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Joint Production and Taxation

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DISCUSSION PAPERS

Joint Production and Taxation

CENTRE OF PLANNING AND ECONOMIC RESEARCH

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ABSTRACT

In this paper we extend Harberger's analysis for tax incidence by allowing for joint production. Our analysis shows that Harberger's results may change considerably depending on relative commodity intensities in value, and physical terms. If they are the same then most of Harberger's qualitative results carry through although quantitatively they change. In this framework, we also consider the effects of commodity taxes on income distribution, commodity prices, and output composition.

1. INTRODUCTION

Since the publication of Harberger's seminal article on the incidence of the corporation income tax, many authors have extended his analysis in various ways.[1] Most of these extensions have been erected on the technological foundations of the model set up by Harberger. Although most of the assumptions of the original model have been modified by several authors, it seems that one important assumption of Harberger's model has drawn rather little attention. Harberger assumed, among others, that his corporate sector produced a good which was distinctively different from the commodity produced by the non-corporate sector. This assumption was first questioned by Ebrill and Hartman (1982), and more recently by Gravelle and Kotlikoff (1989). These authors provide evidence which suggests that the corporate and the non-corporate sectors of an economy usually produce a great spectrum of similar commodities. As Gravelle and Kotlikoff(1989) note for the U.S.A.: "There appear to be very few goods that are not produced by firms subject to the corporate income tax." Moreover, it is well-known that the corporate income tax is imposed according to the legal status of a firm, and not according to its productive activity. The model, therefore, developed by Harberger needs modification to take into account this reality.

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[1]. For a comprehensive review of the literature on tax incidence see, Atkinson and Stiglitz (1980), and Kotlikoff and Summers (1987).

It is clear from the above that one needs to assume that each sector, the corporate and the non-corporate, produces both commodities produced in the economy. Ebrill and Hartman (1982) point out that the Harberger model cannot be easily modified to permit non-corporate production of the corporate good. As they argue, if there is even a single, equally efficient non-corporate producer of the corporate good, corporate production will entirely collapse as a result of the imposition of the corporate tax. To tackle this problem, Gravelle and Kotlikoff (1989), employ a Mutual Production Model(MPM), which uses three factors of production, capital, labor, and managerial input. This is a two-good model with corporate and non-corporate production of both goods. The analysis in this framework leads to results for tax incidence which are quite different from those of Harberger's.

The purpose of this paper is to examine the incidence of the corporate income tax in the framework of the Harberger model, by allowing for production of both commodities by each sector. We assume that in a two-sector economy, each sector produces jointly two goods. Although the assumption of joint production may not fully reflect the fact that each sector produces more than one good, at a very high level of aggregation, as the two-sector economy, this assumption may not be very far from reality. In fact, the framework of our analysis has been borrowed from the theory of international trade, where considerable work has been

done in this area.[2] In the first part of this paper the main features of our model are laid out, and some basic relationships are derived. In the second part, the effects of a corporate income tax are examined, and in the third part we study the effects of a commodity tax on income distribution, prices, and the structure of production. Finally, a concluding section summarizes our main findings.

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[2]. See, for example, Chang and Ethier and Kemp (1980), and Woodland (1977).

2. THE MODEL

We consider a two-sector economy which produces two commodities X_1 and X_2. These commodities are produced jointly by each sector, and they can be represented by activities Z_1 and Z_2. Each activity employs two primary factors of production, capital (K) and labour (L), which are inelastically supplied and intersectorally mobile. Perfect competition is assumed to prevail in all markets, the production functions are linearly homogeneous, and with full employment of all factors we have that:

$$a_{L1}Z_1+a_{L2}Z_2=L \tag{1}$$

$$a_{K1}Z_1+a_{K2}Z_2=K \tag{2}$$

where a_{ij} is the amount of factor i required per unit of activity output (i=L,K; j=1,2).

The outputs X_1 and X_2 are given by the following accounting relationships:

$$b_{11}Z_1+b_{12}Z_2=X_1 \tag{3}$$

$$b_{21}Z_1+b_{22}Z_2=X_2 \tag{4}$$

where b_{kj} is the output of commodity k when sector j operates the activity at unit level (k=1,2;j=1,2).

The zero profit conditions are given by the following relationships:

$$a_{L1}w+a_{K1}r_1=b_{11}p_1+b_{21}p_2=\pi_1 \quad (5)$$

$$a_{L2}w+a_{K2}r =b_{12}p_1+b_{22}p_2=\pi_2 \quad (6)$$

$$r_1=r(i+t)=rT_1 \quad (7)$$

$$q_j=p_j(1+\tau)=p_jT \quad (8)$$

where w is the wage rate, r is the net return to capital, t is the tax rate on the return to capital in the first sector, which is assumed to be the corporate one, τ is the ad valorem tax rate on commodity X_1, p_j is the producer price of commodity X_j, and q_j is the consumer price of commodity X_j.

Differentiating totally eqs. (1)-(4) we obtain:

$$\lambda_{L1}\hat{Z}_1+\lambda_{L2}\hat{Z}_2=L-(\lambda_{L1}\hat{a}_{L1}+\lambda_{L2}\hat{a}_{L2}) \quad (9)$$

$$\lambda_{K1}\hat{Z}_1+\lambda_{K2}\hat{Z}_2=K-(\lambda_{K1}\hat{a}_{K1}+\lambda_{K2}\hat{a}_{K2}) \quad (10)$$

$$\mu_{11}\hat{Z}_1+\mu_{12}\hat{Z}_2=\hat{X}_1 \quad (11)$$

$$\mu_{21}\hat{Z}_1+\mu_{22}\hat{Z}_2=\hat{X}_2 \quad (12)$$

where $\lambda_{Lj}=a_{Lj}Z_j/L$, $\lambda_{Kj}=a_{Kj}Z_j/K$, $\mu_{kj}=b_{kj}Z_j/X_k$, $(i=L,K;\ j=1,2;\ k=1,2)$, and $\lambda_{i1}+\lambda_{i2}=1$. In differentiating eqs.(3) and (4) we have assumed that b_{ij} is constant. It can be easily shown that by assuming b_{ij} variable, our results do not change qualitatively, and for simplicity we take $\hat{b}_{ij}=0$.

Proceeding in a similar way, we obtain from eqs. (5)-(8) the following relationships:

$$\Theta_{L1}\hat{w}+\Theta_{K1}\hat{r}_1=\gamma_{11}\hat{p}_1+\gamma_{21}\hat{p}_2=\pi_1 \quad (13)$$

$$\Theta_{L2}\hat{w}+\Theta_{K2}\hat{r}=\gamma_{12}\hat{p}_1+\gamma_{22}\hat{p}_2=\pi_2 \quad (14)$$

$$\hat{r}_1=\hat{r}+\hat{T}_1 \quad (15)$$

$$\hat{q}_j=\hat{p}_j+\hat{T} \quad (16)$$

where $\Theta_{Lj}=wa_{ij}/\pi_j$, $\Theta_{Kj}=r_j a_{kj}/\pi_j$, $\gamma_{kj}=p_k b_{kj}/\pi_j$, and $\Theta_{Lj}+\Theta_{Kj}=1$.

From the definition of the elasticity of substitution between capital and labour, and the cost minimization assumption, which implies that $\Theta_{Lj}a_{Lj}+\Theta_{Kj}a_{Kj}=0$, we have that:

$$\hat{a}_{Lj}=\Theta_{Kj}\sigma_j(\hat{r}_j-\hat{w}) \quad (17)$$

$$\hat{a}_{Kj}=-\Theta_{Lj}\sigma_j(\hat{r}_j-\hat{w}) \quad (18)$$

Subtracting (10) from (9), and making use of (17), (18), and (15), we get:

$$\lambda(\hat{Z}_1-\hat{Z}_2)=(\delta_1+\delta_2)(\hat{w}-\hat{r})-\delta_1\hat{T}_1 \quad (19)$$

where $\lambda=\lambda_{L1}-\lambda_{K1,}=\lambda_{K2}-\lambda_{L2}$, and $\delta_j=(\lambda_{Kj}\Theta_{Lj}+\lambda_{Lj}\Theta_{Kj})\sigma_j$.

Similarly, from (11) and (12) we have that:

$$\mu(\hat{Z}_1-\hat{Z}_2)=\hat{X}_1-\hat{X}_2 \quad (20)$$

where $\mu=\mu_{11}-\mu_{21}=\mu_{22}-\mu_{12}$. Combination of (19) and (20) yields:

$$\lambda(\hat{X}_1-\hat{X}_2)-\mu(\delta_1+\delta_2)(\hat{w}-\hat{r})=-\mu\delta_1\hat{T}_1 \quad (21)$$

From eqs. (13)-(16) we can also obtain, after some manipulations, the following:

$$\theta(\hat{w}-\hat{r})=\gamma(\hat{q}_1-\hat{q}_2)-\theta_{K1}\hat{T}_1-\gamma\hat{T} \qquad (22)$$

where $\theta=\theta_{L1}-\theta_{L2}=\theta_{K2}-\theta_{K1}$, and $\gamma=\gamma_{11}-\gamma_{12}=\gamma_{22}-\gamma_{21}$. It should be noted that $\mu_{11}+\mu_{21}=\mu_{22}+\mu_{12}=1$, and $\gamma_{11}+\gamma_{21}=\gamma_{22}+\gamma_{12}=1$.

On the consumption side we assume that consumers have identical and homothetic preferences, and that the tax proceeds are redistributed to consumers in a lump-sum way. Hence,we have that:

$$\hat{X}_1-\hat{X}_2=\sigma_D(\hat{q}_1-\hat{q}_2) \qquad (23)$$

where σ_D is the consumption elasticity of substitution between X_1 and X_2. Since in the proceeding section we have assumed that the first sector is the corporate one, and that the commodity tax is imposed on X_1, we also have that $\hat{q}_1=\hat{p}_1+\hat{T}$, and $\hat{q}_2=\hat{p}_2$.

We have now a system of three equations (21), (22), and (23), in three unknowns, and we can proceed to its solution.

3. INCIDENCE OF THE CORPORATE INCOME TAX

Let us consider the case examined by Harberger, that there are no initial distortions in the economy, and the government imposes a tax on the return to capital in the first sector. Having $\tau=0$, and therefore $q_j=p_j$, we can obtain the effect of the corporate income tax on relative factor-prices.

$$\hat{w}-\hat{r}=(1/\Delta)(-\lambda\theta_{K1}\sigma_D+\gamma\mu\delta_1)\hat{T}_1 \qquad (24)$$

where $\Delta=\lambda\theta\sigma_D+\gamma\mu(\delta_1+\delta_2)$.

Following Neary(1978), we can show that stability is ensured with $\Delta>0$. It is obvious that sufficient conditions for this are that $\lambda\theta>0$, and $\gamma\mu>0$. With this in mind we can proceed to the interpretation of eq. (24).

It is clear that in the absence of joint production i.e. $\mu_{kj}=\gamma_{kj}=0$ $(k=j)$, eq. (24) reduces to Harberger's formula for tax incidence, which is

$$\hat{w}-\hat{r}=(\delta_1-\lambda\theta_{K1}\sigma_D)\hat{T}_1/(\lambda\theta\sigma_D+\delta_1+\delta_2) \qquad (24a)$$

If we assume that γ and μ have the same sign i.e. that commodity intensity in value and physical terms is the same, and given that $\lambda\theta>0$ since there are no initial distortions in the economy, then as we can see from (24) and (24a) most of Harberger's qualitative results for tax incidence are still valid. In order to proceed to an evaluation of tax incidence, and to compare our

results with those of Harberger, we shall make some assumptions about relative factor intensities, and factor substitutability. Let us consider, first, the case where in both industries factor substitutability is zero i.e. $\sigma_1=\sigma_2=0$. We can see that in this case eqs. (24) and (24a) become identical, and the tax incidence depends solely on relative factor intensities. If the taxed sector is relatively labour intensive i.e. $\lambda>0$, labour will bear the tax more than in proportion to its initial contribution to national income, and vice versa in the case where $\lambda<0$.

If the elasticity of substitution in consumption between commodities is zero i.e. $\sigma_D=0$, then eqs. (24) and (24a) coincide, and capital bears the tax burden more than in proportion to its initial share in the national income, irrespective of factor intensities. If, on the other hand, $\sigma_1=\sigma_2=\sigma_D=1$, like Harberger's case 9, then (24) and (24a) do not coincide, and it could be easily shown that our result may be different from that of Harberger in the sense that although capital will bear more of the burden of the tax, it may not bear precisely the full burden as in Harberger, but it will depend on the magnitude of relative commodity and factor intensities.

More generally, it can be observed from equations (24) and (24a) that, ceteris paribus, the tax burden on capital may be higher or lower in our model than in Harberger's, depending on relative factor intensities. If the corporate sector is relatively labour intensive, i.e. $\lambda>0$, then the tax burden for capital will be higher in Harberger's model than in ours. If, on

the other hand, $\lambda<0$ the opposite is true, that is capital will bear more of the tax burden in our model than in Harberger's.

Considering the effects of the corporate tax on commodity prices, and output composition, we obtain from eqs. (21)-(23) the following:

$$\hat{p}_1-\hat{p}_2=(\mu/\Delta)(\delta_1\theta_{K2}+\delta_2\theta_{K1})\hat{T}_1 \qquad (25)$$

$$\hat{X}_1-\hat{X}_2=(-\mu/\Delta)\sigma_D(\delta_1\theta_{K2}+\delta_2\theta_{K1})\hat{T}_1 \qquad (26)$$

In the absence of joint production i.e. $\mu=1$, it is obvious that the price of the corporate good would increase, and its production would fall. In our model, however, the price and output effects of the corporate tax, depend on the relative commodity intensity of the two sectors. It is clear from eqs.(25) and (26) that the relative price of the commodity that is produced intensively by the corporate sector will rise, and its production will fall relative to that of the other commodity. With regard to the total output of each sector, we can see that by combining eqs. (20) and (26), we get that the output of the taxed sector falls relative to the output of the untaxed sector.

4. INCIDENCE OF A COMMODITY TAX

Consider now, the case where a consumption tax is imposed on commodity X_1. Assuming that $t=0$ and $\tau>0$ we have that $\hat{q}_1=\hat{p}_1+\hat{T}$ and $\hat{q}_2=\hat{p}_2$. Solving eqs. (21), (22), and (23) for the change in relative factor prices we get:

$$\hat{w}-\hat{r}=-(1/\Delta)\lambda\gamma\sigma_D\hat{T} \tag{27}$$

In the absence of joint production the sign of (27) would depend on the sign of λ alone. With joint production, however, the sign of γ may affect $\hat{w}-\hat{r}$ in the opposite direction than that of λ, since factor and commodity intensities do not necessarily coincide. Hence, if factor and commodity intensities coincide labour bears the tax burden more than in proportion to its initial share in the national product, and vice versa. if both sectors have the same commodity intensity, then capital and labour will bear equally the tax burden.

With regard to price and output changes we get that:

$$\hat{q}_1-\hat{q}_2=(1/\Delta)\mu\gamma(\delta_1+\delta_2)\hat{T} \tag{28}$$

and

$$\hat{X}_1-\hat{X}_2=(-1/\Delta)\sigma_D\mu\gamma(\delta_1+\delta_2)\hat{T} \tag{29}$$

Assuming that commodity intensities in physical and value terms have the same sign, we observe that the consumer price of the taxed commodity will rise relative to the price of the

untaxed commodity, but by less than the amount of the tax. We also observe from eq. (29) that the output of the taxed good falls relative to that of the untaxed one. If we take into account eq. (16), then we can derive from eq.(28) the effect of taxation on producer prices. More specifically we get:

$$\hat{p}_1-\hat{p}_2=(-1/\Delta)\lambda\Theta\sigma_D\hat{T} \qquad (30)$$

which shows that the relative producer price of the taxed commodity falls as a result of the tax but by less than the amount of the tax.

5. CONCLUSIONS

In the preceding analysis we have attempted to extend Harberger's model of tax incidence by allowing for joint production. This assumption has enabled us to overcome the criticism put forward by Ebrill and Hartman, namely that the Harberger's model would collapse if we were to allow for the corporate and the non-corporate sector to produce the same commodities. We have also dealt with this problem in a way that although much simpler, and certainly less sophisticated and realistic, than Gravelle and Kotlikoff, is still quite illuminating about the effects of taxation when each of the two sectors of the economy produces the same two commodities. Our analysis has shown that although most of the qualitative results derived by Harberger still remain valid, the quantitative aspects are significantly influenced by the presence of joint production. We have, also, extended Harberger's analysis by examining the effects of a commodity tax on factor prices, commodity prices, and output composition.

Finally, our model could be considered as a first attempt to examine the effects of taxation in the presense of joint production, a phenomenon rather widespread which has received very little attention in the theory of taxation, although it has been a subject of great concern for trade theorists.

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