Labor-Market Integration, Investment in Risky Human Capital, and Fiscal Competition

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This paper presents a general-equilibrium model where human capital investment increases specialization and exposes skilled workers to region-specific earnings risk. Interjurisdictional mobility of skilled labor mitigates these risks; state-contingent migration of skilled labor also improves efficiency. With perfect capital markets, labor-market integration raises welfare and reduces ex post earnings inequality. If instead human capital investment can only be financed through local taxes, labor-market integration leads to interjurisdictional fiscal competition, shifting the burden of taxation to low-skilled immobile workers. Decentralized public provision of human capital investment creates earnings inequalities and is inefficient. (*JEL* H00)

The extent of interoccupational and geographical mobility of labor appears to vary substantially by labor type, among regions and countries, and over time. Within a local labor market, such as a metropolitan area, some types of workers can easily find many potential employers and, in the absence of regulatory constraints or restrictive labor-market institutions, job changes may be relatively costless. For example, many types of service and production workers, such as those providing basic maintenance, delivery, clerical, assembly, and fabrication services, have skills which are valued by a wide range of employers in different industries. Other types of workers have much more specialized skills and may find only a few potential employers in a locality who might be interested in exploiting those skills. For example, a given locality may have only a few firms, or none at all, who would wish to employ lawyers with expertise in particular types of law, a few major employers who might hire staff to support large-scale advanced information systems, one or two major universities which recruit for very specialized teaching or research staff, or a small number of clinics specializing in particular procedures or in the treatment of specific illnesses. With such a small number of potential employers, the chance of a highly specialized worker finding a good employment match within the local labor market is correspondingly reduced, and it would not be surprising, therefore, to find such workers and firms searching in more than one local market; in some cases, indeed, workers and employers may search over an entire country or over the entire world in order to find the best employment match.

Search over a large geographical area does not, in itself, imply that matches, when found, will be characterized by high turnover; if anything, perhaps the opposite would be the case (see, e.g., Donald O. Parsons [1986] for a discussion of the durability of employment contracts). It does not necessarily follow, therefore, that migration rates will be higher for highly specialized workers. Nevertheless, the empirical evidence indicates that more educated

* Department of Economics, Vanderbilt University, Nashville, TN 37235 (e-mail: wildasin@ctrvax.vanderbilt.edu). This paper has benefited greatly from comments by F. Carlsen, R. Musgrave, W. Oates, A. Sandmo, G. Schjelderup, and A. Weichenrieder, and from the unusually detailed and thoughtful comments of two anonymous referees. Earlier versions have been presented at several workshops and conferences, including "Competition or Harmonization? Fiscal Policy, Regulation, and Standards" (Tutzing, Germany, 1995), "The Multi-Tiered Public Sector: Fiscal Competition, Political Economy, Finance, and Mobility" (Washington University), and "Public Policy and Private Incentives" (Norwegian Research Centre in Organization and Management). Comments from participants have been most helpful, but the author retains sole responsibility for errors. A longer version of this paper, containing additional discussion and technical matter, is available on request from the author. Some of the work for this paper was done while the author was on leave at the Public Economics Division of the Policy Research Department of the World Bank, whose support and hospitality are gratefully acknowledged.

TABLE 1—ANNUAL INMIGRATION, OUTMIGRATION, NET MIGRATION, AND MOVERS FROM ABROAD FOR REGIONS: SELECTED YEARS, 1980–1994
(NUMBERS IN THOUSANDS)

Mobility period and type of migration	Northeast	Midwest	South	West
1993–1994				
Inmigrants	348	706	1,336	746
Outmigrants	676	737	960	763
Net internal migration	−328	−31	376	−17
Movers from abroad	267	132	451	396
Net migration (including abroad)	−61	101	827	379
1990–1991				
Inmigrants	346	782	1,421	835
Outmigrants	932	797	987	668
Net internal migration	−585	−15	433	167
Movers from abroad	209	208	351	617
Net migration (including abroad)	−367	193	784	784
1980–1981				
Inmigrants	464	650	1,377	871
Outmigrants	706	1,056	890	710
Net internal migration	242	−406	487	161
Movers from abroad	207	180	412	514
Net migration (including abroad)	(35)	−226	889	675

Source: http://www.census.gov/population/socdemo/migration/tab-a-2.txt.

workers, who may be presumed to have more specialized skills, do tend to exhibit greater geographical mobility as measured by migration rates.[1] Moreover, the fact that gross migration flows vastly exceed *net* migration flows indicates that mobility provides a mechanism for matching specific attributes of workers and locations. Census data for the United States is illustrative.[2] In 1990, only about 60 percent of Americans resided in the state where they were born, and in no state did this share exceed 80 percent, indicating that a very large fraction of the population changes its state of residence at some point in the life cycle. Some 17–20 percent of the U.S. population changes its residence each year, and although many of these moves occur within small geographic areas (e.g., within a county), about 2.5–3.5 percent of the population has moved from one state to another each year since World War II. The number of internal migrants each year is generally five–seven times greater than the number of movers from abroad. While some of the interstate migration in the United States represents net flows from one region to another, gross flows are consistently far greater than net, as shown in Table 1 for selected years. Thus, there is substantial and continuing internal migration within the United States, much of which takes the form of "cross-hauling" among relatively large geographical units such as states and regions. If all workers (and the tasks that they undertake) were identical, any excess of gross over net migration—i.e., the bulk of all migration—would represent economic waste. (See Wildasin and John D. Wilson [1996] for a model that predicts wasteful migration as an equilibrium outcome with rent seeking and imperfect information.) If, on the contrary, this high level of migration is undertaken because of its economic benefits, the workers in the East who move to the West must not be identical to the workers in the West who move to the East. And, as indicated, these movers are predominantly better educated and trained members of the population. In short, the data indicate that migration provides a mechanism through which workers, especially those with high levels of

[1] See, e.g., Ronald G. Ehrenberg and Robert S. Smith (1988 p. 360), who explain that age is the most important determinant of migration, with young people moving more than old, and that "education is the single best indicator of who will move *within* an age group. ... *[C]ollege* education ... raises the probability of migrating the most"; emphasis in original.

[2] See http://www.census.gov/ftp/pub/population/www/migrate.html.

human capital, continuously match specific skills to specific jobs, and that this process generates a level of gross migration substantially higher than the level of net migration.[3]

The degree of specialization of labor and of labor mobility across firms, industries, and locations depends on many factors. Building on the basic insight of Adam Smith that "the division of labor is limited by the extent of the market," George J. Stigler (1951) emphasizes the importance of expanding *output* markets as a factor contributing to greater specialization. Expanded *input* markets are also likely to play a role. Paul Krugman (1991) emphasizes the benefits of "dense" labor markets to workers and firms and suggests that this is a possible factor contributing to urbanization. By contrast, reductions in the cost of geographical mobility may create dense markets by expanding their geographical scope (Wildasin, 1995). Interfirm and interindustry labor mobility can be enhanced by workers if they acquire general, rather than specific, human capital and by firms if they adopt production technologies that permit greater flexibility in the assignment of workers to tasks. The size of market areas for goods and factors, the degree of urbanization, the choice of organization and technique by firms, and the amount and specificity of human capital embodied in workers should be presumed to be simultaneously determined.[4]

The geographical scope of factor markets, that is, the extent to which factor markets are spatially integrated, is a matter of considerable importance for the analysis of fiscal and other policies. Government tax and expenditure policies typically bear on populations within geographically defined jurisdictional boundaries. The costs and benefits of these policies create incentives for interjurisdictional factor reallocations if jurisdictional boundaries do not enclose market boundaries, with important implications for their efficiency and distributional effects. Moreover, factor mobility may increase the cost to governments of raising revenue, perhaps constraining government expenditures in general and redistributive expenditures in particular. To

[3] A substantial body of research in labor economics has studied the attachment of workers to specific jobs. This research (see Robert H. Topel, 1991; Topel and Michael P. Ward, 1992, and references therein) suggests that young workers are likely to change jobs quite frequently, and that such job switches give rise to rapid earnings growth. As workers succeed in finding higher-wage jobs, however, their rate of turnover diminishes and the employment relationship becomes more stable. In such a stable employment relationship, length of job tenure accounts for much of wage growth. Many studies in this literature do not distinguish between changes in jobs and changes in location, though it is clear that the two are to some degree correlated. The present analysis is not designed to explain recent trends in wage inequality (see, e.g., Chinhui Juhn et al. [1993] for discussion and analysis of these trends), but, as will become clear, it does indicate that changes in geographic mobility can indeed affect the distribution of earnings both by equalizing returns within skill categories across space and by changing the level of skill acquisition. The entire general-equilibrium structure of rewards to skilled and unskilled labor is thus affected by mobility.

[4] The urban or regional specialization of economic activity and its connection to human capital formation has been a topic of renewed interest in recent years and it is not possible to discuss all related literature here. See, e.g., Marcus Berliant and Yves Zenou (1997) for a recent discussion and references. Like the present analysis, Philippe Michel et al. (1996) postulate differentially higher mobility of skilled labor. In the spirit of Paul Romer (1986) and other new growth theorists, these authors postulate labor-market externalities associated with the employment of skilled labor; explicit dynamic analysis shows how these externalities can generate tendencies for long-run agglomeration. Michel et al., however, take the level of investment in human capital as exogenously given. On the empirical side, Sukkoo Kim (1995) analyzes trends in regional specialization in U.S. manufacturing, noting that spatial concentration of factors can contribute to output specialization, and that increased factor mobility can reduce this type of specialization. This is broadly equivalent to saying that demands for specialized factors drive factor movements, as postulated in the present model. Adam B. Jaffe et al. (1993) provide evidence that technological innovation is characterized by substantial localization economies; while their focus is on spillovers, which are absent in the analysis presented below, their basic finding that patent-producing activities tend to be spatially concentrated is consistent with the assumption of local specialization in specialized, human-capital-intensive tasks. Naomi R. Lamoreaux and Kenneth L. Sokoloff (1999) argue that "contractual mobility" for inventors—specifically, the development of markets in which their ideas, embodied in patents, can be traded—facilitates the specialization and division of labor (individuals can more easily specialize in invention). Clearly, as in international trade, "trade can substitute for migration," and "contractual mobility" can substitute for geographic mobility (or, more accurately, one can say that geographic mobility provides one, but only one, type of contractual mobility), highlighting the above-noted interdependency of goods and factor market integration, specialization, urbanization, etc.

some authors, factor mobility threatens basic functions of government, while others see fiscal competition as a constraint on government inefficiency. Both predictive and normative analyses of fiscal interactions in the presence of factor mobility are the focus of a rapidly growing literature.[5]

Factor market integration may increase over time due to institutional change, for instance as a result of structural policy changes such as the formation (or dissolution) of political and economic unions (such as the internal market of the United States or the EU), factor market deregulation (mutual recognition of professional degrees among jurisdictions, relaxation of occupational licensure requirements, lifting of capital controls or of restrictions on foreign investment), and other forms of economic liberalization. Technological changes that facilitate factor movements, such as improvements in transportation and communication, contribute in obvious ways to factor market integration. Technological change is probably an important fundamental determinant of long-term institutional and policy change as well (see, e.g., Timothy J. Hatton and Jeffrey G. Williamson [1994] and Douglass C. North [1996]). The degree of factor market integration depends not only on the cost or feasibility of factor movements, however, but on the *benefit* and desirability of factor movements. Here, the process of accumulation of human capital and the acquisition of increasingly specialized skills that tends to accompany this process is of importance. On the one hand, for the reasons indicated above, individuals with highly specialized skills may wish to participate in labor markets of large geographical scope; on the other hand, reductions in the cost of accessing labor markets of large geographical scope increase the prospect that workers with specialized skills and their potential employers will make successful employment matches and this would appear to make the acquisition of specialized skills more attractive.

The goal of the present paper is to analyze some aspects of the complex interplay between labor-market integration and investment in human capital which may be either privately or publicly financed. Investment in human capital takes the form of acquisition of industry-specific skills which expose skilled workers to wage risks, whereas unskilled workers are assumed to be fully mobile across industries and face no wage risk. Unskilled workers are assumed always to be geographically immobile, while skilled workers are assumed to be either completely immobile or, as a stylized representation of the effect of market integration, costlessly mobile among jurisdictions. In the free-mobility case, spatial arbitrage eliminates the jurisdiction-specific wage risks that skilled workers would otherwise face, so that integration of the labor market for skilled workers reduces the variability of the returns to skilled labor.

Section I investigates the effect of this type of labor-market integration within the context of a simple general-equilibrium model of privately financed investment in human capital. The analysis shows how factor market integration results in a first-best allocation of resources in which the *ex post* net returns to both skilled and unskilled labor are equalized and the level of welfare is increased.

Section II considers the case where human capital investments are financed by "local" governments and compares public financing with the private-financing case of Section I. Governments must decide both on the level of investment to undertake and on the structure of taxation used to finance the investment. The analysis begins with the case where skilled workers are immobile. Section II, subsection B,

[5] A vast and well-established literature has discussed the equity and efficiency implications of local government finance of elementary and secondary education within U.S. metropolitan areas; see Robert P. Inman and Daniel L. Rubinfeld (1979), Dennis Epple and Thomas Romer (1991), Raquel Fernández and Richard Rogerson (1996), and Thomas J. Nechyba (1997) for examples and further references. A number of studies (e.g., Charles A. M. de Bartolomé, 1990; Epple and Richard Romano, 1998, and references therein) have drawn attention to the potential importance of peer-group effects in local education, or to similar externalities that arise in the labor market (e.g., Harry Huizinga, 1997). The present analysis, however, abstracts from such externalities. See Helmuth Cremer et al. (1996) and Wildasin (1998) for recent surveys of the literature examining the implications of factor mobility for tax, income redistribution, and expenditure policies. The general modeling framework used in the present paper is similar in some respects to that in Wildasin (1995, 1997), but the analysis differs by considering endogenous determination of skill levels and endogenous determination of tax and expenditure policies.

shows that government policies may result in higher levels of human capital investment and higher welfare than under private financing. They may, however, introduce "horizontal inequities" that do not arise in the private-financing case. Section II, subsection C, considers the case where skilled workers are mobile. Integration of the labor market for skilled workers imposes new constraints on the ability of decentralized governments to raise revenue. Indeed, competition for mobile skilled workers causes local tax systems to be restructured so that the cost of human capital investment falls entirely on immobile *unskilled* workers. The total level of investment in human capital is less than the first-best level that would be achieved under private financing. Moreover, the equilibrium with public financing is characterized by *ex ante* as well as *ex post* differences in the net returns to skilled and unskilled workers, with the latter being worse off than they would be in the private-financing case.

Section III concludes with a brief review of the principal findings and a discussion of directions for further research.

I. A Model of Private Investment in Human Capital

The following analysis is concerned with the extent of investment in human capital, represented in the model in terms of the proportion of the population that undertakes investment in the acquisition of specialized skills. The present section assumes that there is no obstacle to the financing of such investment by individuals who may wish to do so. This assumption is debatable because of the prohibition of credit contracts in which workers pledge future earnings in order to borrow to finance investments in themselves. Therefore, Section II proceeds on the alternative assumption that human capital investment is financed through the public sector.

A. *Basic Structure*

The economy consists of many *ex ante* identical jurisdictions. Each contains an initial population of N *ex ante* identical "native" individuals. Some of these individuals will acquire specialized skills through investment in human capital while others will remain "unskilled."[6] These skilled and unskilled workers will then work together to produce output which is traded at fixed prices on external markets. All markets are perfectly competitive and, in particular, all workers are paid according to their (*ex post*) marginal products. All markets clear.

Each jurisdiction contains many industries. Given fixed output prices, let units of output be chosen so that the price of one unit of each good is one. The output of industry i in a given jurisdiction is a function $f(s_i, l_i, \theta)$ of the amount of skilled and unskilled labor employed in the industry, denoted by s_i and l_i, respectively, and of a random variable θ. The function f exhibits constant returns to scale in the two types of labor and is the same for all industries, and θ is independently and identically distributed (i.i.d.) across industries and jurisdictions with finite support.[7]

Assumptions about labor mobility among industries and jurisdictions play a critical role in the analysis. Although the model is not explicitly dynamic, some decisions are made prior to the realization of the industry shocks and others are made subsequently. In particular, for an expenditure of e, any worker may acquire the skills necessary to become a skilled worker in a particular industry. This decision is made prior to the realization of the industry shocks and is irreversible. For example, a worker may become a mechanical engineer, an architect, a physician, a lawyer, or a biochemist. The acquisition of any of these skills is initially equally costly, but the decision is a permanent one and cannot be undone, that is, *skilled labor is intersectorally immobile.* Unskilled labor, by comparison, requires no investment in specialized skills; moreover, *unskilled workers are assumed to be intersectorally mobile* after the realization of the industry-specific shocks. So, for instance, random expansions or contractions of the health-care sector or the construction sector may result in *ex post* reallocations of clerical workers, security

[6] As will become clear, the crucial feature of "skilled" labor in this model is the *specialization* of skills. All workers may have some level of general human capital and thus some level of skills in an absolute sense, but "unskilled" workers do not possess specialized skills.

[7] The assumption that the production function f is of the same form for all industries is less restrictive than it appears given that θ takes on industry-specific values.

personnel, or maintenance staff whose labor services are not industry specific; physicians and architects, however, cannot switch industries *ex post.* One implication of the *ex post* mobility of unskilled labor is that the unskilled workers in a given jurisdiction must, in equilibrium, receive the same wage, denoted w_l.

Although unskilled workers are perfectly intersectorally mobile, they are assumed to be completely interjurisdictionally immobile in accordance with the observation that geographical mobility is strongly associated with educational attainment. (Given the strong symmetry assumptions of the model, no unskilled workers will in equilibrium have an incentive to relocate in any case.) With respect to skilled workers, two polar extreme assumptions are considered in order to examine the implications of changes in the geographical integration of markets for skilled labor. In the first polar case, skilled workers are interjurisdictionally immobile, while in the second case, they are costlessly mobile among jurisdictions. Even when skilled workers are free to move geographically, however, they are still assumed to be bound to the specific industries in which they are skilled.

The equilibrium level of skill acquisition, the equilibrium allocation of workers among industries and jurisdictions, and the equilibrium returns to skilled and unskilled labor all depend, in general, on whether the markets for skilled labor are or are not "integrated," i.e., on whether or not skilled workers are geographically mobile.

B. *Factor Market Equilibrium with Immobile Skilled Labor*

When skilled labor is interjurisdictionally immobile, trained native workers are the only source of skilled labor in a given jurisdiction. Thus, if s_i^n denotes the number of native workers who are trained for work in industry i, it follows that the level of employment of skilled workers in industry i must be given by $s_i = s_i^n$. The total number of unskilled workers l in the jurisdiction is simply the total population less the number of skilled native workers, i.e.,

$$\sum_i s_i^n + l = N. \tag{1}$$

The skill-acquisition decision is made *ex ante* and is thus a decision under uncertainty. To understand the nature of this decision, let us work backwards from the *ex post* equilibrium.

Given s_i^n skilled workers in industry i and a total of l unskilled workers, the allocation of unskilled workers among industries and their wage must be determined so that demand and supply are equated. The demand for unskilled labor in industry i is determined as a function of the level of skilled employment, the industry shock, and the unskilled wage rate w_l from the marginal productivity condition

$$f_l(s_i^n, l_i, \theta_i) = w_l \quad \forall\, i \tag{2}$$

where $f_l(\cdot)$ denotes the marginal product of unskilled labor and θ_i denotes the realization of θ in industry i. The equilibrium value of w_l must clear the labor market for unskilled labor, i.e., it must satisfy

$$\sum_i l_i(s_i^n, w_l, \theta_i) = l. \tag{3}$$

Conditions (2) and (3) can be used to solve for the equilibrium *ex post* allocation of unskilled labor and its wage rate w_l in terms of the s_i^n's, l, and the random variables θ_i. Furthermore, the marginal productivity condition for skilled labor,

$$f_s(s_i^n, l_i, \theta_i) = w_{is} \quad \forall\, i \tag{4}$$

can be used to express the wage of skilled labor in industry i, denoted by w_{is}, in terms of the same variables. Note that w_{is} is generally random since it depends on the industry-specific value of θ both directly and, through l_i, indirectly.

Workers are assumed to act so as to maximize expected utility, with increasing concave utility functions defined over net income denoted by $u(\cdot)$. Earnings risk is assumed to be uninsurable, for instance because of underlying informational asymmetries. The absence of insurance markets creates a market failure with important implications for the analysis.[8]

[8] The informational asymmetries that preclude the existence of insurance of earnings risk are not explicitly present

It remains to show how the level of *ex ante* skill acquisition is achieved. Under the assumption that workers are able to access capital markets in order to finance any desired level of investment in human capital, individual workers are free to acquire specialized skills if they find it advantageous to do so. Assume that all workers have identical concave utility functions $u(\cdot)$ defined over net income. Then the expected utility of a skilled worker in industry i is $Eu(w_{is} - e)$, that is, the expectation of the utility of risky earnings net of the cost of skill acquisition. The expected utility of an unskilled worker is $Eu(w_l)$. In equilibrium, expected utilities must be equalized across industries and skill levels, i.e.,

$$(5) \qquad Eu(w_{is} - e) = Eu(w_l) \quad \forall\, i,$$

and, in addition, all workers must be either skilled or unskilled, i.e., (1) must be satisfied. Conditions (1) and (5) can be used to solve for the equilibrium level of investment in human capital in each industry i, as represented by the number of workers s_i^n acquiring industry-specific skills, and for the equilibrium number of unskilled workers l. Under the symmetry assumptions imposed on the model, the system must be in equilibrium when each industry attracts identical numbers of skilled workers, i.e., $s_i^n = s'$.[9] In this situation, the equilibrium wage of unskilled labor is certain since there are many industries in the jurisdiction subject to independent shocks. Thus, in a symmetric equilibrium, there is an allocation of workers to skilled and unskilled work, (s', l'), and industry-specific returns to skilled labor and the returns to unskilled labor $(\{w'_{is}\}, w'_l)$, such that

$$(1') \qquad \sum_i s' + l' = N.$$

$$(5') \qquad Eu(w'_{is} - e) = u(w'_l) \quad \forall\, i.$$

Given the concavity of the production function f, (s', l') are uniquely determined.[10]

C. *Factor Market Equilibrium with Integrated Markets for Skilled Labor*

Now consider the case where the markets for skilled labor are perfectly integrated. In any one jurisdiction, a particular industry i may experience a stochastic shock that raises or lowers the marginal product of skilled labor, leading to *ex post* interjurisdictional flows of the skilled workers specific to that industry. Thus, the level of employment of skilled workers in industry i, s_i, is determined independently of the number of native workers in industry i trained for work in that industry, s_i^n. These *ex post* reallocations improve the overall efficiency of resource allocation and also eliminate any interjurisdictional differentials in the returns to skilled labor in each industry. Because stochastic shocks are i.i.d. and there are many jurisdictions, the return to skilled labor in each industry will be nonstochastic. Furthermore, by the symmetry assumptions of the model, the return to skilled labor will be the same across industries; this common return is denoted by w_s.

In equilibrium, workers must be indifferent *ex ante* between remaining unskilled or investing in skills in any particular industry, i.e., letting (w_s^*, w_l^*) denote the equilibrium wages of

in the model but could be incorporated at the expense of notational and analytical complexity. Earnings risk is of course observed in practice (risky earnings are of central concern in the literature on precautionary savings, e.g., Angus Deaton, 1991) and the moral hazard problems involved in trying to insure against this risk are obvious. As a special case of the model, workers can be risk neutral rather than risk averse, and the analysis in the risk-neutral case yields results that are fundamentally the same as for the case of perfect insurance markets.

[9] The symmetric equilibrium is not the only one. There is an indeterminacy in the allocation of skilled workers across industries because of the assumptions of constant returns to scale. However, it seems plausible to focus on the symmetric equilibrium. Alternatively, small frictions or small amounts of industry-specific factors would be sufficient to rule out asymmetric equilibria.

[10] In the special case of risk neutrality (or when there are perfect markets for the insurance of earnings risk), (5′) implies that

$$(F.1) \qquad E(w'_{is}) - e = w'_l,$$

i.e., the "efficiency condition" that expected return to skilled labor net of the cost of investment in human capital is equal to the return to unskilled labor. With risk aversion and incomplete insurance markets, however, (5′) implies that the expected net return to skilled labor exceeds the return to unskilled labor as the former commands a risk premium.

skilled and unskilled workers, $u(w_s^* - e) = u(w_l^*)$, or

$$(5^*) \qquad w_s^* - e = w_l^*.$$

Thus, in an equilibrium with integrated markets, all wage uncertainty disappears and investment in human capital occurs at an efficient level, such that the extra productivity of skilled labor is just high enough to compensate for the cost of skill acquisition. Because workers and jurisdictions are assumed to be *ex ante* identical, the model cannot explain precisely which workers will acquire skills in particular industries, but, given the symmetry of the model, this is economically irrelevant in any case. The number of individuals acquiring skills in an "average" jurisdiction and the number of workers who remain unskilled are determinate, however, and must take on values (s^*, l^*) satisfying (5*) and

$$(1^*) \qquad s^* + l^* = N.$$

D. *Distributional and Allocative Effects of Market Integration*

A comparison of the two equilibria just described sheds light on the effect of a reduction in the barriers to mobility of skilled labor. The crucial observation to make is that the allocation of resources is first-best efficient when markets are integrated. Skilled workers in each industry are drawn, *ex post,* to the *jurisdictions* in which their productivity is the highest, while unskilled workers in each jurisdiction are drawn, *ex post,* to the *industries* in which their productivity is the highest. Since all workers can make *ex post* switches either among jurisdictions or industries, there can be no *ex post* inefficiencies in the allocation of the stocks of skilled and unskilled labor, nor any interindustry or interjurisdictional wage differentials. From the *ex ante* viewpoint, this means that no workers face any wage uncertainty; in particular, investment in skill acquisition is riskless, and thus is unaffected by the absence of markets in which wage risk can be explicitly insured. *Ex ante* human capital investment decisions are therefore also efficient.

Since the equilibrium with integrated markets is first-best efficient, any other allocation must lower utility for at least some workers. In particular, this must be true for the allocation obtained when skilled workers are immobile. Since all workers obtain the same *ex ante* utility in both equilibria, it follows that all workers are better off, *ex ante,* when factor markets are integrated. In particular, unskilled workers are better off, which means that the equilibrium return to unskilled labor must be higher in the integrated-markets equilibrium, i.e., $w_l^* > w_l'$. Hence we have the following proposition.

PROPOSITION 1: *When investment in human capital is privately financed, the integration of markets for skilled labor*

(i) raises the equilibrium return to unskilled labor,
(ii) eliminates income risk and ex post income inequality among skilled workers,
(iii) equalizes the net incomes of skilled and unskilled workers, and
(iv) raises ex ante (expected) utility for all workers.

Note that while labor-market integration raises the *ex ante* expected utility for all workers, including the skilled, it also eliminates any *ex post* wage variation among the skilled. It is quite possible, therefore, that some (random) portion of the skilled workers would have higher net incomes and utility, *ex post,* when factor markets are not integrated.

The welfare consequences of factor market integration, as described in Proposition 1, are relatively clear-cut. From a predictive viewpoint, it is also natural to ask whether greater mobility for skilled workers results in greater investment in human capital. Intuitively, one might suppose that acquisition of specialized skills is more attractive to risk-averse households when market integration reduces the variability of returns to such skills. The issue is analytically nontrivial, however, since it involves a comparison of two discretely different general equilibria with possibly quite different levels of household welfare giving rise to income effects; moreover, the degree of substitutability between skilled and unskilled labor could be high or low and might indeed vary

significantly from one equilibrium to the next.[11] Analysis of significant special cases of the model, however, suggests that factor market integration tends generally to favor increases human capital investment.[12]

E. *Generalizations*

Many of the simplifying assumptions of the model are made only for simplicity of exposition and can be relaxed without changing the analysis. Others are more critical and would not be so easy to relax. For example, the assumption that all workers are equally able to acquire skills in each industry is clearly much stronger than necessary. There may be some workers who can only be unskilled or who are only able to acquire skills in certain industries. So long as these workers are inframarginal, i.e., provided that there are some workers who, in equilibrium, can move across any pair of skill categories, the analysis is completely unaffected. It is also fairly easy to see what would happen if workers differ in the effective quantities of labor that they provide. For example, a "highly able worker" may be able to supply twice as many effective units of unskilled labor as a "not very able" worker. The existence of heterogeneous endowments of effective labor would give rise to obvious disparities in per capita earnings among workers but would not change the basic findings.

Similarly, the strong symmetry assumptions provide analytical clarity but clearly some relaxation of these assumptions would only weaken the results in a quantitative sense without changing their basic nature. For example, if shocks are partially correlated among industries within a jurisdiction, individual jurisdictions could have "more favorable" or "less favorable" outcomes than average. A jurisdiction with above-average shocks to the productivity of skilled workers would attract more skilled workers when markets are integrated and the equilibrium wage of unskilled workers there would tend to be higher than in other jurisdictions. Participation in an integrated market for skilled labor for such a jurisdiction would tend to be more harmful to the interests of skilled workers since they would suffer greater erosion of incomes due to competition from outsiders. It would, however, be beneficial to the unskilled, whose labor is complementary to the skilled. These and similar effects arising from departures from symmetry are not uninteresting but they have been previously discussed in other contexts and do not fundamentally overturn the findings here; to incorporate them explicitly would also necessitate a substantial increase in notational complexity in order to distinguish "lucky" (or "rich") jurisdictions from "unlucky" (or "poor") ones.

The existence of other factors of production may or may not add significant new complications. A tradeable factor of production such as perfectly mobile capital does not significantly alter the analysis, although it could for example imply that skilled and unskilled labor are not necessarily complementary and this could in turn mean that increases in the amount of skilled labor would reduce rather than increase the return to unskilled labor. Thus, to preserve the results of the analysis while allowing for such other factors of production, it becomes important to impose explicitly the assumption of complementarity of the two labor types. This assumption is probably empirically reasonable, however. The presence of nontraded factors of production other than unskilled labor, or of nontraded goods generally (such as land or housing), raises some additional issues, however,

[11] The effects of uncertainty on human capital investment have been studied previously by numerous authors, such as Joseph T. Williams (1978, 1979), who finds that greater riskiness of returns to human capital reduces the level of investment in human capital by risk-averse agents. Jonathan Eaton and Harvey S. Rosen (1980) and Zuliu Hu (1993) have examined the effects of taxation on labor supply and risk taking when the returns to labor are stochastic. The standard approach in this and other related literature is to treat wage rates as uncertain and, for example, to see what effects a change in the variability of wage rates may have on the level of investment in human capital. Such analyses are clearly of great interest, but their findings are not directly applicable in the present context because (a) they are partial equilibrium in character (in the present model, the returns to different types of labor are simultaneously determined in a general-equilibrium setting) and (b) they do not consider the possibility that investment in human capital per se makes the return to labor more risky (in the present model, increased investment in human capital implies increased occupational specialization and, when labor is immobile, increased earnings risk).

[12] An earlier version of the paper (available on request) shows that with multiplicative uncertainty, factor market integration definitely increases human capital investment if workers are sufficiently risk averse or if they are risk neutral and the production technology is Cobb-Douglas.

and warrants further analysis, as suggested in the conclusion.

The assumption that factor market integration is all-or-nothing is also made for analytical clarity and convenience. More realistically, migration costs would almost never be prohibitively high nor would they be negligible. However, the analysis depends essentially on the fact that reductions in migration costs tend to reduce the interjurisdictional variations in the equilibrium prices of skilled labor, and not on the complete absence of such variations that arises in the extreme case of perfect mobility.

Finally, the assumption that the production function f is the same for all industries may seem odd, although, as noted, nothing precludes very general differences in the *realized* production technology as a function of the two labor types alone, since the random variable θ enters the production function in a very general way. More importantly, as a matter of interpretation, an "industry," for the purposes of this paper, is defined not in terms of the specific commodities that it produces but in terms of the specific skills that it requires of skilled workers. "Industries" would thus correspond statistically more to occupational categories for which comparable amounts of training resources are required (e.g., different types of college or professional degrees) than to particular kinds of consumption goods, and the identical production function assumption then means mainly that different types of skilled workers exhibit identical degrees of complementarity with unskilled workers (and are separable in production from other skilled workers). These assumptions are hardly innocuous, of course, but the results of the analysis are essentially robust to them in the sense that the results should hold, approximately, if the assumptions are approximately valid.

II. Public Finance of Investment in Human Capital

A. *Basic Structure*

While retaining the assumptions regarding technology, tastes, and endowments introduced in Section I, suppose now that workers are not able to finance investment in skill acquisition on an individual basis because of legal restraints on the appropriability of human capital. The present section proceeds under the assumption that investment in human capital can be implemented only through the public sector. Furthermore, attention will be restricted to the case where these public investments are undertaken on a decentralized basis, i.e., where individual jurisdictions finance education for their own residents using their own fiscal resources. The goal of the analysis is to explore the efficiency and equity implications of labor-market integration under these conditions. To do so, it is necessary to specify how the level of investment in human capital is determined and how public expenditures for this purpose are financed.

Fiscal Instruments and Constraints.—As in Section I, skill acquisition occurs prior to the realization of technological shocks, and it is natural to assume therefore that the immediate financial responsibility for human capital investment in a worker falls on the jurisdiction in which that worker is a "native." Thus, in a jurisdiction in which s_i^n native residents are trained with skills in industry i, total public expenditure will be $e \sum_i s_i^n$. These expenditures must be financed with taxes or fees of some kind assessed by the local government. As is always the case, assumptions about the fiscal instruments available to governments are critical and must be chosen carefully. Consider first the revenue instruments available to the public sector.

First, one might assume that a jurisdiction could charge workers directly for the cost of human capital investment, either requiring them to pay immediately for the cost of the investment (e.g., the case of a student attending a college in the United States who pays "full freight") or by extending a loan for which repayment is mandatory (as the federal student loan program in the United States would be if repayment were fully enforced).[13] Such an as-

[13] Exit fees on educated individuals leaving a jurisdiction have been proposed in the "brain drain" context (Jagdish N. Bhagwati, 1976; Bhagwati and Martin Partington, 1976). Such fees could be seen as part of a system in which public investments in education are financed through the domestic tax system for nonmigrants and in which emigrants, who would otherwise escape domestic taxation, are forced to pay in a lump sum at the time of departure. This system can thus be viewed as one that uses lifetime exposure to the tax system to force repayment of implicit loans

sumption would imply either that workers have sufficient nonhuman wealth that recourse to the private capital market to finance human capital investment is not needed or that governments can effectively circumvent the prohibitions on contracts in which workers pledge future earnings in exchange for present resources and thus supplant (or implement) a perfect capital market. These are interesting cases to consider but they obviate any capital market imperfections and, in effect, reduce the problem to the situation already analyzed in Section II; no more need be said about them here.

As an alternative specification, consistent with the existence of imperfect capital markets, this section assumes that jurisdictions must rely on taxes imposed *ex post* on resident workers to finance their expenditures. (Earnings and earnings-related taxes, such as sales taxes, are major sources of revenue for most governments, and most governments are prohibited from, or incapable of, taxing nonresidents.) It is analytically convenient to suppose that each jurisdiction has two potential tax instruments at its disposal, namely, a per capita tax on unskilled workers at rate t_l and a per capita tax on skilled workers at rate t_s. This specification includes a uniform head tax as a special case where $t_l = t_s$. The possibility of differential taxation of workers by skill level is meant to correspond, in a simple way, to those features of real tax systems that bear differentially on skilled and unskilled workers. For instance, both in the model and in reality, skilled workers tend to have higher wage incomes than unskilled workers. Income tax systems with rates that do not decline rapidly with income (and, a fortiori, systems with proportional or progressive rate structures) or with personal exemptions effectively differentiate the tax treatment of high- and low-income households and thus provide instruments through which the tax burdens on skilled and unskilled workers may be varied. Similarly, the choice of a tax mix between income and consumption taxes is likely to affect the distribution of tax burdens between skill groups.[14] Somewhat less obviously, governments can shift effective fiscal burdens among skill groups through indirect mechanisms such as business tax relief or infrastructure investment expenditures (e.g., high-tech research parks) that favor industries that disproportionately employ skilled (or unskilled) workers. It is assumed, however, that governments are unable to impose state-contingent industry-specific taxes on skilled workers. If such taxes were feasible, they would enable the government to provide perfect insurance against earnings risk. We have assumed that such insurance is not possible in the private sector, however, and unless there is some reason to think that governments have better access to relevant information than potential private insurers, endowing the public sector with such tax instruments is not easily justified.

With these tax instruments, the budget constraint of each jurisdiction takes the form

$$t_l l + t_s \sum_i s_i = e \sum_i s_i^n. \tag{6}$$

As in Section I, the level of employment of skilled workers in industry i, s_i, must be equal to the number of native workers who acquire skills in that industry, s_i^n, when skilled workers are assumed to be interjurisdictionally immobile. When labor markets for skilled workers are fully integrated, however, there is no necessary connection between s_i and s_i^n.

It remains to consider possible constraints on the ability of the public sector to control the level of investment in human capital, i.e., the number of people who become skilled. One might suppose that this number is controlled directly by the government, for instance by setting enrollment levels at public universities or by controlling the levels of critical inputs such as the amount of investment in infrastructure in public-sector educational institutions or the

to educated nonmigrants while emigrants are charged an explicit fee to buy their way out of the terms of the implicit loan.

[14] Skilled workers tend to have steeper lifetime earnings profiles than unskilled as well as higher lifetime income; for both reasons, the level and composition of net nonhuman capital income differs between skilled and unskilled workers. This nonwage income is (in principle) part of an income tax base but is exempt from taxation under consumption or earnings taxes, and thus the mix of tax instruments bears differentially on skilled and unskilled workers.

number of staff that they may employ. Indeed, the common practice of setting admissions standards for higher education suggests that there may be an important element of rationing of access to higher education, indicative of quantitative controls on the level of human capital investment.[15] Limits on access to human capital can only be binding, however, if the expected utility of skilled workers exceeds that of the unskilled, a condition that may be observed empirically but not one that can be assumed a priori as it depends on the distribution of tax burdens and on other variables to be determined within the analysis. It is arguable, however, that it is infeasible for governments to implement policies that make unskilled workers better off than the skilled (e.g., high levels of human capital investment coupled with high taxes on the skilled, leading to low after-tax incomes for the skilled relative to the unskilled), since it might be impossible to compel people to participate in skill acquisition or education.[16] If so, it is appropriate to impose an incentive-compatibility constraint on the choice of government policies. The following analysis will therefore examine policy choices both with and without such a constraint.

Policy Determination.—In order to describe the choice of government tax and expenditure policies, it is necessary to formulate some hypothesis as to the decision criteria or objective function that guides public policy.

First, decisions about the level of human capital investment are necessarily made *ex ante,* and the *ex ante* residents of each jurisdiction are, by definition, native workers; it makes sense, therefore, to assume that public expenditure decisions should be made in a manner that reflects their interests.

In the case where skilled workers are mobile, it is less obvious whether tax policy might reflect only the interests of native residents, since new entrants to a jurisdiction may be enfranchised; however, in the spirit of many previous analyses of fiscal competition, it is assumed here that tax policy is chosen in a forward-looking fashion by existing residents with an eye to its impact on future locational choices, i.e., that tax policy decisions cannot be undone after migration decisions are made.[17]

Given that fiscal policies are determined *ex ante,* it is natural to assume that they are chosen to maximize the expected utility of native residents. *Ex ante* choices are made from behind a "veil of ignorance," and expected utility maximization (which, in this model, is equivalent to utilitarianism) is therefore in the interest of all native residents.[18] The choice of policy may additionally be constrained by an "equal treatment" or "horizontal equity" condition, which may be taken to represent an incentive-compatibility constraint; it is also equivalent to Rawlsian maximin. Thus, it is assumed below that fiscal policies are chosen to maximize expected utility for native residents, possibly subject to an equal-treatment constraint.

B. *Optimal Public Policies with Immobile Skilled Labor*

Given levels of *ex ante* investment in industry-specific human capital in a jurisdiction will

[15] To be sure, however, private as well as public institutions impose such standards, which presumably perform an important function in sorting and stratifying applicants. Of course, such a function cannot be captured in the present analytical framework, which assumes *ex ante* identical individuals.

[16] As any professor will attest, students have an inalienable right (one that is occasionally exercised) to refuse to learn.

[17] Whereas the following analysis assumes that tax policy is chosen *ex ante,* one might instead consider the case where tax policy is chosen after investments in human capital are made but before migration takes place. The implications of doing so are discussed further in a longer version of this paper, available on request.

[18] In reality, many decisions about whether *particular individuals* obtain specialized skills (who goes to college, in which fields they study, whether they obtain professional training) are made partly on the basis of individual-specific information, known either to the individuals themselves or to others. The present analysis sheds no light on the mechanisms that determine exactly which individuals become skilled and which remain unskilled. On the other hand, major structural decisions about the scale and scope of education and training (e.g., whether to build a state university system, whether to add new campuses or professional schools to an existing system, whether to execute a long-term shift from public to private financing) involve long planning horizons, generally on the order of decades. Knowledge about the attributes of particular individuals is much more limited in these decision contexts, which correspond to the *ex ante* perspective assumed here.

result in an *ex post* allocation of unskilled workers across industries and equilibrium *gross* wages for unskilled and skilled workers satisfying conditions (2), (3), and (4). The net earnings of skilled workers are equal to their gross earnings net of any tax imposed on skilled workers, $w_{is} - t_s$, and the net earnings of unskilled workers are similarly equal to $w_l - t_l$. The *ex ante* expected utility of a worker who is trained in skills specific to industry i is therefore $Eu(w_{is} - t_s)$ and the *ex ante* expected utility of an unskilled worker is $Eu(w_l - t_l)$. Let us assume that each jurisdiction directly controls the number s_i^n of native workers who receive training in the skills specific to each industry i, and that, reflecting the symmetry of the model, the same number of workers s^n is selected for training in each industry.[19] Thus, as in Section I, subsection B, the equilibrium wage of unskilled workers w_l is nonstochastic.

When a jurisdiction chooses policies subject to an equal-treatment constraint, it attempts to maximize the common level of expected utility for all households. This amounts to solving the problem (denoted "HE" for "horizontally equitable")

$$\text{(HE)} \qquad \max_{\langle s^n, l, t_s, t_l \rangle} u(w_l - t_l)$$

subject to (1), (6), and

$$\text{(7)} \qquad u(w_l - t_l) = Eu(w_{is} - t_s)$$

where (7) is the horizontal equity or equal-treatment constraint. [Note that this equal-treatment or horizontal equity condition is guaranteed in the private-financing case by the arbitrage condition (5′).] As a matter of notation, let $(s^{HE}, l^{HE}, t_l^{HE}, t_s^{HE})$ denote a solution to (HE) and, similarly, let w_l^{HE}, w_{is}^{HE}, and l_i^{HE} denote the corresponding wages and employment levels for unskilled and skilled workers.

On the other hand, when jurisdictions maximize expected utility without an equal-treatment constraint, they solve

$$\text{(U)} \qquad \max_{\langle s^n, l, t_s, t_l \rangle} lu(w_l - t_l) + s^n \sum_i Eu(w_{is} - t_s)$$

subject to (1) and (6). Let (s^U, l^U, t_l^U, t_s^U) denote a solution to (U) and, similarly, let w_l^U, w_{is}^U, and l_i^U denote the corresponding wages and employment levels for unskilled and skilled workers. Let us now characterize the solutions to (HE) and (U).

Optimal Policy with Equal Treatment.—The first-order conditions characterizing a solution to (HE) imply (see Appendix) that

$$\text{(8)} \qquad \frac{\operatorname{cov}(u'[w_{is}^{HE} - t_s^{HE}], l_i^{HE})}{Eu'(w_{is}^{HE} - t_s^{HE})} \left(\frac{dw_l}{dl}\right)^{HE} = t_l^{HE} + e - t_s^{HE}$$

where $(dw_l/dl)^{HE} < 0$ denotes the general-equilibrium response of the wage of unskilled labor to an increase in l, evaluated at the solution to (HE). This condition can be used to compare the optimal horizontally equitable public policy with the private-financing equilibrium.

Consider first the case where workers are risk neutral so that $u'(\cdot)$ is constant. The covariance on the left of (8) is then zero, which, along with the government budget constraint (6), implies that $t_s^{HE} = e$ and $t_l^{HE} = 0$. In this case, skilled workers bear the full cost of their training, just as in the private-financing equilibrium. The optimal level of investment in human capital is also identical to that in the private-financing case, since the horizontal-equity constraint (7) reduces to the arbitrage condition (5′) [or (F.1)] when $t_s - e = t_l = 0$. The public-financing solution thus produces an outcome that replicates that for private financing when workers are risk neutral.

[19] In cases where governments actually *provide* (and do not just *finance*) training, for example through state universities, the empirical counterpart of the choice of the s_i^n's might consist of decisions about whether to establish schools of medicine, engineering, veterinary science, etc., and how many students to admit to each. The assumption that jurisdictions direct the industry or occupational-category composition of human capital investment is not crucial, however. Any mix of skills chosen directly by a local government can be replicated as a decentralized equilibrium.

More generally, however, the covariance in (8) is nonzero. In fact, it would ordinarily be negative, that is, industries with favorable technological shocks would be characterized both by high employment of unskilled labor and by high wages, and thus a low marginal utility of income, for workers with industry-specific skills. It is thus reasonable to assume

$$\text{(A)} \qquad \operatorname{cov}(u'[w_{is} - t_s],\ l_i) < 0.$$

Although it may not hold generally, (A) is plausibly satisfied in many important cases.[20] When (A) is satisfied, it follows from (8) and from the government budget constraint (6) that $t_l^{HE} > 0 > t_s^{HE} - e$. For given tax rates, the equilibrium utility of unskilled workers is decreasing in l and the equilibrium expected utility of skilled workers is increasing in l. Satisfaction of the horizontal equity constraint (7) thus requires a value of l lower than in the private-financing equilibrium. Hence we have the following proposition.

PROPOSITION 2: *Assume that (A) holds, that markets for skilled labor are not integrated, that human capital investment is publicly financed, and that public policies are constrained to be horizontally equitable. Comparing to the private-financing equilibrium, the equilibrium under optimal public financing is characterized by*

(i) a higher common level of ex ante utility for all workers,
(ii) a higher level of investment in human capital,
(iii) tax burdens on skilled workers less than the cost of their training, with positive taxes on unskilled workers,
(iv) higher before-tax wages for unskilled workers, and
(v) lower expected before-tax wages for skilled workers.

One can see from Proposition 2 that there is a clear market failure in the private-financing case, in the sense that it is possible to raise the expected utility of *all* workers by introducing public finance of human capital investment. When condition (A) holds, this is brought about by increasing the level of human capital investment. Since skilled and unskilled labor are complementary factors of production, an increase in the number of skilled workers reduces their wages, and raises the wages of unskilled workers. Starting from the level of human capital investment achieved under private financing, at which the expected utilities of skilled and unskilled workers are equalized, training additional workers would depress the expected utility of the former and raise that of the latter. With public financing of human capital investment, however, the tax system allows unskilled workers (the "gainers" from an increase in the number of skilled workers) to compensate skilled workers (the "losers") by bearing some of the cost of training. This can be done in such a way that both groups, i.e., all workers, are made better off. Note that individual unskilled workers can be better off even when they pay taxes to support skilled workers only because of the general-equilibrium impact that this has on their before-tax wages. In an atomistic environment, no individual unskilled worker can affect the equilibrium structure of wage rates by making a voluntary contribution toward the cost of skill acquisition for others. It is therefore individually irrational for unskilled workers to subsidize investment in human capital. The ability of the public sector to enforce such contributions by all unskilled workers, however, makes it possible for both skilled and unskilled workers to achieve higher welfare. In effect, the general-equilibrium structure of wage rates is a kind of public good which can only be altered by concerted action through the public sector.

Expected Utility Maximization.—Now suppose that government policies are chosen to maximize expected utility in each jurisdiction

[20] As discussed further in an earlier version of the paper, available upon request.

without constraining skilled and unskilled workers to have equal expected utilities. The first-order conditions from the maximization problem (U) imply (see Appendix) that

$$(9.1)\quad \frac{\operatorname{cov}(u'[w_{is}^U - t_s^U],\, l_i^U)}{Eu'(w_{is}^U - t_s^U)}\left(\frac{dw_l}{dl}\right)^U = (t_l^U + e - t_s^U) - \frac{(u[w_l^U - t_l^U] - Eu[w_{is}^U - t_s^U])}{Eu'(w_{is}^U - t_s^U)}$$

$$(9.2)\quad u'(w_l^U - t_l^U) = Eu'(w_{is}^U - t_s^U).$$

The first of these conditions is identical in form to the corresponding first-order condition (8) obtained in the equal-treatment case except for the presence of the terms at the end representing the difference between the level of utility for unskilled workers and the expected utility for skilled workers. At the solution to (HE), this difference vanishes and (8) and (9.1) both hold. However, in the utilitarian case, condition (9.2) must also be satisfied. This condition requires that tax burdens be shared between unskilled and skilled workers so as to equalize the (expected) marginal utilities of income, a standard condition for optimal income distribution under utilitarianism. It is possible that (9.2) could hold at the solution to problem (HE), in which case the solutions to (HE) and (U) coincide.[21] In general, however, the fact that (expected) utility levels are equalized under horizontally equitable policies (or in a private-financing equilibrium) does not imply that (expected) *marginal* utilities are equalized. Hence we have the following proposition.

PROPOSITION 3: *Assume that markets for skilled labor are not integrated and that human capital investments are publicly financed. Government policies that are chosen to maximize aggregate (expected) utility do not generally replicate the private-financing equilibrium, and are not generally horizontally equitable.*

The fact that utilitarianism may be inconsistent with horizontal equity is noteworthy (Joseph E. Stiglitz, 1982). (i) It implies, first, that rationing constraints on either skilled or unskilled employment must be imposed to attain outcomes that are not horizontally equitable. For instance, if the expected utility of skilled workers exceeds that of unskilled workers at the utilitarian optimum, it is necessary to ration access to human capital investment, whereas it would be necessary to ration access to unskilled jobs (i.e., to impose training on workers) if the opposite were the case. In the latter case, however, incentive compatibility may make it impossible to implement the expected-utility maximizing policy; if so, the equal-treatment or "maximin" policy described previously is the best feasible policy from an expected-utility perspective. (ii) Second, it implies that equal treatment lowers average welfare for the residents of a jurisdiction. Assuming that they hope to maximize expected utility, workers standing behind a veil of ignorance would strictly favor utilitarian policies over horizontally equitable ones *and* over private-financing arrangements for human capital investment. From this truly *ex ante* or constitutional perspective, both market outcomes and horizontally equitable government policies are inefficient and would be unanimously rejected in favor of the utilitarian welfare criterion.[22]

Comparing utilitarian outcomes with private financing, it is remarkable that the former are generally characterized by greater *ex post* inequality than the latter. Normally, utilitarian social welfare functions with risk-averse households (or other specifications of individual and social preferences that imply aversion to inequality and risk) give rise to public-sector interventions (e.g., redistributive taxes) which

[21] In particular, (9.2) must hold when workers are risk neutral since they then have identical marginal utilities of income. Expected utility maximization therefore coincides with the optimal horizontally equitable policy which, as already noted, replicates the private-financing equilibrium.

[22] To say that the horizontally equitable policies are inefficient is not to deny that some households might be better off with such policies than they are with those that maximize expected utility. At least some households will be better off in the latter case, however, and all households would strictly prefer a gamble in which, *ex ante,* they have the same chance of being selected as a skilled or unskilled worker as anyone else.

bring about more equal outcomes at the expense of efficiency losses. In this model, however, private financing of skill acquisition is associated with *ex ante* equality among households and is inefficient, i.e., *compared to utilitarian public-sector policies, laissez-faire outcomes sacrifice efficiency but achieve greater equality.*

C. *Policy and Market Equilibrium with Integrated Markets for Skilled Labor*

Integration of the markets for skilled labor significantly changes the conditions under which public policies are made. A jurisdiction's attempts to recapture its investment in human capital by taxing skilled workers will be thwarted by their subsequent mobility. Since the mobility of skilled labor constrains the mix of taxes that jurisdictions will choose, the *ex ante* equilibrium level of investment in human capital will also be affected, as shown in this section.

To begin with, note that the interjurisdictional mobility of skilled workers implies that *after-tax* earnings of workers in each industry must be equalized across jurisdictions and, by the law of large numbers, these earnings are nonstochastic. Assuming that each jurisdiction takes the tax policies of every other jurisdiction as parametrically given, this means that the net return to skilled labor in each industry is taken as parametrically fixed by every jurisdiction. Furthermore, given the symmetry of the model, these returns will be equalized across industries. Thus, let ω_s denote the equilibrium net return to skilled labor. The fact that the equilibrium level of employment of skilled workers, s, is determined *ex post* in such a way as to insure that skilled workers receive the given net rate of return ω_s can be used to decompose and simplify the analysis. In particular, it is possible, first, to show how each jurisdiction's tax policy is chosen; once this is known, one can then analyze the choice of the level of investment in human capital.

Tax Policy.—Note first that the utility of skilled workers is determined by ω_s, which is exogenous to the policy choices of any one jurisdiction. Thus, the choice of taxes (t_l, t_s) can only affect the utility of *unskilled* native residents. For a given level of investment in human capital (s^n, l), this means that the tax policy (t_l, t_s) must be chosen to maximize the net income of the unskilled, $w_l - t_l$.[23] In solving this problem, it is necessary to take into account the dependence of the *ex post* level of employment of skilled workers s on local tax policy.

Solving this problem leads to the well-known result (not derived here formally in order to save space) that $t_s = 0$, that is, when a small jurisdiction can impose lump-sum taxes on those whose welfare it is attempting to maximize (in this case, the welfare of the unskilled workers), it should impose no tax at all on mobile factors of production. Thus, *jurisdictions competing for mobile skilled labor will rely entirely on taxes on immobile unskilled labor to finance human capital investment.*[24]

Investment in Human Capital.—The fact that every jurisdiction chooses $t_s = 0$ when skilled labor is mobile and that any public investment in human capital must be financed by taxes on immobile unskilled workers can be exploited to simplify the analysis of investment in human capital.

First, each jurisdiction takes ω_s as parametrically given. Thus, no jurisdiction's choice of the level of investment in human capital can affect the utility $u(\omega_s)$ of any native workers who acquire specialized skills. Furthermore, since $t_s = 0$, the gross return to skilled labor $w_s = \omega_s$ must be taken as given by each jurisdiction. By constant returns to scale in production, this means that the *gross* rate of return to *unskilled* labor w_l is also exogenously fixed (from the factor-price frontier) from the viewpoint of any one jurisdiction. Hence, the utility of an unskilled worker, $u(w_l - t_l)$, can only be influenced by a jurisdiction's choice of t_l; in particular, then, higher levels of investment in human capital entail higher taxes on unskilled

[23] Recall the problem (U), now optimizing only with respect to the tax instruments (t_l, t_s), taking the level of investment in human capital and thus l and s^n as determined in the first stage and taking $\Sigma_i Eu(w_{is} - t_s) = u(\omega_s)$ as exogenous.

[24] Although it may seem paradoxical that the utility of the unskilled is maximized when they pay all of the taxes and leave the skilled untaxed, this is nothing other than the application of the standard optimal tariff argument to the taxation of a mobile factor of production.

workers which must, in turn, lower their after-tax incomes and make them worse off. In essence, by taxing unskilled workers, a jurisdiction can raise resources that allow other workers to become skilled and thus to obtain the utility level $u(\omega_s)$, but only by harming unskilled taxpayers. For this reason (and as demonstrated formally below) equal treatment for skilled and unskilled workers is incompatible with any nonzero level of public provision of education, and any equilibrium with publicly financed education must be one in which the skilled are better off than the unskilled. Publicly financed investment in human capital must thus be characterized by rationing of access to education. For these reasons, attention is henceforth restricted to the case where each jurisdiction chooses the level of human capital investment to maximize the expected utility of its native residents with no equal-treatment constraint.

Formally, the maximization problem facing any one jurisdiction is thus

$$(U') \qquad \max_{\langle s^n, l, t_l \rangle} W = s^n u(w_s) + lu(E[f_l(s, l_i, \theta_i)] - t_l)$$

subject to (1) and (6). Note that this problem differs in several respects from the corresponding problem (U) for the case where markets for skilled labor are not integrated: the utility accruing to skilled native workers is now exogenously given, their tax t_s is set equal to zero, and the equilibrium value of s is not constrained to be equal to s^n; all of these differences are attributable to the fact that each jurisdiction is small and open *ex post* with respect to the economywide markets for skilled labor. The first-order conditions for this problem (as is readily verified) reduce to

$$(10) \qquad u(w_s) - u(w_l - t_l) = u'(w_l - t_l)(e + t_l).$$

In equilibrium, the systemwide gross rates of return on skilled and unskilled labor, w_s and w_l, must be such that (10) holds in all jurisdictions and such that neither skilled nor unskilled labor is in excess demand or supply.

As noted above, and as demonstrated formally in (10), *the equilibrium utility level of skilled workers must exceed that of unskilled workers.* To interpret (10) further, observe that a jurisdiction that invests in human capital for one additional worker changes the utility of that worker by the utility differential $u(w_s) - u(w_l - t_l)$ shown on the left-hand side of (10). This also necessitates an increase in the tax burden on the remaining population of unskilled workers l, however. Moving one worker from the ranks of the unskilled to the skilled has two effects on the local tax rate t_l. On the one hand, investing in the human capital of one more native worker entails an outlay of e, and, on the other hand, it reduces by one the number of taxpaying unskilled workers, each of whom is contributing t_l in taxes. Thus, the net fiscal loss from investing in one more worker is $(e + t_l)$ and this must be made up by taxing the remaining unskilled workers sufficiently to keep the local budget in balance. The resulting loss in welfare is the term on the right-hand side of (10). This term is definitely positive, implying that the utility differential between skilled and unskilled workers on the left-hand side of (10) must also be positive.

D. *Distributional and Efficiency Effects of Market Integration*

The preceding results suggest that the impact of labor-market integration may be quite different when human capital investments are financed through public rather than private means. We have already observed that the mobility of skilled labor has an important effect on the structure of taxation: when skilled workers are perfectly mobile, competition among jurisdictions eliminates the taxes that they pay ($t_s = 0$) and only unskilled workers are taxed to finance human capital investment. What happens, however, to the level of investment in human capital?

To gain some initial insight into this issue, observe that (10) reduces to (5*) in the special case where the utility function is linear.[25] Thus, if there is no inequality or risk aversion, each jurisdiction will choose the same level of invest-

[25] Take $u(y) \equiv a + by$ and substitute into (10).

ment in human capital s^* that would be obtained in an equilibrium with perfect, integrated markets and private finance of human capital investment. This level of investment satisfies the "production efficiency" requirement that investment is carried out to the level at which the return on the marginal unit of skilled labor is just high enough to cover the cost of skill acquisition. Unlike in the perfect markets case, however, this does not result in the elimination of net income differentials between skilled and unskilled workers, since the latter must, in equilibrium, finance the human capital investments of the former.

More generally, if workers are risk averse, and the utilitarian social welfare function is thus inequality averse, the level of investment in human capital will differ from s^*. Intuitively, some sacrifice in the efficiency of human capital investment is warranted in order to reduce the inequality in the returns to skilled and unskilled labor. Formally, taking a Taylor expansion of u about $w_l - t_l$, we have that

(11)

$$u(w_l + e) = u(w_l - t_l) + u'(w_l - t_l)(e + t_l) + \tfrac{1}{2}u''(w_l - t_l)(e + t_l)^2 + \text{terms of higher order.}$$

Using (10) and the concavity of the utility function, it follows that

(12) $$w_l + e < w_s$$

which implies that the equilibrium level of s with publicly financed human capital and integrated markets for skilled labor must be less than s^*. To summarize, we have the following propositions.

PROPOSITION 4: *When human capital investments are publicly financed and each jurisdiction chooses public policies that maximize the expected utility of native residents, the integration of markets for skilled labor*

(i) drives the tax burden on skilled workers to zero, resulting in a tax burden on unskilled workers sufficient to finance all public expenditures on human capital investment,
(ii) eliminates income risk and ex post income inequality among skilled workers, and
(iii) results in ex ante inequalities by making unskilled workers worse off than skilled workers.

PROPOSITION 5: *Comparing the equilibria with integrated markets for skilled labor with privately financed versus publicly financed human capital investment, public financing results in*

(i) less investment in human capital,
(ii) lower earnings and welfare for unskilled workers,
(iii) higher earnings and welfare for skilled workers, and
(iv) lower aggregate (utilitarian) social welfare.

Of course, if private financing is not feasible, it would be misleading to interpret Proposition 5 to suggest the policy implication that factor market integration favors a switch from public to private financing. Rather, it simply reveals that factor market integration can have quite different efficiency and distributional consequences in different types of economies. Potential policy implications of the analysis are discussed further below.

III. Conclusion

The analysis in the preceding sections has been conducted within the context of a deliberately stylized and simplified model. Its most critical features are the assumptions that human capital investment contributes to specialization, that specialization leads to greater income risk, and that more highly skilled individuals are, or could become, relatively spatially mobile. A first lesson from this analysis is that integration of the markets for skilled labor, by increasing the opportunities for spatial arbitrage among skilled workers, reduces the variability of their incomes and improves the efficiency of the uti-

lization of human capital. This is true whether investment in human capital is privately or public financed.

When the acquisition of human capital is a private decision, for example because capital market imperfections do not impede private finance of education and training, integration of the market for skilled labor produces a first-best efficient allocation of resources, including an efficient level of investment in human capital. Taking all general-equilibrium effects into account, the return to unskilled labor is higher in the integrated equilibrium, as is overall welfare. Increased mobility of skilled workers has quite different effects when skill acquisition is publicly financed, however. In this case, mobility of skilled labor drives individual jurisdictions to shift the entire burden of financing public expenditures onto unskilled workers. This outcome is inequitable in an *ex ante* sense since it results in higher net incomes and welfare for skilled workers. Furthermore, the level of investment in human capital is inefficiently low and the net incomes of unskilled workers, and overall social welfare, are lower than in the case of private financing.

The formal analysis has drawn a sharp distinction between privately and publicly financed human capital investment. In interpreting the results, it is important to remember that, in practice, much human capital investment involves a mix of the two. Public-sector involvement in formal education is found at all levels in modern economies and the public sector may dominate the provision and financing of education in some cases. The U.S. experience clearly illustrates, however, that private and public education can coexist, and the historical experience in many countries attests to the important role that private resources can play in education. Even in societies where most formal education is conducted through public-sector institutions, students often forgo or curtail participation in the labor market and thus sacrifice immediate earnings. This cost of education is typically borne in large part by students themselves (or their families). Private-sector financing also usually predominates in such forms of human capital investment as on-the-job training. An interesting issue suggested by the formal analysis is whether the integration of factor markets might lead to a shift toward more private financing of human capital investment.[26] Recall that when skilled labor is assumed to be immobile, the equilibrium with public financing of human capital generally welfare-dominates the private-financing equilibrium, whereas the opposite is true when skilled workers are mobile. The model focuses on the pure polar cases of private and public finance and it cannot therefore be readily used to show how factor market integration could affect the public-/private-financing mix. Indeed, in a more general model, private capital market imperfections, tax distortions, and factor mobility could give rise to quite complex interactions not captured here. Still, it seems plausible to conjecture that private financing would tend to expand and public financing would tend to contract as the mobility of skilled workers increases.[27] Modeling the equilibrium mix of private and public financing for human capital investment, and its dependence on the nature of labor-market conditions, would be an interesting issue for future research.

There are many ways in which the simple analysis presented here can be developed further. Section I, subsection E, discusses several possible generalizations and conjectures. The presence of immobile resources other than unskilled labor as well as the potential mobility of unskilled workers themselves could certainly have important implications for some of the conclusions. In the present analysis, increases in the mobility of skilled workers implies that the

[26] It may be of interest to note that the share of state government contributions to higher education in the United States declined steadily from 30.7 percent in 1980–1981 to 23.4 percent in 1994–1995; for public institutions of higher education alone, the corresponding figures show a decline in state government contributions from 45.6 percent to 35.9 percent (National Center for Educational Statistics, 1998 Tables 324 and 325). By contrast, tuition and fees account for a rising share of the cost of higher education (from 21.0 percent to 27.2 percent for all higher-education institutions, and from 12.9 percent to 18.4 percent for public institutions alone) over the same period.

[27] Another possibility is that public financing would be shifted from lower to higher levels of government in pace with the expansion of the geographical scope of factor markets. Student loan programs financed by central governments may be of increased importance if the mobility of skilled workers increasingly curtails the ability of lower-level governments to raise revenues for human capital investment.

cost of publicly financed human capital investment is shifted to unskilled workers; that result follows from the assumption that the unskilled are immobile. The presence of additional immobile resources would give rise to other sources of local rents that might end up bearing the costs of skill acquisition, while mobility of the unskilled would imply that they would not bear these costs. As noted at the outset, the differential mobility of skilled and unskilled workers is empirically well established, and the basic conclusions of the analysis here should survive in any more general framework that exhibits such a mobility differential and in which the mobility of skilled workers increases relative to the unskilled. Further explicit analysis of these issues, however, would be worthwhile.[28]

A further issue that warrants discussion is the possibility that investment in human capital itself reduces the costs of migration and thus contributes directly to factor market integration. Foreign-language training provides an obvious example of such investment; as another example, if their advertising is to be believed, many "international" M.B.A. programs equip their graduates to function in "global" markets. Human capital theory typically views education as productivity enhancing either to all firms ("general" human capital) or to individual firms ("specific" human capital) (e.g., Robert J. Willis, 1986). Some forms of education, however, might best be regarded as "mobility enhancing," which might in turn be viewed as a way of reducing the location-specificity, rather than the firm- or industry-specificity, of human capital. One might reasonably postulate that "mobility-enhancing" human capital is complementary to other types of skills. The model analyzed above assumes that skilled workers are also potentially spatially mobile whereas unskilled workers are never mobile and thus can be viewed as embodying this type of complementarity in an extreme form. Rather than arbitrarily assuming mobility costs for skilled workers to be prohibitive or negligible, however, it would be interesting to treat the degree of factor market integration and the level of skill acquisition as jointly endogenously determined.

[28] As discussed in Wildasin (1998), explicitly dynamic models appear to hold considerable promise for fruitful analysis of imperfect labor mobility.

Appendix

DERIVATION OF (8):

Using (1) to eliminate s^n, form the Lagrangian for (HE), $\mathcal{L}_{HE} = u(w_l - t_l) + \rho(t_l l + [t_s - e](N - l)) + \mu(u(w_l - t_l) - Eu(w_{is} - t_s))$. The first-order conditions characterizing a solution to (HE) are (omitting the superscripts ^{HE} for simplicity)

$$\text{(A1.1)}\quad \frac{\partial \mathcal{L}_{HE}}{\partial l} = u'(w_l - t_l)\frac{dw_l}{dl} + \mu\left[u'(w_l - t_l)\frac{dw_l}{dl} - Eu'(w_{is} - t_s)\frac{dw_{is}}{dl}\right] + \rho(t_l + e - t_s) = 0$$

$$\text{(A1.2)}\quad \frac{\partial \mathcal{L}_{HE}}{\partial t_s} = \mu Eu'(w_{is} - t_s) + \rho(N - l) = 0$$

$$\text{(A1.3)}\quad \frac{\partial \mathcal{L}_{HE}}{\partial t_l} = -(1 + \mu)u'(w_l - t_l) + \rho l = 0$$

where dw_l/dl and dw_{is}/dl denote the general-equilibrium changes in the *ex post* wages of unskilled and skilled labor that result from an increase in l. Note that the linear homogeneity of the production function implies that

$$\text{(A2)}\quad \frac{dw_{is}}{dl} = -\frac{l_i}{s^n}\frac{dw_l}{dl};$$

from concavity of the production function, it follows that $dw_l/dl < 0$.

Collect terms in $u'(w_l - t_l)$ in (A1.1) and substitute from (A1.2) and (A1.3) for $(1 + \mu)$ and μ to obtain

$$\text{(A3)}\quad l\frac{dw_l}{dl} + \frac{N-l}{Eu'(w_{is}-t_s)}Eu'(w_{is}-t_s) \times \frac{dw_{is}}{dl} + (t_l + e - t_s) = 0.$$

Since $ns^n = N - l$ where n is the number of industries in a jurisdiction, the law of large numbers implies that $Ex_i = (s^n/[N-l])\sum_i x_i$ for any random variable x_i. Thus, using (A2), $Eu'(w_{is} - t_s)(dw_{is}/dl) = -(s^n/[N-l])\sum_i u'(w_{is} - t_s)(l_i/s^n)(dw_l/dl)$. Hence, the first two terms on the left-hand side of (A3) can be written

$$\text{(A4)}\quad -\frac{\sum_i u'(w_{is}-t_s)l_i - Eu'(w_{is}-t_s)\sum_i l_i}{Eu'(w_{is}-t_s)}$$

from which the result follows.

DERIVATION OF (9):

Using (1) to eliminate s^n, form the Lagrangian for (U), $\mathcal{L}_U = lu(w_l - t_l) + (N - l)Eu(w_{is} - t_s) + \rho(t_l l + [t_s - e](N - l))$. The first-order conditions characterizing a solution to this problem are

$$\text{(A5.1)}\quad \frac{\partial \mathcal{L}_U}{\partial l} = u(w_l - t_l) - Eu'(w_{is} - t_s) + lu'(w_l - t_l)\frac{dw_l}{dl} + (N-l)Eu'(w_{is}-t_s)\frac{dw_{is}}{dl} + \rho(t_l + e - t_s) = 0$$

$$\text{(A5.2)}\quad \frac{\partial \mathcal{L}_U}{\partial t_s} = -(N-l)Eu'(w_{is}-t_s) + \rho(N-l) = 0$$

$$\text{(A5.3)}\quad \frac{\partial \mathcal{L}_U}{\partial t_l} = -lu'(w_l - t_l) + \rho l = 0.$$

Condition (9.2) follows from combining (A5.2) and (A5.3). Using (A5.2) to eliminate ρ in (A5.1) and manipulations similar to those used in deriving (8) yields (9.1).

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