1985

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ISSN 0228-4235
ISBN 0-7714-0679-7

THE CENTRE FOR THE STUDY OF INTERNATIONAL ECONOMIC RELATIONS

WORKING PAPER NO. 8528C

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This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the authors.

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GENERAL EQUILIBRIUM ANALYSIS OF PRICE CONTROLS
A TWO-SECTOR COMPUTATIONAL APPROACH

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October 1985

† This is a revised version of a paper presented at the winter meetings of the Econometric Society at San Francisco, December 28-30, 1983. We are grateful to Don Fullerton and members of an Applied Economics workshop at the University of Western Ontario for helpful comments and criticisms. The second author acknowledges financial support from the Social Science and Humanities Research Council, Ottawa.

In this paper we develop a computational general equilibrium framework for evaluating welfare costs associated with economywide price controls. Price controls have been employed by governments all over the world, during war and peace, in response to all manners of threats (both real and imaginary), and in all ages.[1] Given this long history, other than traditional commodity-specific partial equilibrium analyses, most empirical literature on price controls still concentrates on macroeconomic issues such as the impact of inflation and unemployment despite the fact that the main attack on price controls is usually in terms of their efficiency losses from resource misallocation. Here we seek to reorient empirical literature on the effects of the controls by providing a framework which can be used to address the issue of how large these economic inefficiencies are, and who gains and who loses from them.

Our approach is based on the well-known general equilibrium models of distortions due to Harberger [7] and Shoven and Whalley [14]. Our point of departure is the use of an equilibrating mechanism in the presence of price controls which involves endogenously-determined search costs which yield additional welfare losses under price controls beyond those associated with more traditional tax or tariff models. The parable is that in an economy with price controls the greater the difference between controlled prices and market-clearing prices, the costlier it is for buyers and sellers to find each other and transact. The differences between actual buying and selling prices are endogenously determined to clear markets, involve real resource costs rather than revenues raised and recycled by the government, and thus contribute directly to the social costs of the controls. A similar approach has been taken recently in two other papers in which we have been involved (Nguyen [12] and Nguyen and Whalley [13]). The difference here is that, unlike the other papers, we explicitly incorporate production and apply our approach to the issue of economywide controls using data for an actual economy.

Our formulation differs from analyses of distortions in Harberger type models since the wedge between buying and selling prices is no longer pre-specified. As a result, existing models of distortions are not suitable for analyzing the general equilibrium effects of economywide price controls. Our model is in fact closer to those used to analyze the effects of distortions in developing countries, which involve resource waste or socially valueless transactions as part of the equilibrium concept, such as Krueger's rent-seeking model [10] and the Harris-Todaro [8] model of urban-rural migration.

Our model also differs from those appearing in the literature on fixed-price equilibria (e.g., Drèze [4], Benassy [3], and Barro and Grossman [2]) which employ quantity constraints as an equilibrating mechanism in the presence of (downward) price rigidities. This body of literature has been mainly motivated by the objective of providing a theoretical bridge between general equilibrium theory and Keynesian macroeconomics, rather than by the desire to address micro policy issues such as the evaluation of welfare effects of price controls. In our model prices are fixed by government decree, instead of simply being institutionally rigid.

The analytic structure of the model is more complex than that of traditional distortion-ridden general equilibrium models. In the presence of price controls, endogenous search activity is generated on either the demand or supply of each market, but not on both since only excess demand or excess supply can occur in any one market. Because of the complexities introduced by this one-side-of-market condition, we limit our computational analysis to only two sectors and use a traditional goods and factor general equilibrium model. Furthermore, since with fixed goods and factor prices it is possible to construct an activity which automatically makes positive profits, we limit our analysis to either factor price controls (wage and profit controls) or price controls on goods. Although we use 1972 data for Canada to investigate the costs of controls, our purpose is to illustrate a new approach to these issues rather than provide definitive estimates. These will have to await a more detailed project than we have yet been able to execute.

The plan of the paper is as follows. We summarize our basic approach, which we then illustrate using a small-dimensional numerical model of the Canadian economy in 1972. The data set and calibration procedure in applying the equilibrium model are discussed. We assume that price controls fix prices at their equilibrium values at the date the controls are imposed. Resource allocation problems therefore only arise as subsequent changes occur, which in a free market environment would change relative prices. Simulation results of the welfare costs of price controls operating in the presence of different sectoral productivity growth scenarios are then presented. The paper concludes with some remarks on potential applications of the approach and further planned extensions of the model.

1. THE THEORETICAL FRAMEWORK

In this section we outline our approach to analyzing the impacts of price controls in a traditional two-sector general equilibrium framework for the two cases of factor price (or wage and profit) controls, and goods price controls.

1.1 Factor Price Controls

In this formulation of our model, we assume that the government controls wages and profits at non-market-clearing levels ($\mathbf{w}$, $\mathbf{r}$). Under such controls, in equilibrium there will be real resource costs associated with transactions by agents on the constrained side of each factor market. In effect, a dual price system acts as a surrogate equilibrating mechanism which clears factor markets in the presence of government price controls. The parable is that under wage and profit controls the larger the differences between buying and selling prices, the costlier it is for agents to find each other and transact. Transactions costs are thus endogenously determined in contrast to the usual fixed transactions technology assumption (see Hahn [5] and Foley [4]) in the literature on general equilibrium with transactions costs.

The costs involved in transacting at fixed prices are assumed to be borne by the constrained side of each factor market. Thus under wage and profit controls buyers of factors face buying prices (w^b, r^b) gross of any transactions costs they may bear, while sellers face selling prices (w^s, r^s) net of transactions costs. As a result, there are real resource losses (per unit transacted) associated with the endogenously-determined wedges of $w^b - w \geq 0$, $r^b - r \geq 0$ on the buying side, and $w - w^s \geq 0$, $r - r^s \geq 0$ on the selling side. These differ from the tax wedges in Harberger models since the latter do not involve real resource costs.

More formally, we characterize the production side of the economy by linearly homogeneous production functions

$$X = F(L_x, K_x) \tag{1a}$$

$$Y = G(L_y, K_y) \tag{1b}$$

where L_x, K_x, L_y, K_y are factors used by sectors X and Y respectively. Cost minimization at the factor buying prices (w^b, r^b) results in the derived factor demand functions (per unit of output)

$$l_x = l_x(w^b, r^b), \tag{2a}$$

$$l_y = l_y(w^b, r^b), \tag{2b}$$

$$k_x = k_x(w^b, r^b), \tag{2c}$$

$$k_y = k_y(w^b, r^b). \tag{2d}$$

Zero profit conditions are given by

$$p_x = w^b l_x + r^b k_x = p_x(w^b, r^b) \tag{3a}$$

$$p_y = w^b l_y + r^b k_y = p_y(w^b, r^b). \tag{3b}$$

The demand side of the economy is characterized by demand functions

$$X^d = X^d(p_x, p_y, w^s, r^s), \tag{4a}$$

$$Y^d = Y^d(p_x, p_y, w^s, r^s). \tag{4b}$$

In the one-consumer case, these are derived from consumer utility maximization subject to the budget constraint

$$p_x X^d + p_y Y^d = w^s \bar{L} + r^s \bar{K} \tag{5}$$

where $\bar{L}$, $\bar{K}$ denote aggregate factor endowments of the economy. Our approach can, however, can easily be extended to the multi-consumer case.

Equations (2),(3) and (4) give aggregate factor demands

$$L = L_x + L_y = l_x X^d + l_y Y^d, \tag{6a}$$

$$K = K_x + K_y = k_x X^d + k_y Y^d. \tag{6b}$$

Factor market excess demands differ from those used in the traditional two-sector goods and factor general equilibrium model, being defined as

$$Z_l = (w^b/w) L - (w^s/w) \bar{L} \tag{7a}$$

$$Z_k = (r^b/r) K - (r^s/r) \bar{K} \tag{7b}$$

since the endogenously-determined transactions costs in each market must be included. These costs are denominated in units of the commodities being transacted. $(w^b/w) L$ ($\geq L$) and $(r^b/r) K$ ($\geq K$) denote the <u>gross of transactions costs</u> factor demands under price controls (total factor demands L, K plus the transactions costs borne by buyers). $(w^s/w) \bar{L}$ ($\leq \bar{L}$) and $(r^s/r) \bar{K}$ ($\leq \bar{K}$) denote the <u>net of transactions costs</u> factor supplies under price controls (total factor supplies $\bar{L}$, $\bar{K}$ net of the transactions costs borne by sellers). If no transactions costs are involved, $w^b = w^s = w$ and $r^b = r^s = r$. In this case (7ab) degenerate to the more usual market excess factor demand functions $Z_l = L - \bar{L}$ and $Z_k = K - \bar{K}$, which characterize the two-sector model.

Given that equations (3) guarantee zero profit conditions hold, and equations (6) involve factor requirements which meet goods market demands, a general equilibrium in the presence of factor price controls is given by the factor prices $(w^{b*}, r^{b*}, w^{s*}, r^{s*})$ such that

$$Z_l (w^{b*}, r^{b*}, w^{s*}, r^{s*}) = 0 \tag{8a}$$

$$Z_k (w^{b*}, r^{b*}, w^{s*}, r^{s*}) = 0 \tag{8b}$$

where in addition,

$$\text{either } w^{b*} = w,\ w^{s*} < w \text{ or } w^{b*} > w,\ w^{s*} = w, \tag{8c}$$

$$\text{and either } r^{b*} = r,\ r^{s*} < r \text{ or } r^{b*} > r,\ r^{s*} = r. \tag{8d}$$

Conditions (8ab) clear the factor markets in the sense that the market demands for any factor, gross of any transactions costs on the buying side, equal the market supply of that factor, net of any resource losses from transactions costs on the selling side. Conditions (8cd) require that in any factor market there can only be resource losses either on the buying side or on the selling side, but not both. This reflects the fact that controls in any market can only result in either excess demand or excess supply, but not both at the same time. This one-side-of-market condition is a nontrivial extension of the traditional two-sector general equilibrium model.

To find an equilibrium solution of equations (8), we normalize controlled prices $w, r > 0$ such that $w + r = 1$ and define buying and selling factor prices as

$$w^b = \max(w, s) \geq w \tag{9a}$$

$$w^s = \min(w, s) \leq w \tag{9b}$$

$$r^b = \max(r, 1-s) \geq r \tag{9c}$$

$$r^s = \min(r, 1-s) \leq r \tag{9d}$$

where $0 \leq s \leq 1$ is an unknown variable to be determined. This construction allows demands (2,6) and excess demands (7) to be redefined in terms of the unknown variable s

$$Z_l = \max\{1,\ s/w\} L(s) - \min\{1,\ s/w\} \bar{L}, \tag{10a}$$

$$Z_k = \max\{1,(1-s)/r\} K(s) - \min\{1,(1-s)/r\} \bar{K}. \tag{10b}$$

Substituting equations (3,6,7) into the budget constraint (5) we obtain Walras' law

$$w Z_l + r Z_k = 0.$$

This implies that whenever one factor market clears, so does the other. Therefore, to determine the equilibrium solution s^*, we only have to solve either the equation $Z_l(s^*) = 0$ or the equation $Z_k(s^*) = 0$. Equilibrium buying and selling prices (w^{b*}, r^{b*},

w^{s*}, r^{s*}) calculated from s^* using equations (9) automatically satisfy the one-side-of-market conditions (8cd), since no matter what value s^* has, there can be only two possibilities:

either $s^* < w$ in which case $w^{b*} = w$, $w^{s*} < w$ and $1\text{-}s^* > r$, $r^{b*} > r$, $r^{s*} = r$,

or $s^* > w$ in which case $w^{b*} > w$, $w^{s*} = w$ and $1\text{-}s^* < r$, $r^{b*} = r$, $r^{s*} < r$.

The value s^* can easily be found using a fixed-point or other computational algorithm.

1.2 Goods Price Controls

With price controls applying to outputs, prices are fixed at (p_x, p_y). In this case transactions costs are borne by agents on the constrained side of goods markets, rather than factor markets. These are represented by the price wedges ($p_x^b - p_x$, $p_y^b - p_y$) for buyers (consumers) and ($p_x - p_x^s$, $p_y - p_y^s$) for sellers (producers). Factor prices (w, r) are completely flexible. The relevant equations for the supply side of the model are

$$l_x = l_x(w, r) \tag{11a}$$

$$l_y = l_y(w, r) \tag{11b}$$

$$k_x = k_x(w, r) \tag{11c}$$

$$k_y = k_y(w, r) \tag{11d}$$

$$p_x^s = w\, l_x + r\, k_x \tag{12a}$$

$$p_y^s = w\, l_y + r\, k_y \tag{12b}$$

$$L = L_x + L_y = l_x X + l_y Y \tag{13a}$$

$$K = K_x + K_y = k_x X + k_y Y \tag{13b}$$

Equations (11) are per-unit-output factor demands, (12) zero profit conditions, and (13) total factor demands. On the demand side we have the consumer goods demand functions

$$X^d = X^d(p_x^b, p_y^b, w, r) \tag{14a}$$

$$Y^d = Y^d(p_x^b, p_y^b, w, r) \tag{14b}$$

derived from constrained utility maximization. Excess demands are defined as follows:

(a) in factor markets

$$Z_l = L - \bar{L} \tag{15a}$$

$$Z_k = K - \bar{K} \tag{15b}$$

(b) in goods markets

$$Z_x = (p_x{}^b/p_x)\,X^d - (p_x{}^s/p_x)\,X \tag{15c}$$

$$Z_y = (p_y{}^b/p_y)\,Y^d - (p_y{}^s/p_y)\,Y \tag{15d}$$

With price controls in goods markets, the excess demands for goods measure the differentials between gross demands (i.e., goods demands including transactions costs borne by buyers) and net supplies (i.e., output supplies net of transactions costs borne by sellers). Walras' law implies that

$$p_x Z_x + p_y Z_y + w Z_l + r Z_k = 0. \tag{16}$$

A general equilibrium in this case is defined by the set of prices $(p_x{}^{b*}, p_x{}^{s*}, p_y{}^{b*}, p_y{}^{s*}, w^*, r^*)$ such that

(a) in factor markets

$$Z_l = 0, \tag{17a}$$

$$Z_k = 0, \tag{17b}$$

(b) in goods markets

$$Z_x = 0, \tag{17c}$$

$$Z_y = 0, \tag{17d}$$

(c) and in addition

$$\text{either } p_x{}^{b*} = p_x,\ p_x{}^{s*} < p_x \text{ or } p_x{}^{b*} > p_x,\ p_x{}^{s*} = p_x, \tag{17e}$$

and

$$\text{either } p_y{}^{b*} = p_y,\ p_y{}^{s*} < p_y \text{ or } p_y{}^{b*} > p_y,\ p_y{}^{s*} = p_y. \tag{17f}$$

Computing such an equilibrium is more difficult in this case than for factor market controls, since reducing this system of excess demands to functions of a single parameter is not possible. Nonetheless, it is still possible to apply fixed-point or other computational algorithm to this case, although it rapidly becomes more complex from the point of view of numerical solution as the number of commodities increases beyond two. This partly explains why at this stage of development, we have limited our approach to analyzing only a two-sector model.

2. A NUMERICAL EXAMPLE BASED ON CANADIAN DATA

We illustrate our approach to the analysis of the welfare costs of price controls by using a small dimensional numerical example. Our data are taken from the 1972 Canadian benchmark equilibrium data set compiled by St. Hilaire and Whalley [12, Tables 5,9,10]. We consider two sectors (X for manufacturing and Y for non-manufacturing) and two factors (capital and labor). To consider distributional effects of price controls, we also consider three broad income groups

1. Low income group (less than $8000 in 1972)
2. Middle income group (between $8000 and $18000 in 1972)
3. High income group (above $18000 in 1972).

In this data set the basic information is drawn from a number of sources (e.g., input-output tables, national income accounts, household income and expenditure data, taxation statistics, foreign trade statistics, flows of funds). These are all adjusted for mutual consistency. The final result is a micro consistent data set in which demands equal supplies for all products, zero profit conditions hold for all industries, and all agents satisfy their budget constraints, i.e., the conditions characterizing a general equilibrium for the economy. St. Hilaire and Whalley chose 1972 for their data set since, at the time, this was the year for which the most recent data were available. 1972 was also a year with relatively low unemployment and inflation. The data we use is essentially an aggregated version of this microconsistent data set.

Using this 1972 data, we determine demand and production parameters directly from the consumer and producer equilibrium conditions using the calibration procedures outlined in Mansur and Whalley [10]. The parameter values so calculated will reproduce the benchmark equilibrium data set as an equilibrium solution to the model in the no price control case.

Since we use CES demand and production functions in our example, these calibration procedures require that the elasticities of substitution in production and demands be specified beforehand. Empirical estimates of these parameters for Canada are scarce and those that exist are inconclusive.[2] Using the limited literature available, we have chosen elasticities of substitution of 0.5 for manufacturing production, 0.6 for non-manufacturing production, and experiment with different elasticities of substitution between 0.5 and 1 in the demand functions for the various income groups.

In these calibration procedures, physical units are chosen for both goods and factors such that factor and goods prices equal unity. Given the pre-specified elasticity values, the first-order conditions for cost minimization used to calibrate CES production function parameters imply that share parameters sum to unity, and the normalizing constant representing the scale of operation in each sector can be determined.[3] Similarly, given the pre-specified elasticity values for each income group on the demand side, demand functions (instead of the first order conditions) can be used, through calibration, to determine CES demand share parameters which sum to unity. Table 1 presents our benchmark equilibrium data (in billions of 1972 dollars), and the parameter values determined through calibration.

After being calibrated in this way, the model is used to evaluate the welfare costs of fixing either factor or goods prices at pre-assigned values, and allowing changes to occur over time such that, were it not for the presence of the price controls, the equilibrium prices would also change. Simulations are carried out for a period of 20 years

Table 1: 1972 Benchmark Data for Canada, and Parameter Values Determined Through Calibration

(a) Production Costs (billions of 1972 dollars)

Sector	Labor	Capital	Value Added
X	13.9660	2.9830	16.9490
Y	44.7160	21.7440	66.4600
All	58.6820	24.7270	83.4090

(b) Factor Endowments (billions of 1972 dollars)

Income Group	Labor	Capital
1	17.6804	6.6360
2	30.2672	8.4370
3	10.7344	9.6540
All	58.6820	24.7270

(c) Parameter Values Determined Through Calibration

PRODUCTION

Sector	Constant Term	Share Parameters Labor	Share Parameters Capital	Elasticity of Substitution Assumed
X	1.4085	0.9564	0.0436	0.50
Y	1.8154	0.7688	0.2312	0.60

DEMAND

Income Group	Share Parameters Good X	Share Parameters Good Y	Elasticity of Substitution Assumed
1	0.0677	0.9323	0.75
2	0.0682	0.9318	0.75
3	0.4343	0.5657	0.75

for each of a series of cases. With factor price controls, wages and profits are assumed frozen at initial competitive equilibrium levels, i.e., $w = r = 0.5$. Productivity changes are introduced into the economy through changes in the normalizing constant in the production function for one of the two sectors. Equilibrium buying and selling prices $(w^{b*}, r^{b*}, w^{s*}, r^{s*})$ are then calculated for each year in the simulation.

In the case of Hicksian neutral technical progress at an annual rate of 2% in manufacturing only over the 20 year period (reported in Table 2) the equilibrium buying price r^{b*} for capital is higher than the controlled price r, while the equilibrium selling price w^{s*} for labor is lower than the controlled price w. That is, buyers in the capital market bear additional search costs in transacting at the controlled prices, along with sellers in the labor market. As these configurations of equilibrium prices are part of the solution of the model, they vary from case to case. For example, with differential technical progress in both sectors (results not reported here) we have the opposite result, additional costs are borne by buyers in the labor market along with sellers in the capital market.

We have also calculated the welfare costs of factor price controls in terms of the sum of Hicksian compensating variations (cv) across the three consumer groups, expressed as a percent of national income using our simulation results. The compensating variation is defined as the amount of income we would have to compensate consumers in the equilibrium under factor price controls in order to make them as well-off as they would be at the corresponding no-control competitive equilibrium. A positive value indicates a welfare loss to consumers while a negative value indicates a welfare gain. This essentially involves comparing the two utility streams in the with and without factor price control cases in income terms, and expressing the result as a percent of national income.

Table 2 shows that after 20 years the welfare costs associated with factor price controls are about 1.6% national income for technical progress of 2% in manufacturing.[4] In terms of distributional impacts, 46% of these welfare costs are borne by the middle

Table 2: Impacts of Factor Price Controls with 2% Technical Progress in Manufacturing

Year	r^{b*}	r^{s*}	w^{b*}	w^{s*}	cv as % of national income
0	0.5000	0.5000	0.5000	0.5000	0.0
1	0.5004	0.5000	0.5000	0.4996	0.09
2	0.5008	0.5000	0.5000	0.4992	0.17
3	0.5013	0.5000	0.5000	0.4987	0.25
4	0.5017	0.5000	0.5000	0.4983	0.34
5	0.5021	0.5000	0.5000	0.4979	0.42
6	0.5025	0.5000	0.5000	0.4975	0.50
7	0.5029	0.5000	0.5000	0.4971	0.59
8	0.5033	0.5000	0.5000	0.4967	0.67
9	0.5038	0.5000	0.5000	0.4962	0.75
10	0.5042	0.5000	0.5000	0.4958	0.83
11	0.5046	0.5000	0.5000	0.4954	0.92
12	0.5050	0.5000	0.5000	0.4950	1.00
13	0.5054	0.5000	0.5000	0.4946	1.08
14	0.5058	0.5000	0.5000	0.4942	1.16
15	0.5062	0.5000	0.5000	0.4938	1.24
16	0.5066	0.5000	0.5000	0.4934	1.32
17	0.5070	0.5000	0.5000	0.4930	1.40
18	0.5073	0.5000	0.5000	0.4927	1.47
19	0.5077	0.5000	0.5000	0.4923	1.55
20	0.5081	0.5000	0.5000	0.4919	1.63

income group, 29% by the low income group, and 25% by the high income group. This can be seen in Figure 1 which shows time paths of the welfare costs (as a percent of national income) borne by the three income groups for annual technical progress at a rate of 2% in manufacturing. The longer factor price controls remain, the higher the welfare costs. When calculated relative to their individual incomes, the loss of the high income group is 1.65% of income, the middle income group is 1.64.%, and the low income groups is 1.64%. The high income group (9% of the population) is thus loses more than both the middle and low income groups (44% and 47% of the population, respectively).

Interestingly, the welfare costs of goods price controls under similar technical progress assumptions are much larger than the costs of factor price controls. These are reported in Figure 2, also for the case of annual technical progress at a rate of 2% in manufacturing. Total welfare costs after 20 years are 36% of national income.[5,6]

The reason for these much larger costs is that technical progress directly changes the relative costs of producing the two goods. This leads to larger endogenously-determined transactions costs in the price control case in order to accommodate the changes produced in the cost-covering prices. With controls on factor prices, the implied changes in factor prices from the differential technical progress in a no-control equilibrium reflect relative factor intensities of the two sectors; the effects of differential technical progress are indirect rather than direct. These results therefore suggest that if the major changes in the structure of the economy over time are inter-sectoral productivity effects, either from differential technical progress or from random sector-specific shocks (such as the effects of weather on agriculture), controlling factor prices may be a less costly policy approach than controlling output prices.

FIGURE 1

WELFARE COSTS UNDER WAGE AND PROFIT CONTROLS

Welfare Costs in Terms of Hicksian Compensating Variations by Income Groups and in Total, Expressed as a Percent of National Income: Annual Hicksian Neutral Technical Progress Assumed to be 2% in Manufacturing and 0% in Non-Manufacturing.

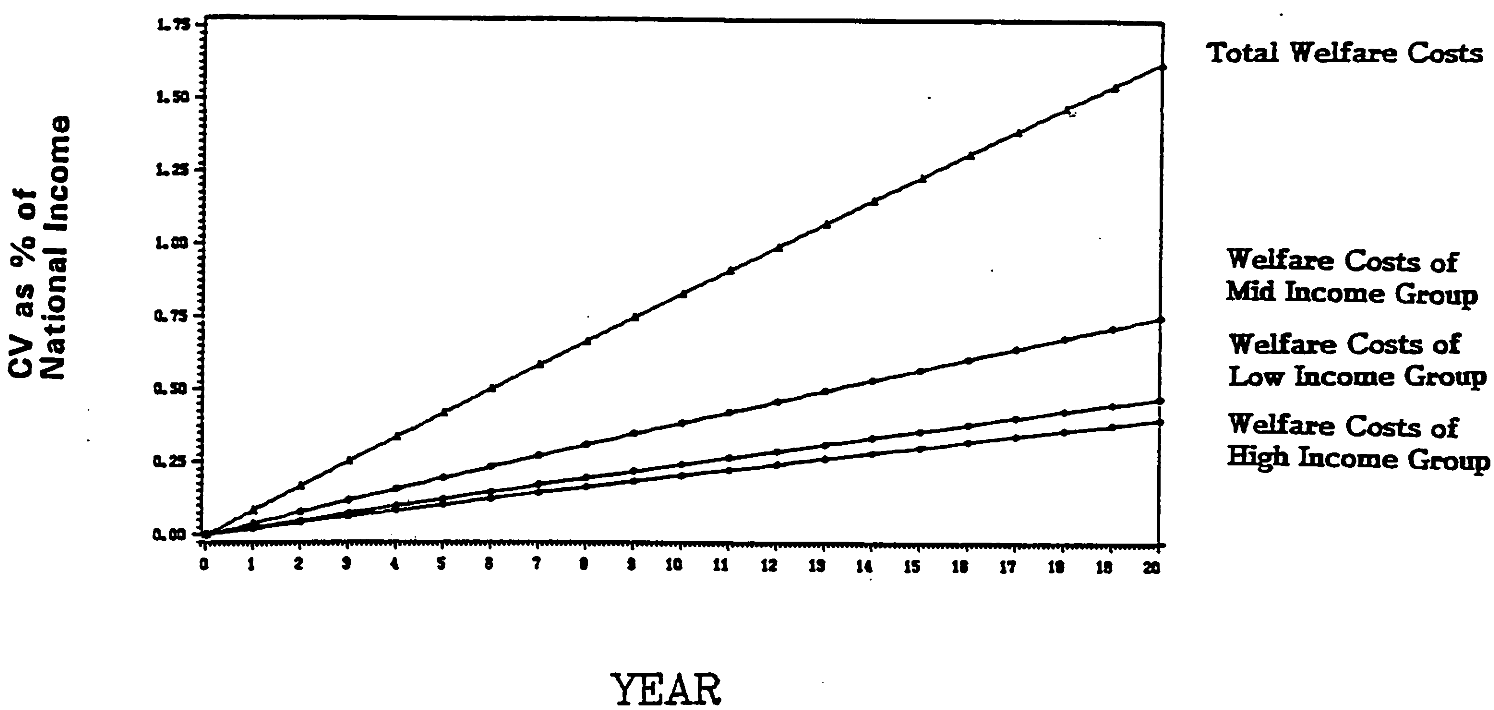
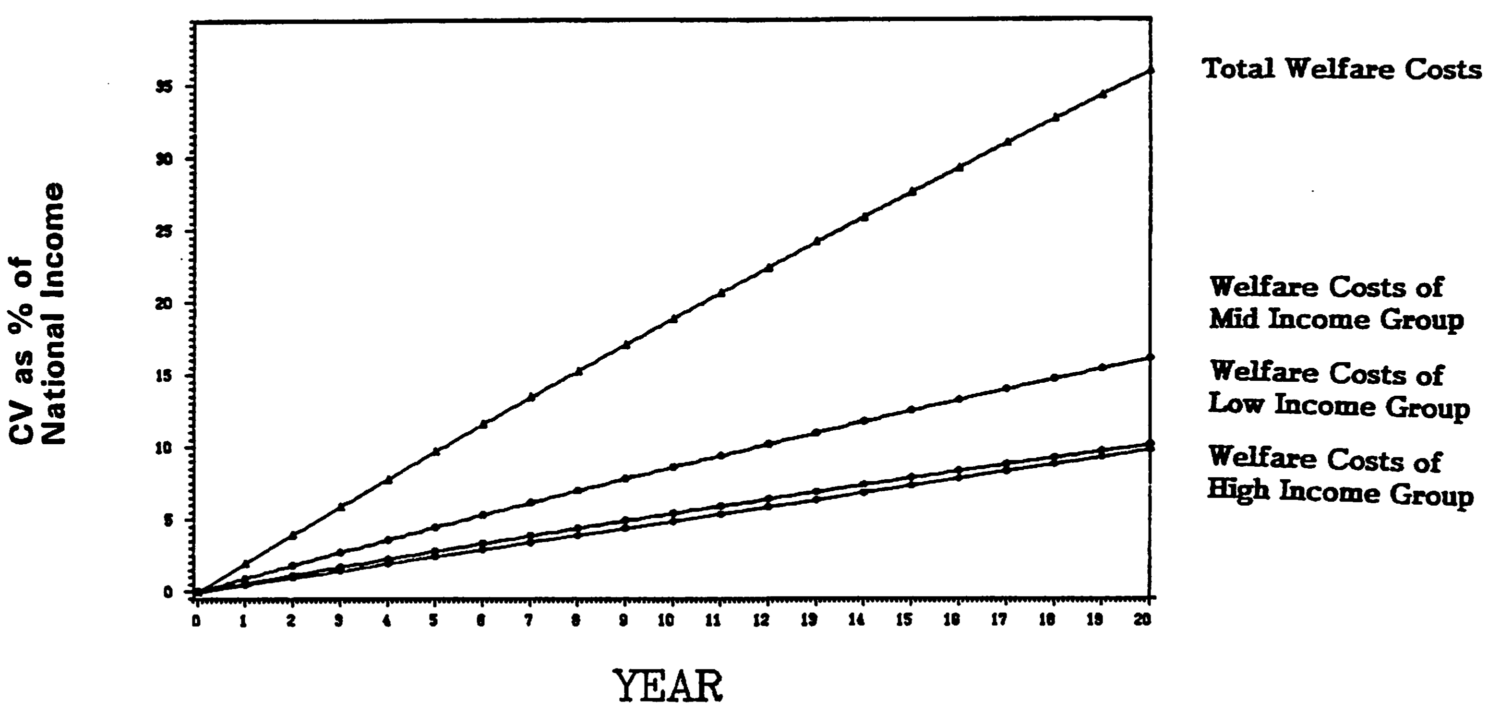


FIGURE 2

WELFARE COSTS UNDER OUTPUT PRICE CONTROLS

Welfare Costs in Terms of Hicksian Compensating Variations by Income Groups and in Total, Expressed as a Percent of National Income: Annual Hicksian Neutral Technical Progress Assumed to be 2% in Manufacturing and 0% in Non-Manufacturing.



3. CONCLUSION

In this paper we outline an approach which can be used to evaluate the welfare costs of wage and profit or output price controls in a general equilibrium model in which the costs of agents transacting at the prices fixed by the government are endogenously determined. We illustrate this approach using numerical examples based on a small dimensional model for Canada in 1972. These examples suggest that if price controls come into effect and prevent changes in relative prices from occurring, their effects are cumulative, i.e., the annual costs as a fraction of each year's national income increases. Also, if the major changes through time are changes in relative productivities across sectors, controlling goods prices is a more costly policy course to follow than controlling factor prices. Extensions of the analysis to increase the dimensionality and realism of the models used are planned in future work.

NOTES

1. Such as the ambitious attempt to control over 900 commodities, 130 different grades of labor, and 41 types of freight rates in 301 A.D. by the Roman emperor Diocletian.

2. For example, Kotowitz [8] estimates that σ is between 0.3 and 0.5 for Canadian manufacturing industries in 1926-39 and 1946-61 while Tsurumi [13], using different estimation technique on the same set of data, finds that $\sigma = 1$. See Ballentine and Thirsk [1, appendix C] for a brief review of empirical research on Canadian consumer demand and production functions.

3. For a CES production function of the form $Q = \gamma\, f(\delta_k, \delta_l, \sigma, K, L)$, $\gamma = 1/f$ since $Q = 1$ along the unit isoquant. Note that from the zero profit condition, $pQ = wL + rK$ which implies $Q = K + L$ since all prices equal unity.

4. These estimates increase to 3.1% of national income for technical progress of 4% in manufacturing, and 4.4% of national income for technical progress of 6% in manufacturing.

5. 45% of these welfare costs are borne by the middle income group, 28% by the low income group, and 27% by the high income group. When calculated relative to their individual incomes, the loss of the high income group is 40% of income as compared to the loss at 35% of income for both middle and low income groups. That is, under output price controls the high income group still loses more than the other two income groups.

6. For technical progress of 4% and 6% in manufacturing, the welfare estimates are extremely high at 65% and 91% of national income, respectively.

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