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Commercial Policy Reform in Pakistan:
A Theoretical and Empirical Analysis*

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Abstract

This is a theoretical and empirical study of commercial policy reform in a small open economy. The first part develops a theoretical model and obtains welfare effects of revenue-neutral tax reforms and expressions for optimal taxes — trade taxes on final goods and intermediate inputs, and consumption taxes — when tax revenue is used to provide a public good. The second part estimates, for Pakistan, the optimal taxes using the formulae developed in the theoretical part and examine if revenue-neutral tax reforms can be welfare improving. These estimates suggest that there is considerable scope for further reducing tariffs on final goods, but not that on intermediate inputs.

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1 Introduction

Pakistan, like most other developing countries, followed an import substitution strategy for industrialization, which relied on high tariffs, import quotas and exchange rate overvaluation. Quantitative restrictions on trade were relaxed during the mid-eighties. Progress in tariff reduction started only in the late eighties. Although maximum tariff rates have been brought down to 25% in 2003,[1] it is by no means clear that further reductions should not be made.

The hesitation in reducing tariff rates is primarily due to two reasons. First, the concern is about the effect it will have on special interest groups. These interest groups benefit from a wide range of discretionary concessions: some groups are allowed imports at zero duty and others at reduced rates.[2] The level of concessions provided are considerable. In 1997-98, revenue foregone due to these concessions (at Karachi customs) amounted to Rs. 23.5 billion (41% of potential tariff revenues at Karachi customs). Concessions are obtained through lobbying efforts by well organized groups, typically representing only a limited number of large organizations. Unlike these groups, those who would benefit from overall reduction in tariff rates are typically less organized and consist of a large number of small firms. Thus by default, policy is strongly influenced by the groups currently enjoying concessions.

The second reason for the hesitation is due to the effect it may have on revenues. In 1997-98, Custom House Karachi reported collection of import duties of Rs. 18 billion on items on which the statutory duty was 35% to 45% (representing 55% of their total collection of import duties). If the duty on these items was reduced to 25%, estimated revenue loss in 1997-98 would have amounted to Rs. 7 billion for Karachi customs. This represented 21% of their total import tariff revenues of Rs. 34 billion for that year. The revenue loss projected for the whole country would be Rs. 15.5 billion or 4.6% of total federal tax revenues of Rs. 338 billion collected in 1997-98.

Another interesting aspect of trade in developing countries is that imports of intermediate inputs form a significant part of total imports. In Pakistan, for example, imports of intermediate inputs formed 54% of total imports in 1999-2000. High import duties on such products can have serious adverse implications for the manufacturing sectors which the import substitution policies are supposed to protect.

In light of government dependence on tariff revenues, the success of tariff reform is contingent upon development of alternative revenue sources and the institutional mechanisms for effective tax administration. During the nineties, countries continued to experiment with commercial policies in order to balance trade liberalization and fiscal reform. In particular, many countries have been depending more and more on consumption taxes rather than tariffs as a source for government revenue. Since consumption taxes do not discriminate

[1] This excludes automobiles on which the duty rates ranged between 75% and 200% in 2002-2003.

[2] As an example, on the imports of Rs. 39.3 billion (at Karachi customs) which were subject to a statutory rate of 45% in 1997-98, tariff revenues should have amounted to Rs. 17.7 billion. However, due to concessions actual collection amounted to only Rs. 12.1 billion implying an average duty rate of 30.8% instead of the statutory rate of 45%.

between domestic and foreign sources, these are acceptable to the multilateral institutions like the World Trade Organization (WTO). However, consumption taxes are more difficult to administer and are politically very sensitive.

The 1993-94 reform envisaged increase in sales tax to compensate for revenue losses due to scaling down of tariff rates. Considerable progress has been made in this regard. The share of sales tax in total tax revenues increased from 13% in 1990-91 to 35% in 2001-2002, while the share of taxes on international trade decreased from 39% to 10% during the same period.[3] The chances of success in raising sales tax (which takes the form of a value added tax) is closely tied to the administrative ability for tax collection.

The purpose of this paper is to carry out a theoretical and empirical study of commercial policy reform in a small open economy with intermediate inputs. The first part develops a theoretical model, based on the stylised facts as outlined above, using duality approach. It then considers welfare effects of piece-meal revenue-neutral policy reforms, and obtains expressions for optimal taxes — discriminatory trade taxes on final goods and intermediate inputs, and non-discriminatory consumption taxes — when tax revenue is used to provide a public good.[4] In the piece-meal reform exercise, we consider two scenarios. In the first, tariffs on final goods are unalterable and the reform involves changing tariffs on intermediate inputs and consumption tax so as to leave tax revenue unchanged at the initial equilibrium. In the second, tariffs on intermediate inputs are unalterable and the reform involves changing consumption tax and tariffs on final goods. These two scenarios correspond to different assumptions on the relative strengths of the various lobby groups. For example workers and management of Pakistan Steel Mills have a strong interest in maintaining high tariffs on the imports of steel that conflicts with the interest of businesses which are users of steel as input in production.[5] In contrast, business groups lobby for tariffs on the products they produce. If the former lobby is dominant then it is reasonable to treat tariffs on steel as unalterable. If business groups become more influential then tariff on importable consumables can be taken as unalterable and tariff on steel as alterable.[6]

In the second part, we estimate, for Pakistan, the optimal taxes using the formulae developed in the theoretical part. We also examine the effects of revenue neutral commercial policy reforms on welfare. It may be instructive to compare our paper with another recent theoretical contribution in the area of tariff and tax reform. In their paper Keen and Ligthart (2002) propose tariff and tax reform strategies which involve reduction in tariffs accompanied

[3]In 2000-2001, other taxes included excise (10%), surcharges (11%) and direct taxes (30.5%).

[4]For second best analysis in the presence of preexisting price distortions see Lloyd (1974), Lahiri and Raimondos (1996), Lahiri *et al* (2000), and Krishna and Panagariya (1997). For an analysis of tariff reforms in the presence of intermediate inputs see, for example, López and Rodrik (1990) and López and Panagariya (1992). Finally, the question of reforms of consumption taxes and tariffs has been analysed in Michael *et al* (1993).

[5]In fact, in the past high tariffs were maintained on the imports of steel precisely for this and other reasons. In recent years, tariffs on steel have come down significantly resulting in significant redundancies in the steel industry.

[6]In fact, the strong lobby of the automobile producers has not allowed any serious reduction in tariffs despite the significant reform in tariffs. The tariffs range between 75 percent and 200 percent in the automobile sector in 2002-2003.

by increases in consumption taxes that leave consumer prices unchanged. They derive conditions under which the coordinated tax-tariff reform increases welfare and public finances. Our paper bears similarities with some of the extensions considered by Keen and Ligthart on their basic model. First, we also allow for the pre-existence of consumption tax and tariffs on final goods and tariffs on intermediate goods. Second, we also allow for government revenue constraint in our model, and as in their paper allow for the possibility that the government ability to raise revenue through lump-sum taxes may be limited and that it may resort to distortionary taxes. Finally fiscal revenues and welfare considerations figure prominently in both models. Our analysis however differs in a number of important respects from that of Keen and Ligthart. First, in our model the entire government revenue is used to finance a public good. The public good aspect does not figure in Keen and Litgthart. Secondly, our paper considers two types of tax reforms. The first set of reforms are of the piecemeal type and this is where our theoretical analysis can be seen as extensions of those of Keen and Ligthart.[7] Here it is assumed that the tax reforms leave government revenue unchanged (revenue neutral reforms).[8] The second set of reforms — which Keen and Ligthart do not address — are those for which optimal tax rates are computed when government's ability to raise taxes by lump-sum means are limited so that at the margin distortionary taxes have to be imposed. Setting optimal taxes involves compensating the loss from the higher prices on private goods implied by taxes and tariffs with the benefit from access to greater level of public goods.

2 The theoretical framework

We consider a general equilibrium model of a small open economy. There are three goods produced in the economy. The first good is the numeraire good, which the country under consideration exports and whose price is set to unity ($p_1 = 1$). Good 2 is an importable final good whose international price is p_2 and which is subject to ad-valorem imports tariffs τ_2. We also assume that there is an ad-valorem value added tax, denoted by t, which is applied uniformly to the consumption of good 2.[9]

Thus the domestic consumer and producer price of good 2 is $p_2(1 + \tau_2)(1 + t)$ and $p_2(1 + \tau_2)$ respectively. Furthermore, we assume that the government is unable to collect all of consumption tax revenue and we denote by γ the fraction of consumption tax revenue that is not collected.[10] However, this does not affect the consumer price as benefit accrues to the seller and is not passed on to the consumers in terms of lower price.

[7]It is also to be noted that unlike us Keen and Litgthart do not verify, using data from a country, if the derived theoretical conditions for the reform strategy to be beneficial hold in the context of that country.

[8]The present analysis can also be seen as a direct extension of Lahiri *et al* (2000) in that Lahiri *et al* (2000) considered a very specific second-best analysis, *viz.* optimal second-best tariffs on steel for unalterable levels of consumption tax rate and tariffs on manufacturing goods.

[9]By assuming uniformity of consumption tax, we are ruling out the equity motive of setting consumption taxes. This has been examined in details in a number of studies including Ahmed and Stern (1991) and Coady (1997). In the sectors, where it is applicable, consumption tax is applied uniformly in Pakistan. It is not used as an instrument of equity.

[10]In our estimates, we used revenue shortfall figure in the range of zero and 20 percent.

Good 3 is a purely intermediate input, the international price of which is denoted by p_3, and the imports of which are subject to tariffs at the rate τ_3.[11]

The expenditure and the revenue function are given by $E(1, p_2(1+\tau_2)(1+t), g, u)$ and $R(1, p_2(1+\tau_2), p_3(1+\tau_3))$ respectively, where u is the level of utility for the representative consumer and g is the level of public good provision. Note that the arguments of the expenditure function are the consumer prices and that of the revenue function are producer prices, and that price of good 3 does not appear in the expenditure functions as it is purely an intermediate good.[12] It is well known that the partial derivative of the revenue function with respect to the ith price gives the supply function for the ith good. Similarly, the partial derivative of the expenditure function with respect to the ith price gives the compensated demand function for the ith good. It is also well know that the supply functions thus obtained can be interpreted as net of intermediate input use (see Dixit and Norman (1980, p.31) and López and Panagariya (1992, p.617)). Therefore, $-R_3$ is the net imports of the intermediate input (good 3).[13] $-E_3$ $(= -\partial E/\partial g)$ > 0 represents the marginal willingness to pay (MWP) for the public good.[14]

The budget constraint of the representative consumer is given by

$$E(1, p_2(1+\tau_2)(1+t), g, u) = R(1, p_2(1+\tau_2), p_3(1+\tau_3)) + \gamma t(1+\tau_2)p_2E_2, \tag{1}$$

where $\gamma t(1+\tau_2)p_2E_2$ is the proportion of consumption tax revenue that accrues to the representative consumer as income, and therefore tax revenue, T, is given by

$$T = \tau_2 p_2(E_2 - R_2) + (1-\gamma)t(1+\tau_2)p_2E_2 + \tau_3 p_3(-R_3). \tag{2}$$

The first three terms on the right hand side of (2) are respectively tariff revenue from good 2, consumption tax revenue from the sale of good 2, and tariff revenue from the imports of good 3.

Finally, it is assumed that the government balances its budget. In other words, the entire tax revenue, T, is used to finance the provision of public good. For simplicity, it is taken that one unit of the numeraire good is used up to produce one unit of the public good. This simplification together with the balanced budget assumption implies that:

$$g = T \tag{3}$$

This completes the description of the model. Since the economy under consideration is a small open one, all the prices are exogenous, and we have three equations in three endogenous variables in u, g and T.

[11] In order to promote exports, many countries including Pakistan give refund for tariffs on intermediate inputs for exporters. For Pakistan, this refund amounts to a very small proportion of total indirect tax revenue.

[12] Since the level of endowments do not vary in our analysis, for brevity, these are left out of the arguments of the revenue function. See Dixit and Norman (1980) for properties of the expenditure and the revenue functions.

[13] R_i and E_i are respectively the partial derivatives of the revenue and the expenditure functions with respect to their ith arguments.

[14] See, for example, Abe (1992) for details.

3 The Theoretical Analysis

Having described the model, we now turn to the analysis. For simplicity we shall henceforth assume that $E_{23} \simeq 0$. This assumption implies that the public good and the non-numeraire private good are taken to be independent in consumption, and all the adjustments of a change in the public good provision (at a given utility level) fall on the numeraire good.[15]

Totally differentiating (1)-(3) we obtain[16]

$$\begin{aligned} & [E_4 - \{\delta\tau_2 + (\gamma + \delta(1-\gamma))t(1+\tau_2)\}p_2 E_{24}]\ du \\ = & \ [\{-(1+t) + \delta + (\gamma + \delta(1-\gamma))t\}p_2 E_2 - (\delta - 1)p_2 R_2 + \\ & (1+t)p_2^2\{\delta\tau_2 + t(1+\tau_2)(\gamma + \delta(1-\gamma))\}E_{22} - \delta\tau_2 p_2^2 R_{22} - \delta\tau_3 p_2 p_3 R_{32}]d\tau_2 \qquad (4) \\ & +[(\delta-1)(1-\gamma)(1+\tau_2)p_2 E_2 + (1+\tau_2)p_2^2\{\delta\tau_2 + t(1+\tau_2)(\gamma+\delta(1-\gamma))\}E_{22}]dt \\ & -[(\delta-1)p_3 R_3 + \delta\tau_2 p_2 p_3 R_{23} + \delta\tau_3 p_3^2 R_{33}]d\tau_3 \end{aligned}$$

where $\delta = -E_3$ as mentioned before, is the marginal willingness to pay (MWP) for the public good. It should be noted that δ is not an exogenous parameter of our model as E_3 depends on both g and u both of which are endogenous.

It is well known that if a government's ability to raise revenue by lump-sum taxation is limited, the government must finance the public good, at the margin, by distorting taxes. Under such circumstances, $\delta > 1$ at the optimum. We assume this to be the case. We shall consider many possible values of this parameter within a reasonable range. A reasonable range for the equilibrium value of δ can be found by looking at the empirical literature on the marginal cost of public funds (MCPF) which an optimizing government should equate to the MWP. Estimates for MCPF vary widely. Fullerton (1991) produced estimates between 1 and 1.25 for the US; Ballard et al (1985) suggest a range of 1.15 to 1.50. For Pakistan, Ahmad and Stern (1991) estimated the range of MCPF to be 1.15 – 2.01. Although there is no consensus on the matter, it seems reasonable to view values below 1.25 as fairly normal, and values above 1.5 as uncommonly high (see Keen and Lahiri (1998)).

Defining the following elasticities

$$\begin{aligned} \eta_2 &= -\frac{\partial E_2}{\partial\{p_2(1+t)(1+\tau_2)\}} \cdot \frac{p_2(1+t)(1+\tau_2)}{E_2} = -\frac{E_{22}}{E_2} \cdot p_2(1+t)(1+\tau_2), \\ \epsilon_2^2 &= -\frac{\partial(E_2 - R_2)}{\partial\{p_2(1+\tau_2)\}} \cdot \frac{p_2(1+\tau_2)}{E_2 - R_2} = -\frac{(1+t)E_{22} - R_{22}}{E_2 - R_2} \cdot p_2(1+\tau_2), \\ \epsilon_2^3 &= \frac{\partial(-R_3)}{\partial\{p_2(1+\tau_2)\}} \cdot \frac{p_2(1+\tau_2)}{-R_3} = \frac{R_{32}}{R_3} \cdot p_2(1+\tau_2), \end{aligned}$$

[15] For the following quasi-linear direct utility function this approximation will hold:

$$u(c_1, c_2, g) = v(c_2) + \lambda_1 c_1 + f(g),$$

where c_i is the consumption of good i ($i = 1, 2$), and λ_1 is a given constant.

[16] We assume that the coefficient of du in the equation below is positive. This assumption is similar to the well-known 'Hatta condition'.

$$\epsilon_3^3 = -\frac{\partial(-R_3)}{\partial\{p_3(1+\tau_3)\}} \cdot \frac{p_3(1+\tau_3)}{-R_3} = -\frac{R_{33}}{R_3} \cdot p_3(1+\tau_3),$$
$$\epsilon_3^2 = \frac{\partial(E_2-R_2)}{\partial\{p_3(1+\tau_3)\}} \cdot \frac{p_3(1+\tau_3)}{E_2-R_2} = -\frac{R_{32}}{E_2-R_2} \cdot p_3(1+\tau_3),$$

equation (4) can be rewritten as

$$\begin{aligned} & [E_4 - \{\delta\tau_2 + (\gamma+\delta(1-\gamma))t(1+\tau_2)\}p_2E_{24}]\ du \\ = \ & p_2(1+\tau_2)E_2\left[(1-\gamma)(\delta-1) - \frac{\{\delta\tau_2 + t(1+\tau_2)(\gamma+\delta(1-\gamma))\}\eta_2}{(1+t)(1+\tau_2)}\right] dt \\ & -p_3R_3\left[\delta - 1 + \frac{\delta\tau_2\epsilon_2^3}{1+\tau_2} - \frac{\delta\tau_3\epsilon_3^3}{1+\tau_3}\right] d\tau_3 \\ & +\delta p_2(E_2-R_2)\left[\frac{\{\delta+(\gamma+\delta(1-\gamma))t-(1+t)\}E_2-(\delta-1)R_2)}{\delta(E_2-R_2)} - \frac{\tau_2\epsilon_2^2}{1+\tau_2}\right. \\ & \left. -\frac{\gamma+\delta(1-\gamma)}{\delta} \cdot \frac{tE_2\eta_2}{E_2-R_2} + \frac{\tau_3\epsilon_3^2}{1+\tau_3}\right] d\tau_2 \end{aligned} \quad (5)$$

Having obtained a general welfare equation, we shall now consider welfare implications of piecemeal policy reforms and derive optimal levels of second-best taxes.

3.1 Revenue-Neutral Reforms

In this subsection, we assume that large changes in the tax rates are not possible and the government can only carry out piece-meal reforms. Furthermore, given the importance of government revenue, we shall also assume that any reform will need to keep tax revenue unchanged at the initial equilibrium, We shall subdivide this exercise into two part. In the first, we shall assume that tariffs on final goods (τ_2) is unalterable and the government can only change consumption tax (t) and tariffs on intermediate inputs (τ_3). In the second, τ_3 is assumed to be unalterable. These two exercises are taken up below in turn.

3.1.1 Reform of t and τ_3:

We now consider a piecemeal reform of t and τ_3 such that government revenue (evaluated at the initial equilibrium values) does not change, *i.e.*

$$(1-\gamma)(1+\tau_2)p_2E_2dt = p_3R_3d\tau_3 \quad (6)$$

Substituting (6) into (5), we obtain

$$\begin{aligned} & [E_4 - \{\delta\tau_2 + (\gamma+\delta(1-\gamma))t(1+\tau_2)\}p_2E_{24}]\ \frac{du}{d\tau_3} \\ = \ & -\delta p_3R_3\left[\frac{\{\delta\tau_2 + (\gamma+\delta(1-\gamma))t(1+\tau_2)\}\eta_2}{\delta(1+t)(1+\tau_2)(1-\gamma)} + \frac{\tau_2\epsilon_2^3}{1+\tau_2} - \frac{\tau_3\epsilon_3^3}{1+\tau_3}\right]. \end{aligned} \quad (7)$$

A number of comments are in order. First, if the right hand side of (7) is negative, we can make a case for reducing tariffs on intermediate input imports and raising consumption tax. Second, since $-R_3 > 0$, when $\gamma = 0$ the sign of $du/d\tau_3$ does not depend on the level of δ, but the magnitude of it is proportional to δ. Finally, a higher initial value of t, τ_2, η_2 or ϵ_2^3 makes it more likely that $du/d\tau_3 > 0$, and a higher value of either τ_3 or ϵ_3^3 makes it more likely that $du/d\tau_3 < 0$. Later on we shall see if the above expression for $du/d\tau_3$ is positive or negative for the economy of Pakistan.

3.1.2 Reform of t and τ_2

In contrast to the analysis of the previous subsection, here we assume that tariffs on the intermediate inputs is unalterable, and consumption tax t and tariffs on good 2 τ_2 are subject to reforms. In particular, we consider a piecemeal reform of t and τ_2 such that government revenue (evaluated at the initial equilibrium values) does not change, *i.e.*

$$(1-\gamma)(1+\tau_2)p_2E_2dt = -p_2(E_2 - R_2)d\tau_2 \tag{8}$$

Substituting (8) into (5), we obtain

$$\begin{aligned}
&[E_4 - \{\delta\tau_2 + (\gamma + \delta(1-\gamma))t(1+\tau_2)\}p_2E_{24}]\,\frac{du}{d\tau_2} \\
&= \delta p_2(E_2 - R_2)\left[-\frac{\tau_2\epsilon_2^2}{1+\tau_2} + \frac{\tau_3\epsilon_3^2}{1+\tau_3} - \frac{\{\gamma+\delta(1-\gamma)\}t\eta_2}{\delta(1-\theta)} - \frac{\delta-1}{\delta}\right. \\
&\left. + \frac{\{\delta + (\gamma+\delta(1-\gamma))t - (1+t)\} - (\delta-1)\theta}{\delta(1-\theta)} + \frac{\{\delta\tau_2 + t(1+\tau_2)(\gamma+\delta(1-\gamma))\}\eta_2}{(1+t)(1+\tau_2)(1-\gamma)\delta}\right], \qquad (9)
\end{aligned}$$

where $\theta = R_2/E_2$ is the share of domestic production of good 2 in the domestic market.

Once again, if the above expression is negative, we can make a case for reducing tariffs on manufacturing imports and raising consumption tax. In contrast to the earlier piecemeal reform, here the sign of $du/d\tau_2$ does depend on the size of δ even when $\gamma = 0$. It is also to be noted that whereas a higher τ_3 or ϵ_3^2 is more likely to make $du/d\tau_2$ positive, a higher ϵ_2^2 is more likely to do the opposite. We shall come back to this exercise once we have presented the parameter estimates for Pakistan.

3.2 Optimal taxes

In this subsection we do not allow any of the tax instruments to be unalterable, and the only distortion in the economy is the government revenue constraint.

The optimal levels of t, τ_2 and τ_3 are obtained as

$$\left\{\epsilon_2^2 - \frac{\epsilon_2^3\epsilon_3^2}{\epsilon_3^3} - \frac{\eta_2}{1-\theta}\right\}\frac{\tilde{\tau}_2}{1+\tilde{\tau}_2} = \frac{\delta-1}{\delta}\left(\epsilon_3^3\left(1 - \frac{1-\gamma}{1-\theta}\right) + \epsilon_3^2\right), \tag{10}$$

$$\frac{\tilde{\tau}_3}{1+\tilde{\tau}_3} = \frac{\tilde{\tau}_2 \epsilon_2^3}{(1+\tilde{\tau}_2)\epsilon_3^3} + \frac{(\delta - 1)}{\delta \epsilon_3^3}, \tag{11}$$

$$\tilde{t} = -\frac{\delta \eta_2 \tilde{\tau}_2}{(1+\tilde{\tau}_2)\xi} + \frac{(1-\gamma)(\delta-1)}{\xi}, \tag{12}$$

where $\theta = R_2/E_2$, as stated before, is the share of domestic production of good 2 in the domestic market,[17] and $\xi = \eta_2(\gamma + \delta(1-\gamma)) - (1-\gamma)(\delta - 1)$.

The optimal value of the consumption tax rate t has two components as can be seen from (12). The second term on the right hand side of (12) is due to the revenue-raising objective of the government and this is equal to zero when $\delta = 1$.[18] The first term corrects distortion introduced on the consumption side by a non-zero value of τ_2: if $\tilde{\tau}_2$ is positive (negative), this component is negative (positive). When $\delta \simeq 1$, the optimal values of t and τ_2 are of the opposite sign. The optimal value of τ_3 also has two components. The second term on the right hand side of (11) is present once again due to the revenue-raising motive of the government. The first term term this time has the same sign as $\tilde{\tau}_2$. This is because τ_3 which is tariff on intermediate inputs, cannot correct distortions on the consumption side, and instead does so on the production side. A higher value of τ_2 moves resources into the production of good 2 by raising the producers' price of this good. A higher value of τ_3 then corrects this distortion by raising the productions costs in sector 2. It can be easily verified that when $\delta = 1$, all the optimal values are zeroes, as one would expect. Once we have presented the parameter estimates for Pakistan, we shall return to these expressions for optimal taxes.

4 An application to Pakistan

In sections 2 and 3 we developed and analyzed a theoretical model which is based on stylised facts related to the economy of Pakistan. The purpose of the present section is to quantify, for the case of Pakistan, the optimal second-best levels of the three policy instruments, the formulae of which have been obtained in subsection 3.2 (see (10)-(12)). We shall also derive empirically the signs of piecemeal policy reform exercises conducted in subsections 3.1.1 and 3.1.2 (see (7) and (9)). In order to be able to do so, we shall need to estimate a number of elasticities, *viz.* elasticity of import demand of intermediate inputs with respect to own price, ϵ_3^3, and with respect to the domestic price of the importables, ϵ_2^3; elasticity of import demand of good 2 (importables) with respect to own price, ϵ_2^2, and with respect to the domestic price of intermediate inputs, ϵ_3^2; and the own price elasticity of consumption demand for the importables, η_2.[19]

As for η_2, we shall rely on estimates obtained by Ahmed, Ludlow and Stern (1988).

[17] It can be easily shown that $\theta = (\eta_2 - \epsilon_2^2)/(\phi_2 - \epsilon_2^2)$, where ϕ_2 is the price elasticity of output for good 2.
[18] For reasonable values of the parameters ξ is expected to be positive.
[19] See table 2 for the precise definitions of importables and intermediate inputs.

They computed uncompensated price elasticity of demand for several category of goods from a modified Linear Expenditure System using a household-level data for 1976. For goods which could be regarded as importables the estimated elasticities are 0.65 (tea), 0.75 (edible oils) and 1.08 (other non-food). In the light of these estimates we take η_2 as 0.90 to be a reasonable approximation for the own price elasticity of consumption demand for the importables. As for the other elasticities, we shall estimate them using regression analysis to annual time series data for the period 1975-2000.[20] In particular, we shall estimate the following two equations:

$$\begin{aligned} lnY &= \alpha_1 + \alpha_2\ ln(p_2(1+\tau_2))/p_1)_{(-1)} + \alpha_3\ ln(p_3(1+\tau_3))/p_1) \\ &+ \alpha_4\ ln(W/p_1) + \alpha_5\ lnX + \alpha_6\ lnY_{(-1)}. \qquad (13) \\ lnZ &= \beta_1 + \beta_2\ ln(p_2(1+\tau_2))/p_1) + \beta_3\ ln(p_3(1+\tau_3))/p_1)_{(-1)} \\ &+ \beta_4\ ln(W/p_1) + \beta_5\ lnX, \qquad (14) \end{aligned}$$

where Y and Z are the imports of respectively intermediate inputs and good 2; W is unit cost of labour; X is real gross domestic products (GDP); and the subscript (-1) denotes a lag of one period.[21]

It is well known that time series data can exhibit non-stationarity and that regression estimates based on such data can be unreliable. However, with only 26 years of data, the scope for elaborate time series modelling is fairly limited. We have, in this paper, restricted ourselves to estimation of regression equations with variables expressed in levels. The estimation techniques are ordinary least squares (OLS), instrumental variables (IV) and seemingly unrelated regression (SUR). The choice of IV is dictated by the consideration that one of the explanatory variables, namely X, is likely to be endogenous. The regression results are given in tables 3, 4 and 5.

The regression results perform well in terms of all the diagnostic tests. For equation (14), the D-W value suggests that the error term is autocorrelated, and these have been corrected by using AR(1) and/or AR(2) terms (see table 4).

The own-price elasticities — which are the coefficients of the price variables in the regression equation — are expected to be negative and they are. These are also statistically significant. The cross-price elasticities (lagged by one period) are also always of the right (positive) sign and are significant. The coefficients of W/p_1 and X are, as expected, positive (with one exception), though the coefficients for the former are not significant in (14). It is also to be noted that the lagged endogenous variable in (13) is significant in the second OLS estimation in table 3. It becomes insignificant when the equation is estimated using IV method which also makes the coefficient for cross-price elasticity insignificant. Considering everything, we believe that the best estimate for the import demand of consumables is provided by the second equation in table 4, and the best regression estimate of the import demand of intermediate inputs is given by the second equation of table 3. However, there

[20] There is a significant empirical literature on the estimation of demand elasticities in international trade (see, for example, Goldstein and Khan (1985) and Panagariya *et al* (2001)). However, the bulk of the literature deals with the estimation of the demand elasticities of exports.

[21] See table 2 for details.

is potential for obtaining more efficient estimates as the error terms in the two equations may be contemporaneously correlated. Allowing for this possibility, we estimate our chosen equations using SUR method. The estimates are given in table 5. Of the two sets presented there, we choose the second set for computing elasticities.

We shall now use these estimates to compute the optimal values of the instruments under various scenarios, and the effects of the two piecemeal policy reform exercises. It is to be noted that our chosen regression for demand for intermediate inputs has lagged endogenous variables and, therefore, to compute long-run values of the elasticities, the estimated coefficients need to be divided by the factor 1 minus the coefficient of the lagged endogenous variable. Therefore, for the chosen equations we have $\epsilon_3^3 = 1.2732$, $\epsilon_2^3 = 0.48$, $\epsilon_3^2 = 0.2411$, and $\epsilon_2^2 = 0.5707$, and as mentioned before, following Ahmed, Ludlow and Stern (1988) we consider $\eta_2 = 0.90$. Furthermore, other parameters, required to carry out the piecemeal reform exercises, are taken to be their current actual values.[22] We also compute that $\gamma = 0.2$ and $\theta = 0.45$. However, around these chosen values we carry out limited sensitivity analysis.

The optimal values of the three instruments are given in tables 6-9 for different values for the parameter δ (MCPF). The four tables differ in that sensitivity analysis is carried out with respect to θ, γ, η_2 and ϵ_3^3 respectively in tables 6 7, 8, and 9.

First consider table 6, which gives optimal values for tariff/tax instruments when government uses these instruments to raise revenues to provide a public good. Table 6 provides the optimal values of these instruments when $\eta_2 = 0.9$ and $\gamma = 0.2$. To recall, these parameters are respectively the own price elasticity of consumption demand for the importables, and the fraction of consumption tax revenue that is not collected by the government. Given these values of η_2 and γ we consider optimal values of tariff/tax instruments by allowing θ (share of domestic production of good 2 in the domestic market) to take four different values: 0.4, 0.45, 0.5 and 0.55. With each of these values, table 6 provides optimal values of tariff/tax instruments for a range of values of the parameter δ (MCPF). The following pattern emerges: (i) all optimal taxes increase as δ increases, (ii) irrespective of the choice

[22]The current values for tariff on final goods (τ_2), tariff and on intermediate inputs (τ_3) are based on values reported in three different sources. A Government of Pakistan publication (Government of Pakistan (2002)) reports import duty on (i) 'consumer goods' at 16%, on (2) 'raw materials for consumer goods' at 16%, on (3) 'capital goods' at 20% and on (4) 'raw materials on capital goods' at 20% in 2000-2001. These figures are based on imports and duty collection at Karachi customs. The respective shares of the imports in these categories are 16%, 60%, 16% and 8%. The WTO secretariats Trade Policy Review of Pakistan (WTO (2001)) reports an average tariff of 20.4% in 2001-2002. It does not provide separate estimates for tariff on final goods and tariffs on intermediate inputs/raw materials. An ongoing World Bank Study (The World Bank (2003)) estimates the average unweighted tariff in 2003 to be 17.3%. These tariffs may have to be adjusted upwards if the affect of some of the income withholding taxes, which are akin to import duties, are also factored in. The order of magnitude of these taxes is not easy to estimate but 1-2 percentage point will not be an unreasonable estimate. With this as a background, our choice of $\tau_2 = 0.185$ and of $\tau_3 = 0.16$ is likely to be a reasonable approximation of the current values of these taxes. The current value of consumption tax t is obtained by noting that the General Sales Tax (which is a value-added tax) is 15%, to which we added another 4.5% which is approximately the current ratio of excise tax to the General Sales Tax. The assumption here is that excise tax is uniformly applied to all goods on which the sales tax is applicable. This assumption is not realistic but one we have applied consistently in calculating the sales tax inclusive prices of final goods.

of δ, optimal trade tariffs increase monotonically with θ, and (iii) irrespective of the choice of δ, optimal consumption tax decreases monotonically with θ.

The pattern of results (i)-(iii) is intuitively plausible. The first result implies that as marginal willingness to pay for a public good increases, taxes which allow the provision of the public good, have to be increased correspondingly. The second result implies that as the share of domestic production of good 2 in the domestic market increases and that of imported goods decrease, the optimal tariffs on final goods have to increase because of the shrinkage of the base of trade taxes.[23] The corollary of this result is the third result which says that as the base of the consumption tax increases, the optimal consumption tax decreases.

We note that for an intermediate value of δ (1.20-1.25) and of θ (0.45), optimal tariff on intermediate good is a little higher than the actual value of it (16%), but the optimal tax on final good is considerably lower than the actual average tax on final goods which is about 18.5%.

Next consider table 7. This table also provides optimal values of tax/tariff instruments but differs from table 6 in that γ is not held fixed at 0.2 but allowed to take four different values (0.00, 0.10. 0.15, and 0.20). On the other hand θ is now held fixed at 0.45, together with η_2 which is held fixed at 0.9 — the same value as in table 6. The simulations suggest the following pattern: (i) all taxes increase with δ (as in table 6), (ii) optimal trade taxes decrease monotonically with γ, and (iii) optimal consumption tax increase monotonically with γ.

Again the results are, as we would expect. The reason why optimal taxes increase with δ was explained above. Results (ii) and (iii) suggest that as the share of the government in total sales tax declines, consumption tax is less effective as a means of raising revenue and thus greater reliance ought to be placed on trade taxes and less on consumption tax.

Turning to table 8, which provides simulation with θ held at 0.45 and γ at 0.2, and η_2 allowed to vary between 0.7 and 1.0, we note the following pattern: (i) all taxes increase with δ (as in table 6 and 7), (ii) all optimal taxes decrease monotonically with η_2. This is because as consumption elasticity rises, the effect of an increase in either t or τ_2 on tax revenue will be larger. Thus the government can set these two tax rates at a lower level when η_2 rises. For reasons explained above (see the discussion following (12)), the optimal value of τ_3 is positively related to that of τ_2.

As in the previous simulations, in table 9, we find that for all four different values of ϵ_3^3 — viz., 1.2732 (our estimated value), 1.50, 1.75 and 1.85 — all three optimal taxes increase with δ. The optimal values of τ_3 and t decreases with ϵ_3^3, but that of τ_2 increases with it. In other words, as the own-price elasticity of intermediate inputs increases, the government should depend less on tariffs on intermediate inputs and more on tariffs on the final importables for raising revenue. This is because a small decrease in τ_3 has a bigger positive effect on the level of imports of intermediate inputs (and thus on tax revenue) when

[23] The increase in tariffs on intermediate inputs is related to the increase in tariffs on final goods (see discussion following (12)).

ϵ_3^3 is bigger rather than smaller. The reason why optimal value of t is negatively related to that of τ_2 has been explained above (see the discussion following (12)).

Looking at all the optimal taxes overall, it can be broadly concluded that for intermediate values of δ around the range 1.20-1.30, optimal levels of t and τ_3 are roughly comparable to their actual current levels (16% and 19.5% respectively), but the optimal value of τ_2 is considerably lower than its actual level (18.5%). Thus, there is still considerable scope for further liberalization of tariffs of final goods.

Finally, as far as the revenue-neutral reforms are concerned (see subsections (3.1.1) and (3.1.2)), we find that in all our simulation runs, the right hand side of (7) is always positive. This suggests that a further decrease, from the present level, in current tariffs on intermediate inputs τ_3 and an associated increase in consumption tax rate t keeping tax revenue constant, will be welfare reducing. However, the right hand side of (9) is positive only for sufficiently high values of δ. In other words, for sufficiently low values of MCPF, a decrease in current tariffs on final goods τ_2 and an associated increase in consumption tax rate t keeping tax revenue constant, will be welfare increasing, but not so if MCPF is high enough. The critical value of δ (MCPF) below which the right hand side of (9) is negative — we shall denote this critical value by $\bar{\delta}$ — depends on some of the parameters such as γ and θ that we have been changing in our simulation exercises. For the benchmark scenario — i.e., when $\theta = 0.45$, $\eta_2 = 0.9$, $\gamma = 0.2$, $\epsilon_3^3 = 1.2732$ — the value of $\bar{\delta}$ is 1.17. Since the right hand side of (9) does not depend on ϵ_3^3 at all, this parameter does not affect $\bar{\delta}$ at all. Furthermore, whereas the third term on the right hand side of (9) decreases with η_2, the last term increases with it. The net effect is that $\bar{\delta}$ is insensitive to changes in η_2 as can be seen from the last row of table 8. However, as can be seen from the last rows of tables 6 and 7, $\bar{\delta}$ is increasing in θ and decreasing in γ. A higher value of θ means a larger share of domestic firms in the domestic market of importables implying a lower import level and thus the tax base for tariffs. Thus, as the level of θ increases, τ_2 becomes less effective as an instrument for raising revenue, and the range of δ over which a shift from tariffs on final goods to consumption tax is welfare improving also increases, i.e., the value of $\bar{\delta}$ goes up. Similarly, when the collection of consumption tax revenue becomes relatively easier — i.e., when the value of γ goes down — consumption tax becomes a more effective method for raising revenue and the value of $\bar{\delta}$ increases.

5 Conclusion

Although trade policy reform has been on the agenda at international negotiations for a long time, and many GATT Rounds have gone by, it is only recently that developing countries in general, and Pakistan in particular, have started bringing down trade barriers. There are many problems with such reforms. First, trade barriers in the developed world for imports from the developing countries make it difficult for the governments in the developing countries to 'sell' those reforms at home. Tariffs are easy to collect (relative to consumption tax) and serves to satisfy domestic political lobbies. Considering serious budgetary difficulties and lobbying activities in most developing countries, this is an important impediment to trade policy reform.[24] Lobby groups however have disparate interests. For example, in Pakistan, concern for large scale lay off of workers in Pakistan Steel Mills, was an important impediment in lowering the very high import tariffs on steel, an intermediate input into the manufacturing industry. On the other hand business groups with investments in import substituting industries, which use intermediate inputs, have a strong interest in lower tariffs on intermediate inputs and higher tariffs on consumables. It is, therefore, instructive to examine the structure of various taxes when the ability of the government to change taxes, is limited, *i.e.* some taxes are unalterable under pressure from interest groups, and when the government faces serious revenue constraint.

There is another type of reform that many international institutions are pushing the developing countries to adopt. Developing countries are being persuaded to move away from distortionary tariffs to non-distortionary value added taxes on consumption, in order to raise tax revenue, *i.e.* the developing countries are under pressure to introduce revenue-neutral tax reforms.

In this paper, we have developed a stylised theoretical model for the economy of Pakistan and then based on the model we have estimated optimal values of second-best taxes as well as analyzed the efficacy of revenue-neutral piecemeal tax reforms. The second part of our analysis, *viz.* the estimation part, has a number of limitations. The most important one arises due to the fact that the time series data is only available for 26 years and this limits the applicability of some of the modern time series econometrics techniques to the data. However, we are able to draw certain conclusions which are rather suggestive. The first set of conclusions is drawn from the revenue-neutral reform exercise. Two types of revenue neutral reforms were considered. In the first, the tariff on final good was considered unalterable at its present level but the tariff on intermediate good and the consumption tax were alterable. Our estimates suggest that reducing tariff on intermediate goods and increasing consumption tax would not be welfare improving. This is an important conclusion considering that lowering of tariff on intermediate inputs is regarded in many quarters as essential if domestic products are to compete on equal footing with imports.

In the second revenue-neutral reform exercise, the tariff on intermediate good was unalterable at its present level and the tariff on final good and the consumption tax were alterable. Our conclusion here is that the welfare affect of lowering of tariff on final good and raising consumption tax from their present levels depends on the marginal willingness to pay for the public good (MWP). For relatively low values of MWP, lowering of tariffs and the corresponding increase in consumption tax to maintain revenue unchanged, would be welfare improving but this substitution would not be welfare improving for high values of MWP. The MWP is sometimes estimated by equating it with the marginal cost of public funds. For Pakistan the estimated range of MCPF is quite wide and this does not allow us to state in a clear-cut fashion whether the substitution would be welfare improving or not. However, a somewhat more clear-cut conclusion that does follow from our analysis is that if a piecemeal reform of taxes in the form of moving away from tariffs to consumption is being considered, then it is important to distinguish between different types of tariffs. In

[24] See Rodrik (1992) for a fuller discussion on the limits to trade policy reforms.

particular, if at all, it is the tariff on final goods, and not that on intermediate inputs, that should be substituted by consumption tax.

The second set of conclusions emerge from the optimal tax and tariff calculations. The optimal tariff calculations are reported for a set of benchmark parameter values and for a range around these benchmark values. These exercises suggest that if the marginal willingness to pay for the public good is neither too high nor too low, then: (1) the optimal values of tariffs on intermediate goods and consumption tax are comparable with the actual values of these taxes (16 percent and 19.5 percent respectively), and (2) the optimal tariff on final good is considerably lower than the actual value of 18.5 percent. These estimates suggest that further lowering of tariff on intermediate goods may not be the best course to follow but there is considerable scope for reducing tariff on final goods.

Table 1: Definitions of Variables in the Theoretical Model

Good	Definition
Good 1	Numeraire good
Good 2	Importable final good
Good 3	Intermediate good
g	Level of public good provision
u	Utility level of the representative consumer
p_1	International price of good 1
p_2	International price of good 2
p_3	International price of good 3
τ_2	Ad-valorem import tariff on good 2
τ_3	Ad-valorem import tariff on good 3
t	Ad-valorem value added tax on good 2
T	Tax revenue
ϵ_2^2	Own price elasticity of import demand for good 2 (final good)
ϵ_3^2	Elasticity of import demand of good 2 (final good) with respect to the price of good 3 (intermediate good)
ϵ_2^3	Elasticity of import demand of good 3 (intermediate good) with respect to the price of good 2 (final good)
ϵ_3^3	Own price elasticity for import demand of good 3 (intermediate good)
δ	Marginal willingness to pay (MWP) for the public good which is equal to marginal cost of public funds
$\bar{\delta}$	The critical value of δ below which the right hand side of (9) is negative.
η_2	Own price elasticity of demand of good 2 (final good)
γ	Fraction of consumption tax revenue that the government is unable to collect
θ	Share of domestic production of good 2 (final good) in the domestic market

Table 3: Import demand for Intermediate inputs

No of observations: 26 (1975-2000)

Dependent variable: $\ln Y$	1 (OLS)	2 (OLS)	3 (IV)
C	0.3018 (0.41, 0.69)	-0.1745 (0.23, 0.82)	-0.1495 (0.19, 0.85)
$\ln\ (p_2(1+\tau_2)/p_1)_{(-1)}$	0.2526 (1.14, 0.27)	0.4069 (1.8068, 0.08)	0.3083 (1.28, 0.22)
$\ln\ p_3(1+\tau_3)/p_1$	-1.1830 (6.64, 0.00)	-0.9341 (4.32, 0.00)	-1.1294 (4.67, 0.00)
$\ln\ W/p_1$	0.7128 (2.15, 0.04)	0.5836 (1.81, 0.08)	0.9110 (2.07, 0.05)
ln X	1.3915 (17.53, 0.00)	0.9904 (4.30, 0.00)	1.3370 (4.73, 0.00)
Ln $Y_{(-1)}$		0.3119 (1.8417, 0.08)	0.0711 (0.35, 0.73)
R^2	0.9593	0.9652	0.9613
DW	1.7407	2.2005	1.8895
Log likelihood	19.1963	21.2328	
F-statistic	123.7753	110.9766	100.8636

Note:
1. The first figure within the parenthesis is the value for the t-statistic and the second gives the probability of not rejecting the null hypothesis $\beta_i = 0$.
2. The subscript (-1) to the variables denotes backward lags in those variables.

Table 4: Import demand for consumer goods

No of observations: 26 (1975-2000)

Dependent variable: ln Z	1 (OLS)	2(OLS)	3 (OLS)	4(IV)
C	3.2845 (3.26, 0.00)	3.3514 (3.71, 0.00)	3.2880 (3.74, 0.00)	3.1383 (3.57, 0.00)
$\ln p_2(1+\tau_2)/p_1$	-0.4128 (1.61, 0.12)	-0.6953 (2.31,0.03)	-0.7240 (2.61, 0.02)	-0.7090 (2.54, 0.02)
$\ln\,(p_3(1+\tau_3)/p_1)_{(-1)}$	0.1538 (0.94, 0.35)	0.3552 (2,13, 0.05)	0.3260 (2.01, 0.06)	0.3169 (1.95, 0.07)
$\ln W/p_1$	-0.0611 (0.19, 0.85)	0.0343 (0.10, 0.92)	0.1275 (0.41, 0.68)	0.1435 (0.46, 0.65)
$\ln X$	1.0417 (10.00, 0.00)	1.0423 (11.17, 0.00)	1.0552 (11.94, 0.00)	1.0655 (11.89, 0.00)
AR(1)		0.1449 (0.59, 0.56)		
AR(2)		-0.4423 (1.94, 0.07)	-0.4374 (1.97, 0.06)	-0.4339 (1.95, 0.07)
R^2	0.9095	0.9057	0.9040	0.9040
DW	1.6412	1.9812	1.7562	1.7749
Log likelihood	17.0667	17.0358	16.8277	
F-statistic	52.7617	27.2074	33.9133	33.9923

Table 5: SUR Estimates

No of observations: 26 (1975-2000)

Estimation #	1	1a	2	2a
Dependent variable:	ln Y	ln Z	ln Y	ln Z
C	-0.1255 (-0.19, 0.84)	2.8030 (3.69, 0.00)	-0.1425 (0.22, 0.82)	2.9301 (3.76. 0.00)
ln $p_2(1+\tau_2)/p_1$		-0.5767 (2.38, 0.02)		-0.5707 (2.28, 0.03)
ln $(p_2(1+\tau_2)/p_1)_{(-1)}$	0.3446 (1.81, 0.08)		0.3565 (1.86, 0.07)	
ln $p_3(1+\tau_3)/p_1$	-0.9440 (5.18, 0.00)		-0.9358 (5.08, 0.00)	
ln $(p_3(1+\tau_3)/p_1)_{(-1)}$		0.2107 (1.51, 0.13)		0.2411 (1.68, 0.10)
ln W/p_1	0.6045 (2.21, 0.03)	0.2199 (0.81, 0.42)	0.5930 (2.16, 0.04)	0.1434 (0.49, 0.63)
ln X	1.0589 (5.50, 0.00)	1.0967 (14.12, 0.00)	1.0560 (5.38, 0.00)	1.0830 (13.45, 0.00)
ln $Y_{(-1)}$	0.2550 (1.79, 0.08)		0.2650 (1.84, 0.07)	
AR(1)				0.1138 (0.53, 0.60)
AR(2)		-0.3788 (1.91, 0.06)		0.3848 ((1.94, 0.06)
R^2	0.9649	0.9013	0.9649	0.9030
DW	2.1878	1.8634	2.1897	2.0132
S.E.	0.1225	0.1405	0.1224	0.1433

Table 6: Optimal taxes (in percent)

$\delta\downarrow$	$\tilde{\tau}_2$				$\tilde{\tau}_3$				$\tilde{t}$			
$\theta\rightarrow$	0.40	0.45	0.50	0.55	0.40	0.45	0.50	0.55	0.40	0.45	0.50	0.55
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
1.05	0.9	1.4	1.9	2.4	4.2	4.5	4.7	4.9	3.6	3.0	2.5	2.0
1.10	1.7	2.7	3.7	4.7	8.4	8.9	9.3	9.7	7.2	6.0	5.0	4.0
1.15	2.4	4.0	5.4	6.9	12.5	13.2	13.9	14.5	10.8	9.1	7.5	6.0
1.20	3.1	5.1	7.1	8.9	16.6	17.6	18.5	19.4	14.4	12.2	10.0	8.1
1.25	3.7	6.2	8.6	10.9	20.6	21.8	23.0	24.2	18.1	15.3	12.6	10.1
1.30	4.3	7.2	10.1	12.8	24.5	26.1	27.6	29.0	21.9	18.4	15.2	12.2
1.35	4.9	8.2	11.4	14.6	28.4	30.3	32.0	33.7	25.6	21.6	17.8	14.3
1.40	5.4	9.1	12.7	16.4	32.3	34.4	36.5	38.5	29.4	24.8	20.5	16.4
1.45	5.9	10.0	14.0	18.0	36.0	38.5	41.0	43.3	33.3	28.0	23.1	18.6
1.50	6.4	10.8	15.2	19.6	39.8	42.6	45.4	48.0	37.1	31.2	25.8	20.7
1.55	6.8	11.5	16.3	21.2	43.5	46.7	49.7	52.7	41.0	34.5	28.5	22.9
1.60	7.2	12.3	17.4	22.7	47.1	50.6	54.1	57.5	45.0	37.9	31.3	25.1
1.65	7.6	13.0	18.5	24.1	50.7	54.6	58.4	62.2	48.9	41.2	34.0	27.3
1.70	8.0	13.7	19.5	25.4	54.2	58.5	62.7	66.9	53.0	44.6	36.8	29.6
1.75	8.3	14.3	20.4	26.8	57.7	62.4	67.0	71.5	57.0	48.0	39.6	31.9
$\bar{\delta}$	1.07	1.17	1.29	1.43								

Note: $\eta_2 = 0.9$, $\gamma = 0.2$, $\epsilon_3^3 = 1.2732$

Table 7: Optimal taxes (in percent)

$\delta\downarrow$	$\tilde{\tau}_2$				$\tilde{\tau}_3$				$\tilde{t}$			
$\gamma\rightarrow$	0.00	0.10	0.15	0.20	0.00	0.10	0.15	0.20	0.00	0.10	0.15	0.20
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
1.05	3.4	2.4	1.9	1.4	5.3	4.9	4.7	4.5	2.1	2.6	2.8	3.0
1.10	6.7	4.7	3.7	2.7	10.5	9.7	9.3	8.9	4.2	5.1	5.6	6.0
1.15	9.9	6.9	5.4	4.0	15.8	14.5	13.9	13.2	6.4	7.7	8.4	9.1
1.20	13.0	8.9	7.0	5.1	21.2	19.3	18.5	17.6	8.6	10.4	11.3	12.2
1.25	16.1	10.9	8.5	6.2	26.5	24.2	23.0	21.8	10.8	13.0	14.2	15.3
1.30	19.0	12.8	9.9	7.2	31.9	28.9	27.5	26.1	13.0	15.7	17.1	18.4
1.35	21.9	14.6	11.3	8.2	37.4	33.7	32.0	30.3	15.3	18.4	20.0	21.6
1.40	24.6	16.3	12.6	9.1	42.8	38.5	36.4	34.4	17.6	21.2	23.0	24.8
1.45	27.3	18.0	13.8	10.0	48.3	43.2	40.9	38.5	19.9	24.0	26.0	28.0
1.50	30.0	19.6	15.0	10.8	53.8	48.0	45.3	42.6	22.2	26.8	29.0	31.2
1.55	32.5	21.1	16.1	11.5	59.3	52.7	49.6	46.7	24.6	29.6	32.1	34.5
1.60	35.0	22.6	17.2	12.3	64.8	57.4	54.0	50.6	27.0	32.4	35.2	37.9
1.65	37.5	24.0	18.2	13.0	70.4	62.1	58.3	54.6	29.4	35.3	38.3	41.2
1.70	39.8	25.4	19.2	13.7	76.0	66.8	62.6	58.5	31.8	38.3	41.4	44.6
1.75	42.1	26.7	20.2	14.3	81.7	71.5	66.8	62.4	34.3	41.2	44.6	48.0
$\bar{\delta}$	1.46	1.32	1.25	1.17								

Note: $\eta_2 = 0.9$, $\theta = 0.45$, $\epsilon_3^3 = 1.2732$

Table 8: Optimal taxes (in percent)

$\delta\downarrow$	$\tilde{\tau}_2$				$\tilde{\tau}_3$				$\tilde{t}$			
$\eta_2\rightarrow$	0.70	0.80	0.90	1.00	0.70	0.80	0.90	1.00	0.70	0.80	0.90	1.00
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
1.05	2.1	1.7	1.4	1.2	4.7	4.6	4.5	4.4	3.7	3.3	3.0	2.7
1.10	4.0	3.2	2.7	2.3	9.4	9.1	8.9	8.7	7.4	6.7	6.0	5.5
1.15	5.9	4.7	4.0	3.4	14.1	13.6	13.2	13.0	11.3	10.1	9.1	8.2
1.20	7.6	6.1	5.1	4.4	18.8	18.0	17.6	17.2	15.4	13.6	12.2	11.0
1.25	9.3	7.4	6.2	5.3	23.4	22.5	21.8	21.4	19.6	17.2	15.3	13.7
1.30	10.9	8.7	7.2	6.2	28.0	26.9	26.1	25.5	24.0	20.9	18.4	16.4
1.35	12.4	9.9	8.2	7.0	32.6	31.2	30.3	29.6	28.5	24.6	21.6	19.2
1.40	13.8	11.0	9.1	7.8	37.1	35.5	34.4	33.7	33.3	28.4	24.8	21.9
1.45	15.2	12.0	10.0	8.5	41.6	39.8	38.5	37.7	38.2	32.3	28.0	24.7
1.50	16.5	13.0	10.8	9.2	46.2	44.0	42.6	41.6	43.3	36.3	31.2	27.4
1.55	17.8	14.0	11.5	9.8	50.6	48.3	46.7	45.5	48.6	40.4	34.5	30.1
1.60	19.0	14.9	12.3	10.4	55.1	52.4	50.6	49.4	54.2	44.6	37.9	32.9
1.65	20.1	15.8	13.0	11.0	59.5	56.6	54.6	53.2	60.0	48.9	41.2	35.6
1.70	21.2	16.6	13.7	11.6	64.0	60.7	58.5	57.0	66.1	53.2	44.6	38.4
1.75	22.3	17.4	14.3	12.1	68.4	64.8	62.4	60.7	72.4	57.7	48.0	41.1
$\bar{\delta}$	1.19	1.18	1.17	1.16								

Note: $\theta = 0.45$, $\gamma = 0.2$, $\epsilon_3^3 = 1.2732$

Table 9: Optimal taxes (in percent)

$\delta\downarrow$	$\tilde{\tau}_2$				$\tilde{\tau}_3$				$\tilde{t}$			
$\epsilon_3^3\rightarrow$	1.2732	1.50	1.75	1.85	1.2732	1.50	1.75	1.85	1.2732	1.50	1.75	1.85
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
1.05	1.4	1.9	2.4	2.6	4.5	3.9	3.5	3.3	3.0	2.5	2.0	1.8
1.10	2.7	3.6	4.7	5.1	8.9	7.8	6.9	6.6	6.0	5.1	4.0	3.6
1.15	4.0	5.3	6.8	7.4	13.2	11.5	10.2	9.7	9.1	7.7	6.1	5.4
1.20	5.1	6.9	8.9	9.7	17.6	15.2	13.4	12.8	12.2	10.3	8.1	7.3
1.25	6.2	8.4	10.9	11.9	21.8	18.8	16.5	15.7	15.3	12.9	10.2	9.1
1.30	7.2	9.8	12.7	14.0	26.1	22.3	19.5	18.6	18.4	15.5	12.3	11.0
1.35	8.2	11.1	14.5	16.0	30.3	25.8	22.4	21.4	21.6	18.2	14.4	12.9
1.40	9.1	12.4	16.3	17.9	34.4	29.2	25.3	24.1	24.8	20.9	16.6	14.8
1.45	10.0	13.6	17.9	19.7	38.5	32.5	28.1	26.7	28.0	23.6	18.7	16.8
1.50	10.8	14.7	19.5	21.5	42.6	35.8	30.8	29.3	31.2	26.3	20.9	18.7
1.55	11.5	15.8	21.0	23.2	46.7	39.0	33.5	31.8	34.5	29.1	23.1	20.7
1.60	12.3	16.9	22.5	24.9	50.6	42.2	36.1	34.2	37.9	31.9	25.3	22.7
1.65	13.0	17.9	23.9	26.5	54.6	45.3	38.6	36.6	41.2	34.7	27.6	24.7
1.70	13.7	18.9	25.2	28.0	58.5	48.3	41.1	38.9	44.6	37.6	29.8	26.7
1.75	14.3	19.8	26.5	29.5	62.4	51.3	43.5	41.1	48.0	40.5	32.1	28.7

Note: $\theta = 0.45$, $\gamma = 0.2$, $\eta_2 = 0.9$

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