MODELLING MONOPOLISTIC BEHAVIOUR OF PRODUCTS AND HOUSEHOLDS WITHIN CGE FRAMEWORK - A SIMPLE MODEL FOR POLAND

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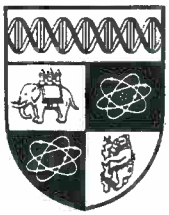

DEPARTMENT OF ECONOMICS

UNIVERSITY OF WARWICK
COVENTRY

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Zbigniew Zolkiewski

Research Centre for Economic and Statistical Studies
Al.Niepodleglosci 208, 02-925 Warsaw
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Zbigniew Żółkiewski

Research Centre for Economic
and Statistical Studies
Al. Niepodległości 208, 02-925 Warsaw
Poland

and

Department of Economics
University of Warwick
Coventry CV4 7AL
England[##]

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ABSTRACT

In the paper, aggregated computable general equilibrium (CGE) model with monopolistic behaviour of producers and households (trade unions) is developed. Monopolistic firms face downward sloping demand curve what makes them reduce output and factor demands so as to maximize profits. Trade unions push wages up over market clearing level when maximizing surplus of wage incomes over disutility of labour. Model has been calibrated for Poland, 1990 assuming certain level of monopolisation of both product and labour market. Simulations have been done that illustrate potential welfare gains of elimination of monopolistic behavior at either of the market and at both.

Keywords: general equilibrium model, monopolistic competition, economies in transition.

1. INTRODUCTION

It has been more than 30 years since the path-breaking work of Johansen (1960), which is widely recognised as the first computable general equilibrium (CGE). The main body of the subsequent literature deals with applied representations of the theoretical framework of the Walras' model of the competitive economy. The lion's share of these applications refer to the less developed countries (LDCs), and in the majority of models "... *only relative prices matter, producers are profit maximizers facing non-increasing returns to scale, consumers are insatiable utility maximizers, and production factors are paid according to their marginal-revenue productivity*" (Decaluwe et al. (1988); Bandara (1991)). If some elements of market imperfections have been introduced into the models (price-fixing, quantity controls, transfer and taxation policies etc.) they have been mainly motivated, as the authors above argue, by the presence of the government or the public sector in the model. Such potential sources of market imperfections as monopolistic behaviour of producers and/or households (trade unions) and increasing returns to scale, presumably quite relevant for 'realistic' modelling of LDCs, have not been treated as major non-'Walrasian' features of the CGE models. The questions of price-fixing, rationing and structural rigidities have been focused within the sub-class of 'structuralist' models (see: Taylor (1990)). It is only during last ten years that the question of modelling monopolistic competition within CGE framework has become more popular, starting probably from the work of Harris (1984). These studies (including: Burniaux et al. (1992); Devarajan and Rodrik (1991)) incorporate industrial organization theory approach CGE framework with its emphasis on such aspects of industry structure as imperfect competition, economies of scale, entry barriers, product differentiation, price setting behaviour etc. When applied to trade liberalization issues, that approach allows us to capture not only

interindustry (comparative advantage) but also intraindustry (industrial organization) effects. The authors above conclude that estimated gains to free trade are much larger than for competitive CGEs or for partial equilibrium models and the branch trade pattern is quite different. At the same time, models belonging to that category are more parameter sensitive than neoclassical models and until now they are not able to capture satisfactorily some other relevant mechanisms, for example entry barriers other than scale economies. Nevertheless, those models represent an important effort to incorporate market imperfections resulting from industrial structure into the CGE framework.

The applications of CGE models to centrally planned economies (CPEs) and subsequently to (so called) countries in transition (CITs)) are not as numerous as for the LDCs (see: Zalai, (1980, 1982, 1993); Robinson & Tyson (1985); Braber et al. (1993); Breuss et al. (1993); Martin (1993); de Haan (1993); Roberts & Żółkiewski (1993, 1994)). Almost all these authors have tried to introduce some market imperfections into their models to reflect the realities of those economies. For instance, in probably the first CGE models developed for CPEs (for Hungary) Zalai (1980, 1982, 1993) focused on rigidities in foreign trade (partly exogenous exports, limited substitutability of domestic goods and imports) especially with COMECON countries. Robinson & Tyson (1985) modify neoclassical allocation rules for capital, labour and foreign exchange as the most important non-Walrasian characteristics of the Yugoslav economy in the seventies and eighties; and Roberts & Żółkiewski (1993, 1994) assume rigidities in factor markets (e.g., sector-specific capital, fixed inter-sectoral capital and wage rentals, unemployment) when modelling income distribution effects of transition. It is the work of de Haan (1993), representing the structuralist strand of CGE models, that seems to be the most far from neoclassical paradigm in modelling CITs. In particular, that model incorporates the following market imperfections:

a technology assumes no substitution between production factors; both material and labour inputs are fixed per unit of output, and capital-labour ratios change only as a consequence of fluctuations in the utilisation rate of capacities,

b some commodity markets (especially agricultural and mining products) clear by price adjustments (output fixed at capacity levels) while other markets (usually manufacturing goods) clear by quantity adjustments (changes in the utilisation rates of capacity),

c assuming underutilisation of both labour and capital, factor remunerations do not obey marginal productivity conditions,

d for some sectors (usually manufacturing) an oligopolistic structure of the market is assumed, modelled through a mark-up price formula,

e there is limited substitution between domestic production and foreign trade, i.e., a major share of imports is considered non-competitive and exports are often treated as exogenously fixed; the exchange rate is exogenously fixed,

f savings adjust to investments through changes in income rather than through an (implicit) interest rate adjustment (neoclassical mechanism).

In fact, this is the only CGE application for CITs published so far that addresses the question of monopolistic structure of production. But even that application neither considers effects of monopolistic behaviour of producers on factor markets nor does it introduce monopolistic behaviour of trade unions.

The aim of this paper is to develop a CGE model with monopolistic behaviour of both producers and households (trade unions) and then to use it for the estimation of potential welfare gains if monopolistic practices are eliminated. Given the stylised character of the

experiment (highly aggregated one-sector model, with no empirical verification of 'monopolistic power' parameters etc.), it is the methodological rather than numerical results that are the focus of the paper.

2. MONOPOLISTIC MARKETS IN CITS - SOME DATA FOR POLAND

Even without precise measures of the degree of monopolisation of markets in Poland, one may suppose that there are still large sectors of the economy that are far from perfectly competitive. The main arguments supporting this can be summarised as follows:

- a relatively small number of enterprises as a result of rationing of economic activities under communist regime,
- a predominance of large state owned enterprises in manufacturing at the beginning of transition as a legacy of centrally planned economy,
- a relatively small share of private sector that has been administratively curbed and rationed under CPE regime,
- the protection of domestic producers against foreign competition in some sectors.
- barriers of entry, especially in capital intensive branches, resulting from a shortage of capital, underdeveloped financial markets and high interest rates,
- rigidities in mobility of production factors which may lead to local natural monopolies.

Table 1 provides some indicators of market structure for different branches of manufacturing that may be used as indirect measures of monopolisation. These are: concentration of production (measured by the share of large companies (1,000 employees and more) in the

total output of the branch), degree of privatisation (measured by the share of private sector in the sales of the branch) and foreign competition (measured by the ratio of imports to the output).

Table 1 Characteristics of Markets of Manufacturing Goods in Poland, 1992 (%).

	Concentration	Privatisation	Foreign competition
Total	**50.6**	**39.7**	**22.4**
Fuels & Power	87.2	0.3	17.3
Metallurgy	92.6	3.1	13.8
Electro-engineering	58.6	38.9	39.5
Chemicals	59.5	28.7	42.3
Minerals	27.9	35.7	12.4
Wood & Paper	45.2	53.7	14.2
Light	33.4	56.0	13.9
Food	28.2	44.3	8.4
Other	11.9	67.9	31.8
Construction	8.6	78.7	n.a.

Data in Table 1 show that different sectors of the economy display different market characteristics. To see the regularities better, let us aggregate the branches into the following groups: consumer goods - 'Wood & Paper Industry', 'Light Industry', 'Food Industry' and 'Other Industries' (mainly 'Printing & Publishing'); intermediate goods - 'Fuels & Power Industry', 'Metallurgy', 'Chemical Industry', 'Mineral Industry'; investment goods - 'Electro-engineering Industry', 'Construction'. The concentration of output and share of private sector criteria seem to be relevant for identifying sectors of the economy where potential monopolistic effects occur. One may expect relatively strong monopoly power in the intermediate goods sector which can be generally characterised as having highly concentrated output (except for 'Minerals') and dominated by public firms. Conversely, we observe a relatively large share of small and medium (SM) enterprises and a high degree of

privatisation for the consumer goods branches which is important (but by no means sufficient) for competitive environment. The exposure to foreign competition, as measured by the ratio of imports to the output, does not seem very useful in discriminating sectors with respect to monopolistic behaviour. The investment goods sector turned out to be heterogenous with respect to all three criteria. One would expect 'Construction' to be competitive and this is confirmed by its low concentration level and high share of private companies. The other investment branch 'Electro-engineering' seems to be close to a monopolistic pattern due to a relatively high share of large, public companies. As other major branches are concerned, data on privatisation show a high share of private sector in 'Trade' (85.4%) and a domination of the public sector in 'Transport' (34.9% of private sector) and 'Communications' (only 2.7% share of private sector).

Based on the information in Table 1, production sectors can be roughly divided into the following groups:

(i) perfectly competitive: CONSUMER GOODS, CONSTRUCTION and TRADE (to a large extent privatised, with a large share of SM enterprises),

(ii) monopolistic: INTERMEDIATE GOODS, ELECTRO-ENGINEERING, TRANSPORT and COMMUNICATIONS, SERVICES (dominated by large, public firms),

(iii) competitive with inelastic supply: AGRICULTURE.

While the concentration of output has been measured here by employment criterion, it is standard to use some measure of output, concentration ratio (CR) indicator. Semmler (1984) proposes CR_4 or CR_8 and owing to the lack of data, CR_4s for Poland could only be estimated

for selected sub-branches. These are presented in Table 2 for comparison with the concentration measures discussed above.

Table 2. Concentration in Selected Sub-branches of Industry (4 digit level) (CR_4)

	Share in the Branch Output	Concentration Ratio (CR_4)
CONSUMER GOODS		
Food Products		
Meat Products	17.7%	**14.5%**
Milk Products	13.0%	**6.3%**
Confectionery Products	5.3%	**44.0%**
Wearing Apparel		
Clothes	81.4%	**13.5%**
INTERMEDIATE GOODS		
Chemicals		
Fertilizers	12.1%	**70.4%**
Plastic Products	8.8%	**6.0%**
Organic Chemicals	4.4%	**96.2%**
Construction Materials		
Cements	28.7%	**44.4%**
Concretes	22.6%	**8.7%**
Stones and aggregates	17.9%	**24.3%**
INVESTMENT GOODS		
Machinery		
Energy Processing Machines	20.9%	**52.9%**
Mining Machinery	11.7%	**48.7%**
Construction Machinery	10.5%	**76.0%**
Transport Equipment		
Cars	50.0%	**80.2%**
Ship Building Industry	16.6%	**83.0%**

Generally speaking, figures in Table 2 confirm the results already shown in Table 1: rather moderate concentration within consumer goods sector comparing to intermediates and investment goods. As discussed by Semmler (1984), it is when CR_4 exceeds 60% that concentration may imply monopolistic profits[1]. As shown in Table 2, it is some branches in intermediates and investment goods sectors that satisfy this criterion. However, one may expect considerable variation of concentration ratios as more detailed analysis is performed. When modelling monopolistic behaviour it is usual to consider the effects of increasing returns to scale. My initial hypothesis would be that this can be of marginal importance for Poland because of heavily depreciated machinery. Therefore increasing output by putting into action idle and usually older and less efficient pieces of equipment, might cause huge increase in marginal costs, thus effectively limiting expansion of supply (see Glikman (1994)) for discussion and justification). While this hypothesis seems to be plausible at the aggregate level, nevertheless there may be sectors in which a potential for scale economies does exist.

Although no empirical estimates of monopolistic power of trade unions in Poland are readily available, it may be rather safely assumed that powerful trade unions of both Solidarity and communist tradition that exist in Poland do seriously affect performance of labour market. High unemployment rate (over 16% of labour force by the mid-1994), a growing share of private sector and a generally bad financial standing of public firms are the main factors limiting position of trade unions. A different situation in various sub-markets

[1]The author argues, quoting several other studies, that concentration *per se* cannot satisfactorily explain monopolistic behaviour unless it is combined with other factors, like entry barriers or productivity advantages of bigger firms.

for labour (with respect to skills, sex, location etc.) should be taken into account, especially if the 'craft' model of trade union would be applied, as in Blanchard & Kiyotaki, 1987.

3. GENERAL FRAMEWORK OF MONOPOLISTIC BEHAVIOUR OF PRODUCERS AND HOUSEHOLDS

In this section, a general framework of monopolistic competition of both firms (producers) and households (trade unions) will be discussed, following the exposition in Dixon & Rankin (1994). Then in the next section, that framework will be built into an aggregated (one-sector) CGE model for Poland.

The starting point will be perfectly competitive (Walrasian) economy with n production sectors and a representative household. Each sector produces a homogenous output X_i, $i=1,2,\ldots,n$, using log-linear technology, defined over inputs of homogenous labour, supplied by households. Given these assumptions, the production function for the representative firm of any sector (subscripts for the sector and firm are dropped) will have the following form:

$$X = \alpha_0 \times L^{\alpha_L} \qquad (1)$$

where:

L - *labour input*,
α_L - *labour elasticity of output* ($\alpha_L \leq 1$),
α_0 - *shift parameter*.

Assuming: (i) profit maximizing behaviour of producers, (ii) position of producers as 'price-takers', (iii) perfect mobility of labour across sectors, (iv) single economy-wide labour

market with money wage W, the labour demand may be derived from the first-order conditions for profit maximization, according to the formula:

$$P \times MPL = W \tag{2}$$

where:

MPL - marginal productivity of labour,
W - money wage,
P - sectoral price.

Solving (2) for L gives the following labour demand function:

$$L_{D_p} = (\alpha_0 \times \alpha_L)^{\frac{1}{1-\alpha_L}} \times \left(\frac{W}{P}\right)^{-\frac{1}{1-\alpha_L}}, \tag{3}$$

where:

L_{D_p} *- labour demand (for perfect competition case).*

Households decide on consumption, holding of money balances and supply of labour so as to maximise their utility function[2]:

$$U(X, \frac{M}{P}, L) = [u_x(X)]^{\gamma} \times [\frac{M_0}{P}]^{1-\gamma} - \theta \times L^{\eta} \tag{4}$$

where:

$X = (X_1, X_2, ..., X_n)$ *- vector of sectoral outputs (consumption)*
$u_x(X)$ *- subutility function (linear homogenous),* (5)
M_0 *- nominal money holdings,*
P *- cost-of-living index,*
$\theta \times L^{\eta}$ *- disutility of supplying L units of labour* ($L \leq \bar{L}$).

[2]The utility function is defined for the representative household but properties of individual utility functions (homotheticity over consumption and real balances) make aggregation possible.

The households will supply labour up to the point where marginal disutility of labour equals marginal benefit of it. Taking real wage[3] as the measure of marginal benefit of work we derive the following labour supply function:

$$L_{S_p} = \left(\frac{1}{\eta \times \theta}\right)^{\frac{1}{\eta - 1}} \times \left(\frac{W}{P}\right)^{\frac{1}{\eta - 1}} \tag{6}$$

where:

L_{S_p} – *labour supply for the perfectly competitive case.*

For the special case when marginal disutility of work is constant ($\eta = 1$) labour supply function is horizontal, i.e., labour supply is perfectly elastic at the constant real wage equal to marginal disutility of labour θ, according to the formula:

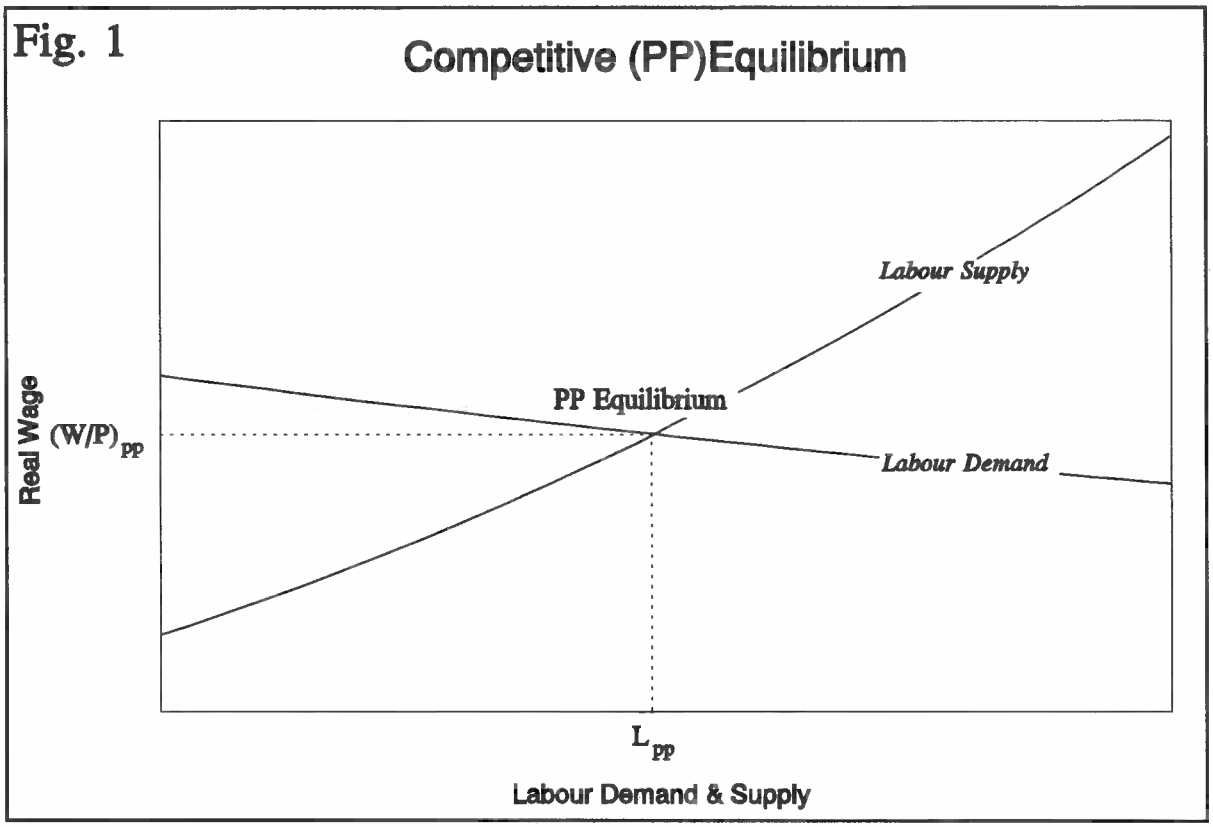
$$W/P = \theta \tag{7}$$

Given assumptions on additive separability and linear homogeneity of utility function (4), households decisions on labour supply depend only on real wages and not on money holdings (no wealth effect).

Equations (3) and (6) may be solved for equilibrium values of real wage and employment. Knowing employment, output will be determined through the production function (1). For any exogenous shock, the equilibrium will be restored by re-adjustment of nominal wages and prices.

[3]Dixon & Rankin (1994) assume symmetric preferences what allows them to set: $P_i = P$, for all $i = 1,2,\ldots,n$ and have sectoral price equal to cost of living index.

Figure 1 illustrates the locus of equilibrium for the perfectly competitive case.



Let us now introduce monopolistic behaviour by both producers and households, starting with the producers. Assuming that:

(i) firms maximise profits subject to technological constraint and less-than-perfectly price elastic demand for their products (with constant perceived price elasticity of demand $\epsilon_i \equiv \epsilon$, $\epsilon \geq 1$),

(ii) there are so many sectors (n large enough) that monopolists treat general price index P as given,

(iii) individual firm considers actions of competitors as given (Cournot regime),

leads to the equilibrium in which monopolist sets price as a mark-up over marginal const, as given by:

$$P = \frac{1}{1 - \frac{1}{\epsilon}} \times MC \tag{18}$$

where:

MC - marginal cost

$\frac{1}{\epsilon}$ - *Lerner measure of monoply power*

Therefore monopolist realizes extra (monopolistic) profits which come from paying labour below its productivity level according to the formula:

$$\frac{W}{P} = (1 - \frac{1}{\epsilon}) \times MPL \tag{9}$$

From (9), the following labour demand function for the monopolistic case can be derived:

$$L_{D_m} = (1 - \frac{1}{\epsilon})^{\frac{1}{1-\alpha_L}} \times (\alpha_0 \times \alpha_L)^{\frac{1}{1-\alpha_L}} \times \left(\frac{W}{P}\right)^{-\frac{1}{1-\alpha_L}}, \tag{10}$$

where:

L_{D_m} - *labour demand (for monopolistic competition case)*

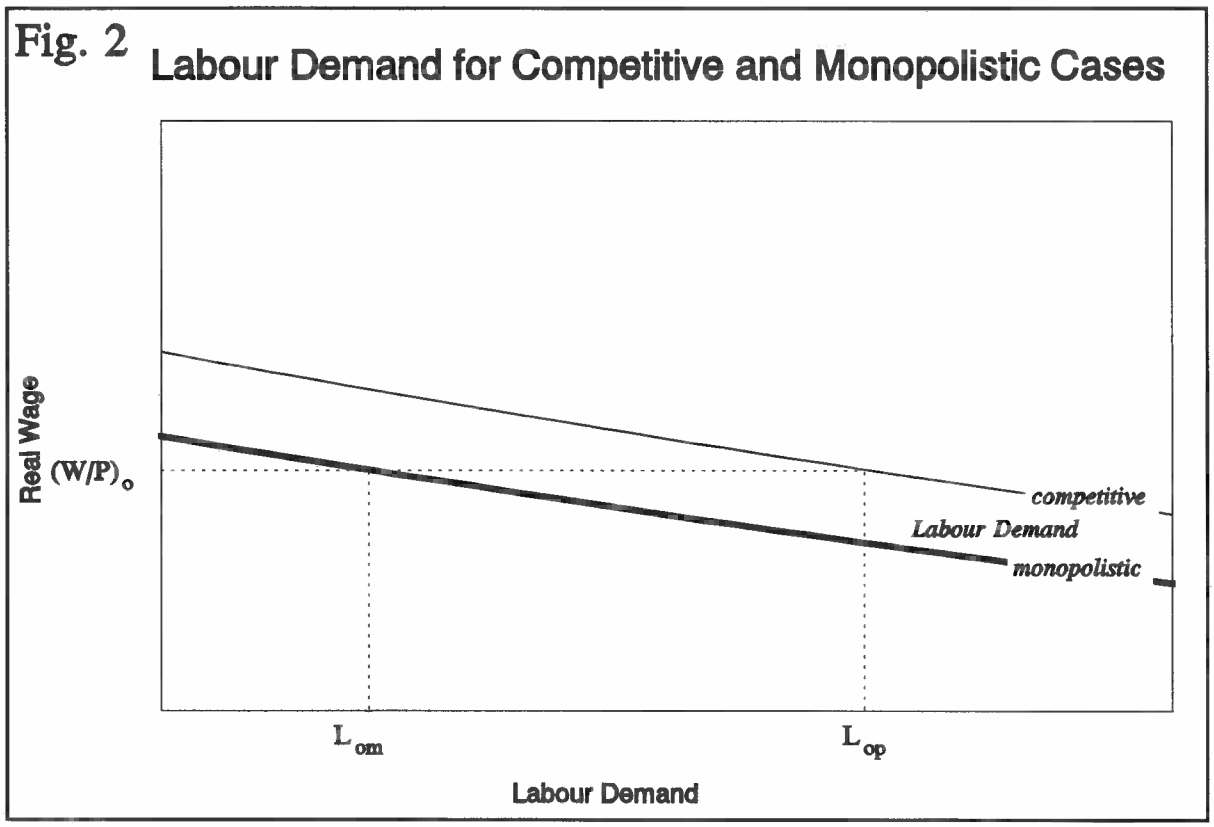
Comparing (10) with (3) reveals the following relationship between the labour demand for monopolistic and perfectly competitive cases, respectively:

$$L_{D_m} = (1 - \frac{1}{\epsilon})^{\frac{1}{1-\alpha_L}} \times L_{D_p} \tag{11}$$

Given assumptions on α_L and ϵ ($\alpha_L < 1$, $\epsilon > 1$), monopolistic firms will demand less labour, for any level of real wage. Under *ceteris paribus* conditions, the higher their monopoly power (larger $1/\epsilon$), the larger mark-up of price over marginal cost and then the lower is their demand for labour. That eventually results in lower output. For given degree of monopoly power, the reduction of demand for labour will be higher, compared to perfectly competitive case, the more labour-elastic is output (higher α_L).

The locus of hypothetical labour demand curves for competitive and monopolistic cases are depicted in Figure 2.

Fig. 2 Labour Demand for Competitive and Monopolistic Cases



Modelling monopolistic behaviour of households will be based on the set of following assumptions:

(i) there is an economy-wide monopoly trade union[4] that unilaterally sets nominal wage,

(ii) the union perceives labour demand curve of firms and therefore it can perfectly anticipate the prices set by the firms and the resultant level of employment.

(iii) the producers behave as monopolists, as defined above.

If the objective function of the trade union will be surplus of wage revenue over disutility (to be maximised), as in Dixon & Rankin (1994), the union's problem may be stated as follows:

$$\begin{aligned} &\textit{maximise}_{w/p} \left(\frac{W}{P}\right)\times L \;-\; \theta\times L^{\eta} \\ &s.t. \qquad L = L_{D_m} \end{aligned} \tag{12}$$

The solution of problem (12) will be the following labour supply function for monopolistic behaviour of the trade union:

$$L_{S_m} = \left(\frac{\alpha_L}{\eta\times\theta}\right)^{\frac{1}{\eta-1}} \times \left(\frac{W}{P}\right)^{\frac{1}{\eta-1}} \tag{13}$$

Comparing (13) to (6) reveals that:

$$L_{S_m} = \alpha_L^{\frac{1}{\eta-1}} \times L_{S_p} \tag{14}$$

Given assumptions that $\alpha_L \leq 1$ and $\eta > 1$ there is: $\alpha_L^{1/(\eta-1)} \leq 1$ which means that compared with the perfect competition case, for a given real wage level, households will supply less

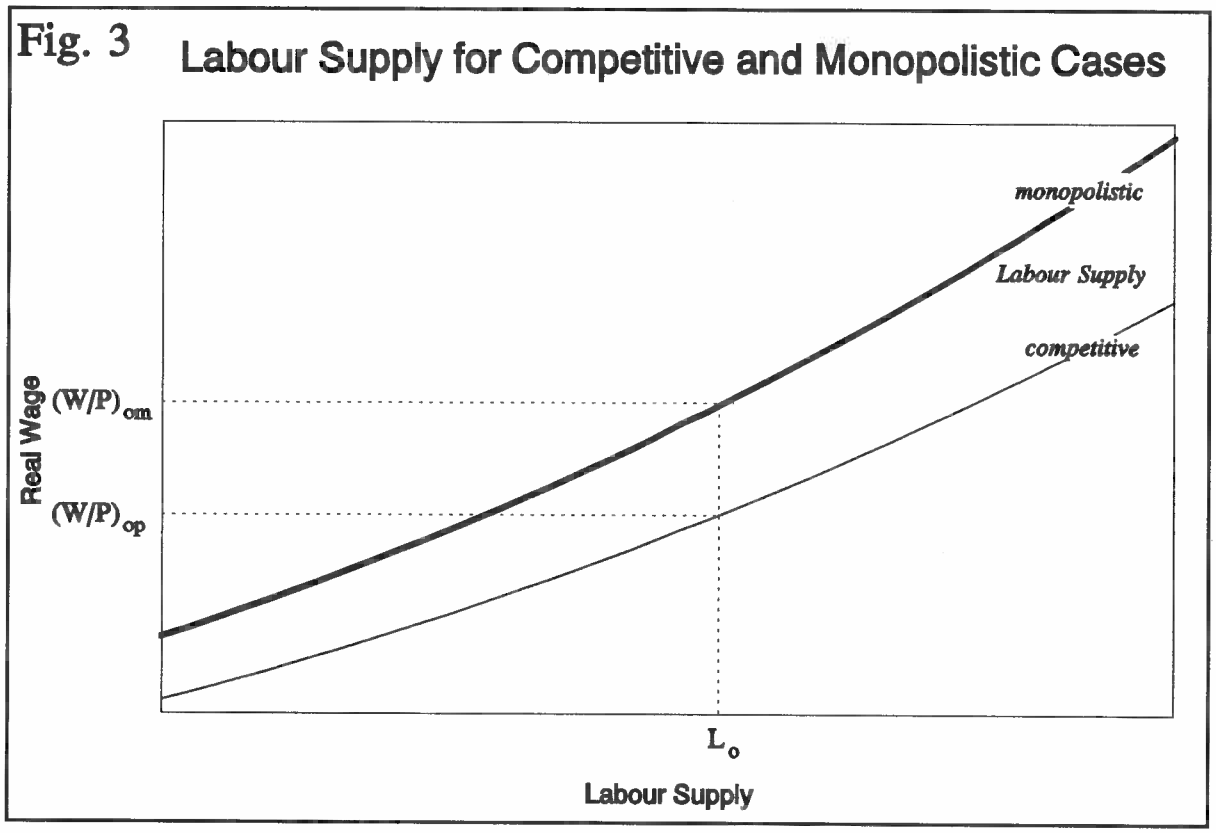
[4] Dixon & Rankin (1994) examine 'sectoral' and 'craft' union models as well.

labour or, in other words, they will demand higher wages for a given amount of work. For the special case of constant marginal disutility of labour ($\eta = 1$) we get the following formula :

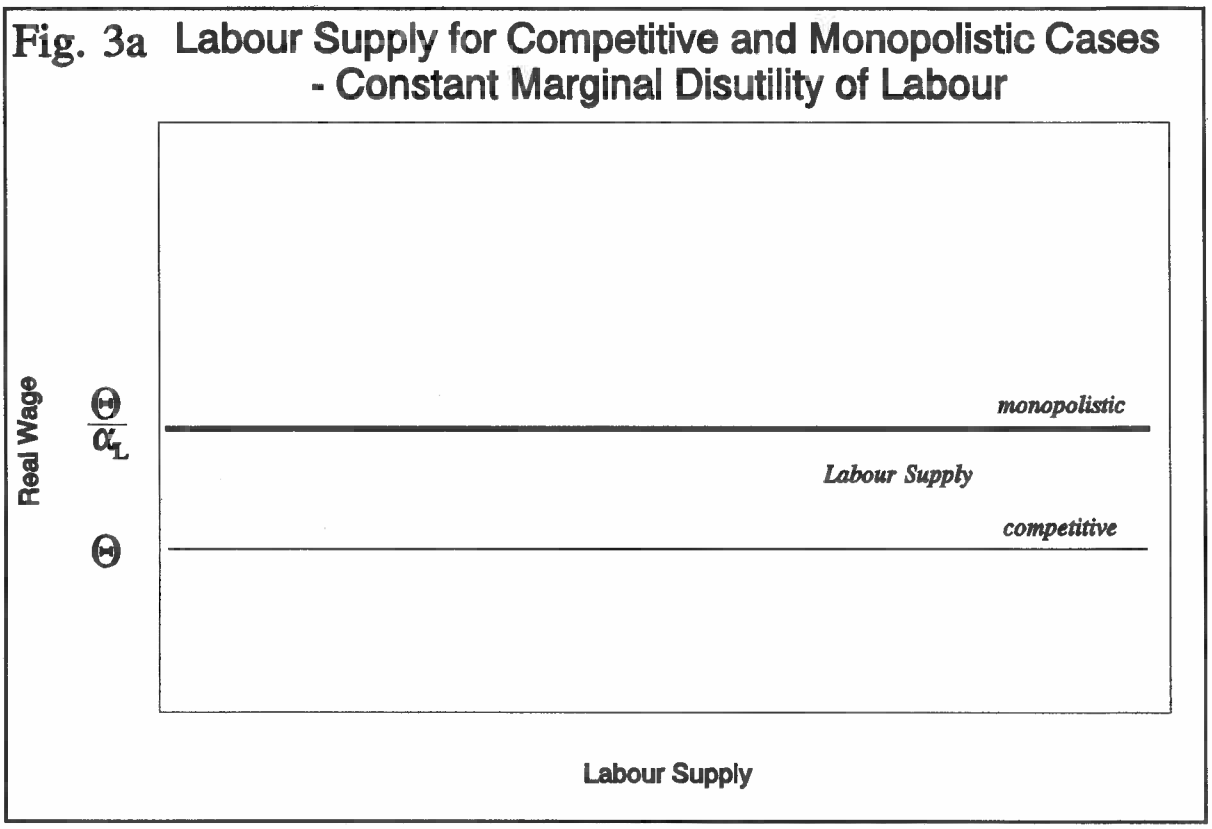
$$\frac{W}{P} = \frac{\theta}{\alpha_L} \tag{15}$$

That means that trade unions set real wage as a constant mark-up, equal to $1/\alpha_L$, over disutility of labour. The less elastic demand for labour, the higher is mark-up demanded by the trade union.

Labour supply curves for competitive and monopolistic cases are portrayed in Figure 3 and 3a.



Therefore the activities of trade unions, as modelled here, lead to a decrease in employment (labour supply curve moves to the left) at the cost of some increase (or at least,

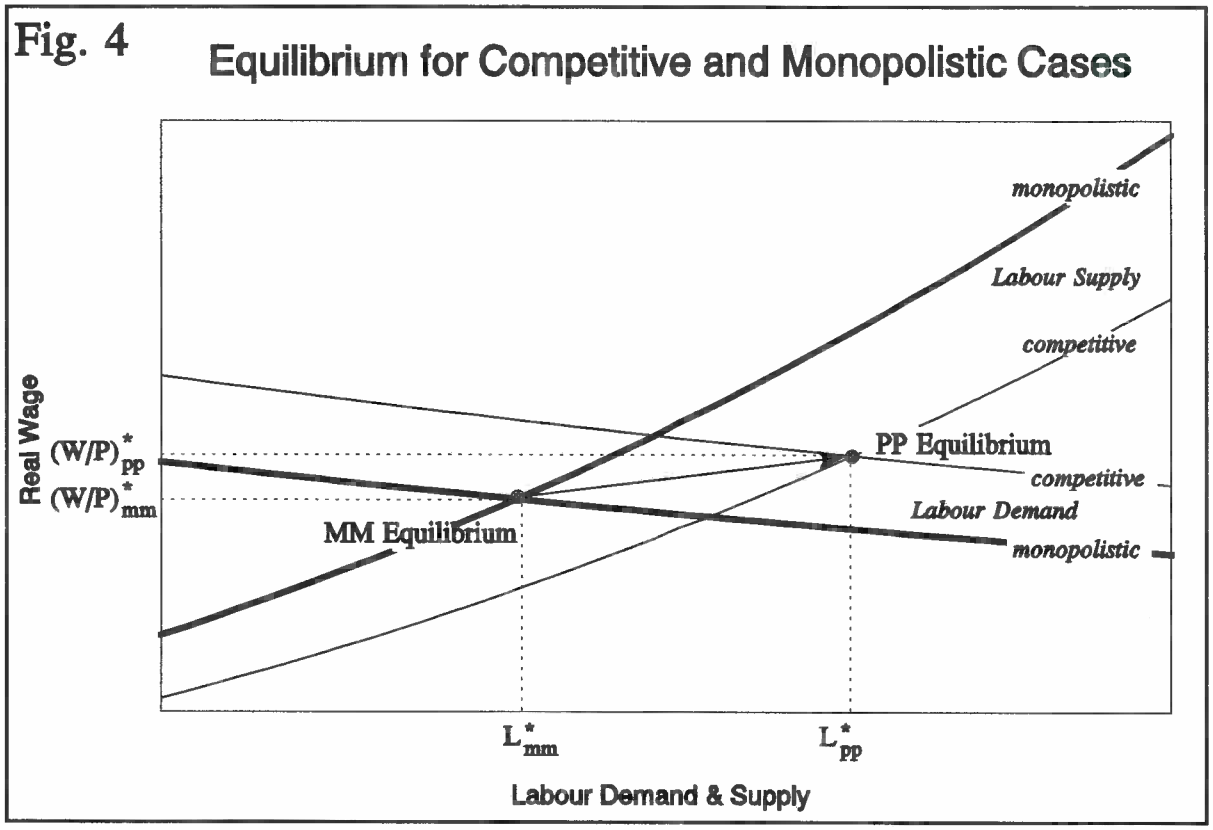


non-decrease) of the real wage and a relative worsening of the position of unemployed households (real wage is higher than marginal disutility of labour).

Solving (10) and (13) for labour and real wage gives an equilibrium point for the monopolistic behaviour of both firms and trade unions (**MM** equilibrium). **Figure 4** illustrates locus of that point with respect to equilibrium for the perfectly competitive case (**PP** equilibrium).

As argued above, when both firms and households (trade unions) behave monopolistically, the result is a lower level of employment and output than for the perfectly competitive case (Pareto-inefficient equilibrium). As far as the real wage is concerned, the result is ambiguous and depends on, roughly speaking, relationship between monopolistic power of producers (parameter ϵ) and trade unions (the intensity with which households perceive disutility of labour as measured by parameter η).

Fig. 4



If $(W/P)^{*pp}$ is the equilibrium real wage for the perfectly competitive case and $(W/P)^{*}_{mm}$ is the equilibrium real wage for monopolistic competition (both firms and households), then the following relationship holds:

$$(i)\quad \left(\frac{W}{P}\right)_m < \left(\frac{W}{P}\right)_p \quad iff \quad \eta > 1 + \frac{(1-\alpha_L)\times \ln \alpha_L}{\ln\left(1-\frac{1}{\epsilon}\right)}, \quad and$$

$$(ii)\quad \left(\frac{W}{P}\right)_m \geq \left(\frac{W}{P}\right)_p \quad iff \quad \eta \leq 1 + \frac{(1-\alpha_L)\times \ln \alpha_L}{\ln\left(1-\frac{1}{\epsilon}\right)}, \qquad (16)$$

where: *iff* - *if and only if*

As (16) shows, the change of regime from perfectly competitive to monopolistic (for both agents) results in the decrease of the real wage if the trade unions are relatively weak (large η) or increase in the real wage if trade unions are strong enough (η is sufficiently small). In

both cases, increasing degree of monopolisation of either of the market results in the lower level of employment.

While it is standard to use price elasticity of demand as a measure of monopoly power of producers, the interpretation of η as an indicator of monopoly power of trade unions needs further explanation. This interpretation is based on observation that small η ($\eta \rightarrow 1$) means horizontal labour supply curve, i.e. trade unions set their target on wages and then adjust to fluctuations in labour demand through changes in the supplied quantity of labour. As long as η goes to infinity, the labour supply curve becomes more and more vertical, i.e. trade unions react through revisions of their wage targets as the demand for labour changes. Therefore η measures the monopoly power of trade unions in a sense that it is related to their willingness to revise wage targets when labour demand fluctuates.

4. ONE-SECTOR CGE MODEL FOR POLAND

In this section, a one-sector Walrasian CGE model for Poland will be generally characterised. The model follows the tradition of CGE models elaborated for developing countries by S. Robinson et al. as presented in Derviş et al. (1982), Robinson (1989), Devarajan et al. (1991). The main features of the model may be summarised as follows:

- producers, households, government and rest of the world are the agents specified within the model,
- producers are assumed to maximise profits subject to technological constraints, in the perfectly competitive environment (sufficiently large number of firms, price taking behaviour)

- households maximise utility with respect to consumption and leisure subject to budget constraint; they supply labour in perfectly competitive manner, i.e. so as to equalise the real wage rate with the marginal disutility of labour,
- the government collects taxes and receives transfers, and spends this revenue on consumption purposes and on transfers to other agents;
- the foreign agents (rest of world) supply domestic economy with imports and transfers, and buy from the domestic agents goods (i.e., exports) and receive transfers,
- product and labour market clear through price adjustments;
- capital is fixed and capital price (user price of capital) adjusts to clear the market,
- with respect to rest of the world, "almost small country" (see: Harris (1984)) assumption has been adopted, i.e., on the imports side, supplies of imports are perfectly elastic at given world prices but goods of foreign origin are treated as imperfect substitutes of domestic products; on the export side, goods produced for domestic market are treated as imperfect substitutes of those destined for exports according to constant elasticity of transformation frontier; a downward sloping world demand curve is assumed for exports and thus its prices in foreign currency are endogenous.
- the model is closed in a neoclassical manner in a sense that: (i) all markets clear through adjustments of flexible prices, (ii) model is saving driven, i.e. investment adjusts to endogenous saving.

The full list of the equations of the model is given in The Appendix.

5. WELFARE GAINS OF ELIMINATION OF MONOPOLISTIC COMPETITION - CGE ESTIMATES FOR POLAND

5.1 Modifications of the Core Model

In this section, the CGE model (M1) - (M43) (see The Appendix) will be modified so as to include monopolistic competition of producers and households, as discussed in Section 3. Then the model will be calibrated for Poland, 1990 assuming monopolistic behaviour of both trade unions (households) and firms, and finally the welfare gains of hypothetical elimination of monopolistic practices will be estimated.

The incorporation of the framework developed by Dixon & Rankin (1994) into the CGE model (M1) - (M43) requires a modification of labour supply and demand functions in the CGE model so as to represent the monopolistic behaviour of trade unions and producers, respectively. Before discussing those modifications, let us make few comments on other differences between the two approaches and the way they are reconciled in the CGE model. They concern the treatment of assets (money and fixed assets) in both models. In Dixon & Rankin (1994) the utility function of the households (4) includes real money balances which are substitutable for goods. Money serves as a store of value in the model and does not enter production cycle again since model is static. Change in money holdings may be treated as a proxy of savings. Since there is no capital in the model, savings are not transformed into the investment (increase of capital). At a macro level, money stock determines absolute level of prices.

Contrary to this, the CGE model (M1) - (M43) belongs to the family of static 'real' CGE models (see: Robinson (1989)). In particular, money is not present in the model and the unit

of measurement is the price of some good (either products or factors or foreign currency) as the *numeraire*. Therefore all the prices are relative with respect to the *numeraire* and absolute prices are indeterminate. In the CGE model (M1) - (M42) the general price level is defined as a *numeraire* which means that all price are measured relative to exogenously fixed price of GDP composite. By definition, a change of *numeraire* will not affect real variables which represents a neoclassical dichotomy between the nominal and real spheres of economy (neutrality of money). Consequently, in our CGE model an implicit utility function of households does not include money holdings ($M_0 = 0$), so households consume and save out of current incomes only. This may be interpreted as a utility function with savings as an additional good[5]. Aggregate savings of the households enter the loanable funds market and will then be used for financing an increase in the stock of real capital. Since the model is static, real investment affects only current demand and does not increase the stock of fixed assets within simulation horizon. Fixed assets are owned by households, firms and government and supplied by them for production purposes. Owners of the capital get revenues from its use as factor services, according to their endowments.

As discussed in Section 3, monopolistic practices of firms affect factor demands (see (10)). Comparing to perfect competition case, less factor will be demanded for it's given price (user's cost) or less remuneration will be offered for factor services, given factor demand level. Resulting shift of the factor demand curves will depend on: (i) degree of monopolistic power (parameter ϵ), and: (ii) elasticity of demand for respective factor. As in (10), the factor demand equations for monopolistic case will take the following form:

[5]Howe (1975) discusses derivation of ELES demand system from Stone-Geary utility function in which saving is treated as additional good.

Labour demand equation - monopolistic case

$$L_D = (1 - \frac{1}{\epsilon}) \times \alpha_L \times \left(\frac{PDF}{PL}\right) \times X_S \qquad \text{(M2a)}$$

where:

PDF - producers price net of indirect tax (factor cost),
PL - price (user's cost) of labour,
ϵ - price elasticity of demand.

Capital demand equation - monopolistic case

$$K_D = (1 - \frac{1}{\epsilon}) \times (1 - \alpha_L) \times \left(\frac{PDF}{PK}\right) \times X_S \qquad \text{(M3a)}$$

where:

PK - price (user's cost) of capital,
ϵ - price elasticity of demand.

Capital supply remains fixed and must be equal to the demand for it, as postulated in equation (M30). Since the price of capital is fully flexible and no monopolistic behaviour of the owners of capital is assumed that means that capital market is modelled as perfect. Extra profits (monopolist profits) will be treated as a capital income. Consequently, capital incomes are not equal to user's costs of capital and will be defined as a surplus of the value of sales (net of indirect taxes) over labour cost:

Capital income - monopolistic case

$$YK = PDF \times X_D - YL \qquad \text{(M12a)}$$

It may be easily shown that factor demand functions (M2a) and (M3a) imply a mark-up price formation rule:

$$PDF = \frac{1}{1 - \frac{1}{\epsilon}} \times MC = \frac{1}{1 - \frac{1}{\epsilon}} \times (PL \times l + PK \times k) \qquad (19)$$

where:

$l := \frac{L_D}{XD}$ - *labour intensity*,

$k := \frac{K_D}{XD}$ - *capital intensity*.

Monopolistic behaviour of households (trade unions) is modelled through the derivation of a relationship between real wage and labour supply that maximises the surplus of wage revenue over disutility of labour, given labour demand curve (see problem (12) in Section 3). According to (13), the perfectly competitive labour supply function (M4) will then be replaced to represent monopolistic behaviour of households by the following equation:

Labour supply equation - monopolistic case

It is worth emphasizing that since monopolistic behaviour of producers and trade unions is modelled by multiplying respective labour supply and demand functions by constants, the model retains the property of zero degree homogeneity with respect to prices and incomes. Therefore it is not subject to criticism put forward by Ginsburgh (1994) who demonstrated the general equilibrium model with monopolistic competition which is not zero degree

$$L_S = \left(\frac{\alpha_L}{\eta \times \theta}\right)^{\frac{1}{\eta - 1}} \times \left(\frac{W}{P}\right)^{\frac{1}{\eta - 1}}$$

where: M4a

L_{S_p} - *labour supply*
W - *money wage rate*
P - *price of composite good*
η, θ - *parameters of household utility function* ($\eta > 1$)

homogenous in absolute prices and incomes, and therefore it's solution is sensitive to the choice of *numeraire*.

5.2 Simulations

The simulation experiments have been organized as follows. The model has been calibrated on data for Poland, 1990 assuming monopolistic behaviour of both firms and households (trade unions). The benchmark solution (original 1990 data reproduced by the model) will be called **MM-equilibrium** (Monopolistic producers, Monopolistic households). Simulations have consisted of changing the market regime for the respective agent, i.e. elimination of monopolistic practices of producers and/or households respectively.[6] Therefore new equilibria have been determined: **PM** - perfect competition of producers and monopolistic behaviour of households, **MP** - monopolistic behaviour of producers and perfect competition at labour market, **PP** - perfectly competitive behaviour of both producers and households. Welfare gains in terms of GDP increase have been estimated for the different

[6] The mechanism of elimination of monopolies is exogenous to the model. Generally, one may explain demonopolisation processes as resulting from institutional changes during transition (e.g., creation of several thousands new enterprises, privatisation, anti-trust laws) and opening of the economy to foreign competition.

regimes with reference to MM - equilibrium. Sensitivity analysis with respect to the parameters representing monopolistic power at both markets has been performed as well. When calibrating the model, the following values of parameters representing monopolistic power have been assumed: $\epsilon = 5.0$ and $\eta = 10.0$. The value of ϵ is consistent with the assumption that 'normal' users' cost of capital has been 17% of the price in the base year[7]. Then the mark-up on marginal costs, consistent with these assumptions, is equal to around 25%. The value of η is not based on any empirically verifiable hypothesis and is the author's 'guesstimate'. The results will be tested for their sensitivity with respect to the ϵ and η values. The main results of the simulation are displayed in the Table 3.

Table 3. Elimination of Monopolistic Behaviour - Main Results (percentage change against MM solution)

			PRODUCERS	
			P - regime	M - regime
H	P	W/P	19.2	-3.4
		L	9.6	7.1
O		GDP	4.9	3.6
U		YL	30.7	3.4
S		YK	-14.2	3.4
E		YH	15.3	2.6
		YC	-14.2	3.4
		YG	- 1.4	3.4
H	M	W/P	23.5	REFERENCE SOLUTION
		L	2.4	
O		GDP	1.2	
L		YL	26.4	
D		YK	-17.0	
S		YH	12.2	
		YC	-17.0	
		YG	- 4.6	

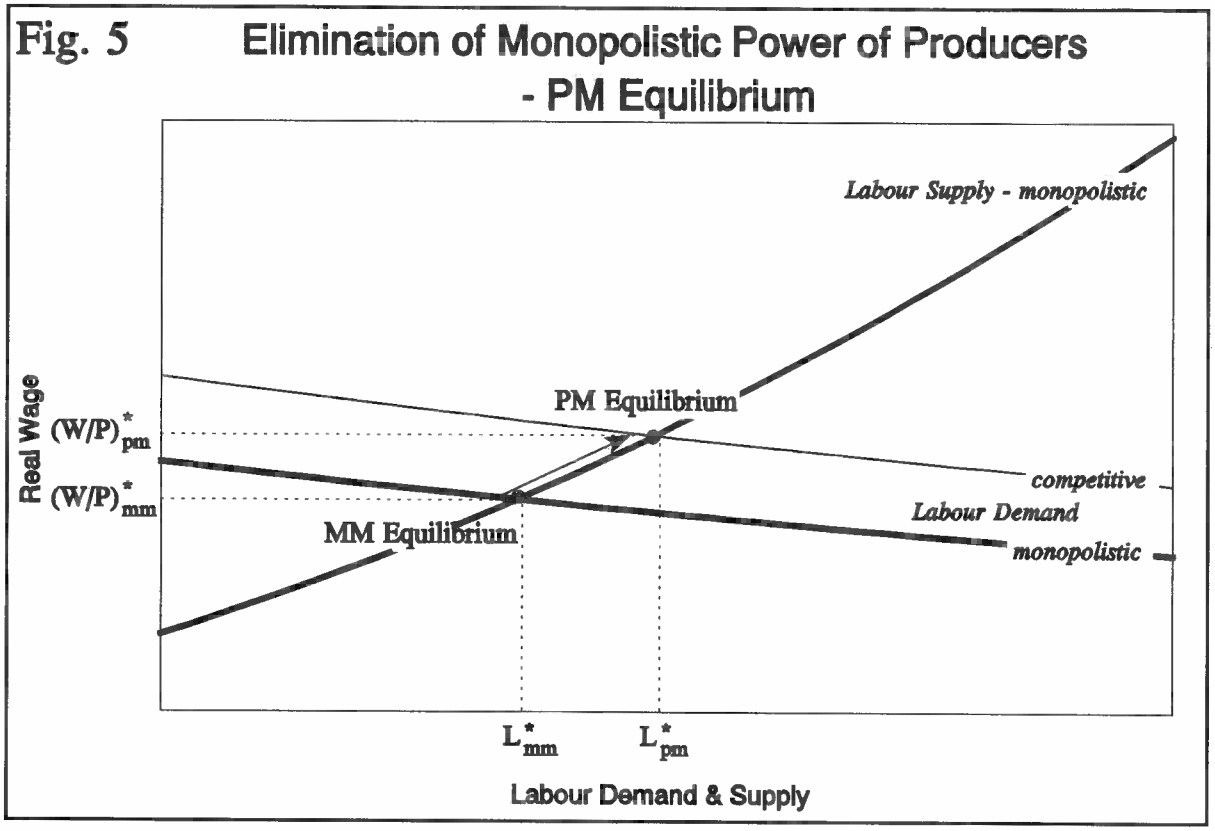
[7]Though 'normal' user's cost of capital assumed here may seem rather high, let us emphasize the relatively high share of capital in value added: 51.4%, as reported in SAM'90 for Poland. That is the result of both structural factors, like branch structure of the economy (large share of capital intensive industries), relatively low level of wages or monopolistic position of firms and by some phenomena specific for transition, like huge 'inflationary' profits gained by enterprises in 1990.

Simulation 1. Elimination of Monopolistic Power of Producers - PM Equilibrium

Introducing perfectly competitive regime for the producers means, among other effects, that they will pay factors according to their marginal productivities. This results in the shift of the labour demand curve to the right, i.e., an increasing demand for labour for any level of real wage. Assuming no change in the locus of labour supply curve, representing monopolistic behaviour of households, increasing demand for labour will be matched by an increasing labour supply at higher real wage, due to increasing marginal disutility of labour. At the new **PM** equilibrium, employment increases by 2.4% with a simultaneous increase in the real wage by as much as 23.5%. This means there is a relatively steep labour supply curve (high marginal disutility of labour) around equilibrium point. GDP increases by 1.2%, i.e. less than employment as capital stock is fixed. Disappearance of extra-profits as a consequence of monopolistic practices of firms results in changes in the income distribution, both factoral and institutional. Labour income increases by 26.4% while capital income decreases by 17.0% (here and below - all growth rates in real terms). As those incomes are allocated to institutions, households gain by 12.2% and companies have their incomes (retained profits) decreased by 17.0%, and government revenues go down by 4.6%. Household incomes increase less than the remuneration of labour since part of household income originates from returns on capital endowments (about 19% in the base year) and partly because these transfers (about 19% in base year) are fixed in real terms. The deterioration of public finance results from: (i) a dependence on corporate taxes rather than income taxes paid by households, (ii) a higher effective tax rate out of profits compared to taxes (mainly income tax) paid by households. In the base year, corporate taxes constituted about 49% of the government revenues comparing to 2.1% share of income taxes paid by

households. At the same time, firms paid about 49% of their profits as taxes while the household income was taxed at the rate of 1.3%[8] .

The locus of new equilibrium as monopolistic power of producers has been eliminated is illustrated in Figure 5.



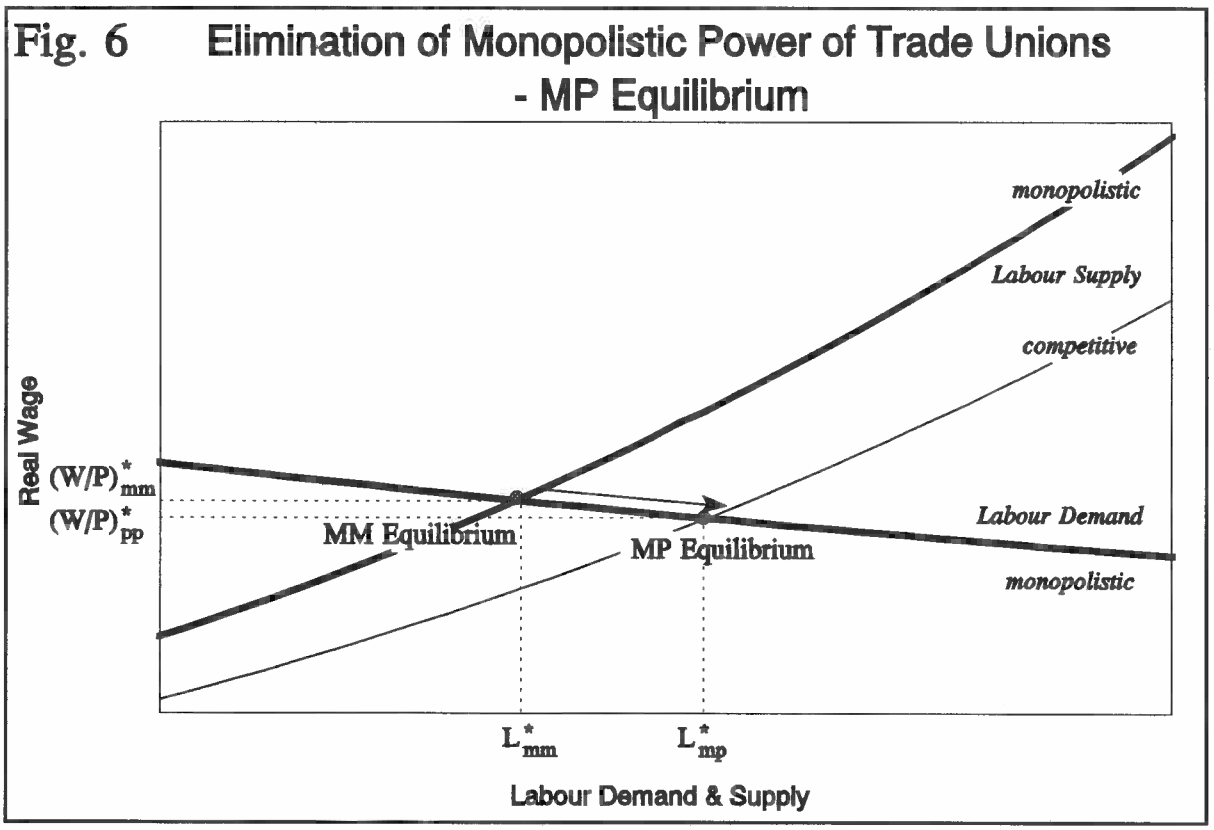
Simulation 2. Elimination of Monopolistic Power of Trade Unions - MP Equilibrium

The elimination of monopolistic power of trade unions while maintaining an assumption of monopolistic practices of firms means that wage earners are willing to supply more labour at any proposed level of real wage. Since the labour demand curve is downward sloping, a shift of labour supply curve into right will result in new equilibrium (**MP**) with higher

[8]It is only after introduction of personal income tax in Poland in 1992 that these proportions changed. For instance, income tax rates for households and firms were 10.6% and 46.2%, respectively, in 1992.

employment and a lower real wage. In our model, a change of regime from MM to MP generates increase of employment by 7.1% with the real wage decreasing by 3.4%. Growth of GDP (by 3.6%) results from larger labour input. There is no significant distributional effect from eliminating monopolistic power of trade unions. Higher employment does not itself produce an increase in labour income because of the deterioration in the real wage. As a result, both labour and capital income increase at the same rate 3.4%. The source of growth of capital income is the increase of its rental rate since the fixed stock of capital constrains output.

Figure 6 illustrates analysis at this point.

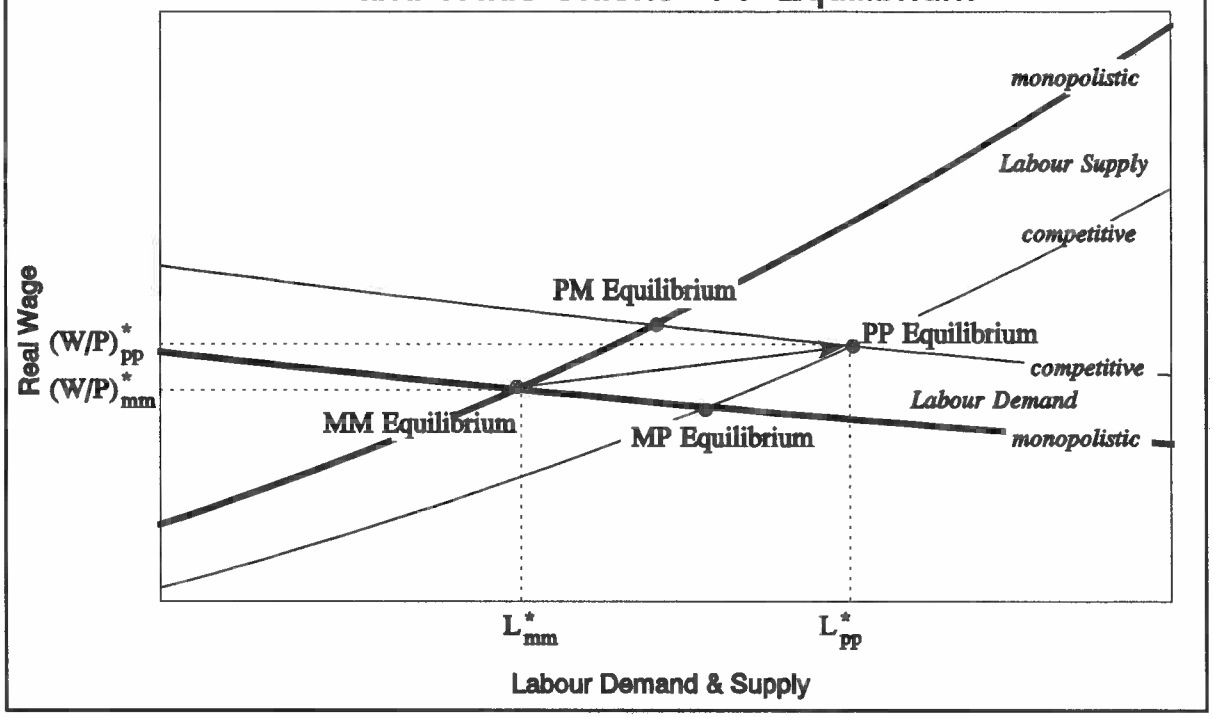


Simulation 3. Elimination of Monopolistic Power of Producers and Trade Unions - PP Equilibrium

Now let us assume that monopolistic practices of both producers and trade unions are eliminated. Therefore producers lose their power to set prices and limit factor employment so as to generate extra-profits. Trade unions no longer try to push wages up which, given a downward sloping labour demand function, induces employers to hire more labour. In terms of our model, a change of the regime from **MM** to **PP** means a simultaneous shift of both labour demand and labour supply curves into right. This unambiguously leads to an increase of employment by 9.6%. As condition (16i) is fulfilled, there is increase in real wage (by 19.2%) at new equilibrium. Production potential enlargened by additional employment generates 4.9% higher output (GDP). Establishing a perfectly competitive regime changes dramatically income distribution. Remuneration of labour increases by 30.7% because of both higher employment level and real wages. Capital income goes down by 14.2% what reflects elimination of extra profits, although moderated by substantial increase in the rental rate of capital (by 36.1%), at the given level of capital. As the result of final distribution of income, households are better off by 15.3%, incomes of companies go down as much as capital remuneration and government revenues decrease by 1.4% as redistribution effects are unfavourable for state budget (increasing share of wages in value added at the expense of profits) countervail general increase of level of activity and income.

The locus of relevant equilibrium points and direction of change is displayed in Figure 7.

Fig. 7 Elimination of Monopolistic Power of Producers and Trade Unions - PP Equilibrium



One of the income distribution effects discussed above is deterioration of the state budget as 'demonopolisation' processes change the pattern of the tax base. This in part reflects the specific features of Polish tax system at the beginning of transition, i.e. its relatively high dependence on corporate profits. The results of the simulations show the need of reforms of tax system if the government is to retain its sources of revenues when the system is released from monopolistic profits. If the Polish tax system is to follow the general pattern prevailing in many countries of Western Europe[9], then reform should go in the direction of, first, increasing the role of indirect versus direct taxation and, second, the relative rise of the tax

[9]Cohen, Lafeber and Zienkowski (1993) analyse differences in the pattern of government revenues in Poland and the Netherlands, using SAM framework.

burden of households versus enterprises[10]. In order to generate the results that are neutral with respect to position of government, additional variant of simulations has been performed with different closure. Government budget deficit[11] has been fixed and a rate of (net) indirect taxes has been made flexible. Since the results of that variant do not differ from the base run (i.e., with variable government budget deficit, see Table 3), they will only be cursorily discussed. Fixing the government budget deficit means introducing new constraint into the model which naturally leads to smaller welfare gains. For the PP simulation, GDP increased by 4.8% (comparing to 4.9% in the base run) and employment rose by 9.5% (previously 9.6%), with the real wage improving by 18.3% (19.2%). Adjustment through changes in the indirect tax rate, as assumed here, are relatively neutral from the point of view of income distribution. Therefore, both labour and capital incomes decreased, compared to the base simulation, by a similar rate. An increase of indirect tax rate by 53% has been necessary to maintain government balance at constant level after having eliminated monopolistic power of both producers and trade unions.

The other adverse effect of 'demonopolisation' is that even if budget balance has been maintained through tax reform, the redistribution of income from profits to wages leads to lower total savings and thus a drop in investment, given households marginal propensity to save. In the variant with a constant government deficit, total savings decreased by 5.6% (retained after tax profits go down by 15%%) while private consumption increases by 14.8%. Therefore, somehow paradoxically, any increase in competition would have unfavourable effect on long run perspectives of the Polish economy. An increase in the propensity to save

[10] Those changes have already taken place, to a large extent, in 1991 - 1993.

[11] Actually, in 1990 it was **surplus**, to great extent due to direct tax revenue from 'extra' profits (inflationary and monopolistic) from enterprises.

by private agents[12], mobilizing foreign sources of capital and increasing of the efficiency of investment processes seem to be the major policy measures supporting the accumulation of investment funds target.

Since indicators of monopolistic power of producers and households are not directly measurable, one may suppose that they are subject to misspecification. To measure the sensitivity of results with respect to ϵ and η specification, the same simulations have been performed as before assuming changes in the values of those parameters, representing '**strong**' or '**weak**' monopoly power for producers and trade unions. Symmetrically, 50% increase and decrease of ϵ and η have been assumed. Therefore 'strong' monopoly power of firms have been assumed at level of ϵ equal to 3.0 (mark-up equal to 50.0%) while '**weak**' monopoly power means $\epsilon = 7.5$ (mark-up equal to 15%). For the trade unions, $\eta = 5$ means 'strong' monopoly power and $\eta = 15$ stands for 'weak' monopoly power.

Table 4. Sensitivity Analysis (**PP** run) for Elimination of Monopolistic Behaviour Simulations (percentage change from the **MM** solution).

		PRODUCERS	
		Weak Monopoly	Strong Monopoly
HOUSE	Weak	W/P: 11.6 L: 6.2 GDP: 2.9	46.3 6.2 3.9
HOLDS	Strong	W/P: 3.8 L: 21.1 GDP: 9.7	38.1 21.8 13.2

The results of the simulations are presented in Table 4 (change from **MM** to **PP** regime).

The results of the test seem to imply rather high sensitivity of results to the values of parameters ϵ and η. The most sensitive variable is real wage which increases by 3.8% for the variant: Weak (Monopolistic) Producers and Strong (Monopolistic) Trade Unions (WS

[12]This is closely related to the question of tax reform.

variant) but increases as much as 46.3% for SW variant. The range for other variables is smaller but significant as well. Therefore reliability of estimates of elimination of monopolistic behaviour at both labour and product markets depends crucially on how reliable are estimates of monopoly power estimates.

6. CONCLUSIONS

In the paper, simple CGE model has been presented that incorporates framework elaborated by Dixon & Rankin (1994) for modelling monopolistic behaviour at product and labour markets. CGE model has been calibrated for Poland, 1990 and then used for simulating welfare gains of elimination of monopolistic power of trade unions and producers. The potential welfare gains of establishing perfectly competitive regimes at both markets are quite substantial: almost 5% increase in GDP and about 10% increase in the level of employment. Significant redistribution effects occur as well with labour income increasing by 29.9% and capital income decreasing by 14.8% (government revenue neutral variant). The model presented here needs further improvements and developments. In particular, experiments are necessary with less restrictive utility and production functions. Hopefully, that would lessen rather considerable sensitivity of the results to parameter estimates, especially measuring monopoly power. More careful examination of demand systems for different agents (domestic households, government, foreign agents) seems to be important. Assuming different price elasticities of demand for different consumers or market sectors (e.g., consumer vs. investment goods), that would enable to analyse the effects relationships between changes in the patterns of demand and degree of monopolisation at different sector

of the economy. Dixon & Rankin (1994) discuss potential effects of fiscal policy in that context.

The natural and non-trivial extension of the model (M1) - (M43) would be to introduce branch breakdown and to include different sub-markets for labour. That raises several questions that will be only generally commented here. As the disaggregation of production activities is concerned, careful examination of production structure of particular branches in terms of degree of monopolisation, entry and exit barriers, potential increasing returns to scale would be important. One may expect significant variation with respect to those parameters across branches. Some data and preliminary conclusions on the degree of monopolisation have been presented in Section 2.

For the labour market, different level of unionisation and therefore different degree of monopoly power of trade unions may be expected for different groups of employees. Both the choice of appropriate trade union model ('craft','sectoral') and measurement of their monopoly power are difficult questions[13]. Decisions in that respect are constrained by the availability of data. In the disaggregated SAM'90, available now, labour is classified according to sex and education (3 levels). Therefore, if 'craft' model of trade unions were to be applied, that would be based on criteria of skills as measured by education level and on assumption that it is rather skill-based than sectoral trade unions that monopolise labour market. Both forms of union organisations exist in Poland and both affect wage formation.

[13]Lindbeck (1993) generally criticizes that type of approach (no distinction between households and trade unions) and proposes the model in which activities of unions (wage setting) are separated from households activities (supplies of factor services).

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A p p e n d i x

Equations of the Model

B1 Production and Factors Employment

Production function

$$XD = \alpha_0 \times L_D^{\alpha_L} \times K_D^{1-\alpha_L} \qquad \text{(M1)}$$

where:

XD – *output*,
L_D – *labour demand*,
K_D – *capital demand*,
α_0, α_L – *parameters of production function.*

Labour demand equation

$$L_D = \alpha_L \times \left(\frac{PDF}{PL}\right) \times X_S \qquad \text{(M2)}$$

where:

PDF – *producers price net of indirect tax (factor cost)*
PL – *price (user's cost) of labour*

Capital demand equation

$$K_D = (1 - \alpha_L) \times \left(\frac{PDF}{PK}\right) \times X_S \qquad \text{(M3)}$$

where:

PK – *price (user's cost) of capital*

Labour supply equation

$$L_S = \left(\frac{1}{\eta \times \theta}\right)^{\frac{1}{\eta - 1}} \times \left(\frac{W}{P}\right)^{\frac{1}{\eta - 1}}$$

where:

(M4)

L_{S_p} – *labour supply*
W – *money wage rate*
P – *price of composite good*
η, θ – *parameters of household utility function* ($\eta > 1$)

Capital supply equation

$$K_S = \overline{K_S}$$

(M5)

K_S – *capital supply*

B2 Exports and Imports

Composite good equation

$$X = \alpha_{0M} \times \left(\alpha_M \times M^{\frac{\sigma_M - 1}{\sigma_M}} + (1 - \alpha_M) \times XDD^{\frac{\sigma_M - 1}{\sigma_M}}\right)^{\frac{\sigma_M}{\sigma_M - 1}}$$

where:

(M6)

M – *imports,*
XDD – *output supplied to domestic market,*
σ_M – *elasticity of substitution of imports for domestic products*
α_{0M}, α_M – *parameters of CES function*

Import demand equation

$$\frac{M}{XDD} = \frac{PDD}{PDM} \times \left(\frac{\delta}{1 - \delta}\right)^{\sigma_M}$$

where:

(M7)

PDD – price of domestically produced goods supplied at domestic market,
PDM – domestic price of imports.

Domestic Goods to Exports Transformation Curve

$$XD = \alpha_{0E} \times \left(\alpha_E \times E^{\frac{\sigma_E + 1}{\sigma_E}} + (1 - \alpha_E) \times XDD^{\frac{\sigma_E + 1}{\sigma_E}} \right)^{\frac{\sigma_E}{\sigma_E + 1}} \quad \text{(M8)}$$

where:

E – *exports*,
σ_E – *elasticity of transformation of domestic goods into exports*,
α_{0E}, α_E – *parameters of CET function*

Export supply equation

$$\frac{E}{XDD} = \left\{ \frac{PDE}{PDD} \times \left(\frac{1 - \alpha_E}{\alpha_E} \right) \right\}^{\sigma_E} \quad \text{(M9)}$$

where:

PDE – domestic price of exports

Export demand equation

$$E = e0 \times \left(\frac{PWE0}{PWE} \right)^{\zeta} \quad \text{(M10)}$$

where:

PWE0 – world price of export substitutes
PWE – world (dollar) price of exports
e0 – shift parameter
ζ – *price elasticity of demand*

B2 Incomes

Labour income

$$YL = PL \times L_D \qquad \text{(M11)}$$

where:

YL – labour income

Capital income

$$YK = PK \times K_D \qquad \text{(M12)}$$

where:

YL – capital income

Households Incomes

$$YH = \gamma_{HL} \times YL + \gamma_{HK} \times YK + tgovh \times P + trowh \times ER \qquad \text{(M13)}$$

where:

YH – total (pre-tax) income of households,
tgovh – transfers government to households,
trowh – foreign transfers to households,
ER – exchange rate,
γ_{HL}, γ_{HK} *– share parameters*

Companies Incomes

$$YC = \gamma_{CK} \times YK \qquad \text{(M14)}$$

where:

YC – total incomes of companies (economic profits before taxation)

Government Income

$$YG = \gamma_{GL} \times YL + \gamma_{GK} \times YK + TARIFF + INDTAX + INCTAX$$

where:

YG – total income of government,
TARIFF – government revenues tariffs,
INDTAX – government revenues indirect taxes,
INCTAX – government revenues income taxes,
γ_{GL}, γ_{GK} – *share parameters* (M15)

Tariff Revenues

$$TARIFF = tm \times pwm \times M \times ER$$

where: (M16)

tm – import tariff rate,
pwm – world (dollar) price of imports.

Indirect Tax Revenues

$$INDTAX = t_{IND} \times PDF \times XD$$

where: (M17)

t_{IND} – *indirect tax rate.*

Income Tax Revenue

$$INCTAX = t_H \times YH + t_C \times YC$$

where: (M18)

t_H – *income tax rate for the households,*
t_C – *income tax rate for the companies.*

B2 Expenditures and Savings

Households Consumption Expenditures

$$P \times HCONS = \beta_H \times YH \times (1 - mpsh) \times (1 - t_H) \quad \text{(M19)}$$

where:

HCONS – private consumption,
β_H *– household expenditure share,*
mpsh – household saving rate.

Households Savings

$$HSAV = mpsh \times (1 - t_H) \times YH \quad \text{(M20)}$$

where:

HSAV – households savings.

Companies Savings

$$COMSAV = (1 - t_C) \times YC \quad \text{(M21)}$$

where:

COMSAV – households savings.

Government Balance

$$YG = P \times GCONS + EXPSUB + tgovh \times P + tgrow \times ER + GSAV \quad \text{(M22)}$$

where:

GONS – real government consumption,
EXPSUB – total export subsidies,
tgrow – government transfers to rest of the world

Export Subsidies

$$EXPSUB = te \times PWE \times E \times ER$$

where: (M23)

te – export subsidy rate,
PWE – dollar price of exports.

Total Savings

$$SAVING = HSAV + COMSAV + GSAV + FSAV \times ER$$

where: (M24)

FSAV – savings of rest of the world (in foreign currency).

Investment Expenditures

$$INV = P \times IN$$

where: (M25)

INV – total investment expenditures,
IN – total real investment,

Nominal GDP

$$TOTVA = PDF \times XD + INDTAX + TARIFF - EXPSUB$$

where: (M26)

TOTVA – nominal GDP at market prices.

Real GDP

$$GDPR = HCONS + GCONS + IN + E - M$$

where: (M27)

GDPR – real GDP at market prices

B3 System Constraints

Goods Market Equilibrium

$$X = HCONS + GCONS + IN \tag{M28}$$

Labour Market Equilibrium

$$L_D = L_S \tag{M29}$$

Capital Market Equilibrium

$$K_D = K_S \tag{M30}$$

Foreign Exchange Market Equilibrium

$$PWE \times E + trowh + FSAV = PWM \times M + tgrow \tag{M31}$$

Saving-Investment Balance

$$SAVING = INV \tag{M32}$$

B4 Price Equations

Import Price Equation

$$PDM = pwm \times ER \times (1 + t_M) \tag{M33}$$

Export Price Equation

$$PDE = PWE \times ER \times (1 + t_E) \tag{M34}$$

Composite Good Price Equation

$$P \times X = PDD \times XDD + PDM \times M \tag{M35}$$

Output Price Equation

$$PD \times XD = PDD \times XDD + PDE \times E \tag{M36}$$

Producer Price Equation

$$PDF = \frac{PD}{1 + t_{IND}} \tag{M37}$$

Labour Price Equation

$$PL = (1 + t_W) \times W$$

where: (M38)

t_W – *tax on wage.*

Capital Price Equation

$$PK = (\tau + R) \times P$$

where: (M39)

τ – *depreciation rate.*

General Price Level Equation

$$PINDEX = \frac{TOTVA}{GDPR} \tag{M40}$$

Closure of the Model

$$PINDEX = \overline{PINDEX} \tag{M41}$$

$$GCONS = \overline{GCONS} \tag{M42}$$

$$FSAV = \overline{FSAV} \tag{M43}$$