Mountains and Seas of People:
A Simple "New Economic Geography"-Based Simulation of
Chinese Migration Trends

by

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Abstract:

Ever since 1979, China has been in the process of implementing a huge number of reforms, particularly economic and social. A major consequence of these changes has been an explosion in the inter-regional migration rate, specifically the number of Chinese migrating from the rural areas to cities. In this paper, I use a simple new economic geography simulation to predict the effect of some recent demographic and political changes on the migration rate, and suggest a number of policy changes that Chinese city administrators might take in response. I conclude with a discussion of avenues of future research in these simulations, particularly in areas that could improve these simulations and their predictions.

Section 1: Introduction

What is it about China? Nearly every day, newspapers carry reports about China's influences on the West; pundits wax eloquent about whether or not we should fear its rise; politicians debate endlessly about what policies the US should enact. The discussions are so reminiscent of the warnings about Japan two decades ago that it is easy to discount the whole thing as nothing more than crying wolf. However, ignoring China is perhaps the worst decision of all: not only is it the world's largest country, with a population of over 1.3 billion people,[1] but it is also an economic powerhouse – especially where the US is concerned. America is

[1] CIA World Fact book

both China's largest trading partner, encompassing over 20% of its international trade[2], and one of China's largest debtor nations: the US trade deficit with China reached over $200 billion in 2005.[3] This deficit contributed to China's foreign reserves, which totaled over $1 trillion in 2006[4] - cementing its position as a world economic force.

While the sheer size of trade between the US and China is interesting in and of itself, it is the type of imports that Americans want from China that is particularly important. While the top three categories of goods (electrical machinery, power generation equipment, and toys) have all seen percentage growth in the double digits, even more striking is apparel, with 56.8% import growth from 2004 to 2005 alone.[5] In all of these cases, relatively cheap and abundant Chinese labor has been able to replace the high cost labor (or capital, in terms of mass-production machinery) found in the United States. However, this has not been accompanied by a concurrent drop in quality, thus shifting production from US-located firms to ones overseas. This, of course, has had major consequences for American manufacturing companies and manufacturing employment, providing much of the political imperative to "do something" about China.[6]

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[2] Ibid
[3] US-China Business Council
[4] CIA World Fact book
[5] US-China Business Council
[6] Examples of the Democratic take at http://www.democrats.org/a/2006/04/bushs_china_pol.php and the Republican one at http://www.gop.com/News/Read.aspx?ID=6252

However, while the vast supply of cheap Chinese labor has made American manufacturers (and thus American politicians) nervous, they are not the only ones. Among Chinese policymakers, concern is growing about the size of the population. Under Mao Zedong, Chinese cities were designed to handle only limited numbers of people, especially after Mao instituted his Third Front strategy in 1964, which shifted the vast majority of industry to the rural areas[7]. However, since the economic reforms of Deng Xiaoping began in 1979, migration from the rural hinterlands to the large cities on China's eastern seaboard has become a huge phenomenon. Working from the 1990 census, Cai (1996) estimated that there were 34.1 million migrants across all of China.[8] In comparison, the 2000 Chinese Health and Nutrition Survey implies an estimated 32.12 million migrants in the nine provinces surveyed that year. This number is likely a severe underestimate of the all-China migration levels, given that the survey did not include Beijing, Shanghai, and other main migrant destinations.[9] Most recently, Huang and Pieke (2003) estimate that the there were nearly 67 million rural-to-urban migrants in 1999.[10] In Beijing alone, the migrant population is estimated to have grown from 2.86 million people in 1997 to over 4 million by 2003.[11] Given these numbers, the recent mass movement of Chinese workers from rural areas into the cities is beginning to overwhelm the existing public infrastructure and

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[7] Naughton (unpublished manuscript)
[8] As cited in Zhao (2005)
[9] CHNS 2000
[10] As cited in Zhao (2005)
[11] Poston and Duan (1999), China Statistics Bureau

cause antipathy between migrants and "locals" in Chinese cities.[12] In addition, while Zhao (2005) estimates that nearly 70% of these migrants are recruited to fill construction jobs, that construction is primarily high-value office buildings and apartments, which go up in place of the low-cost housing that these migrants can afford: new construction averaged at a cost of 1152 yuan/sq. meter in 1999, as compared to the average migrant's yearly income of 4384 yuan.[13] The end result is that construction workers often wind up living in temporary "housing" (essentially, tents) beside the areas where they are working.[14] Thus, while the influx of laborers is satisfying latent demand, Chinese policymakers still need to find a way to manage these huge population shifts.

This paper attempts to explore the economic causes behind this phenomenon, and, using the new economic geography simulations developed by Fujita, et al (1999), predict where current trends are leading. I try to answer the following basic questions: what specific demographic and policy characteristics have led to the explosion in migration? What changes in China's society are likely to affect these trends? And finally, what can both local governments and the central Chinese government do to address the problem?

Section 2: Background

There exists a rich literature of theory and research on migration, with the first of these being E.G. Ravenstein's work from the late 1880's. He investigated

[12] Nielsen, et al (2006)
[13] Chinese Stat Yearbook 2004 and CHNS 2000
[14] As noted by the author, fall 2005

migratory trends from a number of countries, particularly England and the United States, with the goal of determining what it was that drove migratory behavior. His conclusions are evident in the assumptions made today: that migrants prefer to travel shorter distances; that cities gain in population by absorbing surrounding locales; and that migration increases as time passes (Ravenstein 1889). While these ideas have evolved over time, the basic concept is still extant.

As for the specific forces drawing migrants to the cities, the modern literature begins with Tiebout (1956). He makes the assumption that each individual consumer-voter makes location decisions based primarily on preference for public goods; thus, people with children will choose to locate in areas with more spending on education, while those who favor golf will move to areas with higher spending on golf courses.[15] Given a set of preferences for these goods and services, communities will actively try to reach population levels that their residents consider "optimal." This includes everything from setting high property taxes, earmarked for spending on schools, to selling public land to developers building country clubs. He divides these types of actions into two categories: "pull" factors, which would encourage people to migrate to a given city, and "push" factors, that encourage people to leave. The balance between these two makes it possible (assuming unhindered migration) to reach an equilibrium whereby each community perfectly satisfies the needs of its members.

However, Tiebout (1956) makes a point to mention that employment opportunities are not a restriction, and assumes that all consumer/voters

[15] Tiebout (1956)

essentially live off of dividend income.[16] Sjaastad (1962) takes this idea further, and is the first to suggest that the migration decision is based off of income differentials. Specifically, he notes that migration involves both monetary and psychic costs, as compared to the wage increase that results, and thus people will choose to migrate when the net present value of those wages exceeds those costs.

Harris and Todaro's (1972) seminal work on migration decisions takes a different approach. They divide the relevant population into two groups: an agricultural cohort, which produces only an agricultural good and lives in a "rural" area, and an urban cohort, which produces a manufactured good and lives in a centrally defined city. Labor is free to move between these two locations, with the movement decision being based primarily on the wage differential between rural and urban areas. Thus, changes in the wage level offered (based on the marginal productivity of labor relative to manufactured goods) create the migration dynamic between locations. They then introduce a binding wage floor for the urban core, and show that this higher wage rate leads to both a surplus of urban workers, as well as a higher-than-optimal level of migration.

Recent work in urban economics has tended to follow one of these two trends. Perhaps the most famous of the latter kind is developed in Fujita, et al's (1999) "new economic geography," which builds off of ideas from Krugman (1979). Although they divide workers into immobile agricultural and mobile manufacturing workers like Harris and Todaro, they use the monopolistic competition structure of Dixit and Stiglitz (1977) to describe the practices of each

[16] Ibid, p. 419

industry. They also allow for manufacturing activities to occur in the same location as agriculture, and expand those locations from two to six, twelve, and up to *R* distinct areas. By allocating a certain agricultural population amongst regions, the model creates a base level of demand in each region while still allowing manufacturing firms to optimally locate between regions. Krugman (1998) provides a good overview of this literature, pre-Fujita, et al. Expanding on these ideas, Henderson and Wang (2005) simulate how city population and number grow as savings, economic growth, and human capital changes. Incorporating land rent costs and agglomeration factors, they find that high migration costs lead to multiple human capital equilibria at a given growth rate, while the savings rate is positively associated with the stable level of human capital and growth rates. Similarly, Tabuchi, et al (2005) focus on the effects that transportation costs have on city size and number. Using a set of models slightly different than Henderson and Wang (2005), they show that, for a set of cities with varying initial sizes, a reduction in transportation costs has different effects on the equilibrium population of each type of city.

However, discussion of these models has not been limited to the theoretical sphere. Since the mathematics involved are too complicated to solve analytically, research into how these models work has relied on simulations instead. It is not a huge jump to substitute in real-world data to these simulations, and try to replicate as much as possible real-world conditions. One of the most advanced of these attempts is Stelder (2005). He overlays the European continent with a grid defining each "region" in space and, distributing the immobile agricultural workers evenly across the grid, simulates the “optimal” locations of European cities.

Research along these lines has also been applied to China, albeit with a different focus. Henderson’s (2005) research into optimal city sizes showcases the agglomerating effects inherent in economic geography models. He notes a key dichotomy in the Chinese government’s migration policy. Nominally, the policy is to keep migration to a minimum but, when it occurs, to encourage migrants to move to smaller, less-populated cities.[17] However, policy actions favoring the largest eastern cities, particularly market access increases and FDI levels flowing towards these areas, have made these destinations far more desirable.[18] These policies have, in fact, made some cities more productive than previously assumed, and thus actually *undersized* in terms of optimal population. This is not to say that small cities have not participated in the recent migration trends; rather, depending on their proximity to large provincial capitals, the benefits of access to larger markets in encouraging migration might be overwhelmed by the tendency of migrants to skip over the city entirely and just move to its larger neighbor. Thus, the smaller cities will wind up being absorbed by their larger neighbors if migration to these places does not increase.

The “new economic geography” simulations developed by Fujita, et al (1999) are particularly useful in policy discussions as well. Baldwin, et al (2003) provides an excellent summary of techniques developed to simplify these models, and then apply them to various policy questions. In particular, they provide a

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[17] Henderson (2005)
[18] Ibid

series of simulations that test the effect of tax policies and regional infrastructure improvements on population and wage distribution in a simple, two-region economy.

While the simulations above are incredibly useful, they do have one large drawback. These simulations all focus on firms as the main decisions makers: depending on a spectrum of costs and product demand functions, firms choose locations and offer wages to satisfy these conditions. Only then does the freely mobile cohort of works relocate to optimize their income levels, based on the available wage rates. However, the labor-economic literature approaches the questions somewhat differently, focusing on the migrants (either individually or on a household basis) as the primary decision maker. This type of analysis can be divided amongst two types: the former dealing with village- and town-level characteristics to see which locations produce migrants, the latter with migrants and their families to see what household-level characteristics are significant in encouraging migration.

On a village-by-village basis, Zhao (2003) investigates the effects of a range of factors, focusing on the existence of migrant networks in particular. As the number of "experienced" migrants (i.e., individuals who have spent more than four years away from home) from these locales increases, the costs of migration are lowered substantially. In addition, Zhao also finds that village access to transportation positively affects the migration probability. Furthermore, village per capita income has an inverted-U effect: though the poorest may have the most to gain from migration, the costs of migration are too high to undertake it.

However, as per capita income increases, residents are more able to afford migration, and thus are more likely to choose to do so. Past 5,050 yuan/year, migration is no longer an attractive option, and the rate falls.[19] Finally, the availability of non-farm labor plays a direct roll: as more non-farm work opportunities become available, migration rates decline.

The characteristics of migrants and their families are also important. Zhao (2005) cites research showing that a majority of migrants are male, younger, and have slightly higher education levels than non-migrants. However, Zhao (2003) noted that education (like village per-capita income) has an inverted-U effect on migration, with a junior high school education having the strongest positive effect; Zhao (2005) notes that this effect is particularly strong for rural migrants. However, Rozelle et al (1999) notes that the decision to migrate is usually made in the context of not an individual, but of a household; when does this decision make economic sense? If we consider that agricultural income is a rural household's primary concern, Rozelle, et al (1999) would imply that individual characteristics predominate: the aggregate effect of migration is to *reduce* household agricultural productivity, even after including the benefits of greater credit access. Similarly, Taylor et al (2003) – Rozelle among the authors – show that has a significant and negative effect on household crop income, but a statistically insignificant effect on total household income. On the other hand, since the number of household members is reduced by migration, household *per*

[19] Zhao (2003) notes, however, that this level is more than double the mean income level for most villages; thus, rural areas in China are still in the upward-sloping portion of the curve.

capita income increases by up to 43%. Taylor, et al thus conclude that migration allows households to diversify away from agriculture to other forms of production and income. However, since we do not know exactly which yardstick for household earnings is most applicable, it is still unclear whether or not migration is an earnings-maximizing decision for the household as a whole.

Thus, the above literature gives us two ways to interpret migration. The first, the papers using new economic geography-based simulations, focus on the rationale for agglomeration, and in particular the decisions firms makes in choosing location, and what effect those decisions, in turn, have on other firms. The second, based on labor economics, focuses on the decisions of the migrants themselves: what drives them to choose to live in a given location, whether those decisions are family- or individual-based maximizations, and the effects of those location decisions. I now turn to the *interaction* between these two; specifically, what effect does the interaction between firms and employees have on migration? Some of the more recent research into Chinese labor markets starts to investigate this issue. In *Dragon in a Three-Piece Suit (2001)*, Guthrie surveys 181 government officials, lawyers, and managers of Shanghai business to figure out how they have been responding to market-based economic reforms over the past few years. Notably, he is able to pick up on the shift of Chinese businesses away from providing high benefits and lifetime employment to all their employees. This is not to say that the social safety nets that Chinese employees are accustomed to have completely disappeared: instead, responsibilities that once belonged to employers have shifted to local governments – especially those that accrue to laid off workers (known as *xiagang*.) However, Giles, et al (2006) note that the historically strong safety net provided to *xiagang* has reduced the incentive to search for new jobs, leading to huge strains on local governments. Pairing this with the huge wave of migration noted above has led to serious problems: as Nielsen (2006) notes, Chinese cities are simply unprepared to handle it all adequately. Thus, the level of social benefits provided to city residents plays a large role in the process.

The literature discussed above sets up a starting point for investigations into the Chinese economy. I first set up a basic simulation of the Chinese economy following the techniques in Fujita, et al (1999). Next, using local payroll tax rates as a proxy for benefit levels, I attempt to discern what effect, if any, changes in benefit rates, consumption behavior, and education levels will soon be having. Finally, in the spirit of Baldwin, et al (2003) I use the simulations developed to test the likely effects of policy changes by Chinese authorities on the migration picture.

Section 3: The Model

There are three basic questions that the migration model below needs to be able to answer. First, how do workers allocate themselves across regions? Second, how do transportation costs and observation rates affect these dynamics? And third, how does the evolution of various parameters affect this process?

3.1 The basic premise: wage rate differences between two regions and the effects on the supply of migrant labor

We start by looking at the wage definitions for a simplified "core-periphery" (CP) model, in the spirit of Fujita, et al (1999). Let there be two locations, the "core" and the "periphery," with workers divided equally between them, Workers in the core produce a manufactured good and earn a certain wage rate, w_c, while workers in the periphery produce an agricultural good and earn w_p. However, workers in the core also earn a set of benefits in addition to their wages. We assume that the manufactured good exhibits diminishing returns to labor, but the agricultural good has constant returns to labor; thus, w_p is a constant. Finally, workers in either location observe only the wages in the other (i.e., core benefits are invisible to workers in the periphery.) Thus, when $w_p<w_f$, workers move from the periphery to the core, and when $w_p>w_f$, workers move from the core to the periphery. Hence, workers will sort themselves amongst the core and periphery,

Figure 3.1a: Periphery Migrants' View

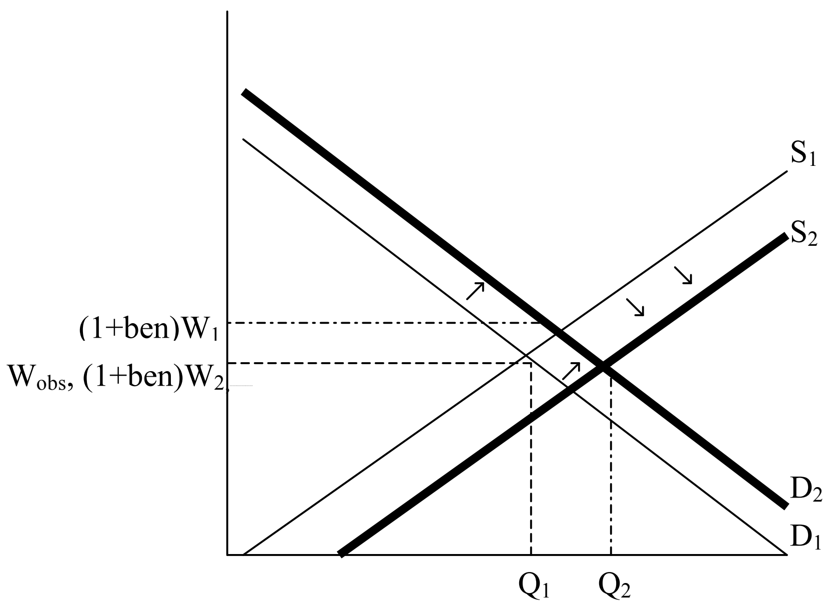
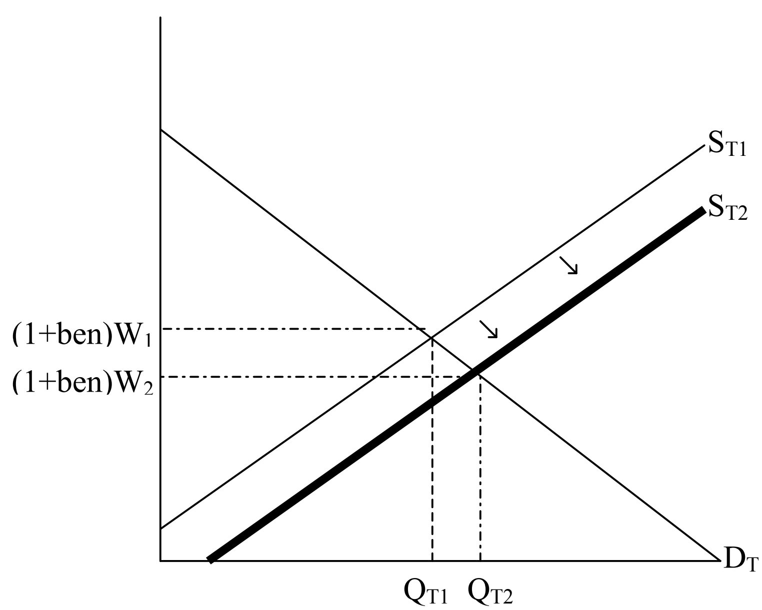


Figure 3.1b: Core Employee's View



with the number of workers in each sorting themselves by their relative wage rates until wages in each area are equivalent.

Now, let us expand the model slightly, and make workers in the periphery have increased (but still biased) information about benefit levels. Thus, instead of observing only the wages earned by workers in the core, they now partially observe the benefits as well. The periphery workers' impression of the core labor market is shown in Figure 3.1a: as a greater percentage of core benefits are observed, periphery workers see this as a change in the demand function. Thus, the increased "wages and benefits" income level available in the core translates into a greater supply of periphery workers emigrating to the core. However, since the manufactured good has diminishing returns to labor, as the supply of workers increases w_c decreases; thus, workers in the core observe an increased supply of workers, pushing out along the demand curve and lowering their total "wages and benefits" income (Figure 3.1b.) Finally, workers in the periphery see the "wages and benefits" income in the core fall, since the supply curve itself has shifted outwards (Figure 3.1a.) Thus, while increased observation of benefits should increase the supply of migrants (i.e., migration rates), its effect on wages is ambiguous.

This description assumes that the demand functions for the agricultural and manufactured goods themselves are unchanged. However, in a two-region situation as described above, this is simply not the case: an influx of migrants to the core increases the demand for manufactured goods in the core, while lowering the demand for manufactured goods in the periphery. Similarly, this process increases the demand for agricultural goods in the core/lowers it in the periphery. However, since we've already assumed that the agricultural good exhibits constant returns to labor, this implies that the act of migration in fact *reduces* the number of agricultural goods produced. Depending on the elasticity of consumption for each good, this reduces (or even halts entirely) the migration wave. Furthermore, this equilibrium is based on zero transportation costs, while in reality the level of transportation costs of moving each type of good from one location to the other would also have an effect on the equilibrium. Complete NEG models take all of these factors into account; I begin by constructing a basic version of such a model below.

3.2 A basic CP model, incorporating consumption preferences, variable production functions, and transportation costs of manufactured goods

Following Fujita, et al (1999) and Brakman, et al (2001), we start with a modified Dixit-Stiglitz model[20] of monopolistic competition, such that for any given individual (consumer), utility is defined as a Cobb-Douglas mix of agricultural and manufactured good consumption. Formally,

$$U = M^{\theta} A^{(1-\theta)} \tag{1.1}$$

where M is a composite of manufactured goods, A is the agricultural good, and θ is the manufacturing share of consumption. Assuming that there are n varieties of a manufactured good f, all of which are produced in the core, the manufacturing composite M is defined as

[20] As given in Fujita, et al (1999)

$$M = \left[\int_0^n (m_f)^\rho \, d(f) \right]^{1/\rho} \tag{1.2}$$

where m_f is the consumption amount of each of n manufactured goods and ρ denotes the strength of preference between any two goods. ρ is defined such that $\sigma = 1/(1-\rho)$ is the elasticity of substitution between any two varieties of n.[21]

The production function for manufactured goods is of the form

$$m_f = N_f^\alpha \Phi_f^{1-\alpha} \tag{1.3}$$

where N is the labor input and Φ is the human capital input, with the production share of each given by α and (1-α), respectively.[22] Agricultural goods, by contrast, only take labor as an input, for which there are constant returns. Thus, the agricultural production function is given by

$$A = \beta N \tag{1.4}$$

As above, manufactured goods are produced only in the core, where firms pay a combination of wages and benefits to their employees, with benefits measured as a percentage of wage payments. Thus, total employer costs in the core are equal to

$$e_f = (1 + ben) w_f N_f + \varepsilon_f \tag{1.5}$$

where w_f are the wages paid by the firm, (1+*ben*) is the multiplier effect of benefits on wages, N_f is the number of workers employed in industry *f*, and ε_f is a composite of the "other costs" paid by the employer. For simplicity's sake, I

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[21] Note that I have set a *constant* elasticity of substitution between any two of the manufactured goods.

[22] Note that α is set to be constant across industries; thus, this model does not provide for workers to sort themselves among industries based on their human capital (in this case, the average education level of workers in industry *f*.)

assume that the benefit rate is equal to the payroll tax rate faced by firm *f*, and restrict ε_f to the capital costs paid by the firm. As for the periphery, as given above the agricultural firms pay no benefits; thus, total employer costs in the periphery are defined as

$$e_p = w_p N_p + \varepsilon_p \tag{1.6}$$

I first solve for the wage and price of manufactured goods. Setting the price equal to p_f defines manufacturing firm *f*'s profit as

$$\pi_f = p_f m_f - (1 + ben) w_f \left(\frac{m_f}{\Phi_f^{1-\alpha}} \right)^{\frac{1}{\alpha}} - \varepsilon_f \tag{1.7}$$

Taking the derivative of profits with respect to production levels m_f, I can then rewrite the price as

$$p_f = \frac{(1 + ben) w_f m_f^{\frac{1-\alpha}{\alpha}}}{\left(\alpha - \frac{\alpha}{\sigma} \right) \Phi_f^{\frac{1-\alpha}{\alpha}}} \tag{1.8}$$

Thus, I am able to write a function defining the price index for manufactured goods produced in the core, G_c, defined as

$$G_c = \sum_{f=1}^{n} \left[\frac{(1 + ben) w_f m_f^{\frac{1-\alpha}{\alpha}}}{\left(\alpha - \frac{\alpha}{\sigma} \right) \Phi_f^{\frac{1-\alpha}{\alpha}}} \right] = \sum_{f=1}^{n} p_f \tag{1.9}$$

Note that this function implies that each manufactured good has equal weight in the price index. This makes sense, since it has already been assumed that there is a constant elasticity of substitution between every good. Thus, even though goods may not be perfectly substitutable, the effect of a price change of one good is identical to price changes in any of the other goods.

It is also possible to create similar equations for the agricultural good. Note, however, that agricultural good production has been forced to have constant returns to labor, implying that the agricultural wage rate is constant. If this wage rate is set to numeraire, I can follow a similar process as in equation (1.7) to show that

$$p_A = \frac{1}{\beta} \tag{1.10}$$

In producing a manufactured good price index for the periphery, I assume the existence of iceberg transport costs for manufactured goods from the core to the periphery, T_{cp}, such that if T_{cp} goods are sent from the core, only one arrives in the periphery. In contrast, I assume that agricultural goods do not face transportation costs to move between regions, which keeps the price of agricultural goods constant. However, manufactured goods do face these costs; thus, the periphery manufactured good price index is

$$G_p = G_c T_{cp} \tag{1.11}$$

Now that price indexes for manufactured goods have been established, I can define the equilibrium level of production of each good. Recall that, in equation (1.1) I defined utility as involving purchases of both the manufactured good composite and the agricultural good, with the share of income of manufactured and agricultural purchases equal to θ and (1-θ), respectively. In maximizing that utility, consumers face the budget constraint

$$p_A A + \int_{f=1}^{n} p_f m_f df = Y_i \tag{1.12}$$

where Y_i is the income level of a given individual. Since I have already developed a price index G for manufactured goods and prices $\frac{1}{\beta}$ for agricultural goods, I substitute these into the income, yielding

$$\frac{1}{\beta} A + GM = Y_i \tag{1.13}$$

However, since I've already noted that θ and $(1-\theta)$ are the shares of income devoted to manufactured and agricultural good consumption, respectively, I can thus rewrite M and A as $M = \frac{\theta Y_i}{G}$ and $A = \beta\left(1-\theta\right)Y_i$, respectively. For manufactured goods of variety f, this implies a quantity demanded of

$$q_{i,f}^{d} = \theta Y_i \frac{p_f^{-\sigma}}{G^{-(\sigma-1)}} \tag{1.14}$$

for each individual consumer.

Note that, while we have limited the pursuit of maximum utility by an individual's income, we have yet to explain what that income is. For simplicity's sake, we assume no endowments, and thus individual income for a worker in either the core or periphery is defined by their wage rate. Hence, we can define the total income Y of both the core and periphery by

$$Y_c = \left(1+ben\right)\sum_{f=1}^{n} w_f N_f \tag{1.15}$$

and

$$Y_p = w_p N_p = w_A N_A \tag{1.16}$$

Keeping these equations in mind, we can now describe the total demand for a given manufactured good *f*, across both regions, as

$$q_f^d = \theta\left(Y_c p_f^{-\sigma} G_c^{\sigma-1} + Y_p \left(p_f T_{cp}\right)^{-\sigma} G_p^{\sigma-1} T_{cp}\right) \tag{1.17}$$

This means that, as the share of manufacturing in consumption increases, or as the income level in each region increases, demand for *f* will also increase. Conversely, as prices (whether in terms of p_f or G) and transportation costs increase, the quantity of *f* demanded decreases.[23] Finally, this is not just the quantity demanded of *f*, but the quantity of *f* demanded that will *maximize worker utility*.

We now need to define the equilibrium quantity supplied. Substituting equation (1.7) in (1.8), setting m_f to be the quantity supplied, and forcing firms to earn zero-profits (thus ensuring a utility-maximizing quantity of *f* is produced), we find that

$$q_f^s = \left(\varepsilon_f \left[\frac{\left(\alpha - \frac{\alpha}{\sigma}\right)\Phi_f^{\frac{1-\alpha}{\alpha}}}{\left(\frac{\alpha+\sigma}{\sigma} - \alpha\right)\left(1+ben\right)w_f}\right]\right)^{\alpha} \tag{1.18}$$

This implies that, as the average education (i.e., human capital, or skill) in industry *f* increases, supply increases as well – thus capturing the increased productivity of higher-skilled workers. On the other hand, increased variable costs

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[23] The effect of transport costs are, technically, somewhat ambiguous. If the constant elasticity of substitution σ is greater than 1, then an increase in transportation costs will decrease demand for *f*. However, if σ is instead less than one, increased transportation costs will, in fact, *increase* demand for *f*. Note, however, that this would require ρ<1, which by the above definitions is impossible; thus, increased transportation costs will always reduce demand.

(in terms of benefits and wage payments) decrease the amount of *f* supplied. Interestingly, note that this is not the case for increases in *fixed* costs: an increase in the capital cost of *f* actually increases the amount supplied, as firms need to cover these increased costs by selling more of their good. Combining the above equations, the final production level of *f* is equal to the equilibrium level, or $m_f = q_f^* = q_f^d = q_f^s$.

One piece is still missing, however – wages. We follow Fujita, et al (1999) in deriving the wage function

$$w_f = \left[\frac{\left(\alpha - \frac{\alpha}{\sigma}\right)\Phi_f^{\frac{1-\alpha}{\alpha}}\theta}{(1+ben)m_f^{\frac{1}{\alpha}}}\right]\left[Y_c G_c^{\sigma-1} + Y_p T_{cp}^{1-\sigma} G_p^{\sigma-1}\right]^{\frac{1}{1-\sigma}} \qquad (1.19)$$

which gives the wage level that ensures monopolistic firms satisfy the zero-profit condition, as given above.

After defining the appropriate parameters, the equations above allow us to simulate how the core-periphery economy stabilized, and determine what the long-run population distribution would be. However, real-world economies do not operate on a full CP-style model; we next expand this model for a more complex world.

3.3 Expanding the model to multiple regions

Of course, the real world economy does not have solely a core and a periphery, with one producing manufactured goods and the other agricultural goods. Instead, there are multiple regions, with each producing some combination of the two. Thus, to more accurately simulate the real world, I relax those assumptions. Unfortunately, for the model to function properly there needs to be a tension between fixed and mobile factors of production. Since I have already set both agricultural and manufactured good production to be dependent on labor only, I must choose some type of this labor to be fixed. Following Fujita, et al (1999) and following papers, I force agricultural workers to be immobile; this allows each region *a* to have both a fixed and a movable factor of production. Hence, the model has become one of not migration in general, but specifically of the migration patterns of non-agricultural workers. I make one final assumption: each industry *b* can only be located in *one* region *a*. Thus, I can still use the notation as above, because each parameter exists for only one industry in one location.

The first key assumption is that, in the above economy, each of the two regions only produce one type of good: the core, manufactured goods, and the periphery, agricultural goods. Thus, after relaxing this assumption, the income level *Y* of any region *a* is given by

$$Y_a = \left(1 + ben_a\right)\sum_{b=1}^{n} w_b N_b + N_{a,A} \tag{1.20}$$

Recall from (1.10) that I have set agricultural wages to be numeraire. Thus, the full income *Y* in region *a* is the sum of manufacturing income, plus benefits, across all industries *b* and the total income of agriculture workers in *a*. In addition, note that benefits are now defined by region, rather than constant across all regions[24].

Second, we open up the model R regions. This means that we now need to include transportation costs between each pair of regions $a,c \in R$; note that $T_{aa}=T_{cc}=1$, and that $T_{ac}=T_{ca}$. Thus, the new price index is defined as

$$G_c = \left[\sum_{a=1}^{R} \left(\sum_{b=1}^{n} \left[\frac{\left(1+ben_a\right) w_b m_b^{\frac{1-\alpha_1}{\alpha_1}}}{\left(\alpha_1 - \frac{\alpha_1}{\sigma}\right) \Phi_b^{\frac{1-\alpha_1}{\alpha_1}}} \right] \right)^{1-\sigma} T_{ac}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{1.21}$$

Note that the new price index for region c incorporates the prices for manufactured goods in all regions, weighted by the transportation costs that exist between each pair of regions (a,c). Finally, equilibrium production and wages are now defined as

$$m_{a,b} = \theta \left(\sum_{a}^{R} Y_a \left(p_{a,b} T_{ac}\right)^{-\sigma} G_a^{\sigma-1} T_{ac} \right) = \left(\varepsilon_{a,b} \left[\frac{\left(\alpha - \frac{\alpha}{\sigma}\right) \Phi_f^{\frac{1-\alpha}{\alpha}}}{\left(\frac{\alpha+\sigma}{\sigma} - \alpha\right)\left(1+ben_a\right) w_{a,b}} \right] \right)^{\alpha} \tag{1.22}$$

and

$$w_{a,b} = \left[\frac{\left(\alpha - \frac{\alpha}{\sigma}\right) \Phi_{a,b}^{\frac{1-\alpha}{\alpha}} \theta}{\left(1+ben_a\right) m_{a,b}^{\frac{1-\alpha}{\alpha}}} \right] \left[\frac{\theta}{m_{a,b}} \sum_{a=1}^{R} Y_a T_{ac}^{1-\sigma} G_a^{\sigma-1} \right]^{\frac{1}{1-\sigma}} \tag{1.23}$$

3.4 The multi-region economy with imperfect information

[24] This can either stand in for the varying tax rates from state to state, as in the US, or in this case, the different tax rates assigned to regular provinces and “special economic zones” (SEZs) in China.

The final change that we need to make is to incorporate imperfect information; that is, the observation rate *obs* of benefits paid in *a* by workers in *c*. Thus, if none of the benefits are observed, *obs*=0, but if some portion are observed, 0<*obs*<1, up to a perfect information rate of *obs*=1. Hence, the final equations for the income levels observed by workers in other regions and the wages paid in each region are

$$OY_a = \left(1 + obs\left(ben_a\right)\right)\sum_{b=1}^{n} w_{a,b}N_{a,b} + N_{a,A} \tag{1.24}$$

and

$$w_{a,b} = \left[\frac{\left(\alpha - \frac{\alpha}{\sigma}\right)\Phi_{a,b}^{\frac{1-\alpha}{\alpha}}\theta}{\left(1+ben_a\right)m_{a,b}^{\frac{1-\alpha}{\alpha}}}\right]\left[Y_aG_a^{\sigma-1} + \sum_{c=2}^{R} OY_cT_{ac}^{1-\sigma}G_c^{\sigma-1}\right]^{\frac{1}{1-\sigma}} \tag{1.25}$$

Note that the price index *does not change*, since, even though there is imperfect information for the workers about income in other locations, the prices charged by firms for their product reflects their price levels. However, since the price index is affected by wages, the observation rate has an *indirect* effect on *G*. Also note that, since wages depend on income in all locations, and the benefits in *a* are perfectly observable to people in *a*, the summation for wages now begins at *c*=2.

I now turn to the parameterizations and alterations necessary to make the above model a functioning simulation.

Section 4: Data and Parameterizations

The machinery above presents a relatively simple and straightforward example of NEG-style population model. However, certain aspects of the model

Table 4.1	General Model Parameterizations
α – labor share of manufacturing production	0.811117
β - agricultural productivity of labor	0.392772977
θ - manufacturing share of consumption	0.275

Source: China Statistical Yearbook 2004, CHNS 2000

are still untested (included benefit levels as separate from wages, for example), and thus, in this paper, I restrict the simulation to a two-region, two-sector discussion. While this restriction is not completely desirable, it allows me to follow Vanbergen (2005) in running the simulations through a simple Mathematica notebook, which does not require a deep understanding of programming to use. In addition, I focus on the location decisions of the mobile manufacturing cohort. Thus, in each of the two regions there exists an exogenous level of agricultural income, given by the immobile agricultural cohort, and an endogenous manufacturing income earned by the mobile manufacturing workers. Restricting the space to two regions also allows for normalization of the population: thus, the manufacturing population in regions 1 and 2 becomes N_1 and $(1-N_1)$, respectively, while the agricultural population becomes N_{A1} and $(1-N_{A1})$. For the purpose of simplification, I define these two regions as *rural* and *urban* China, and thus set the parameters for each based on Chinese data for the two areas. Data for these parameters come from two main sources: the China Health and Nutrition Survey (CHNS) and the Chinese Statistical Yearbook.

The former source, the CHNS, is a survey conducted across nine Chinese provinces approximately every four years for the University of North Carolina's Carolina Population Center. Data for each respondent (contained within the ID number) indicates which province the respondent lives in, detailed information about whether their town is an urban or rural location, the household number of the respondent, and which member of the household is responding to the questions. While there is a wealth of demographic information stored in the survey, only the one conducted in the year 2000 includes the economic information necessary to develop these parameters. The individual surveys done in this year cover 17,170 individuals of all ages, of whom 9103 are currently employed. Interestingly, while under 10% of the employed workers are migrants (defined as someone who has left their registered residence to seek work in another area), these individuals earn wages 56% higher (on average) than their non-migrant counterparts. The household surveys cover 4403 unique households, and provide a more complete set of consumption and income data. Note that, while the average household size is 3.67 people, this includes dependents and non-workers; however, the average income level (which includes government subsidies, rental income, and profits from self-employed workers) is nearly *four and a half times* the average wage of employed workers. Even compared to migrant wages, average household incomes are 183% higher. Thus, any investigation into Chinese migration must take non-wage income into account, which in these simulations is done through benefit rates.[25] This set of data allows me to find the average education levels (as a proxy for human capital/skill levels) and the manufacturing and agricultural population distribution for rural and urban areas. This also allows for the creation of starting wage conditions. In addition,

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[25] See Appendix Table 1 for a more complete set of summary statistics for this survey

the consumption data from the household survey details the number of purchases of a set of goods (including cars, televisions, microwaves, etc) that occurred in the previous year, as well as the total value of these goods owned. Making the (admittedly strong) assumption that the value of each type of good is constant across units, it is possible to find the manufacturing share of consumption and the constant elasticity of substitution for Chinese households. The two parameters I developed are in Table 4.1.

The second source, the Chinese Statistical Yearbook, is a compendium of statistical data published annually by the China Statistical Press in Beijing. This information, divided by province, industry, and year, provided me with starting conditions for output for all three sectors, which in turn made it possible to derive values for agriculture prices and the labor share of manufacturing. This source also includes capital spending levels by industry and region, which I use to substitute for ε_f in the simulation. These values are also shown in Table 4.1. However, it is important to note that these values come from the 2004 version (giving 2003 data) of the statistical yearbook; on the other hand, the CHNS survey that included relevant questions about wages, income, and consumption was the 2000 edition. Thus, while the simulations in the following section are as accurate as possible, there are bound to be some slight discrepancies in comparison with reality due to the difference in years.

Section 5: Results and Analysis

5.1: The Equalized Simulation

I first test to see how the model responds when both regions are identical by setting agricultural population equally distributed between regions, identical capital costs of $\varepsilon_R=\varepsilon_U=$ (insert capital costs), benefit rates of 49%, and an average education level of upper middle school. These parameter settings listed in the first

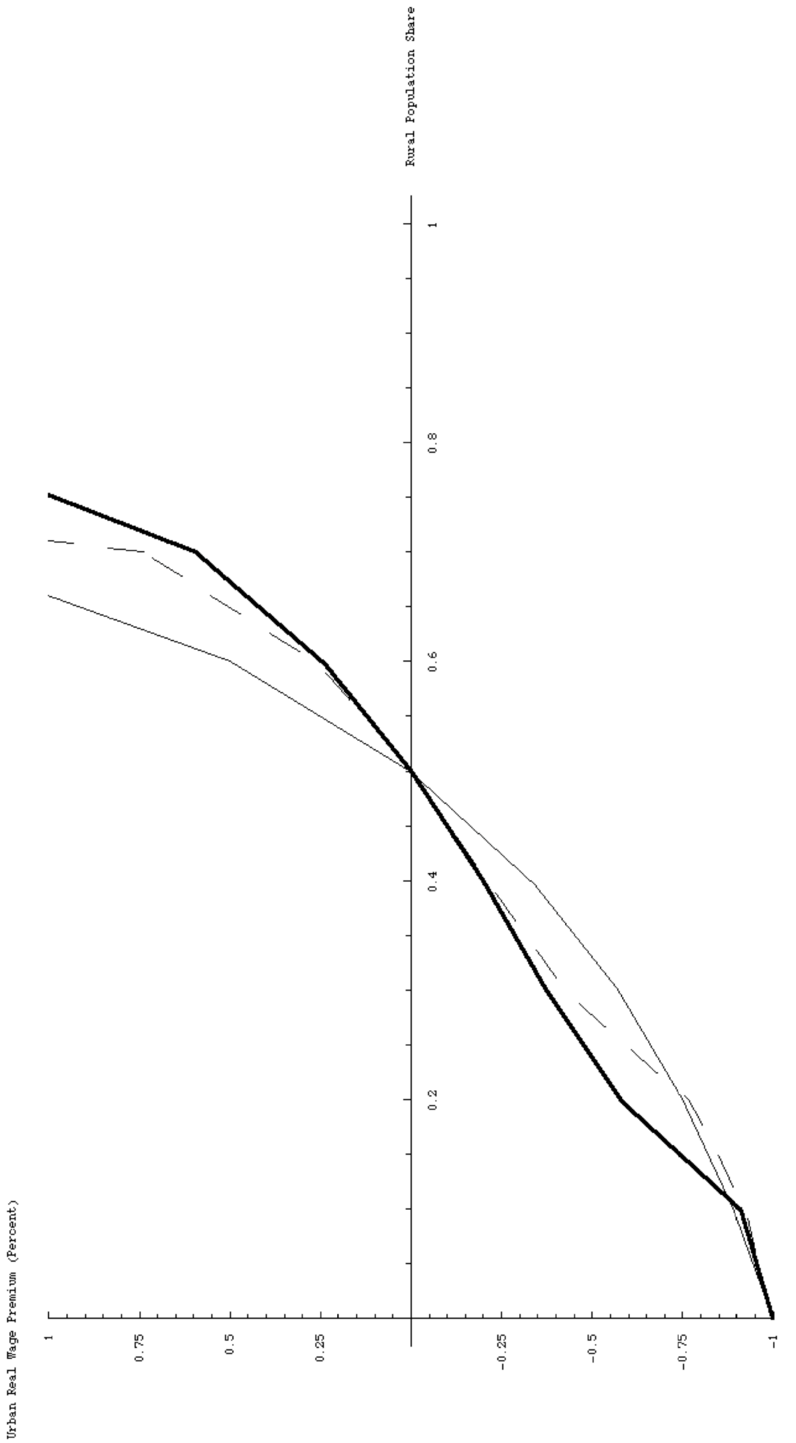
Table 5.1	**Equalized**	**China-Specific**
σ - constant elasticity of substitution	6	1.9898
Rural Values		
ben_R – Rural Benefit rate (% tax on payroll)	49%	49%
Φ_R – average rural education level	3	2.41
Agricultural population share	0.5	0.84725093
ε_R Rural capital costs (yuan)	487304552	487304552
Urban Values		
ben_U - Urban benefit rate (% tax on payroll)	49%	49%
Φ_U – average urban education level	3	3.03
Agricultural population share	0.5	0.15274907
ε_U Urban capital costs (yuan)	487304552	242527448

Sources: China Statistical Yearbook 2004, www.chinaunique.com, CHNS 2000

column of Table 5.1. The other parameters, such as manufacturing share of labor α, agricultural labor productivity β, and manufactured goods share of consumption θ are as shown in Table 4.1. However, I do deviate from that table in one instance: to showcase how these simulations operate, I set a constant elasticity of substitution $\sigma = 6$.[26] With a CES as low as given by the CHNS, even simulations of identical regions do not have enough variation to be visible; I return to using China-based parameters in the simulations below. I conduct this

[26] As used by Fujita, et al (1999) for their simulations.

Figure 5.1 – Identical Regions



------ T = 1 - - - - T = 2 ---- T = 3

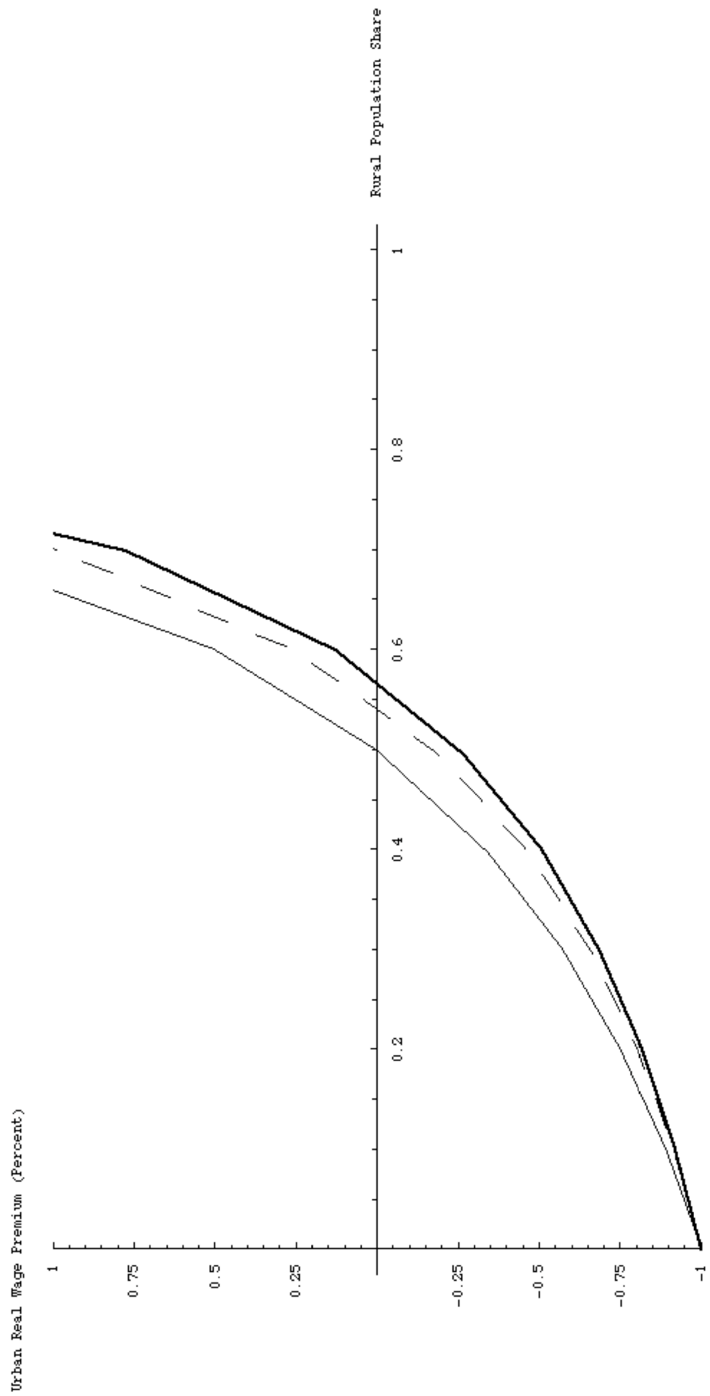
test for low, medium, and high transportation costs (T=1, 2, and 3, respectively). Results are shown in Figure 5.1.

What is the result? When there are no transportation costs (T=1), then a consumer can purchase goods from either region without paying a price premium. In addition, by setting the agricultural population in either region to be identical, there is no inherent market size difference between regions. Thus, there is an equilibrium manufacturing population distribution that occurs at $N_R = 0.5$. If, for example, the "rural" population share increases beyond this value, the "urban" region has a higher real wage rate, thus providing an incentive for workers to move to the urban areas. As population approaches the stable distribution, that real wage "premium" falls, reaching zero at $N_R = 0.5$. Since variations around the equilibrium value create movement back to that value, this is a stable equilibrium. Note that there are no equilibria at the edges ($N_R = 0$ or $N_R = 1$). The only effect of higher populations in one region is to increase the real wage premium in the other; thus, there are no benefits to agglomeration in this simulation.

As transportation costs increase, the size of the wage differential caused by a population shift decreases, but does not disappear entirely. I assume that workers do not instantaneously revert to the stable equilibrium, but instead follow Crozet (2004) in assuming that the size of this differential is a proxy for how quickly workers move. In absolute terms, this means that as workers approach the population differential $N_R = 0.5$ the rate at which they approach this distribution slows. Hence, higher transportation costs, and the resulting shrink in the real wage differential, would mean that workers take longer to reach a long-run equilibrium distribution. Interestingly, as transportation costs continue to increase, there is still no benefit to agglomeration - the equilibrium at $N_R = 0.5$ is still the sole stable equilibrium. I attribute this to the production function given in (fix equation number): while I set capital costs that detract from a firm's final profit, these do no affect the production function. That is only dependent on labor, specifically *marginal* labor requirements without fixed labor costs. Since there is no fixed labor cost, there are no economies to scale (in terms of labor). Thus, with capital costs set to be identical between regions, there is no agglomerating force between the two regions.

It is also important to note that the observation rate discussed above, while having an increased effect as transportation costs increase, the total effect on real wage rate premiums is minimal (see Appendix Table 2 for a full list of these observations.) Why would this be the case? Note that in (equation number), wage rates are primarily determined by "own-region" conditions, which are observed accurately; the bias of observation rates affects only the observed income parameter *OY* for other regions. Since there are only two regions in these simulations, this results in an insignificant direct effect on wage rates. As the number of regions increases, the effects of own-region income on wages shrinks; thus, it is still reasonable to expect that observation rates are important to large multi-region simulations. However, since observation rates have been shown to be irrelevant for the simulations I conduct in this paper, I do not discuss them any further in this section.

Figure 5.2 – China-Based Parameters



------ T = 1 - - - - T = 2 ---- T = 3

5.2: The "Realistic" Simulation

The above simulation provides a "base case" for comparison. In this second simulation, I replace the "equalized" set of parameters with ones that accurately reflect China's current situation. These parameters are listed in the second column of Table 5.1; note that there are a number of changes from the previous simulation. Most important is the shift from a constant elasticity of substitution of $\sigma = 6$ to $\sigma = 1.9898$, which is the number given by the CHNS. This simplifies the wage curve such that movement away from equilibrium yields monotonically increasing (or decreasing) wage premiums. The other important change is the shift from equally distributed agricultural workers to a more realistic distribution, which creates market size differences between the two regions. Results (again, for transportation costs T=1, 2, and 3) are shown in Figure 5.2.

As above, a transportation cost of T=1 has a stable equilibrium at N_R = 0.5. Just like before, since the curve slopes upwards, this equilibrium is "stable": movement away from this point causes a wage premium to arise in the less-populated region, creating an incentive to migrate back to the equilibrium value. Also, note that there is still no significant agglomeration force: there exist no stable equilibria at $N_R = 0$ or $N_R = 1$.

As transportation costs increase, the equilibrium manufacturing worker distribution shifts to the right. Thus, at T=2, the simulation implies an equilibrium at $N_R \approx 0.54$, while at T=3 the equilibrium level is at $N_R \approx 0.575$. Similarly to above, the increase in transportation costs does not affect the stability of these equilibria, nor does it create an agglomeration equilibrium at $N_R = 0$ or $N_R = 1$.

However, one result of the shift of the curve (versus rotating it around a center point) is that increasing transportation do not have constant effects on the wage premiums to either side of equilibrium, So for example, moving from T=2 to T=3 might lower the urban wage premium seen at $N_R = 0.55$, but it will also *increase* the rural wage premium at $N_R = 0.5$.

There are, of course, a few reservations when relating this simulation to the "real" current conditions in China (for example, China is not a two-region-only area, more than one industry exists in each location, etc.) Note, however, that the simulation implies an average urban real wage premium of 95.2% and 74% more than rural real wages for T = 2 and T = 3, respectively, at the current population distribution of $N_R = .696$.[27] This is much lower than the actual wage differential, however: the CHNS implies an average urban wage over 150% greater than rural wages, while official government data puts urban wages at over *three times* rural wages.[28] What ramification does this have for the simulation? Although direct comparisons are not completely accurate, since the CHNS data is based on nominal, not real, wages, this does mean that the simulation vastly underestimates the impetus for migration right now. However, it is unclear if this is a solely a question of magnitude or if the simulation is simply incorrect. For the purpose of this paper, I have to assume that the error lies in magnitude, and that future versions of the simulation will correct this issue. In either case, the wage premiums that the simulation gives do imply huge migration waves towards the urban areas, which is exactly the process we see right now.

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[27] As according to the 2000 CHNS

[28] People's Daily Article, Dec. 15th 2005
http://english.people.com.cn/200512/05/eng20051205_225741.html

However, no matter what the actual magnitude of the difference in wages is, this "current" picture of migration will not stay this way for long. In reality, the parameters that are affecting migration are not static, but in fact are constantly evolving along with Chinese society. I test some of the more basic societal changes in the simulation below.

Table 5.2	**Changes in Manufactured Good Consumption**
Manufactured Good Share	**Real Wage Premium**
θ_I=0.275	95.16%
θ_I=0.5	105.62%
θ_I=0.75	117.08%

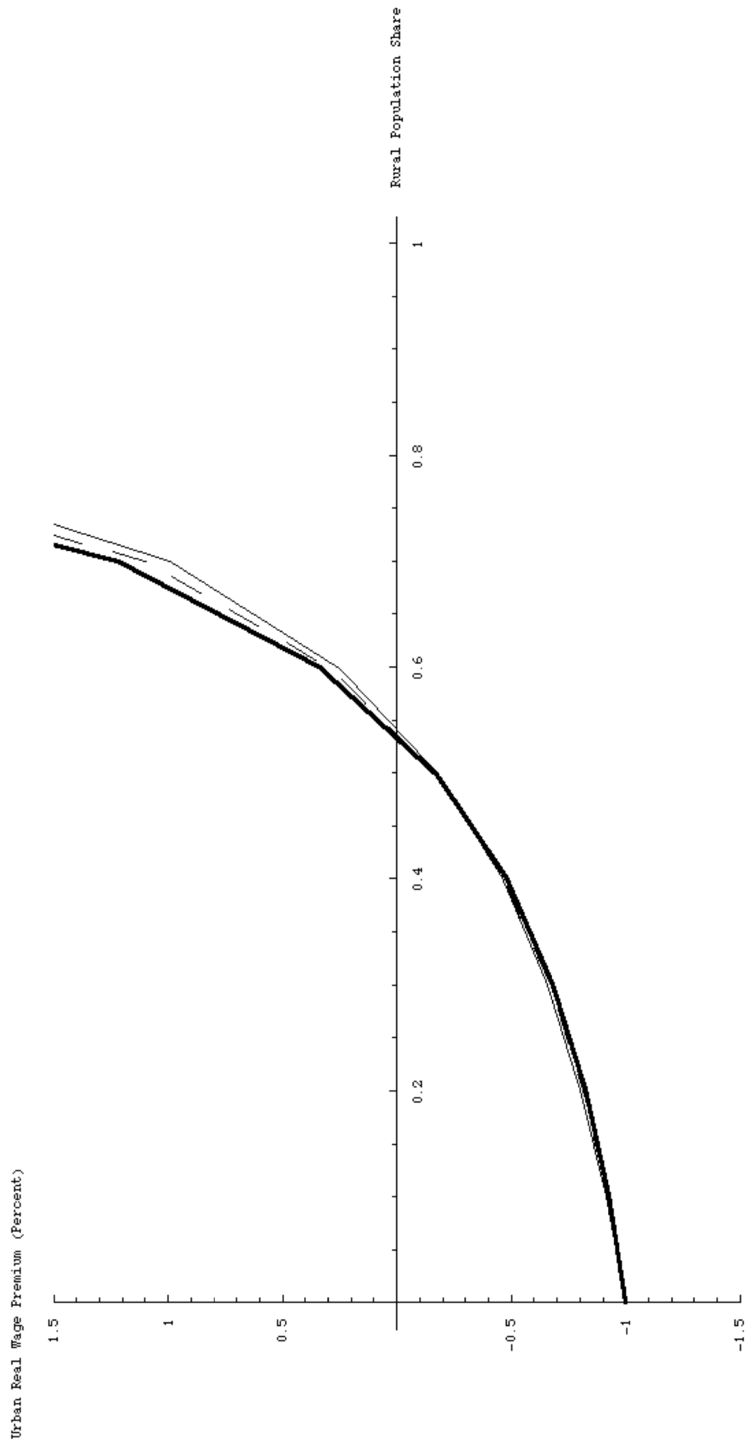
Source: CHNS 2000

5.3 Increased Manufacturing Consumption

One of the key parameters in this simulation is θ_I, the share of manufactured good consumption in total consumer utility. As China becomes more and more industrialized, and wages concurrently improve, that share of consumption is likely to increase. Setting transportation costs constant at 2, I test to see what effects increases in θ_I will have on wage rates and the equilibrium population distribution. Results are given in Figure 5.3.

Two things are apparent in this simulation. First, while a transportation cost of T=2 sets the initial equilibrium population distribution at just under N_R = 0.55, as θ_I increases, the equilibrium point shifts slightly to the left. In practice, that means that an increased share of manufactured goods in consumption would set the equilibrium distribution at a higher urban population share. However, shifting the wage curve like this also increases the urban wage premium for all

Figure 5.3 – Changes in Manufacturing Share of Consumption



- - - - θ = 0.275

------ θ = 0.5

---- θ = 0.75

population distributions to the right of equilibrium. Thus, at current population distributions, this implies that the urban real wage premium will increase from 95% on rural real wages at maximum $\theta_I = 0.275$ to a high of 117% at the maximum $\theta_I = 0.75$. These figures are presented in Table 5.2.

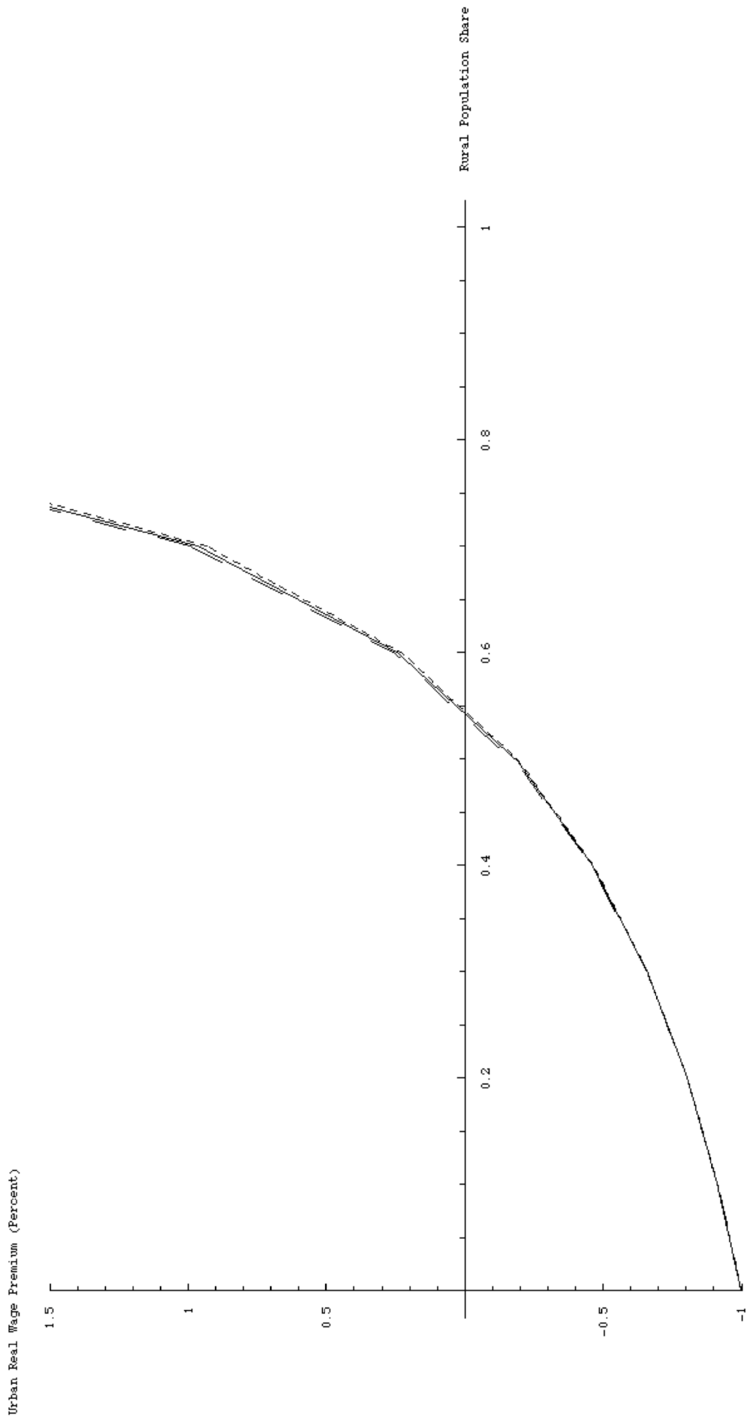
5.4 Increased Use of Education in Manufacturing and Increased Education Rates

I next turn to Φ_a, the average education level of workers in region a. In the past few years, the Chinese Ministry of Education has made increased access to education and reduced illiteracy a major priority.[29] If they are successful in this goal, then it can be expected that Φ_a in both urban and rural regions will increase. At the same time, as workers become more skilled, not only will employers be more able to put those skills to use, but more industries will spring up that take advantage of that increased skill level. Thus, concurrently with education increases, I also test for the effects of increasing (1-α), the share of education in manufactured good production. I increase Φ_R and Φ_U by .5 individually, then concurrently, in simulations with α at the current level of 0.8117, 0.65, and 0.5.

For each level ofα, changing the education level of workers has a minimal effect: the largest fluctuations of the real wage are, at most, 1%. Thus, the simulation I show in Figure 5.4 gives changes in α only and is based on current education levels. However, even when changing α, the visible effects are minimal. Thus, at the current α and population distribution, the real wage

[29] http://www.moe.edu.cn/english/index.htm

Figure 5.4 – Changes in the Labor Share of Production



- - - - α = 0.811117 ____ α = 0.65 ------α = 0.50

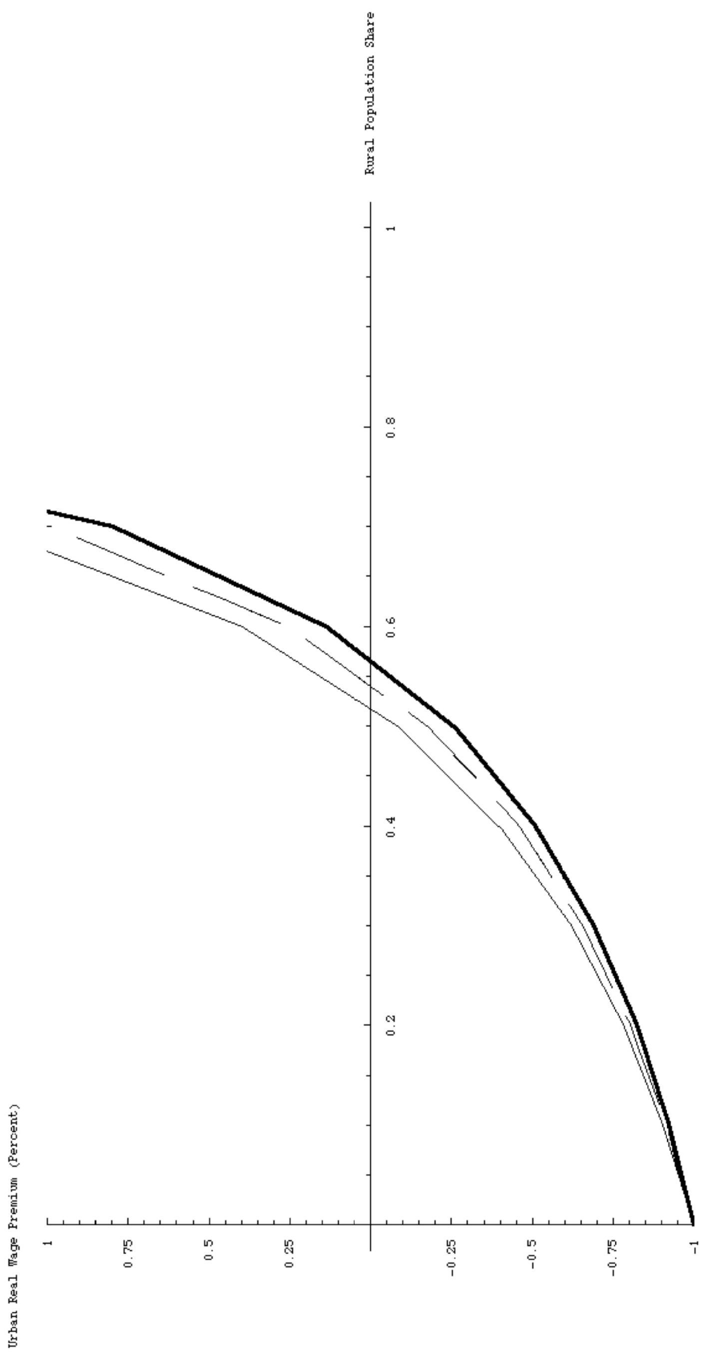
premium is 95.15%, at α=0.65 92.4%, and at α=.5 those premiums are 89.6%. Full results of education increases and shares are given in Table 5.3.

There is one particularly interesting result from the changes in education level, however. Though the size of the fluctuations in wages is small, the lowest urban real wage premium occurs when the average urban education level Φ_U is at its highest, 3.53. This is somewhat counterintuitive, since it states that increasing the education level of urban workers would, in fact, *decrease* the wage spread between rural and urban areas. As far as I can determine, the reason for this is the existence of transportation costs. At a given wage level, an increase in the education rate of one region is essentially an increase in the productivity of labor, making production more efficient and thus lowering the price of goods. However, since T>1, the effect on the price index, and thus real wages, in the "home" region is less than that in the other region (a change of Δp versus $T\Delta p$, respectively.) To see if this intuition is correct, I test the effect of changes in education at the current population distribution for increasing levels of T at 2, 3, and 4. These results are displayed in Table 5.4. Unfortunately, the effect of changes in T on wages is much greater than the effects of education, so results here are confounded. I continue this discussion of education and real wage rates in section 6, below.

5.5 Tax Rates

While the above simulations target specific demographic changes that are occurring in China, none of those changes are in areas that are directly controlled

Figure 5.5 – Changes in the Tax Rate Between Regions



- - - - - $ben_R = ben_U = 49\%$
-------- $ben_R = 49\%$, $ben_U = 34.5\%$
-- -- -- $ben_R = 34.5\%$, $ben_U = 49\%$
-------- $ben_R = ben_U = 34.5\%$

by policymakers. However, policymakers and city managers do have direct control over one important tool: tax policy. Importantly, note that I have required that benefit payments are fully financed by the tax rates – in other words, forced these two levels to be equal. Thus, tax policy has somewhat self-contradictory effects: by setting lower payroll tax rates, policymakers on the one hand lower the costs paid by firms but on the other lower the income levels of that region. Thus, I run this simulation to test which of these effects is stronger. Also, while tax rates may be set independently, the effects are most likely to be felt based on their levels *relative* to the other regions. In China specifically, the simplest action is to have one's city designated a "special economic zone," or SEZ. While this designation brings a number of benefits for the companies locate there, most importantly it allows corporations to avoid paying a portion of local payroll taxes.[30] Using a common set of tax rates from www.chinaunique.com as the basis, I test four benefit rate regimes: both regions at 49% (the non-SEZ rate,) each region at 34.5% (the SEZ rate) while the other is at 49%, and finally, both regions at 34.5%. Results are given in Figure 5.5**.**

As expected, changes in tax policy shift the equilibrium population distribution, in this method altering the urban real wage premium seen at each distribution. The equilibrium that lies closest to an even population distribution, $N_R \approx 0.515$, occurs when the urban region has the lower of the two tax rates. This means that the lower tax rate in urban areas increases the urban real wage premium at each distribution, increasing the incentive to migrate. Conversely,

[30] http://chinaunique.com/business/taxes.htm

when the rural areas have the lower tax rate, there is less of an incentive to migrate to urban areas, and the equilibrium distribution lies at $N_R \approx 0.57$. Note, however, that there is no difference between both regions having the higher tax rate and both having the lower: in either case, the equilibrium lies at $N_R \approx 0.54$. Thus, at the current population distribution, when both regions have the same tax rate the urban area commands a real wage premium of 95.1%; if the rural region has lower tax rates, that premium drops to 76.2%, but if the urban areas have lower tax rates it increases to 116.2%. These results can be seen in Table 5.5.

Section 6: Policy Implications

One important characteristic of the results given above is that they detail the long-run equilibrium position for each scenario. Thus, any changes in the parameters are incorporated first, and then the simulations are run. In the real world, however, that is not how policy and demographic changes function: changes occur over time, even as people attempt to move in optimal paths (in this case, moving towards higher real wages.) Thus, any policy changes that city and government officials might consider have to be looked at against the backdrop of what they will do to affect migration patterns. At the same time, while the above simulations provide general predictions, one must also keep in mind that only two regions were simulated. For many of the recommendations below, the important thing is the region/city's *relative* position compared to other regions/cities of similar characteristics, rather than just their absolute conditions. Finally, keep in mind that the simulations predicted, according to current characteristics, only a

95% urban real wage premium, while data implies that the actual premium is anywhere from 150-230%. Thus, it is entirely possible that the changes described below will have effects of a far greater magnitude than result from the simulations.

6.1 Manufacturing Consumption

As seen above, as the preference for manufactured goods increases in Chinese society, urban incomes will receive an increasing boost relative to rural incomes. A jump to 75% manufactured good consumption (and the commensurate 117% urban real wage premium) is not likely to occur right away; thus, controlling (i.e., slowing) the rate of this change should be a matter of concern policymakers. If the managers of a given city area are worried about migration levels that appear to be "too high" for public services to keep up, what is one way for them to respond? While it may be impossible for city administrators to directly alter the preferences of their constituents, one the first tricks might be imposing an urban sales tax on all manufactured goods. This would have two effects: not only would it increase the price of manufactured goods for residents in the area but if spent on the "overwhelmed" public services, it would counteract some of the pressures brought on by the increasing populations. Furthermore, since these simulations assume a constant elasticity of substitution, a single sales tax for all goods would be sufficient.

In principle, this seems like it might be a good idea – unfortunately, it is not. According to the simulation, a small (6%) sales tax would, in fact*, increase* the urban real wage premium from 95.2%, to 96.9% at the current θ, while at θ_{max} it would increase the premium from 117.1% to 124.5%. Why would this be the case? Note that, according to the wage equation in (insert equation number), wages respond to price levels in their area. Thus, adding 6% to the cost of goods in the urban region increases the price index, which in turn increases wages at a faster rate than prices. This assumes, however, that the sales tax would be incorporated into the price index before calculating wages. If instead I take taxes to come into effect only *after* equilibrium wages and price indexes have been calculated, the story is slightly different: urban real wage premiums decrease from 95.2% to 92.0% at the current θ, while at θ_{max}, the decrease is from 117.1% to 107.8%. These figures can be found in Table 6.1. However, a 6% tax is not enough to hold off all of the premium increase as θ grows. To have a strong enough effect (i.e., holding the wage differential to current levels,) sales taxes would need to be higher – just over 15%. However, in a multi-region economy, as long as the wage differential compared to other cities of similar distances is lower, the 3-10% reductions might be enough to slow migration to manageable levels.

6.2 Education

Next, I return to one of the more intriguing puzzles of the simulations above. As discussed earlier, as education rates in the urban area go up relative to urban workers, the urban real wage premium in fact *declines*; conversely, as rural residents become more and more educated, the urban real wage premium increases. How can this be possible? As I posited above, it may be that the increase in productivity (and the subsequent drop in prices) that an increase in one region's average skill level brings lowers the price index in both areas, but due to transportation costs the effect is actually stronger in the other region. Thus, real wages in both areas increase, but they increase *more* in the opposing region. This does not seem correct, however; an increase in skill levels, if compensated fully, should have *no* effect on prices, but instead should increase the wage level of the workers whose skills improve. Such a change would, naturally, lead to an increased wage premium for the area that had its average skill level improve. This is not what the simulation shows, however. On the other hand, the postulated "magnification effect" of transportation costs does not seem right, either. Were it to be true, the change in real wage premiums should be increasing as transportation costs increase; however, Table 5.4 shows this not to be true. Both nominally and as a share of the total premium, the change caused by an increase in urban skill levels *decreases* as transportation costs increase. Thus, since the process by which this occurs is still unclear, I am uncomfortable recommending any changes from current policy.

From a "production share" point of view, however, the results are far more straightforward: as the share of education (human capital/skill) in the manufacturing production function increases, the wage premium for urban areas decreases (see Table 5.3.) By these results, government policymakers should encourage the formation of these skill-intensive industries, as they will lower the incentive for migration to urban areas. However, note that these results are dependant on *all* industries having an increased share of human capital in production. Thus, this is not a policy change that should fall on the shoulders of regional decision makers, but instead needs to be the role of the central government, which can far better affect all regions at once.

6.3 Tax Policy

We now come to the area in which policymakers have the most control: local tax rates. In the simulations, we focused on using payroll tax rates as indicators of the level of benefits paid to workers. As shown above, the effect of one region having lower rates (relative to the other area) was to increase relative real wages. Thus, for urban areas facing migration pressures, it might make sense to *raise* payroll tax rates. This would have a number of immediate effects: one, fewer firms would want to locate there, decreasing labor demand and thus equilibrium wages. Two, this would provide greater funds available for payment of said benefits, which would offset somewhat the drop in wages due to labor demand. Conversely, for areas that are in need of greater population, lowering payroll taxes is a very effective solution – note that, if both regions have the same non-SEZ tax rates, having the urban area switch to SEZ rates leads to a 21% jump in the urban real wage premium. However, once again, multi-region economies need to take into account all the other possible locations that factor into the migration decision. In addition, note that both regions having the same tax regime gave a constant urban real wage premium, regardless of what the nominal level actually was. Thus, to increase (decrease) migration rates, it should only be necessary to have a lower (higher) tax rate than neighboring locales, rather than adopting a specific absolute change in tax rates.

6.4 Current Policy Evaluation

While the above policies are *normative* descriptions of changes that may need to take place in coming years, I now turn to some of the policy changes that are actually occurring. One of these, the current evolution of what is defined as an "urban" area, is described in Chung and Lam (2004). They note that cities are increasing in population not only because of the migratory pressures, but also because of increases in the geographical jurisdiction of urban areas.[31] How will this effect the population distribution, as given by the simulation? One, by increasing the land area of urban jurisdictions, the number of regions declines; thus, administrators need to worry about balancing their policies against a fewer number of regional "competitors." On the other hand, public services that were once extended only to a small, central group of residents will be available to an increasing population, who (if coming from lower-income rural areas) might not provide a compensatory tax base. Thus, these changes could easily lead to policymakers feeling the pressure of migration more acutely, and shift more areas to discourage in-migration, rather than encourage it.

A second policy change is the shift away from companies being the provider of social benefits to having city governments cover them, as described in Guthrie (2001.) This has the effect of disconnecting the multiplier on income

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[31] Interestingly, this is a very similar process as predicted in Henderson (2005) – specifically, the absorption of smaller locales by their larger urban neighbors.

found in (1.15, 1.20) from the payroll taxes paid by firms. Thus, since wages depend, in part, on the total income levels of each region, Often, this step is taken since firms can no longer afford these benefit levels; thus, one can expect this change to increase wage rates in cities, resulting in higher urban real wage premiums and hence higher migration rates. In addition, the ability of policymakers to use tax policy to control wage premiums is based on the fact that the benefits paid to income are equal to those charged on firms. Once this connection is broken, the ability of policymakers to affect population distribution solely through tax policy is greatly reduced. This, in turn, makes the task far more difficult, since tax policy changes would need to occur concurrently with government spending changes if they are to have the desired (simulated) effect.

Section 7: Conclusion and Future Research

7.1 Conclusion

I have been able to investigate a few concepts. First, while one might expect that the observation rate of benefits would have an important effect on migration rates and wages, the observed effect was so minimal as to be negligible. Second, by using parameters based on current rural and urban conditions in China, I was able to simulate a likely long-term population distribution, as well as simulate the real wage differences that the current migration impetus is based on. Third, using the machinery of simulation, I tested the likely effect that expected changes in the demographic and business nature of China would have on wage differentials between the city and countryside. Finally, I set out some possible policy recommendations (and their respective pitfalls) that regional policymakers could consider, depending on which of the above trends they wished to respond to. In addition, I was able to evaluate the likely effects that increased urban jurisdictions and greater public spending on social benefits (as separate from firm payroll tax payments) will have on migration trends.

7.2 Avenues for Future Research

While the above simulations do a decent job at portraying likely paths that migration in China will take, there still remain a huge range of experiments and simulations that could be run with regards to China, and elsewhere. Fujita and Mori (2005) give a good synopsis of what some of these directions might be, but I instead choose to focus on a few specific areas, relevant to the simulations I conducted above, where I believe progress needs be made.

7.2.1 – Increasing the number of regions and parameters

One of the key problems in developing this simulation was the limitation given by the number of regions. This simulation focused on only two, but there exist data for simulations covering at least the nine provinces described in the CHNS, if not all 31 provinces in China. In addition, this model was limited to labor as a factor of production for agriculture and manufacturing, and education in manufacturing. It would make sense to include land as well: at least in production, if not also in consumption. Fan, Treyz and Treyz (2000) provide an excellent example of one way to do this. They are able to restructure the NEG models given by Fujita, et al (1999) in such a way as to include markets for land, labor, and capital amongst 8- and 50-region economies. The tensions that force redistribution of labor (i.e., migration and city formation) occur because of the demand for a limited amount of land as both a production factor and as a consumed good. Their results are a far more complete simulation than that provided above; future work should both emulate their approach, and build on their results by applying the technique to actual real-world situations,

7.2.2 – Measuring changes in the migration speed

This simulation assumes that migrants base their actions on wage differentials between regions, and thus relocate to wherever their real wages will be higher. However, while this assumption provides an *incentive* for migrants, it doesn't in any way explain how *long* it will take for equilibrium rates to be reached. In the simulations I run, the wage rates and equilibrium population distribution are all long-term equilibria; I make the assumption that the rate of change of population is related to these real wage differentials, but what that speed actually is remains unclear. One important avenue for future research is to define, within these economic geography models, a differential equation that specifies the relationship between the wage difference and the speed of migrants. In addition, while increased transportation costs lower the wage difference and thus indirectly slow migration, it would be interesting to see how transportation costs for workers (separate from the iceberg transportation costs for goods) affect the speed and equilibrium levels of the model.

7.2.3 – Information and Migration

While the above theory stated that observation rates should have a distinct effect on migration, the simulation showed otherwise. However, this does not mean that the question of imperfect information is fully resolved. First, while we assumed that migrants were only unaware of benefit rates, it is entirely plausible that *any* aspect of employment (wages, demand, etc.) could be unknown to potential migrants. Thus, one important question to explore is, how does imperfect or biased information affect each aspect of the simulation? Second, as noted in section 2, research by Zhao (2003) implies that the number of past migrants from a given location is an indicator of the quality of information exchanged, and directly affects the costs of migration. How can this be incorporated into the model? Questions on the 2004 CHNS about the location decisions of migrants might be one way to answer this; however, answers to those questions have yet to be catalogued and made available to researchers.

7.2.4 – Productivity and Real Wages

The most perplexing result I found in these simulations was the effect of the increase in human capital on the urban real wage premium. Why would a higher skill level for workers in a given region imply that their real wages *decrease* relative to the other region? Can this possibly be the case in the real world? Although they are outside the purview of this paper, I would propose two methods by which to test this. First, if the simulation was altered to include a set number of workers, with each assigned one unit of labor and a given skill level, then each would choose to migrate based on this vector of characteristics. In this manner, it would be possible to test whether it is *all* workers who have their real wage rates altered by the change in education, or whether how those education levels/human capital amounts are distributed is the cause for this phenomenon. Secondly, it would make sense to try to test this in the real world. As education rates shift between regions, specifically as rural areas become better educated relative to urban areas, does the real wage gap increase or decrease? One way this would take place is if migration is a selection question: increasing education for rural areas would mean that the wages available to these educated laborers would increase, thus increasing their likelihood of migrating. However, this would leave the least-educated, least-skilled residents in rural areas; assuming average wages depend on skill, this would have the effect of decreasing the average rural wage, and hence increase the urban-rural wage gap. Whether this, or any other similar story, is what is actually going on is unclear – future research into this question will, hopefully, find out the truth.

Section 8: Afterword

The simulations I undertook give a basic portrayal of probable trends, and possible consequences, of Chinese migration and the official responses to it. It is my hope that this analysis will at the very least inspire discussion about these two topics, and hopefully will contribute towards finding an equitable, and manageable, solution to the problem.

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Appendix Table 1: CHNS Summary Statistics

All Interviewees:		**All Households:**	
Count	**17170**	**Count**	4403
Province		**Province**	
Guangxi	2232	Guangxi	512
Guizhou	2241	Guizhou	501
Heilongjiang	1609	Heilongjiang	477
Henan	1982	Henan	476
Hubei	1980	Hubei	487
Hunan	1767	Hunan	488
Jiangsu	1850	Jiangsu	494
Liaoning	1806	Liaoning	482
Shandong	1703	Shandong	486
Male	**8446**	**Mean Household Size**	**3.67**
Urban	**5222**	**Urban**	**1451**
Mean Age	**35.5**	**Mean House Size (m^2)**	**107.35**
Married	**8640**	**Mean House Value (yuan)**	**38335**
Education		**Mean Income (yuan)**	**12405.8**
None	259	**Mean Annual Non-food Expenses (yuan)**	**4244.78**
Elementary School	3204	**Manufactures Consumption Share**	0.275447708
Lower Middle School	4328	**Agriculture Consumption Share**	0.724552292
Upper Middle School	1507	**Elasticity of Substitution**	1.9898
Technical School	645		
University Degree	586		
Master's	9		
Employed:			
Count	**9103**		
Province			
Guangxi	1184		
Guizhou	1189		
Heilongjiang	939		
Henan	1058		
Hubei	1022		
Hunan	912		
Jiangsu	1028		
Liaoning	912		
Shandong	859		
Male	**4796**		
Urban	**2246**		
Mean Age	**39.5**		
Married	**6756**		
Migrant	**818**		
Education			
None	93		
Elementary School	1796		
Lower Middle School	3186		
Upper Middle School	1100		
Technical School	472		
University Degree	446		
Master's	7		
Mean Wage	**2807**		

Migrant Only Mean Wage	**4384**

Appendix Table 2: Urban Real Wage Premium by Observation Rate

	obs=1		
N	T=1	T=2	T=3
0	-100%	-100%	-100%
0.1	-88.89%	-91.35%	-92.01%
0.2	-75%	-80.23%	-81.89%
0.3	-57.14%	-65.61%	-68.74%
0.4	-33.33%	-45.74%	-51%
0.5	0	-17.43%	-25.85%
0.6	50%	25.77%	12.45%
0.7	133.33%	99.03%	77.40%
0.8	300%	242.22%	210.18%
0.9	800%	704.61%	620.21%
1	∞	∞	∞

	obs=.1		
N	T=1	T=2	T=3
0	-100%	-100%	-100%
0.1	-88.89%	-91.34%	-91.97%
0.2	-75%	-80.24%	-81.88%
0.3	-57.14%	-65.71%	-68.81%
0.4	-33.33%	-46.02%	-51.24%
0.5	0	-18.01%	-26.39%
0.6	50%	24.64%	11.36%
0.7	133.33%	96.87%	75.27%
0.8	300%	243.78%	205.68%
0.9	800%	692.77%	607.8%
1	∞	∞	∞

Appendix A: *Mathematica* Simulation of Chinese Migration Patterns - Example

Section 1: Parameter Definitions

```
(*Share of Manufactured Goods in Consumption*)
θ1 := 0.275
(*Observation Rate of Benefits*)
obs := 1
(*Benefit Rates; Rural=1, Urban=2*)
ben1 := .49
ben2 := .49
(*Share of Labor in Manufactured Good Production*)
α1 := .8117
(*Productivity of Agricultural Workers*)
β1 := 1 / 2.564
(*Constant Elasticity of Subtsitution*)
σ := 6
(*Transportation Cost Level*)
T12 := 1
(*Average education level*)
Φ1 := 3.00
Φ2 := 3.00
(*Population in people*)
NA1 := .5
NA2 := 1 - NA1
(*Capital Expenditure in Thousand Yuan = Other Costs*)
ϵ1 := 487304552.000
ϵ2 := 242527448.000
```

Section 2: Evaluation of Wage Levels

```
Clear[w1]
Clear[w2]
N1 := .1
q1 := (N1^α1) (Φ1^(1 - α1))
q2 := ((1 - N1)^α1) (Φ2^(1 - α1))
p1 := ((1 + ben1) w1 * q1^((1 - α1) / α1)) / ((α1 - (α1 / σ)) Φ1^((1 - α1) / α1))
p2 := ((1 + ben2) w2 * q2^((1 - α1) / α1)) / ((α1 - (α1 / σ)) Φ2^((1 - α1) / α1))
output := {θ1 (Y1 * p1^-σ * G1^(σ - 1) + OY2 * (p1 * T12)^-σ * T12 * G2^(σ - 1)) ==
    ((ϵ1 (α1 - (α1 / σ)) (Φ1^((1 - α1) / α1))) / (((α1 + σ) / σ - α1) (1 + ben1) w1))^α1,
  θ1 (Y2 * p2^-σ * G2^(σ - 1) + OY1 * (p2 * T12)^-σ * T12 * G1^(σ - 1)) ==
    ((ϵ2 (α1 - (α1 / σ)) (Φ2^((1 - α1) / α1))) / (((α1 + σ) / σ - α1) (1 + ben2) w2))^α1}
G1 := p1^(1 - σ) + (p2 * T12)^(1 - σ)
G2 := p2^(1 - σ) + (p1 * T12)^(1 - σ)
Y1 := (1 + ben1) (w1 * N1) + NA1
OY1 := (1 + obs * ben1) (w1 * N1) + NA1
Y2 := (1 + ben2) w2 (1 - N1) + NA2
OY2 := (1 + obs * ben2) w2 (1 - N1) + NA2
wages := {1 == (((α1 - (α1 / σ)) (Φ1^((1 - α1) / α1))) / (w1 (1 + ben1) q1^((1 - α1) / α1)))
     ((θ1 / q1) (Y1 (G1^(σ - 1)) + OY2 (G2^(σ - 1)) (T12^(1 - σ)))^(1 / σ)),
  1 == (((α1 - (α1 / σ)) (Φ2^((1 - α1) / α1))) / (w2 (1 + ben2) q2^((1 - α1) / α1)))
     ((θ1 / q2) (Y2 (G2^(σ - 1)) + OY1 (G1^(σ - 1)) (T12^(1 - σ)))^(1 / σ))}
solution1 := FindRoot[{wages}, {{w1, .1}, {w2, .1}}]
ω1 := w1 (G1^(-θ1)) (β1^(θ1 - 1)) /. solution1
ω2 := w2 (G2^(-θ1)) (β1^(θ1 - 1)) /. solution1
RWageRatio1 = {.1, (ω2 - ω1) / (ω1)} /. solution1

Repeat above for N1 = 0, .1, .2, ..., 1
```

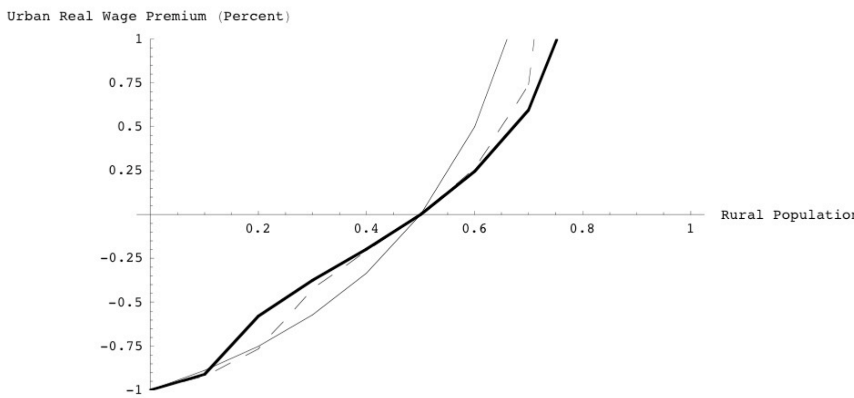
Section 3: Graph Real Wage Differentials

```
Stability3 = ListPlot[{RWageRatio0, RWageRatio1, RWageRatio2, RWageRatio3, RWageRatio4,
   RWageRatio5, RWageRatio6, RWageRatio7, RWageRatio8, RWageRatio9, RWageRatio10},
  PlotRange → {-1, 1}, PlotJoined → True, PlotStyle → Thickness[.004]]

Repeat Sections 2 and 3 for all parameter changes
```

Section 4: Show Graphs Concurrently

```
Show[{Stability1, Stability2, Stability3},
 AxesLabel → {"Rural Population Share", "Urban Real Wage Premium (Percent)"}]
```



- Graphics -