI = \frac{1}{2} \left[ \frac{2}{1} \right] \left. F'(1) \right|_0^1 = -\frac{F'(1)}{2}.
\]

This is the measure we derived in the previous section and it simply states that the variation in foreign exchange endowment which would just compensate for the elimination of all distortions is \(-F'(1)/2 < 0\). Thus, we can see that
our welfare approximation is accurate to the extent that it is legitimate to approximate the compensating variation in foreign exchange as a second order Taylor's series in the distortion index.

F. Note that once one has obtained either the curve in Figure 1 or else the Taylor's series approximation, one could calculate the welfare effect of any change in the distortion index. For example, a doubling of all tariffs and taxes would carry with it a compensating variation of foreign exchange of

\[ \Delta F = \left[ F'(1)/2 \right] \left[ 2^2 - 1 \right] = 3F'(1)/2. \]

Of course all of these approximations are needed only if one wishes to avoid using the numerical integration techniques described in DPSV (1982) or building a CGE model.

**II.5 EXTENSIONS**

In the model just described, we assumed that capital was sector specific but that labor was perfectly mobile between sectors, and was homogeneous. We also postulated that demand functions of individuals were identical and homothetic. In this section we discuss alternative ways of modeling the economy. The thrust of this section is that the linear modeling framework can be used to describe a large range of models and adjustment mechanisms. The only situation it can't handle is a world where the pattern of specialization is uncertain, a problem which crops up when we have all four of the following conditions together: There are no diseconomies of scale, all factors are perfectly mobile, world prices are fixed, and there are more traded goods than
mobile factors.\(^9\) We now turn to particular aspects of economic systems which might be worth modeling.

**a. The Labor Market**

We have assumed that the labor market clears, and that price changes keep the balance of payments in equilibrium. There is no reason, though, why we could not model a situation in which money wages or real wages are inflexible downwards in a few or all sectors as DPSV (1982) describe. Moreover, we have assumed that labor is paid its marginal product, but we could equally well have modeled share cropping arrangements where labor is entitled to some fraction of the output it produces.\(^10\) Also, we have postulated constant proportional wage differentials between sectors, but there is no reason why that too could not be variable,\(^11\) and then if we believe that the Harris-Todaro mechanism is at work creating a throng of urban unemployed who accept unemployment some of the time in return for being employed some of the time at the higher urban wage (see Corden 1974, 144-54), we could model that unemployment (a la Corden) as being dependent on the wage differential.

Similarly, we could recognize that in many sectors wages may only be partially flexible, with the rate of fall being a function of the amount of

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\(^9\)One way of handling the problem is to follow de Melo (1978a; 1980) and others cited there in postulating mildly decreasing returns to scale. De Melo postulates decreasing returns to scale of .9 in all sectors. As de Melo (1980, p. 115) notes, assuming that each industry employs a fixed factor specific to itself amounts to assuming diminishing returns to the other non-specific factors. Thus, the model presented here contains many of the core elements which one would use in modeling a longer run time horizon with most factors of production inter-sectorally mobile.

\(^10\)For discussion of recent work on this problem, see C. L. G. Bell (1979).

\(^11\)For analysis of the long and short run effects of eliminating factor market distortions in Columbia see de Melo (1977).
unemployment in the sector in question.

b. The Exchange Rate

We have assumed the balance of payments to be in perpetual equilibrium. But again we could have held certain internal prices as well as the exchange rate fixed and permitted the balance of payments to vary.

c. Industrial Organization

We have assumed competition in product markets, but one could alternatively use a model of mark up pricing following Staelin's (1976) analysis of the Ivory Coast or Harris's (1982) analysis of Canada.

d. Private Sector Shadow Prices

So far, we have interpreted shadow prices of goods as the gain in social welfare or government stocks of foreign exchange of governmental sale of one unit of the good or factor. Sometimes the government is called upon to evaluate a particular private sector project carried out by someone in a particular category (e.g. small business, large business, or foreigner, etc.). A project carried out by such a person is equivalent to the project being carried out by the government combined with a transfer by the government to the person of a sum of money equal to the project's cash flow. Thus the net sale of a good or factor by such a person is equivalent to the same net sale by the government combined with a net transfer by the government to the person equal to the market value of the good or factor. Thus the shadow price of a good produced or consumed by a private sector project should equal the shadow price as previously calculated plus the shadow price of a transfer from the government to the particular person (which will generally be negative).
Therefore, if the individual is a particularly worthy soul in the eyes of the government, the government will put only a slightly negative shadow price on transfers of revenues from him. Thus it will attach a high shadow price to both commodities he uses and commodities he produces, and if the individual anticipates a profit from the activity, the government should be more likely to approve the activity than if a "less worthy" soul proposes to undertake it.

If it is possible to reform only some aspects of the tax code, those aspects which are reformable should be modified so that producers and consumers in effect respond to shadow prices rather than market prices. The easiest scheme would probably be to publish a common set of shadow prices for each input and output for all firms and levy taxes or subsidies as needed to bring after tax or subsidy market prices in line with shadow prices and then to tax any profits that are left at a rate appropriate to the category of the individual proprietor. Such an approach would be the appropriate way to modify investment codes.

In many cases there are taxes that the government could levy without incurring any efficiency cost at all, such as auctioning of import licenses. If those kinds of taxes are available and it is politically feasible to levy them, it seems hard to justify placing a significant premium on government revenue. Similarly, there may be reasonably efficient taxes that one could levy on the rich. In the limit as revenue collection and income redistribution becomes costless, we do not need to distinguish between shadow prices to the government and the private sector, which simplifies the analysis considerably, for in that case, the shadow price of any good or factor simply becomes the welfare impact of an increase in the economy's endowment of that good or factor. This is the approach we use in subsequent chapters.
e. Heterogeneous Labor

We have assumed that all labor is homogeneous. But there is no reason why we could not recognize that labor is heterogeneous in skills, aptitudes and tastes. Then we could make output in each sector depend on the employment of various types of labor, with whatever degree of substitution between them seems appropriate (on this see DPSV 1982, pp. 76-90). Then on the supply side, we could recognize that labor's willingness to switch industries or to acquire new skills depends on relative wages. We could even have voluntary unemployment and make it dependent on the real wage, and the level of unemployment compensation. Baade and Richardson (1973) have treated labor in this way.

f. Sectorally Mobile Capital

One could also deal with mobile capital in a similar way. We cannot let all factors which are used in producing tradeable goods be perfectly mobile, for then the problem of specialization arises. But we can recognize that as differentials between rates of return to capital in different sectors increase, increasing amounts of capital will move from the low return sectors to the high return ones. We can then relate changes in capital allocation to changes in real rates of return with a matrix of transition coefficients, much as Baade and Richardson (1973) did for labor. If one is building a model to describe the short run, one would want the transition coefficients showing the responsiveness of capital's location to rental differentials to be small, but if one is building a model to describe a longer time horizon, one would want somewhat larger coefficients. Such a scheme is discussed by DPSV (1982, pp. 118-122).
g. Savings

When modeling a still longer time horizon over which savings can take place, one might wish to make the aggregate supply of capital responsive to the rate of return, government revenue or the incomes of certain groups. If each industry produced output using a fixed factor plus variable factors, one could simply assume that capital is allocated so as to equalize rates of return in all industries. Otherwise, in order to avoid the specialization problem one would need to make some alternative assumption, for example by assuming that new capital is allocated to industries in accordance with rates of return and initial capital stocks, but that it is not allocated in such a way that rates of return are equalized or else that there are either decreasing returns to scale (de Melo 1978a; 1980) or that both domestic and foreign demanders view domestic and foreign goods as imperfect substitutes, so that both the foreign and domestic demands for domestically produced goods are less than perfectly elastic (e.g. de Melo and Robinson (1981) and Dervis, de Melo and Robinson (1981)).

h. Demand

We have assumed that within each category of goods domestic and foreign products are perceived as identical by consumers and producers. However, the standard assumption in computable General Equilibrium (CGE) modeling is to postulate that both producers and consumers view domestic and foreign goods to be imperfect substitutes, an assumption that DPSV (1982) have used in this sort of modeling as well. Finally, we have assumed that all consumers have identical demand patterns, but there is no reason why we could not introduce different behavior by different consumer groups who derive their incomes from different sources.
1. Data

While data requirements would depend on the precise use and level of sophistication which one would like to put models of this sort to, in order to apply the model developed in this chapter one needs only know the input-output flows in the base year combined with tariffs, taxes, and quotas, figures showing how value added is broken down into returns to land, capital and labor and have guesses about what income elasticities and elasticities of substitution in production and consumption are. For a discussion of data requirements of a sophisticated linear model see chapter 4 of DPSV (1982), "The ORANI data input files."

j. How Complex?

Calibrating models of this sort can take as much or as little energy as the user wishes. Much use could be made of very simple models with one exportable, one importable and one nontradeable. Also, one can either collect detailed data or just simply assume that many parameter values are very similar to those of other countries and ask knowledgeable country experts to provide the rest based on their best guesses about how the economy in question works. Then one can use a model of this sort to work out the consequences of various changes in endowments, policy parameters or exogenously given circumstances. On the other hand if one wishes to use a model of this sort for detailed sectoral planning, one would wish to use a highly disaggregated model with very careful specification of behavior patterns, and such a task could be very expensive and fraught with both conceptual difficulties and data problems that would require considerable hard work and ingenuity to solve.

For further work on how complex linear models have been constructed, and the uses they have been put to both in the narrow sense of what has been
simulated and in the more general sense of what their impact has been in the
policy making context, see DPSV (1982). Now we consider in Chapter III the
other extreme, namely some applications of quite simple models.
Chapter III

APPLICATIONS TO SECOND BEST TARIFFS

III.1 ON A QUICK AND SIMPLE APPROACH TO
ESTIMATING SECOND BEST TARIFFS

1.a Introduction

Now that we have constructed a reasonably detailed model and explored its implications, we turn to a succession of special cases. In this first section of Chapter III, we discuss a simple procedure for determining second best optimum tariffs and show how it could be useful in the policy advising process. Policy advisors are frequently faced with a problem of the following sort. Import tariffs on certain goods - typically final products - are fixed by political considerations to be above some floor while subsidies on certain exports are forced by factors such as the possibilities for invoice falsification and smuggling not to exceed a certain ceiling. However, there are some imports (perhaps intermediate products and raw materials) whose initial tariffs are low and can be raised without facing political opposition. The problem is, what sort of tariff level should the policy advisor recommend on these goods?

More generally, and in the jargon of economics, suppose a policy advisor faces many distortions and only has a few policy tools to cope with them. How should he set the levels of these tools?

A second problem facing the policy advisor is that he must arm policy makers with policy analysis which is both believable and comprehensible: the
models used must incorporate enough of the policy maker's beliefs about how his economy works so that he believes the models are worth using and they must be sufficiently clear and simple so that policy makers understand them well enough so as to convince others that the recommendations which flow from them should be implemented. To cope with this problem we need to employ in the policy process simple models which are easy for local policy makers to understand, in which the basic economic principles are clear, and which can profitably employ information from the policy makers for their actual implementation.

In this section we develop an approach to the problem noted in the first paragraph which has the benefits cited in the third. Rather than develop a full-blown detailed model, we present a simple model, and then indicate how it can be extended. The economics here is not new, but I believe the approach to policy advice is.

1.b Consumption and Welfare

Throughout this section, we assume that all final demand is consumption; we ignore income-distribution considerations and we assume that consumers know what is good for them; hence private utility is synonymous with social utility. In other words Chapter II's $\alpha$ is equal to zero. We assume away all externality, assume our economy trades at fixed world prices and postulate an import tax or export subsidy equal to $t_i$ levied on the world price of good $i$. Should we have an import subsidy or an export tax levied on the good, $t_i$ would be negative. Since we assume that no good will be both imported and exported $t_i$ will be interpreted as referring to imports or exports of good $i$ depending on whether in the equilibrium considered the good is imported or
exported. $t_i$ is assumed to be expressed as a fraction of the foreign price.

In what follows:

- $p_i^*$ is the world price of good $i$
- $p_i$ is the domestic price of good $i$
- $Q_i$ is the net domestic output of good $i$. Thus $Q_i < 0$ implies that the economy uses more $i$ as an intermediate input than it produces as gross output.
- $E_i$ is net export of good $i$.

Finally, $p_i^*$ will be taken to be the C.I.F. price of good $i$ if it is an import and the F.O.B. price of good $i$ if it is an export in the initial equilibrium.

We define the marginal utility of income as unity in the neighborhood of the initial equilibrium, and since consumers are assumed to know what is good for them, the change in society's utility, $dy$, evaluated at prices to consumers is given by

$$dy = \sum p_i dC_i$$  (1)

where $C_i$ is consumption of the $i$th good and $dC_i$ is its change. Thus, if we knew how consumption of each and every good would be affected by a change in tariffs, we could evaluate the utility associated with that change solely by reference to equation (1).

**1.c Production, Trade and Welfare**

Suppose instead we had information on the $dQ$'s and $dE$'s. Then we could calculate the $dC$'s and proceed as before. However, suppose we have information on the $dQ$'s and the $dE$'s, along with information on tariffs, but no direct information on prices. Let's see how to use that information to calculate the utility of a tariff change.
The balance of payments constraint means that

$$\sum_{i} p_i dE_i = \sum_{i} (p_i^* - p_i) dE_i + \sum_{i} p_i dE_i = 0. \quad (2)$$

The fact that the economy is on its production possibilities frontier means that

$$\sum_{i} p_i dQ_i = 0. \quad (3)$$

Combining (1), (2) and (3) with the fact that $dC_i = dQ_i - dE_i$ implies

$$dy = \sum_{i} (p_i^* - p_i) dE_i. \quad (4)$$

Since the taxes and tariffs are the wedges between buyer and seller, we can reexpress (4) as

$$dy = -\sum_{i} t_i p_i dE_i. \quad (5)$$

Now, suppose that all $t_i$'s are fixed, except for $t_o$, and our problem is to find the optimum level of $t_o$. A necessary condition for us to be at a welfare optimum is that small changes in $t_o$ leave $y$ unchanged. Thus $t_o$ will be at its optimum level when

$$\frac{dy}{dt_o} = \sum_{i} t_i p_i \frac{dE_i}{dt_o} = 0$$

or when

$$t_o^* = \frac{\sum_{i=N} dE_i}{\sum_{i=1}^{N} t_i p_i \frac{dE_i}{dt_o}} \quad (6)$$
where $t^*_0$ is the second-best optimum tariff on good 0, and there are $N + 1$ traded goods in the economy. What equation (6) tells us is that we can calculate $t^*_0$ by knowledge of how trade flows depend on the tariff on the zeroth commodity plus the existing levels of other tariffs and subsidies to trade. We turn now to two applications of this formula.

1.4 One Import and One Export

Suppose our economy imports good "1" and exports good "0", and engages in no other trade. Furthermore, suppose the import tariff on "1" is given, and we need to determine the optimum tax or subsidy on the export of good "0". Since trade is always balanced

$$p_0^* \frac{dE_0}{dt_0} + p_1^* \frac{dE_1}{dt_0} = 0,$$

i.e. any change in imports must be balanced by an equal change in exports. Thus, (6) tells that

$$t^*_0 = t_1.$$

In other words the import tariff on good 1 must be matched by an equal subsidy on the export of good 0. This conclusion is of course familiar from the Lerner neutrality theorem,\(^1\) which states that a common import tariff on all imports which is matched by a common export subsidy on all exports has no economic effect. Note that in applying this formula our policy maker is reminded that exchange rates or relative prices will always be forced to

\(^1\)For a discussion of this theorem, see Kaempfer and Tower (1982).
adjust in such a way that trade is always balanced. This particular example, however, has required no input from the policy maker.

I.e Two Imports and Two Exports

Now let us imagine the case of an economy which imports "0," a non-competitive intermediate input, oil, whose tariff is variable, and a consumer good, brandy, which has an 80% tariff attached. The country produces some manufactured goods which use oil as an input, a traditional agricultural export, cocoa, which does not use oil, and a processed agricultural export, chocolate, which uses both oil and the traditional agricultural export as inputs. Further, let's suppose that the exports of cocoa are taxed at a rate of 30% while the exports of chocolate are subsidized at a rate of 20%. We can summarize this information as:

Table 1

\[
\begin{align*}
t_{\text{oil}} &= \,? \\
t_{\text{brandy}} &= .8 \\
t_{\text{cocoa}} &= -.3 \\
t_{\text{chocolate}} &= +.2
\end{align*}
\]

We would expect that increasing imports of oil would skew the export mix toward the production of chocolate. In the ensuing discussion let all prices refer to foreign prices. We presume that the policy maker has more detailed knowledge of the interrelations within the economy than the policy advisor or else is determined to select policies which are consistent with his beliefs.
about how his economy works. Thus, the policy advisor provides the policy maker with a framework for analysis, but leaves it up to the policy maker to give him the final word on how trade flows will respond to tariff changes. Suppose that it were anticipated by the policy maker that if the exchange rate did not alter, for each additional dollar of imported oil, exports of cocoa would fall by 20¢, exports of chocolate would rise by 60¢, and the increased oil would reduce the price of domestic manufactured goods by enough so that consumers will reduce their consumption of imported brandy by 20¢. Assuming balance of trade equilibrium to begin with, this will generate a trade deficit of 1$ + 20¢ - 60¢ - 20¢ = 40¢.

It will be necessary to depreciate the domestic currency or else reduce domestic wages and prices until trade balance is restored. If we postulate that this cheapening of the relative price of domestic non-traded goods will increase each of the exports by 10¢ and reduce each of the imports by 10¢, this leaves us with net changes indicated in Table 2.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>P*oil</th>
<th>AEoil</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>p*</td>
<td>-1.00</td>
<td>.10</td>
<td>- .90</td>
</tr>
<tr>
<td>p*brandy</td>
<td>+.20</td>
<td>+.10</td>
<td>+.30</td>
</tr>
<tr>
<td>p*cocoa</td>
<td>-.20</td>
<td>+.10</td>
<td>-.10</td>
</tr>
<tr>
<td>p*chocolate</td>
<td>+.60</td>
<td>+.10</td>
<td>+.70</td>
</tr>
</tbody>
</table>

This table emphasizes that a currency depreciation or fall in domestic costs is needed which will just offset the incipient trade deficit which is created
by the liberalization. Thus, the one constraint on the $p^*\Delta E$'s is that they all add up to zero. We can now use this information to calculate the optimum import tariff on oil from (6) as
\[
t_{oil}^* = \frac{-[(.8)(.3)+(-.3)(-.1)+(.2)(.7)]}{-.9} = 46\% \tag{8}
\]

Obviously any calculation such as this depends on a whole set of estimates about how the tariff affects goods flows. Thus, in this particular example, if oil were highly substitutable for brandy in consumption, $p_{brandy}^* \Delta E_{brandy} = -p_{oil}^* \Delta E_{oil}$ and $t_{oil}^* = 80\%$. On the other hand if oil and cocoa were near perfect substitutes in domestic consumption we would expect $p_{cocoa}^* \Delta E_{cocoa} = -p_{oil}^* \Delta E_{oil}$ and $t_{oil}^* = -30\%$, a 30% subsidy.

\subsection*{1.f Benefits from this Approach}

This basic approach forces the policy maker to think in terms of general equilibrium, distortions and adjustment mechanisms. It provides an analytical basis for selecting a restriction level. It also makes clear why there is some uncertainty in selecting the optimal level for the remaining policy instrument, and it indicates clearly, what more detailed information is necessary to select the remaining tariff with confidence. Thus, such an approach might provide a very sound basis for further discussion and for research designed to better determine the impact of the tariff on actual goods flows.
Once the basic approach presented here is agreed upon as being a sensible way to approach the problem, it is easy conceptually to add other distortions like monopoly power, excise taxes, minimum wages, variable world prices, externalities both in consumption and production, and distribution weights in final consumption, or differential utilities attached to consumption and investment.

Moreover, one can build a general equilibrium model and linearize it along the lines of Chapter II to calculate more precisely the changes in goods flows in response to changing tariffs. Such a job can be done with the computer for disaggregated models or else by hand for highly aggregated models. Moreover, if one takes the view that the truly optimum tariff structure should seek to minimize rent seeking,\(^2\) should be perceived as "fair" by the man in the street, and should be easy and low cost to administer, then one may want to have only a few different tariff categories. In such a case, it would be possible to work with fairly simple highly aggregated sorts of models, so the analysis itself need not be costly.

\(^2\)On rent seeking, see the essays by Diamond, Bhagwati, Krugman, Findlay and Wellisz, Feenstra and Bhagwati, and Baldwin in Bhagwati (1982) and the references therein.
III.2 ON USING A SINGLE TARIFF TO EXPLOIT MARKET POWER ON MANY TRADED GOODS*

2.a Introduction

In this essay, we explore a second application of our basic model. Namely, we show how to determine the optimum level of the only tariff which we permit to be variable given the presence of other fixed tariffs and externalities, in this case variable world prices which reflect a country's monopsony or monopoly power on world markets. Thus world price deviates from the country's marginal revenue or marginal expenditure and it is desirable from the individual country's standpoint to use tariffs to correct this distortion. We obtain the important result that the distortion associated with trade in any commodity is simply the excess of the tariff over the optimum one, where the optimum tariff is evaluated using parameters at the observed equilibrium. We then apply this result to a recent paper by Yabuuchi (1982) on the relationship between tariff-induced capital inflows and immizeration where foreign profits are subject to taxation. In the concluding section we show that our result also applies when foreign markets are interrelated.

2.b Non-Interrelated Foreign Commodity Markets

Consider an economy with distortionless internal markets. We define the exchange rate between domestic and foreign currency to be unity and normalize the marginal utility of expenditure of one unit of domestic currency as unity.

*This essay was co-authored with Harold O. Fried. The authors are grateful to S. Yabuuchi for helpful comments.
Then the change in domestic utility can be written just as in the previous section, as

\[ dy = \sum \frac{p_i dM_i}{1} \]  

(1)

where \( p_i \) is the domestic price of the \( i \)'th good and \( M_i \) is the country's net imports of the \( i \)'th good, i.e. foreign net exports of the \( i \)th good.

The balance of payments relationship is

\[ \sum p_i^* M_i = F \]  

(2)

where \( p_i^* \) is the foreign price of the \( i \)'th good and \( F \) is the rate at which foreign exchange reserves are drawn down.

Define the elasticity of foreign excess supply as

\[ \sigma_i = \frac{(dM_i/dp_i^*)}{(M_i/p_i^*)} \]  

(3)

where \( dM_i/dp_i^* > 0 \), \( M_i > 0 \) for imports and \( M_i < 0 \) for exports, so \( \sigma_i > 0 \) for imports and \( \sigma_i < 0 \) for exports.

Let \( t_i \) be the import tariff or export subsidy (border tax for short) on the \( i \)'th good expressed as a fraction of the foreign price, so that domestic and foreign prices are related by

\[ p_i = (1 + t_i)p_i^*. \]  

(4)

Thus a negative \( t_i \) denotes an import subsidy or export tariff.

Differentiating (2), and substituting (3) into the result yields
\[ \sum_i \left[ 1 + \left( \frac{1}{\sigma_i^*} \right) \right] p_i^* dM_i = \bar{F} \]  

which states that the marginal expenditure on good \( i \) (the extra foreign exchange spent to acquire one more unit of \( i \)) is \[ 1 + \left( \frac{1}{\sigma_i^*} \right) \] where \( \bar{F} \) is defined as the autonomous increase in the rate at which foreign exchange is used up.

Substituting (4) into (1) and subtracting (5) from the result yields

\[ dy - \bar{F} = \sum_i \left[ t_i - \left( \frac{1}{\sigma_i^*} \right) \right] p_i^* dM_i. \]  

This means that marginal utility exceeds marginal expenditure on \( i \) by \[ t_i - \left( \frac{1}{\sigma_i^*} \right) \]. Thus the border tax which equates the two, i.e. the optimum border tax, is \( t_i^* = \frac{1}{\sigma_i^*} \).  

Equation (6) can be rewritten as

\[ dy = \sum_i \left[ t_i - t_i^* \right] p_i^* dM_i + \bar{F} = \sum_i \delta_i^* p_i^* dM_i + \bar{F} \]  

where \( \delta_i \) is defined as \( t_i - t_i^* \), the excess of the border tax on the \( i \)'th good above its optimum level, where its optimum level is defined with reference to the elasticity at the prevailing (not necessarily optimum) equilibrium. Thus, \( \delta_i \) is the net benefit from the domestic economy's standpoint associated with a unit increase in net imports of the \( i \)'th good. The lesson of (7) is that any policy which increases net imports of any good with a positive excess border

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1This is the first best optimum tax in the sense that if all sectors are taxed accordingly, welfare is maximized. The Lerner symmetry theorem implies that we can choose one optimum tariff arbitrarily, and through our procedure of normalizing marginal utility, we have arbitrarily set the optimum tariff applying to commodities in perfectly elastic excess foreign supply equal to zero.
tax (i.e. a superoptimum import tariff or export subsidy) is beneficial in that regard.

Pretend now, that all border taxes except for the "zeroth" one are frozen by domestic or international political considerations. Moreover, pretend that a flexible exchange rate keeps the payments balance in equilibrium and hence $dF = 0$. Then

$$\frac{dy}{dt} = \sum_{i=0}^{i=N} \frac{\delta p^* dM}{dt}$$

(8)

where $N + 1$ is the number of traded goods.

The second-best border tax on the zeroth good, $t^{**}$, is given by equating $dy/dt_0$ in (8) to zero:

$$t^{**} = t^* - \frac{\sum_{i=1}^{i=N} \delta p^* dM}{\frac{p^* dM}{dt}}$$

(9)


Recently Yabuuchi has (1982) explored the circumstances under which an increase in the tariff on an import will raise welfare in the presence of an upward sloping supply curve of foreign capital services and a domestic corporation income tax which has two effects: it discourages capital import and it serves to usurp some of the earnings of the foreign capital for use by the domestic government or the domestic residents to which the tax revenues are distributed, the former effect being undesirable from the national standpoint,
and the latter effect being desirable.²

Consider Yabuuchi's result in the context of our analysis. We have shown that the optimum border tax sets up a wedge \( (p_i - p^*_i)/p^*_i = 1/\sigma_i \), so \( p_i = [1 + (1/\sigma_i)]p^*_i \). Thus the optimum border tax as a proportion of the domestic price is \( (p_i - p^*_i)/p_i = (1/\sigma_i)/[1 + (1/\sigma_i)] = 1/(\sigma_i + 1) \). Yabuuchi assumes in his two commodity world that world prices for traded goods are given and the capital intensive good is imported, so that an increased import tariff, by raising the rental rate on capital attracts additional foreign capital. He concludes that the introduction of a small import tax will be immiserizing or beneficial according to whether the corporation income tax is less or greater than \( 1/(\xi + 1) \), where \( \xi \) is the elasticity of supply of the services of foreign capital. Since Yabuuchi's corporation income tax is expressed as a fraction of the domestic rental price of capital, his \( 1/(\xi + 1) \) is simply the optimum tax on foreign capital services. Thus, his result is a special case of our equation (8) for it states that introduction of a small import tariff is welfare increasing if and only if the corporation income tax exceeds the optimum corporation income tax rate. Moreover, his equation (15) is a special case of our (7). Finally, the central point of his article, using our framework, is that raising the import tariff will be beneficial if and only if the capital attracted times the difference between the marginal product of capital and the marginal expenditure on it exceeds the quantity of the import repelled times the difference between its unit value to domestic consumers and its world price.

²For more on this problem see Corden (1974, ch. 12).
2.4 Interrelated Foreign Commodity Markets

Now let us allow the foreign excess supply schedules to be interrelated in the sense that the foreign excess supply of one good may depend on foreign prices of other goods.

Differentiating (2) yields

$$\sum_i \left[ 1 + \sum_j \pi_{ji} \right] p_i^* dM_i = \bar{F} \quad \text{(10)}$$

where

$$\pi_{ji} = \frac{M_i dp_j^*}{p_i^* dM_i} \quad \text{(11)}$$

This states that the marginal expenditure on good $i$ is $\left[ 1 + \sum_j \pi_{ji} \right] p_i^*$. The only trick is that $dp_j^*/dM_i$ in (11) is defined as the change in the $j$th foreign price, which in concert with other foreign price changes would be needed to raise $M_i$ incrementally, while leaving all other $M$'s constant, and as follows from Dixit and Norman (1980, p. 152), obtaining these terms requires inverting the matrix of coefficients showing how incremental changes in foreign excess supplies depend on incremental changes in foreign prices.

Substituting (4) into (1) and subtracting (10) from the result yields

$$dy - \bar{F} = \sum_i \left[ t_i - \sum_j \pi_{ji} \right] p_i^* dM_i \quad \text{(12)}$$

This means that marginal utility exceeds marginal expenditure on $i$ by

$$\left[ t_i - \sum_j \pi_{ji} \right] p_i^*$$. Thus the border tax which equates the two, i.e. the optimum border tax, is $t_i^* = \sum_j \pi_{ji}$. 
With this generalized definition of \( t^*_i \), equations (7), (8) and (9) follow.

Thus, the existence of interrelated foreign commodity markets changes none of the logic of the second section, except it forces us to generalize our definition of marginal expenditure and consequently the expression we use for the optimum border tax.
III.3 SOME THOUGHTS ON THE OPTIMUM TAX ON IMPORTED CAPITAL GOODS IN THE PRESENCE OF TARIFFS ON OTHER IMPORTS

3.a Introduction

This section was stimulated by various discussions about the appropriate import tariff on imported capital goods in the presence of other unalterable tariffs and a fixed corporation income tax. One suggestion was that in the presence of import tariffs on most goods in the neighborhood of 80% it would be appropriate to impose a minimum tariff of about 20%, which would stimulate the use of domestic raw materials, discourage imports of capital goods, impose greater efficiency in the industries using imported inputs, and boost fiscal income considerably. It was also suggested that there should be an export subsidy of 10% to 20%, depending on the category of export. Export subsidies were constrained not to go any higher than the proposed level, because it was felt that any further increases would be an incentive to engage in illegal activity on such a level that it would become a serious problem for the government. Similarly, import tariffs on most goods were constrained to lie above a floor by political considerations. It was felt, however, that there is some degree of freedom on the setting of the import tariff on capital goods, which it was considered do not compete with domestically produced goods.

It is the purpose of this section to calculate the optimum import tariff on capital goods in the context of several simple models for a hypothetical economy with plausible parameter values. Thus we consider a problem similar to that of section III.1, but our focus is different in that the corporation income tax now plays a major role, and we are concerned with the impact of the
tax and tariff structure on the supply of domestic savings. We find that in certain circumstances this optimum tariff might even be zero or negative.

3.b One Good Is Consumed Domestically; No Corporation Income Tax

First, consider a simple model where only one good is produced in a country using imported capital goods and domestic labor. In that case, in the free-trade equilibrium we would import capital goods in order to produce some of our output, part of which would be sold abroad to pay for our imports of physical capital goods. Thus, there would be no imports of non-capital items, so that even if those goods came to be covered by an import tariff, the tariff would be non-binding. If on the other hand, we subsidized the exports of the single good, first best policy would require that we impose a tax on the import of the capital good at precisely the same rate. According to this argument, our country should tax imported capital goods at 10 to 20% to match the export subsidy.¹

3.c A Model With One Imported Consumption Good and One Domestically Produced Good Which is Both Consumed Domestically and Exported, Where all Capital is Imported, and A Corporation Income Tax Distorts Savings Decisions

In order to analyze this problem it is necessary to build a formal model.

Let \( dy = p_c dC + p_m dM + r[1-u][p_c dC_o + p_m dM_o] \) \hspace{1cm} (1)

where

¹We assume that both the export subsidy and the import tariff are based on the foreign prices of the goods in question.
y is the domestic utility defined so that one unit of domestic currency is worth one util,

$p_c$ is the domestic currency price of the domestic good,

$p_m$ is the domestic currency price of the imported consumer good,

$r$ is the before tax real rate of return on capital, and

$u$ is the corporation tax rate. Thus $r[1-u]$ is the after tax real rate of interest.

$C$ and $M$ are respectively, steady state consumption of the domestic good and the imported consumer good.

$C_0$ and $M_0$ are respectively, consumption of the domestic good and the imported consumer good in period zero.

$E$ and $E_0$ are respectively exports of the domestic good generally and in period 0.

Equation (1) can be understood as follows. The first two terms represent the increment in utility from increased steady state consumption of the two goods. The consumption of the two goods is weighted by the corresponding price, because individuals equate price to marginal utility when the marginal utility of money is one, as we have defined it here. Individuals save until the after-tax real rate of return comes to equal their rate of time preference. Thus, the after-tax real rate of interest is simply the marginal utility of a one period increase in consumption relative to the marginal utility of the same steady state increase in consumption. Since we permit only differential changes in prices over our infinite time horizon, the coefficients for one period consumption changes are the same as those for steady-state changes, except they are multiplied by the real rate of interest.

We define a unit of each good, so that its world price is unity, and domestic prices are equal to foreign prices adjusted by the import tariff or
export subsidy. Thus, we have

\[ p_c = (1+s)p_c^* = 1 + s \]  (2)

\[ p_m = (1+t_m)p_m^* = 1 + t_m \]  (3)

\[ p_k = (1+t_k)p_k^* = 1 + t_k \]  (4)

where

- \( p_k \) is the domestic price of the capital good,
- \( p_c^* \), \( p_m^* \), \( p_k^* \) are foreign prices
- \( s \) is the subsidy on the export of the domestic good expressed as a fraction of its foreign price, and
- \( t_m \) and \( t_k \) are the import tariffs on the imported consumption good and capital good respectively.

We have defined one unit of each good as that quantity which sells for one unit of foreign currency on the world market. Hence each foreign price is set equal to one. Moreover foreign prices are assumed to be fixed.

Also, we define a unit of domestic currency as that quantity which exchanges for one unit of foreign currency, so that the exchange rate does not explicitly enter equations (2), (3) or (4).

International trade can be used to transform consumption goods into capital goods according to

\[ dK = - dM_o + dE_o \]  (5)

where

- \( dK \) is the change in the economy's stock of the capital good.
This means that by giving up consumption of one unit of either consumption good and exporting it or ceasing to import it in exchange for one more unit of the capital good, the economy can increase its capital stock by one unit. Incidentally, throughout this analysis we assume that no capital is produced at home, so that it must all be imported.

Let $\delta$ be the rate at which the capital stock depreciates. Then we can write steady-state imports of capital as $\delta K$. Thus, our steady-state balance-of-trade equation becomes

$$dM + \delta dK = dE$$

(6)

where

$M$ is imports of the imported consumption good and $E$ is exports of the domestically produced good.

Since domestic production of the domestically produced good, $D$, must equal what is consumed plus what is exported:

$$D = C + E.$$  

(7)

Since capital is paid its marginal product plus depreciation

$$\frac{p_c}{p_k} \frac{dD}{dK} = r + \delta$$

(8)

where

$p_k$ is the domestic currency price of capital

and

$$\frac{dD}{dK} = \frac{2D}{\delta K}$$ is the marginal product of capital.
The reason that \( \frac{dD}{dK} = \frac{3D}{3K} \) is that throughout the analysis, we hold constant the amount of labor employed in producing D.

We assume that M and D are consumed at home in a ratio that depends only on their relative price. Since that depends only on \( t_m, s \) and world prices, and since all of these terms are fixed, denoting a proportional change with a "\( \hat{\} \)" we have

\[
\hat{M} = \hat{C} \tag{9}
\]

\[
\hat{M}_o = \hat{C}_o \tag{10}
\]

\[
M_o = M \tag{11}
\]

and

\[
C_o = C. \tag{12}
\]

Equation (6) combined with the derivative of (7) yields

\[
d\hat{M} + \delta dK = dD -dC. \tag{13}
\]

Equation (8) and (13) yield

\[
d\hat{M} + \delta dK = (r + \delta) \frac{p_k}{p_c} dK - dC. \tag{14}
\]

Equations (1), (5), (9), (10), (11) and (12) combine to yield

\[
dy = p_c \hat{C} + p_m \hat{M} - r (1-u) \frac{p_c C + p_m M}{C + M} dK. \tag{15}
\]

Plug the derivative of (7) into (8) to eliminate dD. Then plug (9) into the
result to yield
\[ M [M + C] = [(r+\delta) \frac{p_k}{p_c} - \delta]dK. \] (16)

Finally, (15) and (16) combine to yield
\[ \frac{dy}{dK} = \frac{1}{(1+s)} \left[ \frac{p_c + p_M}{M + C} \right] \left[ (r+\delta)t_k - s[\delta + r(1-u)] + ru \right]. \] (17)

Equation (17) states that any policy which expands the capital stock will be beneficial to the extent that \( t_k \) or \( u \) is positive or \( s \) is negative, for all of these factors imply that the import of capital is initially suboptimal. Interestingly enough, \( t_m \) never appears within the brackets, implying that it has no impact on the sign of \( dy/dK \). This is because additional imports of capital have no impact on the relative price of the two consumer goods, so they cause \( M \) to rise or fall only to the extent that they cause real income to rise or fall. Because \( t_m \) is positive, a suboptimum amount of \( M \) is being imported. Thus any increase in \( K \) which raises domestic consumption at constant prices will raise welfare directly and indirectly because it moves the level of \( M \) closer to the optimum. Conversely, any increase in \( K \) which lowers domestic consumption will lower welfare on both counts.

Setting (17) to zero is accomplished by equating the term in the brackets to zero, and this yields the expression for the optimum import tax on capital goods of
\[ t^*_k = s - \frac{ur(1+s)}{r + \delta}. \] (18)

Perhaps the most interesting aspect of this equation is that \( t_m \) does not enter into the determination of \( t^*_k \). This is of course due to the reasons mentioned above.
Two special cases are worthy of note

For \( u = 0 \)

\[
t^*_k = s
\]  
(19)

the same solution as obtained in section 2. Secondly, when \( s = \delta = 0, \)

\[
t^*_k = -u,
\]

the negative of the corporation income tax.

To take a concrete example, approximating \( s \) by 15%, recognizing that \( u = 20\% \) and supposing that \( r = \delta \)

\[
t_k = 3.5\%.
\]  
(20)

Thus, while this particular point estimate for the optimum tariff on the import of capital goods is positive, it is much smaller than the export subsidy, because of the existence of the corporation income tax.
This section pursues further the calculation of optimum tariffs on imported capital goods and intermediate products for a hypothetical less developed country, given that certain other tariffs and export subsidies are fixed. An initial attempt at this problem is presented in the previous section. In that model, I pretended that only one good was produced domestically, using domestic labor and imported capital. This paper by contrast assumes a model which is laid out schematically in Figure 1, and uses it to determine the optimum import tariffs on imported capital and intermediate inputs, given that all other taxes and subsidies on international trade are fixed.

As indicated in the conclusion, the model is constructed in order to indicate some of the contributions to policy analysis that linear models can make. In essence, my goal in this and other sections is to illustrate simple tractable methodologies for applying cost-benefit analysis to small adjustments in existing tariff and tax structures and the devising of optimal structures. Or to describe the analysis in yet another way, the problem attempted in this and other sections is to generalize the logic of Harry G. Johnson's (1971, Ch. 8) work on the Scientific Tariff from his model in which traded goods have no input-output structure and the cross-price elasticities
of demand between them are implicitly assumed to be zero.\footnote{Of course earlier on in that essay Johnson did show how to measure the welfare impact of tariff changes when cross price demand elasticities are taken into account. Moreover, he provided a welfare analysis of the effects of tariffs in a particular input-output context in Johnson (1971, Ch. 13), which could have been applied to the scientific tariff problem. In both of these papers, Johnson makes the implicit assumptions that value added in each sector is produced with a fixed factor (call it capital) which may be combined in variable proportions with a mobile factor (call it labor), and that as the tariff varies, there is no change in the price of the mobile factor (holding the exchange rate constant). However, this requires the twin implicit heroic assumptions that there is at least one tradeable good which is in perfectly elastic domestic supply and that the effective protection of this good is zero.} The approach suggested here is not hampered by any degree of interdependence between markets, although in that it is linear, it suffers from the same flaw as Johnson's does, namely being an approximation.

4.b The Model

In Figure 2, the economy is shown to produce two goods, cocoa which currently has no export tax or subsidy and chocolate which is subject to a 20% export subsidy (where throughout the paper all tariffs and subsidies are expressed as fractions of the world price). Cocoa is produced using land and labor, and domestic production is either exported or used in the production of chocolate.

Chocolate is produced with constant returns to scale using two composite factors, with no substitution between them. The first composite factor is an aggregate of capital and labor, while the second is an aggregate of cocoa and flavorings. Both composite factors are first degree homogeneous functions of the factors which compose them. Both capital and flavorings are imported, with no duty attached and no domestic production of either. The chocolate
Figure 2 - A Hypothetical Economy

is either exported or consumed domestically. Brandy is imported for consumption purposes only and is subject to an 80% import tariff.
What this paper tries to describe is a less developed economy which produces both agricultural goods and manufactured goods where the manufacturing activity uses labor, imported inputs and capital to process the agricultural output. We then recognize that some luxury consumer goods are solely imported, and that the country consumes both the processed agricultural goods and the non-competitive import. While this is a very simple economy, it is complex enough to illustrate the principles of how one would go about analyzing a still more complex model.

The model thus described, is laid out in equations (1) through (28) below, with a description following all of the equations. For a simpler version of this same model, the reader is referred to the previous section.

\[ p_a = (1 + s_a)p^*_a = 1 + s_a \]  
\[ p_c = (1 + s_c)p^*_c = 1 + s_c \]  
\[ p_f = (1 + t_f)p^*_f = 1 + t_f \]  
\[ p_b = (1 + t_b)p^*_b = 1 + t_b \]  
\[ dy = p_c dC + p_b dB + r[1 - u][p_c dC_o + p_b dB_o] \]  
\[ dK = -dB_o - dC_o \]  
\[ B = \hat{C} \]  
\[ \hat{B} = C_o \]  
\[ B = B_o \]  
\[ C = C_o \]  
\[ dB + dF + \delta dK = dE_c + dE_a \]  
\[ dE_c + dC = dX \]  
\[ dE_a + dI_a = dA \]  
\[ (1 + s_a)dA = wdL_a \]  
\[ \hat{X} = \theta L + \theta K + \theta I + \theta F \]  
\[ L_c k a a f \]
\[
\begin{align*}
\dot{L} + L \dot{c} &= 0 \\
K - L &= \sigma \left[ \dot{w} - \dot{r} \right] \\
\dot{I} - F &= \sigma \left[ \dot{p}_f - \dot{p}_a \right] \\
\dot{L} &= -\left[ \sigma / \theta \right] \dot{w} \\
A &= \theta L \\
p_a &= 0 \\
\dot{p}_f &= \dot{t}_f \text{ where } \dot{t}_f = dt_f / [1 + t_f] \\
\dot{i} &= \dot{t}_k + rh \text{ where } h = r / [r + \delta]; \dot{t}_k = dt_k / [1 + t_k] \\
0 &= \theta [\dot{t}_k + \dot{t}_f] + \theta \dot{w} \\
0' L + \theta' K &= 0' I + \theta' F \\
where \quad \theta'_L = \theta_L / [\theta_L + \theta_k]; \theta'_k = \theta_k / [\theta_L + \theta_k]; \theta'_a = \theta'_a / [\theta_a + \theta_f] \\
and \theta'_f = \theta_f / [\theta_a + \theta_f] \\
(1 + s_c)X &= wL_c + (1 + t_k)K[r + \delta] + (1 + s_a)I_a + (1 + t_f)F \\
(1 + s_c)dX &= wdL_c + (1 + t_k)[r + \delta]dK + (1 + s_a)dI_a + (1 + t_f)dF \\
K + t_k &= er
\end{align*}
\]

In these equations, $p_a$, $p_c$, $p_f$, $p_b$ are the domestic currency prices of the agricultural product (cocoa), chocolate, flavorings and brandy. 

*'s denote foreign prices

s's and t's denote export subsidies and import tariffs, expressed as fractions of world prices.

One unit of each good has been defined as that quantity which sells for one unit of foreign currency on the world market. Hence each foreign price is set equal to one, and is assumed to be constant. Also a unit of domestic currency is defined as that quantity which exchanges for one unit of foreign currency, so that the exchange rate does not explicitly enter equations.
(1) - (4). Finally, the exchange rate is held constant and the adjustment process is assumed to occur through flexible wages and prices.

y is domestic utility defined so that one unit of domestic currency is worth one util.

r is the before tax real rate of return on capital.

u is the corporation tax rate. Thus r[1 - u] is the after tax real rate of interest.

C and B are respectively, steady state consumption of chocolate and brandy.

C_0 and B_0 are respectively, consumption of chocolate and brandy in period zero. Since all brandy is imported, B_0 and B represent imports of brandy in the initial period and in steady state equilibrium respectively.

Equation (5) can be understood as follows. The first two terms represent the increment in utility from increased steady state consumption of the two goods. The consumption of the two goods is weighted by the corresponding price, because individuals equate price to marginal utility when the marginal utility of money is one, as we have defined it here. Individuals save until the after-tax real rate of return comes to equal their rate of time preference. Thus, the after-tax real rate of interest is simply the marginal utility of a one period increase in consumption relative to the marginal utility of the same steady state increase in consumption. Since we permit only differential changes in prices over our infinite time horizon, the prices attached to one period consumption changes are the same as those for steady-state changes, except they are multiplied by the real rate of interest.

International trade can be used to transform consumption goods into capital goods according to (6) where

dK is the change in the economy's stock of the capital good.

This means that by giving up consumption of one unit of either consump-
tution good and exporting it or ceasing to import it in exchange for one more unit of the capital good, the economy can increase its capital stock by one unit. Incidentally, throughout this analysis we assume that no capital is produced at home, so that it must all be imported.

We assume that B and C are consumed at home in a ratio that depends only on their relative price. Since that depends only on \( t_b, s_c \) and world prices, and since all of these terms are fixed, denoting a proportional change with a "^\wedge" we have (7) and (8); since prices change only infinitesimally, we have (9) and (10).

Equation (11) is our steady-state balance-of-trade equilibrium condition where \( \delta \) is the rate of depreciation of the capital stock and \( E_c \) and \( E_a \) are exports of chocolate and cocoa in equilibrium.

Equations (12) and (13) are market clearing conditions for chocolate and cocoa respectively, where

\[ A \] is cocoa output,
\[ X \] is chocolate output and
\[ I_a \] is the input of cocoa into chocolate manufacture.

Equation (14) states that labor is paid its marginal product in cocoa, where \( w \) is the common wage rate in both sectors and \( L_a \) is labor in cocoa.

Equation (15) is the production function for chocolate, where \( L_c \) is labor in chocolate. The \( \theta \)'s represent factor shares. Hence \( \theta_L + \theta_k + \theta_a + \theta_f = 1 \). This equation follows from first degree homogeneity and the fact that factors are each paid their marginal products, and is derived in Chapter I.

Equation (16) is the market clearing condition for labor.

Equation (17) indicates that the elasticity of substitution between labor and capital in the labor-capital aggregate is \( \sigma \), where \( i \) is the user cost of capital.
Equation (18) indicates that the elasticity of substitution in forming the intermediate input aggregate is \( \sigma_i \).

Equation (19) is the demand for agricultural labor. It is derived from the relations: \( \hat{N} = 0, \hat{L}_a - \hat{N} = \sigma_a [\hat{n} - \hat{w}] \) and \( 0 = \hat{w} \theta_a^L + \hat{n} \theta_a^N \), where \( N \) is land in cocoa, \( L_a \) is labor in cocoa, and \( n \) is the rental rate on land.

Equation (20) is an alternative version of (14) and states that labor in cocoa is paid its marginal product. Equations (21) and (22) are the differential forms of (1) and (3) respectively.

Equation (23) is the differential form of \( i = p_k (r + \delta) = (1 + t_k) (r + \delta) \), which defines the user cost of capital.

Equation (24) is the dual of (15) with the recognition of (23) and that the fixed \( s_a \) and \( s_c \) mean that \( \hat{p}_a = \hat{p}_c = 0 \).

Equation (25) states that the proportional change in the \( L,K \) aggregate must equal the proportional change in the \( A,F \) aggregate, and is an implication of the assumption that the two aggregates are combined in fixed proportions.

Equation (26) is the product exhaustion statement for chocolate and (27) states that factors are paid their marginal products.

Finally, (28) indicates that the value of capital goods which individuals are willing to hold depends on the real rate of return, with \( e > 0 \) being the elasticity of demand for wealth held in the form of capital goods.

4.c Distortions, Stocks, Flows and Welfare

Equations (1) - (10) combine to yield

\[
dy = [p_c C + p_b B]C - r[1 - u] \left[ \frac{p_c C + p_b B}{C + B} \right] dK.
\]

(29)
Equations (7), (11), and (12) combine to yield

\[ dB + dC = \left[ B + C \right] \hat{C} = -dF - \delta dK + dX + dE. \]  \hspace{1cm} (30)

 Equations (13), (14), (16) and (27) combine to yield

\[ 0 = -\left(1 + s_c \right) dX - \left(1 + s_a \right) dE_a + \left(1 + t_k \right)(r + \delta) dK + (1 + t_f) dF. \] \hspace{1cm} (31)

 Equations (30) and (31) combine to yield

\[ \left[ B + C \right] \hat{C} = -s dX - s dE_a + t_f dF + t_k \delta dK + (1 + t_k) r dK. \] \hspace{1cm} (32)

 Finally, (29) and (32) combine to yield

\[ dy = a\{-sc dX - sa dE_a + tf dF + \left[ tk \delta + \left( tk + u \right) r \right] dK\} \] \hspace{1cm} (33)

\[ \frac{p_c C + p_b B}{C + B}. \]

 Equation (33) is plausible, because the expression in the brackets is simply the sum of the changes in the flows or the capital stock multiplied by the attached distortions, and \( a \) is simply the utility value of a unit of foreign exchange. Regrettably, I have been unable to come up with an intuitive verification of the precise form taken by (33). However, if \( r = 0 \), the expression inside the braces becomes simply the change in the economy's net output valued at world prices.
4.d Optimum Import Tariffs on Capital and Intermediate Inputs When the Elasticity of Substitution Between Labor and Land in Cocoa is Zero

It would not be conceptually difficult to solve this model in general form. However, the mathematical solution of the general case is complex. Thus, we satisfy ourselves with exploring three special cases and describing how to use the computer to solve the general case. In this section, we assume that the elasticity of substitution between labor and land in the production of cocoa is zero. Then in the next section, we will explore the other extreme case of an elasticity of substitution equal to infinity. To make our problem even easier, we consider the case in this section where the elasticity of supply of capital, $e$, is infinite.

From (28) and the assumption that $e \to \infty$:

$$dr = 0$$  \hspace{1cm} (28')

From (24) and (28):

$$\hat{w} = -\frac{\hat{\theta}_k}{\hat{\theta}_L} \frac{\hat{\theta}_f}{\hat{\theta}_L} \hat{t}_k - \frac{\hat{\theta}_f}{\hat{\theta}_L} \hat{t}_f.$$  \hspace{1cm} (24')

From (28') and (23)

$$\hat{i} = \hat{t}_k.$$  \hspace{1cm} (23')

From (19) and the assumption that $\sigma_a = 0$,

$$\hat{L}_a = 0.$$  \hspace{1cm} (19')

From (16) and (19')
\( \hat{L} = 0. \) \hspace{1cm} (16')

From (24'), (23'), (16') and (17)

\[
\hat{K} = -\sigma_v \left\{ [1 + \frac{\theta_k}{L}] \hat{t}_k + \frac{\theta_f}{L} \hat{t}_f \right\}.
\] \hspace{1cm} (17')

From (16'), (17'), (18), (21), (22), and (25)

\[
\hat{I} = -\theta'_k \sigma_v [1 + \frac{\theta_k}{L}] \hat{t}_k + \left[ \theta'_f \sigma_k - \theta'_v \sigma \frac{\theta_f}{L} \right] \hat{t}_f.
\] \hspace{1cm} (18')

and

\[
\hat{F} = -\theta'_k \sigma_v [1 + \frac{\theta_k}{L}] \hat{t}_k - \left[ \theta'_v \sigma_k + \sigma \frac{\theta_f}{L} \right] \theta'_v \hat{f}.
\] \hspace{1cm} (25')

From (15), (25), (16') and (17')

\[
\hat{X} = -\frac{\theta_k}{L} \hat{t}_k - \frac{\theta_f}{L} \theta'_k \hat{f}.
\] \hspace{1cm} (15')

Let us now calculate the optimum import tariff on flavorings and capital. In order to do this, we will make the heroic assumption that the derivatives of each of the flows at world prices, with respect to the \( t \)'s are independent of the levels of the \( t \)'s. This assumption is not legitimate, but we will adopt it as an approximation anyway because of its convenience, and the fact that no equally convenient assumption would be any more accurate.

Now, we take plausible parameter values, namely:

\( t^o_f = t^o_k = 0 \) where the "o" superscript means initial value
Using these we rewrite (17'), (25') and (15') as flows or changes in stocks instead of percentage changes in flows or changes in stocks, and divide all flows or changes in stocks by \( X \) in order to express them as fractions of the same flow:

\[
dK/X = -1.8(\hat{t}_k + \hat{t}_f) = -3.6\hat{t}_k - 0.9\hat{t}_f
\]

\[
dF/X = -0.5(1.2)(.75)(1 + 3)\hat{t}_k + [(5/6) + .75] \hat{t}_f = -0.18\hat{t}_k - 0.95\hat{t}_f
\]

and

\[
X = -3(.5)\hat{t}_k - (.5)(.75)\hat{t}_f = -.15\hat{t}_k - .375\hat{t}_f
\]

Plugging these into (33) and setting \( dy/\hat{t}_k = 0 \) and \( dy/\hat{t}_f = 0 \) yields

\[
\frac{dy}{\hat{t}_k} = -(0.2)(-.15) + \hat{t}_f(-.18) + [0.2\hat{t}_k + 0.02](3.6) = 0
\]

and
\[
\frac{dy}{dx} = -(0.2)(-0.375) + t_f(-0.95) + \left(0.2t_k + 0.02\right)(-0.9) = 0. 
\] (39)

Equations (38) and (39) can be rewritten respectively as

\[-0.72t_k - 0.18t_f - 0.042 = 0 \] (40)

and

\[-0.72t_k - 0.95t_f + 0.057 = 0 \] (41)

which when solved simultaneously yield for the optimum tariffs on capital and flavorings, we get

\[ t_k^* = -7.70\% \] (42)

and

\[ t_f^* = +7.46\% \]

Thus the optimum import tax on capital goods is a subsidy of 7.7% and the optimum import tariff on flavorings is a tax of 7.5%. If we solve (40) for \( t_k \), while constraining \( t_f = 0 \) we get

\[ t_k^* = -5.83\% \] (43)

Thus, if it is politically unfeasible to impose an import tariff on flavorings, the optimum subsidy on imported capital goods is 5.8%. This result is reasonable, since from (38) a subsidy on capital import of 10% would just offset the distortion created by the corporation income tax, while an import tariff on capital of 4.2% would be the appropriate level for offsetting the subsidy on chocolate exports. If we believe that the corporation income
tax is a revenue raising device whose purpose should not be flouted by subsidizing capital import, we should set the import tariff on capital at zero, and use (41) with \( t_k = 0 \) to calculate an optimal \( t^* = 6\% \).

Alternatively, if we do not distinguish between the two tariffs, and constrain them to be the same, let \( t_f = t_k = \bar{t} \) and add (40) and (41) to yield

\[
\bar{t}^* = .74\%.
\]  

(44)

Such an exercise would be appropriate if it was felt that the simplicity of uniform tariff structures created administrative savings and was likely to result in less rent seeking behavior.

4.e Optimum Import Tariffs on Capital and Intermediate Inputs When the Elasticity of Substitution Between Labor and Land in Cocoa is Infinite

In order to get a sense of how robust these estimates of optimum tariffs are, we now proceed to solve the model for the other polar case, where the elasticity of substitution between labor and land in agriculture is infinite. Now the model would become indeterminate if the supply of capital were perfectly elastic. Thus, we will assume that the domestic willingness to invest in capital goods is limited.

The perfectly elastic demand for labor in agriculture means that \( \sigma_a = \infty \), which freezes the wage rate, so:

\[
\hat{w} = 0.
\]  

(19"")

Combining (19") and (24) yields

\[
\hat{r} = \frac{\hat{\theta}_f}{h} \hat{t}_f - \frac{\hat{\theta}_k}{h} \hat{t}_k
\]  

(24"")
which upon combination with (28) and denoting \( \frac{e}{h} \) by \( e' \) yields

\[
\hat{K} = - (1 + e') t_k - \frac{\hat{e}'}{\hat{\theta}} t_k.
\]

(16")

We use (23), (19") and (24") to rewrite (17) as

\[
\hat{L} = \hat{K} - \hat{\theta} \frac{\hat{t}}{\hat{\theta}} \hat{f}.
\]

(17")

Then we use (21) and (22) to rewrite (18) as

\[
\hat{I}_a - \hat{F} = \sigma \hat{t}_f.
\]

(18")

Substituting (17") and (18") into (25) yields

\[
\hat{F} = \hat{K} - \theta' \sigma \frac{\hat{t}}{\hat{\theta}} \hat{f} - \theta' \sigma \hat{t}_f
\]

(25")

and

\[
\hat{I}_a = \hat{K} - \theta' \sigma \frac{\hat{t}}{\hat{\theta}} \hat{f} + \theta' \sigma \hat{t}_f.
\]

(26")

Finally, using (17"), (18"), (25") and (26"), (15) becomes

\[
\hat{X} = - \theta' \sigma \frac{\hat{t}}{\hat{\theta}} \hat{f} + \theta' \left[ -\theta' \sigma \frac{\hat{t}}{\hat{\theta}} \hat{f} + \theta' \sigma \hat{t}_f \right].
\]

(15")

\[
+ \theta' \left[ -\sigma \frac{\hat{t}}{\hat{\theta}} \hat{f} - \sigma \hat{t}_f \right] + \hat{K} = - \theta' \sigma \frac{\hat{t}}{\hat{\theta}} \hat{f} + \hat{K}.
\]
Plugging parameter values into (16''), (25'') and (15'') yields respectively

\[
dK/X = -1.8[(1 + e')\hat{t}_k + (e'/3)\hat{t}_f]
\]

\[
dF/X = .12\left(K - \left[.25(.5)(1/3) + (5/6)(.5)\right]\hat{t}_f\right)
\]

\[
= .12K - .055\hat{t}_f
\]

and

\[
x = -(.25)(.5)(1/3)\hat{t}_f + K
\]

\[
= -.042\hat{t}_f + K.
\]

Substituting these last three equations along with (16'') into (33) and setting derivatives with respect to \(\hat{t}_k\) and \(\hat{t}_f\) equal to zero yields

\[
\frac{dy}{dx} = -.2[-1-e'] + t_f(.12)[-1-e'] + \left[t_k(.2) + .02\right][-1.8(1 + e')] = 0
\]

(45)

and

\[
\frac{dy}{dx} = -.2[-.042-e'/3] + t_f[-.055-e'(.04)] + [t_k(.2) + .02](1.8)(-e'/3) = 0
\]

(46)

From (45), from the standpoint of correcting the distortion generated by the export subsidy on chocolate, the optimum \(t_k\) is 55.56%, and from the standpoint of correcting the distortion due to the corporation income tax it is -10%, regardless of the elasticity of demand for it. Thus if \(t_f = 0\), the optimum \(t_k\), \(t_k^* = 45.56\%.\) Note that \(t_k^*\) is much higher in this case than in the
previous one, because keeping capital out feeds labor from the subsidized manufacturing sector back into the unsubsidized agricultural sector, resulting in a welfare gain, whereas this mechanism was missing in the case analyzed in the previous section. If we ignore the distortion imposed by the corporation income tax, and assume $t_k = 0$, the optimum $t_f$ is

$$t^* = \frac{0.2[0.042 + e'/3]}{0.055 + e'(0.04)},$$

When $e = 0$, $t^*_f$ is 15.27%. When $e = \infty$, $t^*_f$ rises to 166.67%.

When $e' = 0$, (46) can be solved to yield

$$t^*_f = 15.27\%$$

(48)

and (45) along with this value for $t^*_f$ can be solved to yield

$$t^*_k = 40.47\%.$$ (49)

If on the other hand a common import tariff $\tilde{t} = t_f = t_k$ is imposed, the result is

$$\tilde{t}^* = 32.22\%$$ (50)

The reason that the optimum tariff on capital turns out to be so high in this case is that where the demand for labor is elastic in agriculture each hike in the import tariff on capital reduces exports of the subsidized chocolate and increases exports of the non-subsidized cocoa, with a consequent welfare gain.
This is by contrast to the previous analysis in which the output of agricultural goods was frozen and a subsidy on imported capital turned out to be optimal.

For our last exercise, we shall allow the $e$ to approach infinity. In that circumstance, dropping all non-infinite terms in (45) and (46) yield respectively

\[-.2(-e') + t_f(.12)(-e') + [t_k(.2) + .02]1.8(-e') = 0 \tag{51}\]

and

\[-.2(-e') + t_f(.12)(-e') + [t_k(.2) + .02](1.8)(-e') = 0 \tag{52}\]

In this case, the two tariffs have no differential impacts on the system, for they both act via influencing capital accumulation. In this particular case, the optimum common import tariff is given by solving (51) or (52) with $t = t_k = t_f$ to yield

\[\bar{t} = t_k = t_f \text{ to yield} \]

\[\bar{t}^* = 34.17\% \tag{53}\]
III.5 CONCLUSIONS, IMPLICATIONS AND EXTENSIONS

A. The optimum tariffs on intermediate inputs and imported capital goods are very dependent on the particular parameter values assumed. Thus, attempting to find second-best tariffs, while simple in theory is likely to be quite troublesome in practice, both because our knowledge of parameters is uncertain and because parameters are likely to change from time to time. Therefore, it is hard to escape the view that the role of the policy adviser should be, whenever possible, to correct distortions at their source and move the economy back toward first-best equilibria.

B. This view is reinforced by the fact that comparative static analysis is a fiction. In truth each market (goods, capital, labor, savings) adjusts at different speeds, and by convention when we do comparative static analysis we pick a length of run where some markets have adjusted totally and others not at all. In fact, in the very short run unemployment should be permitted. In the long run it is reasonable to assume that most types of unemployment will disappear, but some capital and some labor is still tied to particular sectors. In the still longer run a Heckscher-Ohlin model with both capital and labor internally mobile but with total domestic supplies of labor and capital fixed may be reasonable. Finally, in the very long run both labor and capital in the aggregate will be variable. In calculating optimal tariffs which length of run is reasonable? The answer is none of these. This is because (1) the policy makers must always trade off short versus long run costs and benefits and (2) if everyone knows that the economy is going to move through successive equilibria, it is obvious that the optimum time path of the vector of tariffs will be complex, and individual decision makers will wish to reckon with the dynamic path in making their decisions.
C. We can, actually, be somewhat more optimistic than one would expect from a quick look at the numerical results of section III.4. It is not too surprising since we have let two parameters vary between 0 and \( - \), that we got a wide range of results. In actual fact, the policy adviser is likely to have a somewhat better idea of what parameter values are likely to be, and should be able to narrow the range of estimated optimum tariffs accordingly.

D. One important point, which is illustrated by the preceding section and elsewhere in the paper, is that one can calculate the welfare impact of a tariff change as the sum of a set of distortions multiplied each by a corresponding change in flows of goods induced by a change in the tariff. It is my belief that this is the natural way to deal with problems of the second best, because (1) it focusses on the logical structure of the welfare calculus, (2) it is also a decomposition that facilitates the process of calculation\(^1\) and (3) the source of variance in the estimates of second best values is the estimates of differential flows, not the distortions, so it is convenient to have the two parts of the calculation separated.

E. Typically, one can estimate the changes in the flows only by inverting a large matrix, which must be done on a computer. We have avoided this problem by choosing our parameter values judiciously. However, given the importance of specifying the parameters correctly and doing sensitivity analysis to make this kind of analysis truly useful for policy, it makes sense to specify the model precisely and use the computer to solve it for different parameter values. In so doing, it may be necessary to constrain tariff rates not to fall out of certain ranges, in order to try to achieve greater uniformity of

\(^1\)The importance of this point is illustrated in section II.2 which comments on S. Yabuuchi (1982). Yabuuchi does not recognize this point and as a result is unable to grasp the intuition behind the point he has made.
import tariffs and export subsidies, and gradually to move towards a first best solution. Moreover, since our approach rests on a first order approximation we cannot have much confidence about the veracity of the model's optima when they lie too far from the initial equilibria. Once the policy maker decides on a politically acceptable range of tariffs he could use this approach to determine whether particular tariffs should be at the top or bottom of that range.

F. This approach can also be usefully applied to determine the optimum structure of tariffs to achieve various domestic objectives, such as raising revenue, redistributing income or increasing employment of a particular group at minimum cost. In other words, it is a tractable first approximation to a more sophisticated use of cost benefit analysis to optimize the tariff structure. However, it is still my guess, and that of many others, that in general there will be better instruments for accomplishing the government's goals than tariffs, even in less developed countries, and that in actual fact the use of tariffs will be detrimental. Even so, using this calculus can indicate the costs of failing to use the optimum policies.

G. As mentioned in point E, the optimizing approach has the fault that the optima so calculated may lie outside the range for which the approximation is valid. Even if this is the case, it is still possible to use the linear approach developed here in order to assess the cost benefit ratio for using small changes in the tariff structure to accomplish various goals, which should modestly contribute to optimum economic policy.
Chapter IV

ON THE SYMMETRY BETWEEN EFFECTIVE TARIFFS AND VALUE ADDED SUBSIDIES

IV.1 INTRODUCTION

This chapter is the first of a set of three designed to introduce and explain the meaning of the concepts of the effective rate of protection (ERP) and domestic resource cost (DRC) which have been used so extensively in the World Bank and elsewhere. The problem posed in these chapters is: How should ERP and DRC calculations be used to make inferences about appropriate economic policy?

IV.2 ON ALTERNATIVE DEFINITIONS OF THE NOMINAL RATE OF PROTECTION

Thinking about the effective rate of protection is made difficult by the fact that the concept of the ERP has been used by different authors to refer to two different things and sometimes by the same author to refer to different things. The confusion arises out of the fact that the nominal rate of protection (NRP) is not unambiguously defined. Corden (1971, pp. 21-25) notes that one can define the rate of protection as either (1) the proportional difference between the domestic (p) and foreign (p*) prices of a good, \((p-p*)/p*\), or else (2) the proportional increase in the domestic price of a good that finally results from a protectionist regime. Of course when world prices are fixed both of these concepts are the same, but generally they will be
different. Corden goes on to say (p. 25) "Clearly, which concept one uses depends on one's purpose, but it is at least worth noting that the term rate of protection... is not unambiguous. Generally the second meaning of the term is the one we shall have in mind when considering resource allocation effects of tariffs, export subsidies, and so on. But for marginal welfare analysis the first meaning is the relevant one." This is true, and the same ambiguity applies to thinking about the ERP. I find the definition of the ERP which is analogous to Corden's first definition of the NRP to be useful because the ERP defined in this sense plays the role of a subsidy which is useful in the welfare economics discussed in chapters V and VI. However, I find the second definition to be much less useful. Thus, this chapter will present my preferred definition first, show some of what can be done with it and then criticize the second definition.\footnote{Some authors are inconsistent in their definitions. For example Johnson (1971) used different definitions on p. 310 and p. 334 which are analogous to Corden's first and second definitions of the NRP respectively.}

The next chapter will show how to use this preferred definition to calculate shadow prices.

**IV.3 THEOREM AND IMPLICATIONS**

There are two useful symmetry theorems regarding tariffs, taxes and subsidies in international trade. One is the Lerner Symmetry Theorem which states that across the board taxes on imports and across the board taxes on exports have identical effects.\footnote{For discussion of this and related theorems see Kaempfer and Tower (1982).} The second is the proposition that an import tariff may be viewed as a combination of a consumption tax and a production...
In this chapter we prove a third symmetry theorem closely related to the second:

Consider an economy which uses intermediate inputs in fixed proportions along with primary factors to produce outputs. In such an economy, there is an equivalence between two fiscal structures. One is the levy of a vector of tariffs on net imports, where these tariffs are expressed as fractions of world prices. The other is the levy of a set of consumption taxes (expressed as fractions of prices to sellers) equal to that set of nominal tariffs combined with a set of subsidies to value added (expressed as a fraction of gross value added), equal to the effective rates of protection which the nominal tariffs imply, where these ERP's are calculated as the proportion by which unit value added at domestic prices exceeds unit value added at world prices, with both measures determined using the domestic physical input/output coefficients.

This theorem is rather general, for it holds in both barter and monetary economies and it holds regardless of whether the market structure is competitive abroad or whether or not world prices are fixed, and to a limited extent even if domestic markets are not competitive. It is also a theorem which is closely related to statements in the literature. Still, it has

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3 See for example Harry G. Johnson (1965). Gene Grossman has pointed out to me that this theorem also holds in the presence of imperfect competition or multiple imperfect competitors, just as the Lerner Symmetry Theorem does. For the logic of this proposition in the context of the Lerner Symmetry Theorem, see Kaempfer and Tower (1982) and Eaton et al. (1982).

4 See, for example, Corden (1966) and (1971). Also, Harberger (1974, p. 75) notes that if intermediate inputs are combined in fixed proportions to produce output, there is an equivalence between any given set of taxes on intermediate inputs and output on the one hand and a tax on value added on the other. The reason that it has not been stated explicitly before is, I believe, because the vast majority of authors have used the definition of the ERP for conceptual purposes which is analogous to Corden's second definition of the NRP, even though in performing calculations they define the ERP as we have defined it.
never been stated, and I believe it provides a useful way of looking at the ERP.\textsuperscript{5}

Moreover, the theorem has an important corollary which is:

\textbf{A vector of tariffs on net imports combined with the same vector of consumption subsidies (expressed as fractions of the prices to consumers) and taxes on value added (expressed as fractions of disposable factor incomes) equal to the implied ERPs will be equivalent to free trade.}

From a policy standpoint, the corollary is very important. Missions from the World Bank frequently calculate effective rates of protection. But ERPs have fallen into ill repute in some quarters because they are imperfect indicators of how freeing up trade would move resources or affect economic welfare.\textsuperscript{6} But this is not a proper reason to reject such calculations, because after all even when there is no input-output structure, tariff changes are not perfect predictors of welfare changes or resource movements,\textsuperscript{7} yet it is useful to know what tariffs are for they are essential inputs into any general equilibrium calculation. Similarly, ERPs play an important role in many general equilibrium calculations designed to reach conclusions about both welfare and resource allocation,\textsuperscript{8} for they can be thought of as implicit subsidy rates on value added, and hence the distortion associated with employ-

\textsuperscript{5}Note that we are pretending here that the value added tax or subsidy is neither charged on imports nor rebated on exports, although countries with value added tax tend to do this in practice. For more on this see McKinnon (1971).

\textsuperscript{6}For example, see Ray (1973, p. 256).

\textsuperscript{7}For example, consider the Metzler paradox which implies that cutting the import tariff may cause the level of imports to fall.

\textsuperscript{8}See, for example, Bertrand (1972), Pursell (1978) and Tower and Pursell (1984).
ment of resources in a particular activity.

I conclude, therefore, that policy advisors may find it helpful to interpret ERPs to authorities in the LDCs which they advise as the equivalents of value-added subsidies, and the normative significance they should attach to differential ERPs is precisely the normative significance that one would attach to differential subsidies and taxes on value added in different sectors: namely a value-added subsidy is the amount by which the wage received by the suppliers of factors exceeds the wage paid by demanders of factors.

Competition causes the supply prices of the same factor in all industries to be the same. Therefore, differential subsidies to value added will cause the subsidy-inclusive costs of the same factors to different demanders to differ by the subsidy differential. Thus we can treat the ERP as the distortion associated with the production of value added, which means that the policy maker need only point out that differential ERPs are production distortions, and that to eliminate the distortions on production, differential value-added taxation can be used to offset completely the ERPs, and similarly to eliminate the distortions on consumption, differential consumption subsidies can be used to offset completely the nominal tariffs. Moreover, such a complete offset occurs when consumption subsidies (as a fraction of the prices to consumers) are levied at the nominal tariff rates and value added in all industries is taxed at a rate (as a fraction of disposable income) equal to the effective rate of protection.
IV.4 DEFINING THE ERP AND EXPLORING ITS RELATIONSHIP TO THE NRP

We continue to use the conventional assumption that intermediate inputs and a value-added aggregate are combined in fixed proportions and with constant returns to scale (CRS) to produce output, and that the value-added aggregate is itself a CRS aggregate of primary factors (e.g. capital and labor).

Given our assumed production relationship, any activity can be thought of as the production of a basket of various goods in fixed proportions, where some of the goods are present in the basket in negative quantities - i.e. as inputs. The value of the basket in world prices is simply value added measured in world prices. Similarly, the value of the basket in domestic prices is simply value added in domestic prices.

Corden's first definition of the NRP of a good is simply the proportion by which its domestic price exceeds its world price. If the good is an importable, this is simply the nominal tariff rate expressed as a fraction of the world price, and if it is an exportable it is simply the export subsidy again expressed as a proportion of the world price. By analogy, we choose to define the ERP as simply the proportion by which the domestic price of the basket exceeds the world price. The ERP for an activity then is in this sense the average tariff on the particular commodity basket produced by that activity. Therefore, it is not surprising that it plays a role which is similar to that of the NRP. Moreover, in the special case where there are no intermediate inputs, this definition boils down to that of the NRP.
IV.5 THE EQUIVALENCE PROPOSITION

Let us define the following terms:

\[ p_i^p \] is the price of good \( i \) to producers of good \( i \).

\[ a_{ij} \] is an input/output coefficient for the domestic economy expressed in physical units.

\[ e_i^t \] is the ad valorem excise tax on sales of good \( i \) to consumers, expressed as a fraction of \( p_i^p \).

\[ p_i^c \] is the price of good \( i \) to consumers of good \( i \).

\[ s_i \] is the value-added subsidy on the production of good \( i \) expressed as a fraction of gross payments to primary factors in industry \( i \).

\[ P_i \] is the international price of good \( i \).

\[ t_i \] is the proportion by which the price of good \( i \) to domestic producers of good \( i \) exceeds its world price. Thus for tradeable goods with binding border taxes \( t_i \) will be \( i \)'s import tariff or export subsidy.

\[ v_{i}^g \] is unit value-added in industry \( i \) at domestic prices calculated gross of any tax or subsidy on value added and \( v_{i}^g \) is defined as \( p_i^p - \sum_j a_{ij} p_j^p \).

Thus it is the price of a basket of goods produced by activity \( i \), where the basket's size is defined so that it contains one unit of good \( i \).

\[ v_i^d \] is disposable income accruing to the primary factors of production in industry \( i \) per unit of output produced. Thus it is unit value added at domestic prices inclusive of any subsidy to value added or net of any tax on it.

\[ v_{i}^* \] is unit value added at international prices using domestic physical input/output coefficients, and \( v_{i}^* \) is defined as \( p_i^* - \sum_j a_{ij} p_j^* \).
Whether good i is traded or not it will be true that
\[ p_i^c = (1 + e_i')p_i^p. \] (1)

If good i is either imported or exported
\[ p_i^p = (1 + t_i)p_i^*. \] (2)

Thus for traded goods (1) and (2) yield
\[ p_i^c = (1 + e_i')(1 + t_i)p_i^*. \] (3)

Finally,
\[ v_i^d = (1 + s_i)v_i^g. \] (4)

Let us define the effective protection of value added as
\[ ERP_i = \frac{v_i^g - v_i^*}{v_i} \] (5)

which is consistent with the definition of Balassa and Associates (1982, p. 352). Then we can use (4) to rewrite (5) as
\[ v_i^d = (1 + s_i)(1 + ERP_i)v_i^*. \] (6)

Since \( e_i' \) and \( t_i \) play a symmetric role in (3) and ERP_i and \( s_i \) play a symmetric role in (6) it is clear that the theorem holds with competition and no non-traded goods.

Moreover, when we define consumption subsidies \( (c_i') \) as fractions of prices to consumers, instead of (3) we have
Similarly, when we define value-added taxes (\( \tau_i \)) as fractions of disposable value added instead of (6) we have

\[
V_i(I + \tau_i) = (1 + \text{ERP}_i) V_i^*
\]

so

\[
V_i = \left[\frac{1 + \text{ERP}_i}{1 + \tau_i}\right] V_i^*.
\]

Thus equations (8) and (10) illustrate the corollary, still assuming competition and no non-traded goods.

It is easy to see the logic of these two ideas using the simple diagram in Figure 2. All goods are traded at fixed world prices. D shows the domestic demand for
the good in question. The only input is good \( j \), and \( a_j \) is its input coefficient. Thus \( EE' \) shows the cost of the sole intermediate input per unit of output at world price. \( v \) is drawn with respect to \( EE' \) as the horizontal axis and is the supply curve of value added. In free trade domestic output is at \( G \) with consumption at \( H \). A tariff on the import of \( i \) raises domestic price by \( AC \) to \( A \) so that consumption falls to \( H' \), which is just as if a consumption tax of \( AC \) had been imposed. The import tariff on \( j \), \( T_j \), raises unit costs by \( AB \), so the net increase in unit value added at domestic prices is only \( BC \). This means that production equilibrium moves to \( G' \), with unit value added at domestic and world prices given by \( v_i = BE \) and \( v^*_i = CE \) respectively. Thus, the ERP is given by \( BC/CE \). However the same result could have been brought about by free trade combined with a proportional subsidy to gross value added (i.e. value added before the subsidy) of \( BC/CE \). Thus the equivalence is established. Similarly an import tariff on \( i \) of \( AC \) combined with a consumption subsidy of \( AC \) restores consumption to \( H \), while our set of tariffs combined with a tax on unit value added of \( BC \) restores production equilibrium to \( G \), and this establishes our neutrality proposition.

IV.6 ADDITIONAL EQUIVALENCE PROPOSITIONS

There are two additional equivalence propositions which further clarify the meaning of the ERP, although they are not as useful as the ones we have just discussed. We have defined the ERP as the wedge between the domestic price of a sector's basket of goods and world price created by the tariff structure. It is a small additional step to note that if all of a sector's inputs and outputs were subject to an import tariff or export subsidy equal to the ERP calculated from the existing tariff structure, instead of their actual
tariffs, no real variables would change. Thus the ERP is the average tariff on an activity's inputs and outputs. This gives us equivalence proposition 2:

Consider an economy which uses intermediate inputs in fixed proportions along with primary factors to produce outputs. In such an economy, there is an equivalence between two fiscal structures. One is the levy of a vector of tariffs on net imports, where these tariffs are expressed as fractions of world prices. The other is the levy of a set of consumption taxes (expressed as fractions of prices to sellers) equal to that set of nominal tariffs combined with a set of taxes on each sector's inputs and subsidies on its outputs (expressed as a fraction of world prices) equal to its effective rate of protection.

Moreover, we can come up with an equivalence proposition that holds even when there is substitution in use of intermediate inputs equivalence proposition 3:

Consider an economy which uses intermediate inputs in variable proportions but with constant returns to scale along with primary factors to produce outputs. In such an economy, there is an equivalence between two fiscal structures. One is the levy of a vector of tariffs on net imports, where these tariffs are expressed as fractions of world prices. The other is the levy of a set of consumption taxes (expressed as fractions of prices to sellers) equal to that set of nominal tariffs combined with a set of subsidies to value added equal to the ERPs and a set of taxes on each of a sector's net inputs equal to the initial tariff minus the sector's ERP.

Thus, the ERP still has a meaning as an indicator of incentives even with
substitution between intermediate inputs, but it is questionable whether anyone would find the concept very useful in these circumstances.

IV.7 THE EFFECTIVE RATE OF VALUE ADDED SUBSIDY AND
THE IMPLICIT RATE OF FINAL DEMAND TAXATION

From the standpoint of policy modeling perhaps the most important dividend of this discussion is that one can write the relationship between world prices and prices to final demanders of traded goods as

\[ p_i^c = (1 + \tau_i)p_i^* \tag{11} \]

and label \( \tau_i \) as the implicit rate of final demand taxation, because it is the proportion by which prices to final demanders are raised above world prices by the tax and tariff structure.

Similarly,

\[ v_i^d = (1 + z_i)v_i^* \tag{12} \]

where \( z_i \) is the effective rate of value added subsidy because it is the amount by which disposable value added, \( v_i^d \), exceeds what it would be if inputs and outputs were evaluated at world prices, \( v_i^* \). Substituting from (3) and (6) into these equations yields expressions for these two rates:

9 For a crystal clear discussion of the relationship between the "true" and the "measured" ERP when there is substitution between primary and intermediate inputs which corrects and clarifies earlier proofs by Corden and Finger see Dutton and Stoeckel (1982).
\[ T_i = (1+e_i')(1+t_i') - 1 \]  \( (13) \)

and

\[ z_i = (1+s_i')(1+ERP_i) - 1. \]  \( (14) \)

Since the incentive system can be completely described by our \( T_i \)'s and \( z_i \)'s, these last two formulae are useful summaries of the incentives yielded by any tax or tariff system for use in policy analysis.\(^{10}\)

Finally, it is important not to focus solely on the effective subsidization of value added to the exclusion of implicit final demand taxation. It is important to know both things in order to fully describe the incentives present. Since there is more scope for specialization in production than in consumption the former are more important than the latter, but it would be a mistake to entirely ignore the latter.

**IV.8 NON-TRADED GOODS**

Non-traded goods as inputs and/or outputs create no problem for our equivalence propositions. If they are potentially tradeable, our equations hold with \( t_i \) defined from equation (2) as \( (p_i^P - p_i^*/p_i^*) \), the wedge between

\(^{10}\)Corden (forthcoming) notes that ERPs sometimes take into account consumption taxes and subsidies on inputs as well as production taxes and subsidies. We have defined our ERPs to exclude consumption taxes, but to include subsidies on intermediate inputs, while we have included explicit value added taxation in our zs but not our ERPs. Yet another option would be to include consumption taxes on the good itself in calculating the ERP on production for the home market. Then for each exported good one would calculate two ERPs, one for home consumption and one for export. If one also incorporated explicit value added taxes and taxes on the use of intermediate inputs, then the symmetry theorem would be further simplified; there would be symmetry between the existing structure of taxes, tariffs and subsidies, and an alternative consisting of a set of value added subsidies equal to the calculated ERPs combined with taxes on imported consumption goods equal to the difference between consumer prices and world prices.
domestic producer prices and world prices.

Finally, for both truly non-traded goods, which would not be traded, even in the absence of trade barriers and for potentially tradeable goods, we have four obvious options.

8.a The 'Sophisticated' Corden Method

The first option is to treat any production process along with its associated non-traded inputs as an integrated production process which uses traded inputs and primary factors to produce outputs. This is the Corden method (referred to by Little, Scitovsky and Scott, 1970, as the 'sophisticated' Corden Method to distinguish it from the 'crude' Corden Method explained below) of treating non-traded goods and is described in Balassa and Associates (1982, pp. 352-3). Then in defining the ERP of a non-traded good, $i$, which is consumed domestically we can set $p^*_i = p^p_i$. In this case, assuming zero initial consumption taxes, the observed tariff structure is equivalent to

(1) a set of consumption taxes on tradeables equal to that set of nominal tariffs, plus
(2) zero consumption taxes on non-tradeables plus
(3) a set of subsidies to value added in the integrated tradeables industries equal to their ERPs plus
(4) a set of subsidies to value added in the integrated non-tradeables industries which produce solely for domestic consumption equal to their ERPs. Thus, in this scheme, production of a non-traded good which uses no non-traded inputs, and is both consumed directly and used as an input into the production of another good is counted both as one production process and as part of another.
8. b The Balassa Method

A second option for treating non-traded goods is the Balassa method described in Balassa and Associates (1982, pp. 352-3). Using this method we define the Balassa ERP by (5) with the terms in the right hand side of (5) defined as

\[ v_i^* + H_i = p_i^* - \sum_j a_{ji} p_j^* \] (15)

and

\[ v_i^p + H_i = p_i^p - \sum_j a_{ji} p_j^p \] (16)

where we assume away value added taxation so that \[ v_i = v_i^d = v_i^g \] consists of the physical measure of the jth tradeable used directly in producing a unit of i and indirectly in producing the non-tradeables that go into producing a unit of i; \( H_i \) is value added in producing non-tradeables (home goods) used directly and indirectly in producing a unit of i; and \( v_i^* \) and \( v_i \) refer to value-added in the ith industry narrowly defined, i.e. not vertically integrated as in the Corden method.

Then using (4) and (5) we can produce (6) as before, which indicates the symmetry between the Balassa ERP and value added subsidization. Thus, if we observe a particular set of \( v_i^*, H_i, v_i, p_i^*, p_i^p, \sum_j a_{ji} p_j^*, \sum_j a_{ji} p_j^p \) for some i, and are told there are no value added taxes, we can calculate the Balassa ERP associated with it. If, alternatively, we are confronted with the same data and are told that there are no tariffs and no value-added taxes on intermediate non-traded goods, we can calculate the value added subsidy on good i which is consistent with the data, and this subsidy will be the Balassa ERP for good i.

Thus the Balassa ERP for good i is the subsidy to value added on i which has the same impact on all real variables as the tariff on i and on its direct
and indirect inputs, under the assumption that there is no value added taxation on the non-tradeables which feed into the tradeables.

Clearly then, there is a symmetry between a set of tariffs and zero consumption taxes on the one hand and on the other

(1) a set set of consumption taxes on tradeables equal to the nominal tariffs plus
(2) zero consumption taxes on non-tradeables plus
(3) value added subsidies equal to the Balassa ERPs on the production of both all tradeables and those non-tradeables which are directly consumed plus
(4) zero value-added subsidies on non-tradeables used as intermediate inputs.

8.c The 'Crude' Corden Method

A third option for treating non-traded goods is the 'Crude' Corden method described in Little, Scitovsky and Scott (1970, p. 431-2). Using this method we define the crude Corden ERP (ERPCC) by (5) with the terms in the right hand side of (5) defined as

\[ v_i^* = p_i^* - \sum_j a_{ji}^* p_j \]  

(17)

and

\[ v_i = p_i^P - \sum_j a_{ji} p_j^P \]  

(18)

where \( a_{ji} \) consists of the physical measure of the jth tradeable used directly in producing a unit of i. Thus in this method we treat non-tradeable inputs into i just like primary factors in calculating value added and hence the ERP. The difference between this method and the 'sophisticated' Corden method is that in the former we do not net out traded inputs into non-traded goods in calculating value added.
With this definition, there is a symmetry between a set of tariffs and zero consumption taxes on the one hand and on the other

1. a set of taxes on traded goods consumed or used as inputs into non-tradeables equal to the nominal tariffs plus
2. zero consumption taxes on non-tradeables plus
3. subsidies on the use of primary factors and non-traded goods to produce traded goods equal to the Crude Corden ERPs plus
4. zero subsidies on goods and factors used to produce non-traded goods.

The reader should note that these definitions of the Balassa and Corden methods deviate a bit from those authors' definitions, because in their work, their reference prices are free trade prices rather than world prices. Our procedure has been to choose definitions that fit the symmetry theorems.

8.d The Simple Balassa Method

A fourth option, labeled by Corden (1975, p. 64) the simple Balassa Method, is perhaps the simplest and most reasonable choice in many cases. This is to set \( p_1^* = p_1^p \) for all non-traded goods in the calculation of effective protection of all traded and non-traded goods.\(^{11}\) In words, the reference price for each non-traded good is simply the price which the domestic producer receives for it. Then we treat an excise tax on the sale of the jth good to the ith producer just like a tariff on the jth good in calculating the ERP on i. Thus the ERP on a non-traded good which uses non-traded goods as its sole inputs would be the (negative) value-added subsidy which is equivalent to the excise taxes paid on its intermediate inputs of non-traded goods. Corden

\(^{11}\)The analysis of the next section finds this procedure to be useful. Corden notes that the simple Balassa (1965) method groups non-traded inputs with traded inputs, and treats the former as if they were traded inputs with zero tariffs. He also notes that Balassa has since abandoned use of this method.
(forthcoming) notes that we can define a scale of ERPs for all tradeables, but this fourth definition enables us to calculate an ERP for each traded and non-traded good, and in calculating these ERPs one need look only at direct inputs. Thus, in contrast to the other three methods, no matrix inversion is required. The symmetry theorem which emerges in this case is simply the one noted in the introduction of this section.

Finally, selecting a reference price of $p_i^p$ for non-traded goods is completely arbitrary. The symmetry and neutrality theorems will hold regardless of what price is selected. It is just that when a higher reference price for good $i$ is selected, the ERPs for goods which use $i$ as an intermediate input will be larger and the ERP for good $i$ will be lower than they would otherwise be.

We defer until the next section a discussion of the normative significance of ERPs defined in this way. For the time being, we merely note that these ERPs represent wedges rather than measures of incidence. For example if an intermediate non-traded input is provided inelastically with nontaxed intermediate inputs, and it is taxed, production of that good would bear the incidence of the tax, although the tax would leave its ERP as we propose to calculate it still at zero and would reduce the algebraic value of the ERPs of the sectors which use it.

---

12 Balassa and Associates (1982, p. 353) note, however, that "In practice, an approximation can be used instead of the (partial) inversion of the input-output matrix."
Now, so far we have ducked the problem of monopoly power. Imperfect competition in the home economy will destroy the symmetry of the theorem in its most simple form. The problem is that if the monopolist-monopsonist is not a price taker in either his output market or the market for his intermediate inputs, a given set of nominal tariffs will generate different levels of the calculated ERP depending on what level of output the monopolist-monopsonist chooses. Thus, for the monopolist-monopsonist, ERP will be a function of his level of output:

$$\text{ERP}_i = \text{ERP}_i(Q_i).$$  \hfill (19)

Accordingly, for our monopolist-monopsonist, a symmetry emerges, but it is a symmetry between the effective rate of protection and a subsidy to value-added which has the same functional dependence on output that ERP does:

$$s_1 = \text{ERP}_1(Q_1).$$  \hfill (20)

In the special case where our monopolist-monopsonist is unable to influence the price of any of his traded inputs or the price of his output and non-traded goods are handled using the Corden method, it is not necessary to reckon with the monopoly-monopsony behavior explicitly, and the symmetry theorem which holds under competition continues to hold under monopoly.
IV.10 ABSOLUTE LEVELS OF NOMINAL AND EFFECTIVE PROTECTION DON'T MATTER

If we ignore capital flows between countries, pretend that either the exchange rate or wages and prices are perfectly flexible, and assume that the government's real budget surplus is kept constant by a variable neutral income subsidy, absolute domestic prices cease to play a role, and only relative domestic prices matter. In that circumstance, any fiscal structure (set of e's, t's, s's and ERPs) will be equivalent to any initial fiscal structure (set of $\tilde{e}$'s, $\tilde{t}$'s, $\tilde{s}$'s and $\tilde{ERPs}$) so long as relative prices stay unchanged, i.e. from (3) and (6) so long as for all $i$

$$
(l+e')(1+t_i) = \alpha(l+\tilde{e}_i)(1+\tilde{t}_i) \quad \text{and} \quad (1+s_i)(1+ERP_i) = \beta(1+\tilde{s}_i)(1+\tilde{ERP}_i) \quad (21)
$$

where $\alpha$ and $\beta$ are arbitrary positive factors of proportionality. Thus, for example, we can double the "force"\textsuperscript{13} of each ERP and nominal tariff and/or triple the force of each excise tax without affecting any economic variable.\textsuperscript{14}

\textsuperscript{13}Bacha and Taylor (1971, p. 202) define the force of $x$ as $1 + x$.

\textsuperscript{14}The reason that absolute levels of ERPs don't matter is identical to the reason that the level of prices don't matter in a simple world where wages and prices are flexible, namely that a proportional increase in the money stock will cause all prices to rise by the same proportion, leaving all relative prices unchanged. However, if there were minimum nominal wages, uniformly higher ERPs could raise prices and consequently raise real output levels. Similarly, if there were specific consumption taxes, the inflation generated by uniformly higher ERPs could erode their real value and change real incomes. Finally, international factor mobility will generally invalidate the proposition, for if one country's residents hold wealth denominated in the other country's currency, a uniform increase in domestic ERPs will raise domestic prices and cause domestically owned wealth measured in domestic goods to fall.

However, the proposition also applies even in the presence of international factor mobility and international trade in services so long as the import or export of factors or services is treated just like the import or export of goods and whatever tariff changes apply to goods apply to them as well. For more on this, see Kaempfer and Tower (1982).
This means that policy advisors when talking with clients should emphasize that uniformly positive ERPs mean only that domestic prices will be absolutely higher than foreign ones, but in a barter world or in a non barter world in equilibrium with no price rigidities, the only thing that matters is percentage differentials between the forces of the ERPs.\textsuperscript{15}

\textbf{IV.11 THE NET EFFECTIVE RATE OF PROTECTION}

This idea has led Corden (1966) to introduce the concept of the net effective rate of protection, NERP, where the net ERP is simply the proportional change due to the tariff structure in value added measured in units of a basket of non-traded goods. Thus, the NERP is a device for normalizing ERPs. In general the choice of the basket of goods to use as numeraire is somewhat arbitrary. However, in the special case where value added in every sector is produced with one sector specific factor and a common mobile factor, the services of the mobile factor is the natural choice for numeraire, for then the mobile factor will have moved in or out of the sector in accordance with whether the sign of the NERP is positive or negative.

Corden and Balassa (1982, p. 353) describe the NERP as correcting for the currency appreciation which typically accompanies the imposition of a tariff

\textsuperscript{15}Corden (1984) and others also note that what matters is non-uniformity in the scale of ERPs. As an aid in understanding the differences between the Corden and Balassa ERPs, note that a system of uniform import tariffs and export subsidies of x% will result in no resource misallocation, but Crude Corden and Sophisticated Corden ERPs for all tradeables will be calculated as x%, while either of the Balassa calculations would yield ERPs of tradeable goods of less than x%. Similarly, a proportionate increase in the forces of all import tariffs and export subsidies which would have no implications for resource allocation would result in the same proportionate increases in the forces of all Crude and Sophisticated Corden ERPs for tradeables, but that is not true for either of the Balassa measures. Finally, the force of the ERP is sometimes referred to as the ERP coefficient.
structure. I think this is confusing however, because the appreciation that occurs depends on which basket of goods has its domestic currency price held constant by domestic monetary policy, and this is arbitrary.

It should be noted that in applying Balassa's equations (13) and (14) on page 354 to calculate NERPs requires that the ERPs with which they are used be calculated as the proportional difference between value added in domestic prices in the post-tariff situation and at world prices under free trade, not world prices in the tariff situation. This is because (13) and (14) assume imperfectly elastic foreign excess demands and supplies. However, to calculate ERPs defined with reference to free trade world prices from data applying to the protected equilibrium, when world prices are variable may be a complex process.

Finally, Corden (1971, p. 162) discusses yet another way of treating non-traded goods called the Scott method, which requires treating non-traded goods as other traded goods in calculating value added where in calculating ERPs, the increase in the domestic price of the non-traded good due to the tariff structure is treated just like a tariff which raises the domestic price of a traded good. Denoting \( N \) as the proportional increase in the price of the non-traded good due to the tariff structure, and ERPs as the Scott measure of the ERP of a good, we can solve for the net ERP as

\[
1 + \text{NERP} = \frac{1 + \text{ERPs}}{1 + N}.
\]

Thus, the relationship between the Scott method and the NERP is very close. Both are attempts to solve the general equilibrium problem, and while the numeraire in the Scott method is world prices, in the NERP it is the price of some bundle of non-traded goods.
IV.12 NEGATING THE REAL IMPACT OF A TARIFF STRUCTURE

Similarly, equations (8) and (10) indicate that proportionality between consumer prices and world prices and between domestic and world value added is maintained which means that there are no consumption or production distortions so long as for all $i$

$$\frac{1 + t_i}{1 + \sigma_i} = \gamma$$ \quad and \quad $$\frac{1 + ERP_i}{1 + \tau_i} = \epsilon$$

(22)

where $\gamma$ and $\epsilon$ are arbitrary positive factors of proportionality.

Thus it is possible to offset completely the consequences for resource allocation and hence real income of an existing tariff structure with various sets of consumption subsidies and production taxes so long as the forces of the consumption subsidies are proportional to the forces of the nominal tariffs and the forces of the value added taxes are proportional to the forces of the effective tariffs.

IV.13 ON NEUTRALITY WHEN THERE IS SUBSTITUTABILITY BETWEEN INTERMEDIATE INPUTS

We have established that when intermediate input coefficients are fixed, the effects of a tariff structure on production can be completely offset by taxing value added at a rate equal to the ERP. What happens when there is substitutability between intermediate inputs? Is there an analogous theorem? The answer is yes.

Suppose there is substitutability between intermediate inputs. Moreover,
suppose that the tax authority calculates the ERP for each firm and imposes a tax, \( \tau \), on its value-added equal to its ERP. This means that we have

\[
v_i^{d} (1+\tau_i) = p_i - \sum_j a_{ij} p_j
\]

(23)

and

\[
1 + \tau_i = \frac{p_i - \sum_j a_{ij} p_j}{p_i^* - \sum_j a_{ij} p_j^*}.
\]

(24)

Combining (23) and (24) yields

\[
v_i^{d} = p_i^* - \sum_j a_{ij} p_j^*.
\]

(25)

Thus, we see that with value added taxed at the ERP, disposable value added depends solely on input coefficients and world prices. Thus the firm will select a level of output and blend of inputs which is independent of the tariffs it pays on inputs and receives on its output. This is because it realizes that if it buys more of a heavily tariffed input, its ERP will fall and consequently so will its value-added tax, leaving it with increased costs equal to the value of the increased input at world prices.

Clearly then if there are no non-traded goods, we can achieve production efficiency by taxing value added in each industry at a rate equal to its ERP. Moreover, non-traded goods cause no problems. Define \( p^* \) for non-traded goods as being equal to \( p \). Then we have a symmetry theorem which states:

There is no economic difference between free trade on the one hand, and on the other a set of tariffs just balanced by consumption subsidies equal to those tariffs and value-added taxes levied on each firm (regardless of whether it
uses and/or produces tradeable or non-tradeable goods) equal to its own ERP, and this is true even in the presence of monopoly-monopsony power, variable world prices, variable input-output coefficients for intermediate goods, a fixed exchange rate, inflexible factor prices in real or nominal terms and trade imbalance.

The reason that the symmetry holds even when there is a fixed exchange rate and inflexible factor prices is that substituting the one policy for the other causes no nominal price faced by consumers or factors of production to alter.

IV.14 ON DRAWBACKS

Even aside from the formal symmetry developed here, there is an important moral which emerges. Many countries permit exporters who use imported inputs to drawback the tariffs they have paid. Generally this is argued to be a good idea because it restores the competitiveness of the exporters. But there is a second reason why this is a good idea. It encourages them to choose an import mix as if they faced world prices rather than domestic prices for those imports. Thus even if industries were homogeneous entities it would be better on this ground to offer drawbacks or to tax at ERPs calculated from firm data than to tax at ERPs based on industry wide data on import use.

Now let us consider the related issue of whether a drawback should be paid for imported inputs or for both imported inputs and their domestically produced substitutes. If both goods are perfect substitutes the import tariff will raise the domestic price of the domestic substitute by the amount of the tariff. Initially, we would expect to see those producers eligible for

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16 This discussion owes its basic idea to a memorandum by Garry Pursell.
the drawback using only the imported good, and others using both imports and the domestically produced variety. If use of the domestically produced good becomes eligible for the drawback, those producers which are eligible for the drawback will be indifferent about whether they use the import or the domestic good, and may start to use some of the domestic good. The only effect of this should be to liberate some of the import for use by domestic producers which are not eligible for the drawback, and thereby change the mix of the two (identical) goods used as inputs by various producers. There would be no impact on trade, government revenue or real income of any actor.

In the special case, however, where all domestic use of the imported good is eligible for the drawback, the effective price of the import to all consumers will fall to the world price. This means that the domestic price of the domestic substitute will fall to the world price, if use of the domestic substitute is not eligible for the drawback, but that in effect production of the domestic good will be subsidized to the amount of the drawback if its use too is eligible for the drawback.

If our goal is to minimize the distortionary impact of the tariff system, the best policy would be to limit total drawback claims for the use of each good to the value of imports of it, for this would reduce the likelihood of domestic producers reaping subsidies from the drawback system, and yet it would reduce costs of inventorying and transport by making goods which are perfect substitutes equally attractive to these potential users who are eligible for the drawback.17

17Finally, an alternative, which is just our neutrality theorem once again is that to make all users of both the foreign good and its domestic substitute eligible for the drawback and to tax domestic production at a rate equal to the tariff would be equivalent to free trade in that commodity.
IV.15 EFFECTIVE PROTECTION AS A VALUE ADDED TAX AND ITS IMPACT ON THE EXCHANGE RATE

As a further illustration of the importance of viewing the ERP as a value added subsidy, consider the paradoxical result in Johnson (1966) "that tariff structures may bring about a situation in which appreciation rather than depreciation would be necessary to preserve equilibrium under trade liberalization; this possibility is due to the fact that a tariff structure may impose a tax, rather than provide a subsidy, on particular lines of production" (Johnson, 1971, p. 358). The point is that if a tariff is imposed on an imported intermediate input into production of the sole export, we have in effect taxed labor's use in producing the export and to restore international competitiveness, when the tariff is imposed, labor's wage in world prices must fall; consequently tariff liberalization must be accompanied by a wage hike or else a currency appreciation if wages are held constant.

IV.16 ON A PROPOSAL TO LIBERALIZE TRADE

Now let us see how some of these ideas can be used to facilitate trade liberalization. Let us pretend once again that output is produced using various factors in fixed proportions and initially assume away non-traded goods. If a country wished to liberalize trade without affecting the income of any factor adversely it could immediately abolish all import restrictions, and simultaneously initiate value added subsidies equal to the ERPs while balancing its budget by using a uniform value added tax which would partially offset the value added subsidies. Such a policy would result in consumption gains from trade, without causing any factors to move between sectors.
Moreover factor incomes would remain unchanged. If all factors have identical tastes and unitary income elasticities of demand for all commodities they would share identical proportional increases in their real incomes. More generally, so long as the budget shares in consumption of all the factors are reasonably equal, we would expect all factors to experience roughly the same proportionate change in real income. Then through time, the country could move its value-added taxes to uniformity. Probably a reasonable scheme would be to fix a future time period, say 5 years in the future by which full equality would be achieved, with 20% of the initial discrepancy in each of the taxes eliminated in each year of the transition. The policy maker might wish to leave some leeway so that any industries experiencing excess demand would have any proposed value-added tax increases accelerated, and conversely any industries experiencing excess supply would have any proposed value-added tax cuts accelerated.

Non-traded goods would cause no conceptual difficulties. The only problem is that to find the level of value added taxation that would freeze their output levels and hence factor incomes, it would be necessary for the government to pick norms for disposable factor incomes and be prepared to tax or subsidize as needed to bring incomes in line with those norms.

Such a proposal would be second best to many that could be devised, but I believe it would be preferable to the traditional method of tariff reduction which is to gradually reduce tariffs, and it recognizes that if the policy maker's goal is to avoid rapid changes in income distribution between industries, the best policy is value added taxation and subsidization - not tariffs.

Of course, to the extent that the same domestic and foreign product may not be perfect substitutes, abolishing tariffs could cause changes in the
prices that domestic goods would fetch. Still, we could deal with this problem as with non-traded goods, namely adjust the value added subsidy.\textsuperscript{18}

\textbf{IV.17 OTHER DEFINITIONS OF THE EFFECTIVE RATE OF PROTECTION}

Throughout this section, we have interpreted the ERP as a measure of the implicit subsidy to value added. However, other authors have used other definitions which are analogous to Corden's second definition of the NERP, and they have used the ERP for other purposes. In this section we examine these other definitions and uses.

Bhagwati and Srinivasan (1983, p. 127) write:

"The objective of ERP theory, then, consists in devising a concept of protection that, in the presence of tariff structures involving the imports of intermediate goods, constitutes in effect an index that will perform the same tasks nominal tariffs perform in nominal tariff theory: predicting accurately the changes in gross output, primary factor allocation, real value added, and/or nominal value added."

B&S (p. 127 and p. 129) also write:

"Two basic definitions of an ERP index have developed in the literature. In Corden 1966 and Anderson and Naya 1969 it is defined as the proportionate increment in value added per unit level of an activity brought about by the tariff structure over its free-trade value, whereas in Corden 1969 and Leith 1968 it is

\textsuperscript{18}McKinnon (1971, p. 290) also notes that a value added tax is a better protective device than a tariff since it avoids the consumption distortion. For more on adjustment assistance see various essays in Bhagwati (1982).
defined as the proportionate change (due to the tariff structure) in the "price" of value added (with the assumption that such a "price" can be defined meaningfully)."

... 

"The two definitions generally yield different ERP numbers. However, in the special case of a separable production function where the intermediates are used in fixed proportion to output, both definitions amount to the same thing."

Thus, in the B&S view the ERP is interesting only to the extent that it is correlated with the change, due to the tariff structure, in other variables of interest. Clearly, if we were to solve a general equilibrium system to determine the impact of a tariff structure on real incomes of various groups and levels of outputs in various sectors the concept of the ERP would be superfluous, and it would be sensible to concur with Dixit (forthcoming, section 6.2) who writes

"To sum up, Samuelson's dictum about consumer surplus seems to apply equally well to effective protection: the concept can safely be used only by those who understand it sufficiently well to do without it."

Harberger (undated) on the other hand lists the theory of effective protection as one of the four major developments in economic theory which has contributed to the changes that took place in the economics profession's view of the development process in the past few decades. He notes that this is because "Empirical studies... have shown first how high, typically, the effective rates of protection are, and second how heavy are the burdens, in terms of the resulting inefficiency, that many developing countries have, as it were, imposed upon themselves." He also writes "All the confusion about
what the rate of effective protection is can be avoided only by having a uniform and general tariff on all imports. So while the first lesson emerging from effective protection and analysis is "liberalize," the second is, to the extent that liberalization is incomplete, "equalize" the tariff schedule."

I propose that we drop the use of the ERP as defined in the two senses considered by B&S, and replace it with the concept of the ERP defined as a measure of the tax or subsidy incentive to value added discussed earlier in this section. Then if desired, these incentive measures can be combined with other parameters to calculate the impact of protection on important variables. Moreover, the ERP defined in this way is easier to calculate and I suspect will be correlated almost as closely in most circumstances with variables of importance as the B&S definitions. Of course when world prices are fixed, there are no non-traded goods and the value added aggregate and intermediate inputs are used in fixed proportions all of these definitions are the same.

Kreinin, Ramsey and Kmenta (1971) define two broad types of ERP. The differential form is simply the proportional change in unit value added per proportional change in the tariff structure while the discrete form is the proportional change in unit value added brought about by the tariff structure. They also note that one might consider the alternative of defining effective tariff rates with respect to variables other than unit value added, and they define various effective rates of protection as the proportional change in total value added, output, labor input and profits, using Cobb-Douglas and CES functions to provide exact expressions for them.

Finally, Hartigan (forthcoming) has defined the ERP for particular factors or aggregates of factors as the proportional increase in their utilities due to the tariff structure.

Thus, there are many definitions of the ERP in use and one must be care-
ful to define what he means when using the term. Perhaps the bottom line is that one should be more concerned with the analysis of the effects of protection than the concept of effective protection in the B&S senses.

IV.18 CONCLUSION

To conclude, whereas many like Ethier (1977) have searched for analogies between effective and nominal tariffs, the more appropriate analogy is between the effective tariff and the value-added subsidy. Perhaps we should even rename the effective tariff, the implicit value-added subsidy.19 In fact Johnson (1971, p. 312) in a chapter which is a reprint of a 1964 lecture refers to the ERP as "the implicit rate of protection." The problem is that "effective" is defined by Webster as "operative" or "actual," which to me refers to the ultimate consequences of protection after a new general equilibrium has worked itself out, whereas "implicit" is defined as "capable of being understood from something else though unexpressed," which seems to fit the symmetry concept better.

19Balassa (p. 17 of Balassa and Associates 1982) calls the ERP, calculated as the proportional difference in value added at domestic and world prices "the partial equilibrium effective rate."
Chapter V

THE IMPLICIT RATE OF FINAL DEMAND TAXATION AND THE EFFECTIVE RATE OF VALUE ADDED SUBSIDY AS DETERMINANTS OF SHADOW PRICES

V.1 INTRODUCTION

The previous chapter developed the concepts of the effective value added subsidy, z, and the implicit rate of final demand taxation, τ. Now we turn to the problem of assessing the normative significance of these tools. Bertrand (1972) derives a simple expression for the effects of shifts in consumption and production between sectors on economic welfare in which the tariff and the effective rate of protection play important and symmetric roles. This chapter accomplishes several things. (1) We rewrite Bertrand's formula in a way that is easier to understand and interpret. (2) We permit the existence of explicit value-added and sales taxes so that our z replaces the ERP and our τ replaces the tariff in Bertrand's formula. (3) We show that the existence of non-traded goods and variable world prices leaves Bertrand's formula unchanged if we replace the τ and z with τ̃ and z̃ where τ̃ is defined as \((p^c_1 - p^*_1)/\tilde{p}_1\) where \(p^c_1\) is the price to domestic consumers and \(p^*_1\) is marginal revenue or marginal expenditure on world markets if the good is traded or else price to the

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1This chapter was suggested by Balassa's (1971, p. 318) observation that we can "reinterpret the effective rate of protection as a measure of the cost of foreign exchange i.e., the amount of domestic resources (value added) spent to save (or earn) a unit of foreign exchange." Also see Balassa and Schydowsky (1972), Bertrand and Vanek (1971), Bruno (1972), Krueger (1972) and Pearson (1976) as well as Ray (1980) which covers much of the same ground as Bertrand (1972). In fact Ray's equation (16) is identical to Bertrand's (15) although Ray doesn't reference Bertrand's paper.
producer of the good if it is non-traded, and \( z_i \) is the proportion by which
disposable value added in sector \( i \) exceeds value-added evaluated at the \( \hat{p}_i \)s.
(4) We extend the formula so that it can be used to derive shadow prices of
goods, factors and policy parameters and call it our fundamental equation.
(5) We show how this equation can be used in the Little-Mirrlees procedure of
shadow pricing everything as the amount of foreign exchange it saves, holding
real income constant. (6) We show how similar forms emerge for the fundamen-
tal equation when the reference prices are calculated in several different
ways and thereby generalize the concept of effective protection. (7) We use
the equation to calculate the welfare benefit of removing all of the economy's
distortions, thereby extending a formula of Harry G. Johnson's. (8) We show
how to use the equation to assess the welfare impact of making a number of
simultaneous small adjustments in each of various distortions. (9) We inter-
pret the logic of our analysis geometrically. (10) Finally, we assess the
normative significance of different ways of treating non-traded goods.

V.2 DERIVING THE FUNDAMENTAL EQUATION

Let us first define a reference price, \( \hat{p}_i \), which for exportables is
simply the marginal revenue from selling abroad, \( p_i^* [1 - (1/\eta_i^*]) \), with \( \eta_i^* > 0 \)
being the elasticity of foreign excess demand, or for importables the marginal
expenditure necessary to secure one unit from abroad, \( p_i^* [1 + (1/\sigma_i^*]) \) where
\( \sigma_i^* > 0 \) is the foreign elasticity of excess supply.\(^2\) Thus, for tradeables, the
reference price is the rate at which the country can transform the good in

\(^2\)In the event that foreign excess demand and supply functions are inter-
related, \( \hat{p}_i = p_i^* [1 + \Sigma j \pi_{ji}^] \) as defined in section III.2's equation (10).
question into foreign exchange. For non-tradeables, \( \bar{p}_i \), is defined as the
price received by producers of the good, \( p_i^p \). With these definitions we can
define the consumption distortion on good \( i \) as

\[
\hat{\tau}_i = \left[ p_i^c - \bar{p}_i \right] / \bar{p}_i.
\]

Thus if \( i \) is a non-tradeable \( \hat{\tau}_i \) is simply the excise tax on its consump-
tion, while if \( i \) is traded at fixed world prices, \( \hat{\tau}_i \) is simply the import
tariff, export subsidy, or tariff equivalent of any import quota, for it is
the proportion by which price to consumers exceeds world price.

As before disposable value added is \( v_i^d \). Now, however we must define
reference unit value added as unit value added at reference prices:

\[
\hat{v}_i = \bar{p}_i - \Sigma a_{ji} \bar{p}_j
\]

This enables us to define the value added distortion as

\[
\hat{z}_i = \left[ v_i^d - \hat{v}_i \right] / \hat{v}_i.
\]

Thus when world prices are fixed and there are no tariffs \( \hat{z}_i \) is the explicit
value added subsidy on good \( i \), while if world prices are fixed and there is no
explicit value added tax or subsidy \( \hat{z}_i \) is simply \( ERP_i \). Therefore, \( \hat{\tau}_i \) is the
proportion by which the price of a good to consumers exceeds its marginal rate
of transformation into foreign exchange or else its price to producers while
\( \hat{z}_i \) is the proportion by which the price of the commodity basket produced by
the \( i \)th sector (which contains inputs in negative quantities) to producers in
that sector exceeds its marginal rate of transformation into foreign exchange
or else its price to domestic producers of the various goods in the basket.

Since consumers spend all income, the change in their real income is
given by the changes in their consumption, weighted by the prices they face:

\[ dy = \sum_i p_i^c dC_i. \]  

(4)

We define the exchange rate as unity and the increase in the rate at
which foreign exchange reserves are used up is given by

\[ \tilde{F} = \sum_i \tilde{p}_i dM_i \]  

(5)

where \( M_i \) is net imports of the ith good. Thus if the ith good is exported \( M_i \)
is negative.

The change in the total net product of the economy, valued at reference
prices can be written either as the value of increased net output of each good
summed over all goods, \( \sum_i \hat{p}_i dQ_i \), or else as the value of a unit basket of goods
produced in each sector multiplied by the change in the number of baskets pro-
duced by that sector, \( \sum_i \hat{\nu}_i dX_i \). Thus

\[ \sum_i \hat{p}_i dQ_i = \sum_i \hat{\nu}_i dX_i \]  

(6)

where \( Q_i \) is net output of good i, i.e. gross output minus the quantity of the
good used as intermediate inputs.

Let \( \bar{Q}_i \) be the autonomous increase in government sales of the ith good to
the private sector. Then commodity balance dictates for all i that
\[ dM_i = dC_i - \bar{Q}_i - dQ_i. \]

Multiplying by \( \hat{p}_i \), summing over all commodities and
substituting from (6) yields
\[ \sum_{i} \hat{\pi}_i dM_i = \sum_{i} \hat{\pi}_i [dC_i - \hat{Q}_i] - \sum_{i} \hat{v}_i dX_i. \]  

(7)

We pretend that the economy is competitive, so

\[ \hat{v}_i dX_i = \sum_{j} w_j dL_{ji}. \]  

(8)

where \( w_j \) is the economy-wide wage to factor \( j \) and \( L_{ji} \) is the employment of factor \( j \) in sector \( i \).

Since there is full employment of all factors, for all \( j \)

\[ \sum_{i} dL_{ji} = \tilde{L}_j \]  

(9)

where \( \tilde{L}_j \) is the autonomous reduction in government purchases of services of the \( j \)th factor. Combining (8) and (9) yields

\[ \sum_{i} \hat{v}_i dX_i = \sum_{j} w_j \tilde{L}_j. \]  

(10)

Combining (4), (5), (7) and (10) yields

\[ dy - \bar{F} = \sum_{i} [\hat{\pi}_i \hat{\pi}_i - \hat{\pi}_i] dC_i - \sum_{i} [\hat{v}_i \hat{v}_i] dX_i + \sum_{i} \hat{\pi}_i \hat{Q}_i + \sum_{j} w_j \tilde{L}_j. \]  

(11)

Then substituting (1) and (3) into (11) yields

\[ dy - \bar{F} = \sum_{i} \hat{\tau}_i \hat{\pi}_i dC_i - \sum_{i} \hat{\tau}_i \hat{v}_i dX_i + \sum_{i} \hat{\pi}_i \hat{Q}_i + \sum_{j} w_j \tilde{L}_j. \]  

(12)

If we pretend all goods are traded at fixed world prices, and assume away all taxes except tariffs, \( \hat{\tau}_i \) becomes the \( i \)th tariff and \( \hat{z}_i \) becomes the \( i \)th ERP.
Then if we suppress the terms in $\overline{F}, \overline{Q}_i$ and $\overline{L}_j$, (12) becomes Bertrand's (1972) equation (15).

Now let us define

$$\hat{r}_i^* = \hat{r}_i / (1 + \hat{r}_i) \quad (13)$$

and

$$\hat{z}_i^* = \hat{z}_i / (1 + \hat{z}_i) \quad (14)$$

so that $\hat{r}_i^*$ is the consumption distortion on the $i$th good expressed as a proportion of consumers' price and $\hat{z}_i^*$ is the value added distortion expressed as a fraction of prices to producers in the $i$th sector. Now (1), (3), (13) and (14) can be used to rewrite (12) as

$$dy - \overline{F} = \sum_{i} \hat{r}_i^* p_i^C dC_i - \sum_{i} \hat{z}_i^* v_i dX_i + \sum_{i} p_i^C \overline{Q}_i + \sum_{j} w_j \overline{L}_j \quad (15)$$

which using (8) can be expressed as our fundamental equation:

$$dy - \overline{F} = \sum_{i} \hat{r}_i^* p_i^C dC_i - \sum_{i} \hat{z}_i^* dR_i + \sum_{i} p_i^C \overline{Q}_i + \sum_{j} w_j \overline{L}_j \quad (16)$$

where

$$dR_i = \sum_{j} w_j dL_{j1} \quad (17)$$

and $dR$ is interpreted as the value of resources attracted to sector $i$. 
First, pretend there are no distortions and fixed world prices. Then (16) tells us that each unit of a good or factor released by the government will increase real income by the value of that good or factor at domestic (equal to world) prices. Now let's pretend that the government wishes to absorb one unit of resources or goods from the private sector, but will then liberate just enough foreign exchange from its reserves to keep real income unchanged. Setting $dy = 0$ in (16) tells us that the requisite foreign exchange loss is simply the domestic market value of that good or resource.

Now let's focus on the distortions. Suppose that $\tilde{\tau}^{*}_{\text{radios}}$ is 30% because of a 30% import tariff on radios, and $\tilde{\tau}^{*}_{\text{rice}}$ is -20% because of an export tax on rice, and consider the impact of a small adjustment in excise taxes which shifts 1$ worth of expenditures away from rice onto radios but leaves unchanged both resource allocation in distorted sectors and consumption of all other goods which have consumption distortions. Thus we have $p^{c}_{\text{rice}} \Delta \text{Rice} = -1$ and $p^{c}_{\text{radios}} \Delta \text{Radios} = +1$, which implies that real incomes will rise by 50¢ if foreign exchange usage is unchanged, or the requisite foreign exchange usage necessary to keep the standard of living unchanged falls by 50¢.

The interpretation of the second term is analogous. Suppose $\tilde{\tau}^{*}_{\text{autos}}$ is +200% due to a very high import tariff on assembled vehicles and the $\tilde{\tau}^{*}_{\text{cocoa}}$ is -50% because of an export tax which keeps its domestic price well below its marginal revenue in world markets. A change in some sort of taxes whose sole effect is to shift 1$ worth of resources from autos to cocoa will reduce the
Note that there is a welfare gain from shifting expenditure between goods only when the consumption distortions attached to them are different. Similarly, there is a gain from shifting resources between sectors only when the distortions attached to them are different. This highlights the point made in the last section that it is only differences in distortions that matter as far as real variables are concerned.

V.4 ALTERNATIVE REFERENCE PRICES AND ALTERNATIVE FORMS FOR THE FUNDAMENTAL EQUATION

We have defined reference prices as producer prices for non-traded goods and marginal rates of transformation into foreign exchange for traded goods. How else could we have defined reference prices and what other results would have emerged? In fact, we could have selected arbitrary reference prices. In that case (16) becomes

\[
d y - F = \sum_{i} \left[ \tilde{p}_{i} - p^{**} \right] dM_{i} + \sum_{i} \tilde{r}_{i}^c dC_{i} - \sum_{i} \tilde{z}_{i}^d R_{i} + \sum_{i} \tilde{p}_{i} \tilde{Q}_{i} + \sum_{j} w_{j} \bar{L}_{j}. \tag{16'}
\]

where \( p^{**} \) is marginal revenue or marginal expenditure on world markets, and \( \tilde{r}_{i}^c \) and \( \tilde{z}_{i}^d \) are both defined with respect to the new reference prices, \( \tilde{p}_{i} \).

If we select a reference price of, \( p^{c}_{i} \), the price to consumers, the second term on the right hand side drops out. This enables us to boil all the distortions in the system into one set associated with net imports and a

\[^{3}\text{Corden (forthcoming) argues "the cost of protection will be measured at the margin, essentially by the difference between the rates [of effective protection], though in a multi-good model, this is not a simple idea." Our formula shows the precise sense in which Corden's statement holds.}\]
second associated with primary factor flows.

Alternatively, if we define reference prices as prices to domestic producers and there are no taxes on transactions between domestic producers or value added taxes, then the third term on the RHS drops out and we have been able to boil down our distortions into one set associated with net imports and a second set associated with consumption.

Any one of these equations may be used as the fundamental one for doing welfare analysis. Each one involves calculating the distortions, including our value added distortion with respect to a different reference price. Thus what we have shown is that the concept of \( z^* \) is a useful one for three different definitions of reference prices and it is an intellectual accident that in defining reference prices for ERPs we typically take world prices instead of producer prices, consumer prices or marginal rates of transformation into foreign exchange, because ERPs can be usefully defined with respect to these other reference prices. This discussion also clarifies why it is that any reference price for non-traded goods will work.

In our discussion henceforth we will pretend that reference prices are producer prices for non-traded goods and marginal rates of transformation into foreign exchange for traded goods.

V.5. EVALUATING RESOURCE SHIFTS AND CALCULATING SHADOW PRICES WHEN CONSUMER PRICES ARE FIXED

Now let us calculate the change in real income which accompanies a resource shift under the realization that consumption will change as real income alters. For the time being we hold consumer prices fixed and write
\[ p_i dC_i = m_i dy \]  
\[ (18) \]

where \( m_i \) is the marginal propensity to spend on the \( i \)th good. Combining (4) and (18) implies:

\[ \sum_{i=1}^{m} m_i = 1. \]  
\[ (19) \]

Combining (16) and (18) yields

\[ dy = f \left[ \bar{F} - \sum_{i=1}^{m} \tau_i dR_i + \sum_{i=1}^{m} \bar{p}_i \bar{Q}_i + \sum_{j=1}^{n} w_j \bar{L}_j \right] \]  
\[ (20) \]

where

\[ f = \frac{1}{1 - \sum_{i=1}^{m} \tau_i m_i}. \]

If we assume that increased usage of foreign exchange would leave resource allocation unchanged, \( f \) is simply the increase in real income made possible by a unit increase in foreign exchange. In this chapter we do not distinguish between economic welfare and real income. Therefore, building on the discussion just following chapter II's equation (16) \( f \) is what Warr (1980, p. 34) refers to as "the shadow price of foreign exchange in utility numeraire" and what Bacha and Taylor (1971) refer to as the second best price of foreign exchange. It is just the reciprocal of one minus the weighted average of consumption distortions where the weights are marginal propensities to spend. If this weighted average is 20%, \( f \) is 1.25. This means that we can interpret our earlier example of a shift of \( \$1 \) worth of resources out of autos into cocoa as saving \( \$2.50 \) worth of foreign exchange which with a shadow price of 1.25 attached causes real income to rise by \( \$2.50 \times 1.25 = \$3.12 \). Thus, to keep the last worker employed in autos, consumers pay a tax of \( \$3.12 \) on each
dollar of his take home pay.

Note, this expression is valid no matter which resource (e.g. skilled labor, unskilled labor or capital) we consider to be moving, but remember that it hinges on the assumptions that tax adjustments or direct controls are employed to insure that only the resource in question moves, and relative prices to consumers are kept constant by the assumption that all goods are tradeable. If labor's share in value added were 2/3 in both sectors, and it were assumed that both capital and labor tended to move at the same time from one sector to the other, perhaps because a value-added subsidy is the impetus to the factor mobility, then the implicit tax per dollar of the worker's take home pay would rise to \((3/2) \times 3.12 = 4.68\). Finally, if a tariff is the adjustment mechanism, the consumption mix will alter at the same time that resources flow, and the analysis will be different, a problem we return to later on.

Now let's use (20) to calculate the shadow prices of goods and labor. A unit increase in the endowment of the 0th good, holding \(y\) constant, will cause a saving of foreign exchange equal to

\[
- \frac{\bar{F}}{\bar{Q}_0} = -\sum_i z_i \frac{dR_i^*}{\bar{Q}_0} + \bar{p}_o
\]

(21)

where \(dR_i^*/\bar{Q}_0\) is just the flow of resources into the \(i\)th sector due to a unit increase in the endowment of the 0th good. This is the equation for the Little-Mirrlees shadow price of good zero, and it is simply the amount of foreign exchange that can be saved when the government releases one unit of good zero, and still leave the economy at the same level of real income or what is the same thing, leave the representative consumer on the same indifference curve. The shadow price of a resource is defined analogously.
Moreover, we could modify (21) to calculate the shadow price of a policy parameter, $P_0$, like the height of the value-added tax, VAT, in some sector. All we need do is rewrite (20) as

$$- \frac{\bar{F}}{\bar{P}_0} = - \sum \frac{z^* \bar{dR}_i}{\bar{P}_0}$$

(22)

where $\bar{P}_0$ is the autonomous change in the policy parameter in question. For example, if a unit increase in the VAT in autos shifts 1$ of resources from autos to cocoa, the shadow price of that parameter using our previous example is simply +$2.50, for that is the foreign exchange that raising it by one unit saves. Finally, had we chosen to express shadow prices in utility numeraire, we could have set $\bar{F}$ in (20) equal to zero and solved for $dy$.

V.6. CALCULATING SHADOW PRICES WHEN CONSUMER PRICES ARE VARIABLE

When prices to consumers are variable, (20) no longer holds and we must calculate shadow prices from (16). In that case to calculate Little-Mirrlees shadow prices (21) becomes

$$- \frac{\bar{F}}{\bar{Q}_0} = \sum \frac{\bar{r}^* \bar{dC}_i}{\bar{Q}_0} - \sum \frac{\bar{z}^* \bar{dR}_i}{\bar{Q}_0} + \bar{p}_0$$

(23)

while (22) becomes

$$- \frac{\bar{F}}{\bar{P}_0} = \sum \frac{\bar{r}^* \bar{dC}_i}{\bar{P}_0} - \sum \frac{\bar{z}^* \bar{dR}_i}{\bar{P}_0}.$$ 

(24)

Thus, the problem is that we must deal with induced flows across the consumption distortion as well as across the production distortion, but the essential logic is unchanged.
V.7 INSIGHTS FOR THE SHADOW PRICER

What further insights into how to shadow price goods and resources do we get from equations (16) and (23)?

7.a Traded Goods with Fixed World Prices

First, consider a good which is traded and subject to fixed world prices. If the government sells one unit of this good to the private sector and then withdraws enough foreign exchange to leave private sector real income unchanged, it is just as if the government sold the good to the foreign sector, and as a consequence foreign exchange reserves would rise by the price of the good, with the domestic private sector taking no part in the transaction. In other words, government purchases and sales of goods of this sort, after the private sector is compensated, leave the private sector's consumption and resource allocation unchanged so that the shadow price of such a good is simply its world price.

7.b Traded Goods with Variable World Prices

Second, now pretend that good zero is traded at a variable world price. Suppose that the economy's resources are frozen in place, and no substitution is permitted between goods in final demand, so that with real income fixed consumption of each good is fixed. Then (23) tells that

\[-\frac{F}{Q_o} = \tilde{p}_o.\] (25)

This means that the foreign exchange saved when one unit of good zero is sold by the government, and the private sector's real income is held constant is
simply the marginal revenue attached to that good when it is sold on world markets or else the marginal expenditure attached to it when it is purchased on world markets.

However, to the extent that domestic resources will move and consumption patterns will alter in response to the changed world price of this good, it is necessary to reckon with the first two terms on the right hand side of (23) in calculating shadow prices.

7.c Non-traded Goods

Third, now pretend that good zero is a non-traded good. Also pretend that resources are frozen and that good zero is a very good substitute in consumption for a good that is traded with no tariff and fixed world prices which we will call good 1, and assume neither goods 0 or 1 have excise taxes attached. In that case (23) tells us that the shadow price of the good in question is simply its domestic price.

Now pretend again that resources are frozen, but introduce a positive import tariff on good 1. Government sales of good zero will lower its price and increase its consumption, thereby lowering consumption of good 1, causing \( dc_1 < 0 \) and making the first term on the right hand side of (23) negative. This reduces the amount of foreign exchange which can be saved and still leave the economy at its initial real income. Thus the existence of the tariff lowers the shadow price of the non-traded good zero. The intuition behind this is that the tariff is already artificially discouraging domestic consumption of good 1, and anything which further discourages it is bad in that regard, like the government sale of good zero.

Now let us assume that there is no substitution in consumption but that when the government sells some of good 0, the price fall causes resources to
move out of the production of good 0 into the production of good 1. The second term on the right hand side of (23) tells us that this will raise the shadow price of good 0 above its domestic price if $\hat{z}_1 < \hat{z}_0$ for then resources will be moved out of a sector where artificial encouragements for production are high into where they are relatively lower. This is a good thing for economic efficiency as indicated by our criterion that demands on foreign exchange reserves be lowered, and therefore these differential $\hat{z}$'s reflect themselves in a higher shadow price for good zero.

To actually calculate shadow prices for goods and factors it is necessary to build models which relate consumption and resource shifts to changes in relative prices, an activity which is undertaken in Tower and Pursell (1984).

V.8 GENERALIZING THE INTERPRETATION OF THE FUNDAMENTAL EQUATION

8.a Monopoly/Monopsony Power

So far we have thought of the $\tilde{r}_i$s and $\tilde{z}_i$s as reflecting solely taxes and subsidies, both implicit and explicit, as well as variable world prices. Moreover we have assumed perfect competition. In fact, monopoly and monopsony power is easy to fit into the equation. If a producer faces an upward sloping supply of his intermediate inputs and/or a downward sloping demand for his output, he will recognize that the marginal revenue from producing his basket of goods is less than its price, and he will set marginal cost of production, i.e. unit value added net of monopoly/monopsony profit equal to marginal revenue. If we redefine $v^d_1$ as unit value added net of monopoly/monopsony profit and label $\alpha$ as the wedge between price and marginal revenue, we can imagine that our imperfect competitor is in fact a perfect competitor who pays an additional value-added tax of $\alpha$ on disposable value added, and that this
tax revenue is redistributed to him as a windfall, i.e. it does not affect his calculations. Thus, in calculating the $v^d_1$s throughout the economy one would look at value added before monopoly profits, and in calculating the $\tilde{z}$s one would include tariffs, excise taxes on intermediate inputs, explicit value added taxes and the additional component of implicit value added taxation due to monopoly/monopsony power.

This generalization is irrelevant with regard to tradeables that have fixed world prices. But it is important to take into account where there are non-traded goods. Finally, for goods with variable world prices which are consumed or produced by a domestic monopolist/monopsonist who takes into account the variable world price, there will be less of a distortion than there would be if we thought of the good as being produced competitively.

8.b Minimum Wages and Taxes on Particular Factors

The fundamental equation can also be generalized to deal with taxes on the use of particular factors.

In a simple non Harris-Todaro world a minimum wage in a particular sector is just like a tax on hiring labor there which is redistributed to labor as a windfall. Therefore, we can model that just like any other tax. Alternatively, we can use a variant of our fundamental equation which recognizes that if labor is pushed from a sector 1 with no minimum wage into sector 0 where there is a minimum wage in excess of the market rate, $dR_0 > |dR_1|$, i.e. the value of the inflow of resources into sector zero will exceed the value of resources released by sector 1. Finally, one would deal with explicit taxes or subsidies on factors of production in certain sectors in the same way.
V.9 ON CALCULATING THE SHADOW PRICES OF DISTORTIONS AND
THE WELFARE GAIN FROM ELIMINATING THEM

9.a The Gain From Eliminating Distortion in a Simple Special Case

Harry G. Johnson (1971, p. 347, equation 22) presents a simple formula for the welfare cost of protection using both nominal and effective tariff rates under the assumption of fixed prices. However, his procedure for calculation involves jumping immediately to a consumer surplus measure of a finite change in tariffs, thereby bypassing the logically prior step of assessing the welfare gain associated with a small tariff change. First, we show how (22) could be used handily to assess the welfare cost of Johnson's set of distortions.

Pretend that the compensated demand schedule for good i is given by

\[ \hat{C}_i = -\eta \hat{p}_i \]

where \( \eta > 0 \), a hat, "\(^\wedge\)" denotes a proportional change and \( p_i \) is the price of good i relative to the price of good 0 faced by consumers. Moreover, we normalize the consumer price of good 0 at 1, so that \( p_i \) is also the absolute price of good i.

Since we hold real income constant \( \sum p_i \hat{C}_i = 0 \) which implies

\[ \sum_{i=1}^{N} \hat{C}_0 = -\sum_{i=1}^{N} p_i \hat{C}_i \]

where \( N+1 \) is the number of goods.

Now pretend that value added in each sector is produced with a fixed factor (capital) and a variable factor (labor) whose wage is constant. Then
\[ \hat{X}_i = e_i \hat{v}_i \]  

(28)

where \( e > 0 \) is the elasticity of the supply of output with respect to unit value added, and drawing from chapter II's equation (6') it is the same as the elasticity of supply of output with respect to the wage rate.¹

We will assume that all goods are traded at fixed world prices and that good 0 is also the only one which uses labor as its sole primary input. This freezes both the wage rate and price to consumers of good zero, and means that when labor is drawn into or released from sectors other than zero, it will come from or go to sector zero. This means

\[ dR_0 = - \sum_{i=1}^{N} dR_i. \]  

(29)

Now we can rewrite (16) using (27) and (29) and holding dy at 0 as

\[ -F = \sum_{i=1}^{N} \left[ \tilde{r}_i - \tilde{r}_0 \right] p_i^c dC_i - \sum_{i=1}^{N} \left[ \tilde{z}_i - \tilde{z}_0 \right] dR_i + \sum_{i=0}^{N} p_i \tilde{Q}_i + \sum_{j} w_j \tilde{L}_j \]  

(30)

where as before \(-F\) is simply foreign exchange saved by the government.

In this form, our fundamental equation emphasizes that what matters for efficiency is the differential \( \tilde{r}_i\)'s and \( \tilde{z}_i\)'s on goods between which consumption expenditure and resource allocation is switched, and if there are no differentials small switches don't affect the efficiency of the economy to satisfy wants.

¹To see this, recognize that \( \theta_{ij} p_j / p_i = a_{ij} \), and \( v_j = p_j - \sum_i a_{ij} p_i \), so (6') can be rewritten as

\[ dv_j / p_j = \theta_{ij} \hat{v}_j \hat{w}_j + \frac{\theta_{ij}}{e_j} \hat{x}_j, \]  

so \( \hat{x}_j = e_j [\hat{v}_j - \hat{w}_j]. \)
Substituting (8) and (17) into (30) to eliminate $dR_i$, while assuming away autonomous endowment changes yields

$$-F = \sum_{i=1}^{N} \left[ (\tilde{\tau}_i - \tau_{i0}) p_i^c dC_i - \sum_{i=1}^{N} [\tilde{z}_i - z_{i0}] v^d_1 dX_1. \right]$$  \hspace{1cm} (31)$$

Combining (1), (13) and (26) with their differentials and recognizing that $\tilde{p}_i^*$ is constant yields

$$p_i^c dC_i = -\eta_i C_i p_i^c \frac{d\tilde{\tau}^*}{1 - \tilde{\tau}^*}. \hspace{1cm} (32)$$

Combining (3), (14) and (28) yields

$$v^d_1 dX_1 = e_i X_i v^d_1 \frac{d\tilde{z}^*}{1 - \tilde{z}^*}. \hspace{1cm} (33)$$

Pretending $\eta_i$ and $e_i$ have a functional relationship which keeps $\eta_i C_i p_i^c / (1 - \tilde{\tau}^*)$ and $e_i X_i v^d_1 / (1 - \tilde{z}^*)$ constant as $\tilde{\tau}^*$ and $\tilde{z}^*$ fall from their initial values to zero, we can substitute (32) and (33) into (31) and integrate to yield for the foreign exchange saved in moving to a first best equilibrium:

$$-F = l_2 \left\{ \sum_{i=1}^{N} \left[ (\tilde{\tau}_i - \tau_{i0})^2 \frac{\eta_i p_i^c C_i}{1 - \tilde{\tau}_i} \right. \right. + \left. \left. \sum_{i=1}^{N} [\tilde{z}_i - z_{i0}]^2 \frac{e_i v^d_1 X_i}{1 - \tilde{z}_i} \right] \right\}. \hspace{1cm} (34)$$

It is easy to show that this formula is identical to Johnson's except that unlike Johnson we have permitted distortions to exist on the zeroth good as well as the others, which is a problem that occurs very frequently in highly distorted economies.
9.b The Gain from Eliminating Distortions When Markets are Interdependent

When all markets are interdependent, we can assess the impact of a change in many distortions as

\[ \bar{F} = \sum \frac{dC_i}{d\tau^*_j} \frac{d\tau^*_j}{d\tau^*_i} - \sum \frac{dX_j}{d\tau^*_j} \frac{d\tau^*_j}{d\tau^*_i} \]

To assess the impact of eliminating all distortions, we write the size of the distortion as the product of an index times its initial value. Thus

\[ \tau^*_j = I\tau^*_j \]
\[ z^*_i = Iz^*_i \]

where a zero subscript denotes an initial value.

Hence \( d\tau^*_j = \frac{d\tau^*_j}{dI} dI \) and \( dz^*_i = \frac{dz^*_i}{dI} dI \). Then assuming that \( p^c_i \) and \( z^*_i v^d_j \) do not vary systematically with the distortions we approximate them by constants so that (35) can be integrated between I = 1 and I = 0 to yield for the foreign exchange saved by eliminating all distortions:

\[ \bar{F} = \frac{1}{2} \sum \left[ \frac{d\tau^*_j}{d\tau^*_i} \frac{dC_i}{d\tau^*_j} \right] + \frac{dz^*_i}{d\tau^*_j} \frac{dX_j}{d\tau^*_i} \frac{dz^*_i}{d\tau^*_i} \]

9.c The Gain From Changing Distortions When World Prices are Variable

As a final application, let us consider the impact of eliminating all distortions when world prices are variable. Let us pretend again that there are no non-traded goods, that one tradeable, good 0, is produced with the mobile factor alone and that the demand for each good depends on its price relative to that good zero. Finally, we will pretend that all intermediate inputs are subject to a fixed world price.

For goods with variable world price we can write

\[ -dC_i + dX_i = dE_i \]
where $dE_i$ is the change in exports of the good in question. Labeling $\eta_i^*$ as the elasticity of world excess demand for good $i$ and substituting from (26) and (28) we have

$$+ \eta_i C_1 p_i \dot{c} + e_i X_1 \dot{d} = -E_i \eta_i^* p_i^*.$$  \hspace{1cm} (38)

Since $p_i^c = (1 + \tau_i) p_i^*$

$$p_i^c \dot{c} = \frac{d \tau_i}{1 + \tau_i} + p_i^*.$$  \hspace{1cm} (39)

Also, since $v_i^d = (1 + z_i) v_i^*$

$$v_i^d \dot{d} = \frac{dz_i}{1 + z_i} + v_i^*.$$  \hspace{1cm} (40)

and finally $v_i^* = p_i^*/\theta v_i$.

$$\text{(41)}$$

Combining (38), (39), (40) and (41) yields

$$p_i^* = -b_{\tau_i} \frac{d \tau_i}{1 + \tau_i} - b_{z_i} \frac{dz_i}{1 + z_i}.$$  \hspace{1cm} (42)

where

$$b_{\tau_i} = \eta_i C_1 / D_i$$

$$b_{z_i} = e_i X / D_i$$

and

$$D_i = \eta_i C_i + \frac{e_i X_i}{\theta v_i} + E_i \eta_i^*.$$  \hspace{1cm} (43)

along with

$$p_i^c = (1 - b_{\tau_i}) \frac{d \tau_i}{1 + \tau_i} - b_{z_i} \frac{dz_i}{1 + z_i}.$$  \hspace{1cm} (44)

and

$$v_i^d = -\left( b_{\tau_i} / \theta v_i \right) \frac{d \tau_i}{1 + \tau_i} + \left[ 1 - \left( b_{z_i} / \theta v_i \right) \right] \frac{dz_i}{1 + z_i}.$$  \hspace{1cm} (45)
Then using (26), (28), (43) and (44), (31) can be written as

$$\Delta F = -\sum_{i=1}^{N} \left[ \tilde{\tau}_i - \tilde{\tau}_i^* \right] \eta_i p_i C_i \left[ (1-b_i) \frac{d\tau_i}{1+\tau_i} - b_i \frac{dz_i}{1+z_i} \right]$$

$$- \sum_{i=1}^{N} \left[ \tilde{z}_i - \tilde{z}_i^* \right] e_i v_i d_i \left[ (b_i \theta_i / \theta_i^*) \frac{d\tau_i}{1+\tau_i} + [1 - (b_i / \theta_i^*)] \frac{dz_i}{1+z_i} \right].$$

(45)

This is simply yet another example of how one might use the fundamental equation.

V.10. THE GEOMETRY OF A TARIFF CUT

The discussion in the preceding section has been algebraic, but it is possible to explain the same ideas using geometry. Let us consider an economy which produces and consumes two goods, an agricultural product and a manufactured product which are both traded at fixed world prices, and suppose elimination of the tariff on the agricultural good is contemplated. For simplicity we choose to work with nominal tariffs and pretend that the agricultural good is produced with one mobile and one fixed primary factor while the manufactured good is produced with the mobile factor alone and hence at constant costs.

Figure 3 shows the initial domestic price of the agricultural good to be $p$ and its final price to be equal to the world price, $p^*$. Since $S$ is domestic supply and $D$ is the compensated domestic demand curve, eliminating the agricultural tariff contracts domestic production from $S_0$ to $S_f$ and expands domestic consumption from $D_0$ to $D_f$, thereby liberating domestic resources.

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*This section arose out of discussions with Mateen Thobani.*
valued in domestic currency at the area under AB, and reducing the amount of money spent on consumption of the other good by the area under CE. If we pretend that there is an export subsidy on the other good of 100% of the foreign price then the foreign exchange saved when resources move into the other sector or consumption is diverted from the other sector is 50% of the value of the resource or consumption shift. Thus the foreign exchange saved is the area under $S'$ and $D'$ between $S_F$ and $S_O$ and between $D_O$ and $D_F$ where $S'$ and $D'$ are drawn to be half as high as $S$ and $D$. Since the foreign exchange cost of reduced production and expanded consumption of the agricultural good is given by the area under $p^*$ and between $S_F$ and $S_O$ and $D_O$ and $D_P$, the net saving of foreign exchange is given by the sum of the two shaded areas minus the two cross hatched areas.

One easily sees from this diagram that elimination of one tariff is best when other export subsidies (or import tariffs) are small, that the initial phases of a tariff cut save more foreign exchange than the latter phases, and
in this case the optimum agricultural tariff is just equal to the tariff on the other good.

To determine the gain in real income that would result from this tariff elimination one need only multiply the foreign exchange saved by the shadow price of foreign exchange which we have determined previously in this section.

In figure 4 we generalize this problem to reconsider the supply side of the problem when the agricultural good uses traded intermediate inputs in fixed proportions. \( v \) and \( v^* \) are unit value added in agriculture at domestic and international prices respectively, and \( v' \) is equal to \( v \) divided by \( 1 + ERP_M \) where \( ERP_M \) is the effective rate of protection in the manufacturing sector, i.e. the sector to which resources are diverted when the agricultural ERP, \( ERP_A \), falls. The initial \( ERP_A \) is \( ERP_O \) so that initial unit value added in agriculture is \( v_O \), and equilibrium is at B. When all tariffs on inputs and outputs are eliminated the ERP falls to zero and equilibrium moves to A. The cost in foreign exchange of reducing the gross output of the agricultural good from \( X_O \) to \( X_F \) is that quantity multiplied by \( v^* \), i.e. the area \( \text{AFX}_O \text{XF} \). This liberates resources with a domestic currency value of \( \text{ABX}_O \text{XF} \), and given that they find new employment in manufacturing, where the supply elasticity is infinite they save an amount of foreign exchange equal to the area under \( v' \) between \( X_F \) and \( X_O \). Thus the net foreign exchange saving on the supply side is the shaded area minus the cross hatched area. Clearly then, the tariff cut is wise only if the ERP in the other sector is small. Also, it is easy to see that welfare is maximized on the supply side when the agricultural ERP is equal to that of the other sector, for then there is no production distortion whatsoever.
Equation (20) shows how welfare changes in response to resource shifts. Let us rewrite it now to focus solely on the welfare impact of resource shifts, while pretending that world prices are fixed and there are no explicit taxes other than tariffs so \( z_i^* \) becomes \( \text{ERP}^*_1 = \text{ERP}_1 / [1 + \text{ERP}_1] \) and \( \tau_i^* \) becomes \( \tau_i^* = \tau_i / [1 + \tau_i] \):  

\[
\frac{dy}{dR} = \frac{- \sum \text{ERP}^*_i dR_i}{1 - \sum \text{ERP}^*_i dR_i}.
\]  

(46)

Now we explore how this equation needs to be modified under alternative ways of treating non-traded goods discussed in Section III.1.8. As in that section we assume away explicit value-added taxation so that we do not distinguish between \( v_{ij}^*, v_i^g \) and \( v_i^d \).
11.a The 'Sophisticated' Corden Method

Non-traded goods cause a problem in that any resource shift will create excess supplies and demands for non-traded goods. One way out of the problem is the Corden method of vertically integrating the production of each good with its non-tradeable inputs and considering factor movements between these vertically integrated industries. In this case, the m's in (46) would be constructed under the assumption that price changes to consumers due to rationing or alteration of consumption taxes leave the consumption demands for all non-tradeables constant, except in the event that the factor movement considered is in (or out) of a non-tradeable consumer good industry, (and perhaps other non-tradeables which feed into it) in which case such movement would cause an excess supply (or demand) for that non-tradeable, which would have to be matched by increased (or decreased) consumption demand for it.

11.b The Balassa Method

If the Balassa method is used for dealing with non-traded goods, we can still use a modification of (46) to assess the welfare impact of resource movement. When industry i expands production, primary factors must be shifted into both industry i and the non-traded goods which feed directly and indirectly into it. Assuming fixed proportions everywhere, materials balance will be maintained when both sets of value addeds expand in the same proportions. Thus, when resources are shifted from industry 2 to industry 1, and their associated non-tradeables in such a way that the changed outputs of the non-tradeables just match the changed demands for them, only a fraction \( \lambda_2 \) of the value of them will be withdrawn from direct employment in 2 and a fraction \( \lambda_1 \) will be reemployed directly in 1, with the remaining fractions \( 1-\lambda_1 \) and \( 1-\lambda_2 \) being withdrawn and replaced in intermediate non-traded goods indus-
tries where $\lambda_i = v_i / [v_i + H_i]$, $v_i$ is value added in $i$, and $H_i$ is value added in the non-traded goods which feed directly and indirectly into $i$. Thus using (46), while remembering that in the Balassa approach we have defined the ERP of each non-traded intermediate input to be zero gives an increase in the economy's real income per dollar of resources transferred of
\[
\frac{\lambda_1 \text{ERP}^b_1}{1+\text{ERP}^b_1} + \frac{\lambda_2 \text{ERP}^b_2}{1+\text{ERP}^b_2}
\]
\[
\frac{dy}{dR} = \frac{1 - \sum m_i T_i}{1+\text{ERP}^b_1} (47)
\]
where $\text{ERP}^b$ refers to a Balassa ERP. Thus while the Balassa ERPs are larger in absolute value than the Corden ERPs, to derive expressions for the welfare change associated with resource shift involves using the figures in different ways, and the Balassa ERP is related to the Corden ERP, $\text{ERP}^c$ by
\[
\frac{\lambda \text{ERP}^b}{1+\text{ERP}^b} = \frac{\text{ERP}^c}{1+\text{ERP}^c}. (48)
\]

11. c The 'Crude' Corden Method

Now let us explore the implications of resource shifts when ERPs are calculated using the 'Crude' Corden method. As this subsection is somewhat tedious many readers will wish to skip it for our only conclusion is that by working hard enough we can find an expression for the normative significance of resource shifts using this measure of the ERP. From equation (IV.5) with $v_i = v_i^g$, we have
\[
v_i = [1 + \text{ERP}^{cc}] v_i^* (49)
\]
where the reader will recall from the discussion just following (IV.18) that
we calculate value added in this method by treating non-tradeable inputs into i just like primary factors, and ERPC is the 'Crude' Corden ERP. Define \( T_{ji} \) as the amount of the jth tradeable that feeds both directly and indirectly into producing the non-tradeables used in the production of the ith tradeable. Then define \( \tilde{\tau}_i \) as the average tariff on the \( T_{ji} \)'s which feed into i according to

\[
\Sigma p^T_{ji} = (1 + \tilde{\tau}_i) \Sigma p^{*T}_{ji}.
\] (50)

Now recognize that the change in foreign exchange earned by allocating increased resources to i is given by

\[
dF = v^{*dX} - \Sigma p^{*dT}_{ji}.
\] (51)

where \( X_i \) is the gross output of good i.

Substituting from (49) and (50) into (51) yields

\[
dF = \frac{v dX_i - \Sigma p dT_{ji}}{1 + \text{ERP}^{cc}_i} - \frac{\Sigma p^{*dT}_{ji}}{1 + \tilde{\tau}_i}.
\] (52)

Since labor is paid the value of its net marginal product at domestic prices:

\[
w dL = v dX_i - \Sigma p dT_{ji}.
\] (53)

Let \( \theta_{T_{ji}} \) be the ratio of tradeables used as intermediate inputs in good i to value added by primary factors used both directly and indirectly in the
production of \( i \). Since tradeable inputs are used in fixed proportions to produce output,

\[
\frac{v \frac{dX}{i}}{\sum_j p \frac{dT_i}{j j}} = \frac{v \frac{X}{i}}{\sum_j p \frac{T}{j j}} = \frac{1 + \theta_i}{T_i}.
\]  

(54)

Substituting (54) into (53) yields

\[
\sum_j p \frac{dT_i}{j j} = \theta_i \frac{w}{T_i} dL
\]

(55)

and

\[
\sum_j v \frac{dX_i}{j i} = (1 + \theta_i) \frac{w}{T_i} dL.
\]

(56)

Substituting (55) and (56) into (52) yields

\[
\frac{dF}{dR_i} = \frac{1 + \theta_i}{1 + ER_{i cc}} - \frac{\theta_i}{1 + \tau_i} = \frac{1}{1 + ER_{i cc}} \left( \frac{1 - \theta_i \frac{\tau_i - ER_{i cc}}{T_i}}{1 + \tau_i} \right) - \frac{\theta_i}{1 + ER_{i cc}} \left( \frac{1 - \theta_i \frac{\tau_i - ER_{i cc}}{T_i}}{1 + \tau_i} \right).
\]

(57)

Finally, by analogy with equation (46) and noting that \( \frac{1}{1+x} - \frac{1}{1+y} = \frac{y}{1+y} - \frac{x}{1+x} \) we have: the change in real income that comes from shifting a dollar's worth of resources from the production of good 2 and its associated non-tradeables into good 1 and its associated non-tradeables is given by

\[
\frac{dy}{dR_i} = \frac{\frac{ER_{2 cc}}{1 + ER_{2 cc}} - \frac{ER_{1 cc}}{1 + ER_{1 cc}} + \frac{\theta_i}{T_i} \left( \frac{\tau_i - ER_{1 cc}}{1 + \tau_i} \right) - \frac{\theta_i}{T_i} \left( \frac{\tau_i - ER_{2 cc}}{1 + \tau_i} \right)}{1 - \sum_j m_{ji} \tau_i^*}.
\]

(58)

Thus, the \( cc \) method is also useful.
11.d The Simple Balassa Method

If the simple Balassa method is used the expression for the welfare change associated with a total resource shift of $R_1$ is

$$\frac{dy}{dR_1} = \lambda_2 \text{ERP}^* + \sum_j \lambda_j \text{ERP}^*_j - \lambda_1 \text{ERP}^*_1 - \sum_j \lambda_j \text{ERP}^*_j$$  \hspace{1cm} (59)

where "*"s indicate that ERPs are expressed as fractions of value added at domestic prices. Also, $\lambda_{ji}$ and $\lambda_i$ are the proportions of value added produced in industry $i$ and the nontraded goods which feed into it which are accounted for by value added in the $j$th nontraded good and industry $i$ respectively, so $\lambda_i + \sum_j \lambda_{ji} = 1$. Note that in order to derive these $\lambda_{ji}$'s it is necessary to perform the matrix inversion which we avoided by using the fourth option instead of the Balassa or Corden methods to calculate ERPs in the first place.

All of the four formulae in this subsection yield the same measure of the welfare gain from a resource shift given the same underlying economic situation. It is just that some of them are easier to use than others. It doesn't matter which of the four methods considered one uses, so long as one uses it correctly. More generally, when many different inputs are used in fixed proportions to produce an output, a particular set of input and output taxes will be economically equivalent to any other structure of taxes on inputs and outputs which maintains the same total tax collected per unit of output and the particular equivalence selected is a matter of taste. Still, it seems to me that the fourth option is the natural one to use since it treats traded and non traded sectors symmetrically.
V.12 In what way are non-traded goods a problem and how useful are standard formulae for the effects of tariff structures?

We have shown various ways of dealing with non-traded goods and argued that each is satisfactory, in the sense of being logically consistent. In an important sense, however, none of them are very good. Section 9.a rederived Harry G. Johnson's simple formula for the welfare cost of protection using both nominal and effective tariff rates under the assumption of fixed prices. The reason the formula is so simple is that Johnson assumes each good with a non-zero ERP attached is produced with a sector specific factor in fixed supply in combination with a mobile composite factor whose price is fixed. To maintain this fixity it is necessary to assume that there are at least $N$ tradeables produced using mobile factors and no immobile factors where $N$ is the number of mobile factors in the economy. Then to make the foreign exchange earned determinate, it is necessary to assume that all goods with non-zero ERPs attached are produced with fixed factors in combination with mobile factors.

This is a fairly stringent set of assumptions. But to relax it means that it is necessary to solve the system for the impact that any adjustment in effective or nominal tariffs would have on the prices of mobile factors, hence outputs, consumption levels and welfare as done, for example, by Ray (1971). Moreover, by postulating that all those goods produced with no sector specific factors attached have zero ERPs, Johnson managed to duck the problem of undefined shadow prices discussed by Bertrand (1979) and Bhagwati - Wan (1979).

If one follows Johnson's lead and postulates that there are at least $N$ tradeables produced using mobile factors and all the non-traded goods but no fixed factors, where $N$ is the number of mobile factors plus non-tradeable
goods in the economy, then the prices of all non-traded goods and factors of production will be frozen, and if one further assumes that all of these goods have zero ERPs attached, then one can treat non-traded goods plus the mobile factors used by a sector as a composite factor, since the relative prices of its components are fixed. In this case Johnson's formula would hold using either the Balassa or "sophisticated" Corden methods of treating non-traded goods, but defining e and v appropriately.

Another way to get Johnson's simple formula to apply is to assume that each non-traded good feeds into the production of only one other good. Then even if each non-traded good is produced with both mobile factors and a specific factor, we can integrate each non-traded good with the other good it feeds into and treat the combination as a single good in applying Johnson's formula. However, as soon as a single non-traded good feeds into the production of more than one other good, this simple structure breaks down and one needs a more complex formula than Johnson's. Moreover none of the ways of treating non-traded goods considered in earlier sections obviates the need to solve the system explicitly to learn the welfare impact of tariff changes when non-traded goods are produced with specific plus mobile factors and feed into more than one tradeable. Thus there is no simple solution to the problem of non-traded goods or for that matter to the problem of variable world prices except in special cases.

We should also note that it is easy for the new student of effective protection to take Johnson's formula for the welfare cost of protection or Balassa's (1971, p. 328 equation 26) formula for the impact of a tariff structure on the exchange rate as the last word on the two issues. However, Johnson's formula makes the restrictive assumptions noted above as well as assuming that the compensated cross price elasticity of demand between all
goods with tariffs on them is zero, an assumption that would not be difficult
to lift as he does in the first part of his essay on the scientific tariff
(1971, pp. 198-208). Balassa's formula assumes that all goods are produced
with a fixed factor in combination with a single mobile factor and that the
domestic demand for each good depends on its price relative to the price of
the mobile factor. This too is a rather restrictive pair of assumptions.
There is no reason why one could not derive a whole slew of other quite tract-
able formulae to describe the welfare impacts of tariffs as well as their
impacts on resource allocation under alternative assumptions. Thus the
Johnson and Balassa formulae are nice straightforward passes at the problem
that yield neat tractable results, but when their problems are posed slightly
differently, different formulae will emerge. Therefore, I tend to view these
two formulae as descriptions of special cases which simply illustrate the kind
of calculus that can be fruitfully performed.
Chapter VI

ON THE RELATIONSHIP BETWEEN THE EFFECTIVE RATE OF PROTECTION AND DOMESTIC RESOURCE COST*

VI.1. INTRODUCTION

The previous chapter used ERPs to calculate the welfare significance of a resource flow from one sector to another. But as our treatment of non-traded goods emphasized, any real world project involves a whole matrix of resource flows between many sectors. In this chapter we show how the problem of myriad resource flows leads naturally to using ERPs to calculate shadow prices and hence using these shadow prices to calculate DRCs in order to evaluate projects. Thus we see here by example how ERPs are the building blocks of other important calculations.

Srinivasan and Bhagwati (1978, p. 107) conclude that in the presence of distortions, the effective rate of protection is inappropriate to the task of project selection and that the correct criterion is domestic resource cost. Bhagwati and Srinivasan (1980) explore the problem further and come up with two special cases in which the use of ERPs will yield the correct decision that appropriately defined DRCs inevitably yield. They conclude that in the absence of non-traded goods and in the presence of fixed world prices and constant returns to scale, a project will be beneficial if and only if there exists a critical ERP level, ERP_C, such that in response to implementation of the project no good with a higher ERP experiences an expansion in its

*This section is co-authored with Barbara L. Rollinson.
production, and no good with a lower ERP experiences a contraction. In this chapter, we argue that either the DRC or the ERP is an appropriate tool for project selection, and we generalize the Bhagwati-Srinivasan (1980) argument to cover cases where no critical ERP separates the expanding and contracting industries.

The only difficulty is that if one uses effective protection, one must know and use data on the ERPs for each of the sectors whose production is affected by the expansion of the sector in question (call it the zeroth) as well as the extent of resource movements in and out of these sectors. However, if one chooses instead to use the DRC route, all of the relevant information about ERPs in sectors other than the zeroth, and resource flows elsewhere in the economy per unit of resources attracted into the zeroth sector will be subsumed in the shadow prices for the resources. Thus, in calculating the DRCs for the zeroth sector, it is not necessary to look at resource flows and ERPs elsewhere in the economy. Clearly, if many projects are to be evaluated it is computationally more efficient to calculate shadow prices for domestic resources, and use these to calculate DRCs, than to calculate a batch of differentially weighted ERPs for each sector. But logically, the two approaches are equivalent.

VI.2. ASSUMPTIONS AND DEFINITIONS

We follow Srinivasan and Bhagwati (1978), henceforth SB, in assuming all goods are traded, which rules out any quantitative restrictions on trade; we let output be a constant returns to scale (CRS), fixed proportions function of intermediate inputs and a value added aggregate, where this aggregate is itself a CRS (but not necessarily fixed proportions) function of capital and
labor. Also, we assume world prices are fixed and the only distortions we permit are those assumed by SB: import tariffs, export subsidies, sticky factor prices and factor price differentials, which may reflect themselves in Harris-Todaro type unemployment. Finally, like SB, we assume competition except for these factor price differentials and sticky factor prices.

We follow SB in defining $DRC_0$ as the opportunity cost of earning net foreign exchange via increased production in sector 0 and we write it as

$$DRC_0 = \frac{k_o r_s^o + \ell_o w_s^o}{p_0 - \sum_{i} p_i a_{i0}}$$

where

- $p_i^*$ is the world price of commodity $i$
- $a_{i0}$ is the physical input/output coefficient showing the amount of good $i$ used to produce a unit of good "0", using home technology,
- $k_o$ and $\ell_o$ are the physical input/output coefficients in sector 0 for the primary factors, capital and labor. Thus, they are the amounts of capital and labor used to produce an additional unit of good "0".
- $r_s^o$ and $w_s^o$ are the Little-Mirrlees shadow prices of capital and labor respectively, where by Little-Mirrlees shadow price of a good or factor, we mean the amount of foreign exchange which could be withdrawn from the economy in response to a unit increase in the economy's endowment of a good or factor and still leave domestic utility unchanged, given all of the incentives like taxes and tariffs in place. Defining everything in units of foreign exchange means that the project will be found to be desirable if and only if the DRC is less than unity.

The effective rate of protection for sector $i$ is defined as
where

\[ V_i = [1 + ERP_i]v^*_i \]  

(2)

\[ v_i \] and \( v^*_i \) are unit domestic value added in sector \( i \) at domestic and international prices respectively.

By definition,

\[ v^*_i = p^*_o - \sum \ p^*_i a_{i0} \]  

(3)

and

\[ v_o = k_o r_o + \omega_o w_o. \]  

(4)

where \( r_o \) and \( \omega_o \) are the wage and rental rates actually paid in sector "0".

VI.3. MODELING

Combining equations (1) - (3) yields

\[ DRC_o = [1 + ERP_o] [k_o r^o + \omega_o w^o] / v_o. \]  

(5)

The shadow wage rate is defined as the increase in domestic value added at world prices that results from a unit increase in the economy's endowment of labor\(^1\) or looking at it differently, it is the amount of foreign exchange which could be withdrawn from the economy in response to a unit increase in

\(^1\)Since relative prices to consumers are fixed and inferior goods are assumed away, utility is solely a function of domestic value added at world prices. Therefore it makes sense to use this Little-Mirrlees definition of shadow prices.
the economy's endowment of labor, and still leave domestic utility unchanged. Thus,

\[ w^s = \sum_{i=1}^{N} v_i^* \left[ \frac{\partial X_i}{\partial L_i} \frac{dL_i}{L_i} + \frac{\partial X_i}{\partial K_i} \frac{dK_i}{L_i} \right] \]  

(6)

where 

\( \Delta L \) is a "small" increase in the economy's endowment of labor, 
\( X_i \) is output of good \( i \),
\( \frac{\partial X_i}{\partial L_i} \) and \( \frac{\partial X_i}{\partial K_i} \) are the marginal products of labor and capital respectively in sector \( i \), allowing intermediate inputs to vary, 
\( dL_i/L \) and \( dK_i/L \) are respectively the increases in labor and capital allocated to sector \( i \) per unit increase in the economy's endowment of labor.

We sum from \( i \) to \( N \) because there are \( N \) goods initially produced and we assume that good "0" is not profitable at market prices, hence it is not produced in small perturbations about the initial equilibrium without government intervention. Since factors are paid the value of their net marginal products

\[ w_i = v_i \left( \frac{\partial X_i}{\partial L_i} \right) \]  

(7)

and

\[ r_i = v_i \left( \frac{\partial X_i}{\partial K_i} \right) \]  

(8)

Combining (2), (6), (7) and (8) yields

\[ w^s = \sum_{i} \frac{\Delta R_i/L}{1 + ERP_i} \]  

(9)

where \( \Delta R_i/L = \sum_{i} w_i \Delta L_i/L + r_i \Delta K_i/L \) and \( \Delta R_i/L \) is defined as the value in units of domestic currency of resources attracted to industry \( i \), when these
resources are evaluated at the wages and rentals paid in sector $i$, per unit of increased labor endowment. Equation (9) makes intuitive sense when we realize that efficiency occurs when the value of output at world prices is maximized and $1 + \text{ERP}_i$ is the proportion by which resources in sector $i$ are overvalued in the domestic market place, for it is the proportion by which the marginal net product of primary factors in sector $i$ at domestic prices exceeds the marginal net product at world prices.

By analogy, we have for capital

$$
\frac{dR}{K} = \sum_{i=1}^{N} \left. \frac{dR}{K} \right|_{i} \left( 1 + \text{ERP}_i \right) \tag{10}
$$

where $\frac{dR}{K} = \sum_{i=1}^{N} \frac{dL}{K} + \frac{r}{K}$.

VI.4. MAJOR CONCLUSIONS

Substituting (9) and (10) into (5) yields

$$
\text{DRC} = \left[ 1 + \text{ERP}_o \right] \sum_{i=1}^{N} \lambda_i \left( 1 + \text{ERP}_i \right) \tag{11}
$$

$$
= k_o \left[ \frac{dR}{K} \right]_i + \lambda_i \left[ \frac{dR}{L} \right]_o \tag{11}
$$

where $\lambda_i = \frac{\sum_{i=1}^{N} \lambda_i}{\sum_{i=1}^{N} 1 + \text{ERP}_i}$. Thus $\lambda_i$ is the value of resources drained from sector $i$ per unit value of resources attracted to sector $0$.

Equation (11) is the relationship between domestic resource cost and the effective rate of protection, and as such it indicates the appropriate use of the effective rate of protection concept in project evaluation. Moreover, it helps clarify the meaning of the DRC, as the examination of some special cases indicates.
If all ERPs are the same, $DRC = \sum_{i=1}^{N} \lambda_i$. If there are no factor market distortions, $\sum_{i=1}^{N} \lambda_i = 1$, because each dollar's worth of resources transferred into one sector is drawn from some other sector. This means that $DRC_0 = 1$, and the project is on the borderline of acceptability.

If wages are higher in the project than elsewhere in the economy, but no Harris-Todaro unemployment is generated, the value of resources expelled from other sectors will be less than that of those attracted to "0", $\sum_{i=1}^{N} \lambda_i < 1$ and if all ERPs are equal the project should be accepted. However, if the project creates a great deal of Harris-Todaro unemployment $\sum_{i=1}^{N} \lambda_i > 1$ and the project should be rejected. Similarly, high taxes on value added in certain sectors which supply resources combined with after-tax equality of wages and rentals will lead to $\sum_{i=1}^{N} \lambda_i > 0$ and hence project rejection.

Also, if there are no factor market distortions, so $\sum_{i=1}^{N} \lambda_i = 1$, the project should be accepted if and only if its effective rate of protection is small relative to the effective protection of the sectors which supply resources to it, and in the special case of only one supplying sector, the project should be accepted if its ERP is less than that of the supplying sector.

VI.5. THE CASE OF ONLY ONE MOBILE FACTOR OF PRODUCTION

There is one special case in which there will be a perfect correlation between the DRCs and ERPs attached to proposed new activities. That is when there is only one mobile factor. Here, the DRC of the 0th project is still given by (11) but the $\lambda_i$s in (11) will be the same regardless of what new

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2 This section follows from a discussion with Neil Roger.
sector the labor is being drawn to.

VI.6. MORE THAN TWO FACTORS OF PRODUCTION, TWO GOODS AND ONE TIME PERIOD

We have chosen to follow SB in postulating two mobile factors of production but have departed from them in assuming many traded sectors instead of just two. The reason they assumed just two sectors is so that with constant returns to scale and only two factors of production which are mobile the pattern of production would be determinate with no further constraints on the system (see Bertrand (1979) and Bhagwati and Wan (1979)). Implicitly, we are pretending that the government's incentives (perhaps progressive value added taxes on a sector by sector basis) or else the presence of immobile factors are sufficient to maintain the determinacy of resource allocation.

Our equation (11) relating the DRC to ERPs would be valid regardless of the number of primary factors postulated. The only problem is that the more factors and goods there are, the larger the matrix that one must invert in order to obtain shadow prices.

We have also postulated a timeless model, but there is no reason we could not have considered a project which used factors in different time periods to produce goods in still other time periods. In that case, the DRC is calculated as before while it is recognized that discounting must be used to relate shadow prices in one period to shadow prices in other periods.

VI.7. NON-TRADED GOODS

If there are fewer factors of production than traded goods, constant
returns to scale, and all factors of production are used in producing the traded goods, the fixed world prices for traded goods will freeze the domestic factor prices, which in turn will freeze the prices of non-traded goods. In this circumstance, introducing non-traded goods doesn't change our analysis at all. One could simply work with integrated industries in the 'sophisticated' Corden fashion. Alternatively, one could work with the disaggregated industries, but define the DRC in one of two different ways.

The first alternative would be to leave the numerator as before, defined as the amounts of primary factors evaluated at shadow prices which would be used, while the denominator would be the increase in output minus the increases in use, of the intermediate inputs used by the project, all evaluated by their shadow prices. More generally, if this were a project which used inputs to produce various outputs jointly, the denominator would simply be the sum of the increases of net outputs of these various inputs and outputs, each evaluated at its shadow price. The third alternative would be to treat the non-traded goods just like the primary factors of production, and place them in the numerator instead of the denominator.

Regardless of which of these three methods one used, assuming the denominator is positive, there is a positive net social benefit associated with the project if and only if the DRC is less than one. This is because the numerator is the social cost associated with using up those goods and/or factors which enter the numerator while the denominator is the social benefit from producing the net changes in quantities of those things which enter the denominator. Of course, shadow prices and effective protection may be negative, and to reckon with that case, it is necessary to modify our project selection criterion to be: select the project if and only if $D - N > 0$ where $D$ is the denominator and $N$ is the numerator of the DRC ratio. When $D > 0$ this
boils down to the familiar $DRC = \frac{N}{D} < 1$, but when $D < 0$ it becomes $DRC = \frac{N}{D} > 1$.\textsuperscript{3}

Once we relax the assumption that the prices of non-traded goods are fixed our earlier conclusions that the DRC is a weighted sum of ERPs breaks down, because withdrawing goods and factors will cause the relative prices faced by consumers to alter. In other words it will alter the consumption distortion, and this must be reckoned with in calculating shadow prices. However, even in this circumstance we can still use the DRC ratio to assess whether or not activities which produce and/or use up non-traded goods should be encouraged at the margin. It is only necessary that we evaluate all factors and goods used or produced at their shadow prices, which will be somewhat harder to calculate, and for the purpose we would need section V.2's equation (20) which involves the flow of consumption across final demand distortions as well as primary factors across production distortions.

### VI.8. THE ACTIVITY COST-BENEFIT RATIO

This discussion boils down to the fact that the DRC has in the numerator the social value of resources used up in order to perform an activity and in the denominator the social value of net outputs performed by the activity. Thus a better name for it would be the activity cost benefit ratio. The only reason that DRC has come to be used as the term to describe the idea, is that if all goods are traded at fixed prices their shadow prices are world prices, so it becomes natural to identify the social value of the activity as the foreign exchange which it earns. Similarly, in early work on the shadow

\textsuperscript{3}This discussion was drawn from Pursell and Papageorgiou (1980).
pricing of non-traded goods and factors of production it was thought that a reasonable shadow price for them was their domestic market price. Hence a reasonable measure of the social cost of carrying out the activity was the domestic currency value of the resources used in undertaking it. Thus it was only natural to define a cost benefit ratio for a particular activity as the value of domestic resources used to produce a unit of foreign exchange.

VI.9. HOW TO USE THE DRC

It is not possible to use the DRC for ranking industries from most desirable to least desirable, because it is arbitrary how one defines an activity. Suppose that making steel requires mining coal domestically. One could either calculate the DRC for steel or the DRC for the steel and associated coal mining combined. The former DRC would be calculated using a shadow price for coal which reflects its actual source of supply. Thus if marginal expansion of the steel industry is a good thing the shadow price of steel to users will be low and the DRC whether narrowly or broadly defined will be less than one, but since the broadness or narrowness of an activity is a matter of definition, industries can not be ranked from most productive to least productive using DRCs.

There is a second reason why such a ranking would not be productive. As resources are coaxed into one sector out of others through changes in incentives or government activities, the shadow prices of those goods and factors which are not frozen by fixed world prices will alter, so that to evaluate the costs and benefits of further adjustments, further DRC calculations would be needed. Thus, to conclude, except under extraordinary circumstances DRC is a cost benefit ratio only for marginal changes, and all
we can say with precision is that a small expansion (contraction) of any industry with a DRC which is less than (exceeds) unity is a good thing.

VI.10. THE DRC AND THE ADJUSTMENT MECHANISM ASSUMED

Srinivasan and Bhagwati (1978, p. 251) note that assuming the equilibrium is unique, for existing activities, the DRCs must necessarily be unity. As Bertrand (1979) notes, this is because if the government uses exactly the same technology as the private sector a project consisting of expanding the output of good i in a government firm, will have the effect of drawing all of its resources from the private sector's production of good i, and leave the economy's product mix the same as before. In terms of our mathematics, if sector "1" were already producing, and we calculated DRC$_1$, we would recognize that $\lambda_1 = 1$ with all other $\lambda$s equal to zero, which clearly would give us DRC$_1 = 1$.

This is not surprising for as SB note, Diamond and Mirrlees (1976) have shown: for a product which is produced with constant returns to scale and under competitive conditions, if the government takes over some of the private sector's production by withdrawing inputs and producing output in the same proportions that the private sector had been previously using no levels of outputs or inputs or prices will alter. This will leave welfare unchanged which means that the shadow price of the output must equal the value of the inputs at shadow prices. Another way of saying this is that the shadow value of the resources needed to perform the activity will be equal to the shadow value of the activity's net output, which implies that the DRC is unity.

While the logic behind this point is incontrovertable, this result is certainly at variance with the DRC calculations as typically applied. For example, Krueger (1966) finds that DRCs for activities performed by the
private sector in Turkey varied between 1.07 and 1.60. Suppose we view the adjustment mechanism that is causing the increased output to be an increase in the value added subsidy in that sector. Then the appropriate measure of net benefit would be the shadow price of that subsidy multiplied by the proposed change in the subsidy.

An alternative method, which will yield the same result is to calculate the shadow prices of goods and factors holding the output level and input levels in the industry constant. Then one could calculate the changes in inputs and outputs in the industry in question which would follow from the subsidy change. The resulting change in welfare would then be given by the sum of the changes in net outputs multiplied by these shadow prices. Moreover, one could then define the DRC as the sum of the shadow-price weighted changes in factor inputs divided by the sum of the shadow-price weighted changes in net outputs of goods from the industry in question. Such an approach I believe is what Bruno (1972), Krueger (1966; 1972) and Balassa-Schydlowsky (1968; 1972) had in mind in their discussions of DRCs.

VI.11. IS THE DRC THE BEST COST-BENEFIT RATIO?

We have already seen that the DRC is a cost benefit ratio. Thus we can use the DRC to estimate the welfare cost (in units of foreign exchange) of keeping a sector alive by taking the value at shadow prices of the primary factors devoted to it and multiply by one minus the reciprocal of its DRC. Still, this is only an approximation, because (as noted in section 9) in most cases shadow prices of goods and factors will change as industries expand or contract.

Another use of DRCs, as Kemal Dervis has pointed out to me, is that they
indicate the percent by which efficiency in the use of primary factors would have to grow in order to make the industry viable as an efficient use of society's resources. Suppose we believed that by subsidizing an infant industry we could eventually turn it into a viable producer. If its DRC were initially $1 + \alpha$, to reduce the DRC to unity we would need to reduce our use of primary factors by a factor: $\frac{\alpha}{1 + \alpha}$. Thus unless it were thought that this degree of inefficiency is baby fat that an industry would automatically shed as it grows to maturity, subsidizing it would necessarily be unwise.

However, the kind of ratio that is most likely to interest a policy maker is the economic cost at the margin of doing something the policy maker wishes to accomplish but to which he has trouble attaching a specific economic value, such as increasing employment or redistributing income or fostering economic activity in a particular region. This argues for calculating the economic costs of achieving a unit of non-economic benefits through the expansion of

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4A propos 'non-economic' arguments, Corden (1974, p. 155) writes "Actually the techniques of economics can be used to analyze, or at least define more precisely, all arguments and the use of the term 'non-economic' sometimes means no more than economists have not got around to analyzing an argument properly, rather as miracles are phenomena that scientists have not yet caught up with." In other words one should be able to take account of all 'non-economic' benefits by appropriately defined shadow prices. The only problem is that different observers are likely to attach different values to the same 'non-economic' result.
particular industries or through the use of particular economic instruments, along the lines of the kind of linear models proposed in chapter II. Thus the DRC is only one of many cost benefit ratios that policy makers might with to use.

In fact, there are two other DRC-type measures that may prove to be useful options. The value of primary factors used evaluated at market prices and divided by value added at shadow prices gives the value of domestic resources needed to produce a unit of foreign currency. If all goods in the calculation are traded at fixed world prices, this is simply the effective rate of protection coefficient. Another measure is a net DRC which would be the value of primary factors which must be transferred to a sector to earn a unit of foreign currency net. This would be calculated as N/D with N being the market value of resources needed to produce a unit of output and D being unit value added at shadow prices minus the shadow price of the primary factors used to produce a unit of output. The reason that D measures net foreign exchange earnings is that the shadow price of the primary factors indicates the opportunity cost of the primary factors in their previous uses.
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Phase III: World Product and Income: International Comparisons of Real GDP
Irving B. Kravis, Alan Heston, and Robert Summers
This report restates and extends the methodology set out in the first two volumes. Particular attention is given to the problem of comparing services and to the conflicting demands of regional and global estimates. Comparisons are given of prices, real per capita quantities, and final expenditure components of GDP for thirty-four countries for 1975. By relating the results to certain available national income accounting data and related variables, the authors develop extrapolating equations to estimate per capita GDP for the thirty-four countries for 1950 to 1978. In addition, the 1975 distribution of world product by region and per capita income class is estimated. The 1975 results confirm relations between both quantities and prices and per capita income found in the earlier volumes.


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Macroeconomic and Distributional Implications of Sectoral Policy Interventions: The Case of Energy and Rice in Thailand
P. Armaranand and W. Grais
Presents an economywide framework for policy analysis in Thailand. This framework—the SIAM2 model—is used here to analyze two sets of policies. Focuses on energy pricing and rice pricing. Shows the value of this analytical framework for policy analysis that focuses on structural adjustment in production and trade patterns.

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Innovative model of short-run behavior that combined production and consumption decisions in a theoretically consistent fashion for an agricultural household.


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Yuji Kubo, Jeffrey D. Lewis, Jaime de Meio and Sherman Robinson
An exploration of the use of multisector models as tools for analyzing the relation between alternative development strategies, growth and structural change in a developing country. Dynamic input-output and CGE models are applied to the 1963-73 period in Korea and used as simulation laboratories for analysis.


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Describes existing inequality in incomes in developing countries and proposes a reorientation of development policy to achieve more equitable distribution.

Oxford University Press, 1974; 4th printing, 1981. 324 pages (including annex, bibliography).


A Relationship between the Rate of Economic Growth and the Rate, Allocation, and Efficiency of Investment
Dennis Anderson
Discusses how the methods and results of microeconomics affects the analysis of growth in the relationship described in the title. Drawing on Solow's vintage model of growth, this paper derives an aggregate form of the relationship and compares the approach with those of several long-standing studies of the subject.


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Probes the comparative trade advantage of the Federal Republic of Germany in the 1980s with surprising conclusions: developing countries are competitive with the Federal Republic of Germany in a far wider range of products than has been previously thought. Suggests probable trends, especially toward developed countries. Concludes that the faster income in developing countries grows, the faster these countries will become competitive in an even wider range of goods. Innovation, though a key factor, cannot determine comparative advantage, because innovations spread rapidly through the world economy.
The Structure of Protection in Trade and Employment
Bela Balassa and others
The Johns Hopkins University Press, 1971, 394 pages (including 5 appendixes, index).

Testing for Direction of Exports: India's Exports of Manufactures in the 1970s
Ashok Khanna
Tests the hypothesis that the exports of a developing country with an advanced manufacturing sector will differ among destinations: the capital intensity of exports will be greater to the more labor abundant destinations, and the labor intensity of export will be greater to the more capital abundant destinations. India's exports of manufactures for 1973 and 1978 are used for the analysis.

Trade and Employment Policies for Industrial Development
Keith Marsden
In the last decade, the developing countries have proved that they can compete internationally in exporting manufactured goods, as well as primary products and services. This paper examines three sets of issues: (a) whether good export performance is attributable to special characteristics of the most successful countries or whether their success can be readily replicated in other countries; (b) whether the penetration of the markets of industrial countries has reached, or will soon reach, a limit; and (c) whether trade in manufactures among the developing countries can expand further. Concludes with a discussion of the contribution of small enterprises to the creation of employment and the alleviation of poverty.
1982. 70 pages (including annex).

Why the Emperor's New Clothes Are Not Made in Colombia: A Case Study in Latin American and East Asian Manufactured Exports
David Morawetz
Focuses on the exports of a particular commodity (clothing) from a particular Latin American country (Colombia) in an attempt to understand why Latin America has been so much less successful at exporting manufactured goods to date than East Asia. It is the first study to go into great detail in examining the price, and especially the nonprice, determinants of export success.
Oxford University Press, 1981. 208 pages (including appendixes, bibliography).

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