D.PHIL THESIS

THE CONSEQUENCES OF INTERNATIONAL TRADE PRICE VOLATILITY FOR NATIONAL INCOME AND WELFARE: THEORY AND EVIDENCE

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ABSTRACT

The thesis considers the effect of world trade or commodity price volatility on small open economies. It extends the existing literature by including non-tradeable goods and many volatile prices in the model together with consideration of the welfare effects of participation in international risk or capital markets. In addition the thesis systematically addresses the implications of price volatility for resource allocation and presents empirical estimates of the costs and benefits of volatility for a large sample of countries.

The most important theme in the analysis is the extent of output flexibility in the face of variable prices. It is shown that price volatility gives rise to high returns to flexibility which suggests that commodity exporting countries should regard price volatility as an opportunity to benefit by being flexible as well as a source of welfare costs.

The empirical estimates show that many developing countries have had an inflexible response to changes in world prices over the period 1958-90. Flexibility may improve with the abolition of producer price stabilisation in many countries in the 1980s, a policy reform that is predicted to yield large benefits. These will increase if attempts are also made to improve the functioning of domestic risk and capital markets together with enhanced access to their international equivalents.

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NOTATION

x	Output of the tradeable good(s) with a volatile price
y	Output of other tradeable goods
n	Output of non-tradeable goods
P	Price of x
P_y	Price of y; y is used as the numeraire so P_y is normalised to unity
P_n	Price of n
i	Sector (i=x,y,n)
c_i	Consumption of good i
X_i	Exports of good i
α_i	Share of the value of output of good i in national income
$ß_i$	Share of the value of consumption of good i in national income
γ_i	Share of the value of exports of good i in national income
m	National income
$Var(P)$	Variance of P
ϵ^i_j	Elasticity of j with respect to i
w_i	Wage rate in sector i
r_i	Rate of return to capital in sector i
π_i	Profits in sector i
T	Barter terms of trade
$z_c(P)$	z as a function of P with the economic structure the same as in the counterfactual economy in which P is stable
$z_v(P)$	z as a function of P in an economy subject to volatility and allowing the economic structure to have adapted to volatility
Ln z	Natural log of z
E[.]	Expectations operator

CHAPTER 1

INTRODUCTION, LITERATURE SURVEY & METHODOLOGY

Fluctuations in international trade prices have been the focus of continued interest from both academic economists and policy makers for many years. After the second world war, Keynes put forward proposals for a "Commod Control" organisation, responsible for stabilising commodity prices, as part of the Bretton Woods system. More recently the issue of commodity price stabilisation was a central part of the calls for a New International Economic Order in the 1970s. While these proposals have not come to much, fluctuations in commodity prices remain a serious problem for many economies, particularly those less developed countries with undiversified export structures and, within the developed world, Australia, New Zealand and the Scandinavian countries.

Commodity prices have also attracted attention in two other respects; the first is the question of whether they are in long term decline relative to the price of manufactures as predicted by the Prebisch-Singer Hypothesis, the second is the effect of one-off relative price changes which is considered by the Dutch Disease literature and extended by Bevan et.al. (1990) who include non-tradeable capital goods in the analysis.

While both of these strands in the literature consider

important issues, what is largely missing is work on ongoing fluctuations in relative prices rather than their long run trend or the effects of single shocks. Hence the analysis takes an agnostic view of the Prebisch-Singer Hypothesis, the theoretical chapters assuming a stationary distribution for relative prices and the empirical work taking the long run trends as given with the emphasis solely on price fluctuations around those trends. Single shocks are to an extent implicitly covered by the study of volatility, in that the latter may be thought of as a sequence of shocks, but the two approaches may differ substantially in that agents may perceive a single shock as permanent rather than part of a stationary sequence of temporary shocks.

A third major question in the literature is the extent to which price volatility may affect investment and growth. This has been addressed empirically, with little consensus emerging so far even as to the sign of these relationships, but without much underlying theory. A complete account of the effects of price volatility would require the development of this theory but a prior issue is the impact of volatility in models without investment or growth and hence with stationary output to match the assumption of a stationary price distribution. This defines the scope of the thesis which analyses the effect of stationary price fluctuations in mainstream international trade models which adopt the standard assumption of constant factor supplies and constant technical knowledge. The extension of this work to consider investment and growth is

left for future research. This means that the results may be interpreted either as identifying important factors that determine outcomes under volatility, but without considering all possibilities, or as a complete treatment in the event that price volatility has no effect on the long run capital stock and rate of growth.

This chapter covers all the necessary preliminary material before the analysis proper begins in Chapter 2. The following section gives a full introduction to the work as a whole, describing the motivation for the way the analysis proceeds and highlighting the major themes that emerge. Section 1.2 surveys the relevant literature, of which there is comparatively little concerned with the set of questions considered in contrast to the other areas of research mentioned above. Section 1.3 considers the appropriate choice of counterfactual to use when comparing outcomes under volatility with price stability. It is argued that since price volatility is likely to continue, the choice of counterfactual is to some extent hypothetical but it is useful as an anchor to the analysis. Section 1.4 presents and extends the methodology used in assessing the impact of risk, clarifying the procedures adopted in the subsequent chapters and the appropriate interpretation of the results that are derived. Section 1.5 concludes the chapter with a brief outline of the trade models used later, explaining why they were chosen and defining their important characteristics, particularly in relation to the degree of factor mobility

assumed by each model. This is a prime determinant of the flexibility of output which is a major theme in the analysis that follows.

1.1 GENERAL INTRODUCTION

This section outlines the modelling and empirical approach taken within the overall scope defined above. We consider in turn the variables of interest, the appropriate level of aggregation, the ways in which we should allow an economy to adapt to the presence of volatility, and the models to be used.

The primary goal of much economic analysis is the consideration of welfare, for which we make use of standard expected utility theory, and hence this variable takes centre stage in what follows. In addition an important intermediate variable is income, or in this context expected income, which is of interest in itself as well as being a significant determinant of welfare. In addition if we model agents as having access to risk markets, expected income becomes the central determinant of welfare. Hence we initially analyse expected income before broadening the scope to expected utility.

A second modelling choice is the level of aggregation to be adopted. There are two questions here. The first is whether we are interested only in aggregate welfare and income at the country level, in which case the expected utility of the representative agent and national income become the key variables, or would prefer to take a more microeconomic approach that considers the welfare and expected income of individual factors or sectors. The second issue is whether it

is in any case necessary to take a microeconomic approach in order to determine the aggregate outcome. It is argued that the latter depends sensitively on whether we allow the economy to adjust to the existence of price volatility compared with price stability. With no adjustment of any kind it is possible to analyse the aggregate outcomes directly but if the economy does adjust this is no longer the case. It is argued that adjustment is likely and hence the first question becomes largely redundant and we model both factor/sector and aggregate outcomes.

We allow the economy to adjust to volatility in two ways. The first is that the allocation of any fixed factors between sectors may adjust over time compared with the counterfactual case if, for example, expected income or the exposure to risk differ across sectors. The second is to allow agents access to risk or capital markets. These two responses to volatility are closely related since if agents do not have access to insurance the equilibrium condition for fixed factor allocation would be equal expected utility for the owners of the factor across sectors. Alternatively if agents can fully insure at fair odds the equilibrium condition becomes equal expected income. A further possible change in an economy subject to ongoing price volatility would be for firms to choose different production techniques but we do not pursue this further and adopt the standard assumption that technology and tastes are both fixed and exogenous.

These possibilities give rise to the chapter structure that follows. We examine first the case where the economy does not adjust to the presence of price volatility so that the allocation of fixed factors is the same as in the counterfactual case with which comparisons are made. In addition we initially assume that there are no risk or capital markets of any kind. These assumptions are the basis for Chapter 2, which analyses aggregate outcomes and demonstrates that if there is some flexibility in production in response to changing relative prices, expected income may rise with volatility. The chapter also incorporates this positive effect in a broader assessment of the effects of volatility on expected welfare which includes the more intuitive negative effects of varying income with risk aversion. The net outcome is ambiguous which runs counter to the view often put forward that price volatility must be harmful. The empirical work of Chapter 6 estimates the actual net effect for a large number of countries.

Since it will in general be in the interests of agents to seek insurance if possible, and perhaps adjust the allocation of fixed factors also, the results of this chapter must be regarded as partial while providing a useful base for the later material.

Chapter 3 considers insurance behaviour and its effect on welfare under the assumption that perfect international risk or capital markets are available. These allow agents to fully

insure at fair odds and hence remove the negative effects of income fluctuations while potentially retaining the benefits of flexibility in the face of changing prices.

Output flexibility is a consistently important variable in the theoretical results derived and Chapter 4 analyses the determinants of the responsiveness of output to price changes. Section 4.1 analyses flexibility in terms of the production technology combined with the extent of factor mobility. Given that welfare under volatility is increasing in the degree of flexibility, which in turn depends on factor mobility, it is natural to ask whether the returns from factor mobility accrue to the factors involved. This question is addressed in Section 4.2 where it is found that a given factor, taken as a whole, may not receive the returns from its own mobility but there is nevertheless no difference between the private and social returns from the mobility of an individual worker or unit of capital.

Chapter 5 examines the allocation of fixed factors under different assumptions about the availability of risk markets. Section 5.1 assumes that there is access to perfect international markets, Section 5.2 considers the case of no risk markets of any kind, and Section 5.3 introduces a purely domestic risk market. The distinction between international and domestic risk markets is important because international trade price volatility gives rise to systemic risk for an exporting country so a domestic insurance market cannot lead

to full insurance for all agents. In each case we address in turn the allocation of fixed factors that is socially desirable followed by the allocation that is privately optimal for factor owners given the available set of risk markets.

With no risk markets of any kind it is shown that the socially and privately optimal fixed factor allocation will differ except in a special (and unlikely) case which has a straightforward intuitive interpretation. From an aggregate point of view the allocation of fixed factors involves a tradeoff between reducing the economy's exposure to risk, by reducing the allocation to sectors with volatile prices, and incurring a loss of expected income as a result of distorting the allocation away from that in the counterfactual case. In a decentralised economy private agents will also consider expected income and their exposure to risk but there is no reason why the tradeoff that they face should be the same as that for the representative agent because private agents will not internalise the effect of their allocation decision on the transmission of risk to the rest of the economy. Section 5.3 shows that a domestic risk market establishes a market price for risk so that the market failure possible in fixed factor allocation disappears. This is because the standard marginal conditions are satisfied once there is a price for risk and hence constrained optimality is achieved in factor allocation. As above it may be noted that a purely domestic insurance market can only give rise to constrained optimality in welfare terms, with less than full insurance due to systemic country

risk, since the gains from trade realisable from access to perfect international risk markets are not permitted.

The material in Chapters 2-5 is developed from standard international trade theory with, where appropriate, three divergent assumptions about the underlying mobility of the factors of production. We use the terminology ex ante to describe choices that have to be made prior to the realisation of relative prices, such as the allocation of fixed factors and completion of insurance contracts, and ex post to indicate that choices may be made in response to the particular value of prices prevailing at the time. Hence fixed factors must be allocated ex ante whereas mobile factors may be allocated ex post and thus move between sectors as relative prices change. The three alternative assumptions made about factor mobility are i) that both capital and labour are fixed ex post, ii) that one of them is mobile ex post (the Ricardo-Viner model), and iii) that both are mobile at all times (The Heckscher-Ohlin model) in which case the issue of fixed factors does not arise. We may think of these models as being on a factor mobility spectrum and hence while dealing with three cases leads to a multiplicity of results we may expect consistent themes to emerge.

A further modelling choice is the number of goods to consider together with the presence or otherwise of non-tradeables. Since the goal is a comprehensive analysis we allow for any number of tradeables with volatile prices and also model the

effects of including non-tradeables. In order to build intuition each section considers in turn the cases with a) two tradeables only, with one volatile relative price, b) many tradeables with volatile prices but no non-tradeables, c) one volatile tradeable price plus non-tradeables, and d) the general case of many tradeables with volatile prices plus non-tradeables.

Chapter 6 presents empirical estimates of the costs and benefits from volatility derived in the previous chapters. The chapter starts by discussing the empirical methodology required to estimate the actual values of the theoretical results for a large sample of countries and presents the outcome of these estimations for each country. A major methodological issue arises from the problem of detrending actual price and quantity series, the time series properties of which are hard to ascertain given the available data. Detrending is necessary so that the empirical work is consistent with the scope of the theory developed which is based on stationary relative prices and constant factor supplies.

The theory work identifies the flexibility of output as an important parameter in determining outcomes under volatility. The empirical results show that the relevant aggregate supply elasticities are small in contrast to many other studies that have found considerable flexibility at the micro level. The possible reasons for this are discussed in terms of why micro level flexibility may not lead to aggregate flexibility. It

is argued that producer price controls and export taxes, for example, may lead to a major missed opportunity for economies faced with trade price volatility. This is because producers are likely to respond flexibly to net producer prices but if the latter do not correlate closely with international prices the aggregate supply response to the international price will be weak.

1.2 LITERATURE SURVEY

A number of papers consider the effect of uncertainty in the price of tradeables in the setting described above. The literature focuses almost entirely on the impact of terms of trade volatility on welfare in two good models, thus not distinguishing between the tradeable goods with stable or volatile prices and also not considering the consequences of non-tradeables being present. In addition none of the papers consider the response of expected national income to price volatility, though this is implicit in the analysis of welfare, nor explore the effects of the possible adjustment to the presence of volatility discussed above. This perspective implies that the results that follow cover situations that are essentially special cases, as well as motivating the subsequent theory work aimed at deriving more general results.

The earliest papers concerned with price volatility suggested that welfare benefits were likely. Waugh (1944) for example found that where market instability arises from the supply side, consumers will benefit from the resulting price volatility if their preferences are flexible so that they consume more of the good when its price is low and less when its price is high. Similarly, Oi (1961) showed that where price instability arises from consumers' tastes being variable, producers will benefit if they are able to vary their output levels so as to produce more when the price is high and less when it is low. Massell (1969) combined the two arguments, showing that either producers or consumers gain and

the other loses with the losers being the group causing the instability in the market.

These papers are chiefly of interest because they introduced the idea of flexibility in the face of varying prices giving rise to possible benefits. We do not examine them further, however, because their structure and methodology is very restrictive in that linear supply and demand curves are assumed and the welfare measures used are producer and consumer surplus. The latter implicitly assume that the marginal utility of income is constant which restricts the analysis to the unrealistic case of risk neutrality.

In the 1970s the literature moved to a more modern methodology based on Taylor series and the Arrow-Pratt measures of absolute and relative risk aversion. The results obtained depend closely on the assumptions made about the degree of flexibility in the economy, both in its structure and in what decisions must be taken prior to the realisation of relative prices. Four parameters appear across the papers. These comprise first the degree of aversion to income risk which appears because price fluctuations will cause fluctuations in income, second the marginal propensity to consume the good with a volatile price, important because it is costly in welfare terms if preferences are such that consumption of the volatile good is high when its relative price is high, which may coincide with periods when income is high. The last two factors are those highlighted by Oi and Waugh: the degree of

flexibility in production and consumption as relative prices change. With production flexibility this depends on whether production decisions must be taken before or after prices are known, and with consumption flexibility the same factor plus the extent to which the two goods are substitutes. In both cases flexibility is important because it is advantageous to export more of a good, by producing more and/or consuming less, when its relative price is high and vice versa when its price is low.

Batra and Russell (1974) find that with an arithmetic mean counterfactual, volatility in the terms of trade is always welfare reducing for a small risk averse country. Chapter 2 shows that this is a partial result that depends on two restrictive assumptions. The first is that it is assumed that production decisions must be made ex ante, effectively making all factors immobile ex post and leaving no production flexibility in the face of changing relative prices. Secondly, it is assumed that the country must also fix its level of exports ex ante with imports being determined ex post to satisfy current account balance. These two assumptions prevent any production or consumption flexibility and as a result, with risk aversion present, give rise to terms of trade volatility always being harmful. Hence this paper brings out the costs of volatility due to risk aversion, a factor missing from the earlier literature, but the conclusion that volatility always imposes a welfare cost depends sensitively on the restrictive assumptions which exclude

possible benefits from flexibility.

Turnovsky (1974) analyses a Ricardian model in which production decisions are made ex ante and consumption decisions ex post. He finds that the effect of volatility, compared with an arithmetic mean counterfactual, is ambiguous because sufficient flexibility in consumption may overcome lack of flexibility in production and the welfare costs of risk averse preferences with fluctuating income. If there is risk neutrality, volatility is beneficial (if the good with a volatile price is imported and normal). It may be noted that with production decisions ex ante there is no production flexibility so the assumption of a Ricardian rather than neo-classical technology does not affect the results.

Anderson and Riley (1976) also find an ambiguous result for expected welfare under terms of trade volatility if production decisions are ex ante and there is risk aversion. They derive the following condition for volatility to be welfare increasing compared with an arithmetic mean counterfactual:

$$-\frac{\partial c_x}{\partial P}\Big|_c - 2X\frac{\partial c_x}{\partial m} - X^2A > 0 \qquad (1.2.1)$$

Where A is the coefficient of absolute risk aversion and exports of the good with a volatile price are given by X where $X=(x-c_x)$.

Considering the terms in (1.2.1) individually, the first reflects the price responsiveness or flexibility of

consumption and implies a benefit from volatility since the partial derivative will be negative and hence the term as a whole positive given its sign. The second term implies a cost from volatility (assuming that good x is normal and exported) due to the income effect of price changes leading to high consumption of x at times when its relative price is high as discussed above. The third term reflects the direct cost of volatility from aversion to the income fluctuations that arise from price fluctuations. It is of note that the last two terms imply reductions in welfare from volatility due to income effects whereas the first term indicates a benefit from price fluctuations considered independently of income changes.

The condition above may be compared with that of Eaton (1979) where production decisions occur ex post and a geometric mean counterfactual is used:

$$-P\frac{\partial c_x}{\partial P}\Big|_c - PX^2A + P\frac{dx}{dP} - X\left(P\frac{\partial c_x}{\partial m} - \frac{\partial c_y}{\partial m}\right) > 0 \quad (1.2.2)$$

The geometric mean counterfactual accounts for the difference between the final term of (1.2.2) and the middle term of (1.2.1) and the P in front of the first three terms of the former. Apart from these differences, (1.2.2) differs from (1.2.1) only by the term Pdx/dP which reflects the flexibility of output volumes in response to relative price changes. This term is not present in (1.2.1) because Anderson and Riley assume that all factors must be fixed ex ante which means that output cannot respond at all to changes in prices. If there is some ex post factor mobility this term will be positive and

confer a benefit from the direct effects of price volatility in a similar fashion to consumption flexibility. Hence this expression reflects the Waugh consumption flexibility effect in the first term and the Oi production flexibility effect in the third while also properly accounting for risk aversion.

In relation to (1.2.2) the scope of much of the theoretical work in the thesis is defined by what is not covered by that expression[1], chiefly the effect of including non-tradeables in the model and the impact of many volatile prices.

The papers by Eaton and Anderson and Riley also consider whether the allocation of resources should differ under volatility, deriving results discussed in Chapter 5, but do not relate these to the expressions above. This is a weakness because any change in the allocation of resources that arises from price volatility should form part of the assessment of the change in welfare from that source.

Hence from the above it is clear that the appropriate modelling strategy is to use a model that is as general as possible, including non-tradeable goods and many volatile prices, to derive general results for both arithmetic and geometric mean counterfactual cases, and to allow for the possible welfare effects of a change in the allocation of resources. These results will encompass the expressions

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[1] Apart from sorting out the impact of assuming an arithmetic as against a geometric mean counterfactual which is comparatively minor exercise.

above, which may be derived as special cases, and provide a more complete picture of the effects of volatility. A further innovation is to first analyse the effect of volatility on expected income so as to distinguish between terms that relate to income and those that relate to preferences and income risk. This is important when risk and capital markets are introduced because if such markets are available agents can smooth income fluctuations in which case it is primarily the level of expected income that matters for welfare.

The papers described above form the basis of the theory developed below but mention should also be made of Newbery and Stiglitz's (1981) book and that of Ghosh et.al. (1987). Both of these provide a wealth of material but are primarily concerned with commodity price stabilisation at the international level and its microeconomic effects on producers. The emphasis here is on the effects of price volatility rather than price stabilisation which raises slightly different issues. Given the collapse in the 1980s of virtually all the international commodity agreements that had been in place there appears to be little prospect of further attempts to stabilise prices at the international level. This supports a research focus on the effect of volatility at the country level, together with some of the policy issues that arise, and an analysis of insurance mechanisms to smooth incomes rather than the stabilisation of prices.

In addition Killick (1995) discusses many issues concerned

with economic flexibility but without any analytical detail of relevance here.

Finally the results found in the literature have not been the subject of any empirical work. Newbery and Stiglitz provide some order of magnitude estimates of the effects of price stabilisation at the producer level but these are based on a rather looser theoretical foundation and do not attempt to give systematic estimates of the costs or benefits from volatility across different countries and commodities.

1.3 CHOICE OF COUNTERFACTUAL

This section discusses the appropriate choice of a counterfactual stable price or prices with which to make comparisons between outcomes under price volatility and price stability. The bulk of the discussion concerns the case where only one trade price is volatile with the implications of volatility in more than one price being brought out at the end. Before analysing the issue of the choice of counterfactual we discuss the context in which such a choice is important.

The chapters that follow aim to answer two related sets of questions. The first is whether trade price volatility will increase or reduce the expected values of the variables of interest compared with a situation in which trade prices are stable at some level which we term their counterfactual value. The second question is which parameters affect the expected value of these variables for a given degree of volatility. Clearly the two questions are closely related in that the answer to the first will depend on the relative strengths of different factors identified by the second but they are also distinct in that the first question requires a counterfactual to be defined whereas the second does not. For example with the second question if we find that expected national income under volatility is increasing in some parameter the statement will remain valid under any counterfactual. Hence the issue of the choice of counterfactual discussed in this section arises only when we wish to compare outcomes under price

volatility with price stability, and not if we simply ask which variables affect outcomes under volatility and in which direction.

Given that trade or commodity price volatility is likely to continue it is arguably more important to focus on the second of these questions, identifying the factors that are important in determining outcomes, rather than comparing those outcomes with the hypothetical counterfactual case. If this was the case we could choose any counterfactual as a reference point with the arithmetic mean of the volatile price distribution as perhaps the most convenient. Nevertheless it is natural to ask whether countries exposed to significant commodity price volatility would be better off under more stable conditions and hence we pursue the question of the appropriate choice of counterfactual.

To establish the "true" counterfactual we would need to have extensive knowledge of the workings of commodity markets, be able to identify the stochastic factors at work in making prices in those markets volatile, and establish their feasible stable values and hence the stable market prices that would result from them. Unfortunately our knowledge of commodity markets falls far short of these requirements, however, as shown by the generally poor performance of commodity price forecasts (discussed in Deaton (1992)) and hence the choice of counterfactual for a given commodity must be arbitrary at least to some extent. In addition commodity markets are

heterogeneous and it is unlikely that the true counterfactual has the same relationship to the volatile price distribution across all commodities.

This suggests that no simple rule for choosing a counterfactual can be regarded as the right one and that as a result any statement such as "the expected value of variable z is higher under volatility" must always be qualified by the counterfactual used. As a result the task is to choose an appropriate rule for choosing the counterfactual, knowing that it will be at best an approximation to the true one, and apply it consistently.

This choice is analysed initially on the assumption that the distribution of relative prices is stationary followed by consideration of how to deal with non-stationary price series.

Stationary Relative Prices

With stationary relative prices the most obvious choice for such a counterfactual is to use the expected value, or arithmetic mean, of the volatile price distribution. The literature has discussed this in relation to volatility in the terms of trade rather than volatility in the underlying commodity prices but it is argued that this is unhelpful. One reason is that if we use the terms of trade concept the distinction between exports whose price is volatile and those with stable prices may become blurred. A further reason is

that while in certain circumstances volatility in the terms of trade is a useful aggregate measure of the trade price volatility faced by an economy, it is by nature a summary statistic and a better approach is to model the underlying volatility in commodity prices directly.

The choice of counterfactual is a good example of this point. The literature initially used as a counterfactual the arithmetic mean of the terms of trade but it was pointed out that this gives rise to the problem of numeraire dependence (Flemming, Turnovsky and Kemp, 1977). This problem may be characterised as follows. If it is the export good which has a volatile price, stabilising that price at its arithmetic mean would also stabilise the terms of trade at their arithmetic mean, but if the volatile price is that of imports and their price were stabilised, the resulting stable value of the terms of trade would not be equal to the arithmetic mean of the volatile distribution of the terms of trade. This is because $E[P_x/P_m]$ is not equal to $P_x/E[P_m]$ where P_m is the volatile price of imports since $1/P_m$ is non-linear in P_m. Hence with import price volatility the mean of the terms of trade is an unrealistic counterfactual if it is believed that the true counterfactual should be based on the mean value of the underlying import or export prices. A way to overcome this difficulty is to use the geometric mean of the terms of trade rather than the arithmetic mean and thus achieve numeraire independence. Denoting the geometric mean by GM(.) it is the case that $GM(1/P)=1/GM(P)$. This was done in Eaton

(1979) discussed above. However, this approach implicitly assumes that the feasible stable value of the underlying commodity prices are their geometric rather than arithmetic means. Hence achieving numeraire independence for the terms of trade implies also changing the counterfactual for the underlying commodity prices.

Using the geometric mean may or may not approximate more closely to the true counterfactual defined above, depending on whether the stochastic elements in commodity price determination have an effect closer to a geometric or arithmetic mean preserving spread, but it may be argued that changing the basis of the counterfactual due to an inconvenient property of the terms of trade ratio is a questionable way to proceed. It is much more straightforward to conduct the analysis at the level of individual tradeables prices and make use of either their arithmetic or geometric means or both. We have no prior reason to suppose which one most closely approximates to the true counterfactual and hence the agnostic approach of giving results for both is adopted.

The arithmetic and geometric mean approaches both derive the counterfactual from a simple mathematical operation. A different strategy entirely is to take the counterfactual from the model itself. This approach is discussed in Boonekamp and Donaldson (1979) who contrast the use of the arithmetic or geometric mean with other certainty equivalents based on constant expected utility or the allocation of resources,

arguing against reliance on any one counterfactual. Boonekamp and Donaldson also suggest avoiding counterfactuals which imply benefits from price volatility. This criterion is not pursued further since the analysis shows that it is quite possible for economies to benefit from price volatility against plausible counterfactuals.

It is argued that the alternative counterfactuals that have been suggested are either unsuitable in the context of price volatility or are of interest in themselves but may be encompassed by the use of the arithmetic mean. We discuss each in turn.

Taking first the counterfactual based on a constant allocation of resources, in the current context this presents difficulties since the allocation of fixed factors will depend on the availability of risk markets and their domestic or international nature. Hence this counterfactual would be difficult to implement and the results based on it hard to interpret.

Similar problems arise with the view that countries suffer costs from price volatility due to the absence of risk or capital markets so that a further possible certainty equivalent would be the stable values of the volatile prices that would give the same outcomes as those obtainable when these markets were available. The difficulty with this approach is that it implicitly assumes that all the effects of

price volatility arise due to income variability and hence removing the income risk through full insurance is a good measure of the effects of price volatility. Chapter 2 shows that economies may raise their expected national income if they are sufficiently flexible as well as suffering from uninsured income risk. The key to this point is that while income fluctuations are consistently harmful to welfare, price fluctuations taken on their own are likely to be beneficial. As a result, while the availability of perfect risk markets is certainly desirable for smoothing income, their effect on welfare does not cover all the effects of risk and hence a counterfactual based on them is questionable.

A more promising approach is to assume that commodity price stabilisation schemes are in place and to define the certainty equivalent as the feasible stabilised price such that the buffer stock held by the relevant authority would tend neither to shrink to zero nor grow indefinitely. While this is an interesting case the approach adopted here, partly because the value of the feasible price is beyond the scope of the thesis, is to proceed with an arithmetic mean counterfactual and present results for how much the mean price would have to change to have the same effect as the price being volatile. It may be noted that Newbery and Stiglitz (1981) conclude that the feasible stabilised price will generally be below the arithmetic mean of the volatile price. If a magnitude were to be placed on this the approach adopted would enable a direct judgement on whether such a stabilisation scheme would be

beneficial.

A similar conclusion may be reached in relation to a counterfactual based on expected utility being invariant between the stable counterfactual value and the volatile distribution. This was first suggested by Diamond and Stiglitz (1974) and in effect asks what the counterfactual would have to be for volatility to have a neutral effect. This counterfactual may readily be implemented but the natural question to ask is how this value compares with the mean of the volatile price distribution. There is symmetry between using this counterfactual and seeing how it compares with the mean, and using the mean as the counterfactual and seeing what change in the mean would be necessary to have the same effect on expected utility. We adopt the latter approach by using a mean based counterfactual and use the results to derive the Diamond-Stiglitz value. The following section shows how this is done.

A further point is that no further issues arise if we allow for the possibility that there may be many volatile prices since consistency requires the use of the same counterfactual for each. In addition we do not need to define a counterfactual for the price of non-tradeables since this price is determined endogenously.

Non-Stationary Relative Prices

The discussion above was based on the assumption that the distribution of relative prices was stationary and hence contained no trend. While this is a convenient simplifying assumption, actual relative price series may contain trends and hence the choice of counterfactual must address this possibility. It is argued that this raises the substantive issue of what is meant by volatility, particularly in cases where it is plausible for the counterfactual itself to be stochastic, which results in possible conflicts between the following definitions of the counterfactual:

i) All deterministic components of the relative price series.

ii) The initial value and all permanent changes to the series.

iii) The initial value and all the effects of technological change, as opposed to short run demand and weather based supply shocks.

We discuss this issue in the context of the possible time series properties of relative prices. Econometric methodology necessarily makes a sharp distinction between non-stationary series that contain a deterministic time trend (trend stationarity) or a stochastic trend (difference stationarity) which in turn implies that a random walk component is present. This distinction is important but not central to what follows,

the key issue being the definition of volatility rather than the impact of different time series properties on econometric procedure, but nevertheless it is convenient to discuss these cases in turn.

A further distinction is made between permanent shocks to the value of relative prices, denoted ϵ^P, which are usually attributed to technological change, and transitory shocks given by ϵ^T which may also result from technical change or alternatively from the effects of weather variability on supply or demand fluctuations due to the business cycle in the major commodity consuming countries. These shocks are random variables and little structure is put on their probability distributions at this stage except that they are taken to be stationary. The two types of shocks are initially assumed to be independent.

To establish notation we illustrate the discussion above with reference to the stationary process for the log of the relative price, p=LnP, given by:

$$p_t = p_0 + \epsilon_t^T$$

In this case the counterfactual may unambiguously be defined as P_0 since it corresponds to the value of relative prices in the absence of shocks. The remaining problem, as discussed above, is to establish the (unobserved) value of P_0 from the observed series P_t. This requires an assumption about the probability distribution of ϵ^T that is equivalent to the choices above, including that between the arithmetic and

geometric means. For example, if ϵ^T is normally distributed P is log normal and P^0 is the geometric mean of P.

This choice applies also to the non-stationary cases below though the discussion focuses on the definition of the counterfactual (and hence volatility) rather than assumptions about the probability distribution of ϵ^T.

Trend Stationarity

Turning to the trend stationary case, we assume that relative prices vary around a smooth growth trend with constant growth rate, g, and represent the series in log form again with p=LnP, so that:

$$p_t = p_0 + gt + \epsilon_t^T \qquad (1.3.1)$$

which differs from the expression above by the effect of the growth rate, g, which corresponds to a permanent change to the series of magnitude g each period though we do not refer to these as permanent shocks since the changes are deterministic. Given this smooth growth rate it is natural, as long as the value of g is independent of the presence of the transitory shocks, to define the counterfactual, p^c by:

$$p_t^c = p_0 + gt$$

which incorporates the initial value and subsequent permanent changes, and hence conclude that the volatility component is given by $p-p^c=\epsilon^T$ as in the stationary case.

With this series the impact of technological change on relative prices is assumed to be smooth so that the permanent changes are deterministic and all variability in the series around that trend is a result of temporary demand and weather driven supply shocks. It is quite plausible, however, for technological change to follow a stochastic process in which case the changes to the series from technical progress would not give rise solely to a smooth growth rate. If this is the case the variability in the resulting series for P or LnP will result from both the stochastic effects of technological change and the transitory shocks so ϵ^T will contain stationary technology shocks also. In this case a decision must be taken as to whether we should define volatility as all the variability in the series, including that from technical change, or alternatively as the transitory shocks from short run supply and demand fluctuations only.

Attributing all the variability in relative prices in this situation to volatility is natural, because it puts all of the permanent changes into the counterfactual, but does not correspond to the view that volatility results solely from variations in weather conditions and short run demand fluctuations. This choice is further complicated if technical change gives rise to a difference stationary process for relative prices.

Difference Stationarity

If we assume that technical change occurs in a way that gives the log of a relative price series a random walk component, possibly with drift at rate ϕ also, it may be shown that in the absence of the temporary shocks, ϵ^T, the series is given by:

$$p_t = p_0 + \phi t + \Sigma_{t=0}^{t} \epsilon_t^P \qquad (1.3.2)$$

where ϵ^P are the permanent shocks due to technical progress. (1.3.2) is similar to (1.3.1) in its starting point, p_0, and deterministic component, ϕt, but differs by the third term. This is present because the technology shocks in the difference stationary case are both permanent and stochastic and this term represents the accumulation of these shocks. What is important about (1.3.2) is that the series for p will appear volatile, even though the effects of temporary supply and demand shocks have not yet been added, due to the stochastic trend implied by a random walk. In addition the variance of the third term is unbounded with time which implies that p_t may wander far from the deterministic component given by the first two terms.

If we add the effects of short run supply and demand shocks to (1.3.2) we have:

$$p_t = p_0 + \phi t + \Sigma_{t=0}^{t} \epsilon_t^P + \epsilon_t^T \qquad (1.3.3)$$

In which the variability of the series results from both the stochastic nature of the permanent shocks in the third term

and the transitory shocks of the fourth term.

Having established the nature of the series for the difference stationary case, when technical change gives rise to a pure random walk, we turn to the choice of counterfactual. The idea of commodity price volatility has almost always been based on an explicit or implicit assumption that it is a stationary concept so that volatility refers to possibly large but undoubtedly finite price swings away from a given trend. With trend stationarity this is readily applicable with the deterministic trend being part of the counterfactual and variability away from it counting as volatility. This also corresponds to all permanent changes to the series being in the counterfactual and all transitory changes being part of volatility, even if the latter may include transitory technology shocks as well as those from fluctuations in supply and demand conditions.

With a difference stationary series such as (1.3.3) the appropriate choice of counterfactual, and hence the definition of volatility, is less clear. Since the first two terms are deterministic they should certainly be included in the counterfactual, the key choice being whether the third term should also be included. If the view is taken that volatility should refer to all the variability in relative prices around a deterministic trend the counterfactual should be the first two terms only, with the random walk third term becoming part of volatility. Alternatively if the counterfactual is defined

by the initial value plus all the permanent changes, the third term would be included in it.

The approach taken below is based on the latter with the random walk term included in the counterfactual. This is done for two reasons, the first being that volatility is usually thought of as a stationary concept and the inclusion of the random walk term above in volatility would make it non-stationary. The second reason follows from the first in that including the random walk term in the definition of volatility implies that the impact of volatility may primarily result from the tendency of random walks to vary far from their starting points. Since the overall direction of movement, either raising or lowering relative prices, results from chance this implies that the inclusion of the random walk term in volatility may lead to the conclusion that the major determinant of outcomes under volatility is good or bad luck. In this case the first order effects of the third term in (1.3.3) may dominate the second order effects from the fourth term which are more interesting. Hence we include the random walk component in the counterfactual, so that volatility is stationary and excludes all permanent changes in prices, while recognising that this comes at the cost of the counterfactual becoming stochastic if relative prices are difference stationary.

Two further issues arise. The first is that it was assumed above that technical change implies a simple random walk for

the log of relative prices. It is possible that technical change taken on its own implies that p follows an ARIMA process in which case the final term in (1.3.3) will contain the ARMA component of technical change as well as the transitory effects of supply and demand shocks. This situation is similar to that discussed under trend stationarity when technical change was made stochastic and means that defining the counterfactual by the first three terms in (1.3.3) results in volatility including some of the effects of technical change as well as the other transitory shocks.

The second issue is related and concerns the relationship between the technology shocks and the temporary supply and demand shocks. These must be independent or related in certain ways for the distinction between volatility and the counterfactual to make sense. In both cases we think in terms of short run shocks possibly affecting technical change via research and development investments in either the commodity or non-commodity sectors. This ignores possible reverse causation of technical change affecting short run demand shocks which would occur, for example, in a real business cycle model. This latter possibility is not considered further because it would require explicit modelling of commodity price determination.

There are two cases in which the shocks may be independent. The simplest, and least likely, is where R&D expenditures are

independent of relative prices in which case short run shocks to the latter would have no impact on technical change. The more realistic case is where R&D activity depends solely on long run expected relative prices in which case it will be independent of short run shocks if they do not affect expected prices. In turn this implies that the short run shocks, or volatility, must give rise to an arithmetic mean preserving spread in prices. Hence the required independence of technical change from temporary shocks suggests greater emphasis on an arithmetic mean counterfactual rather than the geometric mean.

These two cases generated independence between technical change and short run shocks. A third possibility is that technical change is related to short run volatility but the relationship, and the volatility, is symmetric in such a way that the distinction between counterfactual and volatility continues to hold. Suppose that R&D does depend on short run relative prices rather than solely their long run expected value and that technical change can either raise or lower relative prices. Given short run shocks, each time the relative price moves away from its central value R&D will respond so that the relative price tends to move back to that value. If those shocks are symmetric, and the R&D response also symmetric, there will be no long run effect of short run shocks on relative prices via technical change even though there is an effect in the short run. Clearly this possibility also focuses attention on an arithmetic mean counterfactual

since that would give the required symmetry to the short run shocks.

It should be emphasised that the support for an arithmetic mean counterfactual from the discussion above rests on the need for consistency between the choice of counterfactual and the distinction between counterfactual and volatility. The discussion does not suggest that the arithmetic mean is the true counterfactual in the sense used at the start of the section, merely that it is a consistent choice and hence the most attractive in the absence of a large scale exercise in modelling commodity price determination. This would be complex and require modelling of R&D decision making, including assumptions about the set of R&D possibilities and how that set might change over time. These difficulties perhaps indicate at least in part why the literature has made comparatively little progress in this area.

A final point in this context is that the responsiveness of R&D expenditures to prices must make the presence of a random walk component much less likely. Random walks tend to wander far from their expected values but such movement is likely to trigger R&D expenditures that will move relative prices back again.

Conclusion

This section has discussed the appropriate choice of

counterfactual, contrasting the "true" counterfactual of the price that would prevail in the absence of shocks with the arithmetic and geometric means and the alternative counterfactuals based on the models themselves. It was argued that establishing the true counterfactual is not readily achievable and hence we are forced to make a choice amongst the others and accept that results about how volatility changes the expected value of a variable must be qualified accordingly. While this is not wholly satisfactory it was noted that for practical purposes we want the analysis to highlight the factors that determine outcomes under volatility rather than solely answering the hypothetical question of what would happen without any volatility. For the former the choice of counterfactual does not matter and the only requirement is consistency in its use.

Turning to the choice between an arithmetic and geometric mean, the literature argues for the latter so as to avoid numeraire dependence in the terms of trade. It is more convenient to model volatile tradeables prices directly, however, particularly when there is more than one volatile price. This approach is general and allows for the goods in question to be imported or exported and use of the terms of trade is redundant. In turn this means that numeraire dependence does not arise so on this basis we would be free to reject the geometric mean counterfactual in favour of the simpler arithmetic mean. While greater emphasis is placed on the arithmetic mean, for completeness results for the

aggregate economy are also presented for the geometric mean at the end of each section. In addition it was noted that using the arithmetic mean encompasses the use of a constant expected utility counterfactual and also generates a useful point of comparison for calculations of the feasible stabilised price that might be achieved by price stabilisation schemes. Hence a further choice between the mathematical counterfactuals and these latter two is unnecessary. This is demonstrated in the methodology section that follows. Other model based counterfactuals such as those defined by a constant allocation of resources or the effect of perfect risk markets were rejected as unhelpful.

This discussion was placed in the broader context of possible trends in relative prices in which case an important choice must be made between competing views about the appropriate definition of the counterfactual and hence volatility. The conclusion reached was that the counterfactual should include the initial value and all subsequent permanent changes to relative prices, noting that this results in the counterfactual itself becoming stochastic in the difference stationary case due to the stochastic trend implied by a random walk. This definition ruled out a possibly dominant first order effect, arising essentially from chance, from volatility caused by the tendency of random walks to wander far from their starting points.

The discussion was qualified by the need for independence

between transitory and permanent shocks or at least a symmetric relationship between them. In either case the use of an arithmetic mean counterfactual was much more likely to be consistent with the definition of the counterfactual than use of a geometric mean. Consideration of the relationship between transitory shocks and technical change also cast doubt on the likelihood of a random walk component in relative prices since R&D expenditures are likely to respond to relative prices and will tend to induce mean reversion.

1.4 METHODOLOGY

This section presents the methodology to be applied in the chapters that follow. The common theme is the conditions under which it is valid to apply the standard Taylor series expansion to the variable of interest as the volatile price changes which is the approach followed in the literature on price volatility. The first circumstance in which this is not an appropriate way to proceed is if the function involved is non-monotonic over the relevant range in which case first order effects dominate the second order effects which are the focus of the standard approach. For the variables of interest, income and welfare, income is monotonic in export prices but welfare is not because for standard reasons welfare rises as relative prices move away from the autarkic price ratio in either direction. This is a straightforward corollary of the case for free trade and it implies that if prices fluctuate to either side of autarky prices, price volatility must be beneficial. This is an exceptional case in practice since it is most unusual for commodities with volatile prices to move between being imported and exported as their prices fluctuate.

The discussion moves on to the case where prices fluctuate entirely to one side of the autarkic price ratio in which case the standard Taylor series approach may be applicable. It is argued, however, that in the case of price volatility there is a substantial qualification to this in that if the economy adjusts to the presence of volatility, by a change in the

allocation of fixed factors for example, the underlying functions relating the variables of interest to relative prices will change and as such the standard approach no longer captures all of the effects of volatility. This is because a Taylor series gives an approximation to the change in the expected value of a function as its argument changes, but does not allow for any shift in the function itself. This point, and the adjustment to volatility underlying it, represents an advance on the existing literature which deals separately with the welfare effects of volatility and its possible impact on the allocation of resources. The argument of this section shows that the two need to be linked.

As we have seen the literature only considers models with one volatile price and while we adopt this assumption initially for expositional purposes the section later develops the appropriate methodology for the case where there are many volatile prices.

The penultimate task of this section is concerned with the fact that the thesis does not explicitly consider fluctuations in supply conditions and hence the quantities produced within the economies in question, though at the global level fluctuating supply is likely to be a major cause of price volatility (together with demand variation). We show that for small economies the effects of stochastic quantity and price fluctuations are separable and hence we may analyse the latter without direct reference to the former.

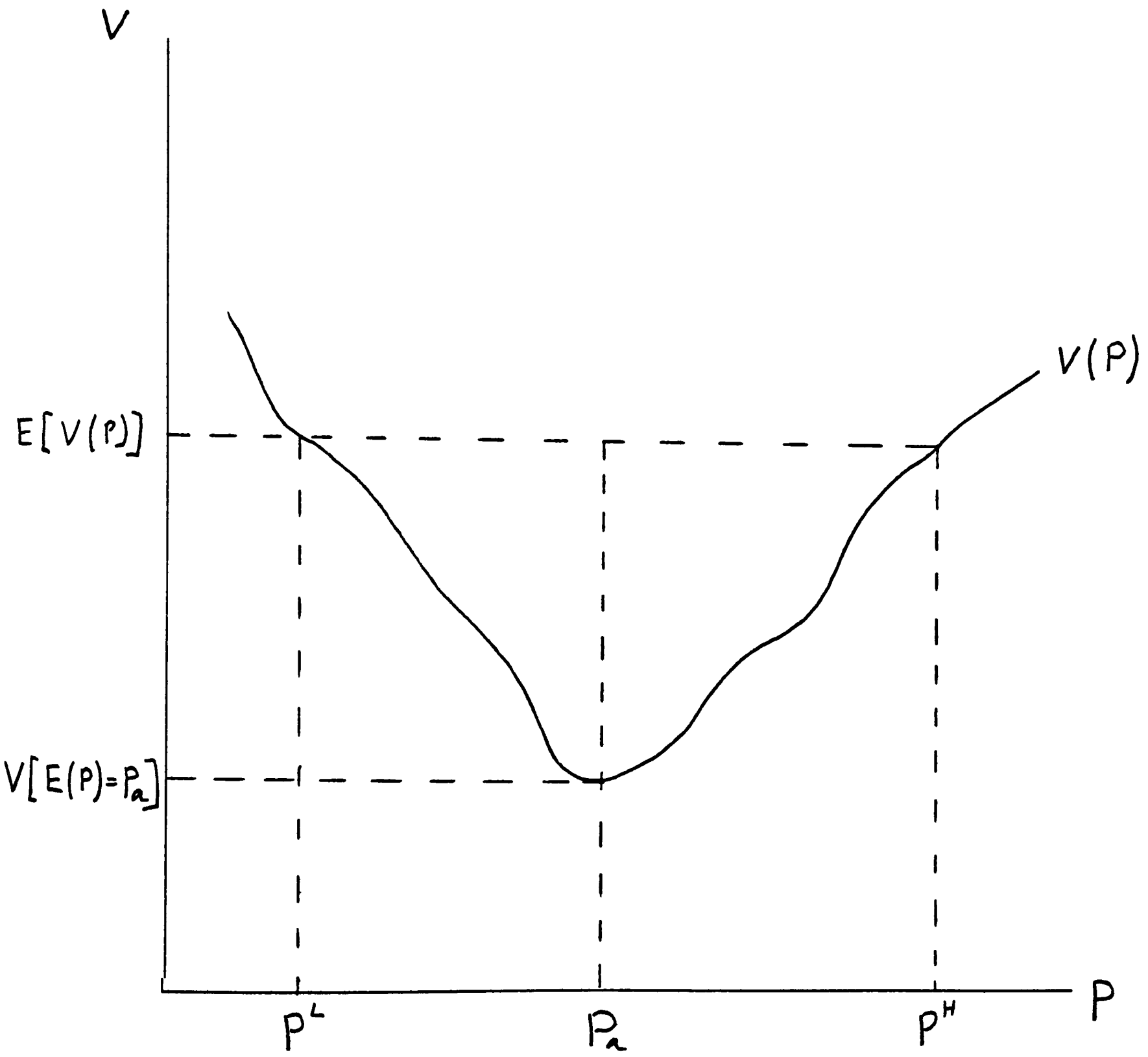
The section concludes by showing how we implement the comparison between the arithmetic mean and the constant expected utility counterfactual of Diamond and Stiglitz. In addition we derive a similar measure that gives the proportionate change in national income that would give rise to the same change in expected utility as the volatility of prices. This is not necessary from the point of view of the discussion of certainty equivalents but it is helpful for the empirical work since it allows the presentation of results in a way that is readily interpretable.

Price volatility around autarky relative prices

The starting point is to note that the standard case for free trade is based on autarky being a welfare minimising point and that an economy will benefit from relative prices moving away from autarky prices in either direction. Given this it would be expected in general that price fluctuations to either side of autarky would be beneficial. This is illustrated in Figure 1.1 which shows autarky prices, P_a, coinciding with the minimum of $V(P)$[1] where $V(.)$ is indirect utility and $P=P_x/P_y$. Thus to the right of P_a good x is exported and P corresponds to the standard definition of the terms of trade, and to the left good y is exported and P is the inverse of the terms of trade. The curvature or second derivative of V(P) is left vague to focus attention on the fact that dV/dP is negative to the left of P_a and positive to the right. This is a

[1]This function will be defined more precisely in Chapter 2.

FIGURE 1.1



consequence of autarky prices minimising the level of welfare and implies that fluctuations in relative prices to either side of P_a will result in significant welfare gains as shown by $E[V(P)] >> V(E[P]=P_a)$.

From Figure 1.1 it is also clear that E[V(P)] will be greater than V(E[P]) for a range of values of E[P] around P_a, even if V(P) is mostly concave to either side of it[2], so long as sufficient weight in the probability distribution lies on either side of that value of the volatile price. In addition if the probability distribution for P lies mostly, but not entirely, to one side of P_a the effect described will tend to raise the expected gains from volatility. This possibility will be mostly ignored in the analysis below because it would distract attention from the influence of the second derivative of V(P). In addition it would only become important if an economy's autarkic price vector is very close to world relative prices or if the economy is highly flexible such that the direction of trade on imports and exports may reverse from time to time as world prices fluctuate. For the major exported commodities of primary concern this is unlikely.

Relative price fluctuations to either side of autarky will be considered again when analysing the allocation of fixed factors in Chapters 4 and 5. If fixed factors are present the argument above needs modification because a change in their

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[2]V(P) will be convex at P_a itself since the function will be continuously differentiable and is rising to either side.

allocation will change the position of the minimum point of the function V(P) shown in Figure 1.1. The implications of this are brought out later but it is found that price fluctuations to either side of autarky will remain welfare increasing irrespective of the concavity or convexity of V(P).

Taylor Series Methodology

Standard Approach

The approach followed in the literature assesses the impact of price volatility by considering the second derivative of a function of interest with prices as the argument, say z(P). For an arithmetic mean counterfactual, considered in relation to Figure 1.2 (page 52), we wish to estimate the value of $E[z_v(P)]$ less $z_v(\bar{P})$ which is the difference between the expected value of z from price fluctuations between P_H and P_L with equal probability and the value of z when the volatile price is stabilised at its arithmetic mean ($\bar{P}$). The results below are general and do not rest on this somewhat simplistic probability distribution.

The standard approach may be described as follows. First we may state the second order Taylor approximation for z(P+h) as follows, where h is small and the price derivatives of z(P) are given by z′ and z′′:

$$z(\bar{P}+h) \approx z(\bar{P}) + hz'(\bar{P}) + \frac{1}{2}h^2 z''(\bar{P})$$

from which, if h takes on the values $+\delta$ and $-\delta$ with equal probability, we may write:

$$E[z(P)] \approx z(\bar{P}) + \frac{1}{2}\delta^2 z''(\bar{P})$$

It may be noted that the term in the first derivative has dropped out leaving only that in the second. This is because the first derivative gives rise to equal changes in either direction, but of opposite sign, which was not the case with price movements to either side of autarky above where the first order changes in utility were of the same sign.

In addition if the Taylor expansion had been taken to higher orders it is clear that all odd numbered derivatives would also cancel. This implies that the expression above implicitly allows for the third derivative of z with respect to P and hence is a closer approximation than it appears. The next term, in the fourth derivative, would have the coefficient 1/4! which is 1/24 and the higher order terms would have rapidly declining coefficients.

Given the above the magnitude of the change in the expected value of z from fluctuations in P may be expressed as:

$$\Delta E(z) = E[z(P)] - z(\bar{P}) \approx \frac{1}{2}\delta^2 z''(\bar{P}) = \frac{1}{2}Var(P)\, z''(\bar{P}) \quad (1.4.1)$$

Equation (1.4.1) confirms that the change in the expected value of z from an arithmetic mean counterfactual will be

positive if z'' is positive or equivalently if the function z(P) is convex, and negative if the function is concave. In addition it tells us that the size of the change will be approximately[3] equal to half the variance of P multiplied by the value of the second derivative.

With a geometric mean counterfactual we know from the earlier discussion that signing the welfare impact of volatility is no longer a simple matter of examining the second derivative of z(P). The concavity or convexity of z(P) remains relevant, however, because a Geometric Mean Preserving Spread (GMPS) in P implies an Arithmetic Mean Preserving Spread (AMPS) in lnP and we can make use of this by signing $d^2z/d(\ln P)^2$ to sign the welfare impact of volatility against a geometric mean counterfactual. For this we need expressions for the log derivatives of z(P) which are as follows:

$$\frac{dz}{d(\ln P)} = P\frac{dz}{dP} = Pz' \qquad (1.4.2)$$

$$\frac{d^2z}{d(\ln P)^2} = P^2\frac{d^2z}{dP^2} + P\frac{dz}{dP} = P^2z'' + Pz' \qquad (1.4.3)$$

So the welfare impact of volatility against a geometric mean counterfactual also rests on the nature of the function z(P) with the first derivative being important also. Loosely, the term in z' above allows for the geometric mean being less than the arithmetic mean while the term in z'' is the second order effect of volatility itself.

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[3]The expression will be exact rather than an approximation in the special case of a quadratic function since the third and all higher order derivatives of a quadratic are zero.

Furthermore, using (1.4.1), the size of the change in the expected value of z away from the geometric mean (GM) of P will be given by:

$$E[z(P)]-z[GM(P)] \approx \frac{1}{2} Var(lnP) \frac{d^2z}{d(lnP)^2} \qquad (1.4.4)$$

From which, making use of (1.4.3), the size of the change in the expected value of z from the GM may be expressed as:

$$\Delta E[z] \approx \frac{1}{2} Var(lnP) [P_{GM}^2 z'' + P_{GM} z'] \qquad (1.4.5)$$

where P_{GM} is the geometric mean of P.

Implications of a Change in the Underlying Functions

The discussion in the previous section concluded that the methodology adopted should be robust to possible changes in the allocation of resources in response to volatility. If this occurs the second derivatives of the relevant functions are no longer sufficient to sign the impact of volatility since a change in the allocation of resources will change the functions themselves. We denote the new function by $z_v(P)$ and the old function, based on an unchanged production structure, by $z_c(P)$ and repeat the steps above.

Rearranging (1.4.1) gives, for an arithmetic mean counterfactual:

$$E[z_v(P)] \approx \frac{1}{2} Var(P)\, z_v'' + z_v(\bar{P})$$

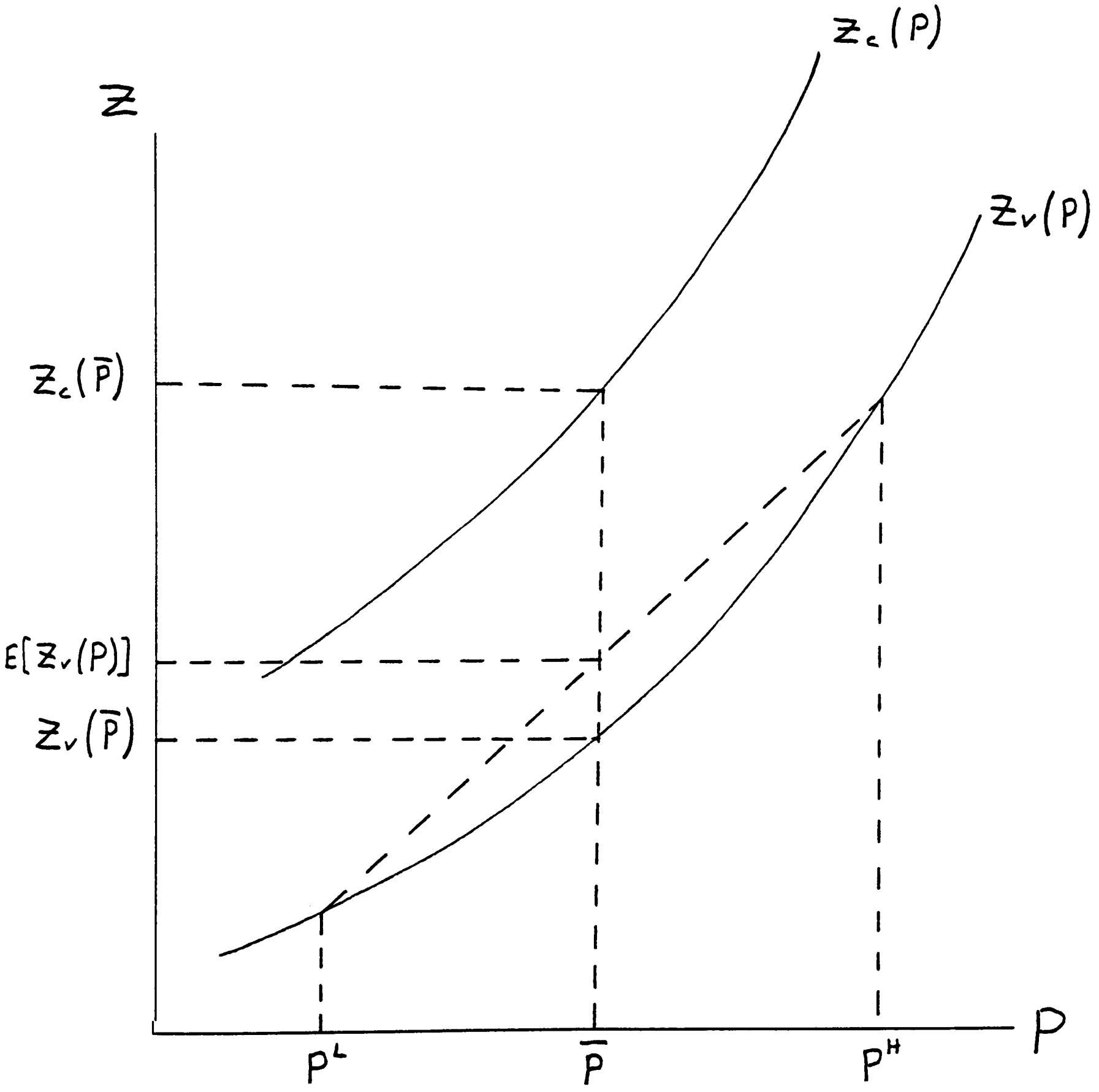
from which the change in the expected value of z from volatility in P, incorporating the effect of any change in the structure of the economy, will be given by:

$$E[z_v(P)] - z_c(\bar{P}) \approx \frac{1}{2} Var(P)\, z_v'' + z_v(\bar{P}) - z_c(\bar{P}) \qquad (1.4.6)$$

where the first term on the right hand side gives the change in expected utility from volatility itself while the last two taken together give the change in the level of utility at $\bar{P}$ arising from a change in the function z(P). If the economic structure remains unchanged the functions $z_v(P)$ and $z_c(P)$ are the same and the expression reduces to (1.4.1) with an unchanged value of the second derivative. Figure 1.2 illustrates (1.4.6), showing the counterfactual function $z_c(P)$ and a possible function following adjustment to the presence of volatility, $z_v(P)$. If we applied the standard methodology described above and considered only the first term in (1.4.6) we would estimate the effect of volatility on the expected value of z as $E[z_v(P)]-z_v(\bar{P})$ whereas the total effect is $E[z_v(P)]-z_c(\bar{P})$ which is given by (1.4.6).

In the case of a geometric mean counterfactual, from (1.4.5) and (1.4.6), the total change in the expected value of z from volatility, allowing for a change in the structure of the economy, will be given by:

FIGURE 1.2



$$E[z_v(P)] - z_c(P_{GM}) \approx \frac{1}{2} Var(lnP) [P_{GM}^2 z_v'' + P_{GM} z_v'] + z_v(P_{GM}) - z_c(P_{GM})$$

(1.4.7)

A final point is of note in relation to (1.4.6) and (1.4.7). The last term in each represents the value of z in the counterfactual or stable case as a function of the mean of the volatile price. It will often be the case, once we have substituted a variable of interest in place of the generic variable z, that this term will represent a maximum. For example the allocation of resources in the stable case may maximise national income at $\bar{P}$. If this is the case a change in the structure of the economy or the allocation of resources cannot raise $z(\bar{P})$ or $z(P_{GM})$ and is likely to reduce it. This implies that the sum of the last two terms in (1.4.6) and (1.4.7) will not be positive and may often be negative. As a result the change in the expected value of z will be less than or equal to the first terms in the equations and hence if the structure of the economy does change with volatility, ignoring this factor will lead to a result overly favourable to volatility compared with the counterfactual.

Many Volatile Prices

We derive an expression for the change in the expected value of the variable of interest, again given by z, when there are many volatile prices. This is done in two equivalent ways, first by looking at the derivatives of z with respect to the factors causing price volatility, and second in differential

form taking the changes in prices as exogenous without considering their underlying cause. We first assume an arithmetic mean counterfactual followed by the geometric mean case.

Let the volatile prices be given by P_i, with each price determined by a combination of an independent idiosyncratic component ϕ_i which may represent world supply or demand uncertainty specific to that commodity, and a systemic component across all commodities Φ which may represent world demand conditions. Under the assumption of an arithmetic (geometric) mean counterfactual we assume that P_i is a linear (log linear) function of Φ and ϕ_i and since each ϕ_i is commodity specific we may normalise its units so that its coefficient is unity and also remove any constant.

Hence:

$$P_i = \phi_i + b_i \Phi$$

Given the independence of the distributions of the two stochastic factors the variance of each price is given by:

$$Var(P_i) = Var(\phi_i) + b_i^2 Var(\Phi)$$

Turning to the change in the expected value of z, and allowing for the independence between the ϕ_i's and between them and Φ, we have:

$$\Delta E(z) \approx \frac{1}{2} \Sigma_i Var(\phi_i) \frac{d^2 z}{d\phi_i^2} + \frac{1}{2} Var(\Phi) \frac{d^2 z}{d\Phi^2}$$

What is required is to transform the variables in this

expression, which is based on the unobservable phi's, into observable P_i's. The first step is to note from the expression for P_i above that $d^2z/d\phi_i^2=d^2z/dP_i^2$, and also use the relationship between the variances above to yield:

$$\Delta E(z)=\frac{1}{2}\Sigma_i Var(P_i)\frac{d^2z}{dP_i^2}+\frac{1}{2}Var(\Phi)\left(\frac{d^2z}{d\Phi^2}-\Sigma_i b_i^2\frac{d^2z}{dP_i^2}\right)$$

which leaves the second step of eliminating the variables in Φ which may be done as follows:

$$\frac{dz}{d\Phi}=\Sigma_i\frac{dz}{dP_i}\frac{dP_i}{d\Phi}=\Sigma_i b_i\frac{dz}{dP_i}$$

In which the notation implies full rather than partial derivatives since P may affect z through several channels. From the above, with i=j=1,2,3,....,n we have:

$$\frac{d^2z}{d\Phi^2}=\Sigma_j\frac{d}{dP_j}\left[\Sigma_i b_i\frac{dz}{dP_i}\right]\frac{dP_j}{d\Phi}$$

and so:

$$\frac{d^2z}{d\Phi^2}=\Sigma_i\Sigma_j b_i b_j\frac{d^2z}{dP_i dP_j}$$

From the assumptions made above about the determination of P_i it may also be demonstrated that, for all i,j:

$$Var(\Phi)=\frac{1}{b_i b_j}Cov(P_i,P_j)$$

and hence, the core result of this section, that:

$$\Delta E(z) \approx \frac{1}{2}\Sigma_i Var(P_i)\frac{d^2z}{dP_i^2} + \frac{1}{2}\Sigma_i\Sigma_{j(i\neq j)} Cov(P_i,P_j)\frac{d^2z}{dP_i dP_j}$$

(1.4.8)

which keeps the variance and covariance terms separate though they may be combined as follows given that $Cov(P_i,P_i)=Var(P_i)$:

$$\Delta E(z) = \frac{1}{2}\Sigma_i\Sigma_{j(\forall i,j)} Cov(P_i,P_j)\frac{d^2z}{dP_i dP_j}$$

This expression gives us a framework within which to evaluate changes in the expected value of a variable of interest by focusing on the price derivatives shown.

Turning to the differential approach and using the same notation we have:

$$dz = \Sigma_i \frac{dz}{dP_i}dP_i$$

and hence the second differential is:

$$d^2z = \Sigma_i \frac{d}{dP_i}\left[\Sigma_i \frac{dz}{dP_i}dP_i\right]dP_i$$

$$= \Sigma_i \frac{d^2z}{dP_i^2}dP_i^2 + \Sigma_i\Sigma_{j,(i\neq j)}\frac{d^2z}{dP_i dP_j}dP_i dP_j$$

so that the change in the expected value of z, which is given by half the expected value of the second differential, is as follows:

$$\Delta E(z) \approx \frac{1}{2}\Sigma_i \frac{d^2z}{dP_i^2}Var(P_i) + \frac{1}{2}\Sigma_i\Sigma_{j,(i\neq j)}\frac{d^2z}{dP_i dP_j}Cov(P_i,P_j)$$

which is the same as (1.4.8) above.

It may be noted that in (1.4.8) the first term is the sum of (1.4.1) for each i so the second term represents the key addition in the many goods case that tells us that the effects of multiple price volatility are not simply additive unless the covariances happen to be zero. In the second term we have the product of the cross derivative for each i,j pair and their covariance. Loosely we may think of this as the effect of other prices changing affecting the first order effects of each price taken on its own. For example, suppose that the covariance is positive for a particular i,j combination and the cross derivative negative. In this case as P_i rises and then falls the first order terms in the Taylor expansion do not offset each other in the usual way since the first derivative is not equal in either direction. As P_i rises, P_j also rises on average and this reduces dz/dP_i, whereas as P_i falls P_j also falls on average which increases dz/dP_i. Most of the cross derivatives that occur are negative and hence the second term above tells us that the expected value of z will generally be lower if the covariances tend to be positive.

Use of a geometric mean counterfactual rather than an arithmetic mean implies that the expressions above must be adjusted. Given that a geometric mean preserving spread in P is an arithmetic mean preserving spread in lnP we have:

$$\Delta E[z] = \frac{1}{2}\Sigma_i Var(lnP_i)\frac{d^2z}{dlnP_i^2} + \frac{1}{2}\Sigma_i\Sigma_{j(j\neq i)} Cov(lnP_i, lnP_j)\frac{d^2z}{dlnP_i dlnP_j}$$

Into which we may substitute:

$$\frac{d^2z}{dlnP_i^2} = P_i^2\frac{d^2z}{dP_i^2} + P_i\frac{dz}{dP_i}$$

and:

$$\frac{dz}{dlnP_i} = P_i\frac{dz}{dP_i}$$

and:

$$\frac{d^2z}{dlnP_i dlnP_j} = P_iP_j\frac{d^2z}{dP_i dP_j}$$

to yield:

$$\Delta E[z] = \frac{1}{2}\Sigma_i Var(lnP_i)\,(P_i^2\frac{d^2z}{dP_i^2} + P_i\frac{dz}{dP_i})$$

$$+\frac{1}{2}\Sigma_i\Sigma_{j(j\neq i)} Cov(lnP_i, lnP_j)\,P_iP_j\frac{d^2z}{dP_i dP_j} \qquad (1.4.9)$$

In which the extra term, compared with (1.4.8), is that at the end of the last line. Once again this is present in order to account for the geometric mean being less than the arithmetic mean. This adjustment occurs for each volatile price once only and does not depend on the relationship between volatile prices so there is no extra term in the second line.

Quantity fluctuations

The differential approach is also useful in demonstrating the separability of fluctuating supply conditions, given by dx_i for small exogenous quantity changes, and fluctuating prices given by dP_i as above, for a small economy. Using this notation we have:

$$dz = \Sigma_i \frac{dz}{dP_i} dP_i + \Sigma_i \frac{dz}{dx_i} dx_i$$

and hence:

$$d^2z = \Sigma_i \frac{d}{dP_i} [dz]\, dP_i + \Sigma_i \frac{d}{dx_i} [dz]\, dx_i$$

$$= \Sigma_i \frac{d^2z}{dP_i^2} dP_i^2 + \Sigma_i \Sigma_{j,(i \neq j)} \frac{d^2z}{dP_i dP_j} dP_i dP_j$$

$$+ \Sigma_i \frac{d^2z}{dx_i^2} dx_i^2 + \Sigma_i \Sigma_{j,(i \neq j)} \frac{d^2z}{dx_i dx_j} dx_i dx_j$$

$$+ \Sigma_i \Sigma_{j,(\forall i,j)} \frac{d^2z}{dx_i dP_j} dx_i dP_j + \Sigma_i \Sigma_{j,(\forall i,j)} \frac{d^2z}{dP_i dx_j} dP_i dx_j$$

in which the first line is the same as (1.4.8) above, the second line the equivalent terms for fluctuations in quantities alone, and the third line the cross effects between price and quantity fluctuations. However, for a small economy in which domestic quantity fluctuations (assumed unrelated to quantity changes elsewhere) do not affect world prices, the expected value of the third line will be equal to zero. This is because E[dxdP] and E[dPdx] are equal to zero if there is no relationship between price shocks and quantity shocks as in the small economy case. Without denying that supply shocks may have serious consequences on their own account, we may therefore analyse price volatility without reference to supply shocks for a small economy, in effect because a supply shock may occur with equal probability when the relative price of the commodity is high or low. For a large economy in which

domestic price fluctuations affect world prices we would need to take account of the cross effects between price and quantity. The analysis that follows is restricted in scope to small economies so we do not pursue these cross effects further except to note from Newbery and Stiglitz (1981) that being a large economy may provide some income smoothing via the world market price. This is because when a large economy experiences a positive supply shock prices will tend to fall and vice versa so that the effect of the shock on income or export revenue is lower than for a small economy.

Constant Expected Value Counterfactuals

The discussion about the choice of counterfactual in the preceding section claimed that the use of an arithmetic mean did not preclude consideration of counterfactuals based on a constant expected value of variables of interest, an example being the Diamond-Stiglitz counterfactual that leaves expected utility unchanged. We demonstrate how this is done by deriving an expression for the proportionate change in the mean of the prices that are volatile that has the same effect on the expected value of the variables of interest as the volatility of those prices.

The equivalent change in prices is derived as follows, assuming that the changes are small so that the change in z, dz, arising from changes in the prices is given by:

$$dz \approx \Sigma_i \frac{dz}{dP_i} dP_i = \Sigma_i P_i \frac{dz}{dP_i} \frac{dP_i}{P_i}$$

It is convenient to make the proportionate change in each of the prices the same, denoting this by $\Delta P^c/P$, and equate dz to $\Delta E(z)$ from volatility to give:

$$\frac{\Delta P^c}{P} = \frac{dP}{P} \approx \frac{\Delta E(z)}{\Sigma_i P_i \frac{dz}{dP_i}} \qquad (1.4.10)$$

where the right hand side is the proportionate change in the mean of each of the volatile prices that gives rise to the same change in the expected value of z as volatility in those prices. Hence if we have $\Delta E(z)$ from volatility based on an arithmetic mean counterfactual we can make use of (1.4.10) to tell us the extent to which the mean of the volatile prices would have to change to have the same effect. It may be noted that (1.4.10) will have the same sign as the change in E(z) so its value should be read as "the effect of price volatility on the expected value of z is approximately equal to the effect of a proportionate change in the mean of each volatile price by the amount given by (1.4.10)." If we placed a minus sign in front of (1.4.10) the interpretation would change to the amount by which the mean of the prices would have to change at the same time as volatility is introduced to leave the expected value of z unchanged. This is not done so that the signs of the results are consistent with a negative value indicating a cost from volatility, or the need to lower the mean of the prices to have the same effect, and a positive the opposite in each case. A final point is that (1.4.10) is also

applicable to the case of a geometric mean counterfactual which would affect the magnitude of $\Delta E(z)$ but not the appropriate structure of (1.4.10).

Hence the use of an arithmetic mean counterfactual readily allows us to derive results concerning the counterfactual that would leave the expected value of a variable of interest invariant to volatility. This counterfactual is defined in relation to the mean of the actual price distribution which allows for easy interpretation. We make use of (1.4.10) in the chapters that follow, presenting its value alongside the results for an arithmetic mean counterfactual. The empirical work in Chapter 6 presents results in this form also, together with a similar measure for the equivalent change in national income rather than prices which we derive below.

Equivalent Income Change Measure of the Effects of Volatility

We show how to express the costs or benefits of volatility in terms of the change in income that would give rise to the same result. This is not necessary from the point of view of the discussion of counterfactuals but it gives us a useful way of gauging the size of the effects of volatility, particularly in Chapter 6 where the empirical results are derived.

The derivation is similar to that for the equivalent change in prices above. For a small change in income:

$$dV \approx \frac{\partial V}{\partial m} dm$$

so:

$$dV \approx m \frac{\partial V}{\partial m} \frac{dm}{m}$$

from which, rearranging and substituting in the change in the expected value of z from volatility we have:

$$\frac{\Delta m^c}{m} = \frac{dm}{m} \approx \frac{\Delta E(z)}{m \frac{\partial V}{\partial m}} \qquad (1.4.11)$$

The sign of which will be the same as that of ΔE(z), following the same convention as above. In addition (1.4.11) is also applicable to the case where ΔE(z) is derived against a geometric mean counterfactual.

Non-Stationary Prices or Quantities

The methodology discussed above has assumed that the volatile relative price(s) are stationary. This is consistent with the view developed in the previous section that volatility is a stationary concept and that any non-stationary element in the series should form part of the counterfactual and hence in effect already be removed from consideration. Given this the possibility of non-stationarity presents no conceptual problems for the expressions above which continue to be valid. There is, however, a more pragmatic issue with non-stationarity in terms of possible parameter instability in the estimation of the empirical magnitudes of the results above.

For example an important parameter in the analysis that follows is the share of exports of the good with a volatile price in national income when relative prices are at their counterfactual value. If relative prices are stationary the measured value of this parameter at current prices will vary but within a small range so that a reasonable estimate of the parameter at counterfactual relative prices may be made. Alternatively if prices are non-stationary, perhaps tending to increase over time, the share of exports of the good in national income will be non-stationary also under standard assumptions about the price response of exports. In this situation the parameter's value will change over time and hence an estimation of the results above would need to be interpreted as the instantaneous gain or loss from price volatility rather than an estimate that would remain valid in the long run.

Conclusion

This section has established the methodology to be used in the chapters that follow. The first set of issues concerned the circumstances in which the standard Taylor Series methodology was appropriate, discussing one that was not likely to be relevant (the case where price volatility spans the autarkic price ratio), and one which was, the possibility of a change in the function of interest as a result of adjustment to the presence of volatility.

The discussion turned to a further extension of the standard methodology, deriving the change in the expected value of a variable under conditions of multiple price volatility. This was followed by a demonstration that for small economies we may analyse price volatility separately from any exogenous supply shocks that may take place.

The section concluded by showing that the use of an arithmetic mean counterfactual permits statements to be made about the value of the Diamond-Stiglitz constant expected utility counterfactual relative to that mean and hence a choice does not have to be made between them. A similar expression was derived for the change in income that would bring about the same change as price volatility which will prove useful in interpreting the empirical results later.

1.5 MODELS

This section outlines the models used in the subsequent analysis. We first discuss those points that are common to all the models followed by those which distinguish them.

The intention is to make use of standard trade models and examine the effects of volatility on them. As a result there is deliberately nothing innovative about their underlying structure. A prime example of this is that it is assumed that factor supplies (of capital and labour) are constant which is consistent with a focus that excludes investment and growth. In addition we assume market clearing, perfect competition and exogenous tastes and technology together with the small economy assumption so the price of tradeables is also exogenous.

The level of disaggregation adopted is to model each tradeables sector with a volatile price separately but to combine tradeables with stable prices and non-tradeables into two aggregates. As a result the number of sectors considered is two plus the number with volatile prices.

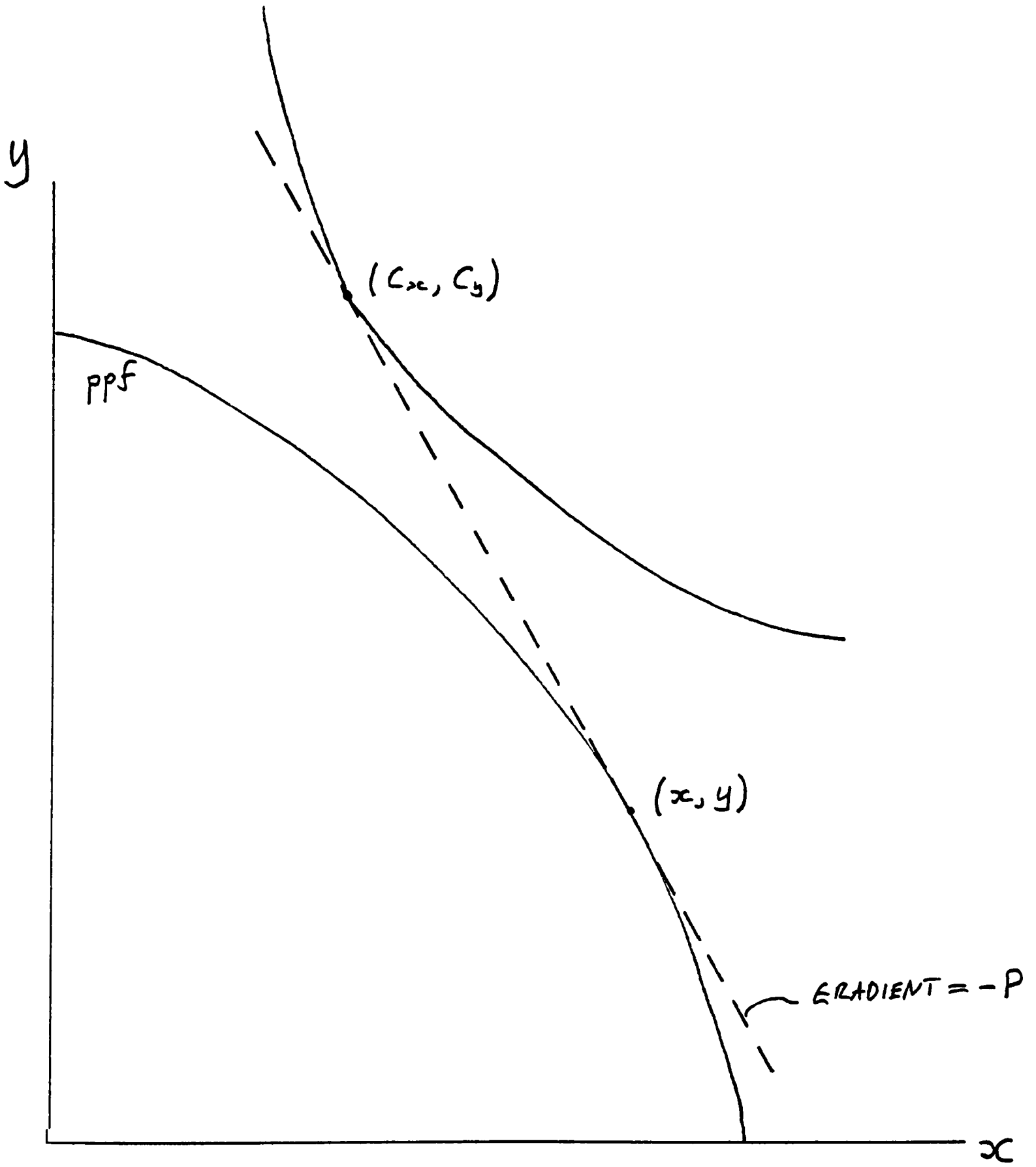
In addition there is no consideration of applying time discount rates to the outcomes in different states. Clearly for an actual economy the order of high and low price states will be important because of time preference but for the purpose of deriving theoretical results we think of each value of P as being a different state of the world which may or may

not occur in the future according to the relevant probability distribution. The actual sequence of realised prices may be thought of as a sample drawn from that distribution but for current purposes our concern is the expected values of the variables of interest arising from the distribution as a whole. Hence in this context time discount rates are not relevant because the time dimension has not been introduced.

The counterfactual defined is common to all the models as well and, abstracting from the non-tradeables sector, shown in Figure 1.3 for the case where there is only one volatile price. The level of output of the two tradeables form the axes, and a bowed out neo-classical production possibility frontier (ppf) shows the possible combinations of the two. The ppf will correspond to that for the Heckscher-Ohlin model since we assume that, ex ante, both capital and labour are mobile. Their ex post mobility is the defining characteristic of the three models considered.

Counterfactual output is determined by equating this gradient to the counterfactual relative price, P, as shown to give the output vector (x,y). Consumption (c_x, c_y) is determined by the relative price line forming the tangent to the relevant indifference curve with saving ruled out by assumption until the section on risk and capital markets. It is of note that the gradient of the relative price line, -P, is not necessarily the same as the terms of trade. This is because the analysis will focus on volatility in the price of

FIGURE 1.3



particular tradeables rather than volatility in the terms of trade more generally. The two would be the same if good x made up either all exports or all imports but we want to allow for the possibility of the good with a volatile price constituting only a part of either of those aggregates. Hence the y sector may contain both exported and imported goods.

At the heart of the analysis is the nature of the functions V(P) and m(P) where V represents the welfare of the representative agent (or indirect utility), P the volatile price (or vector of volatile prices) and m national income. These functions will be properly defined below but it may be noted that the underlying assumptions give V(P) and m as a unique function of P. This is because, in each state of the world (or realisation of a particular value of P), the structure of relative prices leads to a certain level of income which in turn gives rise to a certain level of consumption and hence utility. A further point is that writing the function V(P) is shorthand for V[P,m(P)] where V[.] is the indirect utility function with relative prices and the level of income as its arguments.

The features described above are common to the whole analysis with three particular cases being drawn out according to the degree of factor mobility permitted ex post.

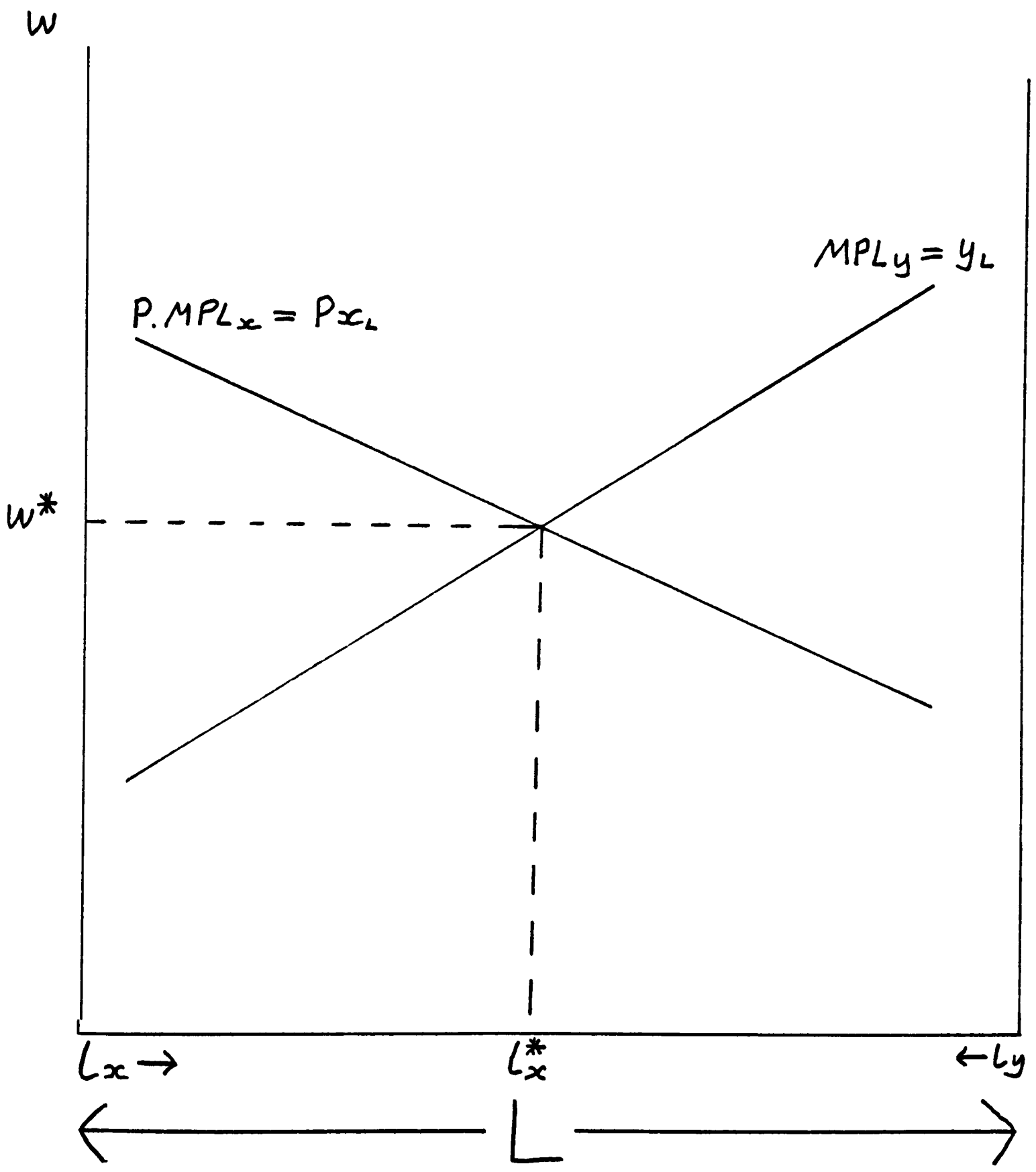
The simplest of these assumes that both factors are immobile ex post so there can be no output response to relative price

changes and the ex post production possibility frontier collapses to a point.

The second variant is the Ricardo-Viner or sector specific capital model. In this model it is largely arbitrary whether capital or labour is assumed sector specific since the factors may be relabelled without altering the derivation of the model's results. The discussion will be in terms of labour being the mobile factor since this is the most likely situation but the results cover both possibilities.

The core of the model is shown in Figure 1.4 which is from Neary (1978). We continue to consider two goods, x and y, and assume that they are produced according to production functions x(l) and y(L-l) with derivatives x_L, x_{LL}, y_L and y_{LL} etc. where l is the amount of a fixed supply of labour, L, allocated to sector x. The allocation of labour is shown in Figure 1.4 at l_x^* and is determined by the interaction of the marginal product of labour schedules in each sector. Labour is assumed to be mobile between sectors at all times, thus ensuring that wages in the two sectors are always equal with the common wage denoted by w and its equilibrium value shown as w^* in the figure. Competitive conditions prevail so the wage is equal to the value marginal product of labour. Capital is sector specific ex post, implying that the production functions exhibit diminishing returns if we adopt the standard assumption that there would be constant returns to scale if both factors were mobile. The marginal product of

FIGURE 1.4



labour schedules are therefore downward sloping with regard to the amount of labour in each sector. These schedules are shown as straight lines in the figure but this need not be the case. Because capital is fixed the ex post production possibility frontier will be within the ex ante one shown in Figure 1.3 (except at the counterfactual output combination) but the mobility of labour will permit some output response to price changes unlike the case above where both factors are fixed ex post.

The total return to capital is determined as a residual from the value of output less wL, the total return to labour. It is also of note that the model focuses entirely on the production side of the economy since that determines the returns to the factors of production. The pattern of consumption becomes important when considering the welfare of factor owners as opposed to their income.

The third model considered is the standard Heckscher-Ohlin framework in which both capital and labour are mobile ex post as well as ex ante. Given this the issue of the allocation of fixed factors does not arise in this model and the ex ante production possibility frontier shown in Figure 1.3 will also hold ex post.

CHAPTER 2

EXPECTED INCOME AND WELFARE WITHOUT INSURANCE

This chapter begins the analysis proper on the assumptions that there is no adjustment in the allocation of fixed factors and no access to risk or capital markets of any kind. The chapter also analyses outcomes for the economy as a whole leaving disaggregation until later.

Section 2.1 initiates the analysis of the impact of volatility by considering the response of expected national income when relative prices fluctuate. The motivation for examining this variable is partly its inherent interest and partly as a prelude to examining expected welfare. The two reasons come together if the economy has access to perfect risk or capital markets since in that situation expected income is the chief determinant of welfare.

Section 2.2 considers the impact of price volatility on the expected utility of the representative agent. This is partly dependent on expected national income but also involves the consequences of risk aversion and other taste parameters. It is shown that benefits from volatility are likely from the direct effects of fluctuations in prices but there will also be costs due to the income fluctuations that result from price volatility. This distinction is of great importance when considering insurance since income changes may be smoothed while price fluctuations continue.

2.1 EXPECTED NATIONAL INCOME

We present four cases in turn; the first where there is only one good with a volatile price and no non-tradeables, the second allows for many volatile prices but still without non-tradeables, the third adds non-tradeables but with only one volatile tradeable price and the fourth has non-tradeables and many volatile prices. The first three of these are special cases of the fourth but they are presented sequentially so as to develop intuition by considering the simpler cases first.

One Volatile Tradeable Price, No Non-Tradeables

We begin by deriving the derivatives of national income with respect to the volatile price. Denoting national income by m, we have:

$$m=Px+y$$

from which:

$$\frac{dm}{dP}=P\frac{dx}{dP}+x+\frac{dy}{dP}$$

$$\frac{dm}{dP}=P\frac{dx}{dP}+x+\frac{dy}{dx}\frac{dx}{dP}$$

so given that P=-dy/dx at the static optimum:

$$\frac{dm}{dP}=x \qquad (2.1.1)$$

and hence:

$$\frac{d^2m}{dP^2} = \frac{dx}{dP} \qquad (2.1.2)$$

so for an arithmetic mean counterfactual, making use of (1.4.1) the change in expected national income will be given by:

$$\Delta E(m) \approx \frac{1}{2} Var(P) \frac{d^2m}{dP^2} = \frac{1}{2} Var(P) \frac{dx}{dP} \qquad (2.1.3)$$

and hence expected income will rise with volatility if there is an output response to relative prices and will be invariant to volatility if there is not.

Intuitively one may think of expected income or the expected value of output as a weighted average of the volume of sectoral outputs with prices as the weights. If sectoral outputs were fixed we would expect no increase in expected output because against an arithmetic mean counterfactual the gains to the value of output from relative price increases for each sector would be exactly offset by losses from relative price falls. If sectoral outputs do respond to relative prices, however, the weighted average would be higher with price fluctuations because physical output for a sector is high when its "weight" is large and vice versa. As a result symmetric fluctuations in prices do not give rise to wholly offsetting effects on the value of output if sectoral outputs respond positively to their prices.

This result, which applies to the more complex cases also, is a major theme in the analysis that follows. Fluctuating

prices are often taken to be harmful to welfare without any apparent need to justify the position. While the welfare analysis of the following section identifies significant costs from price risk, these costs have to be considered alongside the potential benefits of higher average income shown above (if there is sufficient production flexibility) for a balanced assessment. There is also a clear implication that if the economy has access to adequate risk or capital markets price volatility may be beneficial since in those circumstances expected income becomes the prime determinant of welfare.

We may also express (2.1.3) in terms of elasticities as follows, dividing both sides of the expression by m to give the proportionate change in expected income by:

$$\frac{\Delta E(m)}{m} \approx \frac{1}{2} Var(lnP)\, \alpha_x \epsilon_x^P \qquad (2.1.4)$$

where α_x is the share of output of x in national income, evaluated at $\bar{P}$, the arithmetic mean of P.

Many Volatile Prices, No Non-Tradeables

If we allow for many tradeable goods to have volatile prices we need to make use of (1.4.8) which requires the cross derivative:

$$\frac{d^2m}{dP_i dP_j} = \frac{d}{dP_j}\left[\frac{dm}{dP_i}\right] = \frac{d}{dP_j}[x_i] = \frac{dx_i}{dP_j}$$

from which (1.4.8) becomes:

$$\Delta E[m] \approx \frac{1}{2}\Sigma_i Var(P_i)\frac{dx_i}{dP_i} + \frac{1}{2}\Sigma_i\Sigma_{j,i\neq j} Cov(P_i,P_j)\frac{dx_i}{dP_j} \qquad (2.1.5)$$

or in proportional terms:

$$\frac{\Delta E[m]}{m} \approx \frac{1}{2}\Sigma_i Var(lnP_i)\alpha_i\epsilon_{x_i}^{P_i} + \frac{1}{2}\Sigma_i\Sigma_{j,i\neq j} Cov(lnP_i,lnP_j)\alpha_i\epsilon_{x_i}^{P_j} \qquad (2.1.6)$$

The first term in this expression is the simple sum of (2.1.4) for each of the i goods with volatile prices. The second term is new and captures the effect of there being many volatile prices. It will be recalled that in the case with only one volatile price, output flexibility could give rise to higher average income by the weighted average effect if sectoral outputs rise when their relative prices are high and fall when they are low, the fall in one sector's output releasing resources for the expanding sector. If we have more than one volatile price, and a positive covariance between them, more than one sector will be competing for resources to expand at the same time. The second term in (2.1.6) captures this effect. A rise in P_i should lead to increased output of x_i but if there is positive covariance with P_j a simultaneous rise in the latter will tend to expand x_j at the expense of x_i and hence limit the ability of the economy to respond to any one price signal. This suggests that if the covariances are all or mostly positive the sign of (2.1.6) may be ambiguous, in contrast to the case with only one volatile price.

Section 4.1 below shows that this is, in fact, not the case and (2.1.6) will always be non-negative. This result emerges for two reasons, first because even if all the covariances are positive, and hence all the x sectors seeking to expand at the same time, there is still the y sector which will release resources because its relative price has fallen. The second reason is that if for any particular x sector the cross effects are strong enough for it to shrink at a time when its price has risen, which would lead to a negative component of (2.1.6) for that good, the fact that it has contracted means that it has released resources for the other x sectors which will thereby be better placed to expand at that time. This implies that any negative parts of (2.1.6) for a particular good will tend to be offset by larger than otherwise positive components for other x sector goods.

One Volatile Tradeable Price, Non-Tradeables Present

In the three good case we have:

$$m=Px+y+P_n n$$

from which:

$$\frac{dm}{dP}=P\frac{dx}{dP}+\frac{dy}{dP}+P_n\frac{dn}{dP}+x+n\frac{dP_n}{dP} \qquad (2.1.7)$$

where the first term represents the value of extra x produced in response to the price change and the second and third terms the same variable for y and n. From the initial optimum the change in the value of output from small changes in its composition should be zero and hence (2.1.7) take the value of

the last two terms only. This may be made more formal as follows, taking into account the fact that we have two relative price changes in this model:

$$\frac{dx}{dP} = \frac{\partial x}{\partial P} + \frac{\partial x}{\partial P_n}\frac{dP_n}{dP}$$

$$\frac{dn}{dP} = \frac{\partial n}{\partial P} + \frac{\partial n}{\partial P_n}\frac{dP_n}{dP}$$

$$\frac{dy}{dP} = \frac{\partial y}{\partial P} + \frac{\partial y}{\partial P_n}\frac{dP_n}{dP}$$

so that substituting these expressions into (2.1.7) yields:

$$\frac{dm}{dP} = \left(P\frac{\partial x}{\partial P} + \frac{\partial y}{\partial P} + P_n\frac{\partial n}{\partial P}\right) + \left(P\frac{\partial x}{\partial P_n} + \frac{\partial y}{\partial P_n} + P_n\frac{\partial n}{\partial P_n}\right)\frac{dP_n}{dP} + x + n\frac{dP_n}{dP}$$

in which the two bracketed sets of terms are both equal to zero since:

$$\frac{\partial y}{\partial P} = \frac{\partial y}{\partial x}\frac{\partial x}{\partial P} + \frac{\partial y}{\partial n}\frac{\partial n}{\partial P} = -P\frac{\partial x}{\partial P} - P_n\frac{\partial n}{\partial P}$$

and:

$$\frac{\partial y}{\partial P_n} = \frac{\partial y}{\partial x}\frac{\partial x}{\partial P_n} + \frac{\partial y}{\partial n}\frac{\partial n}{\partial P_n} = -P\frac{\partial x}{\partial P_n} - P_n\frac{\partial n}{\partial P_n}$$

so (2.1.7) becomes:

$$\frac{dm}{dP} = x + n\frac{dP_n}{dP} \qquad (2.1.8)$$

Thus the impact effect of a change in the volatile price, P, on national income is equal to the level of output of x, which was the only term in the two good case, plus the change in the value of output of n arising from the change in P. Hence the

addition of a non-tradable good to the model leads to the addition of this valuation term in the expression for the first derivative of national income with respect to P.

For expected national income we need the second derivative which, from differentiating (2.1.8), is given by:

$$\frac{d^2m}{dP^2} = \frac{dx}{dP} + \frac{dn}{dP}\frac{dP_n}{dP} + n\frac{d^2P_n}{dP^2}$$

From which the change in expected income will be:

$$\Delta E[m] \approx \frac{1}{2} Var(P) \left(\frac{dx}{dP} + \frac{dn}{dP}\frac{dP_n}{dP} + n\frac{d^2P_n}{dP^2} \right)$$

which may also be stated as follows, making use of the expressions for dx/dP and dn/dP above:

$$\frac{\Delta E[m]}{m} \approx \frac{1}{2} Var(P) \left[\frac{\partial x}{\partial P} + \frac{\partial n}{\partial P_n} \left(\frac{dP_n}{dP} \right)^2 + \left(\frac{\partial x}{\partial P_n} + \frac{\partial n}{\partial P} \right) \frac{dP_n}{dP} + n\frac{d^2P_n}{dP^2} \right]$$

(2.1.9)

where the first two terms, concerning the own price responses of x and n, will be positive and the bracket in the third term will be negative since it contains the cross price responses of x and n. These cross price partial derivatives will in fact be equal due to their symmetry but little advantage is gained from altering (2.1.9) to take account of this.

With regard to the last two terms it is helpful to derive dP_n/dP, which may be done starting from $n=c_n$ and hence $dn/dP=dc_n/dP$ and simplifying to give:

$$\frac{dn}{dP}=\frac{\partial n}{\partial P}+\frac{\partial n}{\partial P_n}\frac{dP_n}{dP}=\frac{dc_n}{dP}=\frac{\partial c_n}{\partial P_n}|_c\frac{dP_n}{dP}+\frac{\partial c_n}{\partial P}|_c+(x-c_x)\frac{\partial c_n}{\partial m}$$

so that:

$$\frac{dP_n}{dP} = \frac{\frac{\partial c_n}{\partial P}|c-\frac{\partial n}{\partial P}+(x-c_x)\frac{\partial c_n}{\partial m}}{\frac{\partial n}{\partial P_n}-\frac{\partial c_n}{\partial P_n}|c} \qquad (2.1.10)$$

which shows that the change in P_n from an exogenous change in P depends on the balance of the direct and indirect effects on the excess demand for non-tradeables. The first two terms in the numerator show the direct effect of the change in P while the equivalent terms in the denominator show the indirect effect of changes in P_n, these being the gradients of the supply and demand curves for non-tradeables with all other variables held constant. Allowing for the signs in front of these terms, all of these price effects are positive, while the last term in the numerator is the income effect of the change in P on the demand for non-tradeables and will be positive if n is normal and x is exported. Given these standard assumptions dP_n/dP will be positive.

In elasticity terms this derivative may also be expressed as:

$$\epsilon^{P}_{P_n} = \frac{\epsilon^{\partial P}_{c_n|c}-\epsilon^{\partial P}_{n}+\gamma_x\epsilon^{\partial m}_{c_n}}{\epsilon^{\partial P_n}_{n}-\epsilon^{\partial P_n}_{c_n|c}} \qquad (2.1.11)$$

Turning to the second derivative of P_n with respect to P in (2.1.9) it is clear that it cannot be signed in the general case because the sign will depend on how all of the partial

derivatives change with further changes in P and hence, indirectly, m and P_n also. That having been said, if all of the technology and taste elasticities remain constant we may expect the elasticity of P_n with P to increase with P since the income effect will become stronger as $(x-c_x)$ rises. If this is the case the final term in (2.1.9) will be positive. Fortunately the ambiguity in the sign of this term is not relevant for the expected utility of the representative agent in the section that follows since any valuation effect for producers, of either sign, is exactly offset by the opposite effect on consumers.

Turning to the other terms in (2.1.9), with dP_n/dP positive if non-tradeables are normal, d^2m/dP^2 is increasing in the own price supply responses from the first two terms and decreasing in the cross price supply responses in the third term. Clearly it would be advantageous if P_n and P moved in opposite directions so that the two sectors will be absorbing resources alternately rather than both competing for resources when P is high and both tending to lose resources when P is low. Clearly the relationship between P and P_n is thus important in determining the actual degree of flexibility in the composition of output for a given potential degree of flexibility in terms of the partial price supply responses.

Translating the derivatives above into elasticities we have the following expressions for the proportionate change in expected income:

$$\frac{\Delta E(m)}{m} \approx \frac{1}{2} Var(lnP) \left[\alpha_x \epsilon_x^P + \alpha_n \epsilon_{P_n}^P (\epsilon_n^P + \epsilon_{\frac{dP_n}{dP}}^P)\right] \qquad (2.1.12)$$

which is based on the full derivatives of x and n with respect to P. As was seen these may be broken down into partial derivatives with the whole change due to P broken down into effects flowing directly from changes in P and those from the subsequent change in P_n. If this is done (2.1.12) becomes:

$$\frac{\Delta E(m)}{m} \approx \frac{1}{2} Var(lnP) \left[\alpha_x (\epsilon_x^{\partial P} + \epsilon_x^{\partial P_n} \epsilon_{P_n}^P) + \alpha_n \epsilon_{P_n}^P (\epsilon_n^{\partial P} + \epsilon_n^{\partial P_n} \epsilon_{P_n}^P + \epsilon_{\frac{dP_n}{dP}}^P)\right]$$

(2.1.13)

Considering the expressions in the square bracket, the first terms based on dx/dP are essentially the same as the two good case apart from the effect of P_n rising on the output of x. The second term is specific to the three good model and describes how the last part of (2.1.8) varies with P. The key point in relation to (2.1.13) is that if the taste parameters are such that a rise in the price of a tradeable leads to substantial extra demand for non-tradeables, via both price and income effects, the volume of output of the tradeable may not rise much if at all when its price rises. This dynamic version of Dutch Disease does not matter too much from the perspective of expected income since an expansion of the non-tradeables sector also boosts national income but it is harmful to welfare which depends on the response of the tradeables sector rather than non-tradeables.

Many Volatile Tradeables Prices, Non-Tradeables Present

Similar considerations apply to the case where more than one traded good has a volatile price, except that we now want expressions for d^2m/dP_i^2 and d^2m/dP_idP_j which are as follows:

$$\frac{d^2m}{dP_i^2} = \frac{dx_i}{dP_i} + \frac{dn}{dP_i}\frac{dP_n}{dP_i} + n\frac{d^2P_n}{dP_i^2}$$

$$\frac{d^2m}{dP_idP_j} = \frac{dx_i}{dP_j} + \frac{dn}{dP_j}\frac{dP_n}{dP_i} + n\frac{d^2P_n}{dP_idP_j}$$

from which:

$$\Delta E[m] \approx \frac{1}{2}\Sigma_i Var(P_i)\left(\frac{dx_i}{dP_i} + \frac{dn}{dP_i}\frac{dP_n}{dP_i} + n\frac{d^2P_n}{dP_i^2}\right)$$

$$+ \frac{1}{2}\Sigma_i\Sigma_{j(j\neq i)} Cov(P_i, P_j)\left(\frac{dx_i}{dP_j} + \frac{dn}{dP_j}\frac{dP_n}{dP_i} + n\frac{d^2P_n}{dP_idP_j}\right) \quad (2.1.14)$$

or in proportional terms:

$$\frac{\Delta E[m]}{m} \approx \frac{1}{2}\Sigma_i Var(lnP_i)\left[\alpha_i\epsilon_{x_i}^{P_i} + \alpha_n\epsilon_{P_n}^{P_i}\left(\epsilon_n^{P_i} + \epsilon_{\frac{dP_n}{dP_i}}^{P_i}\right)\right]$$

$$+ \frac{1}{2}\Sigma_i\Sigma_{j(j\neq i)} Cov(lnP_i, lnP_j)\left[\alpha_i\epsilon_{x_i}^{P_j} + \alpha_n\epsilon_{P_n}^{P_i}\left(\epsilon_n^{P_j} + \epsilon_{\frac{dP_n}{dP_i}}^{P_j}\right)\right]$$

(2.1.15)

The derivatives above may, however, be broken down into their constituent partial derivatives as follows:

$$\frac{d^2m}{dP_i^2} = \frac{\partial x_i}{\partial P_i} + \frac{\partial n}{\partial P_n}\left(\frac{dP_n}{dP_i}\right)^2 + \left(\frac{\partial x_i}{\partial P_n} + \frac{\partial n}{\partial P_i}\right)\frac{dP_n}{dP_i} + n\frac{d^2P_n}{dP_i^2}$$

(2.1.16)

$$\frac{d^2m}{dP_i dP_j} = \frac{\partial x_i}{\partial P_j} + \frac{\partial n}{\partial P_n}\frac{dP_n}{dP_i}\frac{dP_n}{dP_j} + \frac{\partial x_i}{\partial P_n}\frac{dP_n}{dP_j} + \frac{\partial n}{\partial P_j}\frac{dP_n}{dP_i} + n\frac{d^2P_n}{dP_i dP_j}$$

(2.1.17)

which gives us the following expression for the change in expected income:

$$\Delta E(m) \approx \frac{1}{2}\Sigma_i Var(P_i)\left[\frac{\partial x_i}{\partial P_i} + \frac{\partial n}{\partial P_n}\left(\frac{dP_n}{dP_i}\right)^2 + \left(\frac{\partial x_i}{\partial P_n} + \frac{\partial n}{\partial P_i}\right)\frac{dP_n}{dP_i} + n\frac{d^2P_n}{dP_i^2}\right]$$

$$+\frac{1}{2}\Sigma_i\Sigma_{j(i\neq j)} Cov(P_i, P_j)\left[\frac{\partial x_i}{\partial P_j} + \frac{\partial n}{\partial P_n}\frac{dP_n}{dP_i}\frac{dP_n}{dP_j} + \left(\frac{\partial x_i}{\partial P_n} + \frac{\partial n}{\partial P_j}\right)\frac{dP_n}{dP_j} + n\frac{d^2P_n}{dP_i dP_j}\right]$$

(2.2.18)

which will be ambiguous in sign like the three good case above since the non-tradeables sector may absorb resources and hence prevent output in the x sectors from responding to rises in their prices. Equation (2.2.18) may also be expressed in proportional terms as:

$$\frac{\Delta E(m)}{m} \approx \frac{1}{2}\Sigma_i Var(lnP_i)\left[\alpha_i \epsilon_{x_i}^{\partial P_i} + \alpha_i \epsilon_{x_i}^{\partial P_n} \alpha_n \epsilon_n^{\partial P_i} \epsilon_{P_n}^{P_i} + \alpha_n \epsilon_{P_n}^{P_i}\left(\epsilon_n^{\partial P_n} \epsilon_{P_n}^{P_i} + \epsilon_{\frac{dP_n}{dP_i}}^{P_i}\right)\right]$$

$$+\frac{1}{2}\Sigma_i \Sigma_{j_{(i \neq j)}} Cov(lnP_i, lnP_j)\left[\alpha_i\left(\epsilon_{x_i}^{\partial P_j} + \epsilon_{x_i}^{\partial P_n} \epsilon_{P_n}^{P_j}\right) + \alpha_n \epsilon_{P_n}^{P_i}\left(\epsilon_n^{\partial P_j} + \epsilon_n^{\partial P_n} \epsilon_{P_n}^{P_j} + \epsilon_{\frac{dP_n}{dP_i}}^{P_j}\right)\right]$$

(2.1.19)

Geometric Mean Counterfactual

For each of the cases above we give the corresponding results for the change in expected income from volatility against a geometric mean counterfactual. These results are derived using (1.4.5) when there is only one exogenous volatile price and (1.4.9) when there are many volatile prices.

<u>One Volatile Tradeable Price, No Non-Tradeables</u>

$$\Delta E(m) \approx \frac{1}{2} Var(lnP)\left(P_{GM}^2 \frac{dx}{dP} + P_{GM} x(P_{GM})\right) \qquad (2.1.20)$$

with $x(P_{GM})$ indicating that it is the value of x at P_{GM}, the geometric mean of P. This may also be given as:

$$\frac{\Delta E(m)}{m} \approx \frac{1}{2} Var(lnP) \frac{P_{GM} x(P_{GM})}{m}\left(\epsilon_{x(P_{GM})}^{P} + 1\right) \qquad (2.1.21)$$

where the elasticity of x with changes in P is to be evaluated at the geometric mean. Clearly expected income will now rise with volatility even if there is no output response to price given the addition of unity in the bracket compared with (2.1.3) above. The contrast between the results arises because a geometric mean is less than an arithmetic mean for

a given distribution and hence a geometric mean counterfactual is inherently more favourable to volatility. The addition of unity in the bracket above is the only analytical difference between the results for the geometric and arithmetic mean cases but it may be noted that the empirical magnitude of the geometric mean case will be slightly affected by the fact that the share of output of x in national income in front of the bracket should be evaluated with the relative price at its geometric rather than arithmetic mean. This applies to each of the results below and those for the geometric mean counterfactual in the following section.

Many Volatile Tradeables Prices, No Non-Tradeables

From (1.4.9), we have:

$$\Delta E[m] \approx \frac{1}{2}\Sigma_i Var(lnP_i)\,(P_i^2\frac{dx_i}{dP_i}+P_i x_i)$$

$$+\frac{1}{2}\Sigma_i\Sigma_{j,(j\neq i)} Cov(lnP_i, lnP_j)\,P_i P_j \frac{dx_i}{dP_j} \qquad (2.1.22)$$

or in proportional terms:

$$\frac{\Delta E[m]}{m} \approx \frac{1}{2}\Sigma_i Var(lnP_i)\,\alpha_i(\epsilon_{x_i}^{P_i}+1)$$

$$+\frac{1}{2}\Sigma_i\Sigma_{j,(j\neq i)} Cov(lnP_i, lnP_j)\,\alpha_i \epsilon_{x_i}^{P_j} \qquad (2.1.23)$$

which differs from (2.1.6) only by the addition of unity in the bracket on the first line.

One Volatile Tradeable Price, Non-Tradeables Present

Using (1.4.5) we have:

$$\Delta E[m] \approx \frac{1}{2} Var(lnP)\,(P^2\frac{dx}{dP}+P^2\frac{dn}{dP}\frac{dP_n}{dP}+P^2 n\frac{d^2P_n}{dP^2}+Px+Pn\frac{dP_n}{dP})$$

(2.1.24)

or in proportional terms:

$$\frac{\Delta E[m]}{m} \approx \frac{1}{2} Var(P)\,[\alpha_x(\epsilon_x^P+1)+\alpha_n\epsilon_{P_n}^P(\epsilon_n^P+\epsilon^P_{\frac{dP_n}{dP}}+1)]$$

(2.1.25)

which differs from (2.1.12) only by the addition of unity to each of the brackets.

Many Volatile Tradeables Prices, Non-Tradeables Present

Using (1.4.9) we have:

$$\Delta E[m] \approx \frac{1}{2}\Sigma_i Var(lnP_i)\,P_i(P_i\frac{dx_i}{dP_i}+P_i\frac{dn}{dP_i}\frac{dP_n}{dP_i}+P_i n\frac{d^2P_n}{dP_i^2}+x_i+n\frac{dP_n}{dP_i})$$

$$+\frac{1}{2}\Sigma_i\Sigma_{j,(j\neq i)} Cov(lnP_i, lnP_j)\,P_iP_j(\frac{dx_i}{dP_j}+\frac{dn}{dP_j}\frac{dP_n}{dP_i}+n\frac{d^2P_n}{dP_idP_j})$$

(2.1.26)

or in proportional terms:

$$\frac{\Delta E[m]}{m} \approx \frac{1}{2}\Sigma_i Var(lnP_i)\,[\alpha_i(\epsilon_{x_i}^{P_i}+1)+\alpha_n\epsilon_{P_n}^{P_i}(\epsilon_n^{P_i}+\epsilon_{\frac{dP_n}{dP_i}}^{P_i}+1)]$$

$$+\frac{1}{2}\Sigma_i\Sigma_{j,(j\neq i)} Cov(lnP_i, lnP_j)\,[\alpha_i\epsilon_{x_i}^{P_j}+\alpha_n\epsilon_{P_n}^{P_i}(\epsilon_n^{P_j}+\epsilon_{\frac{dP_n}{dP_i}}^{P_j})]$$

(2.1.27)

In which the only change from (2.1.15) is once again the addition of unity in the two brackets on the first line. This adjusts the value of the expression for the difference between the counterfactuals but clearly does not alter the nature of the analysis in any significant way.

Conclusion

This section has discussed the response of expected national income to price volatility. It was found that under an arithmetic mean counterfactual, with only one volatile price and no non-tradeables, expected national income was increasing in volatility if there was some flexibility in the economy once relative prices are known so that, at any given time, resources may move to the sector that is temporarily enjoying a high relative price.

Allowing for many volatile prices, but again with no non-tradeables, raised the possibility that sectoral outputs may respond perversely to their own price if there are strong cross effects from other prices and positive covariances between them. Chapter 4 shows that expected national income

will nevertheless be increasing in the price responsiveness of output because the sum of the own price effects is greater than the sum of the cross price effects, a strong cross price effect on one good leading to a stronger own price effect on another good.

Adding non-tradeables to the model complicates the picture somewhat in that this sector may absorb resources that would otherwise be available for the sectors with volatile prices or alternatively release resources and hence add to the price responsiveness of output in sectors with volatile prices. As a result the x sectors may not respond to rises in their prices, though measured national income is still likely to rise due to the valuation effect of a sharp rise in non-tradeables prices and expansion in that sector. We examine this further in the next chapter once the following section has established the role of the non-tradeables sector in welfare.

A geometric mean based counterfactual does not alter the substance of these results, that expected national income is an increasing function of ex post production flexibility, but it does change the estimated magnitude of expected national income by inflating the gains from volatility as a result of the geometric mean being less than the arithmetic mean and hence a less attractive alternative to volatility.

2.2 EXPECTED UTILITY OF THE REPRESENTATIVE AGENT

This section applies the methodological approach outlined in Chapter 1 to the question of how relative price volatility affects the expected utility of the representative agent, addressing as before the case where there is no change in ex ante resource allocation or insurance.

Without any insurance or change in the allocation of fixed factors permitted we may adopt the standard methodology and investigate the derivatives of the function relating utility to relative prices. This is done for each of the four combinations of goods.

One Volatile Tradeable Price, No Non-Tradeables

It is convenient to make use of the indirect utility function so we define $V[P,m(P)]=U(c_x,c_y)$ and derive its first and second derivatives. The notation used has (x,y) as the output vector and (c_x,c_y) the consumption vector as above. National income at world prices, m, is given by $m=Px+y$ where good y is taken as the numeraire. In addition there is no saving so $Pc_x+c_y=m$.

Define:

$$U(P)=V[P,m(P)]$$

Hence:

$$\frac{dV}{dP}=\frac{\partial V}{\partial P}+\frac{\partial V}{\partial m}\frac{dm}{dP}$$

$$\frac{dV}{dP}=\Sigma_i\left[\frac{\partial V}{\partial c_i}\left(\frac{\partial c_i}{\partial P}\Big|_c-c_x\frac{\partial c_i}{\partial m}\right)\right]\frac{\partial V}{\partial m}+\frac{\partial V}{\partial m}\frac{dm}{dP}$$

from which, with the pure substitution effects dropping out:

$$\frac{dV}{dP}=-c_x\frac{\partial V}{\partial m}+\frac{\partial V}{\partial m}\frac{dm}{dP}$$

$$\frac{dV}{dP}=\frac{\partial V}{\partial m}\left(\frac{dm}{dP}-c_x\right) \qquad (2.2.1)$$

Therefore using (2.1.1):

$$\frac{dV}{dP}=(x-c_x)\frac{\partial V}{\partial m}=X\frac{\partial V}{\partial m} \qquad (2.2.2)$$

which is intuitively sensible since the exposure of the economy to fluctuations in P is equal to exports of the good whose price is volatile, and this quantity is multiplied by the marginal utility of income to give the impact effect of a change in P on utility.

The welfare consequences of price volatility depend on the convexity or concavity of the function V(P) so we also need the second derivative. Clearly, from (2.2.2) the value of the second derivative will depend on how the volume of exports responds to changes in relative prices and how they affect the marginal utility of income. Both of these will be ambiguous in general. With regard to net exports, the level of output of the export good should rise in response to a higher relative price but on the consumption side there will be both the usual income and substitution effects from a relative

price change and a further income effect as improvements in the export price increase the level of national income, raising consumption of x if it is normal.

The marginal utility of income may also rise or fall with P since on the one hand it will fall as income rises if the representative agent is risk averse, but on the other the marginal utility of income will be affected directly by changes in prices with the level of income held constant.

These factors may be made precise, following from (2.2.2), as follows:

$$\frac{d^2V}{dP^2} = (x-c_x)\frac{d}{dP}\left[\frac{\partial V}{\partial m}\right] + \left(\frac{dx}{dP} - \frac{dc_x}{dP}\right)\frac{\partial V}{\partial m} \qquad (2.2.3)$$

and

$$\frac{d}{dP}\left[\frac{\partial V}{\partial m}\right] = \frac{\partial}{\partial P}\left[\frac{\partial V}{\partial m}\right] + \frac{\partial}{\partial m}\left[\frac{\partial V}{\partial m}\right]\frac{dm}{dP}$$

$$= \frac{\partial}{\partial m}\left[\frac{\partial V}{\partial P}\right] + x\frac{\partial^2 V}{\partial m^2}$$

$$= \frac{\partial}{\partial m}\left[-c_x\frac{\partial V}{\partial m}\right] + x\frac{\partial^2 V}{\partial m^2}$$

$$= (x-c_x)\frac{\partial^2 V}{\partial m^2} - \frac{\partial V}{\partial m}\frac{\partial c_x}{\partial m} \qquad (2.2.4)$$

so substituting (2.2.4) into (2.2.3) gives:

$$\frac{d^2V}{dP^2} = \frac{\partial V}{\partial m}\left[\frac{dx}{dP} - \frac{dc_x}{dP} - \frac{\partial c_x}{\partial m}(x-c_x) - (x-c_x)^2 A\right] \qquad (2.2.5)$$

where A is the coefficient of absolute risk aversion. The second term in the square bracket of (2.2.5) is broken down

into income and substitution effects below but for the time being it is left as it stands so that the expression is in terms of exports which will prove useful empirically. Using the second derivative above gives us the following expression for the change in expected utility from volatility in P, with X representing ($x-c_x$) or exports of x:

$$\Delta E(V) \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{dX}{dP} - X\frac{\partial c_x}{\partial m} - X^2 A] \qquad (2.2.6)$$

or in elasticity terms:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} Var(lnP) \gamma_x (\epsilon_X^P - \beta_x \epsilon_{c_x}^{\partial m} - \gamma_x R) \qquad (2.2.7)$$

where R is the coefficient of relative risk aversion, $\epsilon^P{}_X$ represents the elasticity of export volumes with respect to the price of x, and $\epsilon^{\partial m}{}_{cx}$ the income elasticity of demand for the export good. The latter is given a partial derivative sign to indicate that it is the income elasticity with relative prices held constant.

In addition $ß_x$ is the share of consumption of good x in national income:

$$\beta_x = \frac{Pc_x}{m}$$

This share will usually be very small in practice, both absolutely and relative to the share of output of the good. If $ß_x$ is very close to zero the middle term in the brackets of (2.2.6) and (2.2.7) may be dropped.

γ_x is the share of exports of x in national income:

$$\gamma_x = \frac{PX}{m} = \frac{P(x-c_x)}{m} = \alpha_x - \beta_x$$

The term outside the bracket in (2.2.7) will be positive if x is exported and relative price fluctuations will therefore be welfare improving relative to an arithmetic mean counterfactual if the following condition holds:

$$\epsilon_X^P - \beta_x \epsilon_{c_x}^{\partial m} > \gamma_x R \qquad (2.2.8)$$

The components of this expression will be disaggregated further below but we first discuss each in turn.

i) The price response of exports. On the production side this variable is important because it measures the ability of the economy to move resources into sectors with high relative prices as those relative prices fluctuate. This effect raises expected national income as seen in the previous section. On the consumption side the variable also measures flexibility, this time the degree of flexibility in consumers' preferences which allows them to substitute between goods as relative prices change. This is subject to the effects of any changes in income that are taking place at the same time which we discuss further below.

ii) The income elasticity of demand picks up the income effects on consumer choice, it being advantageous to have a low (or preferably negative) income elasticity of demand so that as income covaries positively with the relative price of the export good, consumption of the latter does not rise too

much (or preferably falls) when its relative price is high. This variable is weighted by the consumption share of the export good so that expected utility in the presence of volatility is higher if the share is small and the export good is normal (the standard case) or large if it is inferior.

iii) The presence of the coefficient of relative risk aversion is also intuitive, the variables on the left hand side of (2.2.8) determining the response of real income to volatility while this variable measures the expected utility cost of fluctuations themselves. The variable is also weighted by the share of net exports in national income which makes sense since this indicates the exposure of the economy to price risk.

Condition (2.2.8) is an interesting result, and applicable in empirical work since each term is in principle measurable, but for theoretical purposes its interpretation is complicated by the fact that it has terms in both the income elasticity of demand and the uncompensated price elasticity of net exports. The latter implicitly contains a term in the income elasticity and it is useful to bring this out so as to properly separate the income and substitution effects.

Hence we further simplify (2.2.6), by making use of the fact that:

$$\frac{dX}{dP}=\frac{dx}{dP}-\frac{dc_x}{dP}=\frac{dx}{dP}-\frac{\partial c_x}{\partial p}\Big|_c-(x-c_x)\frac{\partial c_x}{\partial m}$$

so that (2.2.6) becomes:

$$\Delta E[V]\approx\frac{1}{2}Var(P)\frac{\partial V}{\partial m}[\frac{dx}{dP}-\frac{\partial c_x}{\partial P}\Big|_c-2(x-c_x)\frac{\partial c_x}{\partial m}-(x-c_x)^2A]$$

(2.2.9)

The square bracket of which is comparable to the result of Anderson and Riley given by (1.2.1) apart from the term dx/dP which is missing from their result. This is because they assume that production decisions must be taken ex ante so there is no ex post production flexibility and hence dx/dP is zero.

The change in expected utility is given, in elasticities form, by:

$$\Delta E(V)\ \approx\ \frac{1}{2}m\frac{\partial V}{\partial m}Var(lnP)\,(\alpha_x\epsilon_x^P-\beta_x\epsilon_{c_x}^{\partial P}\Big|_c-2\beta_x\gamma_x\epsilon_{c_x}^{\partial m}-\gamma_x^2R)$$

(2.2.10)

or for the case where $ß_x=0$, such that $\alpha_x=\gamma_x$:

$$\Delta E(V)\ \approx\ \frac{1}{2}m\frac{\partial V}{\partial m}Var(lnP)\,\gamma_x(\epsilon_x^P-\gamma_xR)$$

Expressions (2.2.9) and (2.2.10) allow a more complete understanding of the conditions under which relative price volatility is likely to be welfare increasing or decreasing than (2.2.7) since we know that the first two terms will always be positive if there is some ex post flexibility in production and consumption. As a result if the representative

agent is risk neutral and x is inferior we may conclude that they will benefit from price volatility. As above it would be convenient if x is inferior because it is advantageous to want to consume less of a good when its relative price is high, which in this context will coincide with the state of the world in which income is high. Hence with an inferior good the income effect reinforces the substitution effect in reducing consumption of x when it is costly and vice versa when its relative price is low. This is a result of the trade context inducing covariance between changes in the relative price of an exported good and national income.

In the more general case where the representative agent is risk averse and x is normal rather than inferior the condition is clearly ambiguous but still permits the general statement, first made by Anderson and Riley (1976), that if the initial volume of trade is sufficiently small the economy will benefit from small fluctuations in relative prices. This is a result of the share of exports appearing in front of the negative terms in (2.2.10). Hence if the volume of trade is small the economy is exposed to little risk and will gain from production and consumption flexibility in response to price changes taken on their own, the income effects being negligible if γ_x is small.[1]

Having established general conditions for volatility in the

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[1]In addition if γ_x is small production will be close to its autarky point so there may also be the benefit of prices varying to either side of autarky prices described in Section 1.4.

price of x to be welfare increasing, against an arithmetic mean counterfactual, we may also note the special case in which the good whose price is volatile is not consumed domestically. This may approximate reality in many cases. It is equivalent to setting $ß_x=0$ in the expressions above in which case $\alpha_x=\gamma_x$ and (2.2.8) reduces to:

$$\epsilon_x^P > \gamma_x R \qquad (2.2.11)$$

Removing consumption of the good whose price is volatile thus reduces the condition for volatility to be welfare improving, against an arithmetic mean counterfactual, to a straight comparison between the flexibility of output as relative prices change and the degree of risk aversion weighted by the economy's exposure to risk in the form of the share of exports of x in national income.

Many Volatile Prices, No Non-Tradeables

The results presented above have been concerned with the case where there is only one traded good with a volatile price. In practice, however, many economies facing volatile commodity prices export significant quantities of more than one commodity and hence it is desirable to extend the results for the case where there are many exogenous volatile prices. We denote these prices by P_i corresponding to physical outputs x_i and consumption c_i. Exports of each good are given by X_i.

From the methodology developed in Section 1.4 the change in expected utility from multiple price volatility is given by:

$$\Delta E(V) \approx \frac{1}{2}\Sigma_i Var(P_i)\frac{d^2V}{dP_i^2} + \frac{1}{2}\Sigma_i\Sigma_{j(i\neq j)} Cov(P_i,P_j)\frac{d^2V}{dP_i dP_j}$$

In which d^2V/dP_i^2 is the same as the results above with notation P_i instead of P. The cross derivative $d^2V/dP_i dP_j$ may be derived in a similar manner to yield, in aggregate exports form:

$$\frac{d^2V}{dP_i dP_j} = \frac{\partial V}{\partial m}\left[\frac{dX_i}{dP_j} - X_i\frac{\partial c_j}{\partial m} - X_i X_j A\right]$$

from which we have:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i Var(P_i)\left[\frac{dX_i}{dP_i} - X_i\frac{\partial c_i}{\partial m} - X_i^2 A\right]$$

$$+\frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i\Sigma_{j(i\neq j)} Cov(P_i,P_j)\left[\frac{dX_i}{dP_j} - X_i\frac{\partial c_j}{\partial m} - X_i X_j A\right] \quad (2.2.12)$$

or in elasticities form:

$$\Delta E(V) \approx \frac{1}{2} m\frac{\partial V}{\partial m}\Sigma_i Var(lnP_i)\gamma_i\left[\epsilon_{X_i}^{P_i} - \beta_i\epsilon_{c_i}^{\partial m} - \gamma_i R\right]$$

$$+\frac{1}{2} m\frac{\partial V}{\partial m}\Sigma_i\Sigma_{j(i\neq j)} Cov(lnP_i,lnP_j)\gamma_i\left[\epsilon_{X_i}^{P_j} - \beta_j\epsilon_{c_j}^{\partial m} - \gamma_j R\right] \quad (2.2.13)$$

Disaggregating the price response of exports into output and consumption components as before gives:

$$\frac{d^2V}{dP_i^2} = \frac{\partial V}{\partial m}\left[\frac{\partial x_i}{\partial P_i} - \frac{\partial c_i}{\partial P_i}\Big|_c - 2X_i\frac{\partial c_i}{\partial m} - X_i^2 A\right]$$

and:

$$\frac{d^2V}{dP_i dP_j} = \frac{\partial V}{\partial m}\left[\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}\Big|_c - X_i\frac{\partial c_j}{\partial m} - X_j\frac{\partial c_i}{\partial m} - X_i X_j A\right]$$

and hence combining the two gives us:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i Var(P_i)\left[\frac{\partial x_i}{\partial P_i} - \frac{\partial c_i}{\partial P_i}\Big|_c - 2X_i\frac{\partial c_i}{\partial m} - X_i^2 A\right]$$

$$+\frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i\Sigma_{j(i\neq j)}Cov(P_i,P_j)\left[\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}\Big|_c - X_i\frac{\partial c_j}{\partial m} - X_j\frac{\partial c_i}{\partial m} - X_i X_j A\right]$$

(2.2.14)

In the first line the first two terms within the square bracket represent the pure own price effects on output and consumption of the good with a volatile price. Both are positive, if there is some flexibility on the production side and allowing for the negative sign on the second term, indicating that volatility in one price, or a price not correlated with others, is of itself beneficial. This is because the revenue function and indirect utility function are both convex in price. The other two terms in the first line relate to income effects and are negative (if x_i is normal in consumption) showing that the costs of price volatility arise not from the volatility of prices themselves but from the income effects that they generate. This implies that there may be substantial benefits from income insurance, a possibility explored in the later chapters.

Turning to the second line the first pair of terms, the cross price derivatives of output and consumption of good i, are

negative. This shows that if other prices (P_j) covary positively with P_i they will limit the extent to which x_i and c_i respond in the right direction to P_i if they are simultaneously affected by this cross price effect. The other three terms are income effects and show how positive covariance between P_i and P_j will reinforce the economy's exposure to risk via the term in X_iX_j and further raise c_i at an "inappropriate" time by means of the income effect from variations in P_j weighted by exports of j, X_j. In turn, fluctuations in P_i give rise to a similar income effect on c_j, weighted by exports of i, X_i. Alternatively, if the prices have negative covariance, the addition of further goods with volatile prices may be beneficial since the sectors will usually be expanding and contracting at different times, thus adding to the price responsiveness of exports in each, and also the costs of fluctuating incomes will be weaker since the income effects from each volatile price will tend to offset each other. In practice these potential benefits may often not be realised since commodity prices tend to covary positively. In addition if the country exports many goods with volatile prices it is unlikely that all the covariances will be negative.

It may be noted that this discussion has assumed that the addition of further goods with volatile prices leaves the share in national income of the first good unchanged. If extra goods with volatile prices (with similar variation in the prices) are added but the overall share of all the goods

with volatile prices in national income remains unchanged it is beneficial for the country to be exporting several volatile goods rather than one. This is because, except as a special case, their prices will not move exactly together and hence leave some room for resource movements between them, hence adding to production flexibility, and some smoothing of their income effects. In the special case where the prices of these goods do move exactly in line the volatile sectors could be treated as a Hicksian aggregate and the analysis revert to the one good case.

One Volatile Tradeable Price, Non-Tradeables Present

We now consider the impact of relative price volatility on the welfare of the representative agent when we allow for the presence of non-tradeables. The procedure follows the same steps as above.

Define:

$$U(P) = V[P, P_n(P), m(P)]$$

from which:

$$\frac{dV}{dP} = \frac{\partial V}{\partial P} + \frac{\partial V}{\partial P_n}\frac{dP_n}{dP} + \frac{\partial V}{\partial m}\frac{dm}{dP}$$

and separating out income and substitution effects, denoting the three tradeable goods by i, gives:

$$\frac{dV}{dP} = \Sigma_i \left[\frac{\partial V}{\partial c_i}\left(\frac{\partial c_i}{\partial P}\Big|_c - c_x\frac{\partial c_i}{\partial m}\right)\right] + \Sigma_i \left[\frac{\partial V}{\partial c_i}\left(\frac{\partial c_i}{\partial P_n}\Big|c - c_n\frac{\partial c_i}{\partial m}\right)\right]\frac{dP_n}{dP} + \frac{\partial V}{\partial m}\frac{dm}{dP}$$

in which the pure substitution effects cancel out for small changes in P and P_n to yield:

$$\frac{dV}{dP}=\frac{\partial V}{\partial m}\left(\frac{dm}{dP}-c_x-c_n\frac{dP_n}{dP}\right) \qquad (2.2.15)$$

from which, substituting in (2.1.8), we have:

$$\frac{dV}{dP}=\frac{\partial V}{\partial m}\left[x-c_x+\frac{dP_n}{dP}(n-c_n)\right] \qquad (2.2.16)$$

Since n is non-tradeable, output must equal the level of consumption so $n=c_n$ and (2.2.16) becomes:

$$\frac{dV}{dP}=\frac{\partial V}{\partial m}(x-c_x) \qquad (2.2.17)$$

which is the same expression as that for the two good case.

Hence the valuation effect on the output of non-tradeables found in the derivative dm/dP has netted out and the derivative of utility with respect to the volatile price involves terms in the marginal utility of income and exports only. This would be expected since a change in the price of the non-tradable taken alone should leave welfare unchanged given that a higher price for consumers implies a higher price for producers and the effects on welfare cancel out when a representative agent is being considered.

While the first derivative given in (2.2.17) is the same as for the two good case, the presence of non-tradeables will alter the second derivative since changes in the relative price of those goods will affect the response of c_x, x and the marginal utility of income to P.

After following the same steps as above the second derivative may be expressed as follows, expressing the results initially in terms of exports rather than disaggregating them into production and consumption:

$$\frac{d^2V}{dP^2} = \frac{\partial V}{\partial m}\left(\frac{dX}{dP} - X\frac{\partial c_x}{\partial m} - X^2A - X\frac{\partial c_n}{\partial m}\frac{dP_n}{dP}\right)$$

which is the same as in the two good case except for the last term.

Disaggregating dX/dP as before gives us:

$$\frac{d^2V}{dP^2} = \frac{\partial V}{\partial m}\left[\frac{\partial x}{\partial P} - \frac{\partial c_x}{\partial P}\Big|_{\bar{c}} - 2(x-c_x)\frac{\partial c_x}{\partial m} - (x-c_x)^2A\right.$$

$$\left. - \frac{dP_n}{dP}\left(\frac{\partial c_x}{\partial P_n}\Big|_{\bar{c}} - \frac{\partial x}{\partial P_n} + (x-c_x)\frac{\partial c_n}{\partial m}\right)\right] \qquad (2.2.18)$$

where the top line is common to the two good case while the second line gives the effect on dV/dP of further rises in P due to the induced change in P_n. These comprise the impact of changes in P_n on x and c_x, and thus exports of x, and the final term in the income response of consumption of non-tradeables. The latter is important since income and c_n rise as P and P_n increase and while there is no real income effect from non-tradeables prices on the level of utility, what is important for the second derivative above is changes to the marginal utility of income which falls as P_n rises and rises when P_n falls.

We may also modify equation (2.2.18) to remove the term in dP_n/dP since it will in turn depend on underlying taste

parameters and the output response to price in the non-tradeables sector. To do this we note from the previous section that:

$$\frac{dP_n}{dP} = \frac{\frac{\partial c_n}{\partial P}\Big|_c - \frac{\partial n}{\partial P} + (x - c_x)\frac{\partial c_n}{\partial m}}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}\Big|c} \qquad (2.1.10)$$

which will be positive if non-tradeables are normal and x is exported.

Substituting (2.1.10) into (2.2.18) gives:

$$\frac{d^2V}{dP^2} = \frac{\partial V}{\partial m}\Big[\frac{\partial x}{\partial P} - \frac{\partial c_x}{\partial P}\Big|_c - 2(x - c_x)\frac{\partial c_x}{\partial m} - (x - c_x)^2 A$$

$$- \frac{\left(\frac{\partial c_n}{\partial P}\Big|_c - \frac{\partial n}{\partial P} + (x - c_x)\frac{\partial c_n}{\partial m}\right)\left(\frac{\partial c_x}{\partial P_n}\Big|c - \frac{\partial x}{\partial P_n} + (x - c_x)\frac{\partial c_n}{\partial m}\right)}{\left(\frac{dn}{dP_n} - \frac{\partial c_n}{\partial P_n}\Big|_c\right)}\Big] \qquad (2.2.19)$$

The last term of which could be simplified using the symmetry between the cross price derivatives in the two brackets of the numerator though this gives little benefit so is not done. Equation (2.2.19) may also be expressed in terms of elasticities as follows:

$$\Delta E(V) = \frac{1}{2} m \frac{\partial V}{\partial m} Var(lnP)\Big[\alpha_x \epsilon_x^{\partial P} - \beta_x \epsilon_{c_x}^{\partial P}\Big|_c - 2\beta_x \gamma_x \epsilon_{c_x}^{\partial m} - \gamma_x^2 R$$

$$- \beta_n \frac{\left(\epsilon_{c_n}^{\partial P}\Big|_c - \epsilon_n^{\partial P} + \gamma_x \epsilon_{c_n}^{\partial m}\right)\left(\epsilon_{c_x}^{\partial P_n}\Big|_c - \epsilon_x^{\partial P_n} + \gamma_x \epsilon_{c_n}^{\partial m}\right)}{\left(\epsilon_n^{\partial P_n} - \epsilon_{c_n}^{\partial P_n}\Big|_c\right)}\Big] \qquad (2.2.20)$$

Equation (2.2.20) is the core result of this section and brings out the effects of including non-tradeables in the model. The first line is common to the two good case and hence the impact of non-tradeables is to be found in the second line. This is weighted by the $ß_n$ outside the bracket so that if the non-tradeables sector is small the term will be of minor significance.

Thus including non-tradeables in the model has two key effects; the first being that the export sector and the non-tradeables sector may compete for resources and hence limit the degree of flexibility in expanding exports of x at times when its relative price is high, as seen in the previous section. It is also possible that the non-tradeables sector may provide resources if dP_n/dP is negative[2] but this is unlikely since it requires strong inferiority of non-tradeables. The second effect is concerned with falls in the marginal utility of income as P_n rises with P due to higher levels of consumption of non-tradeables with rising income. This may be thought of as variations in the exogenous volatile tradeables price inducing endogenous price volatility in the non-tradeables sector.

This discussion also suggests that there may be considerable gains in this model from the availability of insurance or capital markets. This is because they permit consumption

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[2] Assuming that the resources in the non-tradeables sector would otherwise be divided between the volatile price sector and the tradeables with stable prices.

smoothing which is likely to lead to much smaller fluctuations in the price of non-tradeables than without insurance and hence lead to more resources being available to the x sector than otherwise. As a result insurance may add to the production flexibility achieved by the tradeables sector and hence give rise to increased expected welfare from this source rather than simply reducing income fluctuations as in the two good case.

Many Volatile Tradeables Prices, Non-Tradeables Present

From the methodology developed in Section 1.4 the change in expected utility from multiple price volatility is given by:

$$\Delta E(V) \approx \frac{1}{2}\Sigma_i Var(P_i)\frac{d^2V}{dP_i^2}+\frac{1}{2}\Sigma_i\Sigma_{j_{(i\neq j)}} Cov(P_i,P_j)\frac{d^2V}{dP_i dP_j}$$

In which d^2V/dP_i^2 is the same as the results above with P_i instead of P. The cross derivative $d^2V/dP_i dP_j$ may be derived in a similar manner to yield, in aggregate exports form:

$$\frac{d^2V}{dP_i dP_j}=\frac{\partial V}{\partial m}\left[\frac{dX_i}{dP_j}-X_i\frac{\partial c_j}{\partial m}-X_iX_jA-X_i\frac{\partial c_n}{\partial m}\frac{dP_n}{dP_j}\right]$$

from which we have:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i Var(P_i)\left[\frac{dX_i}{dP_i}-X_i\frac{\partial c_i}{\partial m}-X_i^2A-X_i\frac{\partial c_n}{\partial m}\frac{dP_n}{dP_i}\right]$$

$$+\frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i\Sigma_{j_{(i\neq j)}} Cov(P_i,P_j)\left[\frac{dX_i}{dP_j}-X_i\frac{\partial c_j}{\partial m}-X_iX_jA-X_i\frac{\partial c_n}{\partial m}\frac{dP_n}{dP_j}\right]$$

or in elasticities form:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} \Sigma_i Var(lnP_i) \gamma_i [\epsilon_{X_i}^{P_i} - \beta_i \epsilon_{c_i}^{\partial m} - \gamma_i R - \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_i}]$$

$$+ \frac{1}{2} m \frac{\partial V}{\partial m} \Sigma_i \Sigma_{j_{(i \neq j)}} Cov(lnP_i, lnP_j) \gamma_i [\epsilon_{X_i}^{P_j} - \beta_j \epsilon_{c_j}^{\partial m} - \gamma_j R - \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_j}]$$

(2.2.21)

Disaggregating the price response of exports into output and consumption components gives us, as before:

$$\frac{d^2V}{dP_i^2} = \frac{\partial V}{\partial m} [\frac{\partial x_i}{\partial P_i} - \frac{\partial c_i}{\partial P_i}|_c - 2X_i \frac{\partial c_i}{\partial m} - X_i^2 A$$

$$- \frac{(\frac{\partial c_n}{\partial P_i}|_c - \frac{\partial n}{\partial P_i} + X_i \frac{\partial c_n}{\partial m})(\frac{\partial c_i}{\partial P_n}|_c - \frac{\partial x_i}{\partial P_n} + X_i \frac{\partial c_n}{\partial m})}{(\frac{dn}{dP_n} - \frac{\partial c_n}{\partial P_n}|_c)}] \qquad (2.2.22)$$

and:

$$\frac{d^2V}{dP_i dP_j} = \frac{\partial V}{\partial m} [\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}|_c - X_i X_j \frac{R}{m} - X_i \frac{\partial c_j}{\partial m} - X_j \frac{\partial c_i}{\partial m}$$

$$- \frac{dP_n}{dP_j} (\frac{\partial c_i}{\partial P_n}|_c - \frac{\partial x_i}{\partial P_n} + X_i \frac{\partial c_n}{\partial m})]$$

which may be expanded by substituting in for dP_n/dP_j to give:

$$\frac{d^2V}{dP_i dP_j} = \frac{\partial V}{\partial m} [\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}|_c - X_i \frac{\partial c_j}{\partial m} - X_j \frac{\partial c_i}{\partial m} - X_i X_j A$$

$$- \frac{(\frac{\partial c_n}{\partial P_j}|_c - \frac{\partial n}{\partial P_j} + X_j \frac{\partial c_n}{\partial m})(\frac{\partial c_i}{\partial P_n}|_c - \frac{\partial x_i}{\partial P_n} + X_i \frac{\partial c_n}{\partial m})}{(\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}|_c)}] \qquad (2.2.23)$$

and hence combining the two gives us:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i Var(P_i)\,[\frac{\partial x}{\partial P_i} - \frac{\partial c_x}{\partial P_i}|_c - 2X_i\frac{\partial c_x}{\partial m} - X_i^2 A$$

$$- \frac{(\frac{\partial c_n}{\partial P_i}|_c - \frac{\partial n}{\partial P_i} + X_i\frac{\partial c_n}{\partial m})\,(\frac{\partial c_i}{\partial P_n}|_c - \frac{\partial x_i}{\partial P_n} + X_i\frac{\partial c_n}{\partial m})}{(\frac{dn}{dP_n} - \frac{\partial c_n}{\partial P_n}|_c)}]$$

$$+ \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i\Sigma_{j_{(i\neq j)}} Cov(P_i, P_j)\,[\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}|_c - X_i\frac{\partial c_j}{\partial m} - X_j\frac{\partial c_i}{\partial m} - X_i X_j A$$

$$- \frac{(\frac{\partial c_n}{\partial P_j}|_c - \frac{\partial n}{\partial P_j} + X_j\frac{\partial c_n}{\partial m})\,(\frac{\partial c_n}{\partial P_i}|_c - \frac{\partial n}{\partial P_i} + X_i\frac{\partial c_n}{\partial m})}{(\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}|_c)}] \qquad (2.2.24)$$

The interpretation of the first and third lines of this expression is exactly the same as that given for the many volatile prices case without non-tradeables above. We therefore focus on the second and fourth lines which demonstrate the effect of including non-tradeables in the model. If non-tradeables are normal both these terms are negative given the sign in front of them. The reason for this is that the normality assumption implies that P_n will always rise with P_i or P_j, thereby in effect ensuring positive covariance between those prices. This implies that the damaging effects of another price rising at the same time as P_i increases come into play in the same way as simultaneous rises in one of the exogenous prices above. This results from both the reduced price response of the sectors with volatile

prices as resources are diverted to the non-tradeables sector, and the direct cost to welfare from fluctuations in the price of non-tradeables. This is further suggestive of the benefits from income insurance analysed in the following chapter.

In the light of this discussion the second line may be regarded as the damaging cross price effect between P_i and P_n, including the determinants of the rise in P_n, and the fourth line the extent to which this is made worse by simultaneous increases in P_j raising P_n further.

Geometric Mean Counterfactual

<u>One Volatile Tradeable Price, No Non-Tradeables</u>

Following the pattern of the previous section, for a geometric mean counterfactual we still wish to examine the derivatives of V(P) but rather than deriving the second derivative alone we want to use:

$$\frac{d^2V}{d(lnP)^2} = P^2\frac{d^2V}{dP^2} + P\frac{dV}{dP}$$

which yields the following expression for the change in expected utility against a geometric mean counterfactual:

$$\Delta E(V) \approx \frac{1}{2} Var(lnP)\frac{\partial V}{\partial m} P\left(P\frac{dx}{dP} - P\frac{\partial c_x}{\partial P}\Big|_c - PX^2A - 2PX\frac{\partial c_x}{\partial m} + X\right)$$

which may be compared with Eaton's condition discussed earlier:

The last term of which differs from the last two terms in the

$$-P\frac{\partial c_x}{\partial P}\Big|_c - PX^2A + P\frac{dx}{dP} - X\left(P\frac{\partial c_x}{\partial m} - \frac{\partial c_y}{\partial m}\right) > 0 \quad (1.2.2)$$

bracket of the previous expression though in fact the two are equivalent. This is because the assumption of no savings implies that total expenditure must increase by the same amount as income. Total expenditure is Pc_x+c_y and hence:

$$P\frac{\partial c_x}{\partial m} + \frac{\partial c_y}{\partial m} = 1$$

so:

$$-X\left(P\frac{\partial c_x}{\partial m} - \frac{\partial c_y}{\partial m}\right) = -X\left(2P\frac{\partial c_x}{\partial m} - 1\right) = X - 2PX\frac{\partial c_x}{\partial m}$$

and the two expressions are the same.

In elasticities form we have:

$$\Delta E(V) \approx \frac{1}{2} Var(lnP)\, m\frac{\partial V}{\partial m}\gamma_x\left(\epsilon_X^P - \beta_x\epsilon_{c_x}^{\partial m} - \gamma_x R + 1\right) \quad (2.2.25)$$

which differs from (2.2.7) only by the addition of unity within the bracket. As a result the condition for a welfare improvement against a geometric mean counterfactual is:

$$\epsilon_X^P - \beta_x\epsilon_{c_x}^{\partial m} > \gamma_x R - 1 \quad (2.2.26)$$

which is the same as before except for minus unity on the right hand side which makes it more likely that the condition will be satisfied. This illustrates once again that the use of the geometric mean counterfactual rather than the arithmetic mean does not alter the economic analysis of the issue (since no additional variables are involved), but merely shifts the point of comparison in favour of volatility since

a geometric mean is less than an arithmetic mean for a given distribution of the volatile price.

The other three cases follow a similar pattern, with the addition of one constant per volatile tradeables price to allow for the gap between the geometric and arithmetic means, the expressions above being otherwise unchanged.

Many Volatile Tradeables Prices, No Non-Tradeables

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} \Sigma_i Var(lnP_i) \gamma_i [\epsilon_{X_i}^{P_i} - \beta_i \epsilon_{c_i}^{\partial m} - \gamma_i R + 1]$$

$$+ \frac{1}{2} m \frac{\partial V}{\partial m} \Sigma_i \Sigma_{j_{(i \neq j)}} Cov(lnP_i, lnP_j) \gamma_i [\epsilon_{X_i}^{P_j} - \beta_j \epsilon_{c_j}^{\partial m} - \gamma_j R]$$

(2.2.27)

One Volatile Tradeable Price, Non-Tradeables Present

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} Var(lnP) \gamma_x [\epsilon_X^P - \beta_x \epsilon_{c_x}^{\partial m} - \gamma_x R - \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^P + 1]$$

(2.2.28)

Many Volatile Tradeables Prices, Non-Tradeables Present

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} \Sigma_i Var(lnP_i) \gamma_i [\epsilon_{X_i}^{P_i} - \beta_i \epsilon_{c_i}^{\partial m} - \gamma_i R - \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_i} + 1]$$

$$+ \frac{1}{2} m \frac{\partial V}{\partial m} \Sigma_i \Sigma_{j_{(i \neq j)}} Cov(lnP_i, lnP_j) \gamma_i [\epsilon_{X_i}^{P_j} - \beta_j \epsilon_{c_j}^{\partial m} - \gamma_j R - \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_j}]$$

(2.2.28)

Conclusion

The previous section identified the price responsiveness of output as the key variable affecting the response of national income to price volatility. This section has broadened the analysis to consider changes in the expected utility of the representative agent under the same conditions. Considering the case where the allocation of fixed factors remains the same as under price stability and there are no insurance possibilities it was found that the price responsiveness of output remained important and variables determined by consumers' preferences and the degree of risk aversion must be considered also. The role of risk aversion in affecting expected utility is clear since relative price volatility causes fluctuations in the level of income and consumption. In addition the representative agent's preferences are also important in determining the price and income elasticities of demand for the export good. The price elasticity is important since it is a measure of the flexibility in consumption in response to relative prices, with the agent gaining from preferences that allow consumption to be sensitive to relative price movements. The income elasticity also has an important role because price volatility causes fluctuations in nominal income and also leads to additional income effects via the usual separation between income and substitution effects with nominal income held constant. These effects stimulate higher consumption of the export good when its relative price is high if the income elasticity is positive and low when the relative

price is low. These fluctuations in the consumption of the export good are costly since it would be more advantageous for consumption of the export good to vary little with income or even for the risky good to be inferior so that consumption of it occurs mostly when its relative price is low.

Adding non-tradeables to the model implies two potential costs to volatility. The first is that the output of tradeables with volatile prices may not respond so well to their own prices due to a cross price effect from the price of non-tradeables rising at the same time. The second is that induced volatility in the price of non-tradeables is itself costly. This is not a pure price effect (which would be beneficial given the convexity of the indirect utility function) but relates to the marginal utility of income. As a tradeables price rises income and the price of non-tradeables (if they are normal) will also rise and the increase in the price of non-tradeables will decrease the benefit to utility of the increase in income.

It was found that the impact of volatility on expected utility was ambiguous in general which is interesting since it suggests that small open economies may gain from relative price fluctuations if they are sufficiently flexible and not too risk averse. If we take consumers' preferences as given the challenge is to examine the factors that influence production flexibility and hence expected national income in an uncertain environment and to analyse how the potential

costs to expected utility arising from income fluctuations may be reduced by different forms of insurance.

CHAPTER 3

PERFECT INTERNATIONAL RISK AND CAPITAL MARKETS

The previous chapter examined the conditions in which a small open economy may gain or lose from price volatility and the circumstances in which expected national income may rise or remain invariant. This work assumed that there was no scope for intertemporal substitution or substitution across states of the world (with a state being a value of relative prices) and hence that consumption in each period or state was equal to income. It was seen that volatility may give rise to higher expected income but nevertheless lead to lower welfare if the representative agent was risk averse or the export good normal. This chapter relaxes the assumption of no cross-state substitution of consumption and thus looks at whether agents can use risk markets to retain the benefits of price volatility while avoiding at least some of the costs. Chapter 2 found that the direct effects of price volatility were potentially beneficial while the indirect effects of price volatility via fluctuations in income were likely to be harmful. This chapter illustrates the distinction between pure price effects and income effects by assuming that perfect risk markets are available and hence agents may smooth their income while still facing volatile prices. The thesis does not address the possibilities for, and effects of, price stabilisation schemes[1] but it may be noted that such schemes

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[1]On this topic see Newbery and Stiglitz (1981).

would in principle lead to stable incomes and prices, thus providing income insurance at the cost of losing the possible benefits of fluctuating prices.

The markets considered are those for insurance, capital, futures and options. There is a substantial literature on the extent to which these markets in practice allow an LDC to smooth export revenue given market imperfections, constraints on borrowing and so on. The intention here is not to explore this literature but to show that these markets, if perfect or unbiased, allow an economy to choose between the pure price and income effects from price volatility by choosing the optimal degree of income insurance. Hence the main task is to derive the optimal amount of insurance and derive the welfare effects of volatility given that level of insurance. The consequences of market imperfections are not addressed explicitly but may be seen as intermediate between the results of Chapter 2 with no risk markets and this chapter with perfect risk markets.

The chapter is structured as follows. Section 3.1 demonstrates that the different markets mentioned above, if perfect or unbiased, may be used to deliver the optimal amount of insurance at equal (zero) cost so in the rest of the chapter it is not necessary to refer to a particular kind of risk market. Section 3.2 considers the optimal insurance decision, and the level of welfare under volatility given optimal insurance, for the representative agent while Section

3.3 looks at the same questions for private agents.

An important point is that we assume that the risk and capital markets are international. This is absolutely necessary when considering the representative agent since if we think of the representative agent as the whole economy it is clear that the economy cannot insure itself. Similarly if we think of the representative agent arising from identical tastes and factor endowments so that there are many representative agents, all with identical outcomes, there would be no incentive for them to trade across states of the world with each other. When looking at the insurance behaviour of private agents we also take the risk markets to be international since a domestic insurance market would not offer insurance at fair odds due to the economy being exposed to systemic risk. This case is analysed in Chapter 5.

3.1 EQUIVALENCE OF RISK AND CAPITAL MARKETS

We consider insurance, capital, futures and options markets in turn, showing that they may play similar roles in providing income smoothing across states of the world.

Insurance market

We denote the payout from the insurance contract written over P_i by I_i and assume that the insurance market is perfect and hence insurance supplied by risk neutral companies with zero expected profits. We denote the quantity of insurance purchased by q_i in which case the insurance contract available to the commodity exporter is:

$$I_i = (\bar{P}_i - P_i)\, q_i \qquad (3.1.1)$$

Where $E[I]=0$ because $E[P_i]=\bar{P}$ so the contract satisfies the zero profit condition for the provider of insurance.

From (3.1.1):

$$\frac{dI}{dP_i} = -q_i \qquad (3.1.2)$$

showing that if q_i is positive a contract of this type will offset rising income as P_i rises, without changing expected income or $m(\bar{P})$.

Capital market

In the case of a perfect capital market the economy or agents

may smooth income fluctuations by depositing funds into an overseas account when national income is high and withdrawing funds when it is low. With a perfect market the economy can borrow or lend as much as it chooses at a constant interest rate. The implication of this is that the expected deposit or withdrawal must be equal to zero.

In these circumstances the economy can smooth fluctuations by adhering to a savings function rather than an insurance contract. If the savings function is defined in terms of the amount withdrawn from the account, and this amount is denoted by W_i, by analogy with the insurance case we have:

$$W_i = (\bar{P}_i - P_i)\, q_i \qquad (3.1.3)$$

so:

$$\frac{dW_i}{dP_i} = -q_i \qquad (3.1.4)$$

and:

$$E(W_i) = q_i E[(\bar{P}_i - P_i)] = q_i (\bar{P}_i - E(P_i)) = 0 \qquad (3.1.5)$$

so with a perfect international capital market the economy can achieve the same reduction in income fluctuations as with a zero profit insurance market.

Futures market

We assume that the economy has access to an unbiased international futures market whereby it can sell forward any amount of its export good at the expected price $\bar{P}$. Denoting

the amount sold forward by q_i and assuming for simplicity that there is only one export good with a volatile price, i, national income will be given by:

$$m=P_i(x_i-q_i)+y+\overline{P}_i q_i \qquad (3.1.6)$$

or:

$$m=P_i x_i+y+(\overline{P}_i-P_i)\,q_i \qquad (3.1.7)$$

so:

$$\frac{dm}{dP_i}=x_i-q_i \qquad (3.1.8)$$

These expressions have the same structure as the cases above so the use of an unbiased futures market allows the economy to sell forward a quantity of the export good with a volatile price and thereby stabilise income to any extent desired.

Before turning to the use of options it may be noted that once a contract of the kind specified above is in place it is fixed and does not alter the subsequent incentives faced by the economy as relative prices change. For example in the futures case a situation may arise in which the economy has contracted to deliver a certain amount of the commodity and it turns out that prices at that time are low so that the normal marginal conditions would suggest producing less than the contracted amount. In this situation the economy should produce the amount that it would in the absence of a futures contract and make up any difference by purchases on the world market for immediate delivery (at a profit) to fulfil the conditions of the futures contract. Similarly if world prices are high,

such that the normal marginal conditions would suggest producing more than the amount specified in the futures contract, the economy should once again produce the amount it would in the absence of the contract and sell the extra volume onto the spot market. Hence a futures or any other type of contract signed in advance need not and should not affect decisions about output and resource allocation.

Options market

An options contract specifies a quantity of the export good, denoted by q_i again, that may be sold to the seller of the option at a price P_o termed the strike price. If the economy buys an option[1] it will therefore exercise it if the prevailing market price is lower than the strike price once production has taken place. This type of contract is not in general susceptible to the same analysis as above because the payoff function to the country expressed in terms of the market price is not smooth at the strike price, P_o. This is because for market prices above P_o the option is not exercised and the payoff to the country from having the contract is equal to minus the cost of the contract whereas for prices below P_o the contract is exercised and the payoff to the country increases with a declining market price.

One way round this problem is to assume that the strike price

[1]Formally a Put Option in the case of the right to sell the physical commodity.

is equal to the highest possible market price, P^H, so that the option is always exercised. If the quantity specified in the contract is q_i and the purchase price of the contract is c, we have:

$$m=P_i(x_i-q_i)+y+P_i^H q_i-c \qquad (3.1.9)$$

With a perfect market the cost, c, will be given by setting the profits of the option seller equal to zero. If we denote these profits by π we have:

$$E(\pi)=E[c-q_i(P_i^H-P_i)]=0 \qquad (3.1.10)$$

where the last term in the square bracket is the cost to the seller of the contract being exercised and equal to the quantity involved multiplied by the difference between the price at which the seller of the option is obliged to buy it and its market value at that time.

For zero expected profits it is clear that:

$$c=q_i(P_i^H-\overline{P}_i) \qquad (3.1.11)$$

and hence national income is given by:

$$m=P_i x_i+y+(\overline{P}_i-P_i)q_i \qquad (3.1.12)$$

which has the same structure as the cases above and hence the optimal value of q_i for the exporting country is the same as in the other cases above.

This example is somewhat artificial in that setting the strike price at the highest point in the range of possible market prices in effect turns an option contract into a form of

futures contract since the option will always be exercised.

A more realistic case would be where the strike price is in the neighbourhood of the expected price, $\bar{P}$, so that the option is exercised approximately half the time. This reintroduces the discontinuity problem so rather than considering the whole range of possible prices we look at a two point distribution such that relative prices take the values P^H and P^L with equal probability.

The rationale for doing this is shown by Figure 3.1. The line OO represents the function m(P) without any options contract. It is drawn as linear for simplicity but in general will be non-linear if dx/dP is non-zero. The effect of an options contract specifying a small quantity is shown by the line 11 where income when the price is above its average value is reduced by the cost of the contract, c_1, whereas at prices below their mean value the slope of the function is reduced, reflecting the fact that a portion of the economy's output of the commodity has been sold at $\bar{P}$ to the seller of the options contract. If the quantity specified in the contract is increased to the whole amount of the economy's output we have the line 22 where income at above average prices is reduced by the higher cost, c_2, and income is invariant to below average prices because all output is sold under the contract. If the quantity specified rises further we reach 33 where income in the right hand half of the figure is reduced by c_3 and income now rises in the left hand half because as prices fall the

FIGURE 3.1

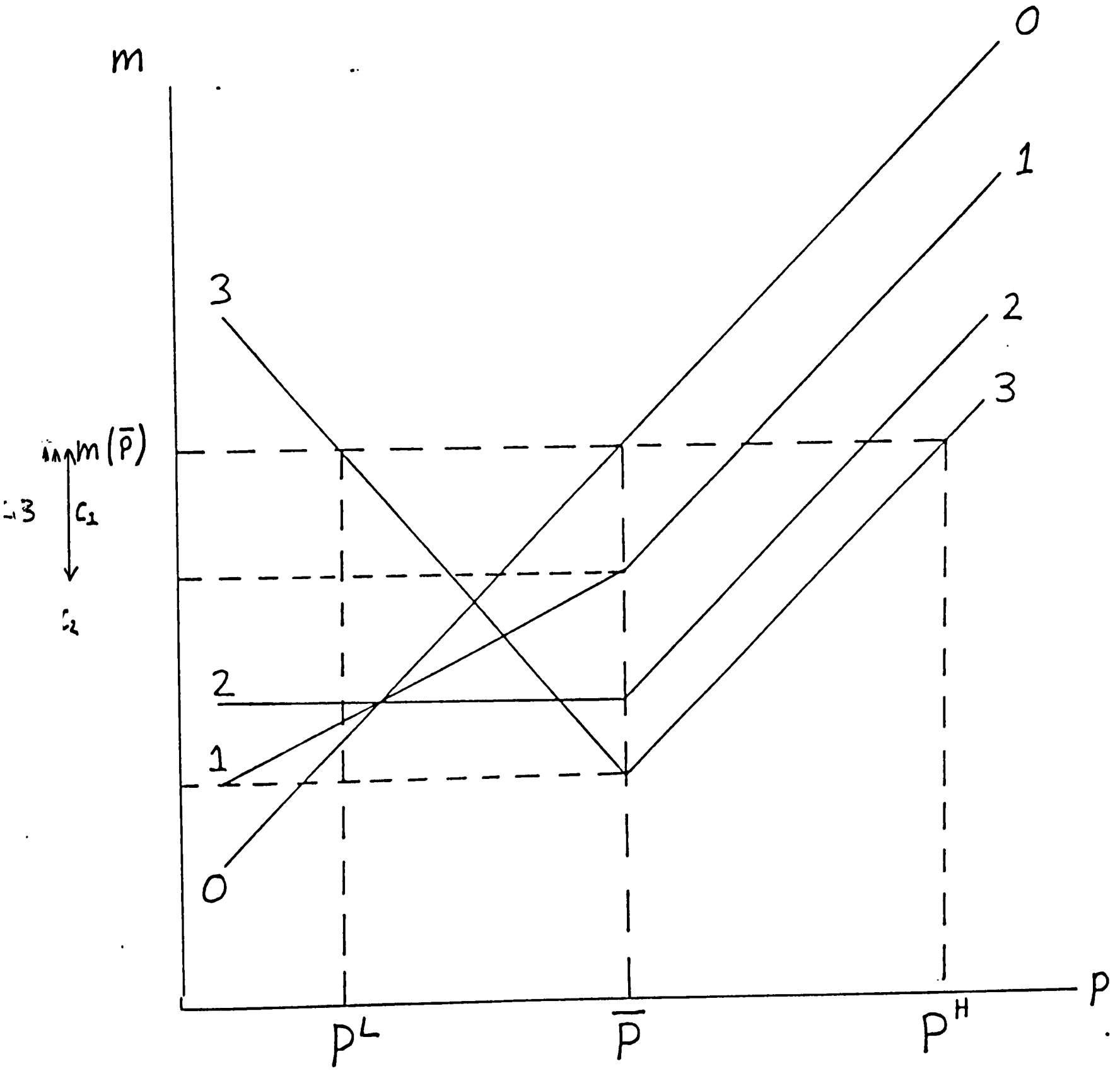
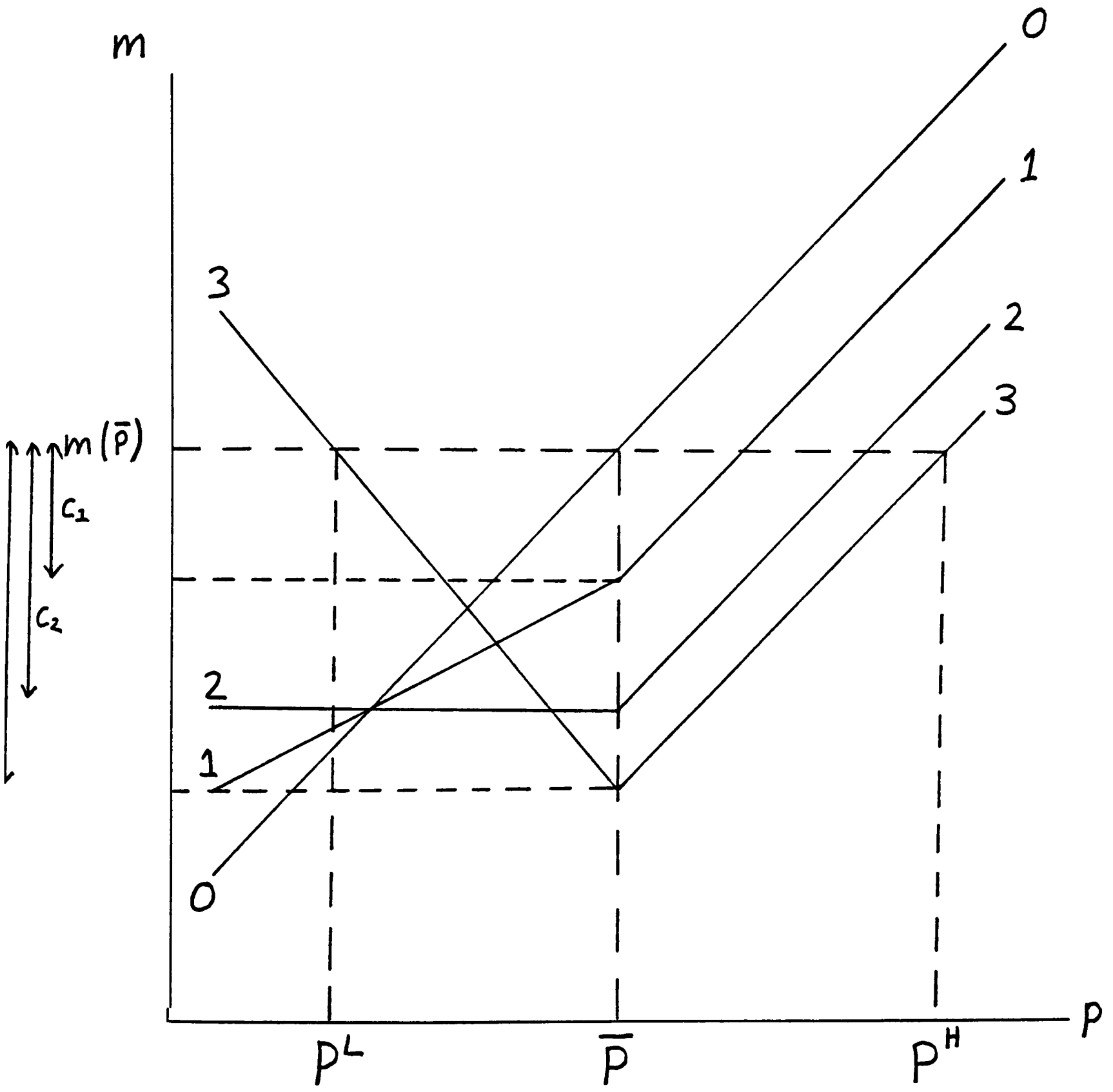


FIGURE 3.1



economy makes larger and larger gains. These gains arise from the options contract specifying a larger quantity than the economy produces itself so that the difference is purchased on the open market and sold at a profit to the option seller at $\bar{P}$. Hence in this situation the payoff to the economy from the commodity price, P, has a V-shape with a change of slope at the bottom of the V. This shows how an options market behaves differently from a futures market but also demonstrates that analysis of them is straightforward if we assume that P can take only two discrete values, as shown on the figure, and hence complete income stabilisation is achieved at $m(\bar{P})$. Clearly this would not be the case if P could take on a range of values between the two extremes.

This may be shown mathematically as follows. For simplicity we also assume that the strike price is equal to $\bar{P}$. On these assumptions income in the two states will be given by:

$$m_H = P_i^H x_i + y - c$$

where the option is not exercised, and:

$$m_L = P_i^L (x_i - q_i) + y + (\bar{P}_i - P_i^L) q_i - c$$

for the case in which the option is exercised.

As before we should determine the value of c, the cost of the contract, by applying the zero profits condition to the payoff to the option seller. This is given by:

$$E(\pi) = \frac{2c - q_i(\bar{P}_i - P_i^L)}{2} = 0$$

the solution to which is:

$$c=\frac{q_i(\overline{P}_i-P_i^L)}{2}=\frac{q_i(P_i^H-\overline{P}_i)}{2}$$

and so:

$$m_H=P_i^H x_i+y+\frac{(\overline{P}_i-P_i^H)\,q_i}{2}$$

$$m_L=P_i^L x_i+y+\frac{(\overline{P}_i-P_i^L)\,q_i}{2}$$

which both have the form:

$$m=P_i x_i+y+\frac{(\overline{P}_i-P_i)\,q_i}{2}$$

so that:

$$\frac{dm}{dP_i}=x_i-\frac{1}{2}q_i \qquad (3.1.13)$$

These expressions are of the same structure as the other cases except for the term in q_i being over two in this instance so the optimal value of q_i will be twice the amount in the other cases.

Hence with a two point distribution of relative prices the options case is comparable to the others except that the optimal quantity specified in the contract has doubled. This implies that in the high price state the economy simply sells exports at the prevailing market price and in the low price state it exercises the option and sells both its own exports to the seller of the option and also buys in the open market to resell to the options seller at a higher price. Hence an

options contract specifies a larger amount so that the economy will make a sufficiently large loss from the cost of the contract in the high price state and a sufficiently large speculative gain in the low price state in order to achieve the desired level of income smoothing.

The case considered was that where relative prices could take on two discrete values only. With a continuous distribution of prices the use of options is more complicated and to achieve a smooth profile of income as prices vary would most likely require a series of options contracts at different strike prices. The difficulty with smoothing is that the payoff from an individual options contract is inherently non-smooth at the strike price so as to achieve smoothing in aggregate would necessitate a sequence of strike prices in different contracts.

3.2 SOCIALLY OPTIMAL INSURANCE

The discussion above showed the equivalence of different types of risk and capital markets and demonstrated that if they are perfect or unbiased a commodity exporter could achieve any degree of income stabilisation or destabilisation as prices change without any reduction in expected income. While maintaining the assumption of perfect or unbiased markets it therefore remains to derive the optimum quantity of "insurance" given by q_i in the expressions above and to see its effect on expected utility under volatility assuming that at least one of these markets is available.

This choice may be analysed by noting that the insurance or other contracts described above will affect expected utility by altering the way in which income responds to price changes. The analysis of Chapter 2 made use of the derivative dm/dP_i whereas now we need to replace this with $dm/dP_i+dI/dP_i$ where I is the payout from the insurance or other risk reducing contract and its price derivative is $-q_i$ in the insurance/capital markets/futures market standard case where q_i is the quantity of insurance.

One Volatile Tradeable Price, No Non-Tradeables

From Chapter 2 the change in expected utility from volatility without insurance is given by:

$$\Delta E(V) \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{dx}{dP} - \frac{\partial c_x}{\partial P}|_c - 2(x-c_x) \frac{\partial c_x}{\partial m} - (x-c_x)^2 A]$$

(2.2.9)

If the economy can trade on a perfect international insurance market along the lines described above the expression should be changed to account for the fact that now dm/dP will become dm/dP+dI/dP and hence x-q replaces x. As a result the new expression is:

$$\Delta E(V) \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{dx}{dP} - \frac{\partial c_x}{\partial P}|_c - 2(x-q-c_x) \frac{\partial c_x}{\partial m} - (x-q-c_x)^2 A]$$

From which it may be seen that a possible choice for the quantity of insurance, q, is $q=x-c_x$ which would remove all variation in real income and leave expected utility increasing in price volatility due to the production and consumption flexibility terms at the front of the square bracket above. This is not, however, the optimal choice which may be derived from the derivative:

$$\frac{d\Delta E(V)}{dq} \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [2 \frac{\partial c_x}{\partial m} + 2(x-q-c_x) A] \qquad (3.2.1)$$

which gives:

$$q^* = x - c_x + \frac{1}{A} \frac{\partial c_x}{\partial m} \qquad (3.2.2)$$

Which will be a maximum since from (3.2.1) the second order condition will be satisfied as long as R is greater than zero which is a standard assumption.[1]

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[1]R>0 is also the necessary and sufficient condition for the second order conditions in the other cases below.

Equation (3.2.2) implies that the socially optimal quantity of insurance is greater than the level of exports if x is normal and if implemented would make real income move in the opposite direction to P. This results from the income response of consumption of x and shows that the representative agent will gain from income rising at times when P is low in contrast to the losses to expected utility that were incurred without insurance by income being synchronised with P and hence the income effect on consumption of x being strong at a time when its price was high. From the expression for q^* this motive for extra insurance will be dampened by risk aversion since this parameter imposes a cost to fluctuations in real income either in phase with P or in anti-phase.

Hence with optimal insurance the change in expected utility from volatility will be higher than simply the first two terms above in production and consumption flexibility since access to risk or capital markets permits an open choice of the relationship between income changes and price changes rather than simply the stabilisation of real income. Substituting the expression for q^* into that for the change in expected utility above we have:

$$\Delta E(V) \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{dx}{dP} - \frac{\partial C_x}{\partial P}|_c + \frac{1}{A} (\frac{\partial C_x}{\partial m})^2] \qquad (3.2.3)$$

in which the first two terms correspond to production and consumption flexibility and the final term to the benefits of optimal income "over" insurance.

It may also be shown that (3.2.3) may be expressed as:

$$\Delta E(V) \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} \frac{dX}{dP} \qquad (3.2.4)$$

because the last two terms in the bracket of (3.2.3) are equal to dc_x/dP once the income effect of the insurance contract is included and hence implicit in dX/dP though the magnitude of this derivative will differ from its no insurance value because of the changed income effect.

Lastly, with one volatile price and no non-tradeables the use of insurance will not affect expected income since that depends on dx/dP alone. The latter variable is a pure price response when there are no non-tradeables and hence unaffected by fluctuations in income or their reduction through insurance.

Many Volatile Tradeables Prices, No Non-Tradeables

With many volatile prices, but still no non-tradeables, the change in expected utility from volatility without insurance was given in the previous chapter by:

$$\Delta E(V) \approx \frac{1}{2} \frac{\partial V}{\partial m} \Sigma_i Var(P_i) \left[\frac{\partial x_i}{\partial P_i} - \frac{\partial c_i}{\partial P_i}\Big|_c - 2X_i \frac{\partial c_i}{\partial m} - X_i^2 A \right]$$

$$+ \frac{1}{2} \frac{\partial V}{\partial m} \Sigma_i \Sigma_{j_{(i \neq j)}} Cov(P_i, P_j) \left[\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}\Big|_c - X_i \frac{\partial c_j}{\partial m} - X_j \frac{\partial c_i}{\partial m} - X_i X_j A \right]$$

(2.2.14)

And hence with insurance we have the following, with q_i, q_j representing the insurance quantities with respect to P_i and P_j:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i Var(P_i)\left[\frac{\partial x_i}{\partial P_i} - \frac{\partial c_i}{\partial P_i}\Big|_c - 2(X_i - q_i)\frac{\partial c_i}{\partial m} - (X_i - q_i)^2 A\right]$$

$$+\frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i \Sigma_{j_{(i\neq j)}} Cov(P_i, P_j)\left[\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}\Big|_c - (X_i - q_i)(X_j - q_j)A\right.$$

$$\left. - (X_i - q_i)\frac{\partial c_j}{\partial m} - (X_j - q_j)\frac{\partial c_i}{\partial m}\right] \qquad (3.2.5)$$

from which:

$$\frac{d\Delta E(V)}{dq_i} \approx \frac{1}{2}\frac{\partial V}{\partial m} Var(P_i)\left[2\frac{\partial c_i}{\partial m} + 2(X_i - q_i)A\right]$$

$$+\frac{1}{2}\frac{\partial V}{\partial m}\Sigma_{j_{(i\neq j)}} Cov(P_i, P_j)\left[\frac{\partial c_j}{\partial m} + (X_j - q_j)A\right] \qquad (3.2.6)$$

The optimal choice of q_i will be given by equating this expression to zero. It may be seen that this involves the value of q_j but if we assume that the economy may insure with respect to P_j as well as P_i the derivative above will be equal to zero if we impose symmetry such that:

$$q_i^* = x_i - c_i + \frac{1}{A}\frac{\partial c_i}{\partial m} \qquad (3.2.7)$$

$$q_j^* = x_j - c_j + \frac{1}{A}\frac{\partial c_j}{\partial m} \qquad (3.2.7)'$$

which are the same as the equivalent expression for the case above with only one volatile price given by (3.2.2). Hence if

the economy can insure against fluctuations in all the volatile prices it faces, the choice of the quantity of insurance against one particular price is unaffected by the presence of other volatile prices. Intuitively the choice of q_i sets the optimal relationship between national income and P_i and need not be affected by non-zero covariance between P_i and P_j so long as q_j has been set to optimise the relationship between national income and P_j.

Substituting (3.2.7) and (3.2.7)' into (3.2.5) for all i,j gives the change in expected utility given optimal insurance which is:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i Var(P_i)\left[\frac{\partial x_i}{\partial P_i} - \frac{\partial c_i}{\partial P_i}\Big|_c + \frac{1}{A}\left(\frac{\partial c_i}{\partial m}\right)^2\right]$$

$$+\frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i\Sigma_{j(i\neq j)} Cov(P_i, P_j)\left[\frac{\partial x_i}{\partial P_j} - \frac{\partial c_i}{\partial P_j}\Big|_c + \frac{1}{A}\frac{\partial c_j}{\partial m}\frac{\partial c_i}{\partial m}\right] \quad (3.2.8)$$

or, expressed in terms of exports:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\left[\Sigma_i Var(P_i)\frac{dX_i}{dP_i} + \Sigma_i\Sigma_{j(i\neq j)} Cov(P_i, P_j)\frac{dX_i}{dP_j}\right]$$

(3.2.9)

Which implies that the change in expected utility from volatility with access to a perfect insurance market is a

function of the response of export volumes to price, in turn comprising the responsiveness of both output and consumption with the latter affected by insurance by its modification of the income effect of a price change.

One Volatile Tradeable Price, Non-Tradeables Present

Introducing non-tradeables, while reducing the number of exogenous volatile prices to one for the time being, gives rise to the following expression from Chapter 2 for the welfare effects of price volatility:

$$\Delta E(V) \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{\partial x}{\partial P} - \frac{\partial c_x}{\partial P}|_c - 2(x-c_x) \frac{\partial c_x}{\partial m} - (x-c_x)^2 A - \frac{(\frac{\partial c_n}{\partial P}|_c - \frac{\partial n}{\partial P} + (x-c_x)\frac{\partial c_n}{\partial m})(\frac{\partial c_x}{\partial P_n}|c - \frac{\partial x}{\partial P_n} + (x-c_x)\frac{\partial c_n}{\partial m})}{(\frac{dn}{dP_n} - \frac{\partial c_n}{\partial P_n}|_c)}]$$

(2.2.19)

from which, if we include as before the quantity of insurance against the volatile price, we have:

$$\Delta E(V) \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{\partial x}{\partial P} - \frac{\partial c_x}{\partial P}|_c - 2(x-q-c_x) \frac{\partial c_x}{\partial m} - (x-q-c_x)^2 A$$

$$- \frac{(\frac{\partial c_n}{\partial P}|_c - \frac{\partial n}{\partial P} + (x-q-c_x) \frac{\partial c_n}{\partial m})(\frac{\partial c_x}{\partial P_n}|c - \frac{\partial x}{\partial P_n} + (x-q-c_x) \frac{\partial c_n}{\partial m})}{(\frac{dn}{dP_n} - \frac{\partial c_n}{\partial P_n}|_c)}]$$

(3.2.10)

and hence, making use of the symmetry between the cross-price effects on consumption and production in the numerator of the second line, the relevant derivative is:

$$\frac{d\Delta E(V)}{dq} \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [2 \frac{\partial c_x}{\partial m} + 2(x-q-c_x) \frac{R}{m}$$

$$+ \frac{2 \frac{\partial c_n}{\partial m} (\frac{\partial c_x}{\partial P_n}|c - \frac{\partial x}{\partial P_n}) + 2(x-q-c_x) (\frac{\partial c_n}{\partial m})^2}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}|_c)}] \qquad (3.2.11)$$

From which:

$$q^* = x - c_x + \frac{\frac{\partial c_x}{\partial m} + \frac{\partial c_n}{\partial m} (\frac{\frac{\partial c_x}{\partial P_n}|_c - \frac{\partial x}{\partial P_n}}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}|_c})}{A + \frac{(\frac{\partial c_n}{\partial m})^2}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}|_c}} \qquad (3.2.12)$$

Hence the inclusion of non-tradeables in the model changes the optimal quantity of insurance. From the expression the

direction of this change is ambiguous even if $x\text{-}c_x$ is unchanged by the addition of the non-tradeables sector which will not be the case in general.

The interpretation of (3.1.12) is helped if we transform it into elasticities which gives:

$$\frac{Pq^*}{m} = \gamma_x + \frac{\beta_x \epsilon^m_{c_x} + \epsilon^m_{c_n} \left(\frac{\beta_x \epsilon^{\partial P_n}_{c_x}|_c - \alpha_x \epsilon^{\partial P_n}_x}{\epsilon^{\partial P_n}_n - \epsilon^{\partial P_n}_{c_n}|_c} \right)}{R + \frac{\beta_n (\epsilon^m_{c_n})^2}{\epsilon^{\partial P_n}_n - \epsilon^{\partial P_n}_{c_n}}} \qquad (3.2.13)$$

Clearly the value of (3.2.13) depends on several parameters so its interpretation is not straightforward. The role of these parameters may be clarified, however, by considering the circumstances under which the expression may either be large or alternatively tend to γ_x which is the value at which the economy is most insulated from price shocks.

Firstly the optimal quantity of insurance will become large if the income elasticity of demand for c_x is large. This results from the costs to expected utility of a strong income effect leading to high consumption of c_x when its price is high. A large quantity of insurance induces negative covariance between the volatile tradeables prices and income and hence turns this cost into a benefit. In addition the desired quantity of insurance will be large if the cross price effects of non-tradeables prices on exports of x are large (the numerator in the bracket). This is because without insurance P_n will rise when a tradeable price rises which reduces the

volume response of exports of x to a rise in their price.

Secondly, the optimal quantity of insurance will tend to γ_x if either R is large and/or $ß_n \epsilon_{cn}^m$ is large. Clearly if risk aversion is the dominant parameter the representative agent would seek to avoid all fluctuations in real income which is achieved by setting the quantity of insurance equal to the volume of exports. A large amount of insurance is also desirable if the income effects on consumption of the non-tradeable are strong because they will induce large swings in P_n for a given change in income which is harmful to the marginal utility of income which is reduced by a rise in P_n. Ideally the economy would like to de-link changes in P_n from changes in income for the same reason as with consumption of c_x above but cannot do so, even with insurance, because income is a major determinant of the price of non-tradeables.

Many Volatile Tradeables Prices, Non-Tradeables Present

From Chapter 2, allowing for non-tradeables plus many volatile prices and insurance quantities given by q_i, q_j we have:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i Var(P_i)\left[\frac{\partial x}{\partial P_i} - \frac{\partial c_x}{\partial P_i}\Big|_c - 2(X_i - q_i)\frac{\partial c_x}{\partial m} - (X_i - q_i)^2 \frac{R}{m}\right.$$

$$\left. - \frac{\left(\frac{\partial c_n}{\partial P_i}\Big|_c - \frac{\partial n}{\partial P_i} + (X_i - q_i)\frac{\partial c_n}{\partial m}\right)\left(\frac{\partial c_i}{\partial P_n}\Big|_c - \frac{\partial x_i}{\partial P_n} + (X_i - q_i)\frac{\partial c_n}{\partial m}\right)}{\left(\frac{dn}{dP_n} - \frac{\partial c_n}{\partial P_n}\Big|_c\right)}\right]$$

$$+\frac{1}{2}\frac{\partial V}{\partial m}\Sigma_i\Sigma_{j_{(i\neq j)}}Cov(P_i,P_j)\left[\frac{\partial x_i}{\partial P_j}-\frac{\partial c_i}{\partial P_j}\Big|_c-(X_i-q_i)\,(X_j-q_j)\,\frac{R}{m}-(X_i-q_i)\,\frac{\partial c_j}{\partial m}\right.$$

$$\left.-(X_j-q_j)\,\frac{\partial c_i}{\partial m}-\frac{\left(\frac{\partial c_n}{\partial P_j}\Big|_c-\frac{\partial n}{\partial P_j}+(X_j-q_j)\,\frac{\partial c_n}{\partial m}\right)\left(\frac{\partial c_n}{\partial P_i}\Big|_c-\frac{\partial n}{\partial P_i}+(X_i-q_i)\,\frac{\partial c_n}{\partial m}\right)}{\left(\frac{\partial n}{\partial P_n}-\frac{\partial c_n}{\partial P_n}\Big|_c\right)}\right]$$

which we need to differentiate with respect to q_i to give:

$$\frac{d\Delta E[V]}{dq_i}=\frac{\partial V}{\partial m}Var(P_i)\left[\frac{\partial c_i}{\partial m}+(X_i-q_i^*)\,\frac{R}{m}+\frac{\partial c_n}{\partial m}\,\frac{\left(\frac{\partial c_n}{\partial P_i}\Big|_c-\frac{\partial n}{\partial P_i}+(X_i-q_i^*)\,\frac{\partial c_n}{\partial m}\right)}{\left(\frac{\partial n}{\partial P_n}-\frac{\partial c_n}{\partial P_n}\Big|_c\right)}\right.$$

$$\left.+\frac{1}{2}\Sigma_{j_{(i\neq j)}}Cov(P_i,P_j)\left[\frac{\partial c_j}{\partial m}+(X_j-q_j^*)\,\frac{R}{m}+\frac{\partial c_n}{\partial m}\,\frac{\left(\frac{\partial c_n}{\partial P_j}\Big|_c-\frac{\partial n}{\partial P_j}+(X_j-q_j^*)\,\frac{\partial c_n}{\partial m}\right)}{\left(\frac{\partial n}{\partial P_n}-\frac{\partial c_n}{\partial P_n}\Big|_c\right)}\right]\right]$$

As in the case with many volatile prices but no non-tradeables, it may be noted that the expression above is symmetric between i and j which, given that the solution for q^* will be symmetric between goods, implies that the solution to the above equation is for both terms to equal zero. This means that the top line must equal zero for all i so that as before the optimal solution in effect takes into account only variations in the price of interest, P_i, and ignores covariance between this price and any others if the optimal amount of insurance has been set with respect to variability in the other prices. Intuitively, an insurance contract over P_i sets the optimal relationship between m, P_i and P_n for the economy, with this being true for all volatile goods. So long

as the economy can insure against each volatile price, the relationships between the prices do not matter from the point of view of how much to insure.

Hence we have:

$$q_i^* = X_i + \frac{\frac{\partial c_i}{\partial m} + \frac{\partial c_n}{\partial m}\left(\frac{\frac{\partial c_n}{\partial P_i}\big|_c - \frac{\partial n}{\partial P_i}}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}\big|_c}\right)}{\frac{R}{m} + \frac{\left(\frac{\partial c_n}{\partial m}\right)^2}{\left(\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}\big|_c\right)}} \qquad (3.2.12)$$

for all i, subject to all the insurance quantities being optimally set. This expression is the same as in the case with only one volatile exogenous price. Hence as before if the economy can insure on perfect markets separately against all volatile prices the optimal quantity of insurance on any one market is independent of the relationship between the volatile prices.

The final task in this section is to substitute (3.2.12) for each i,j into our expression for the change in expected utility from price volatility at the start of this section, thus giving that change on the assumption that the economy is optimally insured at zero cost. It may be shown that the result simplifies to the parsimonious expression:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial m}[\Sigma_i Var(P_i)\frac{dX_i}{dP_i} + \Sigma_i \Sigma_{j_{(i \neq j)}} Cov(P_i, P_j)\frac{dX_i}{dP_j}]$$

which may also be given in elasticity terms by:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m}[\Sigma_i Var(lnP_i)\gamma_i \epsilon_{X_i}^{P_i} + \Sigma_i \Sigma_{j_{(i \neq j)}} Cov(lnP_i, lnP_j)\gamma_i \epsilon_{X_i}^{P_j}]$$

(3.2.14)

which is the same as the expression for many volatile prices but no non-tradeables though the actual magnitude of the export supply elasticities will differ because of the cross price effects of P_n on x and c_x. In turn both will differ from the case without insurance as a result of the changed relationship between P_i and P_n from insurance given that income changes are a determinant of changes in P_n.

3.3 PRIVATELY OPTIMAL INSURANCE

The previous section derived results for the optimum quantity of insurance on perfect risk or capital markets for the representative agent and the welfare change from volatility given that insurance behaviour. This section examines whether in a decentralised economy private agents would choose insurance quantities that taken together correspond to the social optimum.

We look first at the two good case where there are no non-tradeables followed by the case where that sector is included. The many volatile prices cases are not examined since it was seen above that as long as agents can trade on perfect risk markets in all commodities the choice of insurance with respect to each commodity is separable. In addition the only other assumption made is that private agents have the same coefficient of relative risk aversion and income elasticities of demand as the representative agent.

One Volatile Tradeables Price, No Non-Tradeables

Following the same steps as in Section 2.2 for the representative agent, in the two good case the change in expected utility from volatility for a private agent is as follows, denoting their income by w and consumption of the good with a volatile price by c_x^w.

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial w}Var(P)\left[\frac{d^2w}{dP^2}-\frac{\partial c_x^w}{\partial P}\Big|_c-2\left(\frac{dw}{dP}-c_x^w\right)\frac{\partial c_x^w}{\partial w}-\left(\frac{dw}{dP}-c_x^w\right)^2 A^w\right]$$

(3.3.1)

which is the same as (2.2.9) if dw/dP is replaced by x and the superscript w is removed from c_x.

If each agent chooses a quantity of insurance, q_w, which may differ between agents, (3.3.1) becomes:

$$\Delta E(V) \approx \frac{1}{2}\frac{\partial V}{\partial w}Var(P)\left[\frac{d^2w}{dP^2}-\frac{\partial c_x^w}{\partial P}\Big|_c-2\left(\frac{dw}{dP}-c_x^w-q_w\right)\frac{\partial c_x^w}{\partial w}\right.$$

$$\left.-\left(\frac{dw}{dP}-c_x^w-q_w\right)^2 A^w\right]$$

from which, if we differentiate with respect to q_w and set to zero, the optimal quantity of insurance becomes:

$$q_w^* = \frac{dw}{dP}-c_x^w + \frac{w}{R}\frac{\partial c_x^w}{\partial m} \qquad (3.3.2)$$

and hence the sum of the private agents optimal choices is:

$$\Sigma q_w^* = \Sigma\frac{dw}{dP}-\Sigma c_x^w + \frac{1}{R}\Sigma w\frac{\partial c_x^w}{\partial m}$$

and hence, given that the sum of dw/dP for all agents is x and the consumption of x sums to c_x, straightforwardly we have:

$$\Sigma q_w^* = x-c_x + \frac{1}{R}\Sigma c_x^w\frac{w}{c_x^w}\frac{\partial c_x^w}{\partial w}$$

If we assume that the income elasticity of demand is common between private agents and the representative agent this

simplifies to:

$$\Sigma q_w^* = x - c_x + \frac{\epsilon_{c_x}^m}{R} \Sigma c_x^w$$

and hence:

$$\Sigma q_w^* = x - c_x + \frac{1}{A} \frac{\partial c_x}{\partial m} \qquad (3.3.3)$$

which is the same as the optimal choice for the representative agent given by (3.2.2). Hence there is no tension between privately and socially optimal choices of the quantity of insurance with perfect risk markets and no non-tradeables.

One Volatile Tradeables Price, Non-Tradeables Present

In a similar fashion, following the steps of Section 2.2 and those above, if we add non-tradeables the change in expected utility from volatility for a private agent with insurance quantity q_w becomes:

$$\Delta E(V) \approx \frac{\partial V}{\partial w} \frac{Var(P)}{2} [\frac{d^2 w}{dP^2} - \frac{\partial c_x^w}{\partial P}|_c - c_n^w \frac{d^2 P}{dP^2}$$

$$- \frac{dP_n}{dP} (\frac{\partial c_x^w}{\partial P_n}|_c + \frac{\partial c_n^w}{\partial P}|_c + \frac{\partial c_n^w}{\partial P_n}|_c \frac{dP_n}{dP})$$

$$-2 (\frac{dw}{dP} - c_x^w - c_n^w \frac{dP_n}{dP} - q_w) (\frac{\partial c_x^w}{\partial w} + \frac{\partial c_n^w}{\partial w} \frac{dP_n}{dP}) - (\frac{dw}{dP} - c_x^w - c_n^w \frac{dP_n}{dP} - q_w)^2 A^w]$$

Private agents' choice of their optimal quantity of insurance may be found by differentiating this expression and setting the derivative equal to zero. Before doing this it may be

noted that the derivative dP_n/dP appears in the expression above. After private agents have insured, the value of this derivative will change because the extent of a rise in the price of non-tradeables given a rise in an exogenous tradeable price will depend on the change in income at that time which will alter if insurance contracts are in place. However, from the perspective of a single agent this derivative will be a constant since the effect of an individual's insurance on it will be negligible. Hence we treat it as a constant for deriving the optimal quantity of insurance even though it will in fact change.

Given this we have:

$$\frac{d\Delta E(V)}{dq_w} \approx \frac{\partial V}{\partial w} Var(P) \left[\frac{\partial c_x^w}{\partial w} + \frac{\partial c_n^w}{\partial w} \frac{dP_n}{dP} + A^w \left(\frac{dw}{dP} - c_x^w - c_n^w \frac{dP_n}{dP} - q_w \right) \right]$$

and hence:

$$q_w^* = \frac{dw}{dP} - c_x^w + \frac{w}{R} \frac{\partial c_x^w}{\partial w} + \frac{dP_n}{dP} \left(\frac{w}{R} \frac{\partial c_n^w}{\partial w} - c_n^w \right)$$

Which may be aggregated, making use of:

$$\Sigma \frac{dw}{dP} = \frac{dm}{dP} = x + n \frac{dP_n}{dP}$$

to give:

$$\Sigma q_w^* = x - c_x + \frac{1}{A} \frac{\partial c_x}{\partial m} + \frac{1}{A} \frac{\partial c_n}{\partial m} \frac{dP_n}{dP}$$

which is the same as the representative agent's choice of insurance quantity because we obtain (3.2.12) if we substitute the above expression into that for dP_n/dP in Chapter 2 to

eliminate that derivative.

Hence we have the result that the sum of private agents insurance choices corresponds to that of the representative agent so once again this choice may be decentralised without difficulty, at least in the long run.

This is perhaps a stronger result than in the case above without non-tradeables since here private agents are treating dP_n/dP as exogenous even though it will change as a result of all insurance behaviour taken together. As a result of this private agents will initially over-insure and subsequently like to revise their choice of insurance quantity once they have realised that non-tradeables prices are less responsive to tradeables prices than before. Following this they will under-insure and so on iteratively until the socially optimal collective quantity of insurance is achieved at which point private agents will not want to recontract.

CHAPTER 4

DETERMINANTS OF OUTPUT FLEXIBILITY

Chapters 2 and 3 showed that the flexibility of output in response to price changes was a key determinant of outcomes under price volatility and also a source of possible benefit in contrast to the welfare costs of income fluctuations. Flexibility on the consumption side is of less interest since we take this to result from exogenous taste parameters whereas the determinants of output flexibility are more susceptible to analysis.

This chapter examines the determinants of output flexibility along two dimensions. The first is the relationship between output flexibility and factor mobility which we look at in Section 4.1 via the three models outlined in Chapter 1; firstly and most simply the case where neither capital nor labour is mobile between sectors, secondly where one factor is mobile and thirdly where both are mobile. These models demonstrate how flexibility increases with mobility. Which model is most appropriate for a given situation is largely an empirical question but a priori it is likely that the choice would be sensitive to the duration of relative price shocks. In the very short run factor mobility will usually be negligible whereas over the medium to long term both labour and capital may become mobile, with labour normally assumed to become mobile before capital. The time dimension is, however, not considered in this section because introducing time

implicitly requires us to introduce expectations. This results from the fact that if it takes time to move some units of a factor between sectors it will also take time to move them back again if the relative price shock is reversed. This may be costly and hence the initial decision to reallocate involves expectations about the duration of the shock. A further complication is that if mobility increases over the medium to long run total factor supplies may also be changing with population growth or investment. These considerations take us beyond the scope of the thesis so we assume that a factor is either mobile ex post or not and hence the costs of moving sectors are either zero or prohibitive.

The second approach to the determinants of output flexibility is to ask how, within each of the three models, it depends on the nature of the production technology in use. This is done in Section 4.1 which shows how the nature of the technology determines the extent of flexibility for a given factor mobility.

The section also shows that while flexibility is in general beneficial, if there are strong cross price effects from the non-tradeables sector flexibility may not be desirable because it may encourage unhelpful and perverse output-price responses.

Returning to the theme of flexibility increasing in factor mobility there is a question as to whether a factor benefits

from its own mobility or whether some or all of those benefits spill over to other agents. We address this in Section 4.2 by looking at the effect of price volatility on expected factoral incomes for each of the three models. The results obtained are ambiguous; the effect of price volatility on expected incomes depends on the characteristics of the production technology in use.

Hence a factor may not enjoy the benefits of its own mobility but this will not affect its mobility since if it is feasible for units of the factor, such as individual workers, to move between sectors they will find it beneficial to do so. This is for the standard reason that, when feasible, factors move in response to different returns between sectors and when price fluctuations change those returns the incentive to be mobile is always present.

For simplicity in this chapter we make use of an arithmetic mean counterfactual since while a geometric mean alters the form of the results the nature of the analysis and variables involved remains the same. At the level of theory we may therefore proceed using the arithmetic mean without loss of content while noting that the actual value of the results is sensitive to the choice of certainty equivalent.

Finally we turn to the possible effect of government on output flexibility. This is outlined in general terms here but not analysed in detail in what follows since it lies outside the

scope of the thesis.

The response of output to changes in international prices will depend on the extent to which those price signals are reflected in the domestic price structure. In a market economy with minimal government intervention this issue does not arise since the domestic prices of tradeables are wholly determined by world prices. However, if commodity taxes or tariffs are used as revenue sources the domestic price structure will not coincide with world prices and hence output may respond poorly to world prices because the agents involved are maximising with respect to domestic prices. Hence actual measured output flexibility will be low even if underlying flexibility is high. The same result would be obtained if the government controls producer prices and these are either stabilised or correlate very weakly with world prices. A further effect of government would be via its expenditure patterns with a key variable being the government's marginal propensity to consume non-tradeables out of income relative to the same variable for the private sector, with a low propensity being advantageous.

4.1 MICROFOUNDATIONS OF OUTPUT FLEXIBILITY

The previous two chapters found that the price responsiveness of output was a key determinant of outcomes under volatility and hence it is of interest to analyse this variable further to see how it relates to the production structure of the economy and the characteristics of the underlying technology. We discuss each of the three models in turn, assuming that there is only one volatile price initially for clarity.

Both Factors Fixed

With the sectoral allocation of factors fixed by assumption, sectoral output levels cannot change when relative prices change and hence there is nothing to be said about flexibility in this model.

Sector Specific Capital Model

The assumptions of the model imply that the wage is equal to the value marginal product of labour in each sector.

Hence:

$$w=Px_1=y_1$$

Changes in output in response to relative price changes can occur only through the movement of labour so we may derive the former by differentiating the equilibrium condition above to see how much labour moves between the two sectors when the

relative price changes. This gives:

$$\frac{dl}{dP} = -\frac{x_1}{Px_{11}+y_{11}} > 0 \qquad (4.1.1)$$

from which:

$$\frac{dx}{dP} = \frac{dx}{dl_x}\frac{dl_x}{dP} = -\frac{x_1^2}{Px_{11}+y_{11}} > 0 \qquad (4.1.2)$$

which shows that dx/dP, which determines the monetary returns to volatility for the economy as a whole, will be positive and an increasing function of dl_x/dP which corresponds to the degree of factor mobility given that capital is assumed fixed. Clearly both variables depend inversely on the absolute magnitudes of x_{11} and y_{11} so that it is advantageous for the economy as a whole for these derivatives to be small. This is equivalent to the marginal product of labour schedules in Figure 1.4 sloping gently or the elasticity of the marginal product being small.

Turning to the general case with many volatile prices, we may extract from equation (2.2.21) those terms that involve changes in sectoral outputs, and leave out the terms that relate solely to tastes or income effects, we have:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} \left[\Sigma_i Var(\ln P_i)\left(\alpha_i \epsilon_{x_i}^{P_i} - \gamma_i \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_i} + \ldots\right)\right.$$

$$\left. + \Sigma_{i \neq j} \Sigma Cov(\ln P_i, \ln P_j)\left(\alpha_i \epsilon_{x_i}^{P_j} - \gamma_i \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_j} + \ldots\right)\right] \qquad (4.1.3)$$

where the terms in $dP_n/dP_{i/j}$ appear because their magnitude depends partly on changes in the output of non-tradeables. If

we assume that there are no non-tradeables these terms disappear. In this situation the value of the first term in each square bracket will also be different because changes in P_n will affect x_i.

Hence we need to derive both the own and cross price output responses to price changes.

From the assumptions of the model:

$$\frac{dx_i}{dP_i} = x_1^i \frac{dl_i}{dP_i} \qquad (4.1.4)$$

and:

$$\frac{dx_i}{dP_j} = x_1^i \frac{dl_i}{dP_j} \qquad (4.1.5)$$

where x^i refers to the production function of good i.

Thus derivation of the output responses requires analysis of the movements of labour between sectors as a result of changes in prices. This may be approached in the same way as the two good case by differentiating the equilibrium condition:

$$P_i x_1^i = P_j x_1^j = y_1 \qquad (\forall_{i,j}) \qquad (4.1.6)$$

with respect to the price which is changing, and using the labour constraint:

$$\Sigma_i l_i = L$$

where L is the total endowment of labour, to yield:

$$\Sigma_i \frac{dl_i}{dP_i} = \Sigma_i \frac{dl_i}{dP_j} = 0 \qquad (4.1.7)$$

Equation (4.1.3) requires use of the notation i and j to refer to pairs of goods and we add s as notation for those goods with volatile prices apart from i and j. We denote the total number of goods with volatile prices by v. The other goods are y which has a stable price (and production function y(.)) and n for non-tradeables if included.

Without Non-tradeables

We first examine the case without non-tradeables and start with the own price output response dx_i/dP_i. Differentiating (4.1.6) gives:

$$x_1^i + P_i x_{11}^i \frac{dl_i}{dP_i} = P_j x_{11}^j \frac{dl_j}{dP_i} = P_s x_{11}^s \frac{dl_s}{dP_i} \ (\forall_s) = y_{11} \frac{dl_y}{dP_i} \qquad (4.1.8)$$

and substituting these into (4.1.7) gives:

$$\frac{dl_i}{dP_i} = -\frac{x_1^i}{P_i x_{11}^i + \dfrac{1}{\dfrac{1}{P_j x_{11}^j} + \Sigma_s \dfrac{1}{P_s x_{11}^s} + \dfrac{1}{y_{11}}}} > 0 \qquad (4.1.9)$$

where it may be noted that the goods j, s and y have a symmetric role. Equation (4.1.9) may be interpreted by noting that the second partial derivatives indicate the extent to which a sector will release or absorb labour. The equilibrium condition (4.1.6) shows that following a price change labour will move between sectors so as to restore equality between the value marginal products. If the second partial

derivatives are large the marginal physical product of labour will change quickly as labour moves and hence the total movement of labour into or out of a sector will be small. Thus the second partial derivative is an indicator of flexibility with a small value in absolute terms implying high flexibility. Hence (4.1.9) may be explained by noting that the expression is symmetric between the goods and decreasing in the absolute size of the (negative) x_{11} terms and increasing if they become small in absolute terms or the technology is more flexible.

Turning to the cross price response of labour, differentiating (4.1.6) with respect to P_j and simplifying in the same manner gives:

$$\frac{dl_i}{dP_j}=\frac{x_1^1}{P_i x_{11}^i+P_j x_{11}^j+P_i x_{11}^i P_j x_{11}^j(\Sigma_s \frac{1}{P_s x_{11}^s}+\frac{1}{y_{11}})}<0 \qquad (4.1.10)$$

Substituting (4.1.9) into (4.1.4) and (4.1.10) into (4.1.5) gives:

$$\alpha_i \epsilon_{x_i}^{P_i}=-\frac{Lw}{m}\frac{(1+\epsilon^{l_y}\Sigma_{v=2}^{v}\frac{1}{\epsilon^{l_v}})}{\epsilon^{l_i}(1+\epsilon^{l_y}\Sigma_{v=1}^{v}\frac{1}{\epsilon^{l_v}})}>0 \qquad (4.1.11)$$

and:

$$\alpha_i \epsilon_{x_i}^{P_j}=\frac{Lw}{m}\frac{\epsilon^{l_y}}{\epsilon^{l_i}\epsilon^{l_j}(1+\epsilon^{l_y}\Sigma_{v=1}^{v}\frac{1}{\epsilon^{l_v}})}<0 \qquad (4.1.12)$$

where:

$$\epsilon^{l_i} = \frac{l_i x_{11}^i}{x_1^i} \frac{1}{\frac{l_i}{L}} < 0$$

which is the labour elasticity of the marginal product of labour in sector i divided by the share of i sector employment in total employment. This variable may be thought of as an indicator of flexibility weighted by the labour share with a small absolute value implying high flexibility. The role of Lw/m, the share of wages in national income, is also intuitively clear. In the sector specific capital model changes in output can only take place with changes in the allocation of labour. The elasticities above relate to the propensity of sectors to lose or gain labour as prices change so as to maintain the equilibrium condition in (4.1.6) whereas (4.1.11) and (4.1.12) are concerned with changes in output. Hence the share of wages in national income is present since its value will depend on how important labour is in production and thus the extent to which changes in labour allocation feed through into changes in output.

Substituting (4.1.11) and (4.1.12) into (4.1.3) gives us:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} \frac{Lw}{m} \left[\Sigma_i Var(\ln P_i) \frac{(1+\epsilon^{l_y} \Sigma_{v=2}^{v} \frac{1}{\epsilon^{l_v}})}{\epsilon^{l_i} (1+\epsilon^{l_y} \Sigma_{v=1}^{v} \frac{1}{\epsilon^{l_v}})} \right.$$

$$\left. + \Sigma_{i \neq j} \Sigma Cov(\ln P_i, \ln P_j) \frac{\epsilon^{l_y}}{\epsilon^{l_i} \epsilon^{l_j} (1+\epsilon^{l_y} \Sigma_{v=1}^{v} \frac{1}{\epsilon^{l_v}})} \right] \qquad (4.1.13)$$

which may be simplified to:

$$\Delta E(V) \approx \frac{\frac{1}{2} m \frac{\partial V}{\partial m} \frac{Lw}{m}}{(1+\epsilon^{1_y} \Sigma_{v=1}^{V} \frac{1}{\epsilon^{1_v}})} \left[-\Sigma_i Var(lnP_i) \frac{1}{\epsilon^{1_i}} \right.$$

$$\left. - \epsilon^{1_y} \Sigma_{i \neq j} \Sigma \frac{1}{\epsilon^{1_i} \epsilon^{1_j}} (Var(lnP_i) - Cov(lnP_i, \ln P_j)) \right] \quad (4.1.14)$$

where the term outside the square bracket is positive and the first term within it positive also since each of the elasticities is negative. The second line may also be shown to be positive since it may be expressed as follows, changing the summation to i<j:

$$-\epsilon^{1_y} \Sigma_{i<j} \Sigma \frac{1}{\epsilon^{1_i} \epsilon^{1_j}} [Var(lnP_i) + Var(lnP_j) - 2Cov(lnP_i, \ln P_j)]$$

or:

$$-\epsilon^{1_y} \Sigma_{i<j} \Sigma \frac{1}{\epsilon^{1_i} \epsilon^{1_j}} \; Var[lnP_i - lnP_j] > 0$$

Hence (4.1.14) is positive overall because the variance must be positive despite the presence of the negative covariance terms which correspond to the negative cross price elasticities of output in (4.1.3). Thus we have established that the contribution to the change in expected utility from multiple price volatility from changes in the composition of output is positive.

The next question that arises from (4.1.13) and (4.1.14) is whether the change in expected utility from volatility is increasing in the flexibility of the technology in the form of the elasticities above. With one volatile price there is only the own price effect which makes a positive contribution to

expected utility that is increasing in the flexibility of the technology. With many volatile prices, however, increasing flexibility in the form of small and negative elasticities of the marginal product of labour will increase the positive own price effects but also increase some of the negative cross price effects. For example in (4.1.10) it is helpful for sectors i and j to be inflexible and the s sectors flexible because inflexibility in j means that it will absorb little labour when P_j rises, flexibility in s so that they will readily release labour and inflexibility in i so that it does not lose too much labour itself. Hence the question may be expressed by asking whether flexibility is always beneficial despite increasing some of these negative cross price effects or whether the desired degree of flexibility depends on the particular structure of the variances and covariances of the volatile prices.

To address this issue we restate (4.1.13) in terms of ϵ^1, the flexibility of sector 1, bringing out its differing roles as an "i", "j" and "s" good. Symmetry implies that results derived for sector 1 will be general since the choice of that sector amongst the v in total is arbitrary. Re-writing (4.1.13) in this way gives us:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} \frac{Lw}{m} \left[-Var(lnP_1) \left(\frac{1 + \epsilon^{l_y} \sum_{v=2}^{v} \frac{1}{\epsilon^{l_v}}}{\epsilon^{l_y} + \epsilon^{l_1} \left(1 + \epsilon^{l_y} \sum_{v=2}^{v} \frac{1}{\epsilon^{l_v}}\right)} \right) \right.$$

$$- \sum_{i=2}^{v} Var(lnP_i) \left(\frac{\epsilon^{l_y} + \epsilon^{l_1} \left(1 + \epsilon^{l_y} \sum_{v=2(-i)}^{v} \frac{1}{\epsilon^{l_v}}\right)}{\epsilon^{l_y} \left(\epsilon^{l_i} + \epsilon^{l_1}\right) + \epsilon^{l_i} \epsilon^{l_1} \left(1 + \epsilon^{l_y} \sum_{v=2(-i)}^{v} \frac{1}{\epsilon^{l_v}}\right)} \right)$$

$$+ 2 \sum_{i=2}^{v} Cov(lnP_1, lnP_i) \left(\frac{\epsilon^{l_y}}{\epsilon^{l_y} \left(\epsilon^{l_i} + \epsilon^{l_1}\right) + \epsilon^{l_i} \epsilon^{l_1} \left(1 + \epsilon^{l_y} \sum_{v=2(-i)}^{v} \frac{1}{\epsilon^{l_v}}\right)} \right)$$

$$\left. + \sum_{i=2}^{v} \sum_{j=2(i \neq j)}^{v} \left(\frac{Cov(lnP_i, lnP_j) \epsilon^{l_y} \epsilon^{l_1}}{\epsilon^{l_y} \epsilon^{l_i} \epsilon^{l_j} + \epsilon^{l_1} \epsilon^{l_y} \left(\epsilon^{l_i} + \epsilon^{l_j}\right) + \epsilon^{l_1} \epsilon^{l_i} \epsilon^{l_j} \left(1 + \sum_{v=2(-i,-j)}^{v} \frac{1}{\epsilon^{l_v}}\right)} \right) \right]$$

(4.1.15)

where the first pair of lines relate to own price effects and the second pair to cross price effects. The first line corresponds to the own price effect of P_1, the second to the own price effects from fluctuations in prices other than P_1, the third to cross price effects between P_1 and other prices, and the final line to cross price effects that do not include P_1.

In order to see whether expected utility is always increasing in flexibility we must differentiate (4.1.15) with respect to the elasticity in sector 1 and determine its sign. This gives:

$$\frac{d(\Delta E(V))}{d\epsilon^{l_1}} = \frac{\frac{1}{2}m\frac{\partial V}{\partial m}\frac{Lw}{m}}{[\epsilon^{l_y}+\epsilon^{l_1}(1+\epsilon^{l_y}\Sigma_{v=2}^{v}\frac{1}{\epsilon^{l_v}})]^2}\ [Var(lnP_1)\,(1+\epsilon^{l_y}\Sigma_{v=2}^{v}\frac{1}{\epsilon^{l_v}}$$

$$+\ \Sigma_{i=2}^{v}Var(lnP_i)\,(\frac{\epsilon^{l_y}}{\epsilon^{l_i}})^2\ -\ 2\Sigma_{i=2}^{v}Cov(lnp_1,\ln P_i)\,\frac{\epsilon^{l_y}}{\epsilon^{l_i}}\,(1+\epsilon^{l_y}\Sigma_{v=2}^{v}\frac{1}{\epsilon^{l_v}})$$

$$+\ \Sigma_{i=2}^{v}\Sigma_{j=2\,(i\neq j)}^{v}Cov(lnP_i,\ln P_j)\,\frac{(\epsilon^{l_y})^2}{\epsilon^{l_i}\epsilon^{l_j}}\ ] \qquad (4.1.16)$$

where all the terms are positive in themselves but with the negative sign in front of the third term the expression as a whole is ambiguous in sign as it stands. We can, however, exploit the statistical properties of random variables to sign this expression. A standard statistical result is:[1]

$$Var[\Sigma_{i=1}^{n}a_iX_i] = \Sigma_{i=1}^{n}a_i^2Var(X_i) + \Sigma_{i\neq j}\Sigma a_ia_jCov(X_i,X_j) \qquad (4.1.17)$$

where the $X_{i/j}$ are random variables and the $a_{i/j}$s are constants. The structure of the expression on the right hand side of (4.1.17) is similar to that on the right hand side of (4.1.16). As a result if we define:

$$X_i = lnP_i\ ;\quad a_1 = -(1+\epsilon^{l_y}\Sigma_{v=2}^{v}\frac{1}{\epsilon^{l_v}})\ ;\quad a_i = \frac{\epsilon^{l_y}}{\epsilon^{l_i}}\ (i\neq 1)$$

and substitute these into (4.1.17) and rearrange we arrive at the square bracket on the right hand side of (4.1.16). This enables us to write:

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[1]From Mood, Graybill and Boes (1974), page 179.

$$\frac{d(\Delta E(V))}{d\epsilon^{l_1}} = \frac{\frac{1}{2} m \frac{\partial V}{\partial m} \frac{Lw}{m} Var\left[\Sigma_{i=2}^{v}\left[\frac{\epsilon^{l_y}}{\epsilon^{l_i}} lnP_i\right] - \left(1+\epsilon^{l_y}\Sigma_{v=2}^{v}\frac{1}{\epsilon^{l_v}}\right) lnP_1\right]}{\left[\epsilon^{l_y}+\epsilon^{l_1}\left(1+\epsilon^{l_y}\Sigma_{v=2}^{v}\frac{1}{\epsilon^{l_v}}\right)\right]^2} > 0$$

which is greater than zero because the denominator and the numerator outside the variance bracket are both positive and the latter must be also since a variance is non-negative. Hence the result in (4.1.17) has enabled us to sign the right hand side of (4.1.16). Given that the derivative above is positive and the elasticities are negative expected utility will be increasing as the absolute size of each elasticity becomes smaller. It may therefore be concluded that expected utility is increasing in output flexibility for any combination of volatile prices. Intuitively this result makes sense because in the situations in which flexibility could potentially be harmful (where there is a cross price effect between the price of the sector in question and another price) a large negative cross price effect with resources moving out of a given sector will imply a larger own price effect in that other sector.

With Non-Tradeables

Unfortunately if we include non-tradeables much less specific results emerge. We consider the case with only one exogenous volatile price with the many volatile price case discussed later. The discussion is based around the following expression, which extracts the terms that involve output changes from (2.2.18).

$$\Delta E[V] \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{\partial x}{\partial P} - \frac{dP_n}{dP} (\frac{\partial c_x}{\partial P_n}|_c - \frac{\partial x}{\partial P_n} + X\frac{\partial c_n}{\partial m})]$$

where:

$$\frac{dP_n}{dP} = \frac{\frac{\partial c_n}{\partial P}|_c - \frac{\partial n}{\partial P} + X\frac{\partial c_n}{\partial m}}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}|_c}$$

Using the same procedure as in the case without non-tradeables above we may derive:

$$\frac{\partial x}{\partial P} = -\frac{x_1^2 (P_n n_{11} + y_{11})}{P x_{11} P_n n_{11} + P_n n_{11} y_{11} + P x_{11} y_{11}}$$

$$\frac{\partial n}{\partial P} = \frac{\partial x}{\partial P_n} = \frac{n_1 x_1 y_{11}}{P x_{11} P_n n_{11} + P_n n_{11} y_{11} + P x_{11} y_{11}}$$

$$\frac{\partial n}{\partial P_n} = -\frac{n_1^2 (P x_{11} + y_{11})}{P x_{11} P_n n_{11} + P_n n_{11} y_{11} + P x_{11} y_{11}}$$

From which it is straightforward to demonstrate that expected utility will be increasing in the degree of flexibility of the stable price y sector (as measured by a small y_{11} in absolute terms). This is because it is advantageous for this sector to release and absorb resources as the volatile tradeable and non-tradeable price fluctuate, both directly in order to contribute to resource flows into and out of the volatile x sector and indirectly to provide resources to the non-tradeables sector that might otherwise come from the volatile sector.

Turning to the advantages or disadvantages of flexibility in

the x and n sectors, measured by x_{11} and n_{11}, the position is much less clear. From the expressions above it may be shown that:

$$\frac{\partial}{\partial x_{11}}\left(\frac{\partial x}{\partial P}\right) \; ; \; \frac{\partial}{\partial x_{11}}\left(-\frac{\partial x}{\partial P_n}\right) \; ; \; \frac{\partial}{\partial x_{11}}\left(-\frac{\partial n}{\partial P}\right) \; ; \; \frac{\partial}{\partial x_{11}}\left(\frac{\partial n}{\partial P_n}\right) \quad all > 0$$

$$\frac{\partial}{\partial n_{11}}\left(\frac{\partial x}{\partial P}\right) \; ; \; \frac{\partial}{\partial n_{11}}\left(-\frac{\partial x}{\partial P_n}\right) \; ; \; \frac{\partial}{\partial n_{11}}\left(-\frac{\partial n}{\partial P}\right) \; ; \; \frac{\partial}{\partial n_{11}}\left(\frac{\partial n}{\partial P_n}\right) \quad all > 0$$

which implies that differentiating the expression for the change in expected utility above with respect to x_{11} and n_{11} in turn gives expressions of ambiguous sign.

The central reason for this is that increasing the flexibility of the x sector will enhance the beneficial own price output response but also increase the harmful cross price response from a rise in the price of non-tradeables. The same is true of flexibility in the non-tradeables sector in that a high degree of flexibility may raise the contribution of resources to the x sector when the price of x increases, but may also increase the resources absorbed by the non-tradeables sector due to the rise in its own price that results from the rise in the price of the tradeable.

From the production side the direction of these effects depends on whether the elasticity of non-tradeables prices with respect to the volatile tradeable price is greater than or less than one. If it is greater than one, P_n/P will increase when P increases and the net flow of labour will be from the x sector to the n sector. In this circumstance

limited flexibility in both is desirable so that the flow of labour is small and the harmful cross price effect on the output of x is mild. Alternatively if the elasticity is less than one, P_n/P will fall and labour will flow from non-tradeables production to the x sector. If this is the case a high degree of flexibility in both sectors is desirable since it would lead to a large movement of labour between the two.

With non-tradeables in the model we must also consider the consumption side, with a small value for dP_n/dP beneficial so that non-tradeables prices are not too volatile themselves[2], but the effect of changing x_{11} or n_{11} on this derivative is ambiguous since a decrease in their absolute size, implying more flexible technology, will raise both the numerator and the denominator.

Hence adding non-tradeables to the model makes the analysis of the benefits of a more or less flexible technology ambiguous in general though it may be said that flexibility is more likely to be beneficial the lower is dP_n/dP. In that situation greater flexibility is more likely to contribute to desirable own price effects and less to undesirable cross price effects. This issue was not of concern in the case without non-tradeables since in that situation a large negative cross price effect from one tradeable to another would imply a larger positive own price effect in another

[2]As well as reducing the cross price effect on the output of x.

tradeables sector.

The discussion has not addressed the case of many volatile tradeables prices directly but it must be the case that the ambiguity of the results for one volatile tradeable price would carry over to that situation.

Heckscher-Ohlin Model

The Heckscher-Ohlin model, with both capital and labour mobile at all times, is at the extreme of the factor mobility spectrum. As a result the price responsiveness of output will be greatest in this model (for common underlying technology) which corresponds to its production possibility frontier lying outside that for the sector specific capital model at all but one point. In turn the sector specific capital model showed greater flexibility than the model in which both factors were fixed ex post.

We consider the two good case in which the key variable in (4.1.3) is the elasticity based on dx/dP since the second term is not relevant given that there is only one volatile price.

We denote sectoral outputs by:

$$x=x(l_x, K_x)$$

$$y=y(L-l_x, K-K_x)$$

where L and K are the total endowments of labour and capital

in the economy. We use the notation x_1, y_K etc. to denote partial derivatives of the production functions so that:

$$\frac{dx}{dP} = x_l \frac{dl_x}{dP} + x_k \frac{dK_x}{dP} \qquad (4.1.18)$$

implying that we need expressions for the movements of labour and capital between sectors in response to changes in P. These are derived by differentiating the factor market equilibrium conditions that the wage and rate of return to capital are equal across the sectors. These conditions are:

$$Px_l = y_l \qquad Px_K = y_K$$

and differentiating them with respect to P gives:

$$x_l + \frac{dl_x}{dP}(Px_{ll} + y_{ll}) + \frac{dK_x}{dP}(Px_{lK} + y_{lK}) = 0$$

and:

$$x_K + \frac{dl_x}{dP}(Px_{lK} + y_{lK}) + \frac{dK_x}{dP}(Px_{KK} + y_{KK}) = 0$$

from which:

$$\frac{dl_x}{dP} = \frac{x_K(Px_{lK} + y_{lK}) - x_l(Px_{KK} + y_{KK})}{(Px_{ll} + y_{ll})(Px_{KK} + y_{KK}) - (Px_{lK} + y_{lK})^2}$$

and:

$$\frac{dK_x}{dP} = \frac{x_l(Px_{lK} + y_{lK}) - x_K(Px_{ll} + y_{ll})}{(Px_{ll} + y_{ll})(Px_{KK} + y_{KK}) - (Px_{lK} + y_{lK})^2}$$

both of which will be positive if the denominator, which is common to both expressions, is positive (a standard stability

condition) given that the second own partial derivatives will be negative and the second cross partial derivative positive.

These expressions may now be substituted into (4.1.18) to yield:

$$\frac{dx}{dP} = \frac{2x_1x_K(Px_{1K}+y_{1K}) - x_1^2(Px_{KK}+y_{KK}) - x_K^2(Px_{11}+y_{11})}{(Px_{11}+y_{11})(Px_{KK}+y_{KK}) - (Px_{1K}+y_{1K})^2} > 0 \qquad (4.1.19)$$

from which we may conclude that the response of sectoral outputs to relative prices in the Hecksher-Ohlin model is determined by the technology in use in the form of the partial derivatives of the production functions. In particular the response of output will be large if the second cross partial derivatives are large (and positive) and the second own partial derivatives are small in absolute terms (while being negative). In other words production flexibility is enhanced if the movement of a factor into a sector has a modest (negative) effect on its own marginal product and a comparatively large (positive) effect on the marginal product of the other factor in the sector.

4.2 THE DISTRIBUTION OF EXPECTED INCOME

The previous section showed that output flexibility is an increasing function of factor mobility. This section disaggregates the change in expected national income from price volatility derived in Chapter 2 into changes in expected factoral incomes. This is of interest in itself but also shows whether factors in aggregate are likely to receive the reward from their own mobility. This is a different question from whether individual workers or units of capital are rewarded for mobility since a unit of a factor will always gain if there is a difference in return between sectors though this will lead to factors being as mobile as is feasible in a decentralised economy. We consider each model in turn.

Both Factors Fixed

With both capital and labour immobile in the face of changing relative prices, sectoral outputs and hence expected national income are invariant to volatility. It is clear that the same must be true of expected wages and the return to capital since factor returns are the product of price and the marginal physical product. The latter is fixed because the amount of each factor in each sector is fixed and hence symmetric fluctuations in prices around an arithmetic mean counterfactual will be entirely offsetting in their effect on the value marginal product and hence factor returns.

Hence against an arithmetic mean counterfactual, expected

returns in tradeables must be invariant to volatility. This will not necessarily be the case in the non-tradeables sector, however, where the response of expected returns to volatility will depend on the sign of d^2P_n/dP^2. Any effect from this source would apply equally to capital and labour in the non-tradeables sector.

Sector Specific Capital Model

Expected Wages

From the previous section we have:

$$w=Px_1=y_1$$

and:

$$\frac{dl}{dP}=-\frac{x_1}{Px_{11}+y_{11}}>0$$

from which the first derivative of wages with respect to the volatile price is given by:

$$\frac{dw}{dP}=\frac{dl}{dP}\frac{dw}{dl}=\frac{x_1y_{11}}{Px_{11}+y_{11}}>0 \qquad (4.2.1)$$

In looking at the response of expected wages to volatility we need to examine the second derivative. Given that dw/dP is a function of both P and l we can make use of:

$$\frac{d^2w}{dP^2}=\frac{\partial}{\partial P}\left(\frac{dw}{dP}\right)+\frac{\partial}{\partial l}\left(\frac{dw}{dP}\right)\frac{dl}{dP}$$

to derive:

$$\frac{d^2w}{dP^2} = -\frac{x_1}{(Px_{11}+y_{11})^3}\left[2x_{11}y_{11}(Px_{11}+y_{11}) - Px_1(x_{11}y_{111}+y_{11}x_{111})\right]$$

(4.2.2)

the first term of which will be positive since $x_1>0$ and $y_{11}, x_{11}<0$ so we may sign the change in the expected wage from price volatility by signing the expression within the square bracket.

First it may be noted that if $x_{111}=y_{111}=0$, in other words the marginal product of labour declines at a constant rate in both sectors, the sign of the expression must be negative since x_{11} and y_{11} are both negative due to diminishing returns.

Hence the expected return to labour can only rise if the marginal product of labour is declining at a decreasing rate in at least one sector.

The full condition for $d^2w/dP^2>0$ is:

$$y_{111}+\frac{y_{11}}{x_{11}}x_{111} > \frac{2y_{11}(y_{11}+Px_{11})}{Px_1} \qquad (4.2.3)$$

which shows that a necessary but not sufficient condition for the expected wage to rise with relative price volatility is for at least one of the third derivatives to be positive. For the condition as a whole to be satisfied requires that the third derivatives taken together (and weighted by the second

derivatives as shown) are positive and large enough to offset the right hand side expression which is positive.

Expected Return to Capital

We first consider the response of total profits to changes in the relative price, total profits being calculated as the residual from national income, m, and the share of it paid to labour, wL. The analysis is conducted in terms of aggregate or sectoral profits rather than the rate of return to capital but with a fixed overall stock of capital and its allocation between sectors fixed by assumption the same results will apply to both in terms of the direction of change.

Turning first to aggregate profits in the whole economy, denoted by π, we may derive:

$$\pi = Px + y - wL$$

$$\frac{d\pi}{dP} = x - L\frac{dw}{dP}$$

$$\frac{d^2\pi}{dP^2} = \frac{dx}{dP} - L\frac{d^2w}{dP^2} \qquad (4.2.4)$$

which shows that the second derivative of π with respect to the volatile price, which will be proportional to the expected monetary gain to capital from volatility, is given by the price response of x, which is proportional to the total expected monetary gain to the economy, less that part of the total gain that accrues to labour.

Given the ambiguity about the sign of (4.2.3) above, it is clear that (4.2.4) must be ambiguous also. The expected wage may rise or fall compared with the counterfactual of stable prices, and as a consequence expected profits may also rise or fall.

It can be said, however, that if $d^2w/dP^2<0$ the expected wage unambiguously falls with price volatility and hence expected profits unambiguously rise for all non-negative dx/dP. If the expected wage increases, aggregate expected profits may rise or fall.

Sectoral Returns to Capital

Since capital is assumed to be sector specific it is also interesting to consider the behaviour of expected profits in each sector. Denoting these by π_x and π_y, we have:

$$\pi_x = Px - wl_x$$

$$\pi_y = y - wl_y$$

and hence:

$$\frac{d\pi_x}{dP} = x - l_x\frac{dw}{dP} > 0 \qquad (4.2.5)$$

$$\frac{d\pi_y}{dP} = -l_y\frac{dw}{dP} < 0 \qquad (4.2.6)$$

from which:

$$\frac{d^2\pi_x}{dP^2} = \frac{dx}{dP}(1-\epsilon_{P,w}) - l_x\frac{d^2w}{dP^2} \qquad (4.2.7)$$

$$\frac{d^2\pi_y}{dP^2} = \frac{dx}{dP}\epsilon_{P,w} - 1_y \frac{d^2w}{dP^2} \qquad (4.2.8)$$

Clearly (4.2.7) and (4.2.8) sum to (4.2.4) with the division of the aggregate expression between the sectors depending on the initial allocation of labour between them and the price elasticity of the wage. Hence for a given allocation of labour, expected profits in the x sector will be favoured if the wage rises modestly when the volatile price increases and expected profits in the y sector if the wage fluctuates more strongly with that price. This result makes sense intuitively since there will be positive covariance between x and w and negative covariance between y and w. Hence profits in the x sector will be disadvantaged by high wages when the volatile price is favourable and the output of x is large, whereas y sector profits will benefit if swings in the wage are large since wages will be low when P is low and the output of y large.

While we can say in general terms that the division of expected aggregate profits between the sectors will depend on the elasticity of wages, it is clear that the ambiguity about total profits carries over to sectoral profits with (4.2.7) and (4.2.8) able to have the same sign, both positive or both negative, or opposite signs at different values for the parameters and the change in expected wages. This is of note since the results imply that there can be no general conclusion from this model that expected profits in the sector directly exposed to export price uncertainty will suffer

compared with the import competing sector.

Heckscher-Ohlin Model

If both factors are mobile and we assume constant returns we have a Hecksher-Ohlin model and hence the following standard results.

$$Px=l_x w+K_x r$$

$$y=l_y w+K_y r$$

where w, the wage rate, and r, the rate of return on capital, are common across the two sectors since both factors are assumed fully mobile. K_i denotes the quantity of capital in sector i, and l_i the labour allocation to sector i. Differentiating with respect to P we have:

$$x=l_x \frac{dw}{dP}+K_x \frac{dr}{dP}$$

$$0=l_y \frac{dw}{dP}+K_y \frac{dr}{dP}$$

from which, denoting the labour/capital ratio in sector i by k_i:

$$\frac{dr}{dP}=-k_y \frac{dw}{dP} \qquad (4.2.9)$$

and:

$$\frac{dw}{dP}=\frac{x}{K_x(k_x-k_y)} \qquad (4.2.10)$$

which, by the Stolper-Samuelson Theorem, will be positive if

x is labour intensive and hence the labour-capital ratio, k_x, is greater than k_y. In addition the price elasticity of the wage will be greater than one due to the standard magnification effect since:

$$\epsilon_{P,w} = \frac{P}{w}\frac{dw}{dP} = \frac{Px}{wK_x(k_x - k_y)}$$

$$= \frac{l_x w + K_x r}{wK_x(k_x - k_y)} > \frac{k_x}{k_x - k_y} > 1$$

which contrasts with the sector specific capital model where the price elasticity of the wage was less than one.

By similar reasoning the price elasticity of the return to capital, r, will also be greater than one so factor price movements will be proportionately greater than relative price changes.

As before, to determine the sign and magnitude of the change in expected factor returns we need to derive the second derivative of income with respect to the relative price. This is done for wages and the return to capital in turn.

Expected Wages

Recalling (4.2.10) above, the convexity or concavity of w(P) will therefore depend on how x/K_x and $(k_x - k_y)$ vary as P rises. x and K_x will both rise with P, and k_x and k_y will both fall if x is labour intensive or vice versa if it is capital

intensive. Thus a priori it is likely that the sign of the second derivative will depend on the particular technology in use. This may be confirmed as follows. Differentiating the expression for dw/dP above and simplifying we have:

$$\frac{d^2w}{dP^2}=\frac{K_xK_y}{PK_xK_y(k_x-k_y)^2}\left[\frac{dK_x}{dP}(k_yPx+k_xy)-\frac{dl_x}{dP}(Px+y)\right] \qquad (4.2.11)$$

where the term outside the square bracket is positive since the only part that could be negative is squared. Thus the second derivative will be positive if, taking the movement of capital and labour in differential form:

$$\frac{dK_x}{dl_x}>\frac{1}{k_y\alpha_x+k_x\alpha_y}$$

or:

$$\frac{l_x}{K_x}\frac{dK_x}{dl_x}>\frac{1}{(\frac{k_y}{k_x})\alpha_x+\alpha_y} \qquad (4.2.12)$$

Where dK_x/dl_x is the gradient of the contract curve in the Edgeworth Box.

These conditions are ambiguous since if x is labour intensive both sides will be greater than one, the left hand side because K_x/l_x will be rising and hence the elasticity greater than one, and the right hand side because $k_y<k_x$. Similarly, if x is capital intensive, both sides will be less than one while still positive.

The conditions are illustrated in Figure 4.1 (drawn for the case where x is labour intensive) where initial output is at point A, corresponding to a given value of the relative price, and the other variables in the conditions are marked. Clearly the expected wage will rise with volatility if the contract curve is steep relative to the initial labour capital ratios but will be ambiguous in general and dependent on the particular shape of the contract curve and the initial output point. One factor of interest, however, is to note that it is to the advantage of labour for a large amount of capital to move in response to a change in the volatile price relative to the quantity of labour that moves. This is to be expected since the movement of capital enhances the marginal product of labour in the sector it moves into.

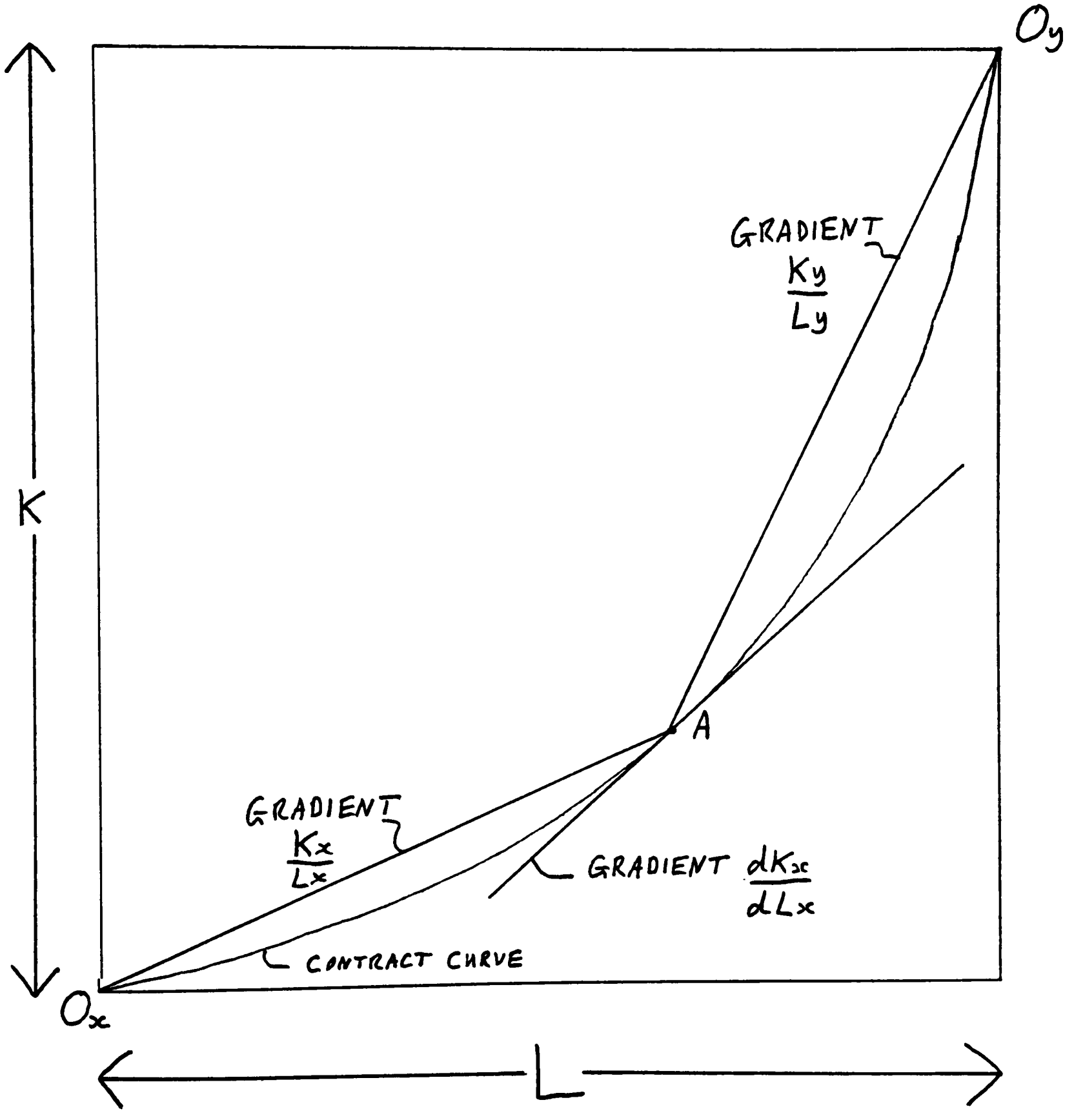
Expected Return to Capital

Turning to the rate of return on capital, we can derive from (4.2.9):

$$\frac{d^2r}{dP^2} = \frac{K_x K_y}{P(l_x K_y - l_y K_x)^2} \left[\frac{dl_x}{dP} (k_x Px + k_y y) - \frac{dK_x}{dP} k_x k_y (Px + y) \right]$$

(4.2.13)

FIGURE 4.1


Oy
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Kx
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GRADIENT dKx
dLx
CONTRACT CURVE
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from which, with the term outside the square bracket positive as before, the expected rate of return on capital will rise with price volatility if:

$$\frac{dK_x}{dl_x} < \frac{k_x\alpha_x + k_y\alpha_y}{k_x k_y}$$

or:

$$\frac{l_x}{K_x}\frac{dK_x}{dl_x} < \left(\frac{k_x}{k_y}\right)\alpha_x + \alpha_y \qquad (4.2.14)$$

which is also ambiguous with both sides greater than one if x is labour intensive or both less than one if it is capital intensive.

While the conditions for improvements in expected factor income are ambiguous in both cases we may note that comparing the two shows that they are not mutually exclusive. This is because the right hand side of (4.2.14) is greater than the right hand side of (4.2.12) and hence there is a range of values for the elasticity of the labour capital ratio in the x sector for which both expected wages and the expected return to capital will rise. If the elasticity is larger the expected wage will rise and return on capital fall and vice versa if the elasticity is smaller that the bottom limit of the range, given by the right hand side of (4.2.14).

We can also note the symmetric effect that the expected return on capital is increasing in the amount of labour that moves in response to a change in the relative price for a given

quantity of capital that moves.

Thus the aggregate expected monetary gain from price volatility increases with the mobility of both factors while the division of those gains will depend on the relative mobility of the factors, in turn determined by the production technology in use. In each case a factor will gain from large movements in the other factor.

CHAPTER 5

RESOURCE ALLOCATION AND RISK MARKETS

The previous chapters have examined the costs and benefits of price volatility without any access to risk markets followed by the case with access to perfect risk markets. In addition the last chapter examined the determinants of output flexibility. This chapter extends the analysis to examine the question of the allocation of resources under price volatility, in particular the allocation of fixed factors since mobile factors will allocate so as to equalise their return across sectors once prices are known.

The conceptual framework may be illustrated with reference to:

$$E[V] \approx \frac{1}{2} Var(P) \frac{d^2V}{dP^2} + V[\bar{P}, m(\bar{P})]$$

in which the first term is the direct effect of volatility on expected utility and the second term the level of utility with the relative price at $\bar{P}$. If there is no change in the allocation of fixed factors the second term may be subtracted from both sides to leave the first term as the change in expected utility which is what was done in the previous chapters. If the allocation of fixed factors does change it will affect the second term so we should no longer identify the effects of volatility solely with the first term. In addition, at the static optimum the second term will be a maximum so any change in fixed factor allocation will reduce this term. Given this we may think of a change in the

allocation of fixed factors in two ways, either as an opportunity to raise the value of the right hand side as a whole (if it is possible to increase the first term by more than the reduction in the second term), or as a change that may make little difference to the first term but cause a big welfare loss by reducing the second term. In both these situations it would be incorrect to identify the effects of volatility solely with the first term.

The allocation of fixed factors is closely linked to the nature of the available risk markets, if any, and so the chapter is structured according to the risk markets that are present. Section 5.1 assumes that perfect international risk markets are available in which case private agents will allocate fixed factors so as to equalise expected returns. Section 5.2 makes the polar assumption that there are no risk markets of any kind and Section 5.3 that there are only domestic risk markets.

In each section we look first at the allocation decisions that would be taken by the representative agent followed by those that would result from the decentralised decisions of private agents. It is found that there is no divergence between these in the case of perfect international risk markets but if all risk markets are absent there may be a strong divergence between private and social costs and benefits. With perfect risk markets the relevant equilibrium condition for private allocation is equal expected income which gives rise to the

social optimum because the effect of allocation on national income is felt by the private agents themselves. This is implied by the envelope theorem. If risk markets are not available, however, the relevant private allocation equilibrium condition is equal expected utility which combines both expected income and exposure to risk. The divergence between private and social costs and benefits arises because the allocation decisions of private agents takes into account their expected income and exposure to risk but does not take into account the fact that their allocation decision affects the risk borne by the rest of the economy.

If domestic risk markets are introduced this divergence is closed and the decentralised allocation, given a domestic risk market but no international market, is the same as that for the representative agent with no risk market, recalling that a domestic risk market is redundant when considering the representative agent. A domestic risk market therefore restores a socially optimal allocation. This is because the price of insurance on such a market reflects the allocation of fixed factors and a market price for risk is established. Fixed factor allocation takes place given this price and hence incorporates the effect of allocation on the risk faced by others.

In addition it may be noted that we do not consider the Heckscher-Ohlin model in this chapter because it assumes that all factors are mobile and hence there is no issue about the

allocation of fixed factors. We also place greater emphasis on the sector specific capital model and for simplicity consider the two good case only. The results may be expected to hold in the many volatile price case, if there is an insurance market for each volatile price, given the separability between insurance over different prices found in Chapter 3.

5.1 PERFECT INTERNATIONAL RISK MARKETS

With perfect risk markets available by assumption we think in terms of expected income as the main determinant of welfare. For the representative agent, or whole economy, this is given by:

$$E[m] \approx m(\bar{P}) + \frac{1}{2} Var(P) \frac{d^2 m}{dP^2} \qquad (5.1.1)$$

In the model with both factors fixed there would be no rationale for adjusting that allocation since the counterfactual allocation would maximise the first term of (5.1.1) and the second term would be zero since there is no output flexibility. Hence the socially optimal allocation would be the same as the counterfactual allocation. This will also be the case for private agents since from Chapter 4 their income is either stable or linear in the volatile price and hence expected factoral incomes will be invariant to volatility.

Turning to the sector specific capital model, the second term on the right hand side above is non-zero since there is some output flexibility and hence the representative agent would allocate the fixed factor, capital, by setting the following equal to zero:

$$\frac{dE[V]}{dK_x} \approx \frac{dm}{dK_x} + \frac{1}{2} Var(P) \frac{d}{dK_x} \left(\frac{dx}{dP}\right) = 0 \qquad (5.1.2)$$

Given that the counterfactual allocation of capital will maximise $m(\bar{P})$ the first term will be zero at the static optimum, positive if K_x is reduced and negative if it is

increased. This means that the optimal movement of capital, if any, is given by the sign of the second term with the level of K_x moving in whichever direction enhances flexibility in the form of the derivative dx/dP. The movement of capital will take place until the benefits of extra flexibility are offset by the cost to static income given by a change to the value of the first term in (5.1.2). If flexibility is invariant to the allocation of capital there would be no incentive to move it away from the counterfactual allocation.

We may make use of the envelope theorem to change (5.1.2) into a form that relates more closely to the behaviour of private agents. The theorem implies that with labour mobile, so that the wage is equal across sectors, we have:

$$\frac{dm}{dK_x} = r_x - r_y \qquad (5.1.3)$$

which means that the effect of changing the allocation of capital on national income will be felt by the return to capital without any effect on the wage. Given this (5.1.2) may be restated as:

$$r_x - r_y + \frac{1}{2} Var(P) \frac{d}{dK_x} \left(\frac{dx}{dP}\right) = 0$$

The second term of which may also be changed as follows. From differentiating (5.1.3) twice and changing the order of differentiation we have:

$$\frac{d}{dK_x} \left(\frac{d^2m}{dP^2}\right) = \frac{d^2r_x}{dP^2} - \frac{d^2r_y}{dP^2}$$

and hence (5.1.2) becomes:

$$r_x - r_y + \frac{1}{2} Var(P) \left(\frac{d^2 r_x}{dP^2} - \frac{d^2 r_y}{dP^2} \right) = 0 \qquad (5.1.4)$$

which may be rearranged to:

$$r_x + \frac{1}{2} Var(P) \frac{d^2 r_x}{dP^2} = r_y + \frac{1}{2} Var(P) \frac{d^2 r_y}{dP^2}$$

or:

$$E[r_x] = E[r_y]$$

which is the equilibrium condition for private agents' allocation of fixed capital between the two sectors. Hence while we cannot say which direction capital should move without knowing its effect on dx/dP (which is in fact ambiguous in the general case and dependent on the technology in use), we can say that decentralised decision making by private agents will bring about the social optimum given by the allocation that would be chosen by the representative agent. This is a result of the relevant conditions being solely a matter of expected income, either national or private, and the envelope theorem which implies that the effects of moving capital are felt in the return to capital so there is no external effect on the rest of the economy.

5.2 NO RISK MARKETS

In this section we analyse the allocation of fixed factors in the absence of risk markets of any kind, starting as before with the representative agent's choice followed by those of private agents. We consider the sector specific capital model and for simplicity assume that consumption of the good with a volatile price, c_x, is zero.

Representative Agent Allocation

Expected utility of the representative agent is:

$$E[V] \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} \left(\frac{dx}{dP} - x^2 A \right) + V[\overline{P}, m(\overline{P})] \qquad (5.2.1)$$

and the allocation of capital will be determined by setting the following derivative to zero.

$$\frac{d}{dK_x}(E[V]) = \frac{\partial}{\partial K_x}(E[V]) + \frac{\partial}{\partial x}(E[V]) \frac{dx}{dK_x} + \frac{\partial}{\partial m}(E[V]) \frac{dm}{dK_x}$$

(5.2.2)

The components of which are as follows:

$$\frac{\partial E[V]}{\partial K_x} \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} \frac{\partial}{\partial K_x} \left(\frac{dx}{dP} \right) \qquad (5.2.3)$$

$$\frac{\partial E[V]}{\partial x} \approx -Var(P) \frac{\partial V}{\partial m} xA \qquad (5.2.4)$$

Plus the partial derivative with respect to income in which we ignore the second order effects of changing income on the first term in (5.2.1) such that:

$$\frac{\partial E[V]}{\partial m} = \frac{\partial v}{\partial m} \qquad (5.2.5)$$

Turning to the derivatives of x and m with respect to K_x and making use of the derivatives from the previous section we have:

$$\frac{dm}{dK_x} = r_x - r_y \qquad (5.2.6)$$

and:

$$\frac{dx}{dK_x} = \frac{dr_x}{dP} - \frac{dr_y}{dP} \qquad (5.2.7)$$

We initiate the analysis of (5.2.2) by assuming that we start from the static optimum such that $r_x=r_y$ so the third term is zero. At this point we have:

$$\frac{dE[V]}{dK_x} \approx \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{\partial}{\partial K_x} (\frac{dx}{dP}) - 2xA\frac{dx}{dK_x}] \qquad (5.2.8)$$

so that more capital will be allocated to the x sector if the first term is dominant such that increasing K_x strongly increases flexibility. If this term is weak or negative the derivative as a whole will be negative and it will be optimal to reduce K_x and hence x in order to reduce the exposure to risk. This will unambiguously be the case if there is no factor mobility since in that case dx/dP is zero.

Anderson and Riley (1976) derive a similar result using a different method. Their equilibrium condition equates, assuming an interior solution, the ratio of marginal costs in the two sectors with the expected marginal benefits of increasing their output by one unit as follows.

$$\frac{MC_x}{MC_y} = \frac{E(p_x \frac{\partial V}{\partial m})}{E(p_y \frac{\partial V}{\partial m})} = \frac{E(P \frac{\partial V}{\partial m})}{E(\frac{\partial V}{\partial m})}$$

At the reference point where P takes its expected value with certainty the ratio of marginal costs will be equal to E(P) and clearly the same outcome will occur if the marginal utility of income is constant such that the right hand side reduces to E(P). In general, however, the marginal utility of income will vary with P and the right hand side will be greater than E(P) if the marginal utility of income is increasing in P. If this is the case the equilibrium condition can only be satisfied by raising the marginal cost of x relative to that for y which in turn may only be achieved by increasing output of x. The change in the direction of optimal output therefore depends on the sign of:

$$\frac{d}{dP}(\frac{\partial V}{\partial m}) = \frac{\partial V}{\partial m}[-(x-c_x)A - \frac{\partial c_x}{\partial m}] \qquad (5.2.9)$$

and hence the optimal output of x will fall relative to the static optimum if the economy is risk averse and x is normal.

Anderson and Riley's result differs from the previous one by the addition of consumption of x, which makes little analytical difference, and their assumption that all output decisions must be taken before relative prices are known so that there is no flexibility and hence no consideration of a change in fixed factor allocation affecting flexibility. This corresponds to the case of zero factor mobility mentioned above.

Turning to the general case concerning the value of (5.2.2) away from the static optimum, making use of (5.2.3) and (5.2.4) and setting (5.2.2) to zero yields the following condition for the representative agent's allocation of fixed capital:

$$\frac{dm}{dK_x} + \frac{1}{2}Var(P)\frac{\partial}{\partial K_x}\left(\frac{dx}{dP}\right) = Var(P)\,xA\frac{dx}{dK_x} \qquad (5.2.10)$$

Which of itself is not particularly helpful in predicting the optimal direction of change in the allocation of K_x, which could go either way depending on the characteristics of the technology, but if we substitute in (5.2.6) and (5.2.7) we have:

$$r_x - r_y + \frac{1}{2}Var(P)\left(\frac{d^2r_x}{dP^2} - \frac{d^2r_y}{dP^2}\right) = Var(P)\left(\frac{dr_x}{dP} - \frac{dr_y}{dP}\right)xA \qquad (5.2.11)$$

in which the difference in the expected return to capital in the two sectors is on the left hand side and the difference in their exposure to income fluctuations, weighted by the risk aversion coefficient, is on the right hand side. This proves useful when discussing domestic risk markets in Section 5.3.

While we cannot derive a simple expression for the optimal K_x or x it is interesting to consider the special case where the economy is very risk averse. This extreme case will reduce the optimal x as far as possible and hence is suggestive of the range of values that the optimal x may take. A question

of particular interest in this context is whether a reduction in x may be large enough to cause a specialisation reversal so that the economy becomes a net importer of x rather than an exporter, assuming that x was exported under the counterfactual.

If A becomes large the choice problem approaches that of maximising the minimum level of utility achieved as prices fluctuate. We consider two cases, the first where the range of fluctuations is such that relative prices are always greater than autarkic relative prices and the second where they cover a range that includes autarky relative prices.

With the relative price always to one side of autarky we consider Figure 5.1. The function V(P) H-O represents the levels of utility achievable at different values of relative prices if all factors are freely mobile ex post as would be the case in a Hecksher-Ohlin model. For given technology this function represents the maximum possible utility for each value of P. If one or both factors is fixed ex ante, utility will generally be lower than the value of this function since income will be lower as fixed factors are unable to reallocate to the sector where returns are highest. At one point in the range of relative prices, however, the function V(P) for a fixed factor economy will take the same value as that in the freely mobile economy when the allocation of fixed factors will be optimal at that value of P. One such function is shown in Figure 5.1 and described as $V(P)x=x(P_L)$ to indicate

FIGURE 5.1

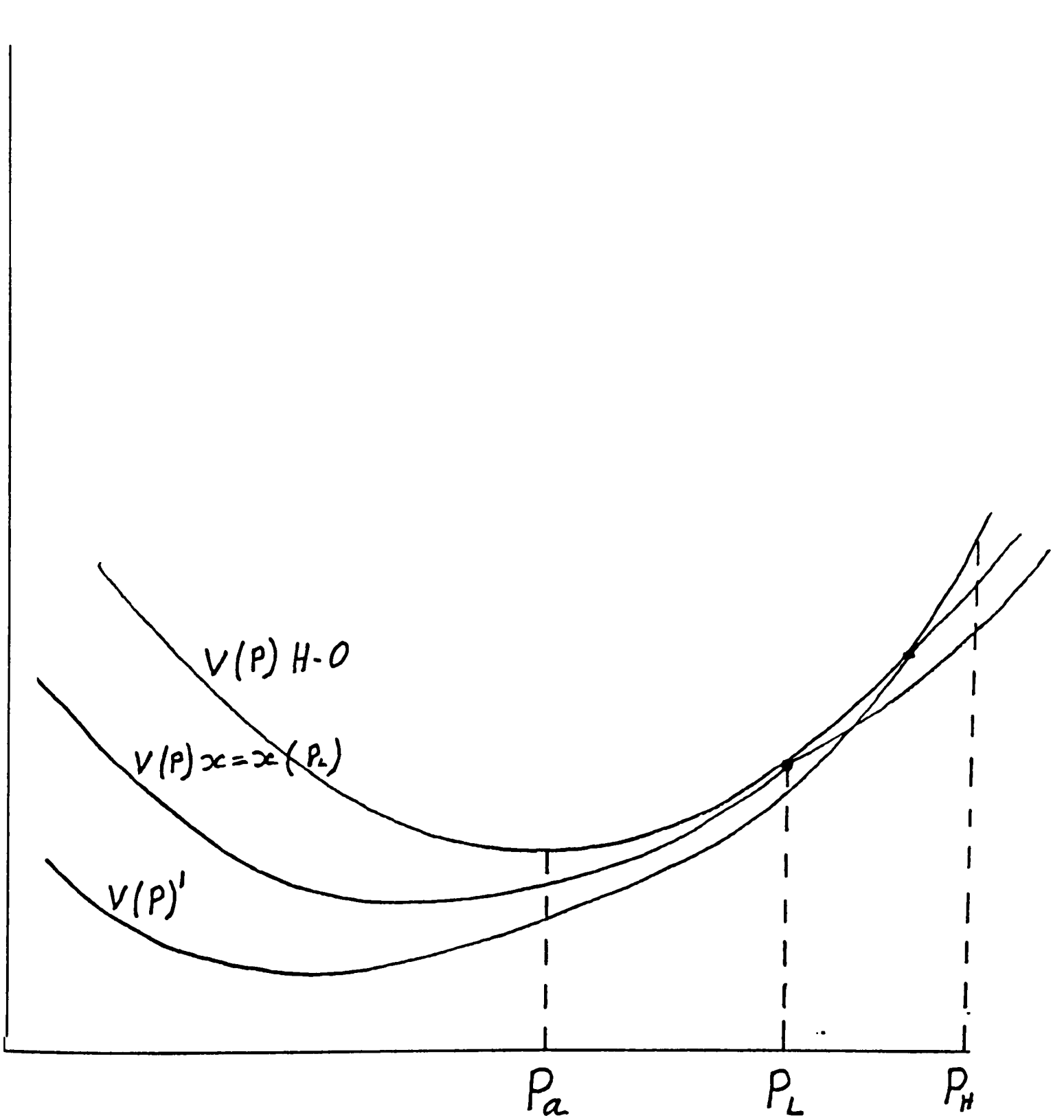
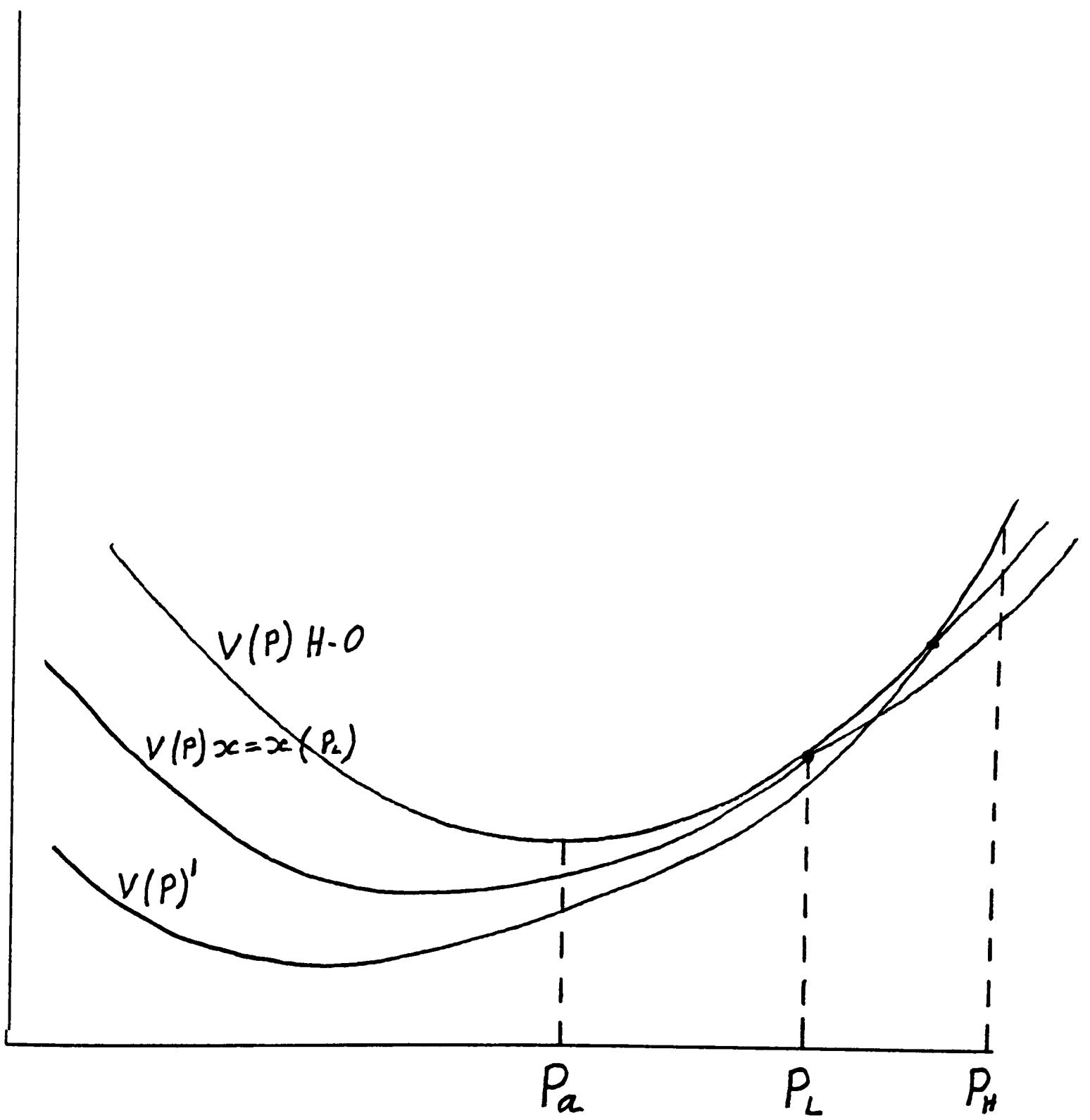


FIGURE 5.1



that fixed factors are allocated in the same way that they would be if all factors were mobile and P was equal to P_L.

If the degree of risk aversion becomes large the economy wants to maximise minimum utility over the range of P. In relation to Figure 5.1 this is equivalent to the economy wanting to select the function V(P), contingent on the allocation of fixed factors, that maximises minimum utility in the range P_L-P_H. If utility is continuously rising in that interval it is clear that the solution to this problem is to set x at the level it would take if relative prices were equal to P_L with certainty so that the function chosen is $V(P)x=x(P_L)$. If more fixed capital was allocated to the x sector the relevant function would be like V(P)' which yields a lower minimum utility at P_L. In addition we know that:

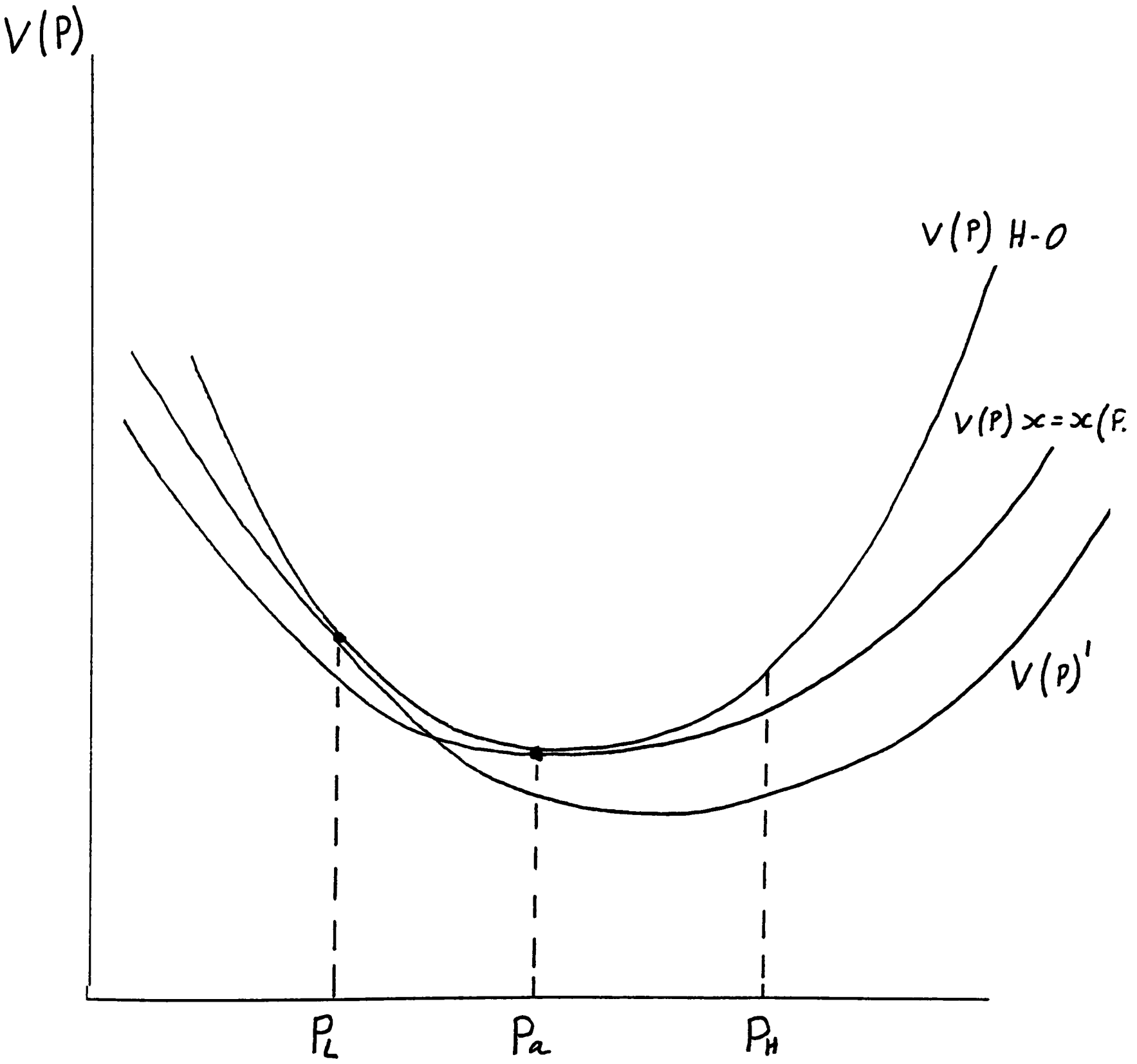
$$\frac{dU}{dP}=(x-c_x)\frac{\partial V}{\partial m} \qquad (2.2.2)$$

so utility will be increasing in P over the range of prices if x is exported over the whole range. We also know that if all factors are freely mobile, x is exported at all values of P greater than P_a which is the autarky relative price. Since the fixed factor and mobile factor V(P) functions are common at P_L, x must be exported at this point in the fixed factor case and hence also exported at relative prices higher than P_L. This completes the argument for allocating fixed factors so that x is equal to the value it would take if prices were to take the value P_L with certainty.

The second case is where relative prices vary to either side of autarky relative prices. This is depicted in Figure 5.2 which shows the function V(P) H-O as before and also the function V(P) that would result from allocating fixed factors so that x is equal to the value it would take were relative prices to be stable at autarky relative prices. With high risk aversion the objective is again to maximise minimum utility but in this case it is achieved by setting $x=x(P_a)$ rather than $x=x(P_L)$. The reason for this is straightforward in that if $x=x(P_a)$, minimum utility will be given by $V(P_a)$ whereas setting x at any other value would reduce utility in the state of the world where $P=P_a$ and thereby reduce minimum utility. An example of such a case is the function V(P)' where the allocation of fixed capital to the x sector is below its counterfactual level at autarky relative prices.

Taking the two cases together we can say that if the economy is very risk averse and as a result this is the dominant factor in optimising the allocation of fixed factors, the optimal value of x will be reduced from its static optimum of $x(\bar{P})$ to $x(P_L)$ or $x(P_a)$ whichever comes first. With large risk aversion the optimal level of output of x is therefore at least as large as its value in autarky. In turn this implies that there will not be a specialisation reversal in the sense that x will still be exported at counterfactual prices, $\bar{P}$, even if it might be imported at P_L. In addition if the level of exports is linear in P (or at least not too concave) x will be exported on average.

FIGURE 5.2



Private Agent Allocation

Having established the nature of the choice of fixed factor allocation from the point of view of the representative agent we now turn to the allocation that will result from the decentralised decisions of private agents. The relevant equilibrium condition in the absence of risk markets is equal expected utility from allocating a unit of capital to either the x or y sectors. Following similar steps to the derivations in Chapter 2 and assuming that $c_x=0$ we have:

$$E[V] \approx V[\overline{P}, r_x(\overline{P})] + \frac{1}{2} Var(P) \frac{\partial V}{\partial m} [\frac{d^2 r_x}{dP^2} - (\frac{dr_x}{dP})^2 A]$$

(5.2.12)

for capital in the x sector and the same expression, after replacing r_x with r_y, in the y sector.

If we compare this expression across the two sectors at the counterfactual allocation and relative price (so in fact $r_x=r_y$ and the marginal utility of income from a unit of capital will be the same in each sector) we have:

$$V[\overline{P}, r_x] - V[\overline{P}, r_y] = \frac{1}{2} Var(P) \frac{\partial V}{\partial r} [A[(\frac{dr_x}{dP})^2 - (\frac{dr_y}{dP})^2] - (\frac{d^2 r_x}{dP^2} - \frac{d^2 r_y}{dP^2})]$$

(5.2.13)

From which the direction of movement of capital will depend on the sign of the right hand side. If this is positive, r_x will have to rise and r_y fall to establish equilibrium which in

turn means that less capital will be allocated to the x sector. The condition for this is:

$$A[(\frac{dr_x}{dP})^2-(\frac{dr_y}{dP})^2] > \frac{d^2r_x}{dP^2}-\frac{d^2r_y}{dP^2} \qquad (5.2.14)$$

whereas the equivalent condition for the representative agent, from (5.2.11) above, is:

$$2xA[\frac{dr_x}{dP}-\frac{dr_y}{dP}] > \frac{d^2r_x}{dP^2}-\frac{d^2r_y}{dP^2} \qquad (5.2.15)$$

which differs both by the coefficient 2x on the left hand side and the fact that the derivatives, dr/dP, are not squared. The latter difference is of greater interest though overall the most important thing is that these conditions differ so that in general the decentralised allocation of capital will not coincide with the social optimum.

The derivatives not being squared in the representative agent condition suggests why this divergence arises. By standard results dr_x/dP is positive and dr_y/dP negative so the left hand side of (5.2.15) will be positive whereas the sign of the left hand side of (5.2.14) is ambiguous. As a result the representative agent would be more likely to reduce the allocation of capital to the x sector which in turn will reduce the output of x and reduce the economy's exposure to risk. A reduction in K_x by the decentralised allocation is less likely since agents will allocate capital according to only the risk faced by that capital while ignoring the risk that may be transmitted to the rest of the economy by a

decision to allocate in the x sector. Hence it makes sense for the social optimum to reduce the exposure to risk more than the private optimum.

5.3 DOMESTIC RISK MARKETS

The chapter so far has derived results concerning the allocation of resources under the polar assumptions of perfect international risk markets and no risk markets. It was found that the direction of change in fixed factor allocation was ambiguous in both cases within the overall theme of a tendency to reduce the allocation to the sector exposed to the volatile price unless doing the opposite gave rise to a major increase in flexibility. More concrete results were possible comparing the socially and privately optimal allocations which coincided under perfect risk markets but diverged in the absence of risk markets.

This section analyses the same variables with a domestic risk market but no international risk market. In this context a representative agent analysis is not applicable since that agent cannot insure themselves and could only trade on an international market. As a result we examine the allocation of fixed capital between sectors as a consequence of private decisions.

We suppose that private agents choose a quantity of insurance, q, bought at price P_I according to a contract with payout, I, given by:

$$I = (\bar{P}-P)\,q-P_I q$$

The price of insurance will depend on the demand for it by private agents but we first analyse the choice of q given P_I

followed by the determination of P_I which is simply that price at which excess demand is zero.

For an individual agent with income w (used to apply to both wages and the return to capital) and insurance q we have:

$$E[V] \approx V[\overline{P}, w] + \frac{1}{2} Var(P) \frac{\partial V}{\partial w} [\frac{d^2 w}{dP^2} - (\frac{dw}{dP} - q)^2 A^w]$$

from which q will be chosen by setting dE[V]/dq to zero:

$$\frac{dE[V]}{dq} = \frac{\partial E[V]}{\partial q} + \frac{\partial E[V]}{\partial w} \frac{dw}{dq}$$

where:

$$\frac{\partial E[V]}{\partial q} = Var(P) \frac{\partial V}{\partial w} (\frac{dw}{dP} - q) A^w$$

and:

$$\frac{\partial E[V]}{\partial w} \approx \frac{\partial V}{\partial w} \qquad \frac{dw}{dq} = -P_I$$

Hence the optimal q, given by q^*, is:

$$q^* = \frac{dw}{dP} - \frac{P_I}{A^w Var(P)} \qquad (5.3.1)$$

From which if insurance was free, as in a perfect market, the agent would insure against all their income fluctuations, dw/dP, and the insurance quantity would be decreasing in P_I but increasing in the variance of P and the degree of risk aversion.

Equation (5.3.1) gives an agent's choice of q at a certain P_I which leaves the determination of P_I by:

$$0 = \Sigma q^* = \Sigma \frac{dw}{dP} - P_I \Sigma \frac{1}{A^w Var(P)}$$

From which:

$$0 = \Sigma q^* = x - \frac{P_I}{AVar(P)}$$

and:

$$P_I = Var(P)xA$$

which is the market clearing price of insurance, or the price of avoiding risk, in terms of the output of the good with a volatile price (the exposure to risk), the variance of that price and the coefficient of absolute risk aversion of the representative agent/whole economy.

Given the price of insurance, private agents will allocate capital between the two sectors. This will in turn affect the price of insurance due to the presence of x on the right hand side above. After an iterative process equilibrium will be achieved when the tradeoff between income and exposure to risk in the allocation of capital is equal to the price of insurance with no subsequent pressure for that price to change.

The allocation of capital with given P_I must be such that the difference in expected income is equal to the difference in exposure to risk multiplied by the price of risk as follows:

$$E[r_x] - E[r_y] = P_I\left(\frac{dr_x}{dP} - \frac{dr_y}{dP}\right)$$

from which, breaking down expected income into its constituent

parts we have:

$$r_x - r_y + \frac{1}{2} Var(P) \left(\frac{d^2 r_x}{dP^2} - \frac{d^2 r_y}{dP^2} \right) = P_I \left(\frac{dr_x}{dP} - \frac{dr_y}{dP} \right)$$

and substituting in the price of risk we must have in equilibrium:

$$r_x - r_y + \frac{1}{2} Var(P) \left(\frac{d^2 r_x}{dP^2} - \frac{d^2 r_y}{dP^2} \right) = Var(P) \left(\frac{dr_x}{dP} - \frac{dr_y}{dP} \right) xA$$

which is the same as (5.2.11), the condition for a socially optimal allocation of capital given the absence of international risk markets.

Hence a domestic risk market creates a price for risk so that subsequent allocation decisions take this price into account and the final allocation coincides with the social optimum when the private allocation without a domestic risk market would in general differ from that social optimum.

CHAPTER 6

EMPIRICAL EVIDENCE

This chapter provides empirical estimates of the costs and benefits of price volatility based on the theory developed in the previous chapters. Section 6.1 discusses methodological issues concerned with the estimation of these results together with the derivation of different ways of presenting their components, focusing in particular on the potential benefits from output flexibility. Section 6.2 outlines the data sources used and presents a full description of the procedure followed. The latter makes use of the data and results for Kenya as an example.

Section 6.3 initiates the presentation of the results, looking at different measures of the degree of volatility in relative prices and the estimates of the export volume elasticities with respect to those prices which are the source of potential gains from volatility or at least a factor that may offset some of its costs. It is found that these elasticities are often negative, and tend to be small if they are positive, which contrasts with much microeconomic evidence that highlights the flexibility of many commodity producers in response to price signals. Possible reasons for this divergence are discussed and the gains from converting micro level flexibility into flexibility at the country level are presented.

Section 6.4 shows the results for the whole effect of volatility, incorporating the elasticity estimates of the preceding section into a larger calculation that takes account of the effects of risk aversion and the other factors derived in the previous chapters. The modest values for the estimated elasticities imply that price volatility produces a net cost for the great majority of countries. The size of this net cost is shown and the section concludes by demonstrating that the elasticity values required for these costs to be offset are mostly within the range that the microeconomic evidence suggests is feasible. This focuses attention back onto the reasons for poor flexibility at the country level and the potential gains from raising it.

6.1 METHODOLOGY

This section discusses the methodological issues that arise in using the theory developed earlier to estimate the empirical magnitude of the effects of volatility. These may be discussed in relation to the key result, from Chapter 2, which gives the change in the expected utility of the representative agent from price volatility, with an arithmetic mean counterfactual and no insurance, by:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} (\Sigma_i Var(\ln P_i) \gamma_i [\epsilon_{X_i}^{P_i} - \beta_i \epsilon_{c_i}^{\partial m} - \gamma_i R - \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_i}]$$

$$+\Sigma_i \Sigma_{j_{(i \neq j)}} Cov(\ln P_i, \ln P_j) \gamma_i [\epsilon_{X_i}^{P_j} - \beta_j \epsilon_{c_j}^{\partial m} - \gamma_j R - \beta_n \epsilon_{c_n}^{\partial m} \epsilon_{P_n}^{P_j}]) \quad (6.1.1)$$

With a geometric mean counterfactual the expression would be the same except for the addition of unity in the square bracket on the first line.

In addition, from Chapter 3, if the economy is insuring optimally on a perfect international market (6.1.1) becomes, for an arithmetic mean counterfactual once again:

$$\Delta E(V) \approx \frac{1}{2} m \frac{\partial V}{\partial m} [\Sigma_i Var(\ln P_i) \gamma_i \epsilon_{X_i}^{P_i} + \Sigma_{i \neq j} \Sigma Cov(lnP_i, lnP_j) \gamma_i \epsilon_{X_i}^{P_j}]$$

(6.1.2)

These expressions are the basis for the results presented

later in the chapter. It may be noted that the previous chapter found that in the absence of a well functioning domestic insurance market (or its equivalent) there may be further costs from price volatility as a result of a distortion to the allocation of fixed factors between sectors. Unfortunately the estimation of this effect would require a large amount of unavailable information about the properties of the relevant production functions in each country and sector and as a result is not possible. Given this we are forced to ignore this possibility and hence the results below for the net effect of volatility may underestimate the true costs and must be qualified accordingly. Fortunately the estimates of the export supply elasticities are not affected and hence this part of the results may be considered robust to possible resource misallocation.

It may be recalled that the expressions above were derived on the basis that the distribution of relative prices facing the economy were stationary and hence volatile around a constant mean in which case the key issue becomes the choice of counterfactual such as the arithmetic or geometric mean. However, if the actual relative price series faced by the countries in the sample may not be stationary there are two prior issues. The first of these is whether any trends in the series should be included in the definition of volatility or alternatively included in the counterfactual. This question was discussed in Chapter 1 which concluded that trends in the relative price series should be incorporated in the

counterfactual. The second issue, which is considered below, is how to implement empirically the inclusion of trends in the counterfactual so as to generate a stationary, de-trended relative price series for use in estimating the expressions above.

The section also discusses some more pragmatic issues which comprise a way of simplifying the task of estimating the elasticities in (6.1.1) and (6.2.2) without losing information, and different ways of presenting the components and overall value of those expressions. It is useful to simplify the estimation of these elasticities since there are 53 countries in the sample and many more elasticities given that there are own and cross price elasticities for each commodity in each country.

Non-Stationarity and Defining the Counterfactual

Following Chapter 1 we take the approach that any non-stationarity in the series under consideration should be incorporated in the counterfactual so that the resulting estimates of deviations from the counterfactual are stationary. These deviations become the estimate of the volatile component of the series to make use of in estimating (6.1.1) and (6.1.2).

Hence the issue to be considered is how to estimate the possible trends in the series so as to include them in the

counterfactual used. This is discussed chiefly in relation to the series for relative prices but the same question arises in relation to the series for export volumes which are used to estimate the elasticity of export volume with respect to the relative price.

Unfortunately the nature of the trends present in real commodity price series are not fully understood with as yet no decisive evidence as to whether they are best described as trend stationary or difference stationary processes, though the most recent literature is more supportive to the former (Leon and Soto (1995)). Trend stationarity may also be favoured on theoretical grounds in that real commodity prices are dominated in the long run by technological change and, as argued in Chapter 1, any substantial movement in a commodity price will tend to induce technological change that will tend to reverse that movement. This is inconsistent with the presence of a random walk component[1] though the mean reversion resulting from such change may be slow.

In addition to debate about the time series properties of real commodity prices there is also some controversy about the best means of estimating the (stochastic) trend in the difference stationary case.

The nature of these disagreements is discussed fully below but

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[1]Unless the effect of technological development is modelled by reflecting barriers in which case the series would appear weakly mean reverting.

their existence forces a pragmatic approach that leads to the use of two methods of removing trends from the data rather than a single ideal one. Fortunately it is found that the results derived under each are very similar, which suggests that the results tend to be driven by large deviations from the estimated counterfactual, and hence the conclusions reached are likely to be robust to different methods of estimation.

The most basic distinction in considering non-stationary time series is between trend stationarity, where the trend is deterministic and either constant or slowly changing, and difference stationarity which gives rise to a stochastic trend as discussed in Chapter 1. The ideal approach to estimating the counterfactual would start from establishing whether the relative price series under consideration was trend or difference stationary and proceed by using the best method of estimation according to which of the two cases apply. The underlying econometric methodology differs fundamentally between the two and this both emphasises the importance of the distinction and makes it very difficult to design powerful tests that discriminate between them. If trend stationarity is the maintained hypothesis it is well known that tests for the significance of the coefficient on the time trend are biased towards accepting the existence of that trend even if the series is in fact difference stationary. It is also well understood that tests for a unit root with difference stationarity as the null hypothesis have very low power

against the alternative of trend stationarity when the sample length corresponds to the available data for many economic variables. When the sample length is much longer the power improves but a longer period may increase the probability of there being a structural break in the series. Structural breaks tend to make a series appear closer to being difference stationary even if their component parts (on either side of the structural break) are trend stationary. Structural breaks are discussed in Perron (1989) and Leon and Soto (1995) while the more general issues in determining the time series properties of real commodity prices are discussed by Deaton (1995).

Given the lack of clear evidence in the literature about the time series properties of commodity prices it is necessary to consider both possibilities. This is reinforced by the comparatively short data period available, a maximum of thirty-two years, which implies that there would be little gain in conducting unit root tests on the series used. Hence we proceed by considering the two cases separately and on an equal basis. Estimation of the counterfactual with trend stationarity as the maintained hypothesis is comparatively straightforward but further constraints are present for the difference stationary case.

If it is assumed that the series under consideration is trend stationary the standard procedure is to take the log of the variable (to transform an exponential trend into a linear

trend) and regress the series against a constant and time with the estimated regression line being used as the counterfactual. This is followed below except that we include the square of time also so that the resulting regression line becomes a quadratic rather than linear. This is done because there is no reason to assume that the time trend is necessarily linear and the procedure allows the data to suggest a linear trend as a special case.

Turning to the difference stationary case a further distinction is required between standard ARIMA models and Unobserved Components or UC-ARIMA models. The key difference between the two is the underlying assumption made about the relationship between the permanent shocks to the series, the random walk component, and the stationary shocks or ARMA component. In the ARIMA case the decomposition of the series into its permanent and stationary components, derived by Beveridge and Nelson (1981), rests on an assumption that the two components are perfectly correlated whereas the UC-ARIMA model assumes zero correlation.

This distinction may be illustrated with reference to the empirical literature on the nature of the US business cycle. In turn this literature refers to the contrast between real business cycle theory, in which cyclical fluctuations are seen as an integral part of the growth process, and the more orthodox approach of assuming that fluctuations arise from either real or monetary demand shocks that are largely

independent of long run growth. Campbell and Mankiw (1987) estimated a standard ARIMA model for US Real GNP and found that most of the fluctuations in the series may be attributed to the stochastic trend or random walk component, a result consistent with real business cycle theory. By contrast, Clarke (1987) estimated an UC-ARIMA model using the same data and found that virtually all of the fluctuations in the series were stationary with the random walk component having a muted effect. The latter result is favourable to orthodox business cycle theory but it is clear that the underlying assumptions made by the models in both papers have a strong influence on their results. The perfect correlation assumption of the ARIMA approach makes the structure of the model consistent with cycles arising from the long run trend, while the independence assumption of the UC-ARIMA model is consistent with the theoretical approach of the orthodox models.

Unfortunately it is not possible to pursue a modelling strategy open to both possibilities because a model with partial correlation between the permanent and transitory components is not statistically identified[2]. This presents great difficulties in using these models for analysing real commodity prices since neither option is entirely satisfactory. The standard ARIMA case is difficult to justify in this context since we have a strong prior that commodity prices are determined by a mixture of long run technology shocks and short run supply and demand shocks and there is no

[2] See Watson (1986) and Harvey (1985).

reason why these should be perfectly correlated. The UC-ARIMA model is more appealing in that the short and long run determinants of commodity prices are perhaps likely to be closer to independent than perfectly correlated but full independence between them would be a very strong assumption.

As a result of these difficulties, together with the most recent econometric evidence and a theory based prior in favour of technical change induced mean reversion, we do not make use of either of the ARIMA based approaches. While rejecting the use of an ARIMA counterfactual it is nevertheless undesirable to rely exclusively on the time trend counterfactual in case the results are sensitive to this specification. In addition it is worth making some allowance for the possibility that real commodity prices do not fluctuate around such a smooth path as a quadratic time trend and hence we also make use of a centred moving average counterfactual. This has been used in the literature on price volatility and investment/growth (see Dawes (1993)) on the pragmatic grounds that it smooths the volatile series while being more flexible and responsive than a time trend since the latter is estimated on the whole data period whereas the moving average uses only the data points for a short period to either side. Clearly there is a risk that the moving average is too sensitive to the series, and hence incorporates some of the volatile component in the counterfactual, but this is an inherent cost of making a counterfactual of this kind less rigid than the time trend.

The justification for this counterfactual is pragmatic rather than based on an underlying model of commodity price determination, it being useful to have a second counterfactual with which to make comparisons with the time trend. In addition a moving average may be more sympathetic to the properties of series closer to the difference stationary case in that the counterfactual it defines adjusts to what may be irregular permanent shocks much more readily than the time trend which is based on the assumption that the permanent changes to the series are smooth. As noted above the cost of this is that the moving average counterfactual may be too sensitive to the series. While this counterfactual is not ideal it is found that the results based on it are close to those based on the time trend and hence it provides reassurance that the results are not too sensitive to the choice of counterfactual. In addition it is of note that Clarke's (1987) UC-ARIMA model of US Real GNP implies that the estimated permanent changes to that series are close to those estimated by a time trend and tend to be between the latter and the actual series. While this far from conclusive it does perhaps suggest that the ideal or "true" counterfactual (that is likely to reflect permanent changes that are more variable than the time trend case but different from those of a UC-ARIMA model due to partial correlation between transitory and permanent changes) may be in the neighbourhood of either the time trend or moving average cases. If this is the case the closeness of the results for the latter two is reassuring in that the econometric constraints on estimating the "true"

counterfactual may not prevent the derivation of results that are correct at least to an order of magnitude.

This discussion has been in terms of the series for relative prices but the same issues arise when considering how best to remove the trend from the series for export volumes in order to estimate the supply elasticities of the latter. In addition the long run pattern of exports may result from a variety of other factors such as the environment and policies towards the commodity producing sectors. A detailed attempt to model these is beyond the scope of the thesis and for simplicity we adopt the same methods of estimating the permanent changes to these series as for those of relative prices.

Simplification of export volume price elasticities

The second issue discussed in this section is more practical than methodological in that it is designed to simplify the process of estimating the sums of the elasticities in equation (6.1.1).

If we assume that the permanent changes in the price and volume series have been removed, leaving stationary series denoted by P^s and X^s, and extract the elasticity terms from (6.1.1) and (6.1.2) we have:

$$\Sigma_i \gamma_i \; [Var(\ln P_i^s)\epsilon_{X_i^s}^{P_i^s} + \Sigma_{j \neq i} Cov(lnP_i^s, lnP_j^s)\epsilon_{X_i^s}^{P_j^s}]$$

From this expression we could proceed to estimate each of the own and cross price elasticities with one estimated equation for each of the commodities with each volatile price as an independent variable. Multicollinearity problems would tend to occur if there are non-zero covariances between the volatile prices which is the exact situation in which the cross price elasticities become relevant. Fortunately, however, separate estimation of all the elasticities is not necessary. This is because we are primarily interested in the sum of the elasticities, weighted by the appropriate variances and covariances as shown, and if the OLS multiple regression formulae are substituted into the expression above it simplifies to:

$$\Sigma_i \gamma_i Cov(lnP_i^s, \ln X_i^s)$$

which allows for a much more economical procedure. In fact while we use this expression for estimating (6.1.1) we also present results for the implicit own price elasticity in the expression (ignoring variations in the prices of the other exports) by rewriting it as:

$$\Sigma_i \gamma_i Var(lnP_i^s) \; \frac{Cov(lnP_i^s, \ln X_i^s)}{Var(lnP_i^s)} \qquad (6.1.3)$$

where the Cov(.)/Var(.) term is the implicit own price elasticity. This value would be a misspecified estimate of the own price elasticity if the covariances with other prices

are non-zero and the true cross price elasticities also non-zero but it is of interest since it demonstrates for each commodity the extent to which innovations in price have been associated with innovations in export volume.

There are two further reasons why the final part of (6.1.3) may not reflect the true own price elasticity of supply. The first results from the relative price series used being the internationally traded relative price of the good which is not necessarily the same as the relative price received by producers. This would occur if there are marketing board structures in place with controlled producer prices. In relation to the theoretical expression that is being estimated this does not affect the desirability of using the international price because the theory implies that there is a benefit from export volumes responding to that price. What it does mean is that if movements in the controlled price do not correlate closely with the international price, and producers respond to the controlled price, the economy may be missing the opportunity to take advantage of this benefit. Hence a low or even negative value for the implicit own price elasticity does not necessarily imply that the true elasticity is not healthily positive. Similar considerations apply to the possibility of varying export taxes affecting producer incentives.

A second possibility is that the country in question may be large and hence the estimated elasticity may partly reflect

the elasticity of demand in the world market for the commodity in question rather than solely the domestic elasticity of supply. The theory developed above was concerned with the small country case where this question does not arise. This is appropriate for the great majority of countries and commodities below, and very few have world market shares in excess of ten to fifteen per cent, and we proceed as if the large country issue was not present, leaving for future research the question of modifying the methodology in this case.

Two further points may be noted at this stage. They both arise from the fact that the supply elasticities are measures of the extent to which export volumes have responded to relative prices year by year in the period considered. As a result we are interested primarily in their estimated numerical value and hence are not concerned with their statistical significance. In addition we do not consider whether lagged export prices may influence current exports in addition to current prices because the theory is clear that it is the response of current export volume to current export price which is relevant for estimating the effects of volatility.

Presentation and Interpretation of Results

The second set of methodological issues is concerned with the presentation of the results. In the first instance a

difficulty arises in that (6.1.1) includes the marginal utility of income. Since a magnitude cannot be placed on this the equation cannot be estimated in full and hence as it stands only its sign could be derived with confidence (given that the marginal utility of income will be positive). This is unsatisfactory and hence we present measures of the impact of price volatility that avoid this problem.

The first measure was defined in Chapter 1 as follows:

$$\frac{\Delta m^c}{m} \approx \frac{dm}{m} \approx \frac{\Delta E(V)}{m\frac{\partial V}{\partial m}} \qquad (6.1.4)$$

so that the change in income equivalent to the effect of price volatility will be given by (6.1.1) without the terms at the front in income and the marginal utility of income. It may also be noted that this measure will have the same sign as (6.1.1) so, for example, a negative value for $\Delta m^c/m$ indicates that price volatility is harmful to expected utility.

The second measure is very similar except that it is defined by the proportionate change in the mean of the prices that are volatile that has the same effect on expected utility as the volatility of those prices. This equivalent change in prices was also derived in Chapter 1 and is given by:

$$\frac{\Delta P^c}{P} \approx \frac{dP}{P} \approx \frac{\Delta E(V)}{m\frac{\partial V}{\partial m}\Sigma_i \gamma_i} \qquad (6.1.5)$$

so that the equivalent change in the means of the volatile prices will be given by (6.1.1) without the terms in income

and the marginal utility of income and dividing by the sum of shares in national income of exports of goods with volatile prices. As with the income based measure above this will have the same sign as the change in expected utility from price volatility. It should also be emphasised that this measure relates to the welfare compensated change in the prices that are volatile rather than all export prices. It may be noted that (6.1.4) and (6.1.5) are similar in structure, the difference being the shares of exports in national income in the denominator. The relationship between the two measures may be seen intuitively by recalling the first derivative of utility with respect to the price of a traded good which is given by:

$$\frac{dV}{dP_i} = X_i \frac{\partial V}{\partial m}$$

from which the effect on utility of a change in price will be equal to the effect of a change in income weighted by the level of exports. The price based measure will therefore be larger since the sum of export shares of goods with volatile prices in national income will be less than one.

In addition to the above two measures of the whole effect of volatility, we also present three sets of figures based on the export volume elasticities. These are of particular interest in that they are a potential source of benefit from volatility and may also be more affected by policy than the other components of the whole effect such as the structure of the economy and the degree of risk aversion.

The first of these figures is a weighted average of the individual elasticities for each commodity which shows the effective degree of flexibility for the economy as a whole[3]. The weights used are the product of the variance of the log of the commodity price and the share of its exports in national income, this being the coefficient on the elasticities in (6.1.3).

The second figure reflects the extent to which an increase in each of the export supply elasticities would reduce the costs or increase the benefits to the economy from price volatility. This is given, from (6.1.3), by the product of the variances of the log of each commodity price and the share of its exports in national income.

The third figure, termed the critical elasticity in the results tables, is not based on the actual estimated elasticities but instead takes the components of (6.1.1) other than the elasticities and states what the weighted average elasticity (as defined above) would have to be in order for the costs from volatility from these other terms to be exactly offset by the benefits of flexibility. If the actual weighted average elasticity is less than this figure the other results will record a net loss from volatility and a gain if it is higher.

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[3]For economies with only one major commodity export this figure is simply the elasticity for that commodity.

The final set of figures given applies to those countries with more than one major commodity export and reflects the extent to which the prices of those commodities tend to move together or alternatively covary negatively. It may be recalled that negative covariances between different relative prices is helpful on two counts. First a negative covariance will lead to higher overall measured flexibility since the commodity sectors will tend to expand and contract at different times so that the cross price effect on the elasticities of supply will be beneficial rather than sectors competing for resources at the same time which will tend to reduce their response to price changes. The second benefit from a negative covariance is that the income effects of price changes will tend to offset each other, thus helping to reduce the costs from volatility arising from risk aversion and the tendency of the non-tradeables sector to expand at times when the export sectors are themselves seeking to expand. This figure is calculated as the negative of the weighted average covariance divided by the weighted average variance, the weights being the size of that sector's exports as a share of national income. This figure is termed the Variance-Covariance Structure and reflects the size of the covariances relative to the variances. It is dimensionless and as a result comparable across countries, varying between +1 and -1, and its sign is positive (indicating a benefit) if the weighted average covariance is negative. Where there is only one commodity the figure is not given but may be thought of as equal to zero for these cases.

6.2 DATA SOURCES AND ECONOMETRIC PROCEDURE

This section describes the sources of data and the procedure by which the results were calculated, making use of Kenya's exports of coffee as an illustrative example.

Almost all the data used is from the IMF's International Financial Statistics (various years) which provides export volume and value data for major commodity exports as well as more general information about both individual countries and world commodity prices and import unit value indices. A small amount of data, particularly on the domestic consumption of commodities, comes from UNCTAD's Commodity Yearbook (1994).

Overall sufficient data was available to cover 53 countries, most of them over the period 1958-1990 or slightly shorter, with 110 country-commodity pairs.

The key components of the analysis are the construction of series for the relative price of each commodity by country and the use of an index of the volume of exports of those commodities. The latter come straight from IFS while the former are derived from IFS data for export values, import unit values, exchange rates and world commodity prices.

IFS presents data on import unit values by country for virtually none of the sample and hence use was made of regional import values or country groupings (series for Africa, Western Hemisphere, All LDCs, and Industrial

Countries), taking the one that corresponds to the location of the country or using the one for all LDCs if a regional index is not available. These indices are based on US Dollar measures and are transformed into an index of unit values in domestic currency using IFS exchange rate data. This index forms the denominator of the relative price series. The numerator, which is the export price of the commodity, comes from two sources and hence leads to two cases that run through the results (making four cases in all given that there are two methods of allowing for the long run trends in the series). The first of these makes use of the export unit value information that is yielded by dividing the IFS series for export values by the export volume index. The second comes from the world commodity price series in IFS transformed into domestic currency terms via the exchange rate. Dividing each of these in turn by the import unit value index gives an index of the relative price of exports.

While the relative price series based on unit values are usually close to those derived from world price series, the use of both helps to confirm the robustness of the results. Arguably the world price series form a more reliable source of information about commodity prices than export unit values but it is possible that in some cases there may be some differentiation within a commodity, or imperfect arbitrage due to transportation costs between different parts of the world market, such that world price series do not correspond exactly to the export prices available to an economy. The use of

country-specific export unit values would in principle avoid these difficulties but are likely to be an imperfect source of information themselves. This may arise for two reasons, firstly the export unit value is calculated as a residual from export values and volumes and hence any measurement error that does not affect both in equal proportion will result in errors in the unit value series.[1] The second concern is that if countries have sold commodities forward under long run contracts at fixed prices, the value of exports and hence the unit value index will reflect these prices and hence indicate the average unit value of exports rather than the marginal unit value which would be more appropriate for calculating the export volume elasticities. It may be noted that comparing the standard deviations of the price series generated shows that for the LDCs the unit value based series are slightly more volatile than those based on world prices, perhaps indicating the measurement error effect, whereas these are reversed for the OECD economies which may reflect forward contracts and an absence of significant measurement error.

This discussion suggests that the world price based series for relative prices may be more reliable but the closeness of the results for the unit value based series is a useful confirmation of their robustness. In addition, for a small number of commodities suitable world price data is not available and the unit value based series is the only feasible

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[1]Errors of this kind will also tend to make the estimated elasticities, based on the response of volume to price, more negative.

option.

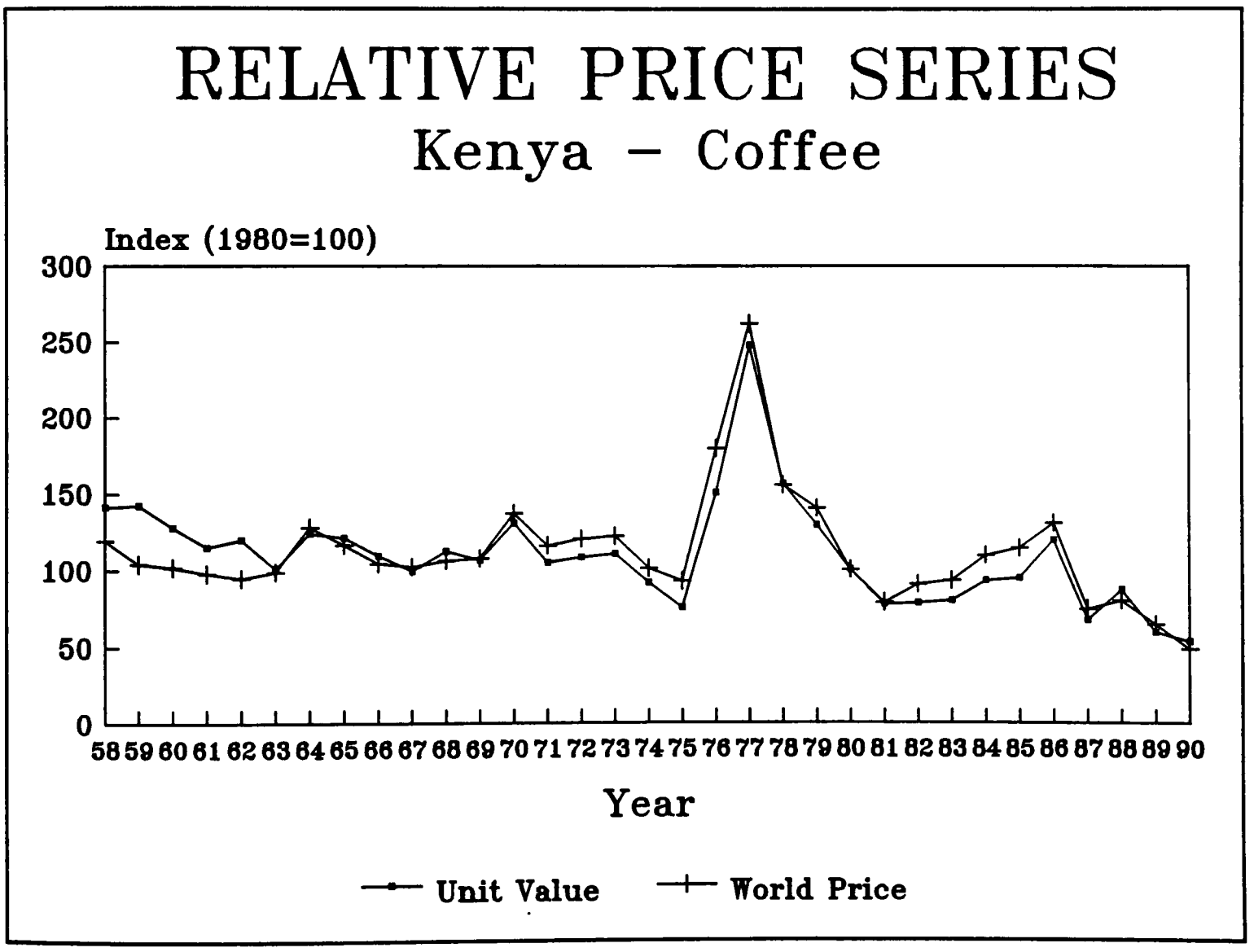
Having established the core series for relative prices and export volumes the log of each is taken and their counterfactual values estimated by first regressing them on time and time squared to yield the quadratic time trend estimate of the permanent changes to the series, and secondly by calculating a seven year centred moving average of each. Use of a seven year period for the latter was suggested by comparing, on a sample of the series, the benefit of a longer period to yield a smoother counterfactual against the costs of losing data points at the start and end of the data period. The years lost in this way were used in the estimation of the time trend but deleted from the calculation of the results to give comparability between the two counterfactuals.

These estimates of the counterfactual allow the transformation of the relative price and volume series from possible non-stationarity to stationarity for use in the subsequent analysis. Given these de-trended series (in logs) it is straightforward to calculate the relative price elasticity of export volume by calculating their covariance divided by the variance of the price. This was done using each of the counterfactuals for each of the series (including both unit value and world price based relative price series) in keeping with the agnostic approach to the estimation of long run trends described above. This is done since there is no presumption that if the counterfactual for relative prices is

best described by a time trend, export volumes may not be better modelled as following a moving average. This yields a total of eight estimates of the elasticity which we discuss further below.

Before doing so we illustrate the procedure above by means of Kenya's exports of coffee. The chart below shows the two estimates of the price of Kenyan coffee relative to the estimate of Kenya's import unit value which in turn is based on the IFS import unit value series for Africa.

Figure 6.2.1

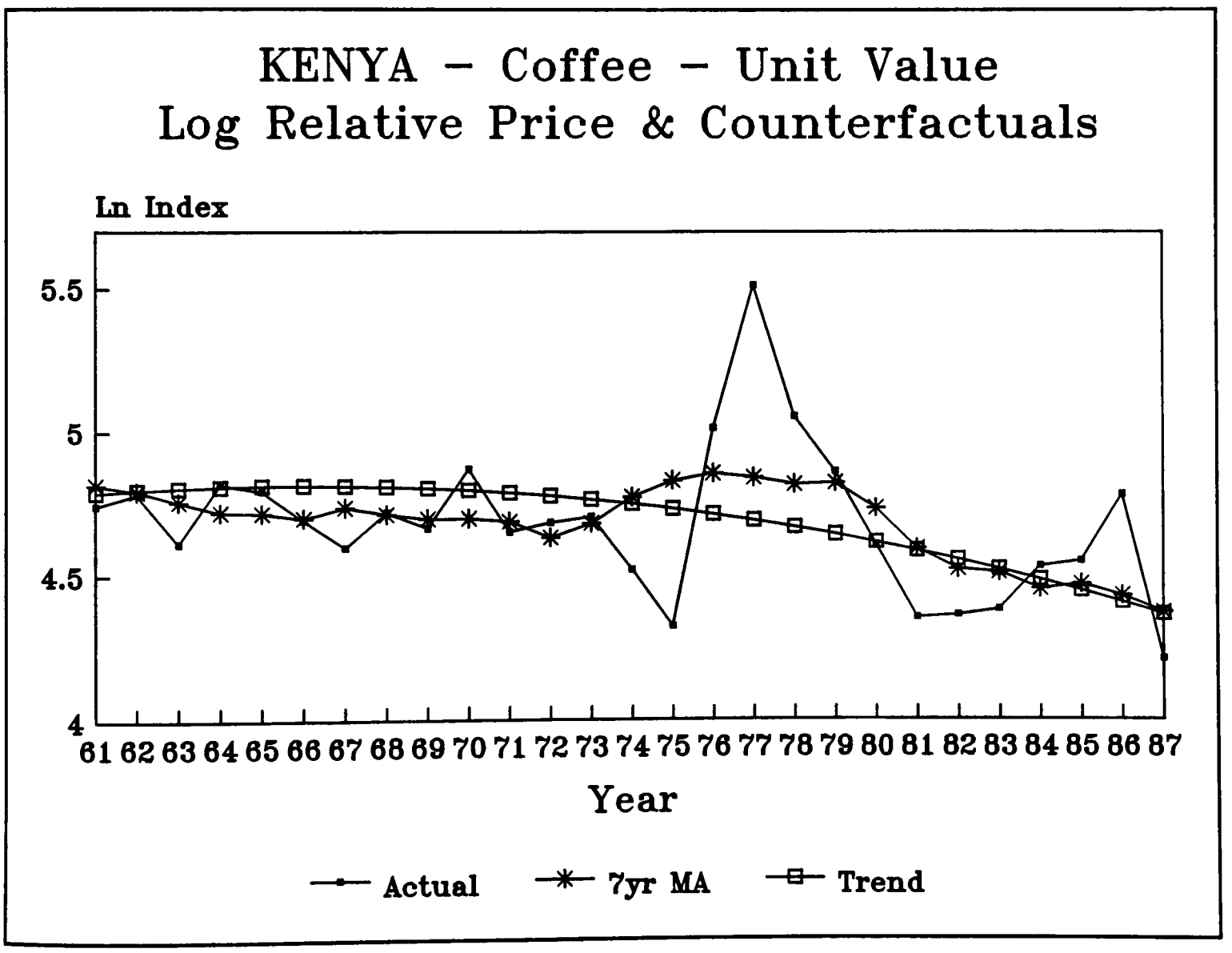


The chart shows that the two estimates follow each other closely, apart from the period 1958-62, with both showing the

coffee boom of the late 1970s together with the further smaller boom in the 1980s.

The chart that follows shows how the trend in the unit value based series is estimated by the quadratic time trend and the moving average. In this case the time trend is arguably more compelling as an estimate of the counterfactual taking the period as a whole because the moving average series appears too responsive to the late 1970s boom. By contrast it might be argued that the moving average performs better in the period to 1973.

Figure 6.2.2

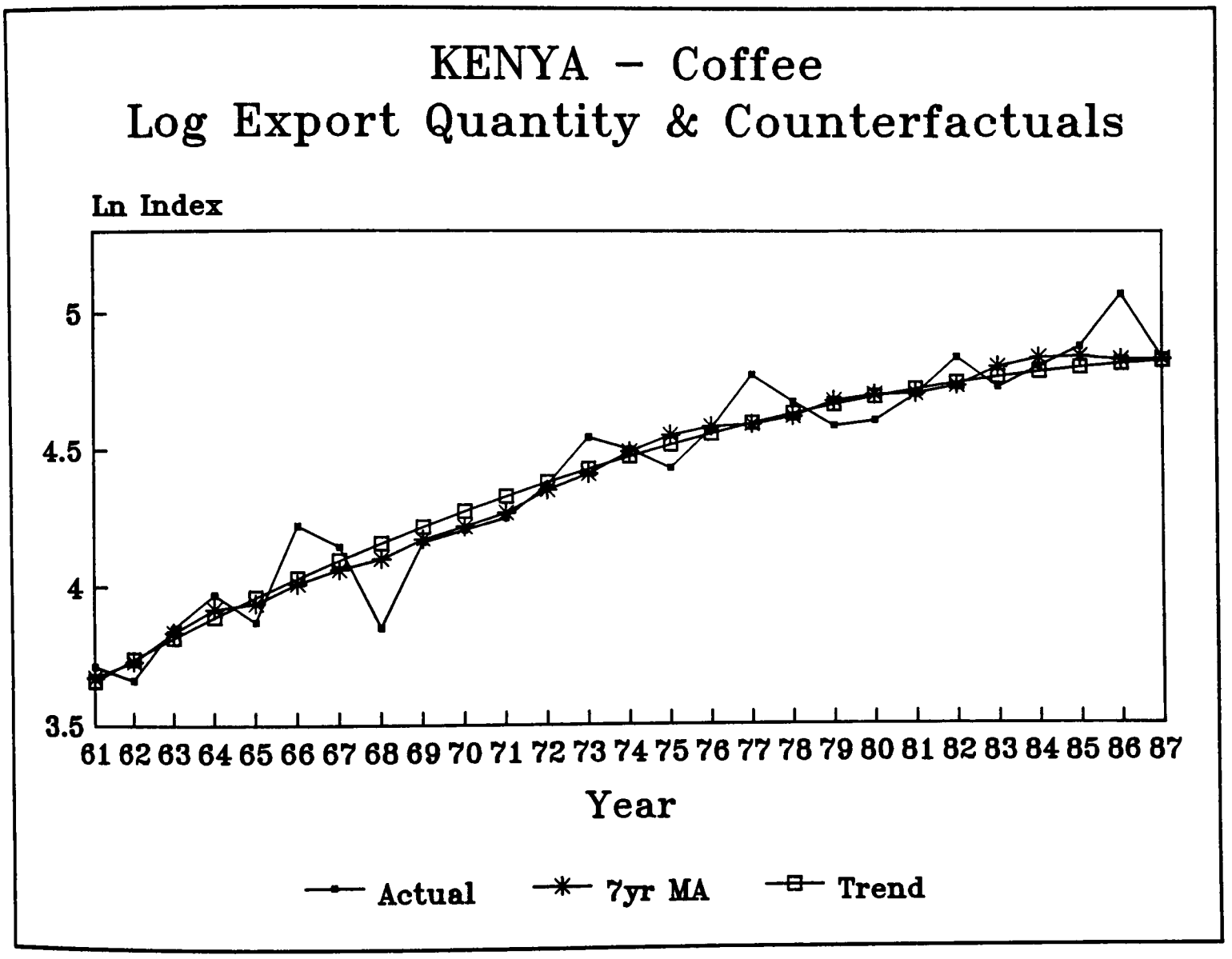


The results derived from these series are, however, quite

close which shows that small differences in the counterfactual do not have a large effect on the results. On a number of rather eccentric series the moving average counterfactual itself becomes more convincing as a counterfactual compared with the time trend since the latter is determined by the whole period and can look too rigid in situations in which the responsiveness of the moving average appears to be a virtue.

Figure 6.2.3 gives the same comparison between actual and counterfactuals for export volumes where it may be seen that the two counterfactuals follow each other very closely.

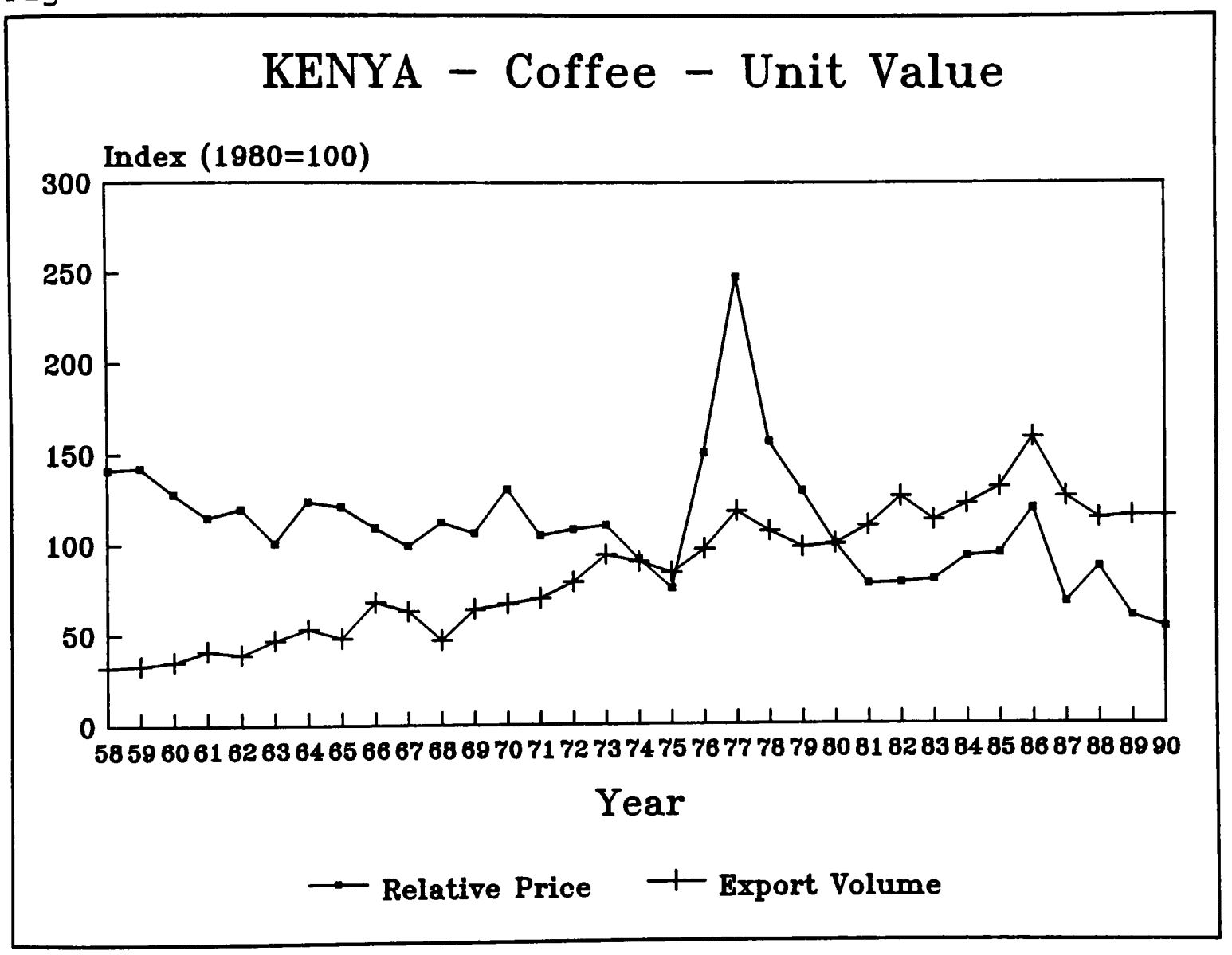
Figure 6.2.3



The deviations from the trend lines in Figures 6.2.2 and 6.2.3

form the basis of the estimation of the export volume elasticities but a feel for the responsiveness of export volume to price may be gained by plotting the actual series for each, before removing the trend, which is given in Figure 6.2.4 for the case with relative price based on export unit value.

Figure 6.2.4



This chart demonstrates a modest positive response of volume to price, most noticeably in the late 1970s and mid-1980s which are the times of greatest price movement. This is reflected in the estimates of the elasticity for the unit value case which are 0.16 for the time trend and 0.21 for the

moving average. These estimates correspond to the assumption that both price and volume should follow the same counterfactual. The cross-counterfactual estimates are 0.15 and 0.2.

Turning back to the cases where the two series are assumed to follow the same counterfactual, the cross-plots between price and volume deviations from counterfactual are as follows, showing that for this case the two counterfactuals generate very similar estimates of the volatile components of the series.

Figure 6.2.5

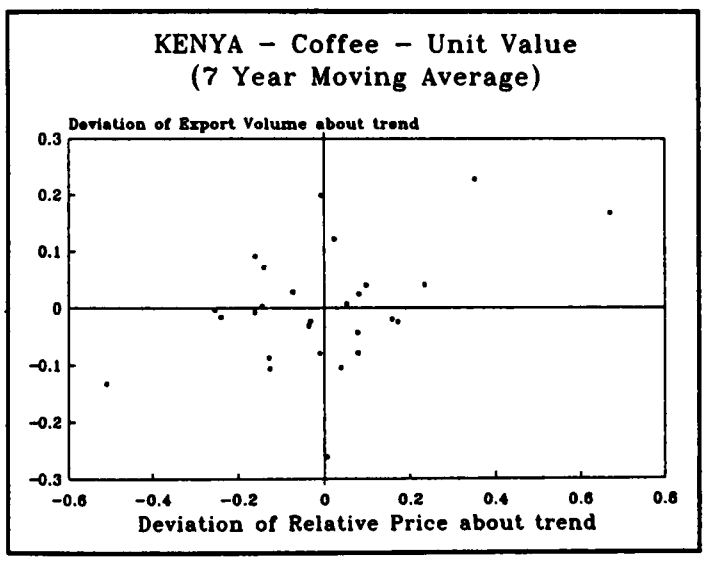
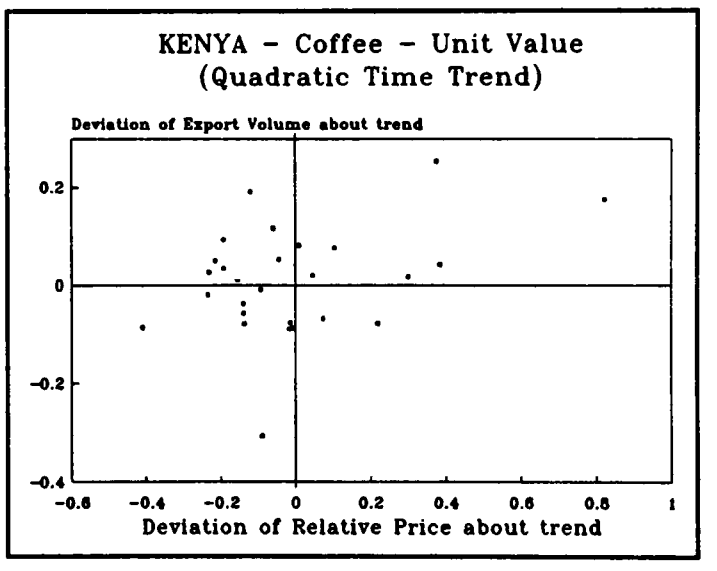


Figure 6.2.6



The elasticities estimated in this way are used in the calculation of (6.1.1) with the deviations of price from counterfactual also used in those expressions.

We turn now to the calculation of the various parameters that appear in (6.1.1). The first of these is the share of exports of a commodity in national income which is calculated by

taking the average of the ratio of the export value series to GDP at market prices, both from IFS. This parameter tends to be large and has a strong influence over the results and hence is calculated using export values and GDP over the whole sample period.

The second parameter is the share of consumption of each commodity in national income. These figures are generally small and are calculated by using UNCTAD consumption data for 1970, 1975, 1985 and 1990 and calculating consumption as a proportion of GDP in those years. The small size of these shares implies that there is little return in terms of accuracy for calculating them over more years and the consumption data is in any case patchy. Unfortunately for a number of the commodity-country pairs there was no consumption data available and assumptions were made of the likely order of magnitude involved, guided by whether the commodity was a food or other crop or a mineral. These assumed values are marked by an asterisk in Table I where these figures are presented.

Two other share parameters were calculated. Firstly the share of non-tradeables in national income, estimates for which were calculated from World bank data (World Development Report 1991) on the structure of production. This data does not give the share of non-tradeables directly but was used because the large number of countries in the sample prevented the use of individual country sources. Data is given for the shares of

agriculture, manufacturing, industry (manufacturing plus utilities) and services (calculated as a residual). The central estimate of the share of non-tradeables was calculated as one minus the sum of shares of agriculture, manufacturing and exports plus consumption of any major mineral exports (the latter making use of the IFS data). This is an imperfect estimate of the share of non-tradeables since some agricultural and manufacturing output may be effectively non-tradeable and some services may be tradeable (particularly tourism). Nevertheless estimates based on these figures are better than simply imposing a range of possible values across the whole sample. Due to the risk of error the results that depend on this parameter are presented with High, Medium and Low variants with high corresponding to the parameter value that will raise the estimated costs of volatility. In this case the estimate described above was used for the Medium variant with the High and Low using this figure plus or minus 0.1 or ten per cent of national income. The only exceptions made to this procedure were for the OECD economies and Singapore where the estimate above was made the High variant as a reflection of the larger traded services sectors in these economies. In addition for a small number of countries the World Bank does not report figures for the structure of production. In these cases estimates were made based on the shares for countries in the same region but allowing for different shares for the major exports. These estimates are also marked by an asterisk in Table I.

The final share figure is the share of exports of a commodity from a country in the world market for that commodity. This is not a requirement for estimating the results but is provided so as to suggest which countries may be effectively large in the market for one or more of their commodity exports. This information was taken from the UNCTAD Commodity Yearbook which gives figures for world production and the production of each of the twenty major producers. The figures generated from this source are presented in Table II where an "S" is inserted if a country is not one of the twenty major producers and figures are not available. In these cases the country must necessarily have a share of the world market less than five per cent and usually much less than that figure.

The penultimate parameter values required are the income elasticity of demand for consumption of the commodity exports and for non-tradeable goods. No attempt was made to estimate these for each country and commodity and in place of this we impose assumed values across the whole sample while incorporating different values in the High, Medium and Low variants. The Medium figure used for each is unity with the High and Low figures being 1.5 and 0.5. While it would be useful to have proper estimates of these elasticities it is likely that the true values fall within the specified range.

This point may be reinforced by considering that the spread of values for the share of non-tradeables in national income, together with the range for these income elasticities and the

response of non-tradeables prices to commodity prices discussed below, are such that all of the parameter values that will give rise to higher estimated costs from volatility are used for estimating the High variant and vice versa for the Low variant. This implies that these variants cover a larger range of possibilities than the spread of the individual parameter values since it is implicitly assumed that they all take their highest or lowest values simultaneously.

Turning to the final parameter value, the elasticity of the price of non-tradeables with respect to a tradeables price, the estimates are based on the theoretical expression for this response from Chapter 2 which is given by:

$$\frac{dP_n}{dP} = \frac{\frac{\partial c_n}{\partial P}\Big|_C - \frac{\partial n}{\partial P} + (x - c_x)\frac{\partial c_n}{\partial m}}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}\Big|_C} \qquad (2.1.10)$$

Making use of the symmetry between cross-price output and compensated consumption effects, (2.1.10) may be expressed as:

$$\frac{dP_n}{dP} = \frac{\frac{\partial c_x}{\partial P_n}\Big|_c - \frac{\partial x}{\partial P_n} + (x - c_x)\frac{\partial c_n}{\partial m}}{\frac{\partial n}{\partial P_n} - \frac{\partial c_n}{\partial P_n}\Big|_C}$$

from which, in elasticity terms, we have:

$$\epsilon^{P}_{P_n} = \frac{\beta_x \epsilon^{\partial P_n}_{c_x}|_c - \alpha_x \epsilon^{\partial P_n}_{x} + \gamma_x \beta_n \epsilon^{\partial m}_{c_n}}{\beta_n (\epsilon^{\partial P_n}_{n} - \epsilon^{\partial P_n}_{c_n}|_c)}$$

which forms the basis of the figures used in the derivation of the results. For these we make use of the estimates already generated for the shares of non-tradeables and exports and consumption of good x (the commodity export). The last two also implicitly define the share of output, α_x. In addition, for the Medium variant we assume that all of the elasticities are equal to unity and achieve a spread on either side of this by assuming that the elasticities in the numerator are 1.5 and those in the denominator 0.5 for the High variant and the other way round for the Low variant. This is equivalent to taking the central estimate, based on unit elasticities, and either multiplying or dividing by three to generate the other two variants. As before this range is large and likely to contain the true value. It may also be noted that the absolute size of the difference between the High and Low variants and the Medium is larger for the High case (whereas for the other parameters there is symmetry between them) and this leads to a greater disparity in the final results between the Medium and High values.

6.3 RESULTS: MEASURES OF VOLATILITY AND ELASTICITY ESTIMATES

This section and the one following present the results derived as a result of following the procedure described above. In this section the focus is on the measures of price volatility and estimates of the export volume elasticities. The results for the latter are used as the dependent variable in a cross sectional regression that provides information on the extent to which the elasticity values differ across different regions and types of commodity.

The tables that follow provide a great deal of information at the individual commodity and country level but the discussion emphasises the overall pattern of the results both as a whole and by region. In addition the tables give the results for the five developed countries in the sample but the charts and cross sectional regression exclude this information so that they focus on the results for the LDCs. The developed country results tend not to diverge far from those for the LDCs but they tend to export rather different commodities which constrains an attempt to compare the results directly.

We start by examining the measures of price volatility and information on shares in national income in Table I. The measure of volatility used is the standard deviation of the log of the detrended relative price series which is also approximately equal to the coefficient of variation of the original detrended series.

TABLE I CORE DATA AND MEASURES OF PRICE VOLATILITY

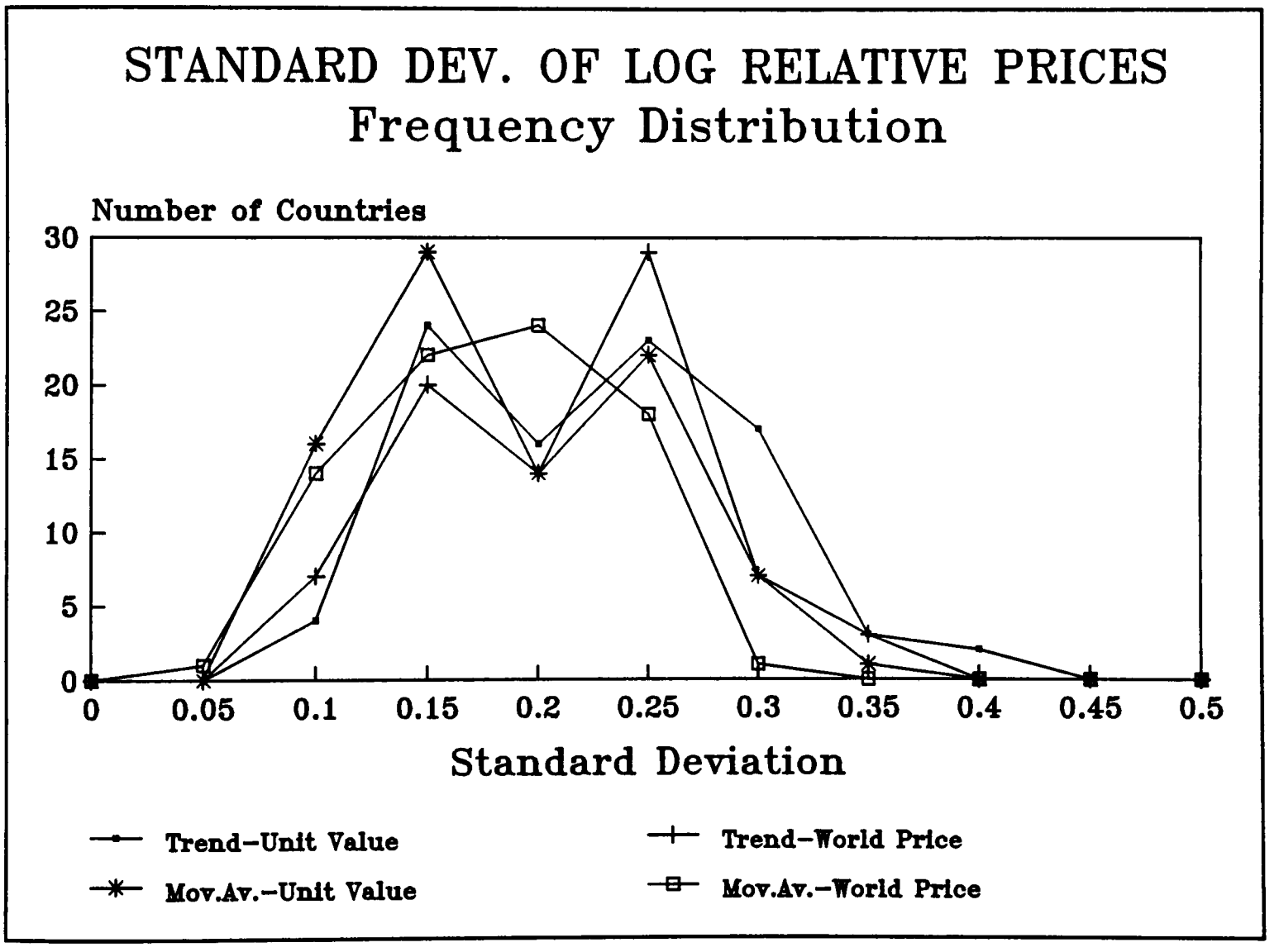
	DATA PERIOD	SHARE OF NON-TRADEABLES		SHARE OF EXPORTS (%)	SHARE OF CONSUMP'N (%)	STANDARD DEVIATION OF LOG RELATIVE PRICES: TIME TREND: UNIT VALUE	TIME TREND: WORLD PRICES	MOVING AVERAG UNIT VALUE	MOVING AVERAG WORLD PRICES	AVERAGES: ALL	AVERAGES: UV	AVERAGES: WP	AVERAGES: TT	AVERAGES: MA
SUB-SAHARAN AFRICA														
CAMEROON	1963-86	57.5%	Cocoa	4.30%	0.25%	0.27	0.3	0.23	0.26	0.27	0.25	0.28	0.29	0.25
			Coffee	4.59%	0.16%	0.21	0.26	0.2	0.23	0.23	0.21	0.25	0.24	0.22
			Wood	1.36%	0.10% *	0.17		0.14		0.16	0.16		0.09	0.07
COTE D'IVOIR	1958-88	39.5%	Coffee	9.38%	0.13%	0.24	0.23	0.2	0.2	0.22	0.22	0.22	0.24	0.20
			Cocoa	6.99%	0.37%	0.28	0.31	0.22	0.25	0.27	0.25	0.28	0.30	0.24
			Wood	5.26%	0.10% *	0.14		0.11		0.13	0.13		0.07	0.06
ETHIOPIA	1958-90	41.0%	Coffee	4.74%	4.39%	0.26	0.24	0.24	0.21	0.24	0.25	0.23	0.25	0.23
			Hides/Skins	0.94%	0.10% *	0.18	0.26	0.18	0.24	0.22	0.18	0.25	0.22	0.21
GHANA	1958-90	43.5%	Cocoa	9.28%	0.28%	0.39	0.31	0.34	0.24	0.32	0.37	0.28	0.35	0.29
KENYA	1958-90	55.5%	Coffee	4.29%	0.12%	0.25	0.24	0.21	0.21	0.23	0.23	0.23	0.25	0.21
			Tea	2.41%	0.32%	0.18	0.17	0.17	0.17	0.17	0.18	0.17	0.18	0.17
LIBERIA	1964-87	31.6%	Iron ore	38.44%	0.00%	0.13	0.1	0.12	0.07	0.11	0.13	0.09	0.12	0.10
			Rubber	9.17%	0.01%	0.14	0.16	0.13	0.17	0.15	0.14	0.17	0.15	0.15
MALAWI	1969-90	52.0%	Tobacco	10.22%	0.21%	0.15	0.14	0.16	0.1	0.14	0.16	0.12	0.15	0.13
			Tea	3.67%	0.27%	0.25	0.21	0.25	0.22	0.23	0.25	0.22	0.23	0.24
			Sugar	1.87%	0.58%	0.39	0.27	0.31	0.25	0.31	0.35	0.26	0.33	0.28
SENEGAL	1962-84	57.2%	Groundnuts	7.66%	2.00% *	0.21	0.2	0.17	0.18	0.19	0.19	0.19	0.21	0.18
			Phosphates	2.28%	0.00%	0.32	0.33	0.28	0.29	0.31	0.30	0.31	0.33	0.29
SUDAN	1958-86	42.0%	Cotton	7.04%	0.10%	0.17	0.13	0.16	0.11	0.14	0.17	0.12	0.15	0.14
TANZANIA	1958-85	38.0%	Coffee	3.23%	0.08%	0.28	0.24	0.25	0.21	0.25	0.27	0.23	0.26	0.23
			Cotton	2.59%	0.10%	0.18	0.13	0.15	0.11	0.14	0.17	0.12	0.16	0.13
			Sisal	2.91%	0.10% *	0.35	0.31	0.25	0.24	0.29	0.30	0.28	0.33	0.25
TOGO	1961-87	43.5%	Phosphates	8.49%	0.00%	0.34	0.3	0.3	0.26	0.30	0.32	0.28	0.32	0.28
			Cocoa	4.12%	0.10%	0.26	0.29	0.24	0.26	0.26	0.25	0.28	0.28	0.25
			Coffee	2.77%	0.02%	0.29	0.25	0.27	0.22	0.26	0.28	0.24	0.27	0.25
UGANDA	1958-84	34.0%	Coffee	10.98%	0.17%	0.27	0.25	0.25	0.22	0.25	0.26	0.24	0.26	0.24
ZAIRE	1963-84	54.6%	Copper	14.36%	0.01%	0.32	0.21	0.31	0.17	0.25	0.32	0.19	0.27	0.24
			Coffee	2.40%	0.30%	0.29	0.27	0.29	0.24	0.27	0.29	0.26	0.28	0.27
ZAMBIA	1958-88	30.6%	Copper	40.89%	0.00%	0.27	0.27	0.16	0.16	0.22	0.22	0.22	0.27	0.16
NORTH AFRICA/INDIAN OCEAN														
EGYPT	1958-90	69.0%	Cotton	4.03%	8.87%	0.28	0.14	0.13	0.12	0.17	0.21	0.13	0.21	0.13
MADAGASCA	1958-83	66.0%	Coffee	4.79%	0.69%	0.23	0.24	0.2	0.21	0.22	0.22	0.23	0.24	0.21
			Vanilla	1.18%	0.01% *	0.12		0.09		0.11	0.11		0.06	0.05
MAURITANIA	1971-90	39.2%	Iron ore	24.31%	0.00%	0.14	0.09	0.11	0.08	0.11	0.13	0.09	0.12	0.10
			Fish	12.07%	2.00%	0.22	0.16	0.16	0.17	0.18	0.19	0.17	0.19	0.17
MAURITIUS	1961-90	66.5%	Sugar	28.28%	1.91%	0.24	0.23	0.15	0.21	0.21	0.20	0.22	0.24	0.18
MOROCCO	1958-90	59.9%	Phosphates	4.12%	0.00%	0.27	0.26	0.24	0.22	0.25	0.26	0.24	0.27	0.23
SOUTH AMERICA														
ARGENTINA	1958-90	50.5%	Meat	0.97%	4.25%	0.22	0.24	0.17	0.15	0.20	0.20	0.20	0.23	0.16
			Corn	0.63%	1.00% *	0.14		0.11		0.13	0.13		0.07	0.06
			Wheat	0.98%	1.00% *	0.17	0.16	0.14	0.13	0.15	0.16	0.15	0.17	0.14
			Hides&Skin	0.47%	0.10% *	0.29	0.3	0.22	0.27	0.27	0.26	0.29	0.30	0.25
			Wool	0.27%	0.06%	0.2	0.25	0.19	0.2	0.21	0.20	0.23	0.23	0.20
BOLIVIA	1958-90	50.0%	Tin	8.51%	0.00%	0.16	0.16	0.13	0.13	0.15	0.15	0.15	0.16	0.13
BRAZIL	1959-90	57.5%	Coffee	1.41%	1.08%		0.26		0.23	0.25	0.00	0.25	0.13	0.12
CHILE	1958-90	56.8%	Copper	10.22%	0.51%	0.31	0.35	0.15	0.17	0.25	0.23	0.26	0.33	0.16
COLUMBIA	1958-90	58.0%	Coffee	6.16%	1.05%	0.26	0.26	0.24	0.23	0.25	0.25	0.25	0.26	0.24
ECUADOR	1958-90	59.5%	Bananas	4.98%	3.98%	0.21	0.11	0.12	0.08	0.13	0.17	0.10	0.16	0.10
			Coffee	2.10%	0.32%	0.29	0.26	0.26	0.23	0.26	0.28	0.25	0.28	0.25
PARAGUAY	1958-89	51.0%	Cotton	1.81%	0.32%	0.19	0.14	0.17	0.12	0.16	0.18	0.13	0.17	0.15
PERU	1958-90	65.1%	Copper	2.93%	0.29%	0.33	0.35	0.16	0.17	0.25	0.25	0.26	0.34	0.17
URUGUAY	1958-89	76.0%	Wool	3.73%	0.79%	0.2	0.25	0.18	0.21	0.21	0.19	0.23	0.23	0.20
			Meat	2.68%	1.10%	0.29	0.23	0.25	0.15	0.23	0.27	0.19	0.26	0.20
CENTRAL AMERICA														
COSTA RICA	1958-90	79.5%	Coffee	7.63%	1.12%	0.29	0.26	0.25	0.23	0.26	0.27	0.25	0.28	0.24
			Bananas	5.59%	1.17%	0.11	0.11	0.08	0.08	0.10	0.10	0.10	0.11	0.08
			Beef	1.39%	3.76%	0.22	0.24	0.16	0.15	0.19	0.19	0.20	0.23	0.18
EL SALVADO	1958-85	62.5%	Coffee	12.55%	0.99%	0.27	0.26	0.23	0.23	0.25	0.25	0.25	0.27	0.23
			Cotton	2.86%	0.50%	0.09	0.13	0.08	0.11	0.10	0.09	0.12	0.11	0.10
GUATEMALA	1958-90	82.0%	Coffee	5.65%	0.68%	0.25	0.26	0.23	0.23	0.24	0.24	0.25	0.26	0.23
			Cotton	1.52%	0.23%	0.14	0.15	0.12	0.12	0.13	0.13	0.14	0.15	0.12
			Sugar	0.81%	2.37%	0.3	0.22	0.2	0.19	0.23	0.25	0.21	0.26	0.20
HONDURAS	1958-90	56.5%	Bananas	9.00%	4.97%	0.14	0.11	0.08	0.08	0.10	0.11	0.10	0.13	0.08
			Coffee	4.91%	0.87%	0.28	0.26	0.24	0.23	0.25	0.26	0.25	0.27	0.24

TABLE I CORE DATA AND MEASURES OF PRICE VOLATILITY

	DATA PERIOD	SHARE OF NON-TRADEABLES		SHARE OF EXPORTS (%)	SHARE OF CONSUMP'N (%)	STANDARD DEVIATION OF LOG RELATIVE PRICES: TIME TREND: UNIT VALUE	TIME TREND: WORLD PRICES	MOVING AVERAG UNIT VALUE	MOVING AVERAG WORLD PRICES	AVERAGES: ALL	UV	WP	TT	MA
NICARAGUA	1958-87	54.5%	Coffee	5.94%	0.39%	0.25	0.25	0.22	0.22	0.24	0.24	0.24	0.25	0.22
			Cotton	4.52%	0.20%	0.11	0.12	0.11	0.11	0.11	0.11	0.12	0.12	0.11
PANAMA	1958-90	76.0%	Bananas	3.70%	2.49%	0.21	0.11	0.09	0.08	0.12	0.15	0.10	0.16	0.09
			Shrimps	1.22%	0.10% *	0.17	0.16	0.15	0.15	0.16	0.16	0.16	0.17	0.15
			Sugar	0.66%	0.07%	0.3	0.22	0.27	0.19	0.25	0.29	0.21	0.26	0.23
CARIBBEAN														
BARBADOS	1958-85	77.7% *	Sugar	13.23%	0.66%	0.24	0.21	0.21	0.2	0.22	0.23	0.21	0.23	0.21
DOMINICAN	1958-90	67.5%	Sugar	6.76%	1.45%	0.26	0.22	0.23	0.19	0.23	0.25	0.21	0.24	0.21
GUYANA	1960-90	55.0% *	Sugar	18.17%	2.37%	0.27	0.23	0.18	0.2	0.22	0.23	0.22	0.25	0.19
			Bauxite	17.27%	0.00%	0.15		0.11		0.13	0.13		0.08	0.06
			Rice	5.29%	2.00% *	0.14	0.19	0.11	0.14	0.15	0.13	0.17	0.17	0.13
JAMAICA	1958-89	60.0%	Alumina	9.53%	0.00%	0.13		0.1		0.12	0.12		0.07	0.05
			Bauxite	5.48%	0.00%	0.19		0.13		0.16	0.16		0.10	0.07
			Sugar	3.26%	0.84%	0.23	0.22	0.17	0.19	0.20	0.20	0.21	0.23	0.18
TRINIDAD & T	1958-88	90.5%	Sugar	2.19%	0.53%	0.24	0.22	0.24	0.2	0.23	0.24	0.21	0.23	0.22
SOUTH ASIA														
BURMA	1958-90	69.3% *	Rice	4.51%	2.00% *	0.24	0.18	0.23	0.16	0.20	0.24	0.17	0.21	0.20
			Teak	1.52%	0.10% *	0.15		0.12		0.14	0.14		0.08	0.06
PAKISTAN	1958-90	51.5%	Cotton	1.01%	2.66%	0.16	0.14	0.15	0.12	0.14	0.16	0.13	0.15	0.14
SRI LANKA	1961-90	56.5%	Tea	9.46%	0.98%	0.16	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
			Rubber	2.87%	0.31%	0.14	0.15	0.14	0.15	0.15	0.14	0.15	0.15	0.15
			Coconut Ps	1.81%	0.10% *	0.26		0.3		0.29	0.29		0.14	0.15
SOUTH EAST ASIA/PACIFIC														
FIJI	1961-90	59.3% *	Sugar	15.13%	1.25%	0.22	0.23	0.14	0.21	0.20	0.18	0.22	0.23	0.18
INDONESIA	1967-90	48.0%	Rubber	1.56%	0.10%	0.16	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16
MALAYSIA	1958-90	57.6%	Rubber	12.41%	0.74%	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
			Tin	5.36%	0.00%	0.16	0.16	0.13	0.13	0.15	0.15	0.15	0.16	0.13
			Palm Oil	3.18%	0.10% *	0.2	0.2	0.2	0.21	0.20	0.20	0.21	0.20	0.21
PHILIPPINES	1958-90	54.0%	Sugar	1.75%	2.35%	0.31	0.22	0.24	0.2	0.24	0.28	0.21	0.27	0.22
			Coconut Ps	2.85%	0.10% *	0.26		0.28		0.27	0.27		0.13	0.14
SINGAPORE	1960-90	78.0%	Rubber	17.22%	0.00%	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.15	0.15
THAILAND	1958-90	59.0%	Rice	3.28%	2.00% *	0.23	0.18	0.23	0.16	0.20	0.23	0.17	0.21	0.20
OECD														
AUSTRALIA	1967-90	70.9%	Wool	1.63%	0.00%	0.23	0.25	0.22	0.24	0.24	0.23	0.25	0.24	0.23
			Wheat	1.05%	0.50% *	0.2	0.18	0.18	0.16	0.18	0.19	0.17	0.19	0.17
			Iron Ore	0.83%	0.10%	0.13	0.09	0.09	0.07	0.10	0.11	0.08	0.11	0.08
			Beef	0.82%	0.90%	0.21	0.17	0.18	0.15	0.18	0.20	0.16	0.19	0.17
			Coal	1.26%	0.50% *	0.13	0.13	0.12	0.12	0.13	0.13	0.13	0.13	0.12
CANADA	1958-86	74.5%	Wheat	1.19%	0.50% *	0.19	0.16	0.16	0.14	0.16	0.18	0.15	0.18	0.15
			Wood	1.36%	0.10% *	0.1		0.08		0.09	0.09		0.05	0.04
			Wood Pulp	0.91%	0.10% *	0.09		0.09		0.09	0.09		0.05	0.05
			Newsprint	0.14%	0.10% *	0.09	0.09	0.06	0.06	0.08	0.08	0.08	0.09	0.06
FINLAND	1958-87	66.5%	Paper	4.28%	0.10% *	0.05		0.04		0.05	0.05		0.03	0.02
			Wood	3.41%	0.10% *	0.09		0.06		0.08	0.08		0.05	0.03
			Wood Pulp	2.11%	0.10% *	0.13		0.12		0.13	0.13		0.07	0.06
			Newsprint	1.36%	0.10% *	0.08	0.09	0.05	0.06	0.07	0.07	0.08	0.09	0.06
NEW ZEALAN	1958-90	75.0%	Wool	4.31%	0.24%	0.21	0.22	0.18	0.2	0.20	0.20	0.21	0.22	0.19
			Lamb/Mutto	2.78%	1.00% *	0.12		0.11		0.12	0.12		0.06	0.06
			Butter	2.07%	0.50% *	0.16		0.14		0.15	0.15		0.08	0.07
			Beef	1.89%	0.75%	0.22	0.2	0.15	0.13	0.18	0.19	0.17	0.21	0.14
NORWAY	1958-90	74.7%	Aluminum	1.81%	0.26%	0.1	0.15	0.07	0.12	0.11	0.09	0.14	0.13	0.10
			Paper	1.37%	0.10% *	0.08		0.05		0.07	0.07		0.04	0.03
			Fish	1.71%	0.50% *	0.1	0.22	0.08	0.21	0.15	0.09	0.22	0.16	0.15
AVERAGES:														
SUB-SAHARAN AFRIC		44.3%		7.81%	0.36%	0.25	0.24	0.22	0.20	0.22	0.23	0.22	0.23	0.20
N.AFRICA/IND.OCEAN		60.1%		11.25%	1.93%	0.21	0.19	0.15	0.17	0.18	0.18	0.18	0.19	0.15
SOUTH AMERICA		58.3%		3.19%	1.06%	0.23	0.24	0.18	0.18	0.20	0.19	0.21	0.22	0.17
CENTRAL AMERICA		68.5%		4.53%	1.31%	0.21	0.19	0.17	0.16	0.18	0.19	0.18	0.20	0.16
CARIBBEAN		70.1%		9.02%	0.87%	0.21	0.22	0.16	0.19	0.18	0.19	0.20	0.17	0.14
SOUTH ASIA		59.1%		3.53%	1.03%	0.19	0.16	0.19	0.15	0.16	0.19	0.16	0.15	0.14
S.E. ASIA/PACIFIC		59.3%		6.97%	0.74%	0.20	0.18	0.18	0.17	0.19	0.19	0.17	0.18	0.17
OECD		72.3%		1.81%	0.33%	0.14	0.16	0.11	0.14	0.13	0.12	0.15	0.12	0.10
ALL LDCs		57.1%		6.51%	0.89%	0.22	0.21	0.19	0.18	0.20	0.20	0.20	0.21	0.17
WHOLE SAMPLE		58.5%		5.66%	0.79%	0.21	0.21	0.17	0.18	0.19	0.19	0.19	0.19	0.16

The Table shows four different figures for this variable, corresponding to the four cases resulting from the use of two different ways of allowing for the long run trends and two ways of deriving the relative price series, and four averages based on them. The frequency distribution of the original four estimates is shown in Figure 6.3.1 below, revealing a similar pattern of variability overall with the distribution peaking in the range 0.15 to 0.25 which is usual for these kind of measures.

Figure 6.3.1



It may be seen that the time trend based measures are a little more variable than those based on the moving average. This is confirmed by the averages at the base of Table I and to be

expected given that the moving average tends to be more responsive to the actual series than the time trend. In addition these averages suggest that the unit value based measures are slightly more variable than those that use world prices which may reflect measurement error in the data for export values and/or export volumes.

This pattern is confirmed by the charts below which compare the average of the original four figures for, in turn, the time trend compared with the moving average and the unit value figures compared with those using world prices.

Figure 6.3.2

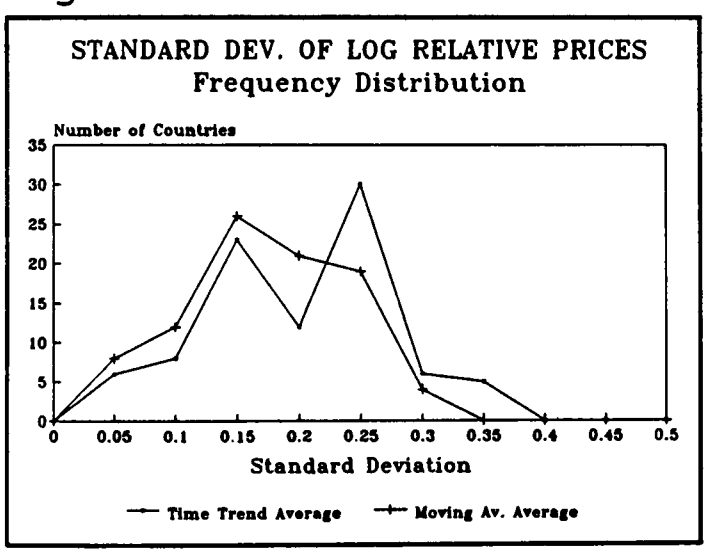
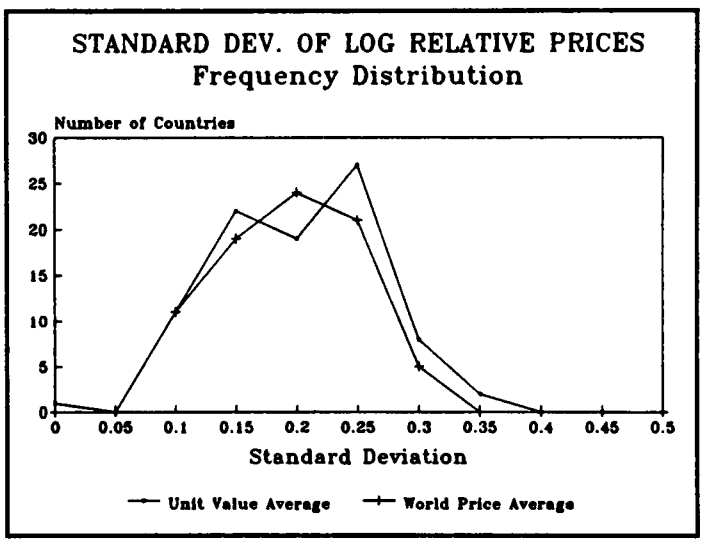


Figure 6.3.3



Considering the regional figures at the base of Table I, those for Sub-Saharan Africa and South America tend to show a greater degree of price volatility faced by the countries in those two groups compared with the rest though the difference is modest.

Turning to the estimates of the export price elasticity of export volumes, Table II presents the eight figures for each

TABLE II WORLD MARKET SHARES AND EXPORT PRICE ELASTICITY OF EXPORT VOLUMES

		WORLD MARKE SHARE (%)	TIME TREND (TT) UNIT VALUE	TIME TREND (TT) WORLD PRICES	MOV. AVERAGE (M UNIT VALUE	MOV. AVERAGE (M WORLD PRICES	P=MA;Q=TT UNIT VALUE	P=MA;Q=TT WORLD PRICES	P=TT;Q=MA UNIT VALUE	P=TT;Q=MA WORLD PRICES	AVERAGES: ALL	TT-UV	TT-WP	MA-UV	MA-WP
SUB-SAHARAN AFRICA:															
CAMEROON	Cocoa	7.3%	-0.05	-0.06	-0.06	-0.07	-0.08	-0.08	-0.04	-0.05	-0.06	-0.04	-0.05	-0.07	-0.07
	Coffee	0.2%	-0.33	-0.14	-0.43	-0.30	-0.40	-0.26	-0.35	-0.18	-0.30	-0.34	-0.16	-0.42	-0.28
	Wood	S	0.56		0.73		0.68		0.55		0.63	0.55		0.71	
COTE D'IVOIR	Coffee	6.0%	-0.10	0.07	-0.15	-0.01	-0.14	0.02	-0.09	0.02	-0.05	-0.10	0.05	-0.14	0.01
	Cocoa	19.8%	-0.37	-0.34	-0.23	-0.24	-0.31	-0.29	-0.19	-0.19	-0.27	-0.28	-0.26	-0.27	-0.26
	Wood	1.0%	-0.30		0.24		0.03		0.06		0.01	-0.12		0.14	
ETHIOPIA	Coffee	3.5%	-0.27	-0.32	-0.17	-0.13	-0.19	-0.18	-0.18	-0.16	-0.20	-0.22	-0.24	-0.18	-0.16
	Hides/Skins	0.9%	-0.16	0.45	-0.06	0.39	-0.09	0.43	-0.10	0.35	0.15	-0.13	0.40	-0.07	0.41
GHANA	Cocoa	18.1%	-0.34	-0.38	-0.16	-0.26	-0.19	-0.29	-0.14	-0.19	-0.24	-0.24	-0.28	-0.18	-0.27
KENYA	Coffee	S	0.16	0.21	0.21	0.22	0.20	0.22	0.15	0.18	0.19	0.16	0.19	0.21	0.22
	Tea	4.8%	0.02	0.06	0.07	0.13	0.06	0.10	0.06	0.11	0.08	0.04	0.09	0.06	0.11
LIBERIA	Iron ore	2.8%	-0.22	0.22	-0.54	-0.28	-0.47	-0.07	-0.38	-0.07	-0.23	-0.30	0.07	-0.51	-0.17
	Rubber	2.5%	-0.19	-0.09	0.18	0.05	0.13	0.04	0.08	0.02	0.03	-0.05	-0.03	0.16	0.04
MALAWI	Tobacco	0.8%	-0.40	-0.24	-0.55	-0.10	-0.46	-0.21	-0.53	-0.08	-0.32	-0.46	-0.16	-0.51	-0.16
	Tea	1.6%	0.08	0.11	0.09	0.12	0.09	0.11	0.09	0.12	0.10	0.08	0.11	0.09	0.11
	Sugar	S	0.38	0.10	0.31	-0.00	0.37	0.02	0.25	0.04	0.18	0.32	0.07	0.34	0.01
SENEGAL	Groundnuts	3.1%	-0.81	-1.11	-1.53	-1.60	-1.52	-1.60	-0.83	-1.11	-1.26	-0.82	-1.11	-1.52	-1.60
	Phosphates	1.3%	0.05	0.09	-0.14	-0.08	-0.08	-0.02	-0.05	-0.01	-0.03	0.00	0.04	-0.11	-0.05
SUDAN	Cotton	1.5%	-1.04	0.77	-1.19	0.98	-1.15	1.01	-0.95	0.63	-0.12	-1.00	0.70	-1.17	0.99
TANZANIA	Coffee	S	-0.16	-0.18	-0.08	-0.12	-0.12	-0.16	-0.10	-0.12	-0.13	-0.13	-0.15	-0.10	-0.14
	Cotton	0.4%	-0.45	-0.24	-0.20	0.28	-0.38	0.07	-0.21	0.09	-0.13	-0.33	-0.08	-0.29	0.17
	Sisal	16.2%	-0.22	-0.23	-0.17	-0.18	-0.23	-0.28	-0.10	-0.14	-0.19	-0.16	-0.19	-0.20	-0.23
TOGO	Phosphates	1.7%	-0.27	-0.39	-0.26	-0.34	-0.25	-0.35	-0.19	-0.26	-0.29	-0.23	-0.32	-0.26	-0.34
	Cocoa	1.3%	0.00	-0.09	0.00	-0.01	0.06	0.01	0.00	-0.03	-0.00	0.00	-0.06	0.03	0.00
	Coffee	S	-0.27	-0.24	-0.37	-0.29	-0.33	-0.27	-0.29	-0.24	-0.29	-0.28	-0.24	-0.35	-0.28
UGANDA	Coffee	4.0%	-0.26	-0.20	-0.16	-0.06	-0.21	-0.13	-0.15	-0.07	-0.16	-0.21	-0.14	-0.18	-0.10
ZAIRE	Copper	6.0%	-0.16	-0.09	-0.25	-0.20	-0.25	-0.17	-0.18	-0.12	-0.18	-0.17	-0.11	-0.25	-0.19
	Coffee	1.7%	0.02	0.13	-0.04	0.15	-0.02	0.16	-0.03	0.10	0.06	-0.00	0.12	-0.03	0.15
ZAMBIA	Copper	8.5%	-0.04	0.01	-0.06	0.08	-0.07	0.06	-0.03	0.02	-0.00	-0.03	0.02	-0.06	0.07
NORTH AFRICA/INDIAN OCEAN:															
EGYPT	Cotton	3.4%	-0.43	-0.36	-0.51	0.07	-0.84	-0.02	-0.14	0.01	-0.28	-0.28	-0.17	-0.68	0.02
MADAGASCA	Coffee	1.5%	-0.20	-0.13	-0.34	-0.32	-0.31	-0.27	-0.25	-0.23	-0.26	-0.23	-0.18	-0.32	-0.30
	Vanilla	N/A	-0.58		-1.08		-1.04		-0.73		-0.86	-0.66		-1.06	
MAURITANIA	Iron ore	1.3%	-0.25	0.26	-0.32	0.36	-0.30	0.31	-0.20	0.27	0.02	-0.22	0.27	-0.31	0.33
	Fish	0.5%	-2.02	-0.79	-1.47	0.05	-2.09	-0.09	-1.07	-0.14	-0.95	-1.54	-0.46	-1.78	-0.02
MAURITIUS	Sugar	S	-0.05	0.13	-0.18	0.04	-0.18	0.06	-0.06	0.05	-0.02	-0.06	0.09	-0.18	0.05
MOROCCO	Phosphates	13.9%	0.07	0.07	-0.04	-0.05	-0.01	-0.02	-0.01	-0.02	0.00	0.03	0.03	-0.03	-0.03
SOUTH AMERICA															
ARGENTINA	Meat	6.4%	-0.08	0.59	-0.14	0.80	-0.08	0.99	-0.12	0.36	0.29	-0.10	0.48	-0.11	0.90
	Corn	N/A	-0.70		-0.35		-0.42		-0.26		-0.43	-0.48		-0.39	
	Wheat	1.6%	-1.06	-0.66	-0.55	0.21	-0.58	0.08	-0.54	-0.02	-0.39	-0.80	-0.34	-0.56	0.15
	Hides&Skin	19.3%	-0.75	0.01	-0.30	0.08	-0.48	0.08	-0.26	0.07	-0.19	-0.50	0.04	-0.39	0.08
	Wool	5.2%	-0.45	-0.23	-0.30	-0.01	-0.33	-0.09	-0.31	-0.06	-0.22	-0.38	-0.14	-0.32	-0.05
BOLIVIA	Tin	11.0%	0.15	0.16	0.12	0.14	0.14	0.16	0.12	0.13	0.14	0.14	0.15	0.13	0.15
BRAZIL	Coffee	26.2%		-0.53		-0.40		-0.47		-0.38	-0.45		-0.46		-0.43
CHILE	Copper	13.5%	-0.11	-0.10	-0.08	-0.09	-0.13	-0.13	-0.03	-0.04	-0.09	-0.07	-0.07	-0.11	-0.11
COLUMBIA	Coffee	12.1%	-0.13	-0.13	-0.19	-0.19	-0.18	-0.19	-0.14	-0.13	-0.16	-0.14	-0.13	-0.19	-0.19
ECUADOR	Bananas	7.0%	0.27	0.52	0.09	-0.00	0.24	0.21	0.06	0.10	0.19	0.16	0.31	0.16	0.11
	Coffee	2.0%	0.11	0.10	0.07	0.04	0.10	0.08	0.07	0.05	0.08	0.09	0.08	0.08	0.06
PARAGUAY	Cotton	0.5%	1.17	-0.34	0.66	-0.10	0.98	0.05	0.61	-0.14	0.36	0.89	-0.24	0.82	-0.03
PERU	Copper	4.0%	-0.12	-0.09	0.21	0.12	0.09	0.04	0.01	-0.01	0.03	-0.05	-0.05	0.15	0.08
URUGUAY	Wool	2.6%	-0.57	-0.21	-0.83	-0.46	-0.77	-0.44	-0.63	-0.28	-0.52	-0.60	-0.25	-0.80	-0.45
	Meat	S	-0.40	-0.02	-0.62	-0.48	-0.61	-0.36	-0.46	-0.20	-0.39	-0.43	-0.11	-0.62	-0.42
CENTRAL AMERICA															
COSTA RICA	Coffee	2.0%	-0.24	-0.25	-0.24	-0.25	-0.25	-0.26	-0.20	-0.21	-0.24	-0.22	-0.23	-0.25	-0.26
	Bananas	3.1%	-0.74	0.46	-0.19	0.27	-0.40	0.38	-0.20	0.18	-0.03	-0.47	0.31	-0.29	0.32
	Beef	S	-0.05	0.01	-0.18	-0.17	-0.12	-0.13	-0.04	0.01	-0.08	-0.04	0.01	-0.15	-0.15
EL SALVADO	Coffee	3.0%	-0.18	-0.08	-0.29	-0.16	-0.27	-0.14	-0.20	-0.11	-0.18	-0.19	-0.10	-0.28	-0.15
	Cotton	S	1.06	0.47	-0.15	-0.23	0.29	0.06	0.10	-0.08	0.19	0.58	0.19	0.07	-0.08
GUATEMALA	Coffee	3.2%	-0.07	-0.00	-0.10	-0.05	-0.10	-0.04	-0.08	-0.03	-0.06	-0.08	-0.02	-0.10	-0.05
	Cotton	0.0%	0.45	-0.14	0.30	-0.05	0.38	-0.01	0.29	-0.10	0.14	0.37	-0.12	0.34	-0.03
	Sugar	S	-0.23	0.25	-0.10	-0.05	-0.14	0.09	-0.06	0.03	-0.03	-0.14	0.14	-0.12	0.02
HONDURAS	Bananas	3.5%	0.49	0.67	0.22	0.00	0.15	0.14	0.12	0.13	0.24	0.30	0.40	0.18	0 07
	Coffee	1.1%	-0.09	0.03	-0.15	-0.03	-0.12	0.01	-0.11	-0.01	-0.06	-0.10	0.01	-0.14	-0 01

TABLE II WORLD MARKET SHARES AND EXPORT PRICE ELASTICITY OF EXPORT VOLUMES

		WORLD MARKE SHARE (%)	TIME TREND (TT): UNIT VALUE	TIME TREND (TT): WORLD PRICES	MOV. AVERAGE (M UNIT VALUE	MOV. AVERAGE (M WORLD PRICES	P=MA;Q=TT UNIT VALUE	P=MA;Q=TT WORLD PRICES	P=TT;Q=MA UNIT VALUE	P=TT;Q=MA WORLD PRICES	AVERAGES: ALL	TT-UV	TT-WP	MA-UV	MA-WP
NICARAGUA	Coffee	S	0.09	0.19	0.05	0.15	0.08	0.16	0.04	0.12	0.11	0.07	0.15	0.07	0.15
	Cotton	S	0.07	0.07	0.06	0.09	0.05	0.05	0.09	0.03	0.06	0.08	0.05	0.06	0.07
PANAMA	Bananas	2.9%	0.67	1.01	0.40	0.39	0.77	0.55	0.19	0.35	0.54	0.43	0.68	0.58	0.47
	Shrimps	N/A	-0.16	-0.04	-0.07	0.03	-0.10	0.03	-0.05	0.04	-0.04	-0.11	-0.00	-0.08	0.03
	Sugar	S	-0.29	-0.36	-0.01	0.11	-0.10	-0.04	-0.08	-0.02	-0.10	-0.18	-0.19	-0.06	0.04
CARIBBEAN															
BARBADOS	Sugar	S	-0.48	-0.36	-0.32	-0.11	-0.41	-0.21	-0.30	-0.15	-0.29	-0.39	-0.26	-0.36	-0.16
DOMINICAN R	Sugar	S	-0.24	-0.17	-0.17	-0.18	-0.14	-0.14	-0.12	-0.12	-0.16	-0.18	-0.14	-0.15	-0.16
GUYANA	Sugar	S	-0.04	0.03	0.12	0.15	0.07	0.12	0.03	0.10	0.07	-0.00	0.06	0.09	0.13
	Bauxite	10.6%	-0.67		-0.45		-0.56		-0.35		-0.51	-0.51		-0.51	
	Rice	S	-1.18	-0.09	-1.42	-0.19	-1.72	-0.16	-0.93	-0.08	-0.72	-1.06	-0.08	-1.57	-0.18
JAMAICA	Alumina	6.5%	0.10		-0.32		-0.25		-0.16		-0.16	-0.03		-0.29	
	Bauxite	14.4%	-0.05		-0.17		-0.15		-0.13		-0.12	-0.09		-0.16	
	Sugar	S	0.18	0.16	-0.08	-0.07	0.04	0.00	0.01	-0.02	0.03	0.09	0.07	-0.02	-0.03
TRINIDAD & T.	Sugar	S	-0.78	0.33	-0.61	-0.31	-0.67	-0.16	-0.66	-0.12	-0.37	-0.72	0.10	-0.64	-0.23
SOUTH ASIA															
BURMA	Rice	1.4%	-1.40	-2.32	-1.20	-1.75	-1.08	-1.82	-1.16	-1.28	-1.50	-1.28	-1.80	-1.14	-1.79
	Teak	N/A	-0.36		-0.31		-0.46		-0.30		-0.35	-0.33		-0.38	
PAKISTAN	Cotton	5.8%	-2.64	-1.43	-2.67	-1.41	-2.82	-1.61	-2.21	-1.06	-1.98	-2.42	-1.24	-2.74	-1.51
SRI LANKA	Tea	13.0%	0.04	0.05	0.01	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.04	0.02	0.03
	Rubber	4.2%	-0.13	-0.10	-0.04	0.01	-0.07	-0.02	-0.07	-0.02	-0.05	-0.10	-0.06	-0.05	-0.00
	Coconut Ps	N/A	-0.79		-0.76		-0.73		-0.82		-0.77	-0.80		-0.74	
SOUTH EAST ASIA/PACIFIC															
FIJI	Sugar	S	-0.40	-0.22	-0.07	-0.02	-0.30	-0.09	-0.10	-0.08	-0.16	-0.25	-0.15	-0.18	-0.05
INDONESIA	Rubber	26.1%	0.14	0.28	0.21	0.34	0.17	0.29	0.14	0.31	0.23	0.14	0.29	0.19	0.31
MALAYSIA	Rubber	37.8%	0.28	0.25	0.29	0.28	0.27	0.26	0.26	0.25	0.27	0.27	0.25	0.28	0.27
	Tin	26.3%	-0.17	-0.16	0.03	0.05	-0.05	-0.03	0.01	0.02	-0.04	-0.08	-0.07	-0.01	0.01
	Palm Oil	37.8%	-0.03	-0.05	-0.27	-0.25	-0.22	-0.20	-0.22	-0.22	-0.18	-0.13	-0.13	-0.25	-0.22
PHILIPPINES	Sugar	2.2%	-0.53	-0.52	-0.25	-0.20	-0.29	-0.22	-0.22	-0.21	-0.31	-0.38	-0.36	-0.27	-0.21
	Coconut Ps	N/A	-0.90		-0.86		-0.72		-0.95		-0.86	-0.93		-0.79	
SINGAPORE	Rubber	S	0.37	0.45	0.24	0.30	0.23	0.31	0.27	0.31	0.31	0.32	0.38	0.24	0.31
THAILAND	Rice	4.3%	-0.85	-1.08	-0.81	-0.97	-0.75	-0.97	-0.72	-0.71	-0.86	-0.78	-0.89	-0.78	-0.97
OECD															
AUSTRALIA	Wool	29.6%	-0.22	-0.13	-0.21	-0.13	-0.23	-0.15	-0.18	-0.10	-0.17	-0.20	-0.12	-0.22	-0.14
	Wheat	2.8%	-0.42	-0.89	-0.15	-0.88	-0.26	-0.93	-0.27	-0.76	-0.57	-0.34	-0.83	-0.20	-0.91
	Iron Ore	9.4%	-0.86	1.04	-0.21	0.52	-0.59	0.58	-0.18	0.54	0.10	-0.52	0.79	-0.40	0.55
	Beef	S	0.04	0.31	0.30	0.66	0.22	0.56	0.18	0.45	0.34	0.11	0.38	0.26	0.61
	Coal	N/A	-0.25	-0.25	-0.19	-0.18	-0.19	-0.19	-0.18	-0.17	-0.20	-0.22	-0.21	-0.19	-0.19
CANADA	Wheat	3.8%	-0.58	-0.17	-0.71	-0.33	-0.65	-0.25	-0.50	-0.17	-0.42	-0.54	-0.17	-0.68	-0.29
	Wood	2.1%	0.19		1.13		0.85		0.50		0.66	0.34		0.99	
	Wood Pulp	N/A	-0.27		-0.37		-0.34		-0.31		-0.32	-0.29		-0.35	
	Newsprint	N/A	-0.06	-0.01	-0.50	-0.38	-0.39	-0.27	-0.21	-0.15	-0.24	-0.13	-0.08	-0.44	-0.33
FINLAND	Paper	N/A	-0.39		-0.94		-0.93		-0.52		-0.69	-0.45		-0.93	
	Wood	1.5%	-0.82		-1.10		-1.46		-0.46		-0.96	-0.64		-1.28	
	Wood Pulp	N/A	-1.42		-0.81		-0.91		-0.81		-0.99	-1.11		-0.86	
	Newsprint	N/A	-1.94	0.75	-1.76	-0.82	-2.32	-0.41	-0.94	-0.23	-0.96	-1.44	0.26	-2.04	-0.61
NEW ZEALAN	Wool	12.0%	-0.24	-0.13	-0.10	-0.08	-0.17	-0.11	-0.11	-0.07	-0.13	-0.17	-0.10	-0.13	-0.10
	Lamb/Mutto	N/A	-0.13		-0.08		-0.09		-0.08		-0.09	-0.10		-0.08	
	Butter	N/A	-0.08		-0.12		-0.12		-0.10		-0.10	-0.09		-0.12	
	Beef	1.0%	-0.10	-0.08	-0.11	-0.00	-0.09	-0.00	-0.04	0.00	-0.05	-0.07	-0.04	-0.10	-0.00
NORWAY	Aluminum	4.7%	0.57	0.43	-0.03	0.20	0.09	0.23	0.08	0.16	0.22	0.33	0.29	0.03	0.21
	Paper	N/A	-0.12		-0.71		-0.80		-0.22		-0.46	-0.17		-0.76	
	Fish	7.0%	-0.11	0.11	-0.15	0.05	-0.10	0.06	-0.12	0.05	-0.03	-0.12	0.08	-0.13	0.05
AVERAGES:															
SUB-S. AFRICA		4.0%	-0.18	-0.08	-0.17	-0.07	-0.18	-0.08	-0.13	-0.05	-0.10	-0.16	-0.06	-0.18	-0.07
N.AFRICA/I.OC		2.9%	-0.49	-0.14	-0.56	0.03	-0.68	-0.00	-0.35	-0.01	-0.34	-0.42	-0.07	-0.62	0.01
SOUTH AMERICA		7.4%	-0.19	-0.07	-0.16	-0.02	-0.15	0.00	-0.13	-0.04	-0.12	-0.16	-0.05	-0.15	-0.01
CENT. AMERICA		1.2%	0.05	0.15	-0.03	0.00	0.01	0.06	-0.01	0.02	0.03	0.02	0.09	-0.01	0.03
CARIBBEAN		3.5%	-0.35	-0.02	-0.36	-0.12	-0.42	-0.09	-0.29	-0.06	-0.25	-0.32	-0.04	-0.40	-0.10
SOUTH ASIA		4.1%	-0.86	-0.95	-0.83	-0.78	-0.86	-0.86	-0.75	-0.58	-0.77	-0.82	-0.76	-0.84	-0.82
S.E.ASIA/PAC.		15.0%	-0.23	-0.13	-0.17	-0.06	-0.18	-0.06	-0.17	-0.04	-0.18	-0.20	-0.06	-0.17	-0.07
OECD		3.7%	-0.36	0.06	-0.34	-0.11	-0.42	-0.07	-0.22	-0.04	-0.25	-0.29	0.02	-0.38	-0.09
ALL LDCs		5.1%	-0.24	-0.06	-0.24	-0.08	-0.25	-0.07	-0.19	-0.06	-0.17	-0.21	-0.07	-0.25	-0.06
WHOLE SAMPLE		4.8%	-0.26	-0.06	-0.26	-0.08	-0.29	-0.07	-0.20	-0.05	-0.18	-0.23	-0.06	-0.27	-0.08

commodity that are derived from the four cases above with each giving rise to two elasticity estimates according to whether export volume has been detrended using the same or the other counterfactual. In practice the estimates for the shared and different counterfactuals tend to be close and to avoid too much proliferation of cases we average these and group them in the final four columns according to the counterfactual used for relative prices. TT, MA, UV and WP refer to time trend, moving average, unit value and world price respectively.

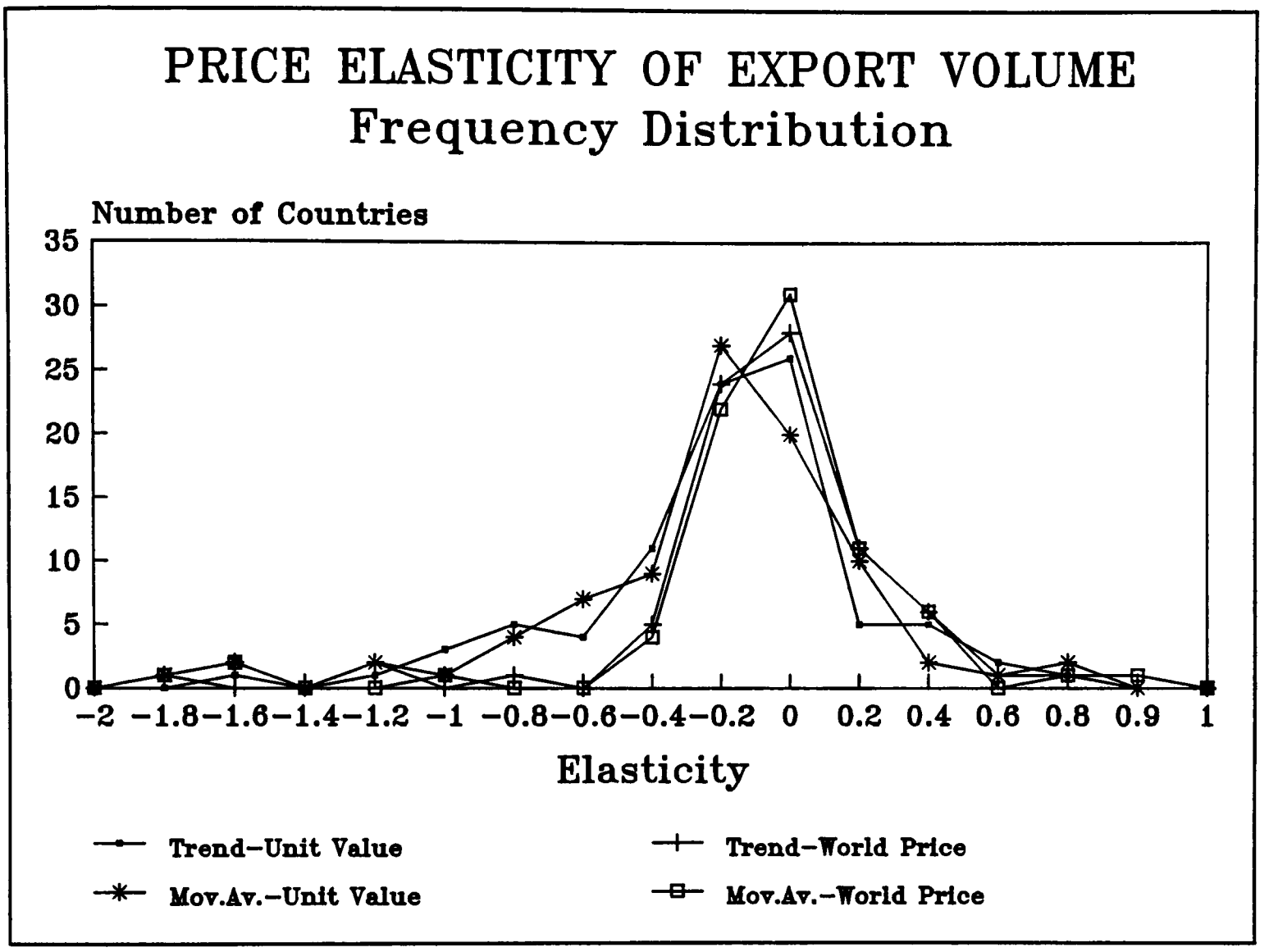
The frequency distribution of each of these four cases is shown in Figure 6.3.4 below which is reassuring in that, in line with the measures of volatility above, the four cases show a very similar pattern across the sample. This implies that the results that follow should not be too sensitive to either the choice of detrending method or the use of a unit value or world price based measure of relative prices.

While the similarity between the cases in the figure is clear, it may be noted that the unit value based estimates tend to be lower which is consistent with the presence of imperfectly correlated measurement errors in the export value and export volume data or alternatively the presence of forward contracts in which case world prices may give a better guide to the marginal price faced by producers.

The averages at the base of Table II show that this difference is present across all the country groupings though in absolute

terms the estimates fall within the same order of magnitude, as demonstrated by Figure 6.3.4.

Figure 6.3.4



Taking all the four cases together it is clear that the elasticities are negative or close to zero for the great majority of commodities and countries which implies that overall net costs from volatility are to be expected since positive elasticities are required to offset the costs of volatility from fluctuating incomes. Furthermore the negative values found, which reflect a seemingly perverse output response, imply that the flexibility effect is contributing a cost from volatility.

One possible explanation for these values would arise if many of the countries in the sample were large in world markets since in that case supply shocks within the country would give rise to world price changes such that world prices rose as exports fell and vice versa. The first column of figures in Table II shows, however, that the great majority of countries have modest world market shares for their commodity exports.

A second explanation may be that there is a limited degree of technological flexibility in the production of the commodities such that it is very difficult for producers to vary output levels by choice. The nature of the technological constraints are discussed further below but overall this proposition is refuted by strong microeconomic evidence, surveyed by Bond (1983) for example, that commodity producers respond flexibly to price incentives. Considering many of the commodities in the sample here, Bond report estimates of supply elasticities that mostly fall within the range 0.3 to 0.8 which are substantially larger than the values reported above. These are supply elasticities rather than export elasticities but these would be expected to be very close because the level of consumption of most of the commodities within the exporting countries is very small.

Two further possible explanations for the estimates found are as follows. The first, and perhaps most important, is that for the greater part of the period considered (1958-90, or within that period if data was not available for all of it)

many developing countries had controlled producer prices that were often stabilised, and/or commodity export tax regimes that tended to raise taxes when world prices were high so that governments captured a large part of the windfall. In this situation individual producers may respond flexibly to the net producer price that they face, which is the relevant price for them, but the economy as a whole show poor flexibility with respect to the world price given that the two prices are imperfectly correlated.

Gersovitz and Paxon (1990) give evidence for the 1980s that suggests that for a number of African countries the correlation between the two was actually negative and only modestly positive for most of the others. The figures for Kenya in Table II are supportive of this argument in that they are amongst the few positive estimates for the African countries and it is well known that Kenya is unusual in the continent in that producers there face prices very close to world prices.

The second further explanation arises from the general equilibrium effect discussed in the theory chapters of the non-tradeables sector tending to expand or contract at the same time as a commodity sector due to the income effect of a change in the commodity price. This gives rise to a cross price effect on the output of the commodity which would tend to limit its expansion or contraction in response to its own price. It is quite possible for this effect to lead to a

seemingly perverse output response in the commodity sector that could account for the negative elasticities found above.

The theory developed above took the capital stock as constant so the expansion of non-tradeables was viewed as an expansion of non-tradeable consumer goods. Any change in the capital stock is implicitly accounted for by the detrending of export volumes at the start of the analysis but this may obscure an expansion of the non-tradeable capital goods sector following a positive commodity price shock. Bevan et al. (1990) found that this will generally be the case and hence the impact of the non-tradeables sector may be greater, and more negative for the elasticities above, than solely the income effect on non-tradeable consumer goods.

Without detailed country case study work it is difficult to disentangle the explanations based on price stabilisation or varying tax regimes on the one hand and the non-tradeables effect on the other. In a few years time, however, it may be possible to do this across many countries since in the 1980s many governments abolished marketing boards for their commodity exports and hence producers now face prices much closer to world prices. Thus it may be possible to test for a structural break at the time of this change and compare estimates for the pre and post reform elasticities. If this difference is significant it would lend much greater weight to the explanation based on producer prices differing from world prices rather than the non-tradeables effect.

Two further possibilities may be noted. The first is that in situations where producer prices or export taxes differ for the same commodity between neighbouring countries there is an incentive for smuggling of the commodity across the border. This has been reported as common in many African countries[1] and would reduce the accuracy of the official export volume statistics reported by the IMF. To the extent that smuggling may increase when prices are high this may also tend to reduce the estimated export supply elasticities but this may not be a compelling explanation for the results found for two reasons. The first is that if both countries involved have controlled producer prices the amount of smuggling would depend on the differential between these rather than the world price, and their effect on each country's estimated elasticity may be small if neither producer price is closely aligned to the world price. The second reason is that negative elasticities have been found for many countries across all the regions when smuggling is thought to be much more prevalent in Africa due to its more open internal borders.

In due course when sufficient data is available further research in this area may also be illuminating since the widespread abolition of producer price stabilisation should lead to prices for the same commodity in neighbouring countries being more closely aligned. This would reduce the incentives to smuggle, hence removing this effect on the

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[1]See Gersovitz and Paxon (1990), and Dercon and Ayalew (1995) for example.

estimates, while also improving the quality of the official export statistics.

A final point concerns the cross price effects from one commodity to another rather than between commodities and the non-tradeables sector. Figures for the variance-covariance structure of the commodity prices faced by each country are given in Table III where it is seen that for most countries in the sample the prices of commodity exports tend to covary positively. This means that all the commodity sectors will tend to be expanding or contracting at the same time and hence there may be significant cross-price effects between them. It would be useful to be able to test for these but as noted in Section 6.1 estimates of the cross-price effects would suffer from multicollinearity problems precisely because of the non-zero covariances between the prices. In addition it was shown analytically in Chapter 4 that these cross price effects would lead to at least one of the sectors having a larger elasticity than in the absence of the cross price effects. Hence these effects may affect the relative size of the elasticities between the commodities within a country but cannot account for all of them being negative or very small if positive. Thus these effects may be important at the country-commodity level but they are unlikely to explain the overall pattern of the results. In addition there is no noticeable difference between countries with more than one major commodity export and those with only one. For the latter countries there is no cross price effect between commodities, only between the

commodity export and the non-tradeables sector.[2]

We turn now to the variation in the estimated elasticities between regions and commodities rather than their overall pattern. The base of Table II presents averages for the regions across the different cases but comparisons between these must take account of the tendency for the different regions to export a different mix of commodities. The breakdown of the commodities by region is shown overleaf, together with an indication of the nature of the production technique which divides the commodities between minerals, tree crops, annuals and what are termed "stock" commodities such as wood or fish. Each of these have rather different characteristics in terms of their potential flexibility. It is often said, for example, that the output of tree crops is relatively inflexible since it takes a great deal of time for new trees to mature before they yield any output. That having been said it may be possible to vary the yield from tree crops for a given capital stock (or number of mature trees) by working them more or less intensively. Annual crops, however, have rather different production characteristics in that it is much easier to vary the "capital stock" by planting a different acreage in different years (or substituting between

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[2]It would of course be beneficial for these countries, assuming the same overall size of the commodities sector and exposure to price risk, if they exported several commodities rather than one as long as the prices of the several commodities did not move exactly together.

COMMODITY		TOTAL	AFRICA	N.AFRICA/ IND.OCEAN	SOUTH AMERICA	CENTRAL AMERICA	CARIBBEAN	SOUTH ASIA	SE ASIA/ PACIFIC
Coffee		17	8	1	3	5			
Sugar		11	1	1		2	5		2
Cotton	A	8	2	1	1	3		1	
Rubber	T	5	1					1	3
Copper	M	4	2		2				
Cocoa	T	4	4						
Bananas	T	4			1	3			
Phosphates	M	3	2	1					
Rice	A	3					1		2
Tea	T	3	2					1	
Tin	M	2			1				1
Meat	A	2			2				
Wool	A	2			2				
Hides/Skins	A	2	1		1				
Wood	S	2	2						
Coconut Prods	T	2						1	1
Iron Ore	M	2	1	1					
Bauxite	M	2					2		
Shrimps	S	1				1			
Sisal	T	1	1						
Vanilla	A	1		1					
Beef	A	1				1			
Groundnuts	A	1	1						
Tobacco	A	1	1						1
Teak	S	1							
Fish	S	1		1					
Corn	A	1			1				
Wheat	A	1			1				
Alumina	M	1					1		
Palm Oil	T	1							1
TOTAL		90	29	7	15	15	9	4	11

A = Annual Crop
T = Tree Crop
S = "Stock" Crop (eg.Wood, Fish)
M= Mineral

different forms of livestock) but this perhaps places greater emphasis on price expectations since acreage or its equivalent must be planned in advance.

Minerals or what have been termed stock crops are potentially more flexible because in principle it is possible to exploit the existing stock (be it a mineral deposit, forest or fish stocks) more rapidly when prices are high without the need for planting in advance. At the same time mining and fishing are often capital intensive and if it takes time to install new capital equipment (with very limited possibilities for disinvestment when prices are low) the potential flexibility from the existence of the stock may be offset by the relative difficulty of varying the amount of capital equipment as opposed to labour input.

Hence these different types of commodity may give rise to different orders of magnitude in the estimated elasticities as well as possible differences arising from the region in which a country is found which may in turn act as a proxy for differences between policy regimes across the regions. To explore these differences a cross sectional regression was estimated for each of the four sets of elasticities presented above. These estimates formed the dependent variable and were regressed against dummy variables for each of the regions and types of commodity (tree, annual crop etc.) together with a dummy for a country being large in the world market for the commodity (defined as greater than 5% world market share).

The results of these regressions are shown overleaf, comprising the values of the estimated coefficients, their standard errors and the R square figures for the regressions as a whole. The latter are of reasonable size for an exercise of this sort where we are trying solely to establish the pattern revealed by the data across regions and commodity type rather than develop a more complex specification.

The reported coefficients should be interpreted as being relative to those for South Asia for the regional dummies and annual crops for crop type which in effect have zero coefficients imposed by the regression. In addition to the dummy variables for crop type there are also reported coefficients for coffee and sugar. Separate dummy variables were possible for these two commodities because of their frequency in the sample and are perhaps desirable because they are the two commodities for which there have been international commodity agreements in place during the period that have involved the use of export quotas. While these quotas were primarily designed to raise average prices rather than reduce volatility it is possible that they may have limited countries ability to vary exports as world prices change. This effect may, however, be weak because a positive response of export volumes to prices would tend to stabilise prices[3] and in fact the coefficients on these dummy variables do not differ markedly from those for the crop types (which

[3]A point taken up in the concluding chapter.

REGRESSION RESULTS

	TIME TREND:				MOVING AVERAGE:			
	UNIT VALUE		WORLD PRICE		UNIT VALUE		WORLD PRICE	
	COEFF.	SE	COEFF.	SE	COEFF.	SE	COEFF.	SE
AFRICA	0.637 **	0.187	0.707 **	0.169	0.639 **	0.201	0.760 **	0.207
N.AFRICA/I.OC.	0.437	0.231	0.859 **	0.215	0.263	0.248	0.919 **	0.263
S.AMERICA	0.790 **	0.205	0.843 **	0.179	0.886 **	0.220	0.935 **	0.219
C.AMERICA	0.886 **	0.204	0.917 **	0.177	0.896 **	0.219	0.906 **	0.217
CARRIBEAN	0.446	0.238	0.832 **	0.225	0.337	0.255	0.771 **	0.275
S.ASIA	0.000	-	0.000	-	0.000	-	0.000	-
S.E.ASIA/PAC.	0.521 *	0.218	0.649 **	0.193	0.532 *	0.234	0.716 **	0.236
ANNUAL CROP	0.000	-	0.000	-	0.000	-	0.000	-
TREE CROP	0.492 **	0.140	0.437 **	0.111	0.644 **	0.150	0.387 **	0.136
STOCK	0.315	0.224	-0.363	0.342	0.524 *	0.240	0.055	0.418
MINERAL	0.411 **	0.147	0.223	0.123	0.523 **	0.157	0.168	0.150
COFFEE	0.263	0.134	0.085	0.103	0.370 *	0.144	0.056	0.126
SUGAR	0.373 *	0.167	0.105	0.137	0.604 **	0.180	0.138	0.168
LARGE COUNTR	-0.041	0.131	-0.090	0.110	-0.031	0.140	-0.092	0.134
CONSTANT	-1.102 **	0.184	-0.961 **	0.161	-1.240 **	0.197	-0.990 **	0.197
R SQUARE	0.337		0.399		0.400		0.288	
ADJ. R SQUARE	0.233		0.291		0.305		0.161	

* Significant at the 5% level
** Significant at the 1% level

exclude these two commodities). The levels of significance reported show that the coefficients are reasonably robust with only those for the stock commodities (where there are few data points) and the large country dummy being consistently weak. The latter has a negative sign throughout which is to be expected but it is surprisingly small.

Figure 6.3.5

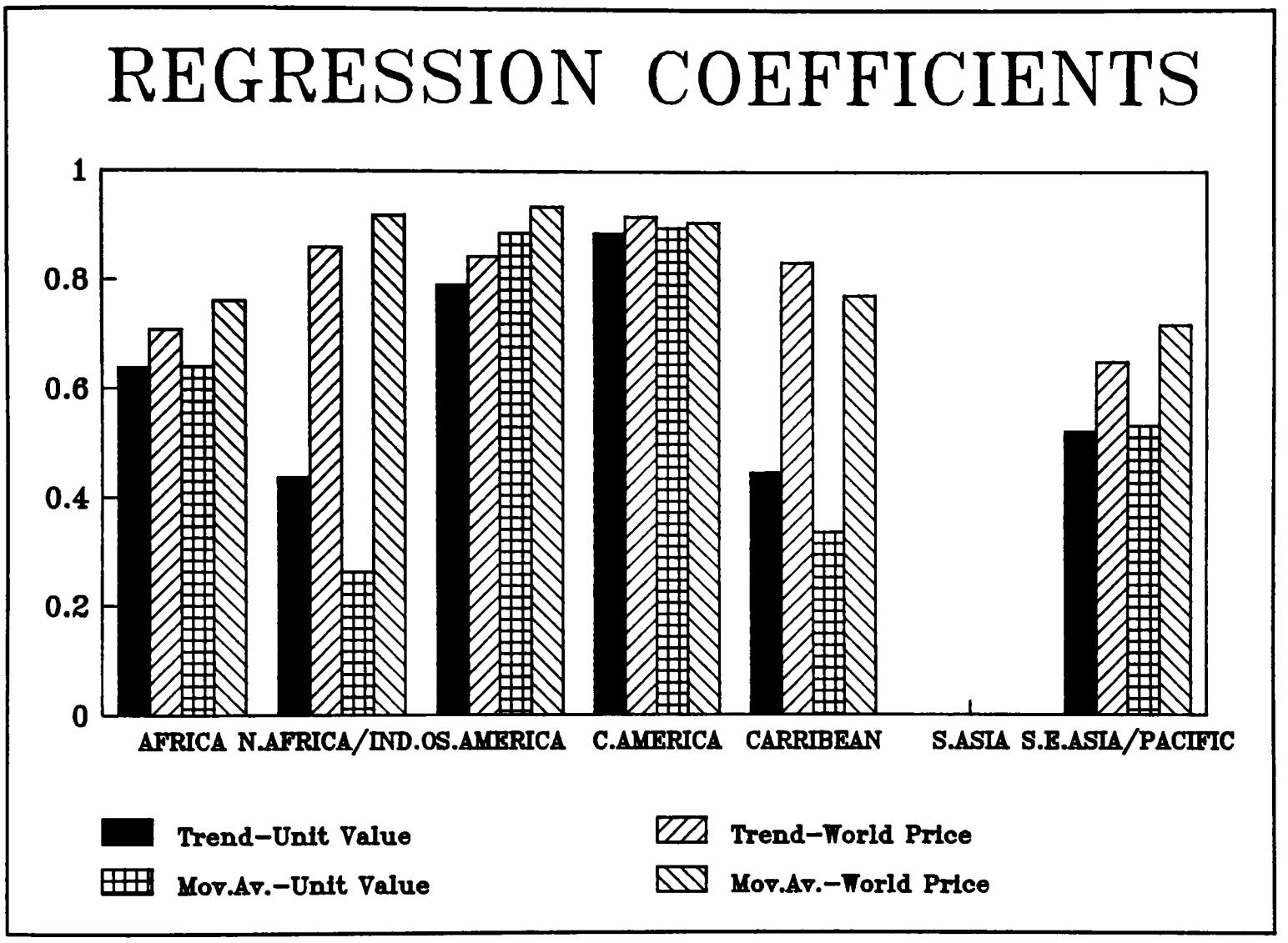


Figure 6.3.5 above shows the coefficients on the regional dummies for each of the four cases. These are of comparable size except for North Africa/Indian Ocean and the Caribbean where the coefficients for the cases based on unit values are rather lower. This difference is confirmed by Figures 6.3.6

and 6.3.7 which separate out the regression results that rest on unit value based relative prices from those that use world prices. Arguably the latter are more reliable and the pattern shown by Figure 6.3.7 given more weight as a result.

Figure 6.3.6

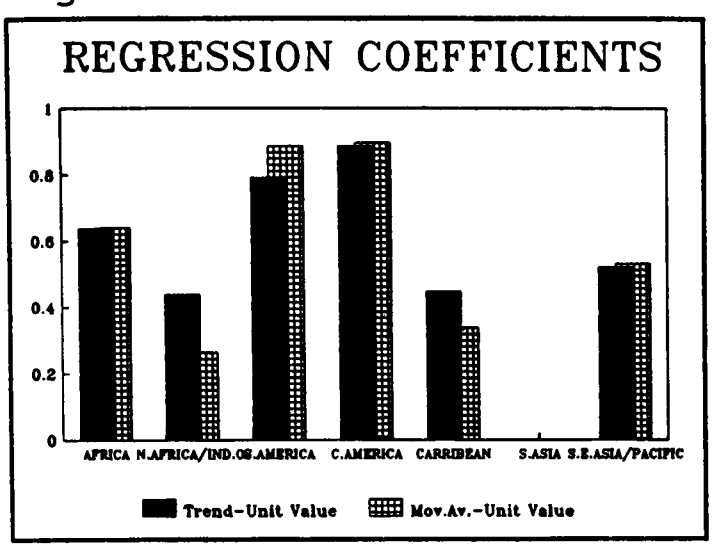
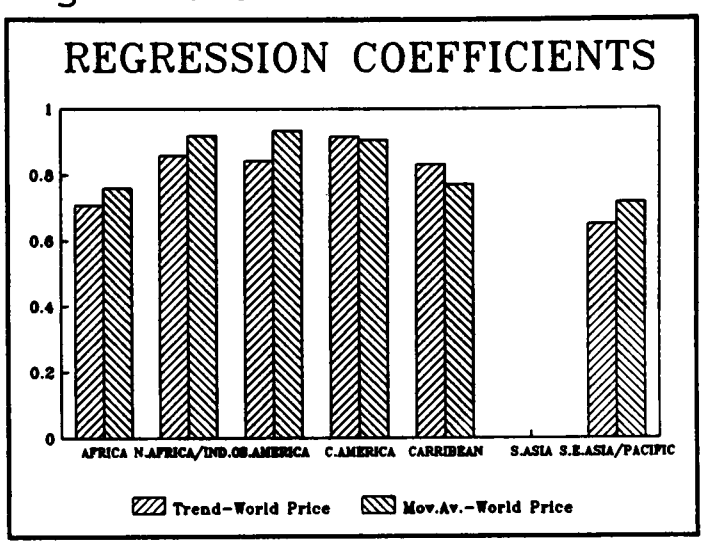


Figure 6.3.7

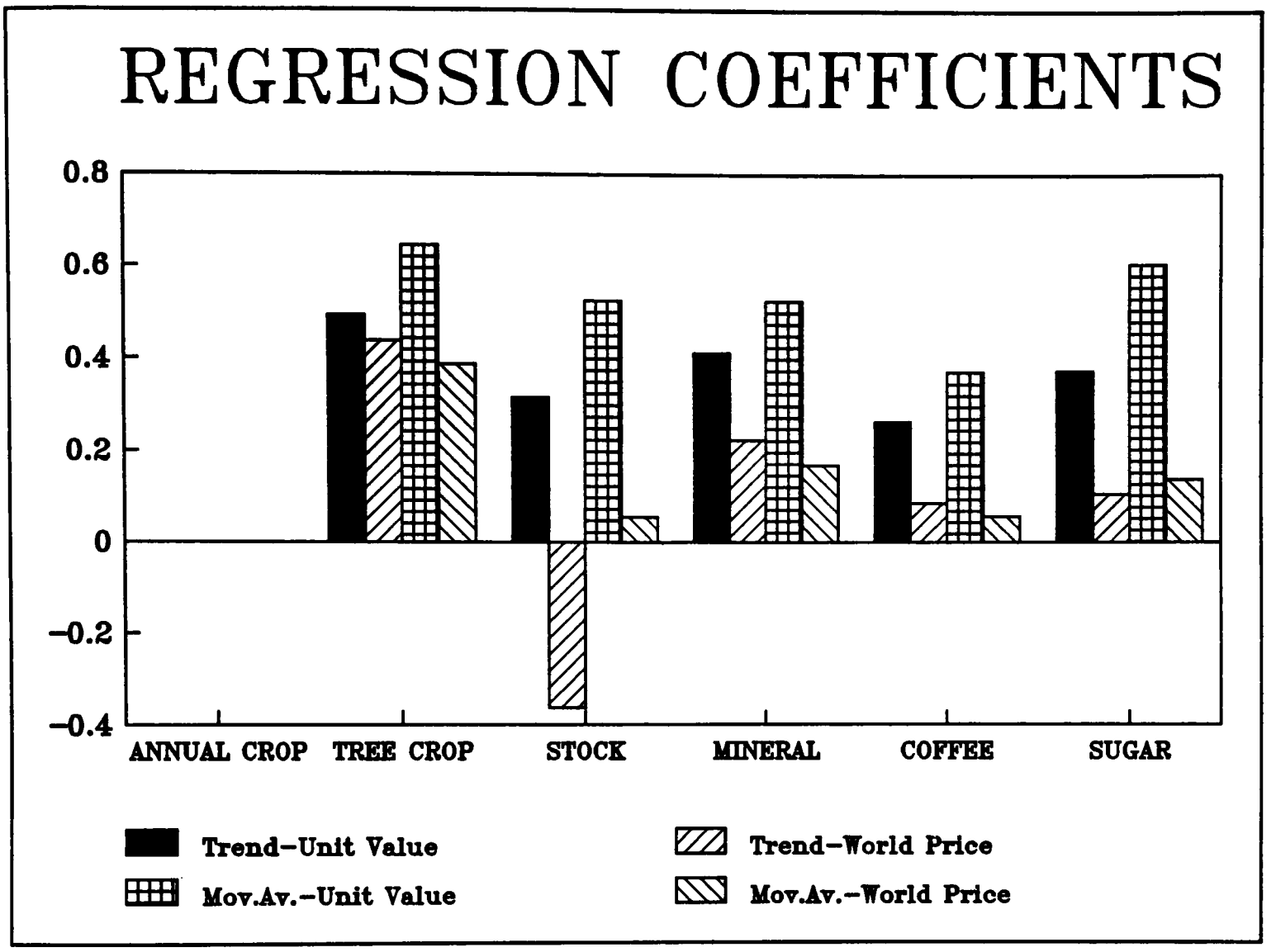


Overall the similarities between the regions is perhaps more striking than the differences, apart from South Asia which is dominated by the large and negative elasticity estimates for Pakistan and Burma. The position of Africa indicating less flexibility than the Western Hemisphere regions is to be expected whereas that of South East Asia/Pacific is initially more surprising. This group of countries includes Fiji and the Philippines, however, and the results for these will be reducing this coefficient which would otherwise reflect the good performance of Malaysia, Singapore and Indonesia reported in Table II.

Turning to the results for the commodity groups plus coffee and sugar, the coefficients for the four cases shown in Figure 6.3.8 are rather less stable than those for the regional

groupings. This is most marked for the stock commodities where there are few data points.

Figure 6.3.8



Leaving the stock coefficients to one side, the other crops and crop groups are clearly ahead of the annual crops. This is surprising in some ways because these crops are sometimes held to be the most flexible, for reasons discussed above, but it appears that the longer lead times on developing greater acreage or opening up new deposits of minerals with the others do not prevent them having greater short run flexibility whereby a mine or existing stock of trees may be worked more intensively.

Comparisons between the dummies for the non-annual commodities is assisted by Figures 6.3.9 and 6.3.10 which separate out the coefficients based on unit value relative prices and those based on world prices.

Figure 6.3.9

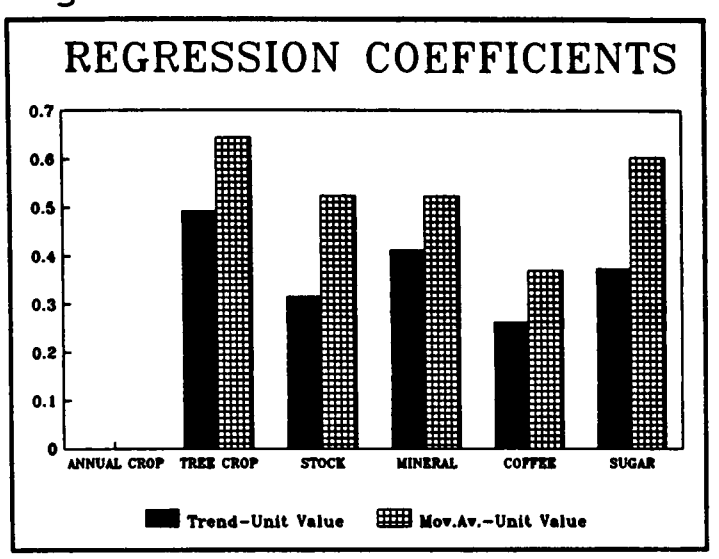
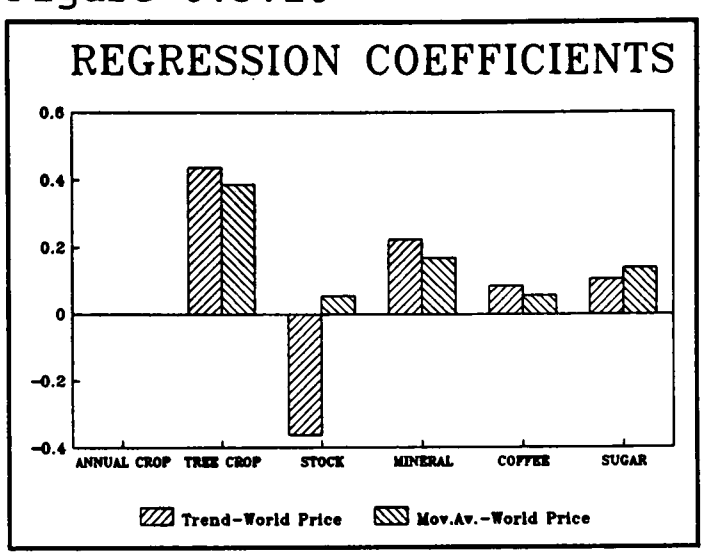


Figure 6.3.10



Despite the variation between the cases, all four agree that tree crops show greater flexibility than minerals, perhaps because the former are more labour intensive and labour is more readily variable. There is also agreement that sugar is more flexible than coffee and both of these tend to be less flexible than tree crops and minerals. Hence coffee is comparatively inflexible when compared against the other tree crops which is unfortunate for Africa where coffee is very important.

Before presenting the results for the whole effect from volatility based on (6.1.1) in the following section we examine further results based predominantly on the elasticity estimates discussed above.

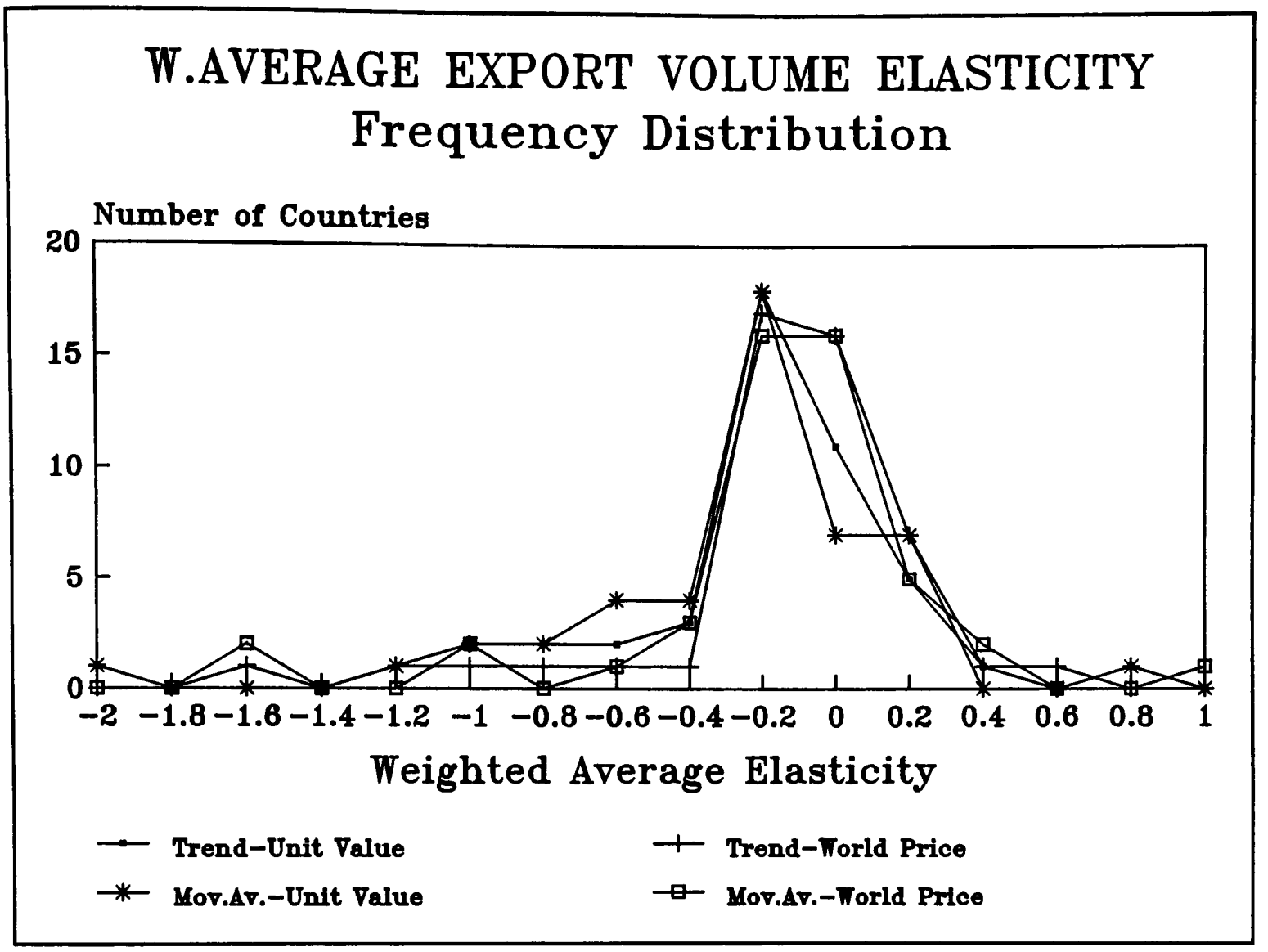
Table III gives the figures for the variance-covariance structure, the weighted average elasticity for each country, and the extent to which an increase in the elasticities would raise the equivalent change in national income measure of the effect of volatility.

The variance-covariance results indicate, as mentioned above, that for the majority of countries (and all the regional averages bar North Africa/Indian Ocean) the covariances between the commodity prices of exports from the same country tend to be positive and hence the figures shown are negative. This indicates that the pattern between the volatile prices tends to be unhelpful in that it is advantageous for them to move in opposite directions both because this assists the output response of each sector to its own price and because the income effects from the individual price changes would offset each other. The second set of figures in the table shows the average of the elasticities for each country weighted by each commodity's size and the degree of volatility in its price. The frequency distribution of these figures is shown by Figure 6.3.11 which shows a similar pattern to the charts for the individual elasticities above. Once again those based on unit values (rather than world prices) tend to be a little lower within a broadly similar pattern. As before the distribution peaks at less than zero but a significant minority of the figures are positive which indicates a benefit from production flexibility for these economies as opposed to a net cost for the others.

TABLE III RELATIONSHIPS BETWEEN VOLATILE PRICES AND ELASTICITY DATA

	VARIANCE-COVARIANCE STRUCTURE:					WEIGHTED AVERAGE ELASTICITY:					EQUIVALENT CHANGE IN MEAN NATIONAL INCOM FOR A UNIT CHANGE IN EACH ELASTICITY:				
	TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:		
	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE
SUB-SAHARAN AFRICA															
CAMEROON	-0.48	-0.56	-0.36	-0.4	-0.45	-0.11	-0.06	-0.16	-0.12	-0.11	0.57%	0.74%	0.45%	0.56%	0.58%
COTE D'IVOIRE	-0.43	-0.38	-0.34	-0.3	-0.36	-0.18	-0.13	-0.17	-0.11	-0.15	1.19%	1.26%	0.79%	0.89%	1.04%
ETHIOPIA	0.11	-0.29	0.1	-0.37	-0.11	-0.21	-0.12	-0.17	-0.04	-0.14	0.34%	0.33%	0.29%	0.26%	0.31%
GHANA						-0.24	-0.28	-0.18	-0.27	-0.24	1.39%	0.87%	1.05%	0.54%	0.96%
KENYA	-0.48	-0.5	-0.67	-0.61	-0.56	0.13	0.17	0.17	0.19	0.17	0.34%	0.31%	0.27%	0.26%	0.30%
LIBERIA	0.49	0.23	0.5	0.24	0.37	-0.25	0.03	-0.35	-0.05	-0.16	0.87%	0.63%	0.68%	0.47%	0.66%
MALAWI	-0.01	-0.1	0.15	0.01	0.01	0.01	0	-0.07	0.01	-0.01	0.75%	0.50%	0.65%	0.40%	0.58%
SENEGAL	-0.54	-0.39	-0.28	-0.11	-0.33	-0.49	-0.61	-0.89	-0.92	-0.73	0.56%	0.56%	0.40%	0.43%	0.49%
SUDAN						-1	0.7	-1.17	0.99	-0.12	0.21%	0.11%	0.19%	0.08%	0.15%
TANZANIA	-0.1	-0.15	-0.04	-0.01	-0.08	-0.17	-0.16	-0.17	-0.15	-0.16	0.69%	0.52%	0.45%	0.35%	0.50%
TOGO	0.05	-0.02	0.22	0.23	0.12	-0.2	-0.24	-0.22	-0.19	-0.21	1.50%	1.28%	1.19%	0.99%	1.24%
UGANDA						-0.21	-0.13	-0.18	-0.1	-0.16	0.81%	0.68%	0.67%	0.51%	0.68%
ZAIRE	-0.2	0.37	-0.25	0.11	0.01	-0.15	-0.06	-0.22	-0.11	-0.14	1.71%	0.78%	1.56%	0.57%	1.16%
ZAMBIA						-0.03	0.02	-0.06	0.07	0.00	3.03%	3.11%	1.07%	1.09%	2.08%
NORTH AFRICA/INDIAN OCEAN															
EGYPT						-0.28	-0.17	-0.68	0.02	-0.28	0.32%	0.08%	0.07%	0.06%	0.13%
MADAGASCAR	-0.04	0.08	-0.22	-0.13	-0.08	-0.25	-0.21	-0.36	-0.33	-0.29	0.28%	0.29%	0.20%	0.22%	0.25%
MAURITANIA	0.03	0.26	0.07	0.3	0.17	-0.97	-0.18	-1.04	0.08	-0.53	1.07%	0.50%	0.62%	0.50%	0.67%
MAURITIUS						-0.06	0.09	-0.18	0.05	-0.03	1.69%	1.53%	0.61%	1.19%	1.26%
MOROCCO						0.03	0.03	-0.03	-0.03	0.00	0.30%	0.21%	0.23%	0.21%	0.24%
SOUTH AMERICA															
ARGENTINA	-0.37	-0.48	-0.24	-0.39	-0.37	-0.41	0.06	-0.33	0.24	-0.11	0.14%	0.15%	0.09%	0.09%	0.12%
BOLIVIA						0.14	0.15	0.13	0.15	0.14	0.21%	0.21%	0.15%	0.15%	0.18%
BRAZIL							-0.46		-0.44	-0.45		0.09%		0.07%	0.08%
CHILE						-0.07	-0.07	-0.11	-0.11	-0.09	1.02%	1.24%	0.23%	0.31%	0.70%
COLUMBIA						-0.14	-0.13	-0.19	-0.19	-0.16	0.41%	0.40%	0.36%	0.31%	0.37%
ECUADOR	-0.34	-0.34	-0.81	-0.54	-0.46	0.13	0.15	0.11	0.07	0.12	0.39%	0.20%	0.21%	0.14%	0.24%
PARAGUAY						0.89	-0.24	0.82	-0.03	0.36	0.07%	0.04%	0.05%	0.03%	0.05%
PERU						-0.05	-0.05	0.15	0.08	0.03	0.32%	0.35%	0.08%	0.09%	0.21%
URUGUAY	-0.38	-0.53	-0.36	-0.51	-0.45	-0.5	-0.19	-0.7	-0.44	-0.46	0.37%	0.38%	0.29%	0.22%	0.32%
CENTRAL AMERICA															
COSTA RICA	-0.13	-0.22	-0.21	-0.31	-0.22	-0.22	-0.14	-0.24	-0.2	-0.20	0.77%	0.65%	0.55%	0.45%	0.61%
EL SLAVADOR	-0.27	-0.26	-0.27	-0.28	-0.27	-0.17	-0.08	-0.27	-0.14	-0.17	0.92%	0.89%	0.69%	0.68%	0.80%
GUATEMALA	0.07	0.08	0.12	0.17	0.11	-0.08	-0.01	-0.07	-0.04	-0.05	0.46%	0.44%	0.35%	0.34%	0.40%
HONDURAS	0.03	-0.31	-0.31	-0.48	-0.27	0.03	0.12	-0.09	0	0.02	0.56%	0.43%	0.34%	0.30%	0.41%
NICARAGUA	-0.33	-0.34	-0.45	-0.34	-0.37	0.07	0.14	0.06	0.14	0.10	0.43%	0.45%	0.35%	0.34%	0.39%
PANAMA	-0.15	-0.15	0.32	0.16	0.05	0.21	0.23	0.12	0.17	0.18	0.25%	0.11%	0.11%	0.07%	0.14%
CARIBBEAN															
BARBADOS						-0.39	-0.26	-0.36	-0.16	-0.29	0.77%	0.60%	0.58%	0.54%	0.62%
DOMINICAN R.						-0.18	-0.14	-0.15	-0.16	-0.16	0.47%	0.34%	0.35%	0.25%	0.35%
GUYANA	-0.15	-0.18	0.01	0.08	-0.06	-0.17	-0.09	-0.17	-0.04	-0.12	1.81%	1.61%	0.90%	1.05%	1.34%
JAMAICA	-0.16	0.04	-0.21	0.06	-0.07	-0.01	-0.02	-0.15	-0.15	-0.08	0.54%	0.52%	0.28%	0.31%	0.41%
TRINIDAD & T.						-0.72	0.1	-0.64	-0.23	-0.37	0.13%	0.11%	0.13%	0.09%	0.12%
SOUTH ASIA															
BURMA	0.03	-0.01	0.07	-0.04	0.01	-1.17	-1.54	-1.07	-1.54	-1.33	0.29%	0.19%	0.27%	0.13%	0.22%
PAKISTAN						-2.43	-1.24	-2.74	-1.51	-1.98	0.03%	0.02%	0.02%	0.01%	0.02%
SRI LANKA	-0.43	-0.37	-0.48	-0.42	-0.43	-0.24	-0.22	-0.24	-0.22	-0.23	0.45%	0.47%	0.49%	0.51%	0.48%
SOUTH EAST ASIA/PACIFIC															
FIJI						-0.25	-0.15	-0.18	-0.06	-0.16	0.72%	0.82%	0.31%	0.64%	0.62%
INDONESIA						0.14	0.3	0.19	0.31	0.24	0.04%	0.03%	0.03%	0.04%	0.04%
MALAYSIA	-0.34	-0.47	-0.42	-0.57	-0.45	0.07	0.07	0.07	0.07	0.07	0.51%	0.51%	0.45%	0.47%	0.49%
PHILIPPINES	0.18	-0.17	0.23	-0.26	-0.01	-0.67	-0.75	-0.63	-0.66	-0.68	0.36%	0.28%	0.33%	0.03%	0.25%
SINGAPORE						0.32	0.38	0.24	0.31	0.31	0.36%	0.37%	0.36%	0.37%	0.37%
THAILAND						-0.78	-0.9	-0.78	-0.97	-0.86	0.18%	0.11%	0.17%	0.08%	0.14%
OECD															
AUSTRALIA	0.04	-0.09	0.03	-0.08	-0.03	-0.2	-0.17	-0.15	-0.17	-0.17	0.20%	0.19%	0.17%	0.16%	0.18%
CANADA	-0.01	-0.03	0.07	0.13	0.04	-0.31	-0.04	-0.35	-0.03	-0.18	0.08%	0.05%	0.05%	0.04%	0.05%
FINLAND	-0.43	-0.09	-0.36	-0.22	-0.26	-0.9	-0.7	-1.04	-0.94	-0.90	0.09%	0.09%	0.06%	0.06%	0.08%
NEW ZEALAND	-0.26	-0.39	-0.45	-0.38	-0.37	-0.13	-0.09	-0.12	-0.09	-0.11	0.36%	0.37%	0.25%	0.28%	0.32%
NORWAY	-0.09	-0.13	0.15	0	-0.02	0.04	0.13	-0.15	0.07	0.02	0.04%	0.13%	0.02%	0.01%	0.05%
AVERAGES:															
SUB-S. AFRICA	-0.16	-0.18	-0.10	-0.12	-0.14	-0.22	-0.06	-0.27	-0.06	-0.15	1.00%	0.83%	0.69%	0.53%	0.76%
N.AFRICA/I.OC	-0.01	0.17	-0.08	0.09	0.04	-0.31	-0.09	-0.46	-0.04	-0.22	0.73%	0.62%	0.35%	0.44%	0.61%
SOUTH AMERIC	-0.36	-0.46	-0.40	-0.46	-0.42	-0.00	-0.09	-0.02	-0.07	-0.07	0.37%	0.34%	0.18%	0.16%	0.25%
CENT. AMERICA	-0.13	-0.20	-0.13	-0.18	-0.16	-0.02	0.04	-0.06	-0.01	-0.02	0.57%	0.50%	0.40%	0.36%	0.46%
CARIBBEAN	-0.16	-0.07	-0.10	0.07	-0.06	-0.29	-0.08	-0.29	-0.16	-0.20	0.74%	0.64%	0.45%	0.46%	0.57%
SOUTH ASIA	-0.20	-0.19	-0.21	-0.23	-0.21	-1.28	-1.00	-1.35	-1.09	-1.18	0.26%	0.23%	0.26%	0.22%	0.24%
S.E.ASIA/PAC.	-0.08	-0.32	-0.10	-0.42	-0.23	-0.20	-0.18	-0.18	-0.17	-0.18	0.36%	0.35%	0.28%	0.27%	0.32%
OECD	-0.15	-0.16	-0.11	-0.11	-0.13	-0.30	-0.17	-0.36	-0.23	-0.27	0.16%	0.17%	0.11%	0.11%	0.13%
ALL LDCs	-0.16	-0.19	-0.14	-0.17	-0.17	-0.24	-0.13	-0.20	-0.14	-0.20	0.66%	0.56%	0.42%	0.37%	0.49%
WHOLE SAMPLE	-0.16	-0.18	-0.14	-0.16	-0.16	-0.25	-0.14	-0.29	-0.15	-0.21	0.60%	0.51%	0.39%	0.34%	0.46%

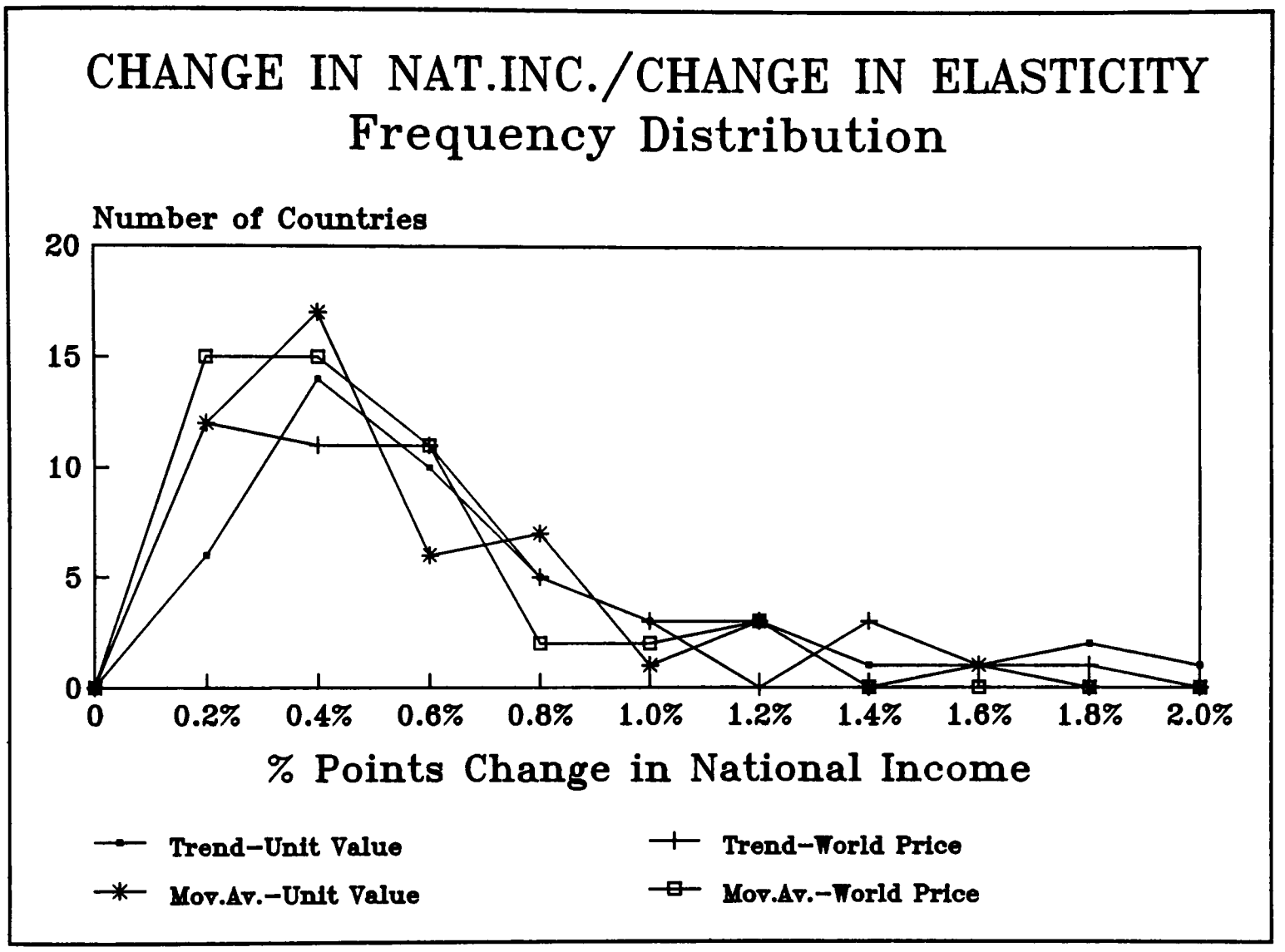
Figure 6.3.11



If the discussion above about producer price and/or export tax regimes reducing flexibility is accurate it is possible that the recent policy reforms in this area will lead to more flexibility. From the theoretical work earlier it is clear that this would be beneficial at the country level (while not necessarily benefitting individual producers since they now face greater risk) and the estimates derived allow the empirical magnitude of this benefit to be calculated. These are shown in Figure 6.3.12 for the four cases where, despite some disparity between them, it is clear that a unit increase in each elasticity would be equivalent to an increase in mean

national income of between 0.1% and 0.7% for the majority of countries. While a unit increase in each elasticity would be a large change it is clear that smaller increases would lead to significant benefits.

Figure 6.3.12



This completes the presentation of results concerned with the elasticities and we turn to the whole effect from volatility in the Section that follows.

6.4 RESULTS: NET BENEFITS OR COSTS FROM VOLATILITY

Following the analysis of the results for the export supply elasticities of the previous section we turn to the estimates of the whole effect of volatility. It will be recalled that where precise parameter estimates were not available, Section 6.2 showed how High, Medium and Low variants were derived with in each case the High case implying the largest costs from volatility. These variants are combined with the four cases to yield twelve estimates of the costs or benefits from volatility. While this spread of results is not ideal the four cases tend to fall close together as already seen and the High, Medium and Low variants in practice cover a limited range.

Table IV overleaf presents the main results from estimating (6.1.1) which is based on an arithmetic mean counterfactual.[1] The first set of figures gives the equivalent change in national income that would have the same impact on welfare as that of price volatility, as defined by (6.1.4) followed by the similar measure for the equivalent change in commodity price means defined by (6.1.5). In both these cases a negative sign indicates a net loss of welfare from volatility and the figures for the change in price means are all larger for reasons discussed above. The third set of figures, the critical average elasticity, is discussed below.

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[1]Results for the geometric mean counterfactual are shown later.

TABLE IV NET BENEFIT/(COST) OF PRICE VOLATILITY WITH NO INSURANCE, ARITHMETIC MEAN COUNTERFACTUAL

		EQUIVALENT CHANGE IN NATIONAL INCOME					EQUIVALENT CHANGE IN COM. PRICE MEANS					CRITICAL AVERAGE ELASTICITY:				
		TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:		
		UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAG
SUB-SAHARAN AFRICA																
CAMEROON	H	-0.2%	-0.2%	-0.1%	-0.2%	-0.2%	-1.6%	-2.1%	-1.3%	-1.6%	-1.7%	0.46	0.50	0.41	0.45	0.46
	M	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.8%	-0.9%	-0.7%	-0.8%	-0.8%	0.18	0.20	0.16	0.18	0.18
	L	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.5%	-0.6%	-0.5%	-0.6%	-0.6%	0.09	0.10	0.08	0.08	0.09
COTE D'IVOIRE	H	-0.6%	-0.6%	-0.4%	-0.4%	-0.5%	-2.7%	-2.6%	-1.7%	-1.7%	-2.2%	0.81	0.76	0.73	0.70	0.75
	M	-0.3%	-0.3%	-0.2%	-0.2%	-0.3%	-1.4%	-1.3%	-0.9%	-0.8%	-1.1%	0.33	0.31	0.30	0.29	0.31
	L	-0.2%	-0.2%	-0.1%	-0.1%	-0.2%	-1.0%	-0.8%	-0.6%	-0.5%	-0.7%	0.16	0.15	0.15	0.14	0.15
ETHIOPIA	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-2.0%	-1.7%	-1.6%	-1.2%	-1.6%	0.46	0.47	0.46	0.48	0.47
	M	-0.1%	0.0%	0.0%	0.0%	-0.0%	-1.2%	-0.9%	-0.9%	-0.5%	-0.9%	0.17	0.18	0.17	0.18	0.18
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.9%	-0.6%	-0.6%	-0.3%	-0.6%	0.07	0.08	0.07	0.08	0.08
GHANA	H	-0.5%	-0.3%	-0.4%	-0.2%	-0.4%	-5.7%	-3.8%	-4.0%	-2.3%	-4.0%	0.52	0.52	0.52	0.52	0.52
	M	-0.3%	-0.2%	-0.2%	-0.1%	-0.2%	-3.4%	-2.3%	-2.2%	-1.4%	-2.3%	0.21	0.21	0.21	0.21	0.21
	L	-0.2%	-0.2%	-0.1%	-0.1%	-0.2%	-2.6%	-1.8%	-1.6%	-1.1%	-1.8%	0.10	0.10	0.10	0.10	0.10
KENYA	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.5%	-0.4%	-0.4%	-0.3%	-0.4%	0.32	0.33	0.36	0.34	0.34
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.13	0.13	0.14	0.14	0.14
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	0.2%	0.2%	0.2%	0.1%	0.06	0.06	0.07	0.07	0.07
LIBERIA	H	-0.7%	-0.4%	-0.5%	-0.2%	-0.5%	-1.4%	-0.8%	-1.1%	-0.5%	-1.0%	1.31	1.28	1.25	0.98	1.21
	M	-0.3%	-0.2%	-0.3%	-0.1%	-0.2%	-0.7%	-0.3%	-0.6%	-0.2%	-0.5%	0.55	0.53	0.52	0.41	0.50
	L	-0.2%	-0.1%	-0.2%	-0.1%	-0.2%	-0.5%	-0.2%	-0.4%	-0.1%	-0.3%	0.28	0.27	0.27	0.21	0.26
MALAWI	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.8%	-0.7%	-0.8%	-0.4%	-0.7%	0.33	0.44	0.30	0.35	0.36
	M	0.0%	0.0%	-0.1%	0.0%	-0.0%	-0.3%	-0.3%	-0.4%	-0.2%	-0.3%	0.13	0.17	0.12	0.14	0.14
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.3%	-0.1%	-0.2%	0.06	0.08	0.06	0.07	0.07
SENEGAL	H	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-2.8%	-3.0%	-2.7%	-2.9%	-2.9%	0.51	0.46	0.43	0.40	0.45
	M	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-2.0%	-2.2%	-2.1%	-2.3%	-2.2%	0.20	0.18	0.17	0.15	0.18
	L	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-1.7%	-1.9%	-2.0%	-2.2%	-2.0%	0.09	0.08	0.08	0.07	0.08
SUDAN	H	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-2.1%	0.3%	-2.1%	0.3%	-0.9%	0.39	0.39	0.39	0.39	0.39
	M	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-1.7%	0.4%	-1.8%	0.5%	-0.7%	0.16	0.16	0.16	0.16	0.16
	L	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-1.6%	0.5%	-1.7%	0.5%	-0.6%	0.08	0.08	0.08	0.08	0.08
TANZANIA	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.4%	-1.1%	-0.9%	-0.6%	-1.0%	0.20	0.21	0.18	0.17	0.19
	M	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	-1.0%	-0.7%	-0.6%	-0.4%	-0.7%	0.08	0.09	0.07	0.07	0.08
	L	-0.1%	-0.1%	0.0%	0.0%	-0.1%	-0.8%	-0.6%	-0.5%	-0.4%	-0.6%	0.04	0.04	0.04	0.03	0.04
TOGO	H	-0.4%	-0.4%	-0.3%	-0.2%	-0.3%	-2.6%	-2.4%	-1.8%	-1.3%	-2.0%	0.34	0.35	0.25	0.22	0.29
	M	-0.3%	-0.2%	-0.2%	-0.1%	-0.2%	-1.6%	-1.6%	-1.2%	-0.9%	-1.3%	0.14	0.14	0.10	0.09	0.12
	L	-0.2%	-0.2%	-0.2%	-0.1%	-0.2%	-1.3%	-1.3%	-1.0%	-0.8%	-1.1%	0.07	0.07	0.05	0.04	0.06
UGANDA	H	-0.3%	-0.2%	-0.3%	-0.2%	-0.3%	-2.9%	-2.2%	-2.3%	-1.6%	-2.3%	0.59	0.59	0.59	0.59	0.59
	M	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-1.7%	-1.1%	-1.3%	-0.8%	-1.2%	0.24	0.24	0.24	0.24	0.24
	L	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.2%	-0.8%	-0.9%	-0.5%	-0.9%	0.12	0.12	0.12	0.12	0.12
ZAIRE	H	-0.8%	-0.3%	-0.8%	-0.2%	-0.5%	-4.8%	-1.5%	-4.7%	-1.3%	-3.1%	0.79	0.58	0.80	0.63	0.70
	M	-0.4%	-0.1%	-0.4%	-0.1%	-0.3%	-2.4%	-0.7%	-2.5%	-0.6%	-1.6%	0.31	0.23	0.32	0.25	0.28
	L	-0.3%	-0.1%	-0.3%	-0.1%	-0.2%	-1.6%	-0.4%	-1.7%	-0.4%	-1.0%	0.15	0.11	0.16	0.12	0.14
ZAMBIA	H	-3.2%	-3.3%	-1.2%	-1.1%	-2.2%	-7.9%	-8.0%	-2.8%	-2.7%	-5.4%	2.11	2.11	2.11	2.11	2.11
	M	-1.4%	-1.3%	-0.5%	-0.4%	-0.9%	-3.4%	-3.3%	-1.2%	-1.1%	-2.3%	0.88	0.88	0.88	0.88	0.88
	L	-0.7%	-7.0%	-0.3%	-0.2%	-2.1%	-1.8%	-1.6%	-0.7%	-0.5%	-1.2%	0.45	0.45	0.45	0.45	0.45
NORTH AFRICA/INDIAN OCEAN:																
EGYPT	H	-0.2%	0.0%	0.0%	0.0%	-0.1%	-4.2%	-1.0%	-1.2%	-0.6%	-1.8%	0.78	0.78	0.78	0.78	0.78
	M	-0.1%	0.0%	0.0%	0.0%	-0.0%	-2.2%	-0.4%	-0.8%	-0.2%	-0.9%	0.27	0.27	0.27	0.27	0.27
	L	-0.1%	0.0%	0.0%	0.0%	-0.0%	-1.5%	-0.3%	-0.6%	-0.1%	-0.6%	0.10	0.10	0.10	0.10	0.10
MADAGASCAR	H	0.1%	0.1%	0.1%	0.1%	0.1%	-1.3%	-1.2%	-1.2%	-1.2%	-1.2%	0.32	0.30	0.34	0.33	0.32
	M	0.1%	0.0%	0.1%	0.1%	0.1%	-0.9%	-0.8%	-0.8%	-0.8%	-0.8%	0.12	0.12	0.13	0.13	0.13
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.7%	-0.6%	-0.7%	-0.7%	-0.7%	0.06	0.05	0.06	0.06	0.06
MAURITANIA	H	-1.0%	-0.2%	-0.6%	-0.1%	-0.5%	-2.9%	-0.6%	-1.7%	-0.4%	-1.4%	0.97	0.72	0.97	0.64	0.83
	M	-0.7%	-0.1%	-0.4%	0.0%	-0.3%	-2.0%	-0.3%	-1.2%	-0.1%	-0.9%	0.39	0.29	0.40	0.26	0.34
	L	-0.6%	-0.1%	-0.4%	0.0%	-0.3%	-1.7%	-0.2%	-1.1%	0.0%	-0.8%	0.19	0.14	0.20	0.13	0.17
MAURITIUS	H	-1.6%	-1.3%	-0.6%	-1.0%	-1.1%	-5.6%	-4.6%	-2.1%	-3.7%	-4.0%	1.80	1.80	1.80	1.80	1.80
	M	-0.6%	-0.5%	-0.3%	-0.4%	-0.5%	-2.3%	-1.6%	-0.9%	-1.4%	-1.6%	0.70	0.70	0.70	0.70	0.70
	L	-0.3%	-0.2%	-0.2%	-0.2%	-0.2%	-1.2%	-0.6%	-0.6%	-0.6%	-0.8%	0.33	0.33	0.33	0.33	0.33
MOROCCO	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.8%	-0.5%	-0.7%	-0.7%	-0.7%	0.24	0.24	0.24	0.24	0.24
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	-0.2%	-0.3%	-0.3%	-0.3%	0.09	0.09	0.09	0.09	0.09
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.2%	-0.2%	-0.1%	0.05	0.05	0.05	0.05	0.05
SOUTH AMERICA																
ARGENTINA	H	0.0%	0.0%	0.0%	0.0%	0.0%	-1.5%	-0.6%	-0.7%	0.0%	-0.7%	0.30	0.32	0.23	0.26	0.28
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-1.1%	-0.1%	-0.5%	0.2%	-0.4%	0.11	0.11	0.08	0.09	0.10
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.9%	0.0%	-0.5%	0.3%	-0.3%	0.04	0.04	0.03	0.04	0.04
BOLIVIA	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.4%	-0.3%	-0.3%	-0.4%	0.48	0.48	0.48	0.48	0.48
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	0.19	0.19	0.19	0.19	0.19
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.3%	0.10	0.10	0.10	0.10	0.10
BRAZIL	H		0.0%		0.0%	0.0%		-2.0%		-1.5%	-1.8%		0.15		0.15	0.15
	M		0.0%		0.0%	0.0%		-1.7%		-1.3%	-1.5%		0.05		0.05	0.05
	L		0.0%		0.0%	0.0%		-1.6%		-1.2%	-1.4%		0.02		0.02	0.02
CHILE	H	-0.4%	-0.4%	-0.1%	-0.1%	-0.3%	-3.5%	-4.2%	-0.8%	-1.1%	-2.4%	0.62	0.62	0.62	0.62	0.62
	M	-0.2%	-0.2%	0.0%	-0.1%	-0.1%	-1.6%	-1.9%	-0.4%	-0.5%	-1.1%	0.24	0.24	0.24	0.24	0.24
	L	-0.1%	-0.1%	0.0%	0.0%	-0.1%	-1.0%	-1.1%	-0.2%	-0.4%	-0.7%	0.12	0.12	0.12	0.12	0.12

TABLE IV NET BENEFIT/(COST) OF PRICE VOLATILITY WITH NO INSURANCE, ARITHMETIC MEAN COUNTERFACTUAL

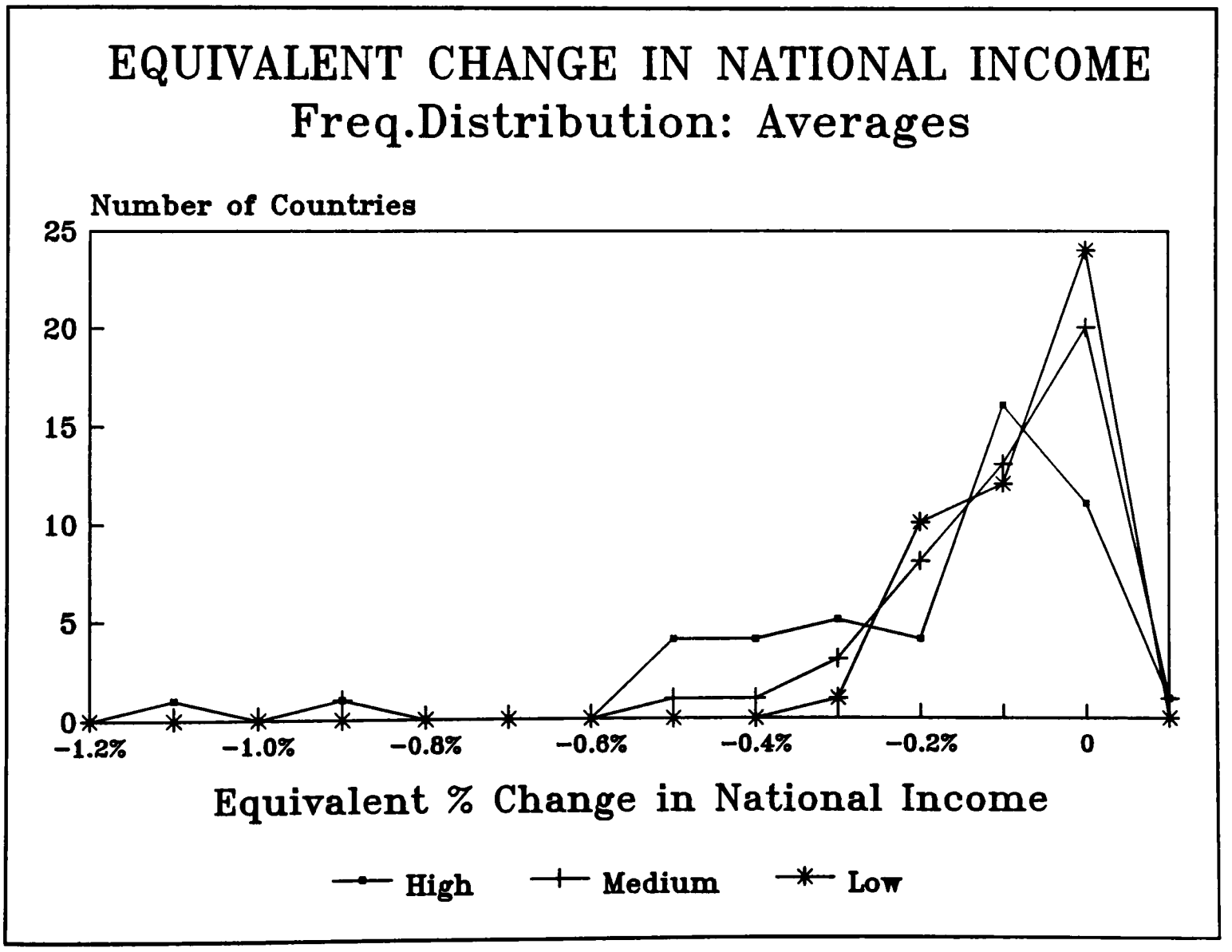
		EQUIVALENT CHANGE IN NATIONAL INCOME					EQUIVALENT CHANGE IN COM. PRICE MEANS					CRITICAL AVERAGE ELASTICITY:				
		TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:		
		UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAG
COLUMBIA	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.8%	-1.8%	-1.7%	-1.5%	-1.7%	0.42	0.42	0.42	0.42	0.42
	M	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.0%	-1.0%	-1.0%	-0.9%	-1.0%	0.16	0.16	0.16	0.16	0.16
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.7%	-0.7%	-0.8%	-0.7%	-0.7%	0.08	0.08	0.08	0.08	0.08
ECUADOR	H	-0.1%	0.0%	0.0%	0.0%	-0.0%	-0.8%	-0.3%	-0.5%	-0.3%	-0.5%	0.44	0.35	0.43	0.36	0.40
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	0.16	0.13	0.16	0.14	0.15
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	1.0%	0.0%	0.3%	0.07	0.06	0.07	0.06	0.07
PARAGUAY	H	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	-0.4%	1.0%	-0.1%	0.5%	0.12	0.12	0.12	0.12	0.12
	M	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	-0.3%	1.1%	-0.1%	0.6%	0.05	0.05	0.05	0.05	0.05
	L	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	-0.3%	1.1%	0.0%	0.6%	0.02	0.02	0.02	0.02	0.02
PERU	H	0.0%	0.0%	0.0%	0.0%	0.0%	-1.3%	-1.4%	-0.1%	-0.2%	-0.8%	0.19	0.19	0.19	0.19	0.19
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.7%	-0.7%	0.1%	0.0%	-0.3%	0.07	0.07	0.07	0.07	0.07
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.5%	-0.5%	0.1%	0.1%	-0.2%	0.04	0.04	0.04	0.04	0.04
URUGUAY	H	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-2.4%	-1.7%	-2.3%	-1.5%	-2.0%	0.34	0.39	0.34	0.39	0.37
	M	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.8%	-1.0%	-1.8%	-1.0%	-1.4%	0.13	0.15	0.13	0.15	0.14
	L	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	-1.6%	-0.8%	-1.7%	-0.9%	-1.3%	0.06	0.07	0.06	0.07	0.07
CENTRAL AMERICA																
COSTA RICA	H	-0.3%	-0.3%	-0.3%	-0.2%	-0.3%	-2.2%	-1.8%	-1.7%	-1.5%	-1.8%	0.61	0.68	0.69	0.77	0.69
	M	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-1.2%	-0.9%	-0.9%	-0.8%	-1.0%	0.23	0.25	0.26	0.29	0.26
	L	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.9%	-0.6%	-0.7%	-0.5%	-0.7%	0.10	0.11	0.11	0.13	0.11
EL SLAVADOR	H	-0.5%	-0.4%	-0.4%	-0.3%	-0.4%	-3.1%	-2.7%	-2.5%	-2.2%	-2.6%	0.87	0.85	0.86	0.85	0.86
	M	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-1.5%	-1.2%	-1.4%	-1.1%	-1.3%	0.34	0.33	0.34	0.33	0.34
	L	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-1.0%	-0.7%	-1.0%	-0.7%	-0.9%	0.16	0.16	0.16	0.16	0.16
GUATEMALA	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.1%	-0.9%	-0.8%	-0.7%	-0.9%	0.31	0.32	0.30	0.28	0.30
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.5%	-0.4%	-0.4%	-0.3%	-0.4%	0.12	0.12	0.11	0.11	0.12
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.3%	-0.2%	-0.3%	-0.2%	-0.3%	0.05	0.06	0.05	0.05	0.05
HONDURAS	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.9%	-0.8%	-0.8%	-0.7%	-0.8%	0.47	0.60	0.56	0.65	0.57
	M	0.0%	0.0%	-0.1%	0.0%	-0.0%	-0.3%	-0.2%	-0.4%	-0.3%	-0.3%	0.18	0.23	0.21	0.25	0.22
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.2%	-0.1%	-0.1%	0.08	0.11	0.10	0.11	0.10
NICARAGUA	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.7%	-0.5%	-0.4%	0.45	0.45	0.49	0.45	0.46
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	-0.1%	-0.1%	0.18	0.18	0.19	0.18	0.18
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.09	0.09	0.09	0.09	0.09
PANAMA	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	0.0%	0.0%	0.0%	-0.1%	0.31	0.25	0.13	0.16	0.21
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%	0.1%	0.1%	0.12	0.09	0.05	0.06	0.08
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.2%	0.1%	0.1%	0.2%	0.05	0.04	0.02	0.03	0.04
CARIBBEAN																
BARBADOS	H	-0.5%	-0.3%	-0.4%	-0.3%	-0.4%	-3.7%	-2.6%	-2.7%	-2.1%	-2.8%	0.86	0.86	0.86	0.86	0.86
	M	-0.3%	-0.2%	-0.2%	-0.1%	-0.2%	-2.1%	-1.3%	-1.5%	-1.0%	-1.5%	0.33	0.33	0.33	0.33	0.33
	L	-0.2%	-0.1%	-0.2%	-0.1%	-0.2%	-1.6%	-0.9%	-1.1%	-0.6%	-1.1%	0.16	0.16	0.16	0.16	0.16
DOMINICAN R.	H	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-2.3%	-1.6%	-1.7%	-1.2%	-1.7%	0.49	0.49	0.49	0.49	0.49
	M	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	-1.3%	-0.8%	-0.9%	-0.6%	-0.9%	0.19	0.19	0.19	0.19	0.19
	L	-0.1%	0.0%	0.0%	0.0%	-0.0%	-0.9%	-0.6%	-0.6%	-0.5%	-0.7%	0.09	0.09	0.09	0.09	0.09
GUYANA	H	-1.4%	-1.0%	-0.6%	-0.4%	-0.9%	-3.4%	-2.4%	-1.4%	-1.1%	-2.1%	1.37	1.11	1.07	0.81	1.09
	M	-0.6%	-0.4%	-0.3%	-0.2%	-0.4%	-1.6%	-1.0%	-0.6%	-0.5%	-0.9%	0.53	0.43	0.42	0.31	0.42
	L	-0.4%	-0.2%	-0.2%	-0.1%	-0.2%	-0.9%	-0.6%	-0.4%	-0.2%	-0.5%	0.26	0.20	0.20	0.15	0.20
JAMAICA	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.7%	-0.5%	-0.5%	-0.4%	-0.5%	0.46	0.33	0.51	0.34	0.41
	M	-0.1%	0.0%	0.0%	0.0%	-0.0%	-0.3%	-0.2%	-0.3%	-0.2%	-0.3%	0.18	0.13	0.20	0.13	0.16
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%	0.09	0.06	0.10	0.06	0.08
TRINIDAD & T.	H	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-2.6%	-0.2%	-2.4%	-0.8%	-1.5%	0.17	0.17	0.17	0.17	0.17
	M	-0.1%	0.0%	0.0%	0.0%	-0.0%	-2.3%	0.1%	-2.1%	-0.6%	-1.2%	0.06	0.06	0.06	0.06	0.06
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-2.2%	0.2%	-2.0%	-0.5%	-1.1%	0.03	0.03	0.03	0.03	0.03
SOUTH ASIA																
BURMA	H	-0.2%	-0.2%	-0.2%	-0.1%	-0.2%	-3.7%	-2.9%	-3.2%	-2.1%	-3.0%	0.35	0.34	0.35	0.35	0.35
	M	-0.2%	-0.2%	-0.2%	-0.1%	-0.2%	-3.1%	-2.6%	-2.7%	-1.8%	-2.6%	0.13	0.13	0.13	0.13	0.13
	L	-0.2%	-0.2%	-0.2%	-0.1%	-0.2%	-2.9%	-2.5%	-2.5%	-1.7%	-2.4%	0.06	0.06	0.06	0.06	0.06
PAKISTAN	H	0.0%	0.0%	0.0%	0.0%	0.0%	-3.6%	-1.5%	-3.3%	-1.3%	-2.4%	0.22	0.22	0.22	0.22	0.22
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-3.4%	-1.3%	-3.2%	-1.2%	-2.3%	0.08	0.08	0.08	0.08	0.08
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-3.3%	-1.3%	-3.1%	-1.1%	-2.2%	0.03	0.03	0.03	0.03	0.03
SRI LANKA	H	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-1.3%	-1.3%	-1.4%	-1.4%	-1.4%	0.55	0.54	0.57	0.55	0.55
	M	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.7%	-0.7%	-0.8%	-0.8%	-0.8%	0.21	0.21	0.22	0.22	0.22
	L	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.6%	-0.5%	-0.6%	-0.6%	-0.6%	0.10	0.10	0.11	0.10	0.10
SOUTH EAST ASIA/PACIFIC																
FIJI	H	-0.4%	-0.5%	-0.2%	-0.3%	-0.4%	-2.9%	-3.0%	-1.2%	-2.1%	-2.3%	0.95	0.95	0.95	0.95	0.95
	M	-0.2%	-0.2%	-0.1%	-0.1%	-0.2%	-1.5%	-1.4%	-0.6%	-0.9%	-1.1%	0.37	0.37	0.37	0.37	0.37
	L	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-1.0%	-0.9%	-0.4%	-0.5%	-0.7%	0.18	0.18	0.18	0.18	0.18
INDONESIA	H	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%	0.3%	0.2%	0.09	0.09	0.09	0.09	0.09
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.2%	0.3%	0.2%	0.04	0.04	0.04	0.04	0.04
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.2%	0.4%	0.3%	0.02	0.02	0.02	0.02	0.02
MALAYSIA	H	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.8%	-0.9%	-0.8%	-0.9%	-0.9%	0.72	0.81	0.78	0.87	0.80
	M	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	0.28	0.32	0.31	0.34	0.31
	L	0.0%	0.0%	-0.1%	0.0%	-0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.14	0.16	0.15	0.17	0.16

TABLE IV NET BENEFIT/(COST) OF PRICE VOLATILITY WITH NO INSURANCE, ARITHMETIC MEAN COUNTERFACTUAL

		EQUIVALENT CHANGE IN NATIONAL INCOME					EQUIVALENT CHANGE IN COM. PRICE MEANS					CRITICAL AVERAGE ELASTICITY:				
		TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:		
		UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAG
PHILIPPINES	H	-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-3.3%	-3.0%	-2.8%	-2.9%	-3.0%	0.16	0.23	0.14	0.24	0.19
	M	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-2.9%	-2.6%	-2.5%	-2.4%	-2.6%	0.06	0.09	0.05	0.09	0.07
	L	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-2.8%	-2.4%	-2.4%	-2.3%	-2.5%	0.03	0.04	0.03	0.04	0.04
SINGAPORE	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.8%	-7.0%	-0.8%	-0.8%	-2.4%	1.03	1.03	1.03	1.03	1.03
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.2%	-0.1%	-0.1%	0.40	0.40	0.40	0.40	0.40
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.0%	0.1%	0.1%	0.19	0.19	0.19	0.19	0.19
THAILAND	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-3.0%	-2.1%	-2.8%	-1.5%	-2.4%	0.31	0.31	0.31	0.31	0.31
	M	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	-2.4%	-1.7%	-2.3%	-1.3%	-1.9%	0.12	0.12	0.12	0.12	0.12
	L	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	-2.3%	-1.6%	-2.1%	-1.2%	-1.8%	0.05	0.05	0.05	0.05	0.05
OECD																
AUSTRALIA	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.5%	-0.5%	-0.3%	-0.4%	-0.4%	0.08	0.14	0.08	0.13	0.11
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.4%	-0.3%	-0.3%	-0.4%	0.03	0.05	0.03	0.05	0.04
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.3%	-0.2%	-0.3%	-0.3%	0.01	0.02	0.01	0.02	0.02
CANADA	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.1%	-0.3%	-0.1%	-0.2%	0.09	0.10	0.08	0.07	0.09
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.3%	-0.1%	-0.2%	0.0%	-0.2%	0.03	0.04	0.03	0.03	0.03
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.3%	0.0%	-0.2%	0.0%	-0.1%	0.02	0.02	0.01	0.01	0.02
FINLAND	H	-0.1%	0.0%	0.0%	0.0%	-0.0%	-0.5%	-0.4%	-0.3%	-0.3%	-0.4%	0.35	0.23	0.32	0.27	0.29
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.3%	-0.3%	-0.3%	-0.3%	0.14	0.09	0.13	0.11	0.12
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.3%	-0.3%	-0.3%	-0.3%	0.07	0.04	0.06	0.05	0.06
NEW ZEALAND	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.8%	-0.9%	-0.7%	-0.7%	-0.8%	0.38	0.46	0.50	0.47	0.45
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%	-0.4%	-0.4%	-0.3%	-0.4%	0.14	0.18	0.19	0.18	0.17
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-0.3%	-0.3%	-0.2%	-0.2%	-0.3%	0.07	0.08	0.09	0.08	0.08
NORWAY	H	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.14	0.16	0.09	0.13	0.13
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.05	0.06	0.03	0.05	0.05
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.02	0.03	0.02	0.02	0.02
AVERAGES																
HIGH:																
SUB-S. AFRICA		-0.5%	-0.5%	-0.3%	-0.2%	-0.4%	-2.8%	-2.1%	-2.0%	-1.3%	-2.1%	0.65	0.64	0.63	0.60	0.63
N.AFRICA/I.OC		-0.5%	-0.3%	-0.2%	-0.2%	-0.3%	-3.0%	-1.6%	-1.4%	-1.3%	-1.8%	0.82	0.77	0.83	0.76	0.79
SOUTH AMERICA		-0.1%	-0.1%	-0.0%	-0.0%	-0.1%	-1.3%	-1.4%	-0.7%	-0.7%	-1.1%	0.36	0.34	0.35	0.33	0.34
CENT. AMERICA		-0.2%	-0.2%	-0.2%	-0.1%	-0.2%	-1.3%	-1.1%	-1.1%	-0.9%	-1.1%	0.50	0.53	0.51	0.53	0.52
CARIBBEAN		-0.5%	-0.3%	-0.3%	-0.2%	-0.3%	-2.5%	-1.5%	-1.7%	-1.1%	-1.7%	0.67	0.59	0.62	0.53	0.60
SOUTH ASIA		-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-2.9%	-1.9%	-2.6%	-1.6%	-2.3%	0.37	0.37	0.38	0.37	0.37
S.E.ASIA/PAC.		-0.2%	-0.2%	-0.1%	-0.1%	-0.1%	-1.8%	-2.6%	-1.4%	-1.3%	-1.8%	0.54	0.57	0.55	0.58	0.56
ALL LDCs		-0.3%	-0.3%	-0.2%	-0.2%	-0.2%	-2.2%	-1.8%	-1.5%	-1.1%	-1.7%	0.57	0.55	0.56	0.53	0.55
MEDIUM:																
SUB-S. AFRICA		-0.3%	-0.2%	-0.2%	-0.1%	-0.2%	-1.5%	-1.1%	-1.2%	-0.7%	-1.1%	0.27	0.26	0.25	0.24	0.26
N.AFRICA/I.OC		-0.3%	-0.1%	-0.1%	-0.1%	-0.1%	-1.5%	-0.7%	-0.8%	-0.6%	-0.9%	0.31	0.29	0.32	0.29	0.30
SOUTH AMERICA		-0.1%	-0.0%	-0.0%	-0.0%	-0.0%	-0.6%	-0.8%	-0.3%	-0.4%	-0.6%	0.14	0.13	0.14	0.13	0.13
CENT. AMERICA		-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.8%	-0.4%	-0.5%	-0.4%	-0.5%	0.20	0.20	0.19	0.20	0.20
CARIBBEAN		-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-1.5%	-0.8%	-1.1%	-0.8%	-1.0%	0.26	0.23	0.24	0.20	0.23
SOUTH ASIA		-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-2.4%	-1.5%	-2.2%	-1.3%	-1.9%	0.14	0.14	0.14	0.14	0.14
S.E.ASIA/PAC.		-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.2%	-1.0%	-1.0%	-0.8%	-1.0%	0.21	0.22	0.22	0.23	0.22
ALL LDCs		-0.2%	-0.1%	-0.1%	-0.1%	-0.1%	-1.3%	-0.9%	-0.9%	-0.6%	-0.9%	0.22	0.22	0.22	0.21	0.22
LOW:																
SUB-S. AFRICA		-0.2%	-0.6%	-0.1%	-0.1%	-0.2%	-1.1%	-0.7%	-0.9%	-0.5%	-0.8%	0.13	0.13	0.13	0.12	0.13
N.AFRICA/I.OC		-0.2%	-0.1%	-0.1%	-0.0%	-0.1%	-1.0%	-0.3%	-0.6%	-0.3%	-0.6%	0.15	0.13	0.15	0.13	0.14
SOUTH AMERICA		-0.0%	-0.0%	-0.0%	-0.0%	-0.0%	-0.4%	-0.4%	-0.1%	-0.3%	-0.4%	0.07	0.06	0.07	0.06	0.06
CENT. AMERICA		-0.1%	-0.0%	-0.0%	-0.0%	-0.0%	-0.3%	-0.2%	-0.4%	-0.2%	-0.3%	0.09	0.10	0.09	0.10	0.09
CARIBBEAN		-0.1%	-0.1%	-0.1%	-0.0%	-0.1%	-1.1%	-0.4%	-0.9%	-0.4%	-0.7%	0.13	0.11	0.12	0.10	0.11
SOUTH ASIA		-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-2.3%	-1.4%	-2.1%	-1.1%	-1.7%	0.06	0.06	0.07	0.06	0.06
S.E.ASIA/PAC.		-0.1%	-0.1%	-0.1%	-0.0%	-0.1%	-1.0%	-0.8%	-0.8%	-0.6%	-0.8%	0.10	0.11	0.10	0.11	0.11
ALL LDCs		-0.1%	-0.2%	-0.1%	-0.0%	-0.1%	-0.9%	-0.6%	-0.7%	-0.4%	-0.7%	0.11	0.10	0.11	0.10	0.10

Clearly the dominant feature of the first two sets of figures is that they are negative and hence imply that the countries involved have suffered net losses to welfare from price volatility. Given the predominantly negative estimates for the export supply elasticities, the only source of potential benefit, this is not surprising since the weighted average export supply elasticity for each country needs to be not only positive but large enough to offset the costs from volatility for the country to record a benefit from volatility. The overall pattern of the income measures of the effect of volatility in Table IV is shown in the figure below.

Figure 6.4.1



The figure shows the averages across the four cases of time trend/moving average and unit value/world price to focus attention on the High, Medium and Low variants. While the latter are undoubtedly significant in their effect on the results the spread created it tolerable in that it may be said that under all three the majority of countries fall between +0.1% and -0.3% and virtually all of them between +0.1% and -0.6%. These figures are confirmed by the evidence below for each of the four cases which show a similar pattern.

Figure 6.4.2

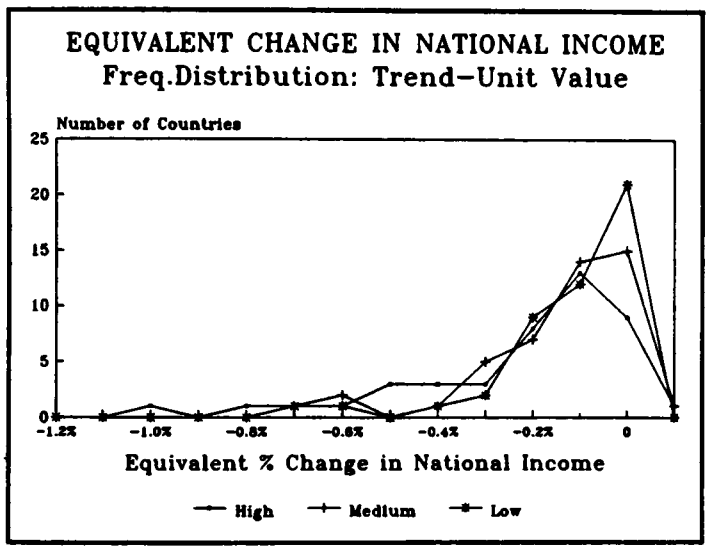


Figure 6.4.3

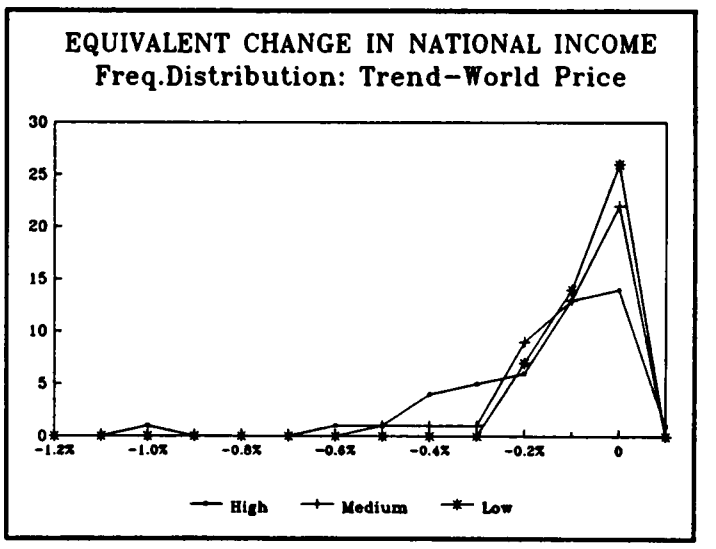


Figure 6.4.4

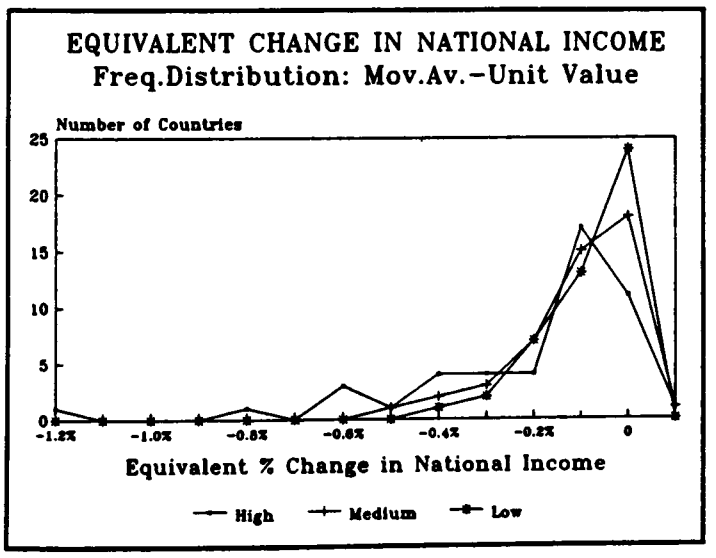
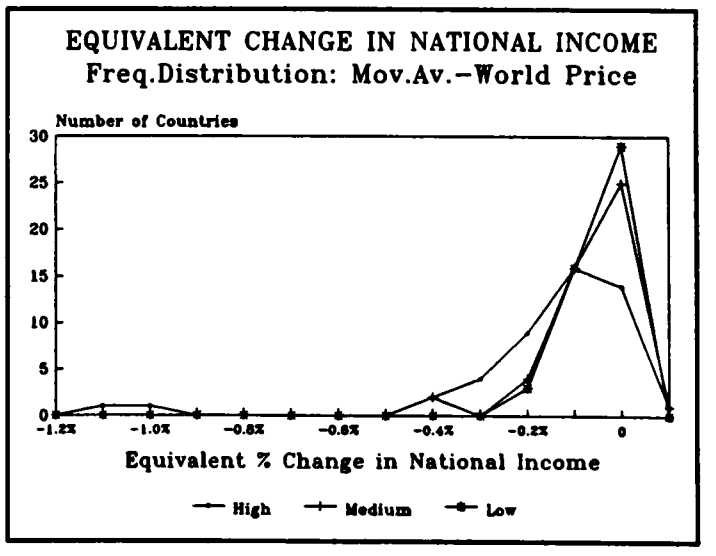
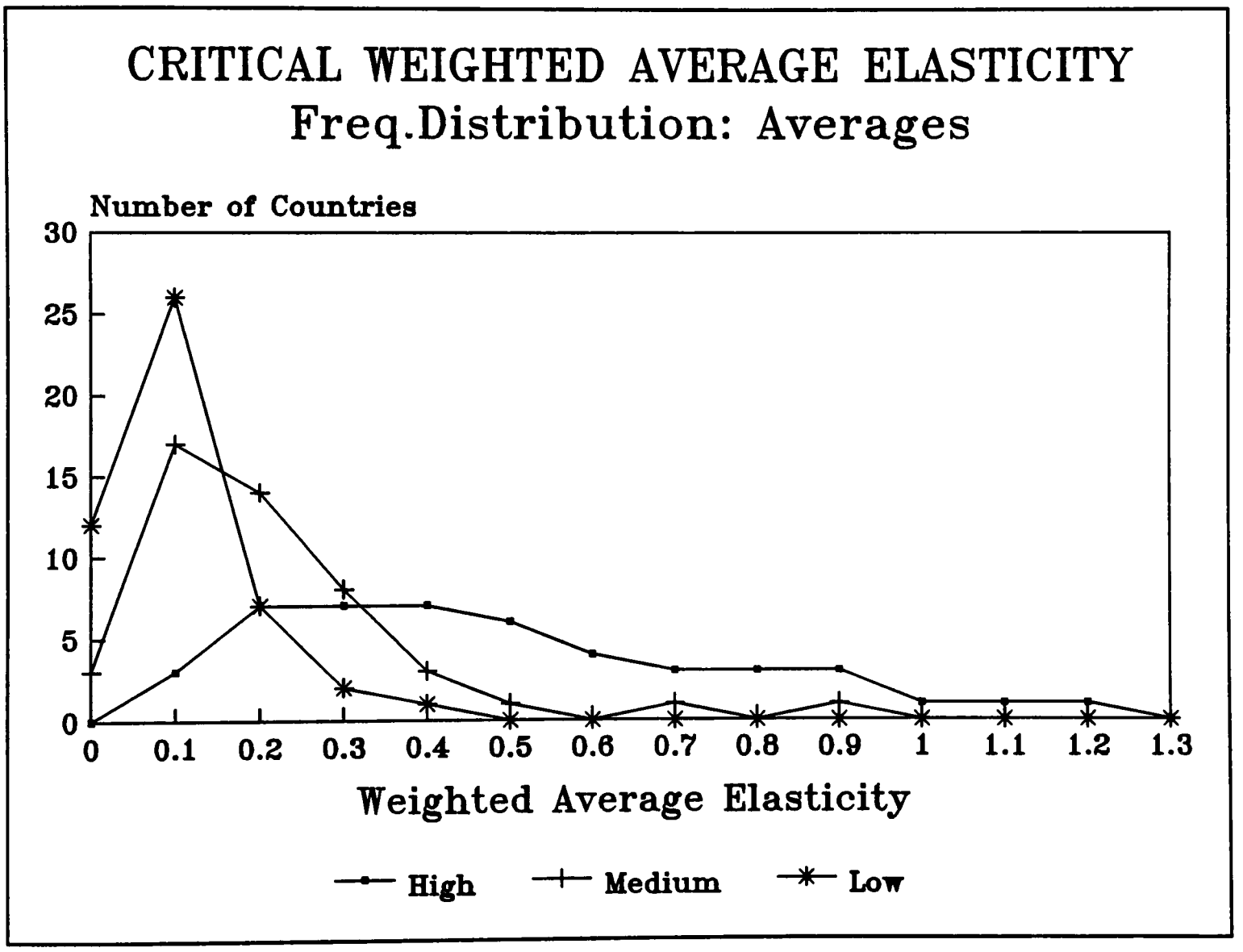


Figure 6.4.5



The third set of figures in Table IV refers to the critical elasticity which is the value of the weighted export supply elasticity for each country that is required for the flexibility benefit from this source to exactly offset the other factors which are all costs. The estimates of these critical elasticities tend to be very similar across the four cases and hence we chart only their average for each of the High, Medium and Low variants.

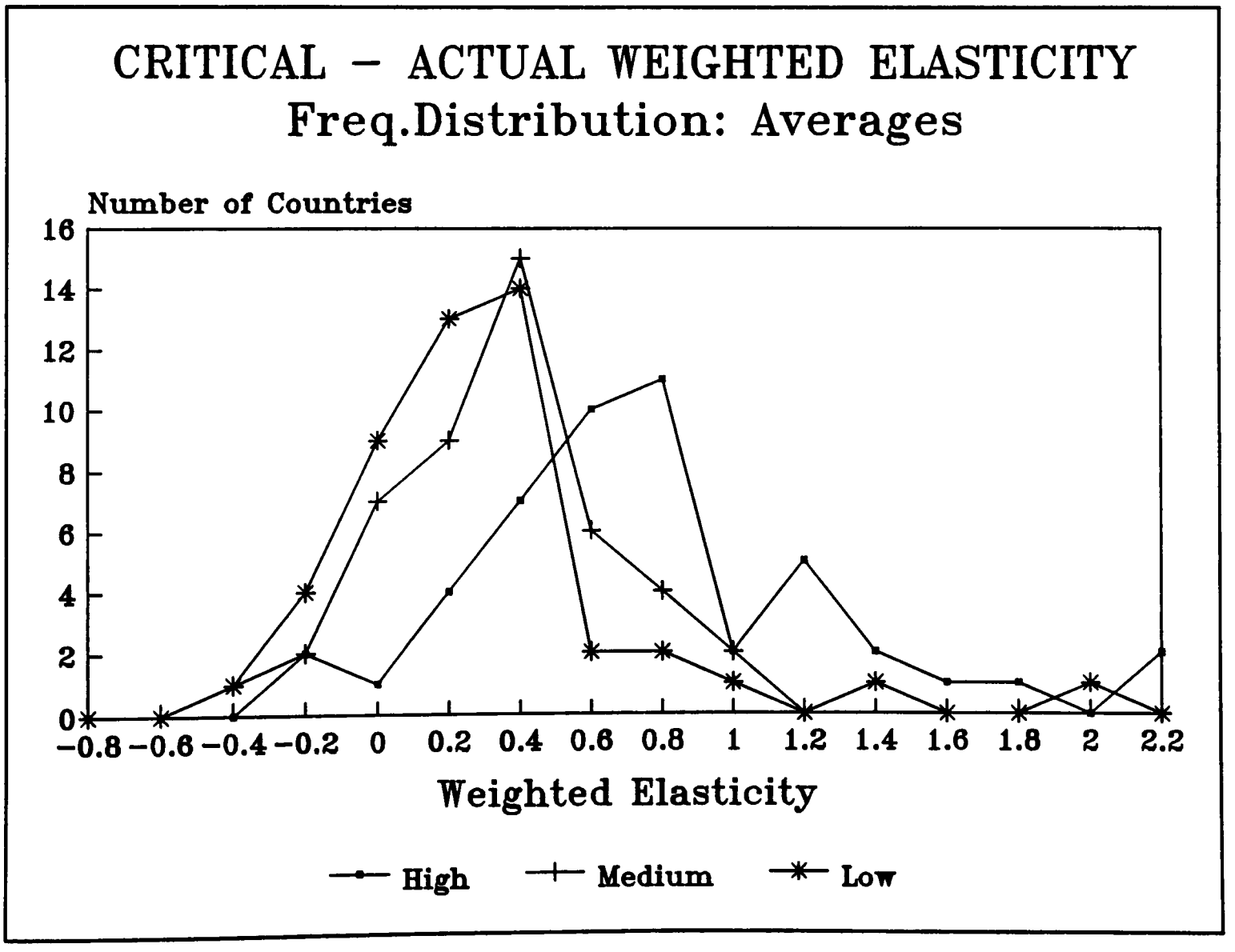
Figure 6.4.6



This figure shows very clearly that the critical elasticities for many countries are not particularly large, most being 0.5 or less for the Medium and Low variants and less than 1 for

the High which is mostly within the range suggested by the micro evidence in Bond (1983). This raises the possibility that the recent reforms to producer pricing in many countries may lead to higher elasticities such that a large part if nor all of the costs of volatility are offset by the flexibility effect. Clearly this depends on both producer pricing being a main contributor to the low elasticities estimated (as opposed to cross effects from non-tradeables) and also the accuracy of Bond's figures in representing the potential degree of flexibility. The final results presented in this chapter show the extent of the increase required, firstly the average across all four cases in Figure 6.4.7.

Figure 6.4.7



This figure shows that for some countries a negative gap is

recorded (implying that they are benefitting from volatility already) while for the most of the rest an increase of 0.5 to 1 would be required. This range is also observable in the charts for each of the four cases below.

Figure 6.4.8

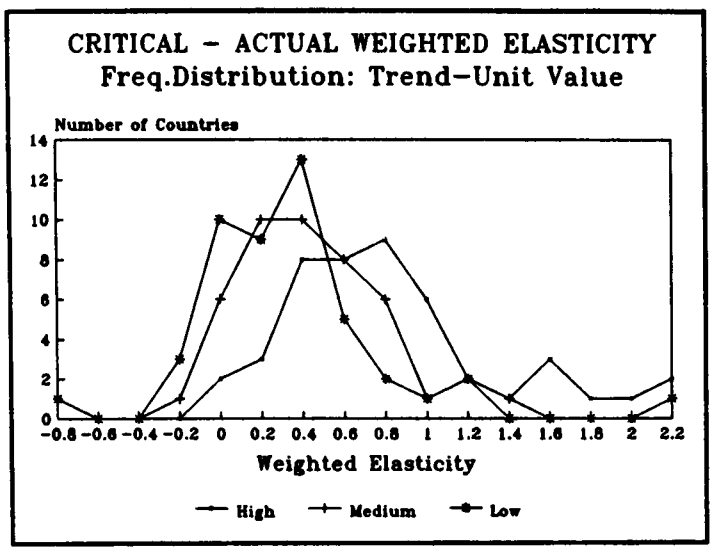


Figure 6.4.9

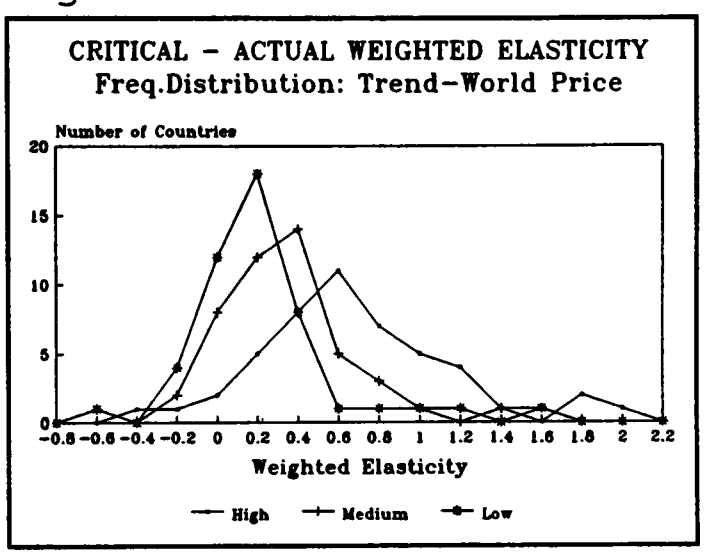


Figure 6.4.10

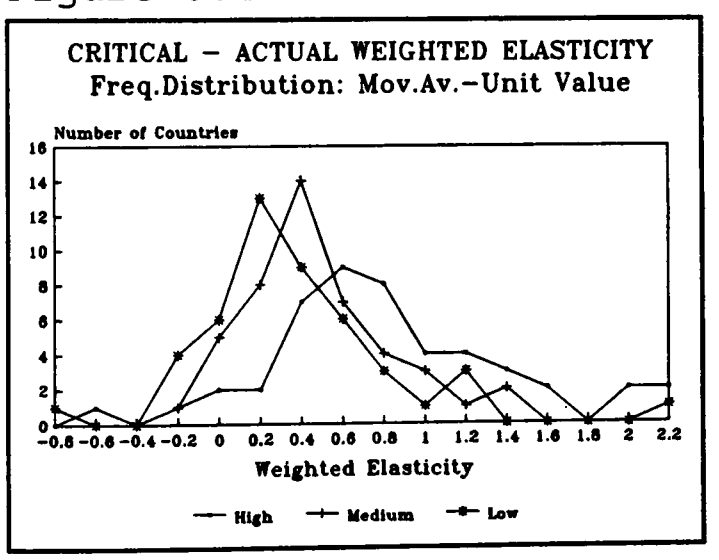
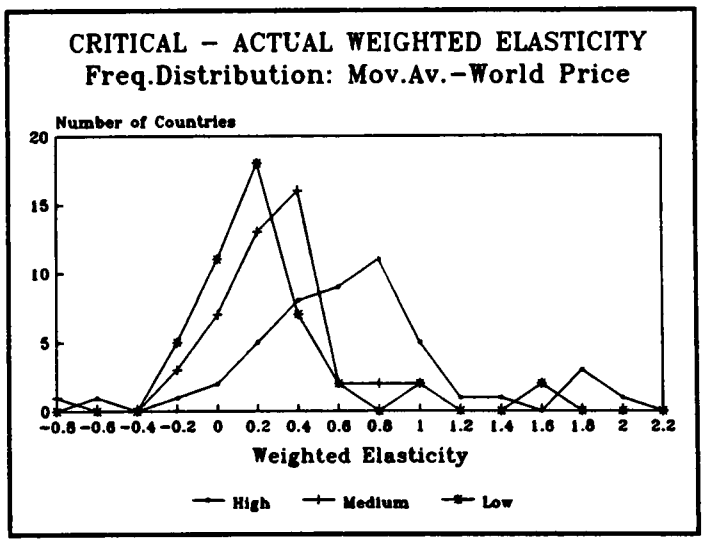


Figure 6.4.11



The results above have all been based on an arithmetic mean counterfactual which is arguably the most interesting case but following the discussion in the first chapter, Table V gives the same measures of the effects of volatility as Table IV but this time for a geometric mean counterfactual.

TABLE V NET BENEFIT/(COST) OF PRICE VOLATILITY WITH NO INSURANCE, GEOMETRIC MEAN COUNTERFACTUAL

		EQUIVALENT CHANGE IN NATIONAL INCOME					EQUIVALENT CHANGE IN COM.PRICE MEANS:					CRITICAL AVERAGE ELASTICITY:				
		TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:		
		UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE
SUB-SAHARAN AFRICA																
CAMEROON	H	0.1%	0.2%	0.1%	0.1%	0.1%	1.2%	1.6%	0.9%	1.2%	1.2%	-0.54	-0.50	-0.59	-0.55	-0.55
	M	0.2%	0.3%	0.2%	0.2%	0.2%	2.0%	2.7%	1.5%	1.9%	2.0%	-0.82	-0.80	-0.84	-0.82	-0.82
	L	0.2%	0.3%	0.2%	0.2%	0.2%	2.2%	3.0%	1.7%	2.2%	2.3%	-0.91	-0.90	-0.92	-0.92	-0.91
COTE D'IVOIRE	H	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.3%	0.2%	0.4%	0.2%	-0.19	-0.24	-0.27	-0.30	-0.25
	M	0.3%	0.4%	0.2%	0.3%	0.3%	1.3%	1.7%	1.0%	1.2%	1.3%	-0.67	-0.69	-0.70	-0.71	-0.69
	L	0.4%	0.5%	0.3%	0.3%	0.4%	1.8%	2.1%	1.2%	1.5%	1.7%	-0.84	-0.85	-0.85	-0.86	-0.85
ETHIOPIA	H	0.1%	0.1%	0.1%	0.1%	0.1%	1.0%	1.2%	1.0%	1.1%	1.1%	-0.54	-0.53	-0.54	-0.52	-0.53
	M	0.1%	0.1%	0.1%	0.1%	0.1%	1.8%	2.1%	1.7%	1.8%	1.9%	-0.83	-0.82	-0.83	-0.82	-0.83
	L	0.1%	0.1%	0.1%	0.1%	0.1%	2.1%	2.3%	2.0%	2.0%	2.1%	-0.93	-0.92	-0.93	-0.92	-0.93
GHANA	H	0.2%	0.1%	0.2%	0.1%	0.2%	1.8%	0.9%	1.7%	0.8%	1.3%	-0.48	-0.48	-0.48	-0.48	-0.48
	M	0.4%	0.2%	0.3%	0.1%	0.3%	4.1%	2.4%	3.5%	1.5%	2.9%	-0.79	-0.79	-0.79	-0.79	-0.79
	L	0.5%	0.3%	0.4%	0.2%	0.4%	4.9%	2.9%	4.1%	1.8%	3.4%	-0.90	-0.90	-0.90	-0.90	-0.90
KENYA	H	0.1%	0.1%	0.1%	0.1%	0.1%	2.1%	2.0%	1.6%	1.6%	1.8%	-0.68	-0.67	-0.64	-0.66	-0.66
	M	0.2%	0.2%	0.1%	0.1%	0.2%	2.5%	2.4%	2.1%	2.0%	2.3%	-0.87	-0.87	-0.86	-0.86	-0.87
	L	0.2%	0.2%	0.1%	0.1%	0.2%	2.7%	2.6%	2.2%	2.2%	2.4%	-0.94	-0.94	-0.93	-0.93	-0.94
LIBERIA	H	-0.2%	-0.1%	-0.2%	0.0%	-0.1%	-0.5%	-0.2%	-0.4%	0.0%	-0.3%	0.31	0.28	0.25	-0.02	0.21
	M	0.1%	0.2%	0.0%	0.1%	0.1%	0.2%	0.3%	0.1%	0.3%	0.2%	-0.45	-0.47	-0.48	-0.59	-0.50
	L	0.2%	0.2%	0.1%	0.2%	0.2%	0.4%	0.5%	0.3%	0.4%	0.4%	-0.72	-0.73	-0.73	-0.79	-0.74
MALAWI	H	0.3%	0.1%	0.2%	0.1%	0.2%	1.6%	0.9%	1.3%	0.8%	1.2%	-0.67	-0.56	-0.70	-0.65	-0.65
	M	0.3%	0.2%	0.3%	0.2%	0.3%	2.1%	1.3%	1.7%	1.1%	1.6%	-0.87	-0.83	-0.88	-0.86	-0.86
	L	0.4%	0.2%	0.3%	0.2%	0.3%	2.3%	1.4%	1.8%	1.2%	1.7%	-0.94	-0.92	-0.94	-0.93	-0.93
SENEGAL	H	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.2%	-0.7%	-0.7%	-0.4%	-0.49	-0.54	-0.57	-0.60	-0.55
	M	0.1%	0.1%	0.0%	0.0%	0.1%	0.9%	0.6%	-0.1%	-0.2%	0.3%	-0.80	-0.82	-0.83	-0.85	-0.83
	L	0.1%	0.1%	0.0%	0.0%	0.1%	1.2%	0.9%	0.1%	0.0%	0.6%	-0.91	-0.92	-0.92	-0.93	-0.92
SUDAN	H	0.0%	0.1%	-0.1%	0.1%	0.0%	-0.6%	1.1%	-0.8%	0.9%	0.1%	-0.61	-0.61	-0.61	-0.61	-0.61
	M	0.0%	0.1%	0.0%	0.1%	0.1%	-0.2%	1.3%	-0.4%	1.0%	0.4%	-0.84	-0.84	-0.84	-0.84	-0.84
	L	0.0%	0.1%	0.0%	0.1%	0.1%	-0.1%	1.3%	-0.3%	1.1%	0.5%	-0.92	-0.92	-0.92	-0.92	-0.92
TANZANIA	H	0.2%	0.2%	0.1%	0.1%	0.2%	2.5%	1.9%	1.7%	1.3%	1.9%	-0.80	-0.79	-0.82	-0.83	-0.81
	M	0.3%	0.2%	0.2%	0.1%	0.2%	2.9%	2.2%	1.9%	1.5%	2.1%	-0.92	-0.91	-0.93	-0.93	-0.92
	L	0.3%	0.2%	0.2%	0.1%	0.2%	3.1%	2.4%	2.0%	1.6%	2.3%	-0.96	-0.96	-0.96	-0.97	-0.96
TOGO	H	0.3%	0.3%	0.3%	0.3%	0.3%	2.3%	1.7%	2.0%	1.9%	2.0%	-0.66	-0.65	-0.75	-0.78	-0.71
	M	0.5%	0.4%	0.4%	0.4%	0.4%	3.2%	2.6%	2.6%	2.3%	2.7%	-0.86	-0.86	-0.90	-0.91	-0.88
	L	0.6%	0.4%	0.4%	0.4%	0.5%	3.6%	2.9%	2.8%	2.5%	3.0%	-0.93	-0.93	-0.95	-0.96	-0.94
UGANDA	H	0.1%	0.1%	0.1%	0.1%	0.1%	0.8%	0.8%	0.7%	0.7%	0.8%	-0.41	-0.41	-0.41	-0.41	-0.41
	M	0.2%	0.2%	0.2%	0.2%	0.2%	2.0%	1.9%	1.8%	1.5%	1.8%	-0.76	-0.76	-0.76	-0.76	-0.76
	L	0.3%	0.2%	0.2%	0.2%	0.2%	2.5%	2.2%	2.1%	1.8%	2.2%	-0.88	-0.88	-0.88	-0.88	-0.88
ZAIRE	H	0.0%	0.1%	0.0%	0.1%	0.1%	0.3%	0.8%	-0.1%	0.4%	0.4%	-0.21	-0.42	-0.20	-0.37	-0.30
	M	0.5%	0.3%	0.4%	0.2%	0.4%	2.7%	1.7%	2.2%	1.1%	1.9%	-0.69	-0.77	-0.68	-0.75	-0.72
	L	0.6%	0.3%	0.5%	0.2%	0.4%	3.5%	1.9%	2.9%	1.3%	2.4%	-0.85	-0.89	-0.84	-0.88	-0.87
ZAMBIA	H	-1.7%	-1.7%	-0.6%	-0.6%	-1.2%	-4.2%	-4.2%	-1.5%	-1.4%	-2.8%	1.11	1.11	1.11	1.11	1.11
	M	0.1%	0.2%	0.0%	0.1%	0.1%	0.3%	0.5%	0.1%	0.3%	0.3%	-0.12	-0.12	-0.12	-0.12	-0.12
	L	0.6%	0.9%	0.3%	0.3%	0.6%	1.9%	2.2%	0.6%	0.8%	1.4%	-0.55	-0.55	-0.55	-0.55	-0.55
NORTH AFRICA/INDIAN OCEAN:																
EGYPT	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	0.1%	-0.4%	0.2%	-0.1%	-0.22	-0.22	-0.22	-0.22	-0.22
	M	0.1%	0.0%	0.0%	0.0%	0.0%	1.8%	0.6%	0.0%	0.6%	0.8%	-0.73	-0.73	-0.73	-0.73	-0.73
	L	0.1%	0.0%	0.0%	0.0%	0.0%	2.4%	0.7%	0.2%	0.7%	1.0%	-0.90	-0.90	-0.90	-0.90	-0.90
MADAGASCAR	H	0.1%	0.1%	0.0%	0.0%	0.1%	1.0%	1.2%	0.5%	0.6%	0.8%	-0.68	-0.70	-0.66	-0.67	-0.68
	M	0.1%	0.1%	0.1%	0.1%	0.1%	1.4%	1.7%	0.9%	1.0%	1.3%	-0.88	-0.88	-0.87	-0.87	-0.88
	L	0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	1.8%	1.0%	1.1%	1.4%	-0.94	-0.95	-0.94	-0.94	-0.94
MAURITANIA	H	-0.5%	0.0%	-0.3%	0.1%	-0.2%	-1.4%	0.1%	-0.9%	0.3%	-0.5%	-0.03	-0.28	-0.03	-0.36	-0.18
	M	-0.2%	0.1%	-0.1%	0.2%	0.0%	-0.5%	0.4%	-0.4%	0.6%	0.0%	-0.61	-0.71	-0.60	-0.74	-0.67
	L	-0.1%	0.2%	-0.1%	0.2%	0.1%	-0.2%	0.5%	-0.2%	0.7%	0.2%	-0.81	-0.86	-0.80	-0.87	-0.84
MAURITIUS	H	-0.7%	-0.5%	-0.3%	-0.4%	-0.5%	-2.6%	-1.9%	-1.1%	-1.6%	-1.8%	0.80	0.80	0.80	0.80	0.80
	M	0.2%	0.3%	0.0%	0.2%	0.2%	0.7%	1.1%	0.1%	0.7%	0.7%	-0.30	-0.30	-0.30	-0.30	-0.30
	L	0.5%	0.6%	0.1%	0.4%	0.4%	1.8%	2.1%	0.5%	1.5%	1.5%	-0.67	-0.67	-0.67	-0.67	-0.67
MOROCCO	H	0.1%	0.1%	0.1%	0.1%	0.1%	2.9%	2.0%	2.0%	1.8%	2.2%	-0.76	-0.76	-0.76	-0.76	-0.76
	M	0.1%	0.1%	0.1%	0.1%	0.1%	3.4%	2.3%	2.4%	2.2%	2.6%	-0.91	-0.91	-0.91	-0.91	-0.91
	L	0.1%	0.1%	0.1%	0.1%	0.1%	3.6%	2.5%	2.6%	2.3%	2.8%	-0.95	-0.95	-0.95	-0.95	-0.95
SOUTH AMERICA																
ARGENTINA	H	0.0%	0.1%	0.0%	0.0%	0.0%	0.6%	1.7%	0.6%	1.3%	1.1%	-0.70	-0.68	-0.77	-0.74	-0.72
	M	0.0%	0.1%	0.0%	0.1%	0.1%	1.0%	2.2%	0.8%	1.6%	1.4%	-0.89	-0.89	-0.92	-0.91	-0.90
	L	0.0%	0.1%	0.0%	0.1%	0.1%	1.1%	2.3%	0.8%	1.6%	1.5%	-0.96	-0.96	-0.97	-0.96	-0.96
BOLIVIA	H	0.1%	0.1%	0.0%	0.1%	0.1%	0.8%	0.8%	0.6%	0.6%	0.7%	-0.52	-0.52	-0.52	-0.52	-0.52
	M	0.1%	0.1%	0.1%	0.1%	0.1%	1.1%	1.2%	0.8%	0.9%	1.0%	-0.81	-0.81	-0.81	-0.81	-0.81
	L	0.1%	0.1%	0.1%	0.1%	0.1%	1.3%	1.3%	0.9%	0.9%	1.1%	-0.90	-0.90	-0.90	-0.90	-0.90
BRAZIL	H		0.0%		0.0%	0.0%		1.3%		1.1%	1.2%		-0.85		-0.85	-0.85
	M		0.0%		0.0%	0.0%		1.6%		1.3%	1.5%		-0.95		-0.95	-0.95
	L		0.0%		0.0%	0.0%		1.7%		1.4%	1.6%		-0.98		-0.98	-0.98
CHILE	H	0.2%	0.2%	0.0%	0.0%	0.1%	1.5%	1.9%	0.3%	0.4%	1.0%	-0.38	-0.38	-0.38	-0.38	-0.38
	M	0.3%	0.4%	0.1%	0.1%	0.2%	3.4%	4.2%	0.7%	1.0%	2.3%	-0.76	-0.76	-0.76	-0.76	-0.76
	L	0.4%	0.5%	0.1%	0.1%	0.3%	4.0%	4.9%	0.9%	1.2%	2.8%	-0.88	-0.88	-0.88	-0.88	-0.88

TABLE V NET BENEFIT/(COST) OF PRICE VOLATILITY WITH NO INSURANCE, GEOMETRIC MEAN COUNTERFACTUAL

		EQUIVALENT CHANGE IN NATIONAL INCOME					EQUIVALENT CHANGE IN COM.PRICE MEANS:					CRITICAL AVERAGE ELASTICITY:				
		TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:		
		UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE
COLUMBIA	H	0.1%	0.1%	0.1%	0.1%	0.1%	1.5%	1.5%	1.1%	1.0%	1.3%	-0.58	-0.58	-0.58	-0.58	-0.58
	M	0.1%	0.1%	0.1%	0.1%	0.1%	2.3%	2.3%	1.9%	1.6%	2.0%	-0.84	-0.84	-0.84	-0.84	-0.84
	L	0.2%	0.2%	0.1%	0.1%	0.2%	2.6%	2.6%	2.1%	1.9%	2.3%	-0.92	-0.92	-0.92	-0.92	-0.92
ECUADOR	H	0.1%	0.1%	0.1%	0.0%	0.1%	1.9%	1.1%	1.0%	0.7%	1.2%	-0.56	-0.65	-0.57	-0.64	-0.61
	M	0.2%	0.1%	0.1%	0.1%	0.1%	2.6%	1.4%	1.4%	0.9%	1.6%	-0.84	-0.87	-0.84	-0.86	-0.85
	L	0.2%	0.1%	0.1%	0.1%	0.1%	2.9%	1.5%	1.5%	1.0%	1.7%	-0.93	-0.94	-0.93	-0.94	-0.94
PARAGUAY	H	0.1%	0.0%	0.0%	0.0%	0.0%	3.2%	0.6%	2.4%	0.6%	1.7%	-0.88	-0.88	-0.88	-0.88	-0.88
	M	0.1%	0.0%	0.0%	0.0%	0.0%	3.4%	0.7%	2.5%	0.7%	1.8%	-0.95	-0.95	-0.95	-0.95	-0.95
	L	0.1%	0.0%	0.0%	0.0%	0.0%	3.4%	0.7%	2.6%	0.7%	1.9%	-0.98	-0.98	-0.98	-0.98	-0.98
PERU	H	0.1%	0.1%	0.0%	0.0%	0.1%	4.1%	4.6%	1.2%	1.4%	2.8%	-0.81	-0.81	-0.81	-0.81	-0.81
	M	0.1%	0.2%	0.0%	0.0%	0.1%	4.8%	5.3%	1.4%	1.5%	3.3%	-0.93	-0.93	-0.93	-0.93	-0.93
	L	0.1%	0.2%	0.0%	0.0%	0.1%	5.0%	5.5%	1.5%	1.6%	3.4%	-0.96	-0.96	-0.96	-0.96	-0.96
URUGUAY	H	0.0%	0.1%	0.0%	0.0%	0.0%	0.5%	1.2%	-0.1%	0.3%	0.5%	-0.66	-0.61	-0.66	-0.61	-0.64
	M	0.1%	0.1%	0.0%	0.0%	0.1%	1.1%	2.0%	0.4%	0.7%	1.1%	-0.87	-0.85	-0.87	-0.85	-0.86
	L	0.1%	0.1%	0.0%	0.1%	0.1%	1.3%	2.2%	0.5%	0.9%	1.2%	-0.94	-0.93	-0.94	-0.93	-0.94
CENTRAL AMERICA																
COSTA RICA	H	0.1%	0.1%	0.0%	0.0%	0.1%	0.4%	0.4%	0.1%	0.0%	0.2%	-0.39	-0.32	-0.31	-0.23	-0.31
	M	0.2%	0.2%	0.1%	0.1%	0.2%	1.4%	1.3%	0.9%	0.8%	1.1%	-0.77	-0.75	-0.74	-0.71	-0.74
	L	0.3%	0.2%	0.2%	0.2%	0.2%	1.8%	1.7%	1.2%	1.0%	1.4%	-0.90	-0.89	-0.89	-0.87	-0.89
EL SLAVADOR	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.2%	-0.3%	0.0%	-0.1%	-0.13	-0.15	-0.14	-0.15	-0.14
	M	0.2%	0.3%	0.1%	0.2%	0.2%	1.5%	1.7%	0.9%	1.2%	1.3%	-0.66	-0.67	-0.66	-0.67	-0.67
	L	0.3%	0.3%	0.2%	0.2%	0.3%	2.0%	2.2%	1.3%	1.5%	1.8%	-0.84	-0.84	-0.84	-0.84	-0.84
GUATEMALA	H	0.1%	0.1%	0.1%	0.1%	0.1%	1.8%	1.9%	1.4%	1.4%	1.6%	-0.69	-0.68	-0.70	-0.72	-0.70
	M	0.2%	0.2%	0.1%	0.1%	0.2%	2.4%	2.4%	1.8%	1.8%	2.1%	-0.88	-0.88	-0.89	-0.89	-0.89
	L	0.2%	0.2%	0.2%	0.2%	0.2%	2.6%	2.6%	1.9%	1.9%	2.3%	-0.95	-0.94	-0.95	-0.95	-0.95
HONDURAS	H	0.2%	0.1%	0.1%	0.1%	0.1%	1.1%	0.8%	0.4%	0.4%	0.7%	-0.53	-0.40	-0.44	-0.35	-0.43
	M	0.2%	0.2%	0.1%	0.1%	0.2%	1.7%	1.4%	0.9%	0.8%	1.2%	-0.82	-0.77	-0.79	-0.75	-0.78
	L	0.3%	0.2%	0.1%	0.1%	0.2%	1.9%	1.6%	1.0%	1.0%	1.4%	-0.92	-0.89	-0.90	-0.89	-0.90
NICARAGUA	H	0.1%	0.2%	0.1%	0.1%	0.1%	1.3%	1.5%	1.0%	1.1%	1.2%	-0.55	-0.55	-0.51	-0.55	-0.54
	M	0.2%	0.2%	0.2%	0.2%	0.2%	1.8%	2.1%	1.5%	1.6%	1.8%	-0.82	-0.82	-0.81	-0.82	-0.82
	L	0.2%	0.2%	0.2%	0.2%	0.2%	2.0%	2.3%	1.6%	1.7%	1.9%	-0.91	-0.91	-0.91	-0.91	-0.91
PANAMA	H	0.1%	0.1%	0.1%	0.0%	0.1%	2.0%	1.0%	1 0%	0.7%	1.2%	-0.69	-0.75	-0.87	-0.84	-0.79
	M	0.1%	0.1%	0.1%	0.0%	0.1%	2.5%	1.1%	1.0%	0.7%	1.3%	-0.88	-0.91	-0.95	-0.94	-0.92
	L	0.1%	0.1%	0.1%	0.0%	0.1%	2.6%	1.2%	1.1%	0.8%	1.4%	-0.95	-0.96	-0.98	-0.97	-0.97
CARIBBEAN																
BARBADOS	H	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-0.7%	-0.3%	-0.5%	0.0%	-0.4%	-0.14	-0.14	-0.14	-0.14	-0.14
	M	0.1%	0.1%	0.1%	0.1%	0.1%	0.8%	0.9%	0.7%	1.0%	0.9%	-0.67	-0.67	-0.67	-0.67	-0.67
	L	0.2%	0.2%	0.1%	0.2%	0.2%	1.3%	1.3%	1.1%	1.4%	1.3%	-0.84	-0.84	-0.84	-0.84	-0.84
DOMINICAN R.	H	0.1%	0.1%	0.1%	0.0%	0.1%	1.1%	0.9%	0.9%	0.6%	0.9%	-0.51	-0.51	-0.51	-0.51	-0.51
	M	0.1%	0.1%	0.1%	0.1%	0.1%	2.2%	1.7%	1.7%	1.2%	1.7%	-0.81	-0.81	-0.81	-0.81	-0.81
	L	0.2%	0.1%	0.1%	0.1%	0.1%	2.6%	1.9%	2.0%	1.4%	2.0%	-0.91	-0.91	-0.91	-0.91	-0.91
GUYANA	H	-0.5%	-0.2%	-0.1%	0.1%	-0.2%	-1.2%	-0.4%	-0.3%	0.2%	-0.4%	0.37	0.11	0.07	-0.19	0.09
	M	0.3%	0.4%	0.2%	0.3%	0.3%	0.7%	0.9%	0.5%	0.8%	0.7%	-0.47	-0.57	-0.58	-0.69	-0.58
	L	0.5%	0.6%	0.3%	0.4%	0.5%	1.3%	1.4%	0.7%	1.0%	1.1%	-0.74	-0.80	-0 80	-0.85	-0.80
JAMAICA	H	0.1%	0.2%	0.0%	0.1%	0.1%	0.8%	0.9%	0.3%	0.4%	0.6%	-0.54	-0.67	-0.49	-0.66	-0.59
	M	0.2%	0.2%	0.1%	0.1%	0.2%	1.2%	1.2%	0.5%	0.6%	0.9%	-0.82	-0.87	-0.80	-0.87	-0.84
	L	0.2%	0.2%	0.1%	0.1%	0.2%	1.3%	1.3%	0.6%	0.7%	1.0%	-0.91	-0.94	-0.90	-0.94	-0.92
TRINIDAD & T.	H	0.0%	0.1%	0.0%	0.0%	0.0%	0.3%	2.3%	0.6%	1.2%	1.1%	-0.83	-0.83	-0.83	-0.83	-0.83
	M	0.0%	0.1%	0.0%	0.0%	0.0%	0.6%	2.6%	0.9%	1.4%	1.4%	-0.94	-0.94	-0.94	-0.94	-0.94
	L	0.0%	0.1%	0.0%	0.0%	0.0%	0.7%	2.6%	1.0%	1.4%	1.4%	-0.97	-0.97	-0.97	-0.97	-0.97
SOUTH ASIA																
BURMA	H	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-1.3%	-1.4%	-1.0%	-1.0%	-1.2%	-0.65	-0.66	-0.65	-0.65	-0.65
	M	0.0%	-0.1%	0.0%	0.0%	-0.0%	-0.7%	-1.0%	-0.5%	-7.0%	-2.3%	-0.87	-0.87	-0.87	-0.87	-0.87
	L	0.0%	-0.1%	0.0%	0.0%	-0.0%	-0.5%	-0.9%	-0.3%	-7.0%	-2.2%	-0.94	-0.94	-0.94	-0.94	-0.94
PAKISTAN	H	0.0%	0.0%	0.0%	0.0%	0.0%	-2.2%	-0.5%	-2.2%	-0.5%	-1.4%	-0.78	-0.78	-0.78	-0.78	-0.78
	M	0.0%	0.0%	0.0%	0.0%	0.0%	-2.0%	-0.3%	-2.0%	-0.4%	-1.2%	-0.92	-0.92	-0.92	-0.92	-0.92
	L	0.0%	0.0%	0.0%	0.0%	0.0%	-2.0%	-0.3%	-2.0%	-0.4%	-1.2%	-0.97	-0.97	-0.97	-0.97	-0.97
SRI LANKA	H	0.0%	0.1%	0.0%	0.1%	0.1%	0.3%	0.4%	0.3%	0.4%	0.4%	-0.45	-0.46	-0.43	-0.45	-0.45
	M	0.1%	0.1%	0.1%	0.1%	0.1%	0.9%	1.0%	0.9%	1.0%	1.0%	-0.79	-0.79	-0.78	-0.78	-0.79
	L	0.1%	0.2%	0.2%	0.2%	0.2%	1.0%	1.1%	1.1%	1.2%	1.1%	-0.90	-0.90	-0.89	-0.90	-0.90
SOUTH EAST ASIA/PACIFIC																
FIJI	H	-0.1%	0.0%	0.0%	0.0%	-0.0%	-0.5%	-0.3%	-0.1%	0.0%	-0.2%	-0.05	-0.05	-0.05	-0.05	-0.05
	M	0.1%	0.2%	0.1%	0.2%	0.2%	0.9%	1.3%	0.5%	1.2%	1.0%	-0.63	-0.63	-0.63	-0.63	-0.63
	L	0.2%	0.3%	0.1%	0.2%	0.2%	1.4%	1.8%	0.7%	1.6%	1.4%	-0.82	-0.82	-0.82	-0.82	-0.82
INDONESIA	H	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	1.3%	1.2%	1.5%	1.4%	-0.91	-0.91	-0.91	-0.91	-0.91
	M	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	1.4%	1.2%	1.5%	1.4%	-0.96	-0.96	-0.96	-0.96	-0.96
	L	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	1.4%	1.3%	1.6%	1.5%	-0.98	-0.98	-0.98	-0.98	-0.98
MALAYSIA	H	0.1%	0.1%	0.1%	0.0%	0.1%	0.4%	0.3%	0.3%	0.2%	0.3%	-0.28	-0.19	-0.22	-0.13	-0.21
	M	0.2%	0.2%	0.2%	0.2%	0.2%	1.0%	0.9%	0.8%	0.8%	0.9%	-0.72	-0.68	-0.69	-0.66	-0.69
	L	0.2%	0.2%	0.2%	0.2%	0.2%	1.2%	1.1%	1.0%	1.0%	1.1%	-0.86	-0.84	-0.85	-0.83	-0.85

TABLE V NET BENEFIT/(COST) OF PRICE VOLATILITY WITH NO INSURANCE, GEOMETRIC MEAN COUNTERFACTUAL

		EQUIVALENT CHANGE IN NATIONAL INCOME					EQUIVALENT CHANGE IN COM.PRICE MEANS:					CRITICAL AVERAGE ELASTICITY:				
		TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:			TIME TREND:		MOVING AVERAGE:		
		UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE	UNIT VALUE	WORLD PRICES	UNIT VALUE	WORLD PRICES	AVERAGE
PHILIPPINES	H	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.1%	0.8%	0.3%	0.5%	-0.84	-0.77	-0.86	-0.76	-0.81
	M	0.0%	0.0%	0.1%	0.0%	0.0%	1.1%	0.5%	1.1%	0.8%	0.9%	-0.94	-0.91	-0.95	-0.91	-0.93
	L	0.1%	0.0%	0.1%	0.0%	0.1%	1.2%	0.6%	1.2%	1.0%	1.0%	-0.97	-0.96	-0.97	-0.96	-0.97
SINGAPORE	H	0.1%	0.1%	0.0%	0.0%	0.1%	0.3%	0.4%	0.2%	0.3%	0.3%	0.03	0.03	0.03	0.03	0.03
	M	0.2%	0.2%	0.1%	0.2%	0.2%	1.0%	1.0%	0.9%	1.0%	1.0%	-0.60	-0.60	-0.60	-0.60	-0.60
	L	0.2%	0.2%	0.2%	0.2%	0.2%	1.2%	1.3%	1.1%	1.2%	1.2%	-0.81	-0.81	-0.81	-0.81	-0.81
THAILAND	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.3%	-0.4%	-0.2%	-0.3%	-0.3%	-0.89	-0.69	-0.69	-0.69	-0.69
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	-0.1%	0.1%	-0.88	-0.88	-0.88	-0.88	-0.88
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.1%	0.4%	0.0%	0.3%	-0.95	-0.95	-0.95	-0.95	-0.95
OECD																
AUSTRALIA	H	0.1%	0.1%	0.1%	0.1%	0.1%	1.3%	1.2%	1.2%	1.0%	1.2%	-0.92	-0.86	-0.92	-0.87	-0.89
	M	0.1%	0.1%	0.1%	0.1%	0.1%	1.4%	1.3%	1.2%	1.1%	1.3%	-0.97	-0.95	-0.97	-0.95	-0.96
	L	0.1%	0.1%	0.1%	0.1%	0.1%	1.4%	1.4%	1.3%	1.2%	1.3%	-0.99	-0.98	-0.99	-0.98	-0.99
CANADA	H	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.6%	0.4%	0.5%	0.5%	-0.91	-0.90	-0.92	-0.93	-0.92
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.7%	0.4%	0.5%	0.6%	-0.97	-0.96	-0.97	-0.97	-0.97
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.7%	0.4%	0.5%	0.6%	-0.98	-0.98	-0.99	-0.99	-0.99
FINLAND	H	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%	-0.65	-0.77	-0.68	-0.73	-0.71
	M	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	-0.86	-0.91	-0.87	-0.89	-0.88
	L	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	-0.93	-0.96	-0.94	-0.95	-0.95
NEW ZEALAND	H	0.1%	0.1%	0.0%	0.1%	0.1%	0.8%	0.7%	0.4%	0.6%	0.6%	-0.62	-0.54	-0.50	-0.53	-0.55
	M	0.1%	0.1%	0.1%	0.1%	0.1%	1.2%	1.2%	0.8%	0.9%	1.0%	-0.86	-0.82	-0.81	-0.82	-0.83
	L	0.1%	0.2%	0.1%	0.1%	0.1%	1.3%	1.4%	0.9%	1.0%	1.2%	-0.93	-0.92	-0.91	-0.92	-0.92
NORWAY	H	0.0%	0.1%	0.0%	0.0%	0.0%	0.4%	1.3%	0.2%	1.0%	0.7%	-0.86	-0.84	-0.91	-0.87	-0.87
	M	0.0%	0.1%	0.0%	0.1%	0.1%	0.4%	1.5%	0.2%	1.1%	0.8%	-0.95	-0.94	-0.97	-0.95	-0.95
	L	0.0%	0.1%	0.0%	0.1%	0.1%	0.5%	1.5%	0.2%	1.1%	0.8%	-0.98	-0.97	-0.98	-0.98	-0.98

It should be noted that these results will very slightly overstate either the benefits or the costs from volatility compared with a geometric mean counterfactual since strictly speaking they should be derived using the value of γ_i evaluated at the geometric mean rather than the arithmetic mean calculated earlier. Hence each figure will be a little too large in absolute value though the difference is likely to be small. In addition the overall change from the earlier figures involves a switch of sign from negative to positive which will be correct.

Comparing Table V with Table IV it is clear that the change in counterfactual makes a substantial difference to the results with almost all countries shown to be benefitting from volatility and having negative critical elasticities. As discussed in Chapter 1 the difference between the results has little economic content, being solely a reflection of the geometric mean being below the arithmetic mean and hence inherently less attractive as a stable alternative to price volatility. That having been said the difference is large and serves as a reminder that changes to the mean of commodity prices that may occur if attempts are made to stabilise them may be highly significant.

CHAPTER 7

CONCLUSION

The volatility of commodity prices has long been a subject of concern to economists, particularly with respect to the position of developing country commodity exporters. They tend to have undiversified export structures and low levels of income. Much of the most recent literature in this area directly addressed the question of the stabilisation of world commodity markets, being focused on the global market and microeconomic producer level. While this work has generated a great deal of useful material, at a practical level there is little prospect of coordinated international action to establish buffer stocks where none exist at present and all but one of the international commodity agreements that did exist have collapsed. This suggests that commodity price volatility is increasingly a problem to be faced at the national level. In addition the issue is sharpened by the fact that following structural adjustment programmes many countries no longer stabilise producer prices. One result is that the private sector is much more exposed to price risks than before. Many developing countries have implemented this reform reluctantly but the thesis demonstrates that removing producer price controls may give rise to substantial benefits. It was shown that production flexibility in response to world prices is highly beneficial and these benefits are sacrificed under price controls or stabilisation.

Against this background the starting point for the thesis was the literature of the 1970s which analysed the effects of volatility at the country level. The scope of the thesis arose from the deficiencies of this literature while fully recognising the value of what had been done as a base for further research. The literature used very simplified models focused on terms of trade volatility rather than volatility in individual tradeables prices. It made no allowance for the presence of non-tradeables or the possibility of a country facing several volatile prices, and did not analyse the effect of insurance or systematically incorporate the resource allocation effects of volatility. In addition there has been no previous empirical work estimating the costs and benefits of price volatility at the national level rather than those for individual producers.

Theory

Following a survey of the literature, Chapter 1 discussed the choice of an appropriate counterfactual with which to compare outcomes under volatility with a stable alternative. It was argued that dropping the use of the terms of trade concept and modelling individual tradeables prices directly undermined the case for a geometric mean counterfactual. This had been used in some papers in order to avoid numeraire dependence in the terms of trade. As a result greater attention was paid to the simpler case of an arithmetic mean counterfactual while recognising that our understanding of commodity price

determination means that any counterfactual chosen can only be an approximation to the true one, the difficulty being that establishing the value of the latter would require a complete understanding of the stochastic factors at work in commodity markets. Against this background the arithmetic mean counterfactual is compelling for its simplicity and it was shown that results based on it may be used to make comparisons with any other counterfactual that might be proposed.

The chapter also discussed the methodology to be followed when confronted with non-stationary relative price series, arguing that price volatility is regarded as a stationary concept and hence any long run trends should be included in the definition of the counterfactual, leaving the volatile component as the residual or deviations of the actual series from the counterfactual. Our comparative ignorance of the determination of commodity prices, and even their time series properties, makes the removal of the non-stationary component a somewhat arbitrary exercise but fortunately the empirical results of Chapter 6 were not too sensitive to the differences between the two methods used. From the point of view of the theory this did not present a problem since we could assume that the long run trends had been removed and consider only the volatile component.

The chapter also explored the methodology to be used in analysing the effects of the stationary, volatile component and contrasted the standard Taylor series approach, which

focuses on the second derivative of the function of interest with respect to the volatile price, and a broader approach that takes into account possible shifts in those functions as a result of volatility. A possible cause of such a shift is a change in the allocation of fixed factors between sectors compared with the stable case.

Assuming for the time being that the allocation of fixed factors is invariant to volatility, Chapters 2 to 4 presented the heart of the analysis of the effects of price volatility on national income and welfare. Chapter 2 assumed that the economy had no access to risk or capital markets and found, following Eaton (1979) for the two good case, that output and consumption flexibility could result in a benefit from price volatility. These were pure price effects with gains arising from the convexity of the indirect utility function on the consumption side and the convexity of the revenue function on the production side. When considering the behaviour of expected national income under price volatility, only the flexibility of output is important but when considering welfare both come into play and are combined in the price response of exports to price fluctuations.

The possible benefits from flexibility arise from pure price responses but changes in export prices have strong income effects on the exporting country and these were seen to be the source of costs from volatility. The simplest of these is the direct cost to welfare from variable income if preferences are

risk averse. In the two good case without non-tradeables there is a second effect that results from a rise in an export price (with a symmetric argument for a fall) increasing national income which in turn raises consumption of the good with a volatile price if it is normal. This effect gives rise to a cost from volatility because it leads to extra consumption of this good at times when its price is high and reduced consumption of it when its price is low. This income effect will tend to offset the beneficial pure price effect which works in the opposite direction with consumers substituting away from the good when its price increases and into it when its price falls.

Chapter 3 showed that in this two good case, assuming that perfect international risk or capital markets were available, optimal insurance behaviour lead to the complete separation of the price and income effects with the economy able to retain the benefits of the former while avoiding the latter.

Including non-tradeables in the model changes the analysis in two ways. The first is that without insurance a rise in an export price will usually increase the price of non-tradeables which will in turn give rise to a harmful cross price effect on the output of the tradeable. Welfare is increasing in the extent to which the exports of this good increase when its price rises (and falls when its price falls). A simultaneous increase in non-tradeables prices will reduce this response by tending to attract resources into the non-tradeables sector.

It is quite possible for this effect to actually reduce the output of the tradeable good when its price increases. The cross price effect from the non-tradeables sector is familiar from the Dutch Disease literature, which considers one-off price changes, and shows that there is a dynamic equivalent under ongoing price volatility that is perhaps of rather greater significance for welfare.

The second implication of the presence of non-tradeables is that the separation of the effects of volatility into price and income effects becomes less clear. This is because changes in the price of non-tradeables are caused in part by income changes given that the non-tradeables price is endogenous. The distinction between the two in welfare terms is maintained, however, because the price effects arising from the change in the exogenous price remain beneficial (the own price responses) whereas those that come from the non-tradeables price (the cross price effects) are harmful and may be thought of as a further symptom of the income effects given that they are ultimately caused by them.

This discussion suggests that with non-tradeables in the model, optimal insurance behaviour will have both the income smoothing effect of the two good case and also a further efficiency effect in that the smoothing of income will dampen the endogenous fluctuations in the price of non-tradeables and hence reduce the damaging cross price effects that come from them.

Chapters 2 and 3 also extended the model to incorporate the possibility that an economy may face more than one volatile tradeable price. This is necessary because this is the case for many actual economies while also being of interest in itself. The principle conclusion of this work was that if these prices tended to covary positively they introduced further harmful cross price and income effects. The cross price effects operate on the production side by means of the sectors with volatile prices usually seeking to expand or contract at the same time if their prices tend to move together, thus reducing the response of any one of them compared with the case where all but one of these prices is stabilised. Symmetric consumption cross price effects are also present with simultaneous changes in several prices leading to a muted substitution response to any one of them. The income effects from volatility in several prices are also harmful if they move together since their income effects will reinforce each other, thus leading to greater fluctuations in income. In addition if we also include non-tradeables these income effects will further reduce the price response of output in the tradeables sectors since they will give rise to an exacerbated diversion of resources to the non-tradeables sector at times when the tradeables sectors ought to be expanding.

The discussion has been based on a comparison between a single volatile price and adding further goods with volatile prices, showing that positive covariances between them reduce the

ability of the economy to benefit from the volatility in any one of those prices. An alternative point of comparison would be the thought experiment by which a single sector with a volatile price was broken up into several sub-sectors, each with their own volatile price. If the latter move exactly together the sub-sectors would form a Hicksian aggregate and little would change but if their prices covary positively but imperfectly the separation of the single sector into several would be beneficial because the cross price effects between them would not be as strong as the cross price effects of their prices changing exactly in line. Hence multiple price volatility, for the usual case of positive covariances, may be thought of as something that limits the effectiveness of the response to any one of those prices or alternatively as a more diversified export structure than having the same amount of resources in a single sector.

The ideal situation with several commodity exports would be for their prices to covary negatively such that the individual prices would tend to move in opposite directions. In this situation having many volatile prices is beneficial against either of the points of comparison discussed above. With a negative relationship between the prices the cross price effects between them become beneficial with different sectors expanding or contracting at different times, each sector contributing to the flexibility of the others. In addition the presence of negative covariances implies that the income effects will tend to offset each other, in the limit allowing

the economy to benefit from the pure price effects while entirely smoothing national income and the costs that arise from its fluctuations. In this situation it might be said that the export structure is fully diversified in contrast to attempts to encourage non-commodity, stable price, activities. Unfortunately in practice, as shown in Chapter 6, the majority of countries have positive covariances between their volatile export prices.

A further point on the many volatile price case is that Chapter 3 showed that insurance decisions are separable between sectors if the economy may insure against fluctuations in any of the prices and hence no further considerations applied.

Chapters 2 and 3 emphasise the benefits of output flexibility, at least with regard to the own price supply responses if not always the cross price effects, and Chapter 4 goes on to analyse the determinants of this flexibility. As expected it was seen that flexibility is increasing in the extent of factor mobility between sectors once prices are known, with the degree of flexibility for a given extent of factor mobility depending on the characteristics of the technology in use.

The effects of technology on flexibility were analysed in some detail for the sector specific capital model. Arguably this is the most appropriate model for considering price volatility

given that commodity price fluctuations are neither long run nor very short run. In this model it was shown that, abstracting from the non-tradeables sector, a more flexible technology is beneficial in contributing to expected welfare. This is trivial where there is only one volatile price but it was shown that the result stands for the many volatile price case despite the existence of negative cross price effects between them that might be exacerbated by a more flexible technology. The result holds because while greater flexibility will increase the negative cross price effects it will also contribute to larger own price effects and, importantly, a large negative cross price effect on one sector will of itself imply a larger own price effect in the other sector.

Unfortunately once non-tradeables were included much less clear cut results were possible. It will be recalled that fluctuations in the output of the non-tradeables sector do not contribute to welfare in the same way as a positive response of tradeables output to their prices. In this situation a more flexible technology may contribute to large negative cross price effects from the non-tradeables sector without a corresponding gain from that sector absorbing resources.

The material discussed above was all developed on the basis that there had been no change in the allocation of fixed factors as a result of volatility and hence the effects of the latter may be assessed by considering the second derivatives

of income and welfare with respect to the volatile price or prices. Chapter 1 argued that, if the allocation does change as a result of volatility, it should be incorporated in our assessment of the effects of that volatility. Chapter 5 focuses on this area, finding that a change in the allocation of fixed factors between sectors may be optimal, by acting as a form of insurance in the absence of risk markets, or by contributing more to greater output flexibility than is lost by the distortion in factor allocation, or may alternatively be very harmful if there is a large distortion away from the static optimum without much benefit to flexibility.

With perfect international risk or capital markets available it was found that the only rationale for changing the allocation of fixed factors was as a contribution to flexibility, and that if a change could contribute to enhanced flexibility the decentralised allocation decisions of private agents would result in the social optimum.

If risk or capital markets are entirely absent, the possibility of greater flexibility remains in place but the representative agent would tend to seek a reduction in the output of the sector with a volatile price, essentially because it acts as a form of quasi-insurance by reducing the economy's exposure to risk, albeit at a cost in terms of the output distortion that results. With the same assumption of no risk markets it was seen that the actions of private agents would usually not correspond to the social optimum and as a

result this possibility must be seen as a potential source of significant costs from volatility.

Chapter 5 concluded by showing that the divergence between privately and socially optimal resource allocation is no longer present if a domestic risk market is introduced, even though a purely domestic insurance market cannot give rise to full insurance given that the economy is exposed to systemic risk. This suggests that the development of such markets are likely to have beneficial efficiency effects as well as their more usual income smoothing benefits.

Empirical Evidence

Chapter 5 concluded the theoretical work, Chapter 6 presenting results for some 53 countries estimated on the basis of the results from Chapter 2. The key finding from this work, taking the sample as a whole, was that in practice the majority of countries do not benefit from the flexibility effect described above with many of the estimated export supply elasticities being negative. Negative values imply a cost from flexibility given that they reveal perverse supply responses to price. It is possible that these perverse responses arise from the cross price effects from non-tradeables but it is also possible, and perhaps probable, that many of these estimated negative values are a result of producers not facing world prices for their output because of producer price stabilisation at the country level or active

export tax regimes. In these circumstances producers may respond flexibly to the prices that they face but overall the economy shows a poor response to world prices. The theory suggests that it is the latter that matters and hence to this extent producer price stabilisation or its equivalent on the tax side may have imposed significant costs on these economies. This possibility was supported by consideration of the microeconomic evidence which pointed towards positive, if not large, supply responses to price. The chapter concluded by showing that the supply elasticities required for the flexibility effect to offset the costs from volatility were modest and on the whole within the range the literature suggested was feasible.

Overview and Directions for Future Research

We conclude by discussing the possible implications of the thesis for policy in the commodity exporting countries together with the research required to support substantive recommendations. In line with the scope of the thesis we abstract from discussing how price volatility may affect investment and growth.

One area highlighted by the material above was the importance of the non-tradeables sector. It was shown that welfare is higher if the expenditure effect of a rise in income on the demand for non-tradeables is muted. While we regarded this as an exogenous taste parameter in the models, if a government is

introduced it would be interesting to consider the appropriate expenditure policies that it should follow in the presence of price volatility. These would comprise both the total level of government expenditure and its sectoral composition with the government's propensity to spend on non-tradeables a key variable. It is likely that government should pursue a contra-cyclical policy towards the non-tradeables sector to avoid the harmful cross price effects discussed above.

The area of greatest interest, however, is the limited flexibility of many countries shown by the empirical results. This may have already been the subject of the appropriate reform given the abolition of producer price stabilisation in many countries under structural adjustment programmes. In principle, countries should enjoy greater benefits or reduced costs from price volatility if their producers face world prices for their output rather than controlled prices.

It would be interesting to develop a formal model to test this conclusion in which case emphasis should be placed on the likely efficiency benefits of switching to world prices together with the greater price risk faced by producers themselves. It is possible that in the absence of appropriate risk markets the increase in risk may lead to production substitution away from those sectors, a distortion that would offset at least some of the benefits of enhanced flexibility. This possibility suggests that policies to promote the existence and proper functioning of domestic risk and capital

markets should go hand in hand with the abolition of producer prices so as to avoid the resource allocation problem. Such markets have a beneficial risk pooling role as well as their efficiency effect. Better access to international markets, particularly capital, futures and options markets is also desirable of course though there may be less that can be achieved by domestic policy alone in this case.

The importance of export flexibility also suggests a high return to proper modelling of the large country case which was largely ignored above. Attempts by large countries to take advantage of temporarily high prices may be frustrated to some extent by the endogeneity of the world price with respect to their output. It would be of interest, however, to model this situation formally in order to assess the benefits of flexibility for these countries also.

Finally, the thesis has not considered world commodity markets except as a source of price volatility for mostly small exporters. This approach strongly favours a change in emphasis in policy from regarding price volatility solely as a problem to thinking of it as part problem and part opportunity with high returns to those economies that become the most flexible. If the general abolition of producer pricing results in greater flexibility there are both the effects analysed above at the country level and an important implication for world markets. Greater flexibility implies that exports rise when prices rise and fall when prices fall

which in turn means that the extent of price fluctuations would be reduced. While it is most unlikely that prices would be stabilised completely, since that would require extremely large export supply elasticities, it is possible that this effect could confer a joint benefit to all the exporters of a commodity. Hence greater flexibility in individual countries will benefit them directly while also causing a positive non-pecuniary externality (of reduced risk) on the other countries.

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