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Workplace Choice, Commuting Costs, and Wage Taxation in Urban and Adjacent Rural Regions[1]

by

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Abstract

We analyze the impact of wage taxation on the workplace choices of and the commuting costs borne by individuals in an aggregate economy consisting of an urban and an adjacent rural region. This economy is inhabited by a continuum of individuals who are uniformly distributed with a total mass of one. These individuals choose whether to work in the urban or in the rural region. The wage is higher (lower) in the urban (rural) region. Our analysis leads to three findings. First, assuming that individuals work in the region in which their after-tax wage net of commuting costs is the highest, we compute the equilibrium number of workers in each region. Second, supposing that the rural region's median voter works in the urban region, we determine the Nash equilibrium in taxes and ask whether either of the two regions ought to tax or to subsidize the wage. Finally, assuming that the rural region's median voter works in the rural region, we solve for the Nash equilibrium in taxes and show that optimality calls for the urban and the rural governments to subsidize the two wages.

Keywords: Commuting Cost, Rural Region, Urban Region, Wage Taxation, Workplace Choice

JEL Codes: R12, H30, R49

1. Introduction

1.1. Literature review

The study of urban and rural regions has been pursued by both development economists and regional scientists for quite some time. Using the lens of development economics, urban regions are generally dynamic, they exhibit relatively rapid economic growth rates, they are industrial, and they are frequently technologically advanced. In contrast, rural regions are often not as dynamic, they are commonly agricultural, they display slow economic growth rates, and they are technologically backward. This viewpoint explains why the early literature in development economics---see Lewis (1954), Sen (1966), and Dixit (1970)---was preoccupied with the study of the so called dual economy. This notwithstanding, it should be noted that this traditional focus on dual development has changed greatly in the past few decades.

Regional scientists, unlike development economists, have concentrated mainly on urban and rural regions in the developed world. Even though they have acknowledged that many rural regions in the developed world are primarily agricultural, for the most part, regional scientists have not analyzed rural regions as the supplier of resource flows to urban regions in a dual economy setting. Instead, Jordan *et al.* (2014), Hall *et al.* (2006), and Yamamoto (2008) have drawn attention to rural-urban differences in, respectively, education, health, and income. This concentration has led regional scientists to address questions concerning the sustainability of rural regions as independent beings in the face of ever increasing urbanization and the simultaneous rise of cities.[4] In turn, this concern with the sustainability of rural regions has now given rise to a

[4] See Alberto and Glaeser (1995), Bettencourt (2013) and Kourtit *et al.* (2015) for additional details on this point.

literature on the nexuses between so called "leading" and "lagging" regions where, predictably, rural regions are often the lagging regions.[5]

Recently, researchers interested in the connections between urban and rural regions have begun to analyze the fact that many rural region residents choose to work in neighboring urban regions and vice versa even though such residents have to bear the attendant *commuting costs*. Matha and Wintr (2009) look at bilateral commuting flows across the border regions of four European Union nations and show that commuting time or distance and language differences have a significant impact on cross-border commuting. Examining data from India, Sharma and Chandrasekhar (2014) point out that rural-urban wage differentials are important push and pull factors in the decision to commute to work. Korzhenevych and Jain (2018) focus on the New Delhi area in India and note that although urbanization has led to the empowerment of women, it has also led to a rise of unsustainable commuting patterns from rural areas. Bosworth and Venhorst (2018) point out that rural to urban commuting gives rise to a scenario in which the relative level of urban wages outperforms rural wages even in the absence of residential migration. Finally, Ferreira *et al.* (2018) study the Lisbon metropolitan region in Portugal and contend that commuting not only affects regional and urban economies but that it also gives rise to significant economic and environmental costs.

1.2. Our objective

Given this review of the literature, we would now like to emphasize four points. First, even though the literature on urban and rural regions has studied aspects of commuting, this literature

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Examples of recent contributions to this literature include Batabyal and Nijkamp (2014a, 2014b), Batabyal and Beladi (2015), Batabyal (2018), and the many references cited in these four papers.

has *not* explicitly analyzed the idea that there is both a game-theoretic and a political economy aspect to commuting stemming from the facts that (i) the governments in urban and rural regions can be in competition with each other to attract workers to their region and (ii) these majority elected governments seek to maximize net income in their respective regions. Second, the literature has recognized—see Beeson *et al.* (2010)---but *not* analyzed how wage taxation can influence commuting between an urban and a rural region in a political-economy setting. Third, our paper breaks new ground in the regional science literature because it is, to the best of our knowledge, the *first* to present a theoretical analysis of the *combined* impacts of commuting costs and wage taxation on workplace choice. Finally, we believe that our "combined impacts" analysis shows how the traditional linear city model that has been used frequently by regional scientists and urban economists can be *expanded* in ways that permit researchers to examine the effects of additional variables that have traditionally received insufficient attention in the literature.

Given the first two points in the preceding paragraph, our objective in this paper is to analyze the impact of wage taxation on the workplace choices of and the commuting costs borne by individuals in an aggregate economy consisting of an urban and an adjacent rural region.[6] Section 2 describes the theoretical framework in which the aggregate economy under study is inhabited by a continuum of individuals who are uniformly distributed with a total mass of one. These individuals choose to work in either the urban (U) or the rural (R) region. The wage is

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It is important to understand that we are interested in studying the workplace choices of individuals in our aggregate economy and *not* their residential location choices. That is why we are focusing on things like commuting costs, wages, and wage taxation because we believe that these are some of the key variables that influence workplace choice. There certainly are other variables that affect workplace choice but including all such variables in the analysis would render the model intractable. Therefore, we have made a judgement call to concentrate on a small number of salient variables. That said, we recognize that if we were interested in analyzing the *residential* location choices of individuals, then it would be necessary to draw on ideas from the fiscal federalism literature and, in particular, on the ideas about how the availability of public goods and frequently local public goods can influence where individuals choose to live. These issues are related to the now well-known "Tiebout hypothesis." For a textbook discussion of these ideas involving public goods and residential choice, see Hindriks and Myles (2013, chapters 7 and 19). For journal articles that concentrate on these same ideas, see Gramlich and Rubinfield (1982), Bayoh *et al.* (2006), and Leung *et al.* (2012).

higher (lower) in the urban (rural) region. There are *ad valorem* taxes τ_U and τ_R on the wages that are paid to the region in which work is performed. Section 3 assumes that individuals work in the region in which their after-tax wage net of commuting cost is the highest and then computes the equilibrium number of workers in each region.[7] Section 4 supposes that the rural region's median voter works in the urban region, determines the Nash equilibrium in taxes, and then asks whether either of the two regions ought to tax or to subsidize the wage. Section 5 assumes that the rural region's median voter works in the rural region, ascertains the Nash equilibrium in taxes, and then shows that it is optimal for the urban and the rural region governments to subsidize the two wages. Finally, section 6 concludes and then discusses one way in which the analysis contained in this paper can be generalized to the case in which there are not just two but $n > 2$ regions in the aggregate economy.

2. The Theoretical Framework

Consider a linear aggregate economy that is composed of an urban region denoted by U and an adjacent rural region denoted by R. As shown in figure 1, the two extreme ends of this

Figure 1 about here

linear aggregate economy are given by $-1/2$ and $1/2$, and the center of the aggregate economy is located at 0. The urban region is located to the left of the center of the aggregate economy and the rural region is located to the right. Our aggregate economy is inhabited by a continuum of

[7] Note that within the setting of our aggregate economy, we are analyzing the decision about which region to work in and *not* the decision about which region to live in. Put differently, we are studying the "which region to commute to for work" decision. Therefore, this decision is *not* the same as a migration decision which typically involves moving to another region to live there for at least some length of time. That said, if we were interested in analyzing the decision to migrate from one region to another region, then, following the work of Basile and Lim (2017), we would need to account for the following two findings in our analysis. First, the relationship between regional wage differentials and the decision to migrate is often nonlinear. Second, in addition to answering the questions "whether to move" and "where to move to," it is also important to answer the "when to move" question.

individuals who are uniformly distributed with a total mass of one. The urban and the rural regions in our model have a population of $1/2$.

The median voter in the urban (rural) region is located at $-1/4$ $(1/4)$. The place where work is performed in the urban (rural) region is located at $-1/3$ $(1/3)$. The reader may want to think of this place as the central business district (CBD) in each region. Wages in the two regions are exogenous. Consistent with existing evidence---see Bucci (1993) and Bosworth and Venhorst (2018)---we suppose that the higher urban wage is given by $\theta > 1$ and that the rural wage equals 1. There are *ad valorem* taxes levied on the urban and the rural wages denoted by τ_U and τ_R. The proceeds from these two taxes are paid to the region in which work is performed.

Individuals in our aggregate economy incur a commuting cost that is given by $1/2$ per unit of distance travelled to one's chosen workplace. The urban and the rural regions are administered by governments that are elected by majorities in the two regions and these governments are assumed to maximize net income. Net income is given by the sum of the median voter's net wage and the fiscal revenue per capita.[8] In symbols, when the median voter in region $j, j = U, R$ works in region $i, i \neq j$, the net income in region j is given by

$$I_j = \{1 - \tau_i\}w_i + \tau_j N_j w_j, \qquad (1)$$

where w_i is the wage in region i and N_j denotes the total number of individuals working in region j. We now suppose that individuals work in the region in which their after-tax wage net of

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Since we are interested primarily in the workplace choice question, our analysis focuses on wages, wage taxation, and commuting costs. In this way of looking at the research question, consumer expenditures are *not* of first-order importance and hence can be omitted from the analysis. That said, one way of accounting for consumer expenditures would be to subsume them in the commuting cost term described below in equation (2). Second, we also do not model "the expenditures of the local governments from the tax revenues" because, as shown below in sections 4 and 5, there are several cases in which optimality calls for wage subsidization and *not* taxation and hence, in these cases, there are no tax revenues to spend.

commuting costs is the highest and then compute the equilibrium number of workers in each region.

3. Number of Workers in Each Region

Let us begin by deriving an algebraic expression for z where $z \in [-1/2, 1/2]$ is the location of the individual who is indifferent between working in either the urban or in the rural region. To find an expression for z, we equate the after-tax wages net of commuting costs to the workplaces in each of the two regions, recalling that the locations of the workplaces (the CBDs) in the urban and in the rural regions are given by $-1/3$ and $1/3$ respectively. Now, some thought tells us that the equation of interest for z is

$$\{1-\tau_U\}\theta - \tfrac{1}{2}\left(z+\tfrac{1}{3}\right) = \{1-\tau_R\} - \tfrac{1}{2}\left(\tfrac{1}{3}-z\right), \qquad (2)$$

where the left-hand-side (LHS) denotes the after-tax wage net of commuting costs in the urban region and the right-hand-side (RHS) denotes the corresponding expression for the rural region. Solving equation (2) for the indifferent individual's location, we get

$$z = \{1-\tau_U\}\theta - \{1-\tau_R\}. \qquad (3)$$

Using this expression for z, the number of individuals working in the urban region is given by $N_U = 1/2 + z$ and the corresponding expression for the rural region is $N_R = 1/2 - z$. Simplifying the preceding two equations further using equation (3), we get

$$N_U = \tfrac{1}{2} + z = \tfrac{1}{2} + \{1-\tau_U\}\theta - \{1-\tau_R\}, \qquad (4)$$

and

$$N_R = \frac{1}{2} - z = \frac{1}{2} - \{1 - \tau_U\}\theta + \{1 - \tau_R\}. \quad (5)$$

Inspecting equations (4) and (5), it is straightforward to confirm that the number of individuals working in the urban and in the rural regions responds to the two wage taxes in the expected manner. Specifically, the number of individuals working in the urban region or N_U is a *decreasing* function of the urban wage tax τ_U and an *increasing* function of the rural wage tax τ_R. Similarly, the number of individuals who are employed in the rural region or N_R is a *decreasing* function of the rural wage tax τ_R and an *increasing* function of the urban wage tax τ_U. These two findings clearly reveal the *interdependent* nature of the wage tax policies utilized by the governments of the two regions under study.

We now assume that the median voter in the rural region works in the urban region, compute the Nash equilibrium in taxes, and then ask whether the optimal course of action for the governments in either of the two regions involves taxing or subsidizing the two wages.

4. Rural Median Voter Works in the Urban Region

Given the structure of our linear aggregate economy model and the expression for the indifferent individual's location in equation (3), it should be clear to the reader that the median voter in the rural region will work in the urban region as long as $z \geq 1/4$. Also, note that when this last inequality holds, the median voter in the urban region also works in the urban region. Keeping these two points in mind, the government of the urban region maximizes net income or I_U. Modifying equation (1), the relevant expression for I_U is

$$I_U = (1 - \tau_U)\theta + \tau_U N_U \theta, \quad (6)$$

where N_U is given by equation (4).

Now substituting for N_U from equation (4) into equation (6) and then differentiating the resulting expression with respect to the urban wage tax τ_U, taking the rural wage tax τ_R as given, gives us the first-order necessary condition for an optimum. In symbols, that condition is

$$\frac{dI_U}{d\tau_U} = \frac{\theta}{2} - 2\theta + \theta^2 - 2\theta^2\tau_U + \theta\tau_R = 0. \quad (7)$$

Simplifying equation (7) gives us the best response wage tax of the government in the urban region. That tax is

$$\tau_U = \frac{\theta + \tau_R - 3/2}{2\theta}. \quad (8)$$

The government in the rural region also maximizes net income. Recalling that the median voter in the rural region works in the urban region, the expression for the rural region's net income is

$$I_R = (1 - \tau_U)\theta + \tau_R N_R, \quad (9)$$

where N_R is given by equation (5).

We can now substitute for N_R from equation (5) into equation (9) and then differentiate the resulting expression with respect to the rural wage tax τ_R, taking the urban wage tax τ_U as given. This gives us the first-order necessary condition for an optimum. We get

$$\frac{dI_R}{d\tau_R} = \frac{3}{2} - \theta + \theta\tau_U - 2\tau_R = 0. \quad (10)$$

Simplifying equation (10), the best response wage tax levied by the government of the rural region is

$$\tau_R = \frac{\theta\tau_U - \theta + 3/2}{2}. \quad (11)$$

Solving equations (8) and (11)---describing the best response wage tax functions in the urban and in the rural regions---simultaneously, we obtain the two Nash equilibrium taxes that we seek. These are given by

$$\tau_U = \frac{1}{3} - \frac{1}{2\theta}, \quad (12)$$

and

$$\tau_R = \frac{1}{2} - \frac{\theta}{3}. \quad (13)$$

Inspecting the two optimal tax expressions in equations (12) and (13) carefully, we see that the optimal urban and rural wage tax rates are both equal to zero when $\theta = 3/2$. In addition, when $\theta < 3/2$, we get $\tau_U < 0$ and $\tau_R > 0$ and, in contrast, when $\theta > 3/2$, we obtain $\tau_U > 0$ and τ_R<0. These findings yield three clear results. First, we see that there exists a threshold value of the urban wage θ such that when the urban wage equals this threshold, it is optimal for the governments in both regions to *not* tax wages at all. Second, when the urban wage is only a *little higher* ($\theta < 3/2$) than the rural wage, it is optimal to subsidize the urban wage and to tax the rural wage. Finally,

when the urban wage is *much higher* ($\theta > 3/2$) than the rural wage, it makes sense to tax the urban wage and to subsidize the rural wage.

We have already noted in the first paragraph of this section that the median voter in the rural region will work in the urban region as long as $z \geq 1/4$. Using this inequality in the expression for z in equation (3) along with equations (12) and (13), we get

$$z = \{1 - \tau_U\}\theta - \{1 - \tau_R\} \geq \frac{1}{4} \Rightarrow \theta \geq \frac{3}{4} \qquad (14)$$

The weak inequality on the RHS of (14) gives us an explicit restriction on the magnitude of the parameter θ that must hold for the Nash equilibrium in taxes that we have been studying thus far in this section to exist. So, when this equilibrium exists, excluding the relatively small range where $\theta \in [3/4, 3/2)$, it is optimal for the urban (rural) region to tax (subsidize) the wage. Note that in this last scenario, because the urban region is employing some rural individuals, the optimal "tax" action by the urban government that we have just mentioned involves including in the urban tax base some people who actually live in the rural region.

In our final task in this paper, we first suppose that the rural region's median voter works in the rural region. Next, we ascertain the Nash equilibrium in taxes. Finally, we demonstrate that it now makes sense for the urban and the rural governments to subsidize the two wages.

5. Rural Median Voter Works in the Rural Region

When the median voter in the rural region works in the same region, the objective of the government in this region---as in the urban region---is to maximize net income which can now be expressed as

$$I_R = (1 - \tau_R) + \tau_R N_R, \qquad (15)$$

and N_R is given by equation (5).

Substituting for N_R from equation (5) into equation (15) and then differentiating the resulting expression with respect to the rural wage tax τ_R gives us the first-order necessary condition for an optimum. In symbols, the condition we seek is

$$\frac{dI_R}{d\tau_R} = \frac{1}{2} - \theta + \theta\tau_U - 2\tau_R = 0. \tag{16}$$

Simplifying equation (16) gives us the best response wage tax of the government in the rural region. That tax is

$$\tau_R = \frac{\theta\tau_U - \theta + 1/2}{2}. \tag{17}$$

To continue the analysis, suppose that the urban median voter works in the urban region. Then we can solve equations (8) and (17) simultaneously to determine the two optimal taxes. After a few steps of algebra, the Nash equilibrium taxes are given by

$$\tau_U = \frac{1}{3} - \frac{5}{6\theta}, \tag{18}$$

and

$$\tau_R = -\frac{1}{6} - \frac{\theta}{3}. \tag{19}$$

Inspecting equation (19), it is clear that the optimal rural tax is, in fact, a *subsidy* for all positive values of the parameter θ. If the rural median voter is to work in the rural region then this "subsidy" result must hold because the net wage in the rural region is *lower* than the net wage in the urban region.

The Nash equilibrium that we have been studying thus far in this section exists as long as the location of the indifferent individual in our aggregate economy satisfies the condition

$$-\frac{1}{4} < z < \frac{1}{4}. \tag{20}$$

Recall that z in (20) is given by equation (3). Therefore, substituting the values of τ_U and τ_R from equations (18) and (19) into (20) and then simplifying the resulting expression gives us an explicit condition that θ must satisfy in order for the Nash equilibrium of this section to exist. That condition is

$$\frac{1}{4} < \theta < \frac{7}{4}. \tag{21}$$

If θ must satisfy the condition given in (21) then looking at this range of values of θ in the context of the optimal urban wage tax given in equation (18), it should be clear to the reader that the optimal urban tax is also a *subsidy*. In other words, to get the urban median voter to work in the urban region, the government of this region also subsidizes the wage. In sum, if the urban and the rural median voters are to work in their respective regions then the optimal policy for the governments in these two regions is not to tax but instead to *subsidize* the two wages.

In this and in the preceding section, we have identified a number of cases in which it is optimal for the government to subsidize and *not* tax wages. We emphasize that this central policy conclusion which tells us that there are circumstances in which it makes sense for governments to subsidize wages is not just a "theoretical option." In fact, this policy conclusion tells us that in the presence of interregional commuting for work, a regional government can often best compete for workers with its neighboring regional government by boosting or subsidizing wages in its own jurisdiction.

That said, the reader should note that wage subsidies have been used by many governments in a variety of circumstances. In this regard, a general argument for using wage subsidies in the United States has been made by Cass (2018) who points out that subsidizing wages is a well-tailored response to the challenges that globalization presents for American workers and that such subsidies help sustain communities that lose their tradable sector. A recent United States government document[9] points out that states can use welfare grants as a source of wage subsidies for participants placed in jobs and that such subsidies have the potential to increase employment opportunities. Finally, Almeida *et al.* (2014) discuss the many practical instances in which wage subsidies have been used throughout the world. Here are three examples. One wage subsidy program used in the United States in the past is the "New Jobs Tax Credit" of the 1970s. In 1998, the United Kingdom enacted a targeted wage subsidy program called the "New Deal for Young People" for people in the 18-24 age group. Finally, in Sweden, a particular program provided employer subsidies of up to 50 percent of earnings for firms that hired individuals who have been unemployed for more than six months.[10]

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9 For more details, go to https://aspe.hhs.gov/report/reworking-welfare-technical-assistance-states-and-localities/30-work-experience-and-subsidized-employment. Accessed on 4 March 2020.

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In addition to the central policy conclusion mentioned above, there are two other policy conclusions emanating from our analysis that deserve some comment. First and looking only at the "number of workers" metric, a regional government that is engaged in strategic competition with a neighboring regional government can best attract workers to its own region by maintaining a low wage tax environment. Second, there exists a scenario in which the regional government in one region (the urban region) can shift a part of the tax base onto individuals who are resident in the second (rural) region. This can be done when the first (urban) region government is successful in getting workers from the second (rural) region to come work in its region. This completes our discussion of workplace choice, commuting costs, and wage taxation in urban and adjacent rural regions.

6. Conclusions

In this paper, we studied the impact of wage taxation on the workplace choices of and the commuting costs borne by individuals in an aggregate economy consisting of an urban and an adjacent rural region. This aggregate economy was inhabited by a continuum of individuals who were uniformly distributed with a total mass of one. These individuals chose whether to work in the urban or in the rural region. The wage was higher (lower) in the urban (rural) region. Our analysis led to three results. First, assuming that individuals worked in the region in which their after-tax wage net of commuting costs was the highest, we computed the equilibrium number of workers in each region. Second, on the assumption that the rural region's median voter worked in the urban region, we determined the Nash equilibrium in taxes and then asked whether either of the two regions ought to tax or to subsidize the wage. Finally, supposing that the rural region's

As pointed out in section 1.2, our objectives in this paper explain why we have concentrated on wage taxes and subsidies in considerable detail. Depending on the question being analyzed, it is certainly possible that the government in one or both regions may use different policy instruments such as the provision of high quality schools and/or property taxes to attract potential residents. Clearly, in our paper, the question of providing high quality schools does not arise because we are analyzing workplace choice and *not* residential choice.

median voter worked in the rural region, we solved for the Nash equilibrium in taxes and then showed that it was optimal for the urban and the rural governments to subsidize the two wages.

We now outline one way in which the analysis contained in this paper can be generalized to study questions similar to those studied here but with the additional feature that there are $n > 2$ regions in the aggregate economy. To this end, consider an aggregate economy in which there are $n > 2$ regions that are competing among themselves to attract workers. Each region is endowed with one unit of capital (K) and this capital is immobile across the n regions. The aggregate economy also contains one unit of labor (L) that is mobile across the different regions. We suppose that all regions produce a final good (Q) with a constant returns to scale Cobb-Douglas production given by $Q = F(K, L) = K^{3/4}L^{1/4}$. For convenience, the price of this final good is fixed at \$1.

In the above setting, we would begin our analysis by studying the benchmark case in which no region taxes either capital or labor, in two steps. In the first step, we would focus on labor---although we could focus on capital as well---and then determine the equilibrium wage rate and the allocation of labor across the n regions. In the second step, we would determine how the equilibrium wage and the total income of workers responds to changes in, for instance, the actual number of regions or n. The point of this second step would be to examine the nature of the functional relationship between the equilibrium wage rate and the size of the aggregate economy.

Next, moving away from the benchmark case, we would study the effects of differential taxation of labor income by the regions in the model. To this end, suppose region 1 taxes labor income at rate τ_1 and that the remaining $n - 1$ regions do not tax labor income. Again, to keep matters straightforward, suppose that the tax revenue is used by the government in region 1 to buy more output of the final good at the fixed price \$1. Questions of interest now include the following

four. First, is there a scenario in which the tax imposed by region 1 is, in fact, not a tax but a subsidy? Second, if such a scenario does not exist then what is the after-tax return to labor in region 1? Third, what is the new or after-tax equilibrium wage rate and the allocation of labor across the n regions? Finally, from a comparative statics standpoint, what is the total income of workers and the tax revenue in region 1 and how sensitive are these two metrics to changes in, for instance, the number of regions n and the tax rate τ_1? Studies that analyze these aspects of the underlying problem will increase our understanding of the nexuses between wage taxation on the one hand and the workplace choices of individuals on the other.

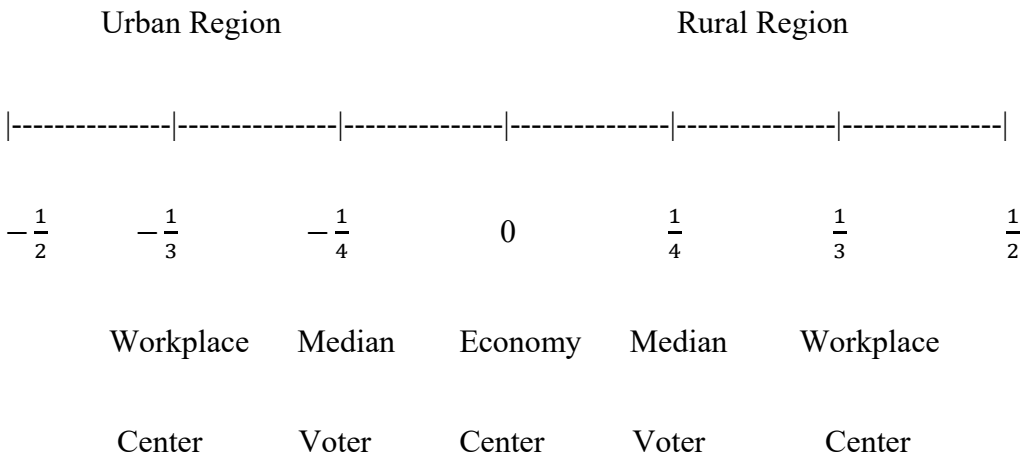

Figure 1: The linear aggregate economy

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