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Interregional Demand for Workers and the Effects of Labor Income Taxation[1]

by

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Abstract

We study the short-run impacts of labor income taxation in an aggregate economy of $N > 2$ regions. The distinct regions demand workers. Each region is endowed with one unit of immobile capital. The aggregate economy also has one unit of labor that is mobile across the regions. All regions produce a final good with identical Cobb-Douglas production functions. The price of output is normalized to unity. We perform five tasks. First, we focus on the benchmark case in which no region taxes either capital or labor. We find the equilibrium wage, the allocation of workers across the regions, and the total income of labor and capital. Second, we study the impact of a tax τ on labor income in region 1 when the other $N - 1$ regions do not tax labor income. We ascertain the after-tax return to labor in region 1, the equilibrium wage, and the allocation of labor across the regions. Third, we compute the total income of capital and labor and the tax revenue in region 1. Fourth, we discuss whether workers in region 1 are better off with a tax on labor income. Finally, we comment on the policy implications of our research.

Keywords: Capital, Labor, Interregional Demand, Labor Income Taxation, Factor Mobility

JEL Codes: R12, H71

1. Introduction

1.1. Literature review

Regional scientists and urban economists have now modeled and studied a variety of interactions between different regions where a region is understood to be a sub-national geographic entity. For instance, one group of researchers has analyzed the differences between rural and urban regions in the developed world. In this regard, Hall *et al.* (2006), Yamamoto (2008), and Jordan *et al.* (2014) have concentrated on rural-urban differences in, respectively, health, income, and education, in a variety of regions in the developed world. This line of research includes a smaller but salient group of studies---see Batabyal and Nijkamp (2014a, 2014b), Batabyal and Beladi (2015), and Batabyal (2018)---about lagging and leading regions where rural (urban) regions are frequently the lagging (leading) regions.

A second group of researchers has analyzed the effects of tax competition between different regions. In this regard, Bucovetsky (1995) showed that when people are mobile between the different regions being studied, tax competition between these regions will give rise to insufficient migration. Dembour and Wauthy (2009) concentrate on two contiguous regions and demonstrate that in the presence of interregional spillovers, the optimal level of infrastructure in these two regions is affected by the intensity of tax competition between them. Wang and Miao (2015) point out that tax competition between different provinces in China influences the nature of mergers and acquisitions undertaken by firms and also leads to interregional capital flows. Finally, Bai *et al.* (2019) focus on thirty provinces in China and point out that interregional tax competition has a negative impact on the local environment and, in addition, it also leads to worsening environmental quality in what they call spatially correlated regions.

1.2. Our objective

Very recently, Batabyal and Nijkamp (2020) have combined aspects of the two literatures discussed in the preceding two paragraphs and have analyzed the effects of wage taxation in a linear aggregate economy consisting of an urban and an adjacent rural region. They show that when these two regions demand workers, *inter alia*, there are a number of circumstances in which the Nash equilibrium wage taxes are, in fact, not taxes but subsidies. A limiting feature of the linear model analyzed by these researchers is that it consists of only *two contiguous* regions. Therefore, our principal goal in this paper is to extend the Batabyal and Nijkamp (2020) analysis by analyzing a model of labor income taxation in which there are $N > 2$ regions and these N regions are not necessarily contiguous to each other.

Before proceeding to the paper itself, we would like to point out that the subject of interregional competition resulting in demand for workers and labor income taxation is of interest not only from a theoretical but also from a practical standpoint. To see this, the reader should first recognize that as noted by Rutkowski (2007), there are many different kinds of labor taxes and that labor or personal income taxes are one kind of tax on labor. That said, regions in many different countries of the world engage in competition with each other and demand workers and therefore the nature and the magnitude of labor income taxes have a clear impact on the ability of such regions to compete effectively.[4]

Focusing on Canada, the work of Esteller-More and Sole-Olle (2002) shows that the provinces within Canada compete with each other using the personal income tax. However, this

[4] In the next paragraph, we discuss tax competition between regions in different nations of the world but this discussion deliberately focuses only on labor/personal income taxes. That said, it should be noted that regions in different nations also engage in competition using other kinds of taxes such as corporate income and property taxes.

competition appears not to be intense, most likely, because of the large size of the individual provinces. Blochliger and Pinero-Campos (2011) refer to previous research and point out that municipalities within Denmark compete with each other using the personal income tax. In this setting, lower tax rates lead to "in-migration" and large municipalities have higher tax rates. Moving on to Finland, Kangasharju *et al.* (2006) note that municipalities in this nation have raised the personal income tax over time and that municipalities that have received grants generally tend to have higher tax rates. In addition, although demographic factors appear to play no role in the determination of the tax rates, the density of the population does matter. Finally, Edmark and Agren (2008) examine the competition engaged in by municipalities in Sweden using the personal income tax. Their analysis shows that there is spatial correlation in the tax rates among local governments and that the underlying competition influences the setting of tax rates.[5]

The reminder of this paper is organized as follows. Section 2 describes the theoretical framework of an aggregate economy consisting of $N > 2$ regions that are not necessarily adjoining regions. Section 3 focuses on the benchmark case in which no region in the aggregate economy taxes either capital or labor. In particular, this section determines the equilibrium wage, the allocation of workers across the regions, and the total income received by labor and capital. Section 4 studies the impact of a tax at rate τ on labor income in region 1 when the remaining $N - 1$ regions do not tax labor income. Specifically, this section ascertains the after-tax return to labor employed in region 1, the equilibrium wage, and the allocation of labor across the regions in the

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As noted in the first paragraph of this section, our objective in this paper is *not* to focus specifically on regions that are contiguous to each other. In this respect, our analysis is general and therefore the N regions we study may or may not be contiguous to each other. That said, we note that in the European Union, for example, there are many examples of border---and hence contiguous---regions that are linguistically homogeneous but may have different tax systems. Examples include the border regions in Belgium and the Netherlands where Dutch/Flemish is spoken, the border regions of south Belgium and France where French is spoken, and the border regions of Austria and Germany where the language spoken is German.

aggregate economy. Next, this section computes the total income received by labor and capital and the tax revenue in region 1 as a function of the number of regions (N) and the tax rate (τ). Section 5 discusses the policy implications of our research. Finally, section 6 concludes and then discusses two ways in which the research delineated in this paper might be extended.

2. The Theoretical Framework

Consider an aggregate economy that is made up of $N > 2$ regions. Each of these N regions is endowed with one unit of capital (K). Capital is immobile across the regions in the model. This assumption makes sense only in the short-run and hence the reader should note that the subsequent analysis we undertake in this paper is best viewed as a *short-run* analysis of the impacts of labor income taxation in an aggregate economy. The aggregate economy under study also has one unit of labor (L). Since the regions in the aggregate economy are demanding workers, we assume that the available labor is fully mobile across these regions.

Each of the regions in the aggregate economy produces a final good (Q) with a constant returns to scale Cobb-Douglas production function given by[6]

$$Q = F(K, L) = K^{3/4}L^{1/4}. \quad (1)$$

The price of the output (Q) of this final good is normalized to \$1. We now proceed to analyze the benchmark case in which no region taxes either capital or labor.

[6] If we replace the exponents ¾ and ¼ with arbitrary constants then the subsequent analysis would not change qualitatively. That said, the underlying algebra would be more complicated and it would be hard to interpret some of the results in a straightforward manner.

3. No Taxes on Capital or Labor

We begin by ascertaining the equilibrium wage and the allocation of labor across the various regions. If none of the regions tax either capital or labor then the initial equilibrium must be symmetric. This means that $L = 1/N$ in each region. The wage that we seek is given by

$$w = \frac{\partial F(\cdot,\cdot)}{\partial L} = \frac{1}{4}\left(\frac{K^{3/4}L^{1/4}}{L}\right). \tag{2}$$

Now, using the result that $L = 1/N$, we can simplify the right-hand-side (RHS) of equation (2). This gives us

$$w = \frac{\partial F(\cdot,\cdot)}{\partial L} = \frac{1}{4}\left(N^{3/4}\right). \tag{3}$$

Using a similar process, the equilibrium interest rate or the return to capital is given by

$$r = \frac{\partial F(\cdot,\cdot)}{\partial K} = \frac{3}{4}\left(\frac{K^{3/4}L^{1/4}}{K}\right) = \frac{3}{4}\left(N^{-1/4}\right). \tag{4}$$

Having determined the equilibrium wage and the interest rate, it is straightforward to compute the total income accruing to labor and to capital. Specifically, using equation (3), the total labor income in the aggregate economy is

$$I_L = wL = \frac{1}{4}\left(N^{3/4}\right), \tag{5}$$

and, similarly, the total income of capital in our aggregate economy is

$$I_K = NrK = \frac{3}{4}\left(N^{3/4}\right). \tag{6}$$

To study the dependence of the equilibrium wage and the interest rate on the size of the aggregate economy or N, let us compute the actual values of w and r when there are, respectively,

[Table 1 about here]

two regions[7] and twenty regions in our aggregate economy. Inspecting Table 1 we see that the interest rate *falls* from 0.63 to 0.35 as the number of regions increases but, in contrast, the wage rate *rises* from 0.42 to 2.36. This happens because the *fixed* stock of labor in the aggregate economy becomes *scarcer* relative to capital as the number of regions in the model goes up. Having studied

[7] Recall that this is the case studied by Batabyal and Nijkamp (2020).

this benchmark case, we can now analyze the impact of labor income taxation by region 1 given that the remaining $N-1$ regions do not tax labor income.

4. Tax on Labor Income

Our first task is to ascertain the after-tax wage for labor employed in region 1. To this end, let us denote the labor employed in region 1 by L_1. To continue the analysis, we have to make an assumption about what the taxing authority in region 1 does with the tax revenue. To this end, to keep the analysis straightforward, we suppose that this authority uses the tax revenue to purchase the final good produced in this region at price \$1.

If L_1 is the labor employed in region 1 then the labor left over is divided equally among the remaining $N-1$ regions. Denoting the tax rate by τ, the real wage of labor employed in region 1 is $(1-\tau)w_1$. Now, with the individual regions in the aggregate economy demanding workers, the allocation of labor has to be such that the wage across all the regions is equated. This tells us that L_1 must satisfy the following relationship

$$(1-\tau)\frac{1}{4}(L_1)^{-\frac{3}{4}} = \frac{1}{4}\left(\frac{1-L_1}{N-1}\right)^{-3/4}. \qquad (7)$$

After several steps of algebra, we can simplify equation (7) further and obtain an explicit expression for L_1. That expression is

$$L_1 = \frac{(1-\tau)^{4/3}}{N-1+(1-\tau)^{4/3}}. \quad (8)$$

Because the remaining labor, i.e., the labor not employed in region 1 is divided equally among the remaining $N-1$ regions, we deduce that

$$L_i = \frac{1}{N-1+(1-\tau)^{4/3}} \quad (9)$$

for $i = 2,3,\ldots,N$. Inspecting equations (8) and (9), we see that the labor employed in both the taxing region 1 and in all the other regions *decreases* as the number of regions (N) comprising the aggregate economy increases.

Let us now compute the equilibrium wage in region 1. From the left-hand-side (LHS) of equation (7), we deduce that the wage we seek is given by

$$w_1 = \frac{1}{4}(L_1)^{-3/4} = \frac{1}{4}\left[\frac{\{N-1+(1-\tau)^{4/3}\}^{3/4}}{1-\tau}\right]. \quad (10)$$

Using a similar line of reasoning, the wage in the ith region, $i = 2,3,\ldots,N$, is

$$w_i = \frac{1}{4}(L_i)^{-3/4} = \frac{1}{4}\{N - 1 + (1-\tau)^{4/3}\}^{3/4}. \quad (11)$$

Inspecting equations (10) and (11), it is easy to confirm that an increase in the size of the aggregate economy or (N) *increases* the equilibrium wage not only in the taxing region 1 but also in all the other regions comprising the aggregate economy. This happens because the total amount of capital in the aggregate economy i*ncreases* by one unit every time a new region is added but the total amount of labor is *unaffected*.

What are the rewards to the two factors capital (K) and labor (L) in region 1 before the imposition of the tax on labor income? This question can be answered by using equations (7) and (4). Specifically, the before-tax labor income in region 1 is given by

$$w_1 L_1 = \frac{1}{4}(L_1)^{-3/4} L_1 = \frac{1}{4}\left[\frac{(1-\tau)^{1/3}}{\{N-1+(1-\tau)^{4/3}\}^{1/4}}\right]. \quad (12)$$

Using a similar line of reasoning, capital income in region 1 is

$$r_1 K_1 = \frac{3}{4}(L_1)^{1/4} = \frac{3}{4}\left[\frac{(1-\tau)^{1/3}}{\{N-1+(1-\tau)^{4/3}\}^{1/4}}\right]. \quad (13)$$

Let us denote the revenue from the imposition of the tax (τ) on labor income in region 1 by (R_1). Simple algebra shows that this revenue is given by

$$R_1 = \tau w_1 L_1 = \frac{1}{4}\left[\frac{\tau(1-\tau)^{1/3}}{\{N-1+(1-\tau)^{4/3}\}^{1/4}}\right]. \quad (14)$$

Using equation (14), we can state two results. To see the first, let us differentiate the RHS of equation (14) with respect to N. Doing this, we see that for a given tax rate, the revenue from this tax is *decreasing* in the size of the aggregate economy. This result arises because as the size of the aggregate economy becomes larger, the tax base becomes *smaller*.[8]

Second, for every integer value of N, there exists a *maximum* level of tax revenue for $\tau \in [0, 1]$. This is illustrated in Figure 1. Specifically, the top solid curve shows how tax revenue

[Figure 1 about here]

changes as the tax rate is gradually increased for a small $(N = 2)$ aggregate economy. The middle dashed curve and the bottom dotted curve depict the same information when the aggregate economy is of intermediate size $(N = 5)$ and when it is large $(N = 10)$.

Finally, how does the tax on labor income in region 1 affect the welfare of workers as measured by the wage in this region? To answer this question, let us fix the tax rate at $\tau = 0.20$ and consider two cases. In the first case, the aggregate economy is small in the sense that it is made

[8] Recall that the amount of labor in our aggregate economy is fixed at one unit.

up of only two regions and hence $N = 2$. In the second case, the aggregate economy is ten times larger and therefore $N = 20$ now. Using equation (10), Table 2 gives us the answer. We see that

[Table 2 about here]

in both small and large aggregate economies, the tax increases the equilibrium wage and therefore makes workers in region 1 *better off*. Similar computations (not shown) demonstrate that the wage in the remaining $N - 1$ regions, after the imposition of the tax in region 1, *declines* irrespective of the size of the aggregate economy. We now discuss the policy repercussions that arise from the research we have undertaken in this paper.

5. Policy Implications

Inspecting equations (8) and (9), it is easy to confirm that the amount of labor in any one of the regions in our model is a *declining* function of the number of regions (N) in the aggregate economy. In addition because the total amount of labor in the aggregate economy is fixed at one unit, the larger the number of regions, the more *dispersed* is this labor as long as the individual regions are homogeneous. The preceding point also means that this dispersed labor will earn, in general, the *same* real wage in every region.

Next, let us understand what happens to the welfare of workers in both the taxing region 1 and in the remaining $(N - 1)$ non-taxing regions. As far as the *amount* of labor is concerned, we want to compare the pre-tax amount with the post-tax amount. Without any tax on labor income imposed by region 1, the amount of labor in the ith region is $L_i = 1/N$. With the region 1 tax in place, the amount of labor in the ith region is given by equation (9). Comparing the $L_i = 1/N$ expression with the RHS of equation (9), it is clear that the amount of labor in the ith region with the tax is *higher* than the amount of labor without the tax. So, from a purely *amount or quantity*

standpoint, as expected, the region 1 labor income tax drives some labor out of region 1 and into the remaining $(N-1)$ non-taxing regions. That said, the analysis of Table 2 in the last paragraph of the previous section tells us that from a *wage standpoint*, the employed workers in region 1 (all other regions) benefit (lose) from the labor income tax because their post-tax wages are *higher (lower)* than the pre-tax wage.

The key message to take away from this discussion is fourfold. First, in region 1, after the imposition of the labor income tax, the amount of workers employed in this region is *smaller* but these employed workers are paid a *higher* wage. Put differently, the labor income tax in region 1 works somewhat like a minimum wage program. This means that relative to the no minimum wage (no labor income tax) equilibrium, the equilibrium with the minimum wage (labor income tax) results in a higher wage but for a smaller pool of employed workers. Second, the story is different for the remaining $(N-1)$ non-taxing regions. After the imposition of the labor income tax in region 1, these regions collectively benefit from a *larger* amount of employed labor but this employed labor receives a *lower* wage. Third, in terms of the "price effect," region 1 gains (higher wage) and the remaining $(N-1)$ regions lose (lower wage). In terms of the "quantity effect," region 1 loses (smaller pool of labor) and the remaining $(N-1)$ regions benefits (larger pool of labor). Finally, since the price and the quantity effects in region 1 and in the remaining non-taxing regions work in *opposite* directions, it is unlikely that all the regions in our aggregate economy lose with the region 1 labor income tax but, theoretically speaking, this possibility *cannot* be ruled out with probability one.[9] This completes our discussion of interregional demand for workers and the effects of labor income taxation.

[9]

6. Conclusions

In this paper, we studied the short-run impacts of labor income taxation in an aggregate economy of $N > 2$ regions where the individual regions demanded workers. Each region was endowed with one unit of capital and capital was immobile. The aggregate economy also had one unit of labor that was fully mobile across the regions. All regions produced a final good with identical Cobb-Douglas production functions. The price of output was normalized to unity. In this setting, we completed five tasks. First, we focused on the benchmark case in which no region taxed either capital or labor. We determined the equilibrium wage, the allocation of workers across the regions, and the total income received by labor and capital. Second, we examined the impact of a tax at rate τ on labor income in region 1 when the remaining $N - 1$ regions did not tax labor income. We ascertained the after-tax return to labor employed in region 1, the equilibrium wage, and the allocation of labor across the regions. Third, we calculated the total income received by labor and capital and the tax revenue in region 1. Fourth, we discussed whether workers in region 1 were better off with a tax on labor income in the region in which they were employed. Finally, we commented on the policy implications of our research.

The analysis in this paper can be extended in a number of different directions. Here are two suggestions for extending the research described here. First, it would be useful to analyze the tax policy of a region and the allocation of workers to the different regions when these decisions are made over time and not at a point in time. Second, it would be helpful to expand the policy instruments that regional governments are able to use to attract workers to their regions.[10] Studies

[10] Our commentary on the impact of the region 1 labor income tax on the wage in region 1 and in the remaining $(N - 1)$ regions is based on the Table 2 analysis where $\tau = 0.2, N = 2,$ and $N = 20$. We have worked with many other combinations of numerical values for τ and N and hence we believe that our reported results are robust. That said, comparing equations (3) and (10) should convince the reader that it is *not* possible to make a general statement about what happens to the wage with the labor income tax without imposing a lot more structure on the problem that we are studying here.

that analyze these aspects of the underlying problem will increase our understanding of the nexuses between tax policies on the one hand and the workplace choices of individuals on the other.

Suppose that the revenue from labor income taxation in region 1 is used in a way that either enhances the productivity of the capital in this region or provides outstanding educational facilities that workers care about. Then we could think of the analysis conducted in this paper not only in terms of the interregional demand for workers but also in terms of the interregional competition between regions for workers.

Factor Return	$N = 2$	$N = 20$
w	$\left(\frac{1}{4}\right)2^{3/4} = 0.42$	$\left(\frac{1}{4}\right)20^{3/4} = 2.36$
r	$\left(\frac{3}{4}\right)2^{-1/4} = 0.63$	$\left(\frac{3}{4}\right)20^{-1/4} = 0.35$

Table 1: Dependence of factor rewards on the number of regions

Tax Rate $\tau = 0.20$	$N = 2$	$N = 20$
Before Tax	$w_1 = \left(\frac{1}{4}\right)2^{3/4} = 0.42$	$w_1 = \left(\frac{1}{4}\right)20^{3/4} = 2.36$
After Tax	$w_1 = \left(\frac{5}{16}\right)1.74^{3/4} = 0.47$	$w_1 = \left(\frac{5}{16}\right)19.74^{3/4} = 2.92$

Table 2: Welfare of workers in region 1 before and after the imposition of the tax

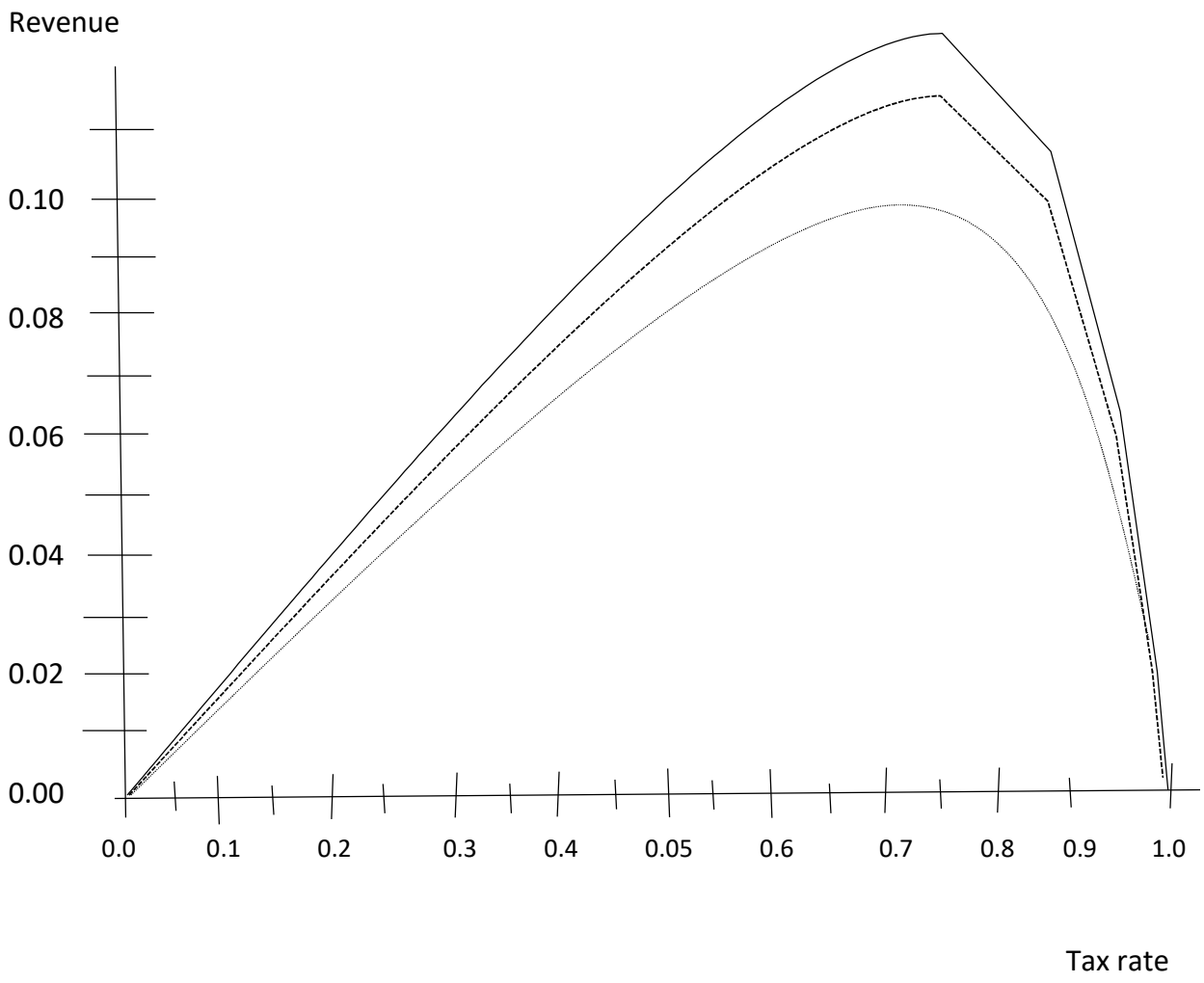

Figure 1: Dependence of tax revenue on the tax rate τ and the number of regions N; top solid curve shows revenue changes as τ is increased for a small $(N = 2)$ aggregate economy. The middle dashed and the bottom dotted curves depict the same information for intermediate $(N = 5)$ and large $(N = 10)$ aggregate economies.

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