Job Rotation and Public Policy:
Theory with Applications to Japan and the USA

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Introduction
A high level of job rotation is a distinctive feature of the Japanese employment system. It is a condition that supports and supplements the “three sacred treasures” of the Japanese economic miracle: lifetime employment, seniority wages, and enterprise unionism. When market conditions and employment requirements change, Japanese corporations rotate their core labour force from one department to another, or from one occupation to another, to meet changing conditions[1-3].

Frequent worker reassignments from one job to another, within the same or different departments, is a common practice in Japan, far more common than in the USA. “An electrical engineer may go from circuit design to fabrication to assembly; a technician may work on a different machine or in a different division every few years; and all managers will rotate through all areas of business”[4]. A typical steel worker in the US works in about a dozen different jobs within the steel plant by retirement, whereas a similar worker in Japan works in about three dozen different jobs[2].

Though an integral part of the Japanese employment system, job rotation has drawn far less theoretical attention than the “three sacred treasures”. The explanations in the literature are mainly confined to differences in philosophical and cultural attitudes to production and work[2,5], and to the divergent evolution of enterprise unionism and trade unionism. Piore[6], for instance, claims that, due to a historical discontinuity, Japanese labour unions did not follow the American concept of a trade union that aims to protect workers’ rights to employment in a specific line of work rather than their rights to employment regardless of the tasks required to be done. In contrast to American labour unions that organize workers by trade, Japanese labour unions organize workers by enterprise. Workers in Japan can, therefore, be rotated from plumbing to, say, the electric power monitor division and still be represented by the same union. Piore’s argument, however, does not explain...
why the effects of the historical discontinuity in union evolution have persisted to this day. Moreover, it must be remembered that the unionization rate in the US at least has fallen from around 40 per cent in the 1950s to around 15 per cent in the 1990s.

It is our belief that the literature has no coherent model to explain the difference between American and Japanese job rotation rates. The explanation in our article focuses on the differences in public policy between the two countries. Specifically we consider the question: Why is it that a typical worker in the US tends to specialize in or concentrate on jobs requiring a narrow set of skills while a typical worker in Japan tends to do several jobs (often within the same firm) requiring several sets of skills? Is it because public policies towards labour differ in the two countries? If so, what is the appropriate public policy? We argue that the differences in labour market behaviour cited above are indeed due to differences in labour market policies. Moreover, while arguing against laissez faire policies, we show that the policies followed in Japan and the US are probably not optimal, with Japanese policies even farther away from the optimal than those in the US.

When technologies change, the market tends to reallocate labour from one job to another, and the workers soon enough acquire new skills through learning by doing. This skill acquisition, however, is after the fact. Sometimes workers move from job to job to learn new skills, in anticipation of technological change. This kind of anticipatory job mobility is a way for the workers to insure themselves against the uncertainty of industry’s future skill needs, when no income insurance, public or private, is available.

Acquiring skills in this way is not costless, however. The cost of being a Jack-of-all-trades is being the master of none. Besides, when someone who is good at weaving suddenly takes up carpentry to learn a carpenter’s skills, he or she may have to, at least for a time, sacrifice the high income that he or she could have earned as a weaver.

In this article we conjecture that job rotation is higher in Japan than in the US partly because anticipatory job mobility is higher in Japan than in the US. We then go on to argue that anticipatory job rotation is higher in Japan because Japanese labour market policies encourage anticipatory job rotation while US policies provide help with retraining after a worker has lost his job due to technological change.

Public policies towards labour are largely the same in Japan and the US in the sense that insurance against the loss of income is far too inadequate in both[7], which is why one would expect to see anticipatory job rotation in both economies.

But why more in Japan? Because there is one important difference between the labour policies of Japan and the US. Dore et al. argue as follows:

The government [labour market] schemes [in Japan] are various and of a type found in most societies... They do have... special features, however. One can divide schemes into those which are designed to assist the various ways by which the original employer of an about-to-be-redundant worker helps that worker obtain employment, and schemes which help those who
Displacement programmes of the American type are designed to cure unemployment. They provide monetary compensation and retraining allowances that help displaced workers cope with unemployment and acquire the skills needed to find a new job. By contrast, unemployment programmes of the Japanese type are preventive. They provide assistance to companies to deal with the possibility of unemployment before it happens. Indeed, the Japanese government provides subsidies and loans to companies to train workers internally or to transfer them to company subsidiaries. The 1983 Special Measures Law for Employment Security, for instance, provided government assistance to companies that helped workers deal with changing skill requirements. Japanese workers must, therefore, have stronger incentives to undergo retraining, perhaps through job rotation, than their American counterparts, because once unemployed they have nowhere to turn for retraining. This perhaps also explains the long duration of unemployment in Japan. In 1990, long-term unemployment accounted for 19.1 per cent of all unemployment in Japan compared to 5.6 per cent in the US.

But is it efficient to subsidize anticipatory job mobility? This article argues that it is not. We analyse anticipatory job mobility in an orthodox neo-classical model without insurance markets for uncertain future income. The absence of insurance markets implies that the competitive equilibrium allocation is not Pareto optimal, and that government intervention is desirable.

Ideally the government should fully insure workers against future losses of income, but should neither encourage nor discourage job rotation through subsidies or taxes. This would provide a complete market structure and thereby fulfil all requirements of the First Welfare Theorem and generate a Pareto optimal outcome. If the government does not provide workers with insurance and neither encourages nor discourages anticipatory rotation (as is largely the case in the US) the level of rotation will be higher than optimal. If the government provides little or no insurance and encourages anticipatory job rotation (as is largely the case of Japan) rotation levels will obviously be even higher.

Our model may also be used, we think, to shed light on another important issue in the comparative study of the American and Japanese economies. That issue is lifetime employment, which is an important characteristic of the Japanese labour market but not of the American labour market. If workers in Japan have an added incentive to move from one sort of work to another, and if they have no particular reason to prefer moves from one line of work in one firm to another line of work in another firm over moves from one line of work to another within the same firm, then it is easy to see that a firm will find it easier to employ a worker for life in a situation where the firm's skill requirements keep changing over time.

The analysis in this article is closely related to the literature on workers' investments in skill acquisition. In Grossman and Shapiro[11] and Kim[12], to
take two recent contributions, workers invest in skill acquisition in the first period – the process is a little like going off to school to learn some trade – and use those skills to make money in the second period. Here again, in the absence of insurance markets, workers tend to invest in a broader range of skills in response to uncertainty.

What is missing in this literature, however, is the fact that many skills can be learnt only by doing or by practice. Once one realizes that learning follows from doing, a theory that explains why workers invest in the acquisition of a broad range of skills becomes a theory of worker rotation from one sort of productive activity to another. This linking of the skill acquisition literature to learning by doing is the main plank of this article.

Another important difference between the analysis in this article and that in Grossman and Shapiro[11] and Kim[12] is that those articles used partial equilibrium analysis while ours is a general equilibrium analysis.

Finally, we would like to emphasize that it is possible, even likely, that job rotation differences are due to several factors and not on just the one factor that we have highlighted. Indeed, we hope to study this issue further in future articles. What the present article does provide, however, is a general equilibrium model of job rotation with just one non-orthodox element – the absence of a full range of insurance markets.

The rest of the paper is as follows. The model is described and its equilibrium discussed in the second section. The third section discusses optimality and the role of public policy, and the fourth section discusses retraining subsidies. The fifth section discusses the effect of public policy on job rotation. The sixth discusses the reasonableness of our assumption of incomplete markets, and the seventh section concludes our discussion.

The Model and its Equilibrium

This section analyses the general equilibrium of a perfectly competitive economy. Consumers maximize utility, and firms maximize profits, taking prices as given, and all markets clear. Some of the uncertainty in the economy, however, cannot be insured away. The market structure, in other words, is incomplete.

It is assumed that there are two periods, each a year long, called year one and year two. Year two has two states, state A and state B, which are equally likely.

It is also assumed that there is one final good, good X, which is for consumption only – it cannot be stored or invested as capital. There are two basic skills, skill 1 and skill 2, which are needed as inputs for the production of good X.

There are two individuals named J and K. Individual J (resp. K) is endowed with a high level, h, of skill 1 (resp. skill 2) and a low level, l, of skill 2 (resp. skill 1).

The amount of the services of a particular skill supplied by a worker (measured in effective worker units) is given by the product of his/her expertise (which could be either h or l) in that skill and the time he/she spends in
productive activities that use that skill. So, letting $\theta^J$ be the time spent during year one by $J$ in activities that require skill 1, in which his/her expertise happens to be $h$, and letting $1 - \theta^J$ be the time spent by $J$ during year one in activities that require skill 2, in which his/her expertise is $l$, we can say that the amounts of skills 1 and 2 supplied by $J$ during year one are $\theta^J h$ and $(1 - \theta^J) l$ respectively[13]. Similarly letting $\theta^K$ be the time spent by $K$ during year one in the use of skill 2, in which his/her expertise is $h$, we can conclude that the amounts of skills 1 and 2 supplied by $K$ during year one are $(1 - \theta^K) l$ and $\theta^K h$ respectively.

An individual's skills at the beginning of year two are assumed to depend first on his/her skills at the beginning of year one, and second on the time spent during year one in activities that require the use of those skills. Skill acquisition, in other words, is a matter of learning by doing. Specifically, $J$'s expertise in skill 1 is assumed to go from $h$ at the beginning of year one to $f(h, \theta^J)$ at the beginning of year two, and his/her expertise in skill 2 is assumed to go from $l$ to $f(l, 1 - \theta^J)$. Similarly, $K$'s expertise in skill 1 is assumed to go from $l$ to $f(l, 1 - \theta^K)$, and his/her level of skill 2 would go from $h$ to $f(h, \theta^K)$. The signs of the partial derivatives of $f(\cdot, \cdot)$ will be assumed to be as follows: $f_1, f_2 > 0$; $f_{11}, f_{22} \leq 0$. In the fifth section, however, $f_{22}$ will be assumed.

The production technology in year one is

$$X = L_1^{1/2}L_2^{1/2}$$

(1)

where $L_1$ and $L_2$ represent the amounts of skills 1 and 2, in effective worker units.

The technology in state A of year two is

$$X = L_1,$$

(2)

and the technology in state B of year two is

$$X = L_2.$$

(3)

Notice that a worker going into year two with only one skill would be gambling on his/her future. This technological uncertainty is particularly important here because insurance markets are assumed not to exist. The only way a worker can reduce his/her year two risks is by making sure he/she learns something of both skills before year two begins.

A worker who, at the beginning of year one, is expert at skill 1 but lacking in skill 2 can reduce his/her year two uncertainty by doing skill 2 related jobs for at least part of year one instead of spending all of year one on activities related to skill 1. This is the phenomenon that we have been calling job rotation or job mobility, and the factors determining the rates of job mobility of workers is the focus of this article.

During year two, of course, no one can use both skills because in state $A$ skill 2 is of no use and in state $B$ skill 1 is of no use.

Let $w_1, w_2, w_1^A, w_1^B, w_2^A$ and $w_2^B$ denote the real wages, in units of final good per effective worker, of, respectively, skill 1 in year one, skill 2 in year one, skill
1 in state A, skill 1 in state B, and so on. It should be obvious from the linear technologies (2) and (3) and our competitive assumptions, that \( w_A^1 = w_B^2 = 1 \) and \( w_B^1 = w_A^2 = 0 \). It follows that J’s wage earnings, to take one example, are \( w_1 \theta^1 h + w_2 (l - \theta^1) \), \( f(h, \theta^1) \) and \( f(1, 1 - \theta^1) \) in year one, and in states A and B of year two respectively. Here are no other earnings such as dividend payments because our assumptions of constant returns to scale technologies and perfect competition imply zero profits.

Also, because the final good cannot be stored and because there is no capital accumulation in the model, consumption will coincide with income. So, the amounts consumed by J and K in year one, and in states A and B of year two, are as follows:

\[
\begin{align*}
C^J (w_1, w_2, \theta^J) &= w_1 \theta^J h + w_2 (1 - \theta^J), \\
C^K (w_1, w_2, \theta^K) &= w_2 \theta^K h + w_1 (1 - \theta^K),
\end{align*}
\]

As consumers, J chooses \( \theta^J \) and K chooses \( \theta^K \) to maximize lifetime utility, taking wages as given. Lifetime utility of J is defined as

\[
V^J (w_1, w_2, \theta^J) = U \left[ C^J (w_1, w_2, \theta^J) + \frac{\beta}{2} \left[ U \left( f(h, \theta^J) \right) + U \left( f(l, 1 - \theta^J) \right) \right] \right],
\]

where \( \beta \), the discount rate, is assumed to lie in \((0, 1)\). The utilities in the states A and B of year two are each multiplied by \( \frac{1}{2} \) because the two states are assumed equally likely. Lifetime utility of \( K \), \( V^K (w_1, w_2, \theta^K) \), is defined analogously. The maximization problem for individual \( i \), where \( i \) could be \( J \) or \( K \), can be written as

\[
\max_{0 \leq \theta^i \leq 1} V^i (w_1, w_2, \theta^i).
\]

The first order condition for this problem, then, is

\[
\frac{\partial V^i}{\partial \theta^i} = 0,
\]

for interior solutions. If \( \frac{\partial V^i}{\partial \theta^i} \) is positive at \( \theta^i = 1 \), then \( \theta^i = 1 \) is optimum. If \( \frac{\partial V^i}{\partial \theta^i} \) is negative at \( \theta^i = 0 \), then \( \theta^i = 0 \) is optimum.

It can be shown that the optimal values of \( \theta^J \) and \( \theta^K \) are non-increasing in the discount rate \( \beta \). This is intuitive: an increase in \( \beta \) implies a greater regard for
the future and, therefore, a greater desire to learn the skill that one does not already have, which means a smaller $\theta^J$ or $\theta^K$.

Returning to production, firms maximize profits taking technologies (1) to (3) and wages as given. One consequence of our competitive assumptions is that factor payments in year one must exhaust output produced in year one[14]:

$$w_1L_1 + w_2L_2 = L_1^{1/2}L_2^{1/2}.$$  \hspace{1cm} (12)

Also, the equality of supply and demand for skills 1 and 2 implies

$$L_1 = \theta^Jh + (1 - \theta^K)l,$$

$$L_2 = (1 - \theta^J)h + \theta^Kl.$$  \hspace{1cm} (13)

It is easier to derive the equilibrium relations by exploiting the perfect symmetry of the model. The symmetry of the model should lead one to expect $w_1 = w_2$ and $\theta^J = \theta^K$ in equilibrium. The supply and demand conditions (endowments and technologies) are exactly the same for skills 1 and 2 which would imply $w_1 = w_2$. And $w_1 = w_2$, together with the symmetric year one skill endowments, the identical utility functions and the identical skill learning functions would imply that the decision problems of J and K (see (10)) are really identical, thus indicating $\theta^J = \theta^K$.

Substitution of $w_1 = w_2 = w$ and $\theta^J = \theta^K = \theta$ in (12) and (13), yields

$$2w(\theta h + (1 - \theta)l) = \theta h + (1 - \theta)l,$$

which gives

$$w_1 = w_2 = w = 1/2.$$  \hspace{1cm} (14)

Under (14) and $\theta^J = \theta^K = \theta$, note that the utilities of $J$ and $K$, $V^J(\frac{1}{2}, \frac{1}{2}, \theta)$ and $V^K(\frac{1}{2}, \frac{1}{2}, \theta)$, are identical functions of $\theta$. For brevity we will denote this function $V(\theta)$, and it is

$$V(\theta) = U\left(\frac{\theta h + (1 - \theta)l}{2}\right) + \frac{\beta}{2}\left[U \left(f \left(h, \theta\right)\right) + U \left(f \left(l, 1 - \theta\right)\right)\right].$$  \hspace{1cm} (15)

Writing out the first order condition, equation (11), in full, we get

$$V_\theta(\theta) = U \left(\frac{\theta h + (1 - \theta)l}{2}\right) \left(\frac{h - 1}{2}\right)$$

$$+ \frac{\beta}{2}\left[f \left(h, \theta\right)f_2 \left(h, \theta\right) - f \left(l, 1 - \theta\right)f_2 \left(l, 1 - \theta\right)\right] = 0,$$  \hspace{1cm} (16)

which can be solved for $\theta$. 

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As before, (16) can be modified for corner solutions. The conditions for an interior optimum are $V_\theta(0) > 0$ and $V_\theta(1) < 0$. Under these conditions, the equilibrium value of $\theta$, or the value of $\theta$ that solves (16) – let us call it $\theta^e$ – will lie in $(0, 1)$, thereby indicating the presence of job rotation. If $V_\theta(1) > 0$ (resp. $V_\theta(0) < 0$) we will get the corner solution $\theta^e = 1$ (resp. $\theta^e = 0$).

Also as before it can be easily verified that $\theta^e$ is a non-increasing function of $\beta$.

It can also be showed that if $f_{12} > 0$ is assumed, then $f(h, \theta^e) > f(l, 1 - \theta^e)$. This is intuitive because it says that if one starts out with higher expertise in skill 1 relative to skill 2, then one might try to reduce that disparity by developing skill 2 during year one, but will not go so far as to reverse the initial disparity and end up with more skill 2 than skill 1. This result will also have an important role in the next section, which is on optimality.

Regarding optimality, the key question is whether it is possible to make either $J$ or $K$ better off, compared to the laissez faire utility $V(\theta^e)$, without making the other worse off.

Notice also that (16) indicates that the presence of job rotation does not depend on the heterogeneity of $J$ and $K$ with respect to their year one skill endowments. If $h = l = a$ is substituted in (16), we get

$$U(f(a, \theta))f_2(a, \theta) = U(f(a, 1 - \theta))f_2(a, 1 - \theta),$$

which yields $\theta = \frac{1}{2}$. This represents the highest level of job rotation because both skills are being used for equal lengths of time.

If $h > l$ the value of $\theta$ could be greater than or less than $\frac{1}{2}$. There are two clashing effects involved. On the one hand one wants to do what one is good at because of the higher income. On the other hand one wants to spend more time developing the skill one has less of so as to insure oneself against the uncertain future. But no matter which effect is stronger, the job rotation level will be lower than when $h = l$ because rotation is maximum when $\theta = \frac{1}{2}$. When $h$ and $l$ are equal only the second of the two effects just discussed has any significance, and, therefore, both skills are given equal importance.

**Optimality and Government Policy**

The optimality of the equilibrium in the previous section needs to be assessed for purposes of policy recommendations. To do this we will consider a simple form of government intervention and show how such intervention can raise the welfare of all agents, thereby demonstrating, at one stroke, the suboptimality of the laissez faire equilibrium of the previous section and the existence of a government policy that can correct the suboptimality.

Consider a government which transfers the lump sum amount $\tau$ from $J$ to $K$ in state $A$ of year two and from $K$ to $J$ in state $B$, but otherwise leaves the economy alone. Note that when $\tau > 0$ the urgency of having to learn more of one's "low expertise" skill is reduced. One can guess that intervention of this
sort is a potential way of insuring J and K against income uncertainty. But more on this later.

Analysing the equilibrium under this intervention amounts to doing the previous section all over again but with $C^A_J$ and $C^B_K$ reduced by $\tau$ and $C^A_K$ and $C^B_J$ increased by $\tau$. In this modified equilibrium, each individual's utility will be

$$V(\theta, \tau) = U\left(\frac{\theta h + (1 - \theta)l}{2}\right) + \frac{\beta}{2}\left[U\left(f(h, \theta) - \tau\right) + U\left(f(l, 1 - \theta) + \tau\right)\right], \quad (18)$$

and the new equilibrium condition will be $V_\theta(\theta, \tau) = 0$ or

$$U\left(\frac{\theta h + (1 - \theta)l}{2}\right)\left(h - l\right) + \frac{\beta}{2}\left[U\left(f(h, \theta) - \tau f_2(h, \theta)\right) - U\left(f(l, 1 - \theta) + \tau f_2(l, 1 - \theta)\right)\right] = 0, \quad (19)$$

which is clearly analogous to (16). The laissez faire equilibrium condition (16) is the same $V_\theta(\theta, 0) = 0$.

As far as the government's choice of $\tau$ is concerned let us assume that $\tau$ is chosen to maximize $V(\theta, \tau)$. This implies $V_{\tau}(\theta, \tau) = 0$ or

$$f(h, \theta) - \tau = f(l, 1 - \theta) + \tau. \quad (20)$$

This is the familiar "full insurance" condition that equates after-tax keepings in states A and B.

Let $\theta^*$ and $\tau^*$ solve (19) and (20). It can be shown that $\theta^*$ and the consumption allocations

$$C^J = C^K = \frac{\theta^* h + (1 - \theta^*)l}{2}, \quad (21)$$

and

$$C^A_J = C^B_K = f(h, \theta^*) - \tau^* = f(l, 1 - \theta^*) + \tau^* = C^A_K = C^B_J \quad (22)$$

represents a Pareto optimal allocation. In other words, no feasible allocation can yield utilities higher than $V(\theta^*, \tau^*)$.

Recall that the common lifetime utility of J and K under laissez faire was $V(\theta^e)$. This has to be less than $V(\theta^*, \tau^*)$ unless, by sheer coincidence, $\theta^* = \theta^e$ and $\tau^* = 0$. Thus laissez faire is suboptimal in general. This is the expected consequence of the absence of insurance markets.

If we define $\theta(\tau)$ as the $\theta$ that solves (19) for given $\tau$, it can be shown that, under our concavity assumptions, $\theta(\tau)$, the time one spends on one's "high skill" job during year one, increases with $\tau$. $\theta(\tau) > 0$. As was mentioned before, a higher $\tau$ reduces the incentive to do jobs related to one's "low expertise" skill.
Also, under the additional assumption \( f_{12} > 0 \), it can be shown that \( \theta^* > \theta^e \).

Recall that we had asserted in the previous section that when \( f_{12} > 0 \) it can be shown that \( f(h, \theta^e) > f(l, 1 - \theta^e) \). From (18) we get

\[
V_\epsilon(\theta^e, 0) = \frac{1}{2} \left[ U'(f(l, 1 - \theta^e)) - U'(f(h, \theta^e)) \right].
\]

(23)

Under concavity of \( U(.) \) this must be positive when \( f(h, \theta^e) > f(l, 1 - \theta^e) \). Thus, getting from the laissez faire \( \theta^e \) to the optimal \( \theta^* \) would require \( \tau \) to be increased from \( \tau = 0 \), which is after all the laissez faire value of \( \tau \), to \( \tau^* > 0 \). Therefore, because \( \theta'(\tau) > 0 \) (see last paragraph), it must be that \( \theta^* > \theta^e \).

To summarize, laissez faire is not Pareto Optimal. Government intervention, in the form of judicious lump sum transfer payments, is a substitute for the income insurance that the market fails to provide, and it increases the lifetime utility of all agents.

One exceptional case in which laissez faire is indeed Pareto optimal arises when both \( J \) and \( K \) have identical skills at the beginning of year one: \( h = l = a \).

In this case \( \theta = \frac{1}{2} \) and \( \tau = 0 \) solves both (19) and (20) as can easily be verified by substitution. That is, the economy is optimal without government intervention. Thus the absence of insurance markets cannot by itself be the source of the suboptimality we saw earlier. When workers are identical, there may be no need for trade (in insurance or anything else), and in such circumstances whether markets exist or not would naturally be irrelevant.

**Subsidized Learning by Doing**

In this section we modify the model of the second section to analyse the consequences of a government’s efforts to encourage job mobility through subsidies. The analysis gains relevance because the subsidy scheme considered here is at bottom very similar to policies followed by for instance, the Japanese government.

Suppose the government wants \( J \) (resp. \( K \)), who has the low level, \( l \), of skill 2 (resp. skill 1), to spend more time on job 2 (resp. job 1) during year one, perhaps to make \( J \)’s (resp. \( K \)’s) job 1 and job 2 skills more equal in year two.

To this end, suppose the government provides a subsidy \( \mu \) to \( J \) (resp. to \( K \)) for each unit of time spent at job 2 (resp. job 1). The total amount that \( J \) (resp. \( K \)) gets in subsidy is, therefore, \( \mu(1 - \theta^J) \) (resp. \( \mu(1 - \theta^K) \)).

The subsidy will be paid for by a lump sum tax, \( T \), imposed on \( J \) and on \( K \). The level of the tax will be determined so as to keep the budget balanced.

With the subsidy and the lump sum tax, \( J \)'s year one income (and, therefore, consumption) is

\[
C^J(w_1, w_2, \theta^J, \mu, T) = w_1 \theta^J h + w_2 (1 - \theta^J) l + \mu(1 - \theta^J) - T,
\]

(24)

and \( K \)'s year one consumption is

\[
C^K(w_1, w_2, \theta^K, \mu, T) = w_2 \theta^K h + w_1 (1 - \theta^K) l + \mu(1 - \theta^K) - T.
\]

(25)
Analysing the equilibrium outcome with this tax-subsidy scheme thrown in, is mainly a matter of reworking the second section with (24) instead of (4) and (25) instead of (7), and making sure that total subsidies are equal to total taxes.

We define $V_J^2(w_1, w_2, \theta, \mu, T)$ to be the same as $V^1(w_1, w_2, \theta, \mu, T)$ of the second section except that $C_J^1(w_1, w_2, \theta, \mu, T)$ is now substituted for $C_J^1(w_1, w_2, \theta, \mu, T)$. Similarly, $V^2_K(w_1, w_2, \theta, \mu, T)$ is also defined.

A gain, as in the second section, optimization by $J$ and $K$ requires $\partial V_J^2 / \partial \theta_J = 0$ and $\partial V_K^2 / \partial \theta_K = 0$. Moreover, the symmetry discussion of the second section continues to apply and, therefore, we can set $w_1 = w_2 = 1, w_A^1 = w_B^1 = 1/2, w_A^2 = w_B^2 = 0, \theta_J = \theta_K = \theta$, in either $\partial V_J^2 / \partial \theta_J = 0$ or $\partial V_K^2 / \partial \theta_K = 0$ to get the equilibrium relation. This relation can then be solved for $\theta$.

Writing out the equation $\partial V_J^2 / \partial \theta_J = 0$ fully, with the aforementioned symmetry substitutions made, we get

$$U\left(\frac{\theta h + (1 - \theta)l}{2} + \mu(l - \theta) - T\right)\left(\frac{h - l}{2} - \mu\right) + \frac{B}{2}\left\{U'((f(h, \theta))f_2(h, \theta) - U'((f(l, 1 - \theta))f_2(l, 1 - \theta))\right\} = 0. \quad (26)$$

Notice that (26) is the same as (16) except for the terms involving $\mu$, the subsidy, and $T$, the tax.

For total taxes, $T + T$, to be equal to total subsidies, $\mu(l - \theta) + \mu(l - \theta)$, we must have $T = \mu(l - \theta)$. Under this condition (26) becomes

$$U\left(\frac{\theta h + (1 - \theta)l}{2}\right)\left(\frac{h - l}{2} - \mu\right) + \frac{B}{2}\left\{U'((f(h, \theta))f_2(h, \theta) - U'((f(l, 1 - \theta))f_2(l, 1 - \theta))\right\} = 0. \quad (27)$$

which is even more similar to (16).

Let us denote the value of $\theta$ that solves (27) by $\theta(\mu)$. The functional notation makes explicit the dependence of the equilibrium $\theta$ on the subsidy rate $\mu$. Under our assumptions (especially $U'' < 0$ and $f_{22} < 0$) it can be shown that the comparative static derivative $\partial \theta / \partial \mu$ obtained from (27) is negative: the higher the subsidy one gets to learn the job one is now not good at, the greater is the time spent on that job. This means less specialization on what one is currently good at.

The Degree of Job Rotation and Public Policy

The focus of this article has been on job rotation. The theory presented in this article has linked rotation from one activity to another with the desire of workers to increase the breadth of their skills by engaging in productive activities requiring the use of each of the two skills in our model.
One important question that remains to be addressed is the impact of the sorts of public policy discussed in the third and fourth sections on the degree of job rotation. The variable that is closely related to the level of rotation is \( \theta \), which is the time that \( J \) (resp. \( K \)) spends in activities related to the use of skill 1 (resp. skill 2), which is where his/her expertise is \( h \). We know from the third section that \( \theta^* > \theta^e \). But this does not tell us whether the laissez faire level of rotation is higher or lower than the optimal level. The highest level of rotation corresponds to \( \theta = \frac{1}{2} \), and out of \( \theta^* \) and \( \theta^e \) the one that is closer to \( \frac{1}{2} \) would represent the higher level of rotation.

The general model seen so far does not admit any clear conclusion on which of \( \theta^* \) and \( \theta^e \) is closer to \( \frac{1}{2} \). And, therefore, it does not say anything conclusive about the impact of public policy on job rotation.

In this section we will consider a special case of the general model that will show one possible way in which differences in labour market policies may affect rotation. In particular, we will show how differences in American and Japanese public policies can explain the higher observed rates of job rotation in Japan.

We assume: (1) that \( h = l = a \), i.e. \( J \) and \( K \) are identical individuals; (2) that \( f_2(a, \theta) \) is convex in \( \theta \) (or, \( f_{22}(a, \theta) > 0 \)) for all \( a \) and \( \theta \), i.e. learning by doing involves increasing returns; and (3) that \( U'(f(a, \theta))f_2(a, \theta) \) is convex in \( \theta \), i.e.

\[
U'(f(a, \theta))\left[f_2(a, \theta)\right]^2 + U'(f(a, \theta))f_{22}(a, \theta) < 0
\]

for all \( a \) and \( \theta \).

Assumptions (1) and (3) imply that \( V(\theta) \), defined by (15), is concave. This in turn implies that the laissez faire value of \( \theta \) must be in the interior of \([0, 1]\). Substituting \( h = l = a \) in (16) yields \( \theta^e = \frac{1}{2} \), which is the maximum level of rotation.

To take a specific example, let \( h = l = 1 \) and let \( f(h, \theta) = h^2 \theta^2 \), and let \( U(C) = C^{\frac{1}{2}} \). It can be checked that these specifications satisfy assumptions (1) to (3) above.

Note that total output in year one is

\[
X = L_1^{1/2}L_2^{1/2} = (\theta + (1 - \theta))(1) = 1,
\]

for all values of \( \theta \), and that second period outputs in states \( A \) and \( B \) are

\[
X^A = L_1^A = f(1, \theta) + f(1, 1 - \theta) = L_1^B = X^B.
\]

Thus in laissez faire equilibrium, in which \( \theta = \frac{1}{2} \), we have \( X = 1, X^A = \frac{1}{2} + \frac{1}{2} = \frac{1}{2} = X^B \).

Note, however, that under either \( \theta = 0 \) or \( \theta = 1 \) we have \( X = 1, X^A = 1 + 0 = 1 = X^B \).

Obviously this shows that laissez faire is suboptimal. Indeed it can be shown that “zero rotation”, i.e. \( \theta^* = 0 \) or 1, is Pareto optimal.

It can also be shown that had insurance markets been available laissez faire would have coincided with the “zero rotation” Pareto optimal solution.
This Pareto optimum outcome can be implemented under government policy intervention of the sort discussed in the third section with (see (20))

\[ r^* = \pm \frac{f(a, 1) + f(a, 0)}{2} \tag{28} \]

Recall that the government in this scheme uses a lump sum tax-transfer mechanism, \( \tau \), but otherwise leaves the economy alone. When the positive (resp. negative) value of \( \tau \) is implemented, \( \theta^* \) will be 1 (resp. 0). This analysis can be set in terms of the discussion in the third section: \( \theta^* \) and \( \tau^* \) above maximize \( V(\theta, \tau) \), which was defined by (18) in the third section. But another way of looking at it is to recall, again from the third section, the result that \( \theta^* (\tau) > 0 \), which continues to apply under assumptions (1) to (3) above. This result implies that \( \tau \) can be used to move \( \theta \) from \( \frac{1}{2} \) (the laissez faire value) to either 1 or 0 (the optimal values).

It can be shown that, even under assumptions (1) to (3) above, the optimum and laissez faire outcomes would have coincided had insurance markets been available. The absence of such markets, combined with our other assumptions, especially increasing returns in learning, yields the consequence that laissez faire rotation is so much higher than the optimum level. In the optimum allocation J spends all of year one in activities that use one particular skill (doesn’t matter which), and K spends all of year one in activities that use the other skill. There is no rotation.

As was indicated in the introduction, American labour market policies aim to help workers who have lost income with lump sum payments such as those discussed in the third section. This help is never comprehensive enough, however, to compensate a worker for the total loss of income from work (as in (20)). Japanese policies, on the other hand, rely less on payments of this sort and more on training subsidies of the sort seen in the fourth section.

In terms of the model of this section, if \( \tau \) is set close to the level in (28), but not exactly equal to it – this is what American-type policies typically look like – the outcome will still involve some rotation, but not a lot (\( \theta \) will not be 0 or 1 but it will be close). If \( \tau \) is still smaller (i.e. if there is less insurance, as in Japanese-type policies) then there will be more rotation (\( \theta \) will be closer to \( \frac{1}{2} \)). If on top of this there are subsidies, of the sort in the fourth section, encouraging workers to learn both skills – this is the hallmark of Japanese policies – then rotation will obviously be even higher.

Thus we see how differences in public policy towards labour can provide one explanation of the higher job rotation in Japan.

Note again that in this section’s model the optimal outcome involves zero rotation. Thus policies that lead to higher job rotation may actually be inefficient.

The Unavailability of Insurance

Our results depend heavily on the assumption that insurance markets do not exist. In making this assumption we think we are only reflecting the situation that exists in real-world labour markets.
Still, it is necessary to discuss why such markets would not be likely to exist a priori. Our model does not address this issue formally, however, and the discussion below will be largely heuristic.

In our model workers are uncertain about which skill will be in demand in the second period; a technological uncertainty renders skill 2 useless in state A and skill 1 useless in state B. So, in the absence of income insurance, a worker going into period two equipped only with skill 1 (resp. skill 2) would be in dread of state A (resp. state B) occurring in period two. As we have seen, this provides an incentive to learn both skills in period one.

A less extreme and more realistic version of our model would be one in which the technological uncertainty would not be quite so sharp – not all firms would use skill 1 (resp. skill 2) in state A (resp. state B); some, say a 5 per cent minority, would use skill 2 (resp. skill 1) instead. Thus a few skill 2 (resp. skill 1) jobs would be available even in state A (resp. state B).

So a worker who is prepared for skill 2 related jobs only and has bought insurance, will be insured against the possibility of state A happening and he/she not being among the lucky few who will get skill 2 jobs even in state A. Note, however, that those who have this sort of insurance are unlikely to search assiduously for the few skill 2 jobs available in state A, because they know that they will be compensated anyway. This introduces an element of “moral hazard”; the insurance claim is contingent on the insured person not finding a job, and the likelihood of him/her finding a skill 2 job in state A depends on how hard he/she searches.

It is well known that “moral hazard” reduces the availability of insurance and may even make insurance markets impossible. In such a case, the reasons in favour of the public provision of income insurance that were discussed earlier would remain and, in addition, the government will have to step in and take charge of the allocation of the few skill 2 jobs available in state A (and skill 1 jobs available in state B), thereby taking job search out of workers’ hands. In other words, the insurer (i.e. the government) will have to decide, perhaps by randomization, who among the skill 2 (resp. skill 1) workers would get the few skill 2 (resp. skill 1) jobs available in state A (resp. state B), and then make insurance payments to the others.

Conclusion
This article has argued that the differences in job mobility between Japan and the US reflect the differences in social policies towards displaced labour in the two countries. Japanese style policies encourage anticipatory job mobility while American style policies do not. We have not, however, argued that differences in public policy are the only or even the main reason for the differences in job rotation rates.

Our arguments were rationalized within a simple two-period general equilibrium model of a perfectly competitive economy with incomplete insurance markets.
We also showed that government subsidies designed to encourage job rotation are inefficient. Laissez faire is not efficient either, however, and public provision of insurance against loss of income can yield a Pareto improvement. But if Japanese style policies lead to excessive job rotation, how can one explain the success of Japanese companies in international competition? We feel that high job mobility may contribute to the firm in other ways. For instance, if workers rotate from job to job and thus acquire multiple skills, the introduction of new technologies may be easier. High job rotation may also contribute to product quality and the introduction of new products.

More elaborate models than ours may illuminate these positive aspects of job mobility.

Notes and References
13. It is tacitly being assumed that all productive activities can be identified with the use of one skill or the other but not both.
14. This follows from Euler’s Theorem and the equality of the marginal product of each type of labour and its real wage.