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Measuring Welfare Changes from Commodity Price Stabilization in Small Open Economies

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and
Chris Jones

New formulas for calculating the welfare changes from commodity price stabilization are derived within a general equilibrium framework. A better option than storage or varying import levies may be to use financial instruments for hedging against risk.

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This paper — a product of the International Trade Division, International Economics Department — is part of a larger effort in the department to research commodity price risk management by developing countries. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Dawn Gustafson, room S7-044, extension 33714 (November 1992, 26 pages).

Coleman and Jones extend the widely used Newbery and Stiglitz (1981) approach to measuring welfare changes from commodity price stabilization to a general equilibrium setting. They derive the welfare changes in terms of net consumer and producer surplus, rather than in terms of producer income as in the Newbery and Stiglitz approach.

Coleman and Jones present formulas for measuring the welfare changes for domestic price stabilization achieved through profitable storage (as assumed by Newbery and Stiglitz) and for stabilization through a variable tariff scheme. These formulas differ significantly, so it is inappropriate to use the Newbery and Stiglitz formula to justify the use of domestic price controls such as a variable levy.

In recent years, governments in many developing countries have liberalized their trade policies in the pursuit of improved economic performance. But this has exposed their economies to variations in international prices and raised questions about the desirability of domestic price stabilization programs. A popular mechanism for this purpose is a variable import levy scheme.

Coleman and Jones' analysis confirms that domestic welfare is lower under trade policies that stabilize domestic prices, as such policies serve only to shift the price uncertainty from producers and consumers to the government budget — while incurring the social costs of the distortionary tariffs and subsidies.

Coleman and Jones focus on a comparison of the welfare effects of price stabilization under a variable tariff scheme and storage, but suggest a better option: to use financial instruments for hedging against commodity price risks. This requires that there be no capital controls — one of the main reasons private insurance is seldom undertaken in developing countries.

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Measuring Welfare Changes from Commodity Price Stabilization in Small Open Economies

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1. Introduction[1]

Many governments in small open economies use trade policies to reduce the variance in their real domestic incomes caused by the variability of world prices. They typically use variable taxes and subsidies to stabilize the domestic prices of traded commodities; buffer stock schemes are not used because the countries are two small for their efforts to affect world prices. For example, the governments of Brazil, Ethiopia, Papua New Guinea and Venezuela apply variable tariff schemes to a number of imported grain products.

In this paper we use an approach popularized by Newbery and Stiglitz (1981) to measure the welfare effects of a mean-preserving reduction in the domestic price variability of an imported commodity in a small open economy. We compare the welfare effects of domestic trade policies (specifically, a variable tariff scheme) and profitable storage such as that which could be carried out under an international commodity agreement[2],[3]. A variable tariff scheme uses tariffs and subsidies on imports to insulate the domestic price from world price variability, while storage stabilizes the world price. Our key results are summarized as follows:

(i) Trade policies provide no *aggregate risk benefits*, i.e., they do not reduce the variance in domestic surplus (combined consumer, producer and government surplus); profitable storage does, however, because it eliminates world price uncertainty.

(ii) Trade policies and profitable storage both reduce the mean value of domestic surplus.

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[1]We are indebted to Ron Duncan, George Fane, Mark Harrison, Ngo Van Long, Vikram Nehru and Ted Sieper for their helpful comments and suggestions.

[2]Profitable storage means that the difference in the commodity price between two points in time must be more than sufficient to cover storage costs.

[3]The comparison of domestic trade policies with storage is made only for its analytical implications. The storage case refers to exogenous price stabilization and is compared with a variable tariff scheme where stabilization is undertaken domestically.

These results are consistent with those obtained by Dixit (1987a, 1987b,1989) who examines the use of trade policies under three different circumstances accounting for the lack of private insurance.[4] He demonstrates that with moral hazard and exclusive insurance (Dixit (1987a)) and with adverse selection (Dixit (1989)) there is no insurance role for trade policy. When there are imperfectly observed outcomes (Dixit (1987b)) he finds an opening for trade policy to improve welfare.

Newbery and Stiglitz assume domestic residents cannot insure privately so that price stabilization generates risk benefits by lowering the variance in real income. In this paper we assume that residents are unable to insure against aggregate uncertainty caused by world price fluctuations because there are controls on foreign capital. This means they cannot smooth income by borrowing and lending from foreigners. This is a realistic assumption as many governments in developing countries adopt capital controls to protect their exchange rates and/or to restrict foreign investment[5].

The approach adopted by Newbery and Stiglitz assumes agents are homogeneous with quadratic preferences over real aggregate income, i.e., domestic welfare is raised by a higher mean and a lower variance. They derive a formula for the welfare benefits from stabilization based on profitable storage; it includes risk benefits from a lower variance in producer income and transfer benefits from profitable storage which raises mean domestic surplus (i.e., sum of producer and conumser surplus). We adopt their approach, which is widely used in applied work (e.g., Hinchy and Fisher (1988), Akiyama and Varangis (1991) and Jolly, Beck and Bodman (1990)), and extend it to general equilibrium to derive formulae for the welfare effects of stabilization in terms of net producer and consumer surplus rather than in terms of producer revenue.

We show that it is not appropriate to use the Newbery and Stiglitz formula based on profitable storage[6] to justify the use of domestic price controls because it provides an incorrect assessment of the welfare effects. Storage and domestic price controls deal with price variability in different ways

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[4] Dixit and Stiglitz (1981) emphasize the need to isolate reasons for the lack of private insurance if the welfare effects of government policies are to be properly understood.

[5] See Footnote 12.

[6] Domestic storage cannot affect the world price so it must be undertaken internationally.

and their welfare effects are therefore quite different.[7]

Trade policies stabilize the domestic price by shifting uncertainty to the government budget. This does not lower the variance in domestic surplus, but it does lower mean surplus by the social costs of the distortionary tariffs and subsidies; domestic welfare is unambiguously lower under the scheme. *Storage* reduces the variance in domestic surplus by removing uncertainty from the world price, however, it also reduces mean domestic surplus by transferring income to foreigners who receive the gains from profitable storage; domestic welfare may rise or fall under these circumstances.

The results obtained on the reductions in mean surplus under both storage and variable tariff schemes are consistent with the work of Waugh (1944) and Oi (1961) who show, respectively, that consumers and producers benefit from price variability when it is exogenous to them; as it is in a small open economy. This is not inconsistent with the work of Massell (1969) who reconciled the findings of Waugh and Oi by demonstrating that there are gains in aggregate (or global) surplus when storage is profitable; in small economies these gains accrue to foreign residents when uncertainty derives in the foreign country.

Most previous work on stabilizing traded goods prices examines the effects of storage rather than domestic trade policies. Hueth and Schmitz (1972) extend the analysis of Waugh, Oi and Massell to examine the distribution of the welfare gains from price stabilization between importers and exporters of goods traded under *large* country assumptions. Bieri and Schmitz (1973) extend their analysis by adding existing distortions and Just, Lutz, Schmitz and Turnovsky (1977) go further by allowing for multiplicative rather than additive disturbances, and they also examine trade policies but do not specify the reasons for the lack of private insurance. In more recent work, Newbery (1984) shows how large countries can transfer income from foreigners by increasing buffer stocks above their competitive level to raise commodity prices in world markets.

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[7] Wright and Williams (1988) identify two separate factors which determine the welfare effects of price stabilization. One is the source of price uncertainty, the other the method of stabilization used to reduce it. In a small open economy uncertainty is exogenous to domestic consumers and producers so we confine our analysis to a comparison of the method of stabilization used - a variable tariff scheme and profitable international storage.

The paper is organized in the following way. In section 2 we present the intuition for our results diagrammatically. We then analyze the welfare effects of a variable tariff scheme in section 3 using the approach adopted by Newbery and Stiglitz and extending it to a simple general equilibrium model. This is repeated for storage in section 4 where we also compare the results for variable tariff schemes and storage, and in section 5 as an example, we compare the welfare effects of price stabilization for commodities such as wheat, maize, rice and sugar in a hypothetical developing country setting. There are concluding remarks in section 6.

2. A Diagrammatic Exposition of the Welfare Effects

The intuition for our results, which are presented formally in later sections, is exposited using Figure 1 below where $\bar{x}_i$ and $\bar{q}_i$ are, respectively, demand and supply for the imported good i when price is stabilized at its mean $\bar{p}_i$. The domestic demand (D_i) and supply (S_i) schedules are linear under the Newbery and Stiglitz approach because terms higher than second order in a Taylor series expansion around the indirect utility function are assumed to be zero.

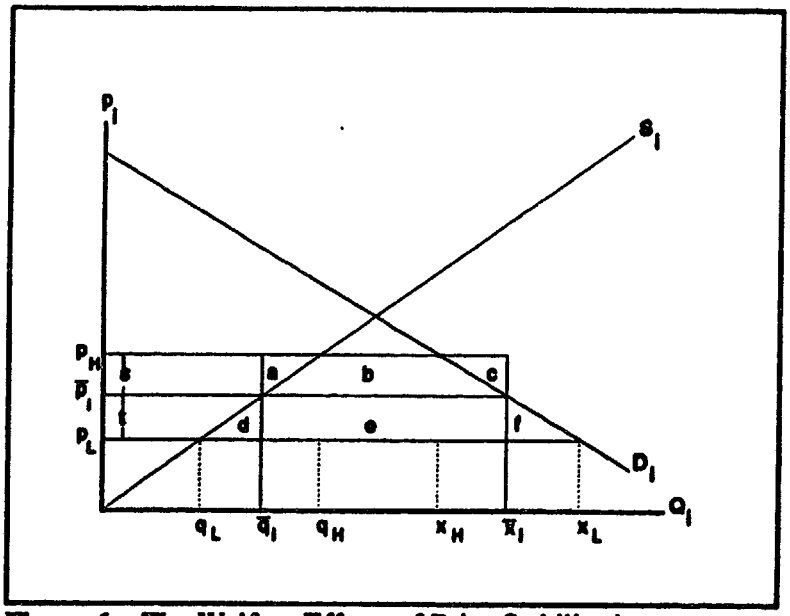

Figure 1: The Welfare Effects of Price Stabilisation

This also means there are two identifiable changes in welfare under their approach: the change in expected (or mean) domestic surplus, and the change in the variance of domestic surplus. We initially consider these changes for the variable tariff scheme and then for profitable storage.[8]

[8] While the analysis is undertaken for an importable good, the results will carry over directly to an exportable good.

2.1 The Variable Tariff Scheme

Variable tariff schemes can take different forms. There are *reference price schemes* which use tariffs and subsidies on imports to keep domestic prices at a pre-determined reference price (e.g., sugar in Mexico), *price band schemes* which use tariffs and subsidies to keep domestic prices within pre-determined upper and lower bounds (e.g., basic grains in El Salvador), and *minimum price schemes* which use tariffs to stop domestic prices falling below pre-determined floors (e.g., variable levies in the European Community). The scheme we consider in this paper is a reference price scheme which stabilizes the domestic price of the imported commodity at its mean ($\bar{p}_t$).

For simplicity assume the world price rises to p_H with probability 0.5 and falls to p_L with probability 0.5. If the world price rises to P_H a subsidy (s) lowers the domestic price to $\bar{p}_t$, and if the world price falls to p_L a tariff (t) raises the domestic price to $\bar{p}_t$.

Table 1 summarises the changes in domestic surplus with and without the scheme; it compares the variance and the mean in each situation. $\bar{x}$ represents the surplus when price is stabilized at its mean value $\bar{p}_t$.

Table 1: A Summary of the Changes in Domestic Surplus under the Tariff Scheme[9]

	Without Scheme	With Scheme
p_L	$\bar{x}+d+f+e$	$\bar{x}+e$
p_H	$\bar{x}-b=\bar{x}+d+f-e$	$\bar{x}-(a+b+c)=\bar{x}-e$
Mean	$\bar{x}+d+f$	$\bar{x}$
Variance	e^2	e^2

Mean Surplus: When the domestic price is stabilized at its mean there is an expected loss of:

$$E(a+c+d+f) = a+c = d+f.$$

[9] The results in Tables 1 and 2 depend on the linearity assumption which makes a=d, and c=f. However, the overall reduction in welfare under the tariff scheme does not depend on the linearity assumption (which is commonly adopted in applied work). Note also that a+b+c=e, which means the scheme is self-financing over time. To simplify the analysis we assume a zero interest rate.

When the world price falls to p_L the loss under the scheme, d+f, is the amount the potential gain from a lower domestic price, d+e+f, exceeds the actual gain which consumers receive as tariff revenue via the government budget, e. When the world price rises to p_H there is also a loss of a+c. It is the excess of the subsidy cost, a+b+c, which consumers fund through the government budget, over the potential loss from a higher domestic price, b.

Therefore, the tariff scheme reduces mean surplus to $\bar{x}$ from its free trade level $\bar{x}+d+f$. This reduction is caused by the social costs of distortionary tariffs and subsidies which are used to stabilize the domestic price.

The Variance in Surplus: Under the Newbery and Stiglitz approach there are potential risk benefits if the scheme reduces the variance in domestic surplus.

When the world price falls to p_L surplus rises less under the scheme (as tariff revenue e) than it does in free trade (d+e+f). This generates risk benefits; however, these benefits are offset by the extra loss in surplus when the subsidy applies. A higher world price reduces surplus (as subsidy cost a+b+c) more than it falls in free trade (b). This larger loss under the subsidy, a+c, is exactly equal to the smaller gain under the tariff, d+f. *Thus, the variance in domestic surplus remains unchanged and there are no aggregate risk benefits from a variable tariff scheme.*

Thus, tariff scheme unambiguously reduces aggregate domestic welfare; it lowers mean surplus (by the social costs of tariffs and subsidies) and leaves the variance unchanged.

2.2 Storage[10]

Table 2 below summarises the changes in domestic surplus when costless storage stabilizes the world (and therefore the domestic) price of good i at its mean value.[11],[12] For the purpose of comparing variable tariff schemes and storage we assume there is a new technology invented which makes it possible to store the commodity at zero cost. This results in the world price being stabilized at its mean value.

Table 2: A Summary of the Changes in Domestic Surplus under Storage

	Without Storage	With Storage
P_L	$\bar{x}+d+f+e$	$\bar{x}$
p_H	$\bar{x}-b=\bar{x}+d+f-e$	$\bar{x}$
Mean	$\bar{x}+d+f$	$\bar{x}$
Variance	e^2	0

Mean Surplus: When the world price is stabilized by storage there is an expected loss of:

$$E(d+e+f-b) = E(a+c+d+f) = a+c = d+f,$$

where b=e-a-c.

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[10] We are not considering storage as a policy option, since storage carried out by a small open economy cannot affect world prices. If storage is economically feasible it will be performed internationally by private operators. We consider it only as a way to capture the welfare effects of exogenous price stabilization.

[11]Costless storage is assumed by Newbery and Stiglitz when they measure their welfare effects under storage. If there are storage costs, price variability is not eliminated. It is analytically clearer to ignore storage costs since we are not interested in storage as a policy option.

[12] We are grateful to George Fane for pointing out that storage could also be interpreted as a government run price stabilization scheme which is financed with foreign borrowing. Instead of financing the scheme domestically to maintain a balanced budget the government finances its budget imbalance internationally; it runs a budget deficit (surplus) and a corresponding trade deficit (surplus). In the presence of capital controls this provides risk benefits because the government has done what the private sector could not do; that is, borrow from foreigners when prices are low and repay these borrowings when prices are high, thereby insuring against price uncertainty. If government can borrow internationally to finance a price stabilization scheme, then the welfare effects of storage and the tariff scheme are identical. Both schemes reduce welfare by the same transfer losses.

Consumers gain more from lower prices than they lose from higher prices, while producers gain more from higher prices than they lose from lower prices. Notice that these losses under storage are equal to the welfare costs of the variable tariff scheme.

The Variance in Surplus: When storage stabilizes the world price at its mean there is no variance in domestic surplus, while in the absence of storage the variance is e^2.

Thus, the welfare effects of storage are ambiguous; it lowers both the mean and the variance in domestic surplus.

When the reference price $\bar{p}_i$ is set at the expected domestic price the scheme is self financing. See Figure 1 where the expected tariff revenue, $E(e)$, is equal to the expected subsidy cost, $E(a+b+c)$.

3. The Welfare Effects of Trade Policies

In this section we formally derive the welfare effects which were exposited diagrammatically in the previous section. For simplicity we assume the world price of the importable good i is the only random world price (on the basis that commodity i's price deviates much more than all other commodity prices). There are no tariffs or subsidies on other commodities, and all goods are traded in world markets under price-taking assumptions. Domestic producers use a domestic input (l) that is fixed in supply and non-traded, so its price (p_l) is determined domestically. The price of a traded good (0) is chosen as numeraire so all variables are measured in units of the good whose price p_0 does not fluctuate.

To capture the full impact of price controls on domestic welfare we need to account for the budgetary consequences of the stabilization scheme. This is done in a general equilibrium setting by linking consumer income to the government budget. When there are controls on foreign capital the scheme must be financed domestically i.e., the trade account must balance. For simplicity it is assumed that any surplus or deficit in the government budget impacts on consumers in a lump-sum way. Under the variable tariff scheme all tariff revenue raised (or subsidy payments made) when the price of good i is being stabilized is returned to consumers in a lump sum; they do not observe any direct relationship

veen changes in domestic prices and changes in their lump-sum share of the government budget sed by the variable tariff scheme. In other words, they face distorted domestic prices when ng their consumption and production choices. Consumers are endowed with a fixed supply of omestic input and they are also owners of firms as shareholders; therefore, consumer income is to firm profits plus the returns to the fixed domestic input less (plus) the budget deficit s). The role of these assumptions will become clear in the following discussion.

consumer problem is:

$$\left\{\begin{array}{l} \underset{\{x,l\}}{\textit{Maximize}}\ \{EU(x)|\tilde{M} - px = 0\} \\ \textit{Subject to:} \\ \tilde{M}_0 = \tilde{\pi} + p_l l = pq \quad - \text{ without price stabilisation} \\ \tilde{M}_1 = \tilde{\pi} + p_l l - \tilde{t}(\bar{q}_i - x_i) = \bar{p}\bar{q} - \tilde{t}(\bar{q}_i - x_i) \quad - \text{ with price stabilisation} \\ \tilde{\pi} = pq(l) - p_l l \end{array}\right.$$

bol notation:

- is the vector of consumption demands for the j=0,1,.....,J traded goods;

- is expected utility over the J+1 consumption goods x;

- is the vector of (real) domestic prices which are world prices when there is no price stabilization. Price p_w is the only random world price;

$+\tilde{t}$ - is the vector of (real) domestic prices which are stabilized at their mean $(\bar{p})$ by the tariffs and/or subsidies on good i, so that the tariff (t) is now random, and domestic prices are world prices plus the tariff (which is a subsidy when $t<0$). Under the scheme $E(\tilde{t})=0$; the vector of (J) domestic traded outputs which are produced under perfect competition by

technologies with $\partial q_j/\partial l_j > 0$, and $\partial^2 q_j/\partial l_j^2 < 0$ for all j, and l_j is the usage of l by firm j;[13]

$\bar{q}_i$ - is the domestic output of good i when price p_i is stabilized at its mean;

$\tilde{\pi} = pq(l) - p_l l$ - is the vector of (real) profits of domestic firms which is their net traded output less the cost of the non-traded input $(p_l l)$ used in production. All profits accrue to the domestic input which is fixed in supply;

$\tilde{M}_0 = pq$ - is real income without price stabilization, which is equal to net traded output, where $E(\tilde{M}_0) \equiv \bar{M}_0$. Since all goods are traded and there are controls on foreign capital, $pq = px$;

$\tilde{M}_1 = \bar{p}\bar{q} - \tilde{t}(\bar{q}_i - x_i)$ - is real income with price stabilization, where $E(\tilde{M}_1) \equiv \bar{M}_1$. It is equal to traded output, $\bar{p}\bar{q}$, plus any tariff revenue (or less any subsidy payments) on imports of good i which consumers receive in a lump sum from the government, $-\tilde{t}(\bar{q}_i - x_i)$. Notice how the variable tariff scheme transfers world price uncertainty from domestic prices to the government budget, and this impacts on consumers through their share of this budget. Once again there is trade balance because of the foreign capital controls.

After solving the consumer problem in (1), we obtain the indirect utility functions:

$EV_0\{p, \tilde{M}(p,l)\}$ - without price stabilization, assuming no tariffs or subsidies are present; and,

$EV_1\{\bar{p}, \tilde{M}(\bar{p}, \tilde{t}, l) - B_i\}$ - with price stabilization, where B_i is the amount of good 0 consumers are willing to pay (or require as compensation when $B_i < 0$) for reduced price variability.

Following Newbery and Stiglitz (1981), B_i is the amount which makes $EV_0 = EV_1$ when the real domestic price of good i is stabilized at its mean value $(\bar{p}_i)$. It will be negative when the efficiency losses caused by tariffs and subsidies are greater than the risk benefits. After Taylor series expansion around $\bar{p}_i$ we have (see Appendix A.1 for workings):

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[13] The model can be extended to allow for extra inputs, both traded and non-traded, but this complicates the exposition without changing the substance of our findings.

$$(2) \qquad B_i = \frac{1}{2}\sigma_i^2 \frac{V_u}{V_M} - \frac{1}{2}\sigma_{P_i}^2 \frac{V_{P_i \cdot P_i}}{V_M},$$

where $V_{P_i \cdot P_i}$ is the second partial of V for p_i. (Following Newbery and Stiglitz all higher order terms are ignored. This implies that the demand and supply schedules are linear.) Notice how income depends on domestic prices, tariff revenue (or subsidy cost) and the fixed supply of the domestic input (l) in general equilibrium; therefore, all the income effects caused by changes in tariffs and subsidies are captured in the terms V_u and $V_{P_i \cdot P_i}$.

Additional insight into (2) is obtained by evaluating the partial derivatives for indirect utility.

$$(3) \qquad V_{P_i} = V_M \{ \frac{\partial M_0}{\partial p_i} - x_i \}$$

is the change in welfare when the domestic price of good i rises. This is the familiar expression used in Roy's identity which is augmented by changes in consumer income in general equilibrium.

Using the budget constraint in (1) without price stabilization:

$$\frac{\partial M_0}{\partial p_i} = q_i = \sum_j p_j \frac{\partial x_j}{\partial p_i} + x_i,$$

where under profit maximization with a fixed supply of the domestic input

$$\sum_j p_j \{ \frac{\partial q_j}{\partial l} \frac{\partial l}{\partial p_i} \} = 0.$$

We can write (3) as:

$$(3.1) \qquad V_{P_i} = V_M(q_i - x_i) = -V_M m_i,$$

where $m_i \equiv -(q_i - x_i)$.

Notice how the welfare effect of a change in price is determined by the change in domestic surplus in general equilibrium where q_i captures the change in profit and x_i the change in consumer surplus.[14] Consistent then with the findings of Waugh and Oi there are net consumption gains on imported goods, and net production gains on exported goods, when price p_i fluctuates about its mean.

The change in welfare when the tariff (or subsidy) is raised at unchanged domestic prices, is:

$$(4) \qquad V_t = V_M \frac{\partial M_1}{\partial t}.$$

Using the budget constraint in (1) with price stabilization:

$$\frac{\partial M_1}{\partial t} = \bar{t} x_{iM} \frac{\partial M_1}{\partial t} - (\bar{q}_i - \bar{x}_i) = - \left[\frac{\bar{q}_i - \bar{x}_i}{1 + \bar{t} x_{iM}} \right] = \sum_j p_j \frac{\partial x_j}{\partial t},$$

where $x_{iM} = (\partial x_i / \partial M_1)$ and, because no domestic prices change, $(q_i/\partial t) = 0$. We can rewrite (4) as:

$$(4.1) \qquad V_t = V_M \left[\frac{m_i}{1 + t x_{iM}} \right],$$

where $x_{iM} = (\partial x_i / \partial M_1)$.

A tariff transfers the net gain in consumer surplus on existing imports (m_i) as tariff revenue to the government budget when the world price falls.

To compute the potential risk benefits from price stabilization we calculate the second partial derivatives for the indirect utility function and substitute them into (2), where (see Appendix A.2 for workings):

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[14] By using a general equilibrium approach we are able to measure the benefits (or costs) from stabilization in terms of consumer and producer surplus. Newbery and Stiglitz stabilize producer income to restrict the effects of price changes to one variable.

$$(2.1) \qquad B_i = \frac{1}{2}\sigma_i^2 \frac{R}{M_0}\bar{m}_i^2 - \frac{1}{2}\sigma_{p_i}^2\left\{\frac{R}{M_0}\bar{m}_i^2 - \frac{\partial m_i}{\partial p_i}\right\} = \frac{1}{2}\sigma_{p_i}^2 \frac{\partial m_i}{\partial p_i} < 0.$$

with $\sigma_i^2 = \sigma_{p_i}^2$, and $R<0$ the measure of relative risk aversion.[15]

Expression 2.1 is similar to equation 9.2 on page 123 in Newbery and Stiglitz, however, they confine their measure of any risk benefits to one good by estimating the benefits to producers from stabilizing producer income. We replicate their approach by assuming the only prices to change are the world price of good i and the domestic input price.

In this general equilibrium setting any welfare changes are measured in terms of net consumer and producer surplus rather than being restricted to producer income as it is under the Newbery and Stiglitz approach. Equation 2.1 measures the fall in expected net surplus when the domestic price of good i is stabilized. Notice that there are no risk benefits in equation 2.1 it is as though consumers are risk neutral (with $R=0$). When tariffs and subsidies are used to stabilize price, uncertainty is transferred to consumer income through the government budget; it is not removed from real income. Therefore, the only welfare effects for domestic residents in aggregate are the efficiency losses from distorting tariffs and subsidies[16] which were previously identified in Figure 1 as areas a+c+d+f.

Any persistence with variable tariff schemes must be motivated by a desire to redistribute income when there is price uncertainty; if so, there are other ways of achieving this which are less costly to welfare. Governments quite often prefer one-sided schemes because they minimize budgetary commitments (e.g., minimum price schemes). Tariffs will be used when domestic prices fall below

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[15] It is easy to verify that domestic welfare is unambiguously reduced by the scheme. In each state indirect utility is lower than it is in free trade, so their probability weighted sum must be lower than the probability weighted sum of their free trade counterparts.

[16] We implicitly assume that consumers can borrow and lend domestically so that income distribution through the government budget provides them with no risk benefits. What they cannot do is insure against aggregate income variability when world prices fluctuate because there are foreign capital controls. The approach of Newbery and Stiglitz, which is adopted in most applied work for measuring risk benefits, assumes homogeneous consumers and producers and therefore measures the benefits from a reduction in the variability in *aggregate* income. Cassing, Hillman and Long (1986) demonstrate the potential that exists for tariff schemes to raise welfare when heterogeneous consumers cannot insure domestically. The redistributions which occur through the government budget can substitute for incomplete domestic insurance.

the reference price but subsidies are unlikely to be paid when domestic prices rise above it. This is more costly to welfare for any given reduction in price variability because it concentrates on one, rather than on two, distorting margins. To see this, raise the reference price in Figure 1 to p_H and observe how the marginal welfare costs of higher tariffs eventually rise more than they fall under smaller subsidies. Furthermore, trade policies are likely to become hostage to producers who are concentrated politically. They will support schemes which place floors under domestic prices because they provide protection from lower-cost imports, but will oppose schemes which prevent domestic prices from rising. Producer support for one-sided price stabilization reinforces the budgetary attraction of these schemes.

4. The Welfare Effects of Price Stabilization with Storage

It is instructive to compare the welfare effects of variable tariff schemes and storage. To do this, assume the price of good i is stabilized at its mean by storage. With no tariffs, subsidies or other distortions, we have:

$$EV_0\{p, \tilde{M}, (p,I)\} = EV_1\{\bar{p}, \tilde{M}(\bar{p},I) - B_S\}.$$

Expected utility under price stabilization, EV_1, is no longer stochastic because storage removes uncertainty from consumer income. By shifting good i through time, foreign storage stabilizes the world price. Its value to consumers (after Taylor series expansion of the indirect utility function around the mean price for good i) is:

$$(2.2) \qquad B_S = -\frac{1}{2}\sigma_{p_i}^2 \frac{R}{M_0}\bar{m}_i^2 + \frac{1}{2}\sigma_{p_i}^2 \frac{\partial m_i}{\partial p_i}.$$

(This expression is rearranged in Appendix equation A.3 to make it similar to the familiar Newbery and Stiglitz expression for the benefits from stabilizing producer income.)

There are two separate components of the welfare change. The first term in equation 2.2 is the risk benefit which raises welfare, while the second term is the fall in expected surplus (which Newbery

and Stiglitz refer to as the transfer benefit from profitable storage when uncertainty is not exogenous to domestic consumers and producers).

Risk benefits arise because storage reduces the variance in net surplus. This term is absent under the variable tariff scheme.

Recall from previous discussion that world price uncertainty is exogenous to domestic residents when goods are traded under small country conditions. Therefore, as Waugh (1944) and Oi (1961) have shown, consumers and producers are made worse off by price stabilization. Consumers gain more surplus when price falls than they lose when price rises while producers gain more surplus when price rises than they lose when price falls[17].

Using the import demand function illustrated in Figure 2, these losses in surplus are depicted by the shaded triangles (ABH+BDE). They are equal in value to the welfare loss triangles (a+c+f+d) in Figure 1 for the variable tariff scheme. Therefore, mean surplus falls by the same amount under storage as it does under the tariff scheme.

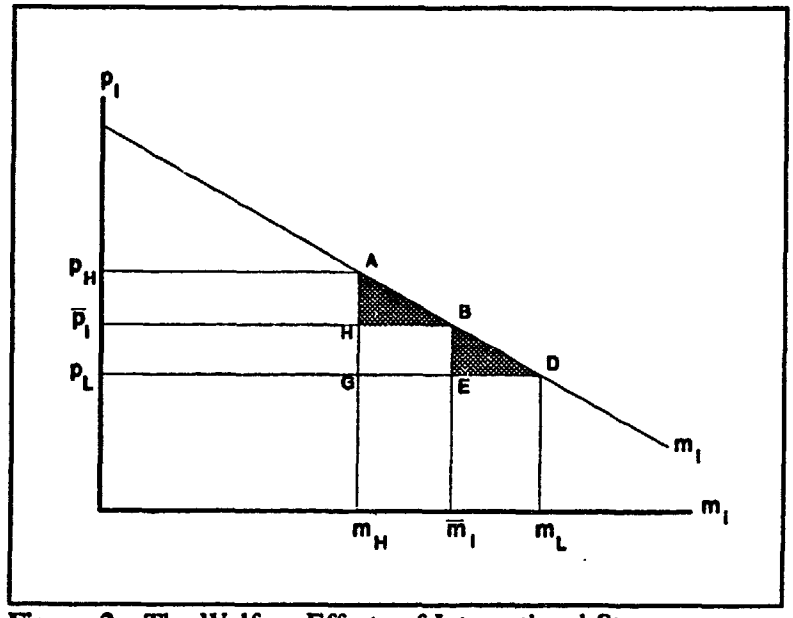

Figure 2: The Welfare Effects of International Storage

Notice how the risk benefits in equation 2.2 depend on the variance in price $(\sigma^2_{p_i})$ and the level of imports $(\bar{m}_i)$, as well as the coefficient of relative risk aversion, R. Stabilization avoids an expected loss in surplus of $P_H ABp_i$, and an expected gain in surplus of $\bar{p}_i BDp_L$, which generates aggregate risk benefits. The larger are imports and the variance in the

[17]It is also the case that producers are worse off because of the convexity of the profit function with respect to price. In our general equilibrium model consumers own firms so we concentrate on the consumer condition.

world price, the larger are these fluctuations in free trade surplus; and therefore, the greater are any risk benefits from price stabilization.

The transfer losses depend on the variance in the world price ($\sigma_{p_t}^2$) and the responsiveness of import demand to price changes ($\partial m_t/\partial p_t$). When price is stabilized, the expected transfer losses are equal to ABH+BDE. The larger is the variance in price and the more responsive import demand is to a change in price, the greater are these losses.

Thus, the welfare effects of storage are ambiguous and will ultimately depend on the price variance ($\sigma_{p_t}^2 = \sigma_t^2$), consumer risk preferences (R), the level of stabilized imports ($\bar{m}_t$), and the responsiveness of consumers and producers to price changes ($\partial m_t/\partial p_t$).

These effects differ from those identified by Newbery and Stiglitz where transfer benefits for domestic residents augment the risk benefits from reduced income variability. In contrast, our welfare measures for commodities traded under small country assumptions are ambiguous because there are transfer losses to foreigners which are offsets to any potential risk benefits for domestic residents. It is certainly the case that from a world perspective there are net gains from profitable storage, but when uncertainty originates in foreign countries, these gains accrue to foreigners. This was Massell's (1969) reconciliation of the Waugh and Oi findings.

5. Estimates of the Welfare Effects of Price Stabilization

Estimates of the welfare effects of price stabilization can be obtained relatively easily using the expressions derived in equations 2.1 and 2.2. In this section we present estimates of these welfare effects for price stabilization generated through a variable tariff scheme and through storage for selected commodities in developing countries. Many developing countries are net importers of grains (especially maize, rice and wheat) and are "small" countries in that their purchases of grain do not affect international prices. Recently, major agricultural trade reforms have been implemented in such countries, in which the overall strategy has been to introduce competitive forces by reducing government controls over trade. In several cases most quantitative restrictions on trade have been eliminated and a variable tariff scheme to insulate domestic producers and consumers from volatile international prices has been set up. Welfare estimates are made for a hypothetical country importing

maize, rice, sugar and wheat. Private price insurance is assumed to be absent due to government restrictions on access to foreign capital.

The welfare effects of the tariff scheme are measured by estimating the parameters in equation 2.1. Included in this expression is the variance of international price ($\sigma^2_{p_t}$) and the slope of the import demand function ($\partial m_t/\partial p_t$). For storage (equation 2.2) the components to be determined are the price variance ($\sigma^2_{p_t}$), the coefficient of relative risk aversion (R), a measure of stabilized income ($\overline{M_0}$) and the level of imports when the price is stabilized ($\overline{m_t}$). Estimates of these parameter values are presented in Table 3 together with the elasticities of import demand assumed.

Table 3: Parameter Values for Welfare Estimates.

Commodity	Price		Elasticity of Import Demand
	Mean	Variance	
Maize	1.48	0.45	-0.35
Rice	4.22	1.95	-0.40
Sugar	3.59	2.75	-0.40
Wheat	1.87	0.69	-0.30

International prices of maize, sugar, rice and wheat for the period 1970-89 were deflated by the US producer price index. These deflated series were used to calculate the mean and variance for each commodity price, and since prices were stabilized at their mean values, the variances of the tariffs and subsidies were set equal to these price variances. For each commodity representative linear demand and supply functions were selected to provide import demand functions which were used to calculate import levels at the stabilized price ($\overline{m_t}$) as well as the average value of imports plus consumption as the measure of stabilized income ($\overline{M_0}$).[18] The coefficient of relative risk aversion (R) was assumed to be unity.

[18]These functions were obtained from Sullivan, et al (1989).

The results are reported in Table 4. As discussed in section 3 there are no risk benefits from using a variable tariff to stabilize price at its mean value, however, there are small risk benefits from storage.

Table 4: The Welfare Effects of Commodity Price Stabilization.
(percentage of average value of consumption)

Commodity	Tariff Scheme	Storage	Newbery & Stiglitz
Maize			
Risk Benefits	0.00	1.67	10.88
Net Surplus Losses	0.61	0.61	4.35
Net Benefits	-0.61	1.06	6.53
Rice			
Risk Benefits	0.00	4.09	35.01
Net Surplus Losses	0.47	0.47	10.78
Net Benefits	-0.47	3.62	24.23
Sugar			
Risk Benefits	0.00	12.31	89.55
Net Surplus Losses	12.58	12.58	23.06
Net Benefits	-12.58	-0.27	66.49
Wheat			
Risk Benefits	0.00	2.63	9.00
Net Surplus Losses	0.65	0.65	2.49
Net Benefits	-0.65	1.98	6.51

Insights into the factors which determine the sizes and signs of the risk benefits and transfer losses can be obtained from Figure 2. The risk benefits depend on the variance in price and the level of imports (as well as the coefficient of relative risk aversion). Stabilization avoids an expected loss in net surplus of $p_H AB\bar{p}_l$ and an expected gain in net surplus of $\bar{p}_l BDp_L$ which generates aggregate risk benefits. The larger are imports and the variance in the world price, the larger are these fluctuations in free trade net surplus, and therefore, the greater are any risk benefits from price stabilization. The transfer losses depend on the variance in the world price and the responsiveness of import demand to price changes. When price is stabilized, the expected transfer losses are equal to HBEG (= ABH +

BDE). The larger is the variance in price and the more responsive import demand is to a change in price, the greater are these losses.

The largest risk benefits from storage were obtained for sugar (12.31%) (see column 2, Table 4). This is explained by the large estimated standard deviation of price. The risk benefits from storage for maize and wheat differ somewhat, 1.67% and 2.63%, despite fairly similar price variances. This difference can be explained by the differences in the assumed elasticities of import demand. The welfare costs of the variable tariff scheme (ABH + BDE) are the same as the transfer losses from storage (HBEG). They are also determined by the level of price variability and the responsiveness of import demand to price changes. The net losses for maize and wheat are respectively, 0.61% and 0.65% of the average value of imports for each commodity (see column 1, Table 4). These small losses reflect the low level of price volatility as measured by the standard deviations. Slightly greater net losses were incurred by wheat compared to maize on account of greater price instability. The net loss for sugar is 12.58%. This is relatively high compared to other commodities and is explained by the high price variance for sugar.

Finally, we compare these results with those derived using the expression of Newbery and Stiglitz (equation 6.54 on p. 93) on the same data. The risk benefits are much larger under the Newbery and Stiglitz approach (see column 3, Table 4). For example, the risk benefit for sugar is 89.55%. The much larger estimate is explained by the fact that welfare is measured in terms of income (i.e., price times quantity) and not in terms of welfare triangles as in our approach. Also, the risk benefits are larger than reported in other studies using the Newbery and Stiglitz approach because here price is assumed to be perfectly stabilized, causing the coefficient of variation of stabilized income to be equal to zero; whereas, in other studies, stabilized income is based on a partially stabilized price. The two approaches give fairly similar results for transfer losses with larger losses estimated for sugar and rice, and smaller losses for maize and wheat.

6. Conclusion

In this paper we have extended the widely-used Newbery and Stiglitz approach to measuring the economic benefits from price stabilization to a general equilibrium setting. In this setting, any

welfare change is measured in terms of net consumer and producer surplus, rather than being restricted to producer income effects as it is under the Newbery and Stiglitz approach. Like Newbery and Stiglitz we assume that domestic residents cannot insure privately, so that price stabilization policies generate risk benefits by lowering the variance in real income. But as Dixit and Stiglitz (1981) have shown, the circumstances accounting for the lack of private insurance are important if the appropriate government policies are to be followed. We have assumed for the empirical analysis that private price insurance is not possible because of government restrictions on access to foreign capital, so that domestic consumers and producers cannot smooth their income by borrowing and lending from foreigners or by using internationally-traded financial instruments. Empirical analysis focussing on different reasons for the lack of private price insurance will be the subject of further work.

The welfare effects identified in our paper differ from those identified by Newbery and Stiglitz where transfer benefits for domestic residents augment the risk benefits from reduced income variability. In contrast, our welfare measures for commodities traded under small country assumptions are ambiguous because there are transfer losses to foreigners which are offsets to any potential risk benefits for domestic residents. Newbery and Stiglitz derive a formula for measuring the welfare benefits from price stabilization based upon an assumption of profitable storage to stabilize prices from one period to another. We provide formulae for measuring the welfare benefits in a general equilibrium setting when stabilization is achieved by storage and by a domestic variable import levy scheme. These formulae differ significantly and thus it is not appropriate to use the Newbery and Stiglitz formula to justify the use of domestic price controls such as a variable levy.

Our analysis confirms previous work which shows that (i) domestic welfare is lower under trade policies which stabilize the domestic price, as they serve only to shift the price uncertainty from producers and consumers to the government budget while incurring the social costs of the tariffs and subsidies, and (ii) while storage reduces the variance in domestic surplus by removing uncertainty from the world price, it also reduces domestic surplus by transferring income to foreigners who receive the gains from profitable storage -- under these circumstances domestic welfare may rise or fall because these transfers offset the risk benefits from the fall in price variability (this ambiguity is not made clear by the Newbery and Stiglitz formulation).

In the empirical analysis we compare the estimates of the welfare effects of price stabilization for four

commodities (wheat, maize, rice and sugar), typically imported by developing countries, under a variable tariff scheme and a storage scheme. We also compare the effects from storage as estimated from the Newbery and Stiglitz formula. The results are worked out for a hypothetical developing country.

There are small risk benefits from stabilizing through storage, as estimated in the general equilibrium formulation. These benefits are largest in the case of sugar, due to the world sugar price having the largest variance. The measured risk benefits are much larger under the Newbery and Stiglitz approach -- a result explained by welfare being measured in terms of income rather than in terms of welfare for the general equilibrium case. The offsetting net surplus losses are much smaller than the risk benefits in each case except for sugar where they are slightly larger. In the Newbery and Stiglitz case the risk benefits from stabilizing the sugar price far outweigh the net surplus losses.

The welfare costs of the variable tariff scheme are generally small, except in the case of sugar, due to its high price variance. By comparison with the results under the tariff scheme which are always negative, the net benefits for maize, rice and wheat under storage are positive -- illustrating the invalidity of using results derived under an assumption of stabilization through storage for justifying the use of domestic price controls.

While our discussion has focused on a comparison of the welfare effects of price stabilization under a variable tariff scheme and storage, we are not arguing in favor of either of these policy instruments. Instead we argue against them on welfare grounds. A better option is to use financial instruments for hedging of commodity price risks. But this means that there should be no controls over capital instruments--which is one of the major reasons why private insurance is seldom undertaken in developing countries. Such controls restrict foreign borrowing and lending and the purchase of foreign insurance contracts and therefore reduces private insurance. The use of commodity futures and options markets by some developing countries has grown over the past few years. However, many governments in developing countries continue to maintain capital controls to protect their exchange rates and/or to restrict foreign investment. As a result, financial risk management techniques have not been adopted widely and variable tariff schemes have tended to be the main instrument of price stabilization.

Appendix

A.1 Taylor series expansion of EV_0 yields:

$$V(\bar{p}) + V_{p_i}(\bar{p})E(p_i-\bar{p}_i) + \frac{1}{2}V_{p_ip_i}(\bar{p})E(p_i-\bar{p}_i)(p_i-\bar{p}_i),$$

and Taylor series expansion of EV_1 yields:

$$V(\bar{p}) + V_M(\bar{p})E(\tilde{M}_1-B_t-\bar{M}_1) + \frac{1}{2}V_{tt}(\bar{p})E(\tilde{t}-\bar{t})(\tilde{t}-\bar{t}).$$

These expressions are simplified by noting $E(p_i-\bar{p}_i)=0$ under the scheme. The value of B_t in (2) equates EV_0 to EV_0. Note that under the scheme any change in income caused by fluctuations in the world price are captured in the terms V_{tt} and $V_{p_ip_i}$ in general equilibrium.

A.2 Using the budget constraint without price stabilization (evaluated at the mean price), (3.1) becomes:

$$V_{p_i} = V_M\sum_j p_j\frac{\partial x_j}{\partial p_i} = -V_M\bar{m}_i,$$

and using the budget constraint with price stabilization (evaluated at the mean price), (4.1) becomes:

$$V_i = V_M\sum_j p_j\frac{\partial x_j}{\partial p_i} = V_M\bar{m}_i,$$

Therefore the second partial derivatives of the indirect utility functions (evaluated at the mean price) are:

$$V_M = V_M \frac{R}{M_0} \sum_j p_j \frac{\partial x_j}{\partial t} + V_M \sum_j \frac{\partial p_j}{\partial M} \frac{\partial x_j}{\partial t} = V_M \frac{R}{M_0} \bar{m}_i;$$

$$V_{ii} = V_M \frac{R}{M_0} \sum_j p_j \frac{\partial x_j}{\partial t} + V_M \sum_j \frac{\partial p_j}{\partial t} \frac{\partial x_j}{\partial t} = V_M \frac{R}{M_0} \bar{m}_i^2;$$

$$V_{p_i M} = V_M \frac{R}{M_0} \sum_j p_j \frac{\partial x_j}{\partial p_i} + V_M \sum_j \frac{\partial p_j}{\partial M} \frac{\partial x_j}{\partial p_i} = -V_M \frac{R}{M_0} \bar{m}_i;$$

$$V_{p_i p_i} = V_M \left[\frac{R}{M_0} \bar{m}_i^2 - \frac{\partial m_i}{\partial p_i} \right].$$

nce higher order terms in the Taylor series expansion on indirect utility are ignored this implies the ɔort demand schedules are linear where, (by the envelope theorem and Roy's identity):

$$-\frac{V^3_{p_i p_i p_i}}{V_M} = \frac{\partial^2 m_i}{\partial p_i^2} = 0.$$

$\frac{V_{MM}}{V_M} \bar{M}_0 < 0$ is the measure of relative risk aversion.

substituting these second partial derivatives into (2) we have (2.1).

The risk benefits in (2.2) can be converted to an expression which is similar to that derived by ɔwbery and Stiglitz, as:

2.2') $$\frac{B_i}{\bar{M}_0} = -\frac{1}{2} \sigma_{p_i}^2 \frac{1}{\bar{p}_{p_i}^2} \left(R \bar{k}_i^2 - \bar{k}_i \eta_{m_i} \right)$$

ere:

$\bar{k}_i = \frac{\bar{p}_i \bar{m}_i}{M_0}$ - is the budget share of imports evaluated at $\bar{p}_i$, and,

$\eta_{m_i} = \frac{\partial m_i}{\partial p_i} \frac{\bar{p}_i}{m_i}$ - the import elasticity of demand for good i with respect to its own domestic price.

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