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# EARLY-TRANSITION OUTPUT DECLINE REVISITED

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**ABSTRACT:** *In this paper we revisit the issue of aggregate output decline that took place in the early transition period. We propose an alternative explanation of output decline that is applicable to Central- and Eastern-European countries. In the first part of the paper we develop a simple dynamic general equilibrium model that builds on work by Gomulka and Lane (2001). In particular, we consider price liberalization, interpreted as elimination of distortionary taxation, as a trigger of the output decline. We show that price liberalization in interaction with heterogeneous adjustment costs and non-employment benefits lead to aggregate output decline and surge in wage inequality. While these patterns are consistent with actual dynamics in CEE countries, this model cannot generate output decline in all sectors. Instead sectors that were initially taxed even exhibit output growth. Thus, in the second part we consider an alternative general equilibrium model with only one production sector and two types of labor and distortion in a form of wage compression during the socialist era. The trigger for labor mobility and consequently output decline is wage liberalization. Assuming heterogeneity of workers in terms of adjustment costs and non-employment benefits can explain output decline in all industries.*

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**Keywords:** *output decline price liberalization adjustment costs non-employment benefits*

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**JEL Classification:** F11; J21

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## INTRODUCTION

It is a well established stylized fact that all Central- and Eastern-European countries (CEE) and Commonwealth of Independent States (CIS) experienced a large aggregate output decline soon after they initiated the process of economic reforms. The decline resulted in an extensive theoretical and empirical research, which tried to understand its causes and economic mechanisms. Theoretical explanations of output decline can be divided into two strands of literature. According to the first one, the decline was caused by stabilization policies, which caused excessive inward shift of aggregate demand (e.g. Berg and Blanchard, 1994; Rosati, 1994). The second strand of the literature, recently receiving more attention, focuses on the factors underlying the inward shifts of aggregate supply. Calvo and Coricelli (1993) related the output decline to a reduction in available credit for financing production. Blanchard and Kremer (1997) built a model in which

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price liberalization triggers a process of bargaining between firms in vertical supply chains, which may, under incomplete contracts or asymmetric information, lead to an output decline.<sup>3</sup> Roland and Verdier (1999) propose a search model that relates price liberalization, interpreted as a freedom to contract, to output decline. The fall of output takes place because firms are willing to postpone their relational investment in a situation where the option of ongoing search is more valuable than immediate investment. Blanchard and Kremer (1997) recognized that their explanation was more relevant for CIS countries, which also applies to the model of Roland and Verdier (1999). For more liberal CEE countries that did not face such bargaining inefficiencies and information asymmetries, we still do not have a convincing explanation why price liberalization may have caused aggregate output decline.

In this paper we propose an alternative explanation of the output decline in CEE countries that partly builds on the work of Gomulka and Lane (2001). Starting with a simple two-period two-sector general equilibrium model, we first consider the effect of price liberalization, interpreted as elimination of distortionary taxation, on sectoral and aggregate dynamics of both output and employment. The elimination of price distortions increases the price of initially subsidized good and decreases the price of initially taxed good. This creates incentives for relocation of workers from the subsidized sector to taxed sector. However, workers are assumed to differ in terms of adjustment or mobility costs and non-employment benefits provided by the government and supplemented by income generated by working in informal economy. Specifically, both mobility costs and non-employment benefits increase with age of workers. These costs and benefits work as a sorting mechanism, creating incentives for younger workers to move to the sector with increasing prices and incentives to move to inactivity by older workers. The aggregate number of hours worked declines due to hours lost in mobility and hours lost due to inactivity of workers. While the output of sector with increasing price expands, this increase is smaller than a decline in the sector with declining price, causing aggregate output decline evaluated at initial relative prices. At the same time the adjustment costs create a wedge between the wages prevalent in the two sectors, thereby increasing the wage inequality.

This model has several attractive features that are not present in the model developed by Gomulka and Lane (2001). In particular, they assume prohibitive adjustment costs to labour mobility and predetermined real wages. These two assumptions imply that expanding sectors cannot employ additional workers and thus cannot increase output, while real wage rigidity causes a decline in sectors with increasing price. While their model can explain aggregate output decline, it is inconsistent with several stylized facts regarding the functioning of labour markets that our model takes into account. In particular, their model does not feature a large proportion of voluntary shifts of workers from employment to inactivity due to high non-employment benefits (see Boeri, 2000a; Boeri and Terrell,

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<sup>3</sup> Konings and Walsh (1999) used data for a sample of Ukrainian firms and showed that firms with more complex production structures indeed grew more slowly in terms of employment, which supports the theory developed by Blanchard and Kremer (1997).

2002; Vodopivec, Wörgötter and Raju, 2003)<sup>4</sup> and participation in an informal economy (Johnson, Kaufmann and Shleifer, 1997; Lacko, 2000), and completely ignores an increase in wage inequality during the period of output decline (Milanovic, 2002). The real wage rigidity assumed by Gomulka and Lane (2001) implies that labour outflows should be involuntary and inequality should not change. Our model also provides a more convincing explanation for the duration of output decline as we rely on non-employment benefits and income generated in informal economy, rather than on sustained wage rigidity in the economy with high unemployment and no government benefits. In our view, voluntary flows of workers to inactivity and persistence of the real wage rigidity had the same cause. The combined benefits put an effective lower bound on the real wages in declining sector and provided an attractive alternative to work in the official economy.

In spite of its attractive features, the two-sector model with price liberalization is not able to explain output decline that took place in virtually entire economy (see Roland, 2000). In the second part we show that wage liberalization, interpreted as elimination of cross-subsidization of less productive workers, could explain output decline in all industries as long as workers are different in human capital if we preserve similar heterogeneity of workers in terms of adjustment costs and non-employment benefits. However, given scarce microeconomic evidence, we cannot argue that the proposed mechanism dominates the effects of trade embargoes and aggregate demand shifts.

The remainder of the paper is organized in three sections. In the second section we present a model of price liberalization, the third section discusses the effects of wage liberalization. The last section concludes.

## 1 A MODEL OF PRICE LIBERALIZATION

In this section, we develop a simple theoretical model that allows us to analyze the effects of price liberalization on both sectoral and aggregate employment and output. Following the work of Gomulka and Lane (2001), we focus on a specific mechanism that works through changes in relative prices and thus leave aside bargaining inefficiencies and search frictions that could have arisen after price liberalization.

In our model price liberalization is considered as elimination of distortionary taxes on firms' revenues. In reality, however, socialist governments used a wide variety of measures that distorted both prices and allocations. On one hand, they interfered with decisions on employment, investments and new research activities, and on the other hand, they pursued desired allocations through direct setting of prices, wages and interest rates (Kornai, 1994). Since allocations, prices of production factors and prices of final goods were mostly inconsistent with the market determined ones, governments supported these allocations through extensive redistribution systems, which combined different types of

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<sup>4</sup> Even for Russia, where employment reductions were particularly modest, Earle and Sabirianova (2001) find that 75 percent of all separations were voluntary.

taxes and subsidies ranging from direct taxation to inflationary taxation.<sup>5</sup> Nevertheless, by focusing merely on one type of government intervention -- distortionary taxation -- and its elimination, no substantive insight is lost. In fact, in the framework with linear production technologies and exogenously given number of products that we consider below, distortionary tax system alone can generate any desired allocation of labour. Therefore, in what follows, we consider introduction and removal of only this type of government intervention.<sup>6</sup>

## 1.1 Setup

### 1.1.1 Firms

We assume that firms produce two distinct goods,  $x$  and  $y$ , according to the same Ricardian production function, which require one unit of labor to produce one unit of final good:

$$q_j = l_j, j = x, y, \quad (1)$$

where  $q_j$  and  $l_j$  denote sector  $j$ 's output and employment, respectively. Since we are interested in a relatively short period of output decline that in CEE countries typically lasted two to three years, we assume away accumulation of physical capital and technological progress. In addition, firms face no entry and exit costs, which combined with constant returns to scale production function leaves market structure indeterminate. These assumptions greatly simplify the modeling framework, ensure tractability, and allow us to reduce the value maximization problem of firms into a standard profit maximization problem.

The profit of the representative firm producing good  $j$  is:

$$\pi_j = (1 - \tau_j)p_j q_j - w_j l_j, \quad (2)$$

where  $p_j$  and  $w_j$  denote the price of good  $j$  and the wage rate paid for unit of labour in production of  $j$ , respectively.  $\tau_j$  denotes the proportionate tax (or subsidy) rate levied on sales. Note that the choice of sales tax is not very restrictive as the same equilibrium allocations could be achieved by introducing sector specific taxation of gross wages. Namely, linear production functions imply that it is irrelevant what type of tax is used in order to distort allocation of labour between sectors, which can be observed from the first order conditions for profit maximization:

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<sup>5</sup> Note that disinflationary policies could have the same effect as price liberalization as subsidies through inflationary monetary policy had to be reduced.

<sup>6</sup> Distortionary taxation and direct measures of resource allocation may give very different results in the context of new products and services. A ban on entry of private firms may effectively limit the extent of product variety, which could be achieved only by prohibitively high taxation on firm entry.

$$(1 - \tau_j)p_j = w_j. \quad (3)$$

Since net wages were equal between sectors, differences in taxation of wages were reflected in labor costs and consequently in differences in prices.

### 1.1.2 Households

The economy is populated by a continuum of one worker/consumer households indexed on an interval between 0 and 1. Their utility function is defined over a consumption bundle of two goods and leisure time. The utility function for household  $i$  is:

$$u(x_i, y_i, v_i) = (x_i^{\frac{\sigma-1}{\sigma}} + y_i^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}} + \delta(H - v_i h), \quad 0 < \delta < 1. \quad (4)$$

The first part of (4) is a standard CES subutility function defined over quantities of goods  $x$  and  $y$  consumed with an elasticity of substitution,  $\sigma$ , that is assumed to exceed 1. The second part of (4) is a subutility function defined over leisure time, where  $H$  denotes the total time available per period and  $h$  denotes the statutory working time. For simplicity we shall assume that both parameters,  $H$  and  $h$ , assume value 1.  $\delta$  is a weight that households give to leisure relative to consumption. In order to simplify the framework, we assume that working time regulation prevents free choice of working hours. Households can thus choose between working and not working, which is captured in an indicator variable  $v$ , which is equal to 1 in the former case and 0 in the latter case.

Household  $i$  maximizes the utility function in (4) subject to the following budget constraint:

$$p_x x_i + p_y y_i \leq v_i \max\{w_{pi}, w_{ai}(1 - \kappa i)\} + (1 - v_i)\beta i, \quad \beta, \kappa \geq 0. \quad (5)$$

On the left-hand side is a standard expression for the cost of consumption bundle, whereas on the right-hand side is a non-standard expression for income earned per period, which also reflects the labor market choices that consumers face. Suppose first that consumer prefers activity to inactivity, i.e.  $v_i$  equals 1. In this case, she still faces the choice of sector of employment, which is made upon comparison of earned wages in the two sectors.  $w_{pi}$  and  $w_{ai}$  denote the wage rates earned per period in the prior and alternative sector of employment, respectively. For example, if worker stays employed in sector  $x$ , then  $w_{pi}$  equals to  $w_x$ . Alternatively, if worker, initially employed in sector  $x$ , moves to sector  $y$ , she earns a wage equal to  $w_y(1 - \kappa i)$ . Here  $\kappa i$  is the time lost in inter-sectoral mobility, such as search, re-training or commuting costs.  $\kappa$  is a parameter that determines the size of mobility costs, while  $i$  is an index of workers. Although in reality consumers may choose to use either working or leisure time for investment in mobility and that mobility may also entail other types of costs, such as monetary or psychological costs, the qualitative nature of results derived below does not hinge on assumed form of mobility costs. The

key feature of assumed form of mobility costs is introduction of worker heterogeneity. We think of index  $i$  as a proxy for age, which implies that older workers face higher mobility costs. This assumption is readily justified. On one hand, over the work cycle, workers gradually lose general human capital, which is necessary for re-training. On the other hand, older workers may be less familiar with various search channels and are more likely to be tied to a specific location through ownership of housing. Moreover, older workers have shorter remaining life spans, which implies lower values of investments in mobility.<sup>7</sup>

Suppose next that worker prefers inactivity, i.e.  $v_i$  equals 0. In this case, the government provides non-employment benefits. We assume that the size of these benefits depends on parameter  $\beta$  and an index of worker. Thus, non-employment benefits introduce another type of heterogeneity of workers. This assumption can be justified by actual institutional arrangements prevalent in Central and Eastern European countries (see Boeri and Terrell, 2002; Vodopivec et al., 2005), which typically entitled older workers to more generous non-employment benefits. Namely, the rules that determined entitlements typically related the amount and length of both unemployment benefits and severance payments to age. Moreover, an early retirement option was typically given only to workers older than some statutory minimum age.

The solution to the utility-maximization problem given by the objective function in (4) and the budget constraint in (5) can be found in two steps. In the first step, we determine the demand functions for both goods, which are then used in the second step – calculation of indirect utility functions related to different labor market choices. The demand functions are obtained from the first order conditions for utility maximization. These have a well-known form for CES utility function:

$$x_i^d(I_i, p_x, p_y) = \frac{p_x^{-\sigma}}{p_x^{1-\sigma} + p_y^{1-\sigma}} I_i,$$

$$y_i^d(I_i, p_x, p_y) = \frac{p_y^{-\sigma}}{p_x^{1-\sigma} + p_y^{1-\sigma}} I_i,$$

where demand functions of consumer  $i$ ,  $x_i^d$  and  $y_i^d$ , depend on the relative price of goods and combined income and non-employment benefits ( $I_i$ ).<sup>8</sup> The expression for income depends on the labour market choices that workers make. In general, there are five different choices that workers can make and thus five different types of workers. However, since changes in the relative wage are symmetric, it is sufficient to consider only one direction of wage change. In particular, we shall assume that price liberalization terminates preferential treatment of sector  $x$  and consequently to reduction of wage in

7 We recognize that proper treatment of time to invest consideration requires introduction of vintage human capital and overlapping generations structure. This would, however, greatly complicate the model without changing the substantive results of much simpler model that we propose.

8 Note that assumed inability of workers to transfer resources between periods implies equality of individual income and expenditure.

sector  $x$ . Given this assumption, we are left with four different groups of workers. In the first group are workers that stay in sector  $x$  and earn wage rate and income  $w_x$ . In the second group are workers that move from sector  $x$  to sector  $y$  and earn income  $w_y(1 - \kappa i)$ . In the third group are workers that move from sector  $x$  to inactivity and earn  $\beta i$  and in the last group are workers that stay in sector  $y$  and earn  $w_y$ .

As already noted, each labour market choice corresponds to a specific form of demand functions and thus also different indirect utility functions. Labour-market choice is made upon ranking the values of indirect utility functions. Given assumed pre-transition preferential tax treatment of sector  $x$ , after price liberalization workers employed in sector  $y$  will not have incentive to move either to sector  $x$  or to inactivity.<sup>9</sup> On the other hand, workers in sector  $x$  must compare the indirect utilities of three labour-market choices. The assumptions of increasing mobility costs and non-employment benefits with age imply that in equilibrium only the youngest workers move to sector  $y$ , the middle-aged workers stay in sector  $x$  and the oldest workers become inactive. The comparison of indirect utility functions gives the following conditions for the youngest workers:

$$w_y(1 - \kappa i) \geq w_x, \text{ for } i \leq i_{xy}, \tag{6}$$

where  $i_{xy}$  denotes the index of worker that is indifferent between staying in sector  $x$  and moving to sector  $y$ . On the other end of age distribution, only those workers employed in sector  $x$  move to inactivity for which holds that nonemployment benefit exceeds the wage earned in sector reduced by the value of lost leisure time. Formally, this condition can be stated as

$$\beta i \geq w_x - \delta, \text{ for } i \geq i_{xu}, \tag{7}$$

where  $i_{xu}$  denotes the index of worker that is indifferent between staying in sector  $x$  and becoming inactive.

The aggregate demand functions are calculated as sums of individual demand functions. Hence, these are:

$$X^d = \frac{p_x^{-\sigma}}{p_x^{1-\sigma} + p_y^{1-\sigma}} \int_0^1 I_i di, \tag{8}$$

$$Y^d = \frac{p_y^{-\sigma}}{p_x^{1-\sigma} + p_y^{1-\sigma}} \int_0^1 I_i di,$$

where the integral runs over all consumers.

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<sup>9</sup> We shall assume that the highest non-employment benefits cannot exceed the income earned in sector  $y$ . This assumption is necessary in order to prevent outflows of workers from the sector  $y$  as well.



### 1.1.3 Government

The government collects revenues by imposing sales tax, which is spent either on subsidies of firms' revenues or non-employment benefits to inactive workers. We assume that the government complies with the balanced budget constraint in each period:

$$\tau_{xt}P_{xt}X_t + \tau_{yt}P_{yt}Y_t = \int_{\Omega} \beta_i di, \quad (9)$$

where  $\Omega$  denotes the set of inactive workers. We assume that in the pre-transition period government subsidizes revenues of sector  $x$  and taxes revenues of sector  $y$ . In the transition period, government liberalizes prices by eliminating distortionary tax rates and applies one tax rate in both sectors.

### 1.2 Pre-transition equilibrium

Equilibrium in any period cannot be determined unless we make an assumption on the prior sectoral allocation of labour. Namely, the incentives for mobility between sectors and to inactivity depend on the interplay between prior labour allocation and current period tax policy. In order to focus on the transition period dynamics, we assume that prior labour allocation corresponds to current tax policy in a way that workers have no incentives to move from sector of initial employment. In other words, we assume a stationary pre-transition equilibrium. Furthermore, we assume that prevalent wage exceeds non-employment benefits for all workers and that no one prefers inactivity to work. This assumption normalizes the pre-transition inactivity to zero.

We are now ready to characterize the pre-transition equilibrium. Since this is the first period in our model, all the variables for this period have sub-index 1. We select labour as a numeraire and set the wage rate to 1. Note again that we assume that socialist government preferred goods produced in sector  $x$  and subsidized its revenues for which it raised resources by taxing the revenues of  $y$ . These assumptions and the first order condition for the profit maximization give:

$$p_{j1} = \frac{1}{(1 - \tau_{j1})}, j \in \{x, y\}, \quad (10)$$

which implies that the relative price of good  $y$  in terms of good  $x$ ,  $p_{y1} / p_{x1}$ , exceeds 1. Plugging the pricing equation (10) in the aggregate demand function (8), we get the relationship between the tax rates and output levels. The assumed form of production functions (1) also implies equality between output and employment levels:

$$X_1 = \frac{(1 - \tau_{x1})^\sigma}{(1 - \tau_{x1})^{\sigma-1} + (1 - \tau_{y1})^{\sigma-1}} = L_{x1}, \quad (11)$$

$$Y_1 = \frac{(1 - \tau_{y1})^\sigma}{(1 - \tau_{x1})^{\sigma-1} + (1 - \tau_{y1})^{\sigma-1}} = L_{y1}. \quad (12)$$

Note that employment and output increase with increases in respective tax rates. In particular, as government imposes a positive tax rate on revenues generated in sector  $y$  and thus a negative tax rate on revenues generated in sector  $x$ , the output and employment levels in sector  $x$  exceed those of sector  $y$ .

In order to complete the characterization of equilibrium, we need to establish the relationship between the tax rates. This relationship is obtained from the balanced budget constraint and the labor market clearing condition:

$$L_{x1} + L_{y1} = 1 \quad (13)$$

Since no worker opts for inactivity, the balanced budget constraint simplifies to

$$\tau_{x1} p_{x1} X_1 + \tau_{y1} p_{y1} Y_1 = 0.$$

Using the pricing relations (10), the equilibrium output, the labor allocations given in (11) and (12) and the labor market clearing condition (13), we get the following relationship between the tax rates in the two sectors:

$$\tau_{x1} (1 - \tau_{x1})^{\sigma-1} = -\tau_{y1} (1 - \tau_{y1})^{\sigma-1}. \quad (14)$$

This relationship depends on the value of elasticity of substitution. For Cobb-Douglas utility with  $\sigma$  equal to 1, there is a linear relationship between the tax rates. Specifically, an increase in  $\tau_{y1}$  by one percentage point implies a decrease in  $\tau_{x1}$  by one percentage point. For values of  $\sigma$  exceeding 1, this relationship is non-linear. For values of  $\sigma$  below 2.5, this relationship is monotonically decreasing for a wide range of  $\tau_{y1}$ . In what follows, we shall consider only values of  $\sigma$  for which higher  $\tau_{y1}$  corresponds to lower  $\tau_{x1}$ . It is also important to note that higher values of  $\sigma$  correspond to higher  $\tau_{y1}$  for given  $\tau_{x1}$ , which is a consequence of greater responsiveness of firms' revenues to changes in tax rates.

### 1.3 Transition equilibrium

We now turn to determination of equilibrium in transition period. All the variables for this period have sub-index 2. We start by assuming complete price liberalization, which government achieves by imposing equal tax rates for all sectors. As a consequence, the prices that firms set must change as well, which is evident from the modified price-setting equation:

$$p_{j2} = \frac{w_{j2}}{(1 - \tau_2)}, j \in \{x, y\}, \quad (15)$$

Namely, the price of good  $x$  must increase, whereas the price of good  $y$  must decrease. These price shifts change the structure of aggregate demand in favour of good  $y$ . If workers faced no obstacles to mobility, they would move from sector  $x$  to sector  $y$  and the wage rates and prices in two sectors would equalize as well. However, we assumed that workers face mobility costs that increase with age (index) of workers. Hence, the wage rates and prices can no longer be equal in two sectors. The relative price of good  $x$ ,  $p_{x2} / p_{y2}$  is thus equal to the relative wage rate in sector  $x$ ,  $w_{x2} / w_{y2}$ .

The relative wage rate is determined by an arbitrage condition given in (6). Continuously increasing mobility costs ensure that there exists a worker with an index  $i_{xy2}$ , who is indifferent between staying in sector  $x$  and moving to sector  $y$ . For this worker the wage rate earned in sector  $y$  multiplied by the share of remaining time after mobility between sectors must be equal to the wage rate (and wage) earned in sector  $x$ :

$$w_{y2}(1 - \kappa i_{xy2}) = w_{x2}. \quad (16)$$

This equation segregates workers previously employed in sector  $x$ . Only those with index (age) below  $i_{xy2}$  move to sector  $y$ , while older workers either stay in this sector or move to inactivity. Equation 15 implies that these differences in wages are also reflected in differences in prices across sectors.

The second arbitrage condition stems from decisions of workers initially employed in sector  $x$  with index that exceeds  $i_{xy2}$ . These workers face sufficiently high mobility costs to have no incentive to move between sectors. From inequality (7) we know that only workers above certain age decide to become inactive. That is, continuously increasing non-employment benefits imply that for sufficiently high  $\beta_2$ , there exists a worker who is indifferent between inactivity and work in sector  $x$ . We denote the index of this worker by  $i_{x1} - i_{xu2}$ . The arbitrage condition that relates non-employment benefits parameter and the wage rate in sector  $x$  is:

$$\beta_2(i_{x1} - i_{xu2}) = w_{x2} - \delta. \quad (17)$$

In order to calculate the equilibrium prices and allocations, we need to determine the indices of marginal workers,  $i_{xy2}$  and  $i_{xu2}$ . For this purpose, we need to use labour and final goods market clearing conditions. The goods market clearing conditions equate the aggregate demand and supply functions. However, due to Walras law, we only use one of these conditions. Namely, using the expressions for aggregate demand (8) and aggregate supply of labour, the good  $x$  market clearing condition is:

$$X_2^d = \frac{P_{x2}^{-\sigma}}{P_{x2}^{1-\sigma} + P_{y2}^{1-\sigma}} I_2 = L_{x2} = X_2^s. \quad (18)$$

Here  $I_2$  is the aggregate income that is a sum of incomes for four groups of workers: i) the young who move from sector  $x$  to sector  $y$  and earn wage  $w_y(1 - \kappa i)$ , ii) the middle-aged who stay in sector  $x$  and earn wage  $w_{x2}$ , iii) the old who move from sector  $x$  to inactivity and receive nonemployment benefits  $\beta_2 i$  and iv) all workers that are employed in sector  $y$ . Formally, the aggregate income is:

$$\begin{aligned} I_2 &= w_{y2} \int_0^{i_{xy2}} (1 - \kappa i) di + w_{x2} \int_{i_{xy2}}^{i_{x1} - i_{xu2}} di + \beta_2 \int_{i_{x1} - i_{xu2}}^{i_{x1}} i di + w_{y2} \int_{L_{x1}}^1 di \\ &= w_{x2} (i_{x1} - i_{xu2} - i_{xy2}) + w_{y2} (1 - i_{x1} + i_{xy2} - \frac{\kappa}{2} i_{xy2}^2) + \beta_2 i_{xu2} (2i_{x1} - i_{xu2}). \end{aligned} \quad (19)$$

Here we have used the same ordering of workers as above. Note also that normalization of aggregate labor time to 1 implies that indices, or differences between indices, represent labor shares. For example,  $i_{x1}$  is an index of the last worker employed in sector  $x$  in the first period and the share of labor engaged in this sector in the pre-transition period. Similarly,  $i_{xy2}$  is a share of young movers from sector  $x$  to sector  $y$ ,  $i_{xu2}$  is the share of older workers that move to inactivity and  $\kappa / 2 i_{xy2}^2$  is a share of labor lost due to intersectoral mobility. Combining pricing relations (15), (16) and (17) with goods (18) and labour market-clearing conditions:

$$i_{x2} = i_{x1} - i_{xu2} - i_{xy2}, \quad (20)$$

allows us to eliminate the wage rates, the prices and  $\beta_2$  from the goods market clearing condition. We obtain the first of the two equations with two unknowns,  $i_{xy2}$  and  $i_{xu2}$ , that determine the transition equilibrium:

$$\frac{(1 - \tau_2)}{1 + (1 - \kappa i_{xy2})^{\sigma-1}} \left( 1 + \frac{(1 - i_{x1}) + i_{xy2} (1 - \frac{\kappa}{2} i_{xy2})}{(1 - \kappa i_{xy2})(i_{x1} - i_{xu2} - i_{xy2})} + \frac{(1 - \delta) i_{xu2} (2i_{x1} - i_{xu2})}{(i_{x1} - i_{xu2})(i_{x1} - i_{xu2} - i_{xy2})} \right) = 1. \quad (21)$$

The second equation that determines the equilibrium is obtained by combining the balanced government budget constraint

$$\tau_2(p_{x2}X_2 + p_{y2}Y_2) = \beta_2 \int_{i_{x1} - i_{xu2}}^{i_{x1}} idi,$$

with pricing relations (15), (16) and (17), production function (1) and labor market clearing condition (20), to:

$$\frac{\tau_2}{1 - \tau_2} \left( (i_{x1} - i_{xu2} - i_{xy2}) + \frac{(1 - i_{x1}) + i_{xy2}(1 - \frac{\kappa}{2}i_{xy2})}{(1 - \kappa i_{xy2})} \right) = \frac{(1 - \delta)i_{xu2}(2i_{x1} - i_{xu2})}{(i_{x1} - i_{xu2})}. \quad (22)$$

The system of equations (21) and (22) determines the shares of workers in sector  $X$  that move either between sectors,  $i_{xy2}$ , or to inactivity,  $i_{xu2}$ . These, in turn, determine the equilibrium output levels, the prices and the wage rates. Since the solution to this system can not be expressed analytically, we examine the role of various parameters of the model in a simple simulation exercise. However, our highly stylized model is not suitable for calibration to real transition economies, which makes the choice of parameters arbitrary, serving only illustrative purpose.

### 1.3.1 Simulation exercise

In order to calculate the equilibrium allocations and prices, we need to choose the values of parameters. We start with parameters that determine the pre-transition allocation of labour, which also affects the transition equilibrium. From equations (10), (11), (12) and (14) follows that only two parameters, elasticity of substitution and sales tax rate in one of the sectors, determine this equilibrium. In the baseline scenario, for which we summarize parameter values in Table 1, we assume elasticity of substitution equal to 1 and a 15 percent subsidy rate on revenues generated in sector  $x$  in the pre-transition period. This subsidy rate corresponds to a 15 percent tax rate on revenues generated in sector  $y$ . For these parameter values and the wage rate set to 1, we have employment and output levels in sectors  $x$  and  $y$ , summarized in the first column of Table 2, equal to 0.575 and 0.425, respectively. The prices of goods  $x$  and  $y$  that support these allocations are 0.870 and 1.177, respectively. In other words, preferential subsidy given to firms in sector  $x$  allows them to set lower price and increase employment and output by 15 percent at the expense of employment and output in sector  $y$ .

Now that we have determined the pre-transition labour allocation, we need to choose the remaining values of parameters that affect the transition equilibrium. In particular, we need to specify the weight of leisure in the utility function, the common tax rate on firms' revenues, and the mobility cost parameter,  $\kappa$ . In the baseline scenario, we set  $\delta$  to 0.35, which implies that additional unit of leisure increases utility by the same amount as an increase of consumption of both goods from, say, 0.50 to 0.85 units.  $\kappa$  is set to 3, which on one hand implies zero mobility cost for the youngest worker in sector  $x$ , while the oldest worker faces prohibitive mobility cost equal to 2.1 units of leisure time. The common sales tax rate in transition is set to

0.065, which in equilibrium implies  $\beta_2$  equal to 1.343. This gives a range of non-employment benefits between 64.9 percent of the wage rate in sector  $x$  for the youngest and 77.2 percent for the oldest mover to inactivity.<sup>10</sup>

The transition period prices and allocations for this scenario are summarized in the lower part of the first column of Table 2. In comparison to the pre-transition levels, the output and employment levels in sector  $x$  decline from 0.575 to 0.466, a 18.96 percent decline, whereas the output and employment in sector  $y$  increase from 0.425 to 0.441, a 3.76 percent increase. As the decline of employment in sector  $x$  exceeds the increase of employment in sector  $y$ , there is a 10.2 percent aggregate employment decline. A large part of output decline in sector  $x$  is related to outflow of workers to inactivity ( $l_{xI2}$  is 0.091), although there is also a small part related to inter-sectoral mobility of workers ( $l_{xy2}$  is 0.017). The share of labour lost due to high mobility costs is relatively low ( $\kappa / 2 i_{xy2}^2$  is 0.0004). The prices that support these allocations changed as well. An increase in production of good  $y$  is consistent with consumer optimization only if the relative price of this good decreases. Moreover, while in the pre-transition period workers in two sectors earned the same wage rate, in transition period the wage rate in sector  $y$  exceeds the wage rate in sector  $x$  by 5.52 percent. In other words, wage inequality increases due to mobility costs that determine the sectoral wage gap. The change in aggregate output or real GDP depends on the choice of appropriate weights for the two goods. Following the standard methodology of statistical offices, we use the prices applicable in the pre-transition period. Due to relative scarcity of good  $y$  in the pre-transition period, the relative price of good  $y$  in this period is higher than in the transition period. Thus, while output of good  $y$  increases in transition period and output of good  $x$  decreases, the real GDP decline is smaller than the aggregate labor decline. For the baseline parameter values, the aggregate output decline amounted to 7.45 percent, which is 1.70 percentage points less than the aggregate employment decline.

Table 1: *Baseline parameter values*

Parameter	Description	Value
$\sigma$	Elasticity of substitution	1.000
$w_1$	Pre-transition nominal wage rate	1.000
$w_{x2}$	Transition nominal wage rate in sector $x$	1.000
$\delta$	Weight of leisure in utility function	0.350
$\tau_{x1}$	Pre-transition subsidy rate on revenue in sector $x$	-0.150
$\tau_{y1}$	Pre-transition tax rate on revenue in sector $y$	0.150
$\tau_2$	Transition tax rate on firms revenues	0.065
$\kappa$	Adjustment cost parameter	3.000

10 Note that we consider only tax rates that are to the left of the maximum of the Laffer curve. Over that range of parameter values, higher tax rate corresponds to higher non-employment benefits.

Table 2: The equilibrium allocations and prices for the baseline parameter values and alternative assumptions

Variable	Baseline parameter values	Deviations from the baseline scenario				
	(1)	$\tau_{y1} = 0.20$	$\sigma = 1.50$	$\kappa = 5.00$	$\tau_2 = 0.10$	$\delta = 0.45$
$Q_{x1} = L_{x1}$	0.575	0.600	0.623	0.575	0.575	0.575
$Q_{y1} = L_{y1}$	0.425	0.400	0.377	0.425	0.425	0.425
$P_{x1}$	0.870	0.833	0.870	0.870	0.870	0.870
$P_{y1}$	1.177	1.250	1.216	1.177	1.177	1.177
$GDP_1$	1.000	1.000	1.000	1.000	1.000	1.000
$Q_{x2} = L_{x2}$	0.466	0.475	0.492	0.470	0.438	0.457
$Q_{y2} = L_{y2}$	0.442	0.430	0.412	0.438	0.431	0.438
$i_{xy2}$	0.017	0.032	0.037	0.013	0.006	0.014
$i_{xu2}$	0.091	0.093	0.094	0.092	0.131	0.104
$L_2 = L_{x2} + L_{y2}$	0.908	0.906	0.904	0.908	0.892	0.895
$P_{x2}$	1.069	1.087	1.069	1.069	1.111	1.069
$P_{y2}$	1.129	1.201	1.204	1.147	1.131	1.115
$GDP_2^{CP}$	0.925	0.934	0.929	0.924	0.888	0.913
$w_{y2}$	1.055	1.105	1.125	1.072	1.017	1.043
$\kappa / 2 i_{xy2}^2$	$4 \cdot 10^{-4}$	$15 \cdot 10^{-4}$	$20 \cdot 10^{-4}$	$4 \cdot 10^{-4}$	$0.5 \cdot 10^{-4}$	$3 \cdot 10^{-4}$
$\beta_2$	1.343	1.282	1.228	1.345	1.463	1.167

Note: Columns (2)-(6) differ from the baseline scenario only in the value of parameter in the head of the table.

Next, we examine the effects of parameter variation on equilibrium outcomes. We compare equilibria by varying one parameter, while keeping all remaining parameter values in line with the baseline scenario. First, we consider greater initial miss-allocation. In our model, this is achieved by an increase in the tax rate on revenues of sector  $y$  from 15 to 20 percent. The equilibria that correspond to higher value of  $\tau_{y1}$  are summarized in the second column of Table 2. Higher  $\tau_{y1}$  is reflected in greater employment and output levels in sector  $x$  and lower employment and output levels in sector  $y$  in the pre-transition period. As a consequence, removal of distortions creates greater incentives for mobility of workers from sector  $x$  to both sector  $y$  and inactivity. Therefore, we can observe greater employment and output decline in sector  $x$ , and greater employment and output surge in sector  $y$  in the transition period. Nevertheless, the size of the aggregate employment

decline is greater. Since greater distortions imply that more workers bear mobility costs, there is also greater wage inequality. At the same time we observe lower endogenously determined  $\beta_2$ . This result suggests that countries with worse miss-allocation of labour could not afford to pay as generous non-employment benefits as countries with smaller distortions. The most important, but also controversial, prediction of the model is related to the change in real GDP in response to an increase in  $\tau_{y1}$ . The model predicts that this relationship is negative, which counters empirical observation that countries with worse initial conditions experienced greater output decline. It is important to note that we obtained our theoretical result by applying the pre-transition prices, which is theoretically equivalent to applying GDP deflators on nominal GDP growth rates. However, one should bear in mind well-documented measurement errors pertaining to calculation of change in real GDP. Both under-reporting of activity in small and growing firms and over-estimated measures of inflation due to coverage of primarily large firms with above average price increases could lead to overestimated output decline (Bartholdy, 1997).<sup>11</sup> Moreover, the extent of real GDP growth could be substantially reduced in a proper multi-period setting in which adjustment of workers could not take place within an interval of one time period. Nevertheless, the prediction that countries with greater distortions could experience smaller output decline raises concern and suggests that the proposed model can only complement the existing explanations of output decline, rather than replace them. This conviction is reinforced when higher values of elasticity of substitution are considered. In the fourth column of Table 2 we show the pre-transition and transition equilibria for  $\sigma$  equal to 1.5 and conclude that higher elasticity of substitution leads to greater dispersion of prices and miss-allocation of labour in the pre-transition period and greater decline of aggregate employment, while real GDP decline is in fact lower.

Next, we consider variation of parameter that reflects mobility cost,  $\kappa$ , which implies a proportionate change of mobility costs for all workers in sector  $x$ . The equilibria that correspond to this type of deviation from the baseline scenario are summarized in the fourth column of Table 2. An increase in  $\kappa$  to 5, does not affect the pre-transition equilibrium. However, since all workers in sector  $x$  face higher mobility costs, the transition equilibrium exhibits a smaller share of workers in sector  $x$  that move to sector  $y$  and a greater share of workers that become inactive. The share of workers that stay in sector  $x$  is thus higher, while the share of workers employed in sector  $y$  is lower. The net effect of higher adjustment costs is lower aggregate employment and lower real GDP. Moreover, higher  $\kappa$  also implies greater difference between hourly wage rates and thus greater dispersion of income between households. It is also important to note on the relationship between  $\kappa$  and employment lost due to mobility costs,  $\kappa / 2 \dot{l}_{xy2}^2$ . While higher  $\kappa$  reduces  $\dot{l}_{xy2}$ , the direction of change of aggregate mobility costs depends on response of  $\dot{l}_{xy2}$  to  $\kappa$ . In general, the relationship between  $\kappa$  and aggregate mobility

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11 Inability of the model to replicate the observed empirical relationship between the initial distortions and the extent of output decline is related to the assumption that the socialist governments achieved the desired allocations of resources only by distortionary taxation. This assumption, however, does not include the possibility that government used a ban on entry of private firms that could increase the variety of products. In that situation, sectoral output would not respond to a change in relative prices, but rather to liberalization of entry of firms. More importantly, changes of prices of goods could only be measured for existing firms. Therefore, application of GDP deflators, based on prices of continuing firms, to nominal GDP changes could yield greater output decline especially in those countries with worse initial distortions.



costs is hump-shaped. For low values of  $\kappa$  its increases lead to higher aggregate mobility costs and vice versa. In extreme case, where  $\kappa$  is prohibitive for all workers in sector  $x$  and there are insufficient benefits to participation in hidden economy, no worker would decide to move from sector  $x$  and employment (and output) in all sectors would remain unchanged. In summary, for moderate values of  $\kappa$ , the model predicts that countries with higher inter-sectoral mobility costs should exhibit greater output decline, greater income inequality and higher share of inactive workers.

The third experiment is variation of the common tax rate on the transition equilibrium. As higher tax rate corresponds to higher parameter for non-employment benefits, we interpret this experiment as a variation of generosity of non-employment benefits system.<sup>12</sup> The results for higher  $\tau_2$ , equal to 0.10, which corresponds to  $\beta_2$  equal to 1.463, are summarized in the fifth column of Table 2. Higher non-employment benefits make inactivity preferred choice for more workers in sector  $x$ . This decreases the share of employed workers in sector  $x$ , which implies that good  $x$  is relatively more scarce and its relative price is higher. As a result of, the wage gap between sectors and wage inequality are smaller, which reduces the incentives for inter-sectoral mobility and employment in sector  $y$ . The aggregate employment and the real GDP that correspond to higher non-employment benefits are both lower. Thus, in conclusion, this model predicts that countries that offered more generous non-employment benefits to inactive workers should exhibit greater output declines and lower wage inequality.

Lastly, we consider the effects of variation of relative value of leisure, captured by parameter  $\delta$ . This parameter allows an alternative interpretation, namely, a measure of relative productivity in formal as opposed to informal economy. As countries with higher relative productivity in formal economy are typically more developed with higher GDP, the relative value of leisure may be lower. In other words, variation of  $\delta$  may capture differences in the initial level of GDP per capita. In Table 2, we report the transition equilibrium that corresponds to the value of  $\delta$  equal to 0.45, which is higher than in the baseline scenario. An increase of relative value of leisure has similar effect on labour flows as an increase of transition-period tax rate. Namely, the share of workers that stay employed in the two sectors decreases, which results in higher aggregate employment and output decline. Higher outflow of workers from sector  $x$  to inactivity also implies lower wage inequality. The only difference is that non-employment benefits parameter decreases, which is a consequence of lower taxes collected due to outflow of workers to inactivity. In conclusion, countries with lower income per capita should exhibit greater output decline as inactivity may be a more attractive option for greater share of workers in declining sectors.

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12 The standard Laffer curve features a hump-shaped relationship between the tax rate and the total tax revenue. The setup of this model features this relationship. However, as an increase in the tax rate increases the outflow of workers from sector  $x$ , the relative price of this good increases and thus eliminates the incentive for outflow to more workers and further output decline. As a consequence, the relationship between the tax rate and the mass of taxes is only positive in this setup. The case where this relationship could be negative is ruled out as it would feature a decline in output also in sector  $y$ .

### 1.4 Trade embargo

Above we show that the model of price liberalization predicts that countries with greater initial distortions, *ceteris paribus*, should exhibit smaller output decline due to offsetting effect of sectoral changes in production and initial relative prices. In fact, under extremely large distortions, we could observe even real output surge. The second prediction that runs against the evidence is that the real GDP decline is smaller than the aggregate labour decline. In reality, we have observed that output decline is typically greater than that of aggregate employment, which suggests that other mechanisms may have played more important role.

One important piece of evidence is that countries with greater export shares to CMEA countries exhibited greater output decline. Djankov (1998) pointed out that FSU countries imposed import tariffs or even complete bans of imports. This trigger is easily analysed within our setup as an introduction (or an increase) of import tariffs also works through changes in relative prices. The appeal of this trigger of relative price changes is movement of prices and quantities in the same direction rather than in the opposite when relative prices change due to distortionary taxation, and consequently greater aggregate output decline.<sup>13</sup>

In order to illustrate this point, we assume a small open economy with exogenously given relative prices. Let us denote the relative price in CMEA as  $(p_x/p_y)^C$  and assume that its value exceeds 1. Exogenously given relative price allows us to determine the pattern of pre-transition specialization. Keeping the same form of production function as above, the relative productivity of two sectors is equal, which combined with common wage rate across sectors implies that the relative price in closed economy is equal to 1. Thus, given higher relative price of good  $x$  in CMEA, the country completely specializes in its production.<sup>14</sup> That is, output and employment in sectors  $x$  and  $y$  are 1 and 0, respectively. The pre-transition period levels of exports and imports are determined by plugging the aggregate demand functions given in (8) in the balanced international trade constraint:

$$\begin{aligned}
 X^e &= X^s - X^d = 1 - \frac{p_x^{-\sigma}}{p_x^{1-\sigma} + p_y^{1-\sigma}} I_i = \\
 &= 1 - \frac{p_x^{-\sigma}}{p_x^{1-\sigma} + p_y^{1-\sigma}} p_x = 1 - \frac{1}{1 + \left(\frac{p_y}{p_x}\right)^{1-\sigma}}.
 \end{aligned}$$

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13 Autor, Dorn and Hanson (2016) analyze show that entry of China in WTO in 2001 lead to important changes in employment of US workers and output. These effects are in our model analogous to trade embargo, but with the opposite direction of adjustment of workers.

14 While complete specialization is extreme, this is a consequence of preserving the same structure of economy as in the model of price liberalization. Modelling more complicated trade structure would necessarily yield more complicated expressions without changing the qualitative nature of results.

e fact that  $I = w = p_x$ . Thus, higher relative price of good  $x$  implies higher exports share. Similarly, the pre-transition imports is increasing in relative price:

$$Y^m = Y^s - Y^d = 0 - \frac{p_y^{-\sigma} p_x}{p_x^{1-\sigma} + p_y^{1-\sigma}}$$

Let us now consider the effect of trade embargo that takes place in the transition period. The equilibrium is determined in the same way as above. The only peculiarity is the extreme initial condition, which features complete specialization, and implies the same change in sectoral employment and output, irrespective of the change in initial relative prices. An important difference is, however, the prediction that the change in real GDP is increasing with relative price of  $x$ . For higher relative price of  $x$  greater weight is given to the decline in production of  $x$  and lower weight is given to the production of good  $y$ , which confirms our point. This result suggests that trade embargos (or increases in tariffs) likely had important effects on output decline in the FSU countries and possibly in CEE countries.

## 2 A MODEL OF WAGE LIBERALIZATION

In the previous section, we analysed output and employment dynamics in a model that featured simultaneous price and wage liberalization. The price liberalization acted as a trigger for the relative price change, while wage liberalization was necessary to enable also changes in wages, which induced inter-sectoral labour reallocation. In this section we show that wage liberalization alone could have generated labour mobility that resulted in simultaneous output decline. Moreover, unlike in the model with price liberalization, this model predicts that output decline takes place in all firms simultaneously. In order to show this, we modify the model developed before in two directions. First, we assume only one production sector with firms producing one homogeneous good. Second, we assume that workers differ in terms of skills. The former assumption simplifies the model, while the latter introduces heterogeneity of labour in terms of acquired human capital. As before, we shall assume that socialist government uses distortionary taxation that affects the skill composition in the labour force. This assumption is clearly not realistic as socialist governments typically achieved wage compression by direct wage determination. However, it is a convenient assumption in order to preserve a common modelling framework in the two periods.<sup>15</sup> The presentation of the setup of the model and key results follows the same structure as above.

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15 In order to achieve no unemployment among low-skill workers, direct wage determination needs a complementary intervention -- direct employment determination. If governments did not intervene in such way, low-skill workers would be unemployed. This phenomenon was often referred to as latent unemployment.

## 2.1 Setup

### 3.1.1 Producers

We assume that firms produce the final good according to the standard Cobb-Douglas production function with two production factors:

$$q = l_s^\psi l_u^{1-\psi}. \quad (23)$$

Here  $q$ ,  $l_s$  and  $l_u$  denote output, skilled and unskilled labour, respectively. As above, we shall omit time indices in the presentation of the setup.  $\psi$  and  $1-\psi$  are elasticities of output with respect to skilled and unskilled workers. Again, we assume costless entry and exit of firms, which combined with constant returns to scale production function leaves market structure indeterminate. The profit of the representative firm is:

$$\pi = pq - w_s l_s - w_u l_u, \quad (24)$$

where  $w_s$  and  $w_u$  denote the gross wage rates for skilled and unskilled workers, respectively. We choose the composite good to be a numeraire and set its price,  $P$ , to one. The first-order conditions for profit maximization are:

$$\psi l_s^{\psi-1} l_u^{1-\psi} = w_s, \quad (25)$$

$$(1-\psi) l_s^\psi l_u^{-\psi} = w_u. \quad (26)$$

From these conditions, we obtain firm-level demand functions, which have, due to linear homogeneity of production function, the same form as aggregate production functions:

$$L_s^d = \psi \frac{Q}{w_s}, \quad (27)$$

$$L_u^d = (1-\psi) \frac{Q}{w_u}. \quad (28)$$

Here  $L_s^d$  and  $L_u^d$  denote aggregate labor demand functions for high- and low-skilled workers, respectively, and  $Q$  denotes the aggregate output. These expressions imply that labor demand increases with increases in aggregate output and weight in utility function and decreases with increases in gross wage rates.

### 2.1.2 Households

The economy is populated by a continuum of households, whose index (age) is evenly distributed on an interval between 0 and 1. The utility maximization problem for these households is similar to that given in (4) and (5). However, since we no longer have two types of goods, the utility function simplifies to:

$$u(q_i, v_i) = q_i + \delta(H - v_i), \delta > 0, \quad (29)$$

where  $q_i$  denotes a quantity of the composite good consumed by worker  $i$ . The labour market choices that individuals make are reflected in budget constraints with one important difference. In the two-sector model, workers made choice between sectors of employment and inactivity, whereas here only low-skilled workers face a choice on investment in skills and inactivity as they represent a group that experiences a negative income shock after wage liberalization. In particular, since elimination of distortionary tax on wages increases the relative wage of high-skill workers, low-skill workers decide between increasing their human capital, not investing in human capital, but staying employed, and becoming inactive, while high-skill workers face no trade-off and just consume their income. The budget constraint that reflects these choices of low-skill workers is:

$$q_i \leq v_i \max\{w_u(1 - \tau_u), w_s(1 - \tau_s)(1 - \kappa i)\} + (1 - v_i)\beta i, \quad \text{with } \beta, \kappa \geq 0, \quad (30)$$

where  $w_u(1 - \tau_u)$  is the net wage rate for worker that preserves the skill-type, while  $w_s(1 - \tau_s)$  is the net wage rate if skill-level improves. Since we assume no adjustment cost for high-skill workers to become low-skill workers and government sets below market skill-premium in the pre-transition period, we have only four types of workers. In the first group are young low-skill workers that decide to invest in human capital and earn net wage  $w_s(1 - \tau_s)(1 - \kappa i)$ . In the second group are middle-aged low-skill workers that do not invest in human capital, but decide to remain active and earn  $w_u(1 - \tau_u)$ . In the third group are older workers that prefer inactivity as they receive sufficiently high non-employment benefits. The last group of workers are high-skill workers that earn  $w_s(1 - \tau_s)$  and have no incentive to make a change.<sup>16</sup> Workers with low human capital endowments compare indirect utilities of three competing options. As above, we assume that both the cost of investment in human capital as well as non-employment benefits increase with age (as indexed by  $i$ ), ensuring that only the youngest individuals will choose to invest in their human capital, the oldest workers will become inactive, while the middle-aged workers will find it optimal to maintain both their skill-level and type of employment. The choice of the youngest workers to invest in education is driven entirely by the following condition:

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<sup>16</sup> The remaining alternatives are, of course, easily eliminated as educated workers ( $h$ ) have no incentive to become inactive nor can they lose their human capital.

$$w_s(1 - \tau_s)(1 - \kappa i) \geq w_u(1 - \tau_u) \text{ for } i \leq i_{us} \tag{31}$$

where  $i_{us}$  indexes the oldest worker still choosing to invest in skill improvements. On the other end of the distribution, the choice between continued work as low-skill worker and inactivity is governed by:

$$\beta i + \delta \geq w_u(1 - \tau_u) \text{ for } i \geq i_c \tag{32}$$

where  $i_c$  denotes the worker that is indifferent between staying employed and becoming inactive.

Finally, the aggregate demand function, calculated as a sum of individual demand functions is simplified by the fact that the composite good price is set to one.

$$Q^d = \int_0^1 q_i^d di. \tag{33}$$

### 2.1.3 Government

We assume that government collects revenues by imposing a tax on gross wage and uses these either for gross wage subsidies or non-employment benefits. Thus, the balanced-budget constraint is:

$$\tau_s w_s L_s + \tau_u w_u L_u = \int_{\Omega} \beta i di, \tag{34}$$

where  $\Omega$  denotes the set of inactive workers. As already noted, we assume that government cross-subsidizes wages of low-skilled workers in the pre-transition period in order to ensure low wage inequality. This is reflected in a positive tax rate on wage earned by high-skilled workers and a negative tax rate on wages earned by low-skilled workers. In transition period, government liberalizes wage determination and applies a common tax rate on gross wages in order to finance non-employment benefits.

## 2.2 Pre-transition equilibrium

We start with determination of pre-transition equilibrium. As before, we assume a stationary skill structure. In other words, labour income taxation in the pre-transition period is such that no low-skilled worker is better off by investing in additional human capital or moving to inactivity. This is true only when equality between net wage rates of low- and high-skilled workers holds:

$$w_{s1}(1 - \tau_{s1}) = w_{u1}(1 - \tau_{u1}) \quad (35)$$

and when the oldest low-skilled worker, who is entitled to the highest non-employment benefit, does not prefer to move to inactivity.

Besides relationship between net wages, the equilibrium is determined by the first order conditions from firms' profit maximization, labor market clearing condition and the balanced-budget constraint. The ratio between first-order conditions, (25) and (26), we get the relationship between employment shares of low- and high-skilled workers:

$$\frac{L_{u1}}{L_{s1}} = \frac{w_{u1}}{w_{s1}} \frac{1 - \psi}{\psi}. \quad (36)$$

Combining (35) and (36), this ratio can be expressed as a function of tax rates:

$$\frac{L_{u1}}{L_{s1}} = \frac{1 - \psi}{\psi} \frac{(1 - \tau_{s1})}{(1 - \tau_{u1})}. \quad (37)$$

While one of the tax rates can be set freely, the other one must be set in line with the balanced-budget constraint. In equilibrium, no low-skilled worker prefers inactivity to work, which simplifies the budget constraint to:

$$\tau_s w_s L_s + \tau_u w_u L_u = 0.$$

Using the relationship between gross wage rates (35) and the fact that the sum of low- and high-skilled workers equals to one:

$$L_{s1} + L_{u1} = 1, \quad (38)$$

we get a familiar relationship between the tax rates:

$$\tau_{s1} = -\frac{1 - \psi}{\psi} \tau_{u1}. \quad (39)$$

We combine equations (37), (38) and (39) to calculate the shares of low- and high-skilled workers:

$$L_{u1} = 1 - \psi(1 - \tau_{s1}),$$

$$L_{s1} = \psi(1 - \tau_{s1}).$$

The corresponding aggregate output is:

$$Q = K(1 - \tau_{s1})^\psi (1 - \psi(1 - \tau_{s1}))^{1-\psi}, \quad (40)$$

where  $K$  is  $\psi^\psi (1 - \psi)^{1-\psi}$ , the level of output in the case of no distortionary taxation.

In summary, in the pre-transition period government pursued the goal of low income inequality by using distortionary taxation. Higher tax rates on gross wages of high-skilled workers and thus higher subsidy rates on gross wages of low-skilled workers lead to lower share of high-skilled workers and higher share of low-skilled workers. However, an unwanted consequence of distortionary taxation was lower aggregate output.

### 2.3 Transition equilibrium

In transition period, government liberalizes wage setting by equalizing the tax rates on wages of two types of workers. For given pre-transition skill structure that corresponds to high tax rate on wage of high-skilled labour and low tax rate on low-skill labor, the tax rate equalization increases the skill premium. Therefore, some low-skilled workers now find alternative options, such as investing in human capital or becoming inactive, more attractive. In particular, since both costs of investment and non-employment benefits increase with age of workers, only young low-skilled workers decide to invest in human capital, middle-aged workers remain low-skilled and older low-skilled workers choose inactivity. Outflow of workers to inactivity and time spent in the process of education reduce the share of low-skilled workers. Consequently, aggregate output declines. In the remainder of this section, we derive the system of equations that determines this equilibrium.

We start by specifying the equilibrium relationship between the wage rates of two types of workers. As investment cost increases with age of workers, there exists a worker who is indifferent between investing in education and remaining active as a low-skill worker. For this worker, the net wage earned as high-skilled worker must be equal to the net wage earned as a low-skilled worker. Equality of tax rates simplifies (31) to:

$$w_{s2}(1 - \kappa_{us2}^i) = w_{u2}. \quad (41)$$

As before, the cost of education for the marginal worker that invests in education determines the skill premium. Note that the index of the marginal worker also equals to the share of workers that decide to invest in education.

On the other end of age distribution, there exists a low-skilled worker who is indifferent between moving to inactivity and staying active as a low-skill worker. From this condition, we get the relationship between net wages and government benefits:



$$\beta(i_{u1} - i_{ux2}) = w_{u2}(1 - \tau_2) - \delta, \quad (42)$$

where  $i_{u1} - i_{ux2}$  is an index of the youngest worker that chooses inactivity.

We now turn to final good market-clearing condition that equalizes the aggregate demand to the aggregate supply. The demand is a sum of individual demand functions for four groups of workers. In the first group are young low-skill workers that decide to invest in education. Their index ranges between 0 and  $i_{us2}$ , the index of the oldest worker that invests in education. These workers earn the wage rate of high-skilled workers,  $(1 - \tau_2)w_{s2}$ , although they earn lower wage due to time used for schooling. In the second group are the middle-aged low-skilled workers that do not invest in education and thus earn  $(1 - \tau_2)w_{u2}$ . Their index runs between  $i_{us2}$  and  $i_{u1} - i_{ux2}$ . In the third group are old low-skilled workers that have an option to receive high non-employment benefits. The index of these workers runs between  $i_{u1} - i_{ux2}$  and  $i_{u1}$ . In the last group are all high-skilled workers. The aggregate demand for output good by these groups of workers is a sum of their after tax income:

$$Q_2^d = (1 - \tau_2) \left\{ w_{s2} \left( \int_0^{i_{us2}} (1 - \kappa i) di + \int_{i_{u1}}^1 di \right) + w_{u2} \int_{i_{us2}}^{i_{u1} - i_{ux2}} di \right\} + \beta_2 \int_{i_{u1} - i_{ux2}}^{i_{u1}} idi, \quad (43)$$

which can be integrated to:

$$Q_2^d = (1 - \tau_2) \left\{ w_{s2} (1 - i_{u1} + i_{us2} - \kappa / 2 i_{us2}^2) + w_{u2} (i_{u1} - i_{ux2} - i_{us2}) \right\} + \beta_2 i_{ux2} (i_{u1} - 1 / 2 i_{ux2}). \quad (44)$$

The aggregate supply is:

$$Q_2^s = L_{s2}^\psi L_{u2}^{1-\psi} = (1 - i_{u1} + i_{us2} - \kappa / 2 i_{us2}^2)^\psi (i_{u1} - i_{ux2} - i_{us2})^{1-\psi}. \quad (45)$$

Using the arbitrage conditions (41) and (42) and the first-order conditions (26), we get the first of the two non-linear equations that determine the shares of workers that invest in skills and workers that become inactive:

$$(1 - \tau_2) \left( 1 + \frac{\delta i_{ux2} (i_{u1} - 1 / 2 i_{ux2})}{(1 - \tau_2) (i_{u1} - i_{ux2})} \right) = Q_2 \left( 1 + \frac{(1 - \psi) (1 - \tau_2) i_{ux2} (i_{u1} - 1 / 2 i_{ux2})}{(i_{u1} - i_{us2} - i_{ux2}) (i_{u1} - 1 / 2 i_{ux2})} \right) \quad (46)$$

The second equation is obtained from the balanced-budget constraint. This constraint is in transition period equal to:

$$\tau_2 (w_{s2} L_{s2} + w_{u2} L_{u2}) = \beta_2 \int_{i_{u1} - i_{ux2}}^{i_{u1}} idi,$$

which can be further simplified using the arbitrage conditions (41) and (42) and the first-order conditions (26):

$$\frac{\tau_2}{1 - \tau_2} \frac{i_{u1} - i_{ux2}}{i_{ux2}(i_{u1} - 1/2i_{ux2})} = \frac{1 - \psi}{i_{u1} - i_{us2} - i_{ux2}} - \frac{\delta}{(1 - \tau_2)Q_2}. \quad (47)$$

The system of equations (46) and (47) determines the indices of marginal workers  $i_{us2}$  and  $i_{xu2}$ . From these we can determine the aggregate output and wage rates. Again, as this model yields no closed form solution, we analyze the model via simulations.

### 2.4 Analysis of the model

Analogous to the analysis of price liberalization we turn to a simulation exercise to study the implications of wage liberalization in transition. In order to determine the pre-transition equilibrium, we need to choose two parameters, the tax rate on skilled workers' wage  $\tau_{u1}$  (or alternatively the tax rate on unskilled wages) and the weight of skilled in the production function,  $\psi$ . Table 3 summarizes the baseline parameter values, where the subsidy rate on unskilled labour is equal to 0.2, while the weight in production function is 0.4. Note that price level of final good is normalized to 1. Under the baseline parameter values the respective shares of skilled and unskilled workers are equal 0.720 and 0.280, while the output is 0.493. The preferential subsidies, given to unskilled labour, combined with the taxes on skilled labour, ensure that the net wages of all workers are the same. For the assumed values of parameters, the gross wages are equal to 0.33.

Using the pre-transition labour allocation, we can calculate the transition equilibrium by choosing the values of remaining parameters. The weight of leisure in the utility function ( $\delta$ ) is set to 0.3, the parameter that determines the distribution of cost of education ( $\kappa$ ) to 2, while the common income tax rate in the transition period ( $\tau_2$ ) is 8%. Properties of the transition equilibrium are summarized in the bottom part of Table 4. A comparison of the pre-transition and transition equilibrium reveals that even though the size of the skilled labour force increases marginally, the size of the total labour force decreases from 1 to 0.816. This decline was brought on by a relatively large flow to inactivity (0.182), while the effect of the actual cost of 'vertical' labour mobility was marginal at best ( $\kappa/2i_{us2}^2 = 0.0016$ ). The large outflow to inactivity (of unskilled workers) also adversely affects the production level, which declines from 0.493 to 0.416. The reallocation of labour from unskilled to either skilled labour or to inactivity is supported by a change in the gross wages of the two groups of workers. The net and gross wage of skilled are 0.489 and 0.532, respectively, while the corresponding wages of unskilled are 0.456 and 0.496.

We also consider how equilibria change in response to different parameter values. As before, we change value of one parameter, while keeping the values of remaining parameters unchanged. First, we start by increasing the subsidy given to unskilled gross wages from 0.200 to 0.300. This increases initial distortion to skill composition as the share of unskilled labour increases from 0.720 in the baseline case to 0.780 in this scenario.

The removal of those distortions in transition subsequently motivates greater mobility both from unskilled to skilled labor as well as to inactivity. While initial output is lower, also the size of output decline in transition period is lower in both absolute and relative terms. The share of workers moving to inactivity increases from 0.182 in the baseline example to 0.198, and the share of workers choosing to invest in skill improvements more than doubles. The decline of aggregate employment is, consequently, also larger, while an increase in inequality is larger.

Consider next an increase in the elasticity of substitution between two skill types from 0.40 to 0.50. This change causes slightly greater output decline and lower employment decline. This is a consequence of greater initial share of skilled workers, which do not need to invest in education and are not attracted to inactivity. Wage inequality is also smaller in this case, as non-employment benefits reduce unskilled to similar levels for skilled and unskilled workers. The remaining parameters have similar effects on output and employment dynamics as in the model with price liberalization. An increase of adjustment costs in the form of education and training reduces investments in skills and consequently increases output decline, while it increases wage inequality. Both increases in transition period tax rate and value of leisure lead to greater output decline and lower wage inequality, as more workers are attracted to inactivity.

Table 3: *Baseline parameter values*

Parameter	Description	Value
$\psi$	Elasticity of substitution in production	0.400
$P_1$	Pre-transition price	1.000
$\delta$	Weight of leisure in utility function	0.300
$\tau_{u1}$	Pre-transition subsidy rate on unskilled labor wages	-0.200
$\tau_{s1}$	Pre-transition tax rate on revenue in sector $y$	0.300
$\tau_2$	Transition tax rate on firms revenues	0.080
$\kappa$	Adjustment cost parameter	2.000

Table 4: *The equilibrium allocations and prices for the baseline parameter values and alternative assumptions*

Variable	Baseline parameter values	Deviations from the baseline scenario				
	(1)	$\tau_{u1} = -0.30$	$\psi = 0.50$	$\kappa = 3.00$	$\tau_2 = 0.15$	$\delta = 0.4$
	(1)	(2)	(3)	(4)	(5)	(6)
$Q_1$	0.493	0.470	0.490	0.493	0.493	0.493
$L_{u1}$	0.720	0.780	0.600	0.720	0.720	0.720
$L_{s1}$	0.280	0.220	0.400	0.280	0.280	0.280
$w_{s1} = w_{u1}$	0.330	0.261	0.370	0.330	0.330	0.330
$Q_2$	0.416	0.405	0.412	0.415	0.358	0.361
$L_{us2}$	0.034	0.074	0.009	0.029	0.001	0.002
$L_{xu2}$	0.182	0.198	0.175	0.185	0.290	0.294
$L_2 = L_{x2} + L_{y2}$	0.816	0.795	0.825	0.813	0.697	0.707
$w_{s2}$	0.532	0.562	0.504	0.539	0.511	0.512
$w_{u2}$	0.496	0.478	0.504	0.492	0.509	0.509
$\kappa / 2L_{xy2}^2$	$1.6 \cdot 10^{-3}$	$7.7 \cdot 10^{-3}$	$0.1 \cdot 10^{-3}$	$1.6 \cdot 10^{-3}$	$6.2 \cdot 10^{-7}$	$6.9 \cdot 10^{-6}$
$\beta_2$	0.291	0.241	0.367	0.285	0.316	0.172

Note: Columns (2)-(6) differ from the baseline scenario only in the value of parameter in the head of the table.

### 3 CONCLUSION

In this paper we develop two simple models that show how price and wage liberalization may have contributed to a part of the large aggregate output decline and an increase in income inequality in the early transition. The relationship between price liberalization and output decline is not a unique feature of our model (see Atkeson and Kehoe, 1996; Blanchard and Kremer, 1997; Roland and Verdier, 1999 and Gomulka and Lane, 2001), but rather the proposed mechanism, which is consistent with a wide set of stylized facts relevant for the CEE countries.

We interpret initial distortions as direct political control over prices, wages and allocations and price liberalization as complete elimination of these distortions. In particular, we model price liberalization as a shift of preferences from those of social planners to preferences of consumers. These assumptions are in line with empirical evidence (Vodopivec, 1994), but contrast Gomulka and Lane (2001), who model price liberalization as elimination of distortionary tax system. An important problem of their interpretation is also in calculation of real GDP growth according to standard statistical methods, which may even exhibit growth of output.

According to our model, price liberalization alone is not sufficient for output decline. In order to comply with evidence on labor market flows during the early transition (Boeri and Flinn, 1999; Boeri, 2000a; Boeri and Terrell, 2002), we assume varying adjustment costs to labor mobility across different sectors and introduce non-employment benefits and reservation wage. Our explanation, however, differs from Atkeson and Kehoe (1996), who assume that adjustment costs are sufficiently low and investment horizon sufficiently long that workers are willing to bear adjustment costs. In their model, output decline is a consequence of investment in adjustment costs, which is inconsistent with observed low inter-firm, inter-sectoral and inter-occupational mobility and suggests that adjustment costs were not viable investments for the majority of workers. In addition to the interpretation of distortionary taxes, our model differs also from the other extreme model by Gomulka and Lane (2001), who assume prohibitive adjustment costs. Under this assumption alone, no worker would move between firms, which leads them to assume real wage rigidity. While this assumption is inconsistent with observed increase in wage inequality, it is also inconsistent with observed labour flows. If predetermined wages were indeed the cause of output decline, workers should have been forced to become inactive. Boeri (2000a) summarizes evidence that contradicts this assumption as labour flows were mostly voluntary. Hence, in our model, we assume that government provided non-employment benefits to workers and reservation wage earned in hidden economy. Both adjustment costs and non-employment benefits are positively related to age, which triggered young workers to move between sectors, middle-aged to stay in the same sector, while the oldest workers to become inactive. The decline of output and increased inequality are thus a consequence of trigger in the form of price liberalization and interplay between adjustment costs and non-employment benefits. The reduced labour supply due to increased inactivity leads also to aggregate output decline. In addition, wage liberalization that increased returns to education could alone be responsible for a part of decline as long as governments provided sufficiently high non-employment benefits.

We conclude with the following observation. Lack of firm- and individual-level data for the early transition period prevent us from empirically testing which of these explanations is the most plausible. Hence we cannot provide evidence on the relative importance of different supply-side and demand-side mechanisms. As it was argued already in Roland (2000), we cannot attribute the entire output decline to just one or the other mechanism. Hence, the aggregate demand shocks that worked either through expected income changes or trade embargos could be held responsible for a part of output decline. Nevertheless, consistency of our theoretical predictions with observed dynamics of sectoral employment

and output, labor flows and wage inequality suggests that our proposed mechanisms may have played some complementary role in output decline. Hence we believe that transition governments, following typical Western European practice of offering generous nonemployment benefits (see Blöndal and Scarpetta, 1997; Nickell, 2004), can be held partly responsible for aggregate output decline that took place in the early transition.

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