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## The Centre for Research in Applied Economics (CRAE)

**01012016, January 2016**

## Series in Public Economics

# Inter-state transfers for cost differences in federations with population mobility and natural resources

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**Acknowledgments**
This publication series is underwritten by Curtin University, the Curtin Business School and the School of Economics and Finance.

**ISSN 1834-9536**

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# Inter-state transfers for cost differences in federations with population mobility and natural resources

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December 8, 2015

**Abstract**

The Australian system of horizontal fiscal equalization (HFE) transfers output from low to high cost states. This paper develops a standard model of a federation with an imperfectly mobile population and states which capture economic rents from natural resources and recycle the revenue on the basis of residency. A federal agency, which can be thought of as mimicking the role of the Commonwealth Grants Commission, chooses an inter-state transfer to maximize national social welfare. The contribution of the paper is to show that under the assumptions of the model, the optimal transfer to a state is increasing in its costs, for given costs in other states. This supports the notion of inter-state transfers in favour of high cost states. However, the result does not necessarily validate the magnitude of transfers that we see in practice in the Australian federation.

*Key Words:* federalism, intergovernmental relations, inter-governmental differentials and their effects, federal state relations.

*JEL:* H73, H77.

## 1 Introduction

In 2015-16, the Commonwealth Government is anticipated to allocate \$57,200 million of Goods and Services Tax (GST) revenue as unconditional general revenue grants to the states for services such as education and health.[1] This revenue is distributed using the principles of horizontal fiscal equalization (HFE) which nominally allocates the entire GST revenue pool on an equal per capita basis and then subtracts or adds revenue for each state according to whether it has above or below average fiscal capacity. In this way, the HFE system equalizes the fiscal capacity of the states so that they have approximately similar ability to provide the average level of services to their citizens while imposing an average tax burden.

To achieve equalization of fiscal capacities, HFE in effect redistributes income across states. A measure of this redistribution is illustrated in Table 1 for 2015-16. The first row shows the grant that would have been made to each state under an equal per capita allocation of the GST pool while the second row shows the actual grant expected to be received with HFE. The third

[1] In this paper, states are assumed to include the Northern Territory and the Australian Capital Territory.

row of the Table provides an indication of the redistributive effect of equalization relative to an equal per capita benchmark. From this, one can see that income is redistributed away from New South Wales, Victoria and Western Australia, states deemed to have higher than average fiscal capacity, in favour of all the other states which are deemed to have below average fiscal capacity. One can also see that $6,858 million, or 11.9% of the GST revenue pool, is redistributed across states in order to achieve approximate equalization of state fiscal capacities.

Table 1: Inter-state redistribution arising from HFE, 2015-16

| | NSW | Vic | Qld | WA | SA | Tas | ACT | NT | Redist |
|---|---|---|---|---|---|---|---|---|---|
| | $m | $m | $m | $m | $m | $m | $m | $m | $m |
| Equal per capita | 18,200 | 14,234 | 11,525 | 6,425 | 4,050 | 1,224 | 942 | 599 | |
| Grant with HFE | 17,311 | 12,755 | 13,046 | 1,935 | 5,525 | 2,236 | 1,040 | 3,351 | |
| Redistribution | -899 | -1,479 | 1,521 | -4,490 | 1,475 | 1,012 | 98 | 2,752 | 6,858 |

Note: Redistribution of $6,858 million is the sum of the positive (or negative) terms in the redistribution row.
Source: Commonwealth Grants Commission (2015), Table 1, Chapter 3, page 76.

In Table 2, the inter-state redistribution induced by HFE is dissected further for each state according to its source within the equalization methodology; namely, (i) revenue needs; (ii) expenditure needs - consisting of socio-demographic features of state populations and differences in inter-state costs; and (iii) the impact of other Commonwealth payments. It can be seen that, for a number of states, inter-state cost differences are a major cause of deviation from what they would receive under an equal per capita approach, and hence a significant factor behind the pattern of inter-state redistribution.

For example, the relatively low cost status of New South Wales is the single most important reason why its grant is less than what it would be under an equal per capita system. Western Australia's requirement for additional revenue because of high costs ($2,953 million) offsets 38.3% of its negative revenue need of $7,714 million. Cost is also the second most important reason why Victoria and the Northern Territory deviate from their equal per capita share of the GST pool.

Table 2: Inter-state redistribution by source and state, 2015-16

| | NSW | Vic | Qld | WA | SA | Tas | ACT | NT |
|---|---|---|---|---|---|---|---|---|
| Revenue Needs | 1,638 | 3,366 | 43 | -7,714 | 1,598 | 694 | 291 | 85 |
| Expend Needs: | | | | | | | | |
| Socio | -1,121 | -2,858 | 1,552 | 294 | 416 | 524 | -453 | 1,644 |
| Costs | -1,844 | -2,046 | 0 | 2,953 | -407 | -168 | 210 | 1,304 |
| Comm Payments | 438 | 59 | -74 | -22 | -132 | -38 | -51 | -282 |
| Redistribution | -889 | -1,479 | 1,521 | -4,490 | 1,475 | 1,021 | 98 | 2,752 |

Source: Commonwealth Grants Commission (2015), Table 4, Chapter 3, page 80.

What emerges from the discussion above is that equalization for differences in inter-state costs causes a significant portion of the redistribution arising from the application of HFE to distributing the GST pool. However, the allocative efficiency implications of redistribution based on inter-state cost differences - or cost equalization - have received scant attention. There is some evidence that policy makers are aware of a link between equalization for cost differences and allocative efficiency. For example, this was raised, and discussed briefly, during a review of the GST distribution process in 2012 (Commonwealth of Australia (2012)). From its terms of reference, it appears the yet to be released Federation White Paper also has the capacity to consider cost equalization and allocative efficiency (Commonwealth of Australia (2015)).

Most economists would consider cost equalization, and the induced redistribution highlighted in Table 2, to be a source of inefficiency since it encourages more output in high cost states. This view is sometimes expressed in the fiscal federalism literature by way of general comment.[2] A different argument is put by Petchey (1995) who shows that there are cases where efficiency actually requires transfers in favour of high cost jurisdictions. Other than this, it seems fair to say there has been no particular focus in the literature on cost equalisation and efficiency.

In view of this apparent gap, and the importance of cost equalization in many federations in practice, particularly Australia, the objective of this paper is to take a closer look at the relationship between allocative efficiency and cost equalization. This is achieved by developing a standard model of a federation in the tradition of the efficiency-in-migration literature, as surveyed in Boadway (2004). To capture the Australian setting, the model has two states which differ in terms of their production technologies and endowments of a fixed factor, which is assumed to be a natural resource. As in Mansoorian and Myers (1993), the population has some attachment to state and hence is imperfectly mobile. State governments are assumed to capture economic rents arising from their resources and to distribute these rents to citizens on the basis of residency. This means resource rents distort migration decisions. As is known from the efficiency-in-migration literature, this requires a corrective inter-state transfer to establish first best allocative efficiency. It is supposed that a central agency chooses the inter-state transfer to maximize national social welfare which is the weighted sum of social welfare in each state. One can think of the agency as mimicking the role of the CGC in the Australian federal system, albeit with a different objective.

The contribution of the paper is to use the first order necessary condition from the agency's optimization problem to examine the effect of a cost increase in any one state on the direction of the optimal inter-state transfer. This produces general expressions showing how the transfer responds to a state-specific cost increase. From this, it is shown that the optimal transfer received by a state is an increasing function of its cost, for a given cost structure in the other state. It is concluded that, under the model's assumptions, social welfare maximization requires the optimal inter-state transfer to redistribute income *from* low to high cost states. This is consistent with the HFE methodology in Australia, as shown in Table 2. However, it is noted that this does not necessarily validate the magnitude of the cost equalization transfers that we see in practice.

The paper is set out as follows. Section 2 develops a model of a federal economy. Section 3

[2]See, for example, Albouy (2012) page 827.

presents the key results and Section 4 discusses assumptions, extensions and policy implications. Section 5 concludes while mathematical details are placed in Annexes.

# 2 Model

Consider a federation with $i = 1, 2$ states and a given homogeneous population, $N$. Each person supplies one unit of labour so $N$ is the fixed supply of labour for the federation. Denoting $n_i$ as the labour supply of state i, and setting $N = 1$ for convenience, the following labour supply constraint holds:

$$n_1 + n_2 = 1. \tag{2.1}$$

The production process in each state uses two inputs, mobile labour and a fixed factor, $T_i$, which is assumed to be a natural resource. These inputs are combined to produce a numeraire using the continuous and concave production function,

$$f_i(n_i, T_i) \qquad i = 1, 2. \tag{2.2}$$

Supposing the numeraire has a given price of one, $f_i(n_i, T_i)$ also defines the value of output in state i. It is assumed that the wage rate in state i is equal to the marginal product, that is,

$$\frac{\partial f_i(n_i, T_i)}{\partial n_i} = w_i > 0. \tag{2.3}$$

As in Boadway et al. (2003), economic rent arising from the natural resource in state i,

$$\pi_i = f_i(n_i, T_i) - w_i n_i \qquad i = 1, 2, \tag{2.4}$$

accrues to that state's government. This could be by way of direct ownership of the natural resource, as is the case in Australia where states own on-shore natural resources such as iron ore or coal, or because states use taxes that capture the economic rent. In practice, there is no constraint on Australian states from levying, say, a resource rent tax. In general they do not, but the taxes they do levy on natural resources, such as value of production royalties, can be thought of as proxies which the states use to charge a rental, $\pi_i/T_i$, for the extraction of natural resources owned by them.

As an example, in 2013-14, Western Australia, the dominant resource rich state, raised \$7,204 million from royalties and grants in lieu of royalties from natural resource extraction. The latter included payments to the state from the Commonwealth for tax revenue raised by the Commonwealth from the North West Shelf. This revenue, a large potion of which is likely to include economic rent, made up approximately 26% of the state's total revenue base in that year. It was used by the state to fund services that benefit state residents, including migrants. To capture this recycling of economic rents arising from natural resources to residents through state budgets, it is also assumed in this paper that state i redistributes the rents it captures on a lump sum, equal per capita, basis to residents of the state. From the model set up, these rents are enjoyed by existing citizens and recent migrants alike.

Suppose a federal agency redistributes output from state 1 to 2 using a lump sum self-financing inter-state transfer, denoted as $\rho$. Note that $\rho$ can be either positive or negative. When $\rho > 1$, output is transferred from state 1 to 2, but when when $\rho < 1$ output is reallocated from state 2 to 1. As will be shown below, the agency is assumed to make its transfer choice to maximize national social welfare.

The residents of state i receive their wage income, $w_i n_i$, plus the state's economic rent, which, as noted above, is recycled to them on an equal per capita lump sum basis by the state's government. In other words, residents receive the state's numeraire output, $f_i(n_i, T_i)$, as income. Taking into account the transfer of numeraire undertaken by the federal agency, net income in state 1 is $f_1(n_1, T_1) - \rho$ while in state 2 it is $f_2(n_2, T_2) + \rho$. In each state, this is transformed into a pure private good, $x_i$, which has a given per unit cost of $c_i$, for $i = 1, 2$. Note that the private good could also be considered as a vector of private goods, some of which might be state provided services.

The feasible constraint for state 1 requires the total value of expenditure on the private good to be equal to output of the numeraire, net of the inter-state transfer, that is: $c_1 x_1 n_1 = f_1(n_1, T_1) - \rho$. Similarly, the feasible constraint for state 2 is $c_2 x_2 n_2 = f_2(n_2, T_2) + \rho$. Per capita consumption of the private good in state i, identical across all residents of the state, can, therefore, be stated as:

$$x_i = \frac{f_i(n_i, T_i) \pm \rho}{c_i n_i} \qquad i = 1, 2. \tag{2.5}$$

Residents of state i have homogeneous preferences described by the continuous and strictly concave utility function,

$$u_i(x_i) \qquad i = 1, 2. \tag{2.6}$$

Imperfect population mobility with attachment to place, as in Mansoorian and Myers (1993), implies the migration constraint, $u_1(x_1) + a(1 - n_1) = u_2(x_2) + an_1$, must also be satisfied where $0 \leqslant a$ is the standard attachment parameter. If $a = 0$, the population is perfectly mobility and the migration constraint is simply $u_1(x_1) = u_2(x_2)$. Using the definition of per capita consumption from equation (2.5), and $n_2 = 1 - n_1$ from equation (2.1), the migration constraint with attachment can be expressed as:

$$u_1\left(\frac{f_1(n_1, T_1) - \rho}{c_1 n_1}\right) + a_1(1 - n_1) = u_2\left(\frac{f_2(1 - n_1, T_2) + \rho}{c_2(1 - n_1)}\right) + an_1, \tag{2.7}$$

From equation (2.7), $n_1$ is, implicitly, a function of the inter-state transfer conditional on the cost parameters, fixed natural resource endowments and the given attachment parameter; that is, one can define:

$$n_1(\rho : c_i, T_i, a) \qquad i = 1, 2. \tag{2.8}$$

The implication is that one can totally differentiate the migration condition and obtain expressions which show how $n_1$, and hence $n_2$, respond to changes in the transfer or parameters.

It is clear from the discussion above, and in particular equation (2.5), that residents of a state earn the state's average product; that is, output per capita adjusted by the transfer and costs. It is well-known from the efficiency-in-migration literature, that this means any distribution of the population in which equation (2.7) is satisfied, is spatially inefficient. This is, in essence, because of the assumed distribution of economic rents by states to citizens based on residency. Since this is a well-known result, it is not explained further here. However, the interested reader can consult the detailed discussion in Petchey and Shapiro (2006) for an explanation. As will be seen later in the paper, this means there is an efficiency case for a corrective inter-state transfer in this model. It is the purpose of the paper to explore the relationship between this corrective (or optimal) transfer and changes in costs in either state.

Finally, it is assumed that the federal agency moves first and chooses $\rho$ while mobile labour selects its location after the agency has made its transfer choice. The agency correctly anticipates the migration responses to its choices while mobile labour makes its location choice to satisfy the migration constraint conditional on the transfer.

This completes the description of the basic model. Its salient features are as follows. A homogeneous population supplies one unit of labour to the state it resides in, consumes a pure private good and settles itself across states to equate per capita utility adjusted for attachment to state. The production process in each state uses a fixed input (natural resource) and mobile labour to produce a numeraire. State governments have a simple role; namely, they fully capture all local economic rent and redistribute it via their budgets to citizens on the basis of residency. This is a simple assumption designed to capture the essence of what happens at the state level in Australia with respect to the taxation of natural resources. It means that mobile residents earn the state's average product, adjusted by the inter-state transfer and costs, as income. This means economic rents distort migration decisions, and there is a role for a non-zero inter-state corrective transfer to maximize social welfare. The next Section of the paper derives the optimal transfer from a social welfare maximization problem and examines how it responds to cost changes in each state.

## 3 Effects of a cost increase on the optimal transfer

This Section of the paper characterises an optimization problem for the federal agency in which it chooses an inter-state transfer. The analysis then examines how the optimal transfer responds to a change in the cost structure in either state. The agency is assumed to choose the transfer to maximise national social welfare which is the weighted sum of utilities for a representative resident from each state. One can think of the agency in this stylized model as mimicking the role of the CGC in the Australian federation.[3]

Given this, and noting once more that $n_2 = 1 - n_1$ from equation (2.1). the federal agency

[3]Of course, the CGC does not explicitly pursue social welfare maximization. Rather, it has the goal of equalizing state fiscal capacities.

solves the following optimization problem:

$$\underset{\rho}{Max} \quad W = \delta u_1 \left( \frac{f_1(n_1, T_1) - \rho}{c_1 n_1} \right) + (1-\delta) u_2 \left( \frac{f_2(1-n_1, T_2) + \rho}{c_2(1-n_1)} \right) \tag{3.1}$$

subject to the migration constraint, (2.7), where W is a social welfare function and $0 < \delta < 1$ is a parameter which denotes the weight given to each state. In restricting $\delta$ from taking extreme values of one or zero, I have ruled out malevolence on the part of the agency. In pursuing its objective, the agency will always care about both states, though to varying degrees. This seems to be reasonable: it is difficult to imagine Australian policy makers deliberately constructing policy to completely exclude the interests of any one group, albeit a state in this case. That said, by varying the welfare weight between zero and one the inter-state distribution of income implied by a given transfer will change. In this sense, the federal agency cares about inter-state equity, but only in terms of redistributing along a utility possibilities frontier defined between representative residents of states 1 and 2. Any point on the frontier must also be consistent with the migration constraint, equation (2.7). With attachment to state, this is not necessarily a point on the frontier where per capita utilities are equal across states, as would be so with perfect mobility where $a = 0$.

A solution to the agency's maximisation problem yields the following first order necessary condition for the inter-state transfer as:[4]

$$\frac{\partial n_1}{\partial \rho} \left\{ \delta \frac{u_{x_1}}{c_1 n_1} \mu_1 - (1-\delta) \frac{u_{x_2}}{c_2 n_2} \mu_2 \right\} - \delta \frac{u_{x_1}}{c_1 n_1} + (1-\delta) \frac{u_{x_2}}{c_2 n_2} = 0, \tag{3.2}$$

where

$$\mu_1 = (w_1 - c_1 x_1), \qquad \mu_2 = (w_2 - c_2 x_2), \tag{3.3}$$

are the marginal social benefits from adding a unit of labour to states 1 and 2 respectively. For each state, this consists of the contribution of a marginal unit of labour to output (their wage, $w_i$) less the value of their per capita consumption, $c_i x_i$.

Total differentiation of the migration constraint, equation (2.7), yields the federal agency's anticipated migration response to a change in the equalization transfer as:

$$\frac{\partial n_1}{\partial \rho} = \frac{A}{D}$$

where

$$A = \left\{ \frac{u_{x_1}}{c_1 n_1} + \frac{u_{x_2}}{c_1 n_1} \right\} > 0, \qquad D = \left\{ \frac{u_{x_1}}{c_1 n_1} \mu_1 + \frac{u_{x_2}}{c_2 n_2} \mu_2 \right\}. \tag{3.4}$$

Using this migration response, the first order necessary condition for the transfer, equation (3.2), can be expressed in the following form:

$$F = \mu_1 - \mu_2 - 2a \left\{ (1-\delta) \frac{c_1 n_1}{u_{x_1}} - \delta \frac{c_2 n_2}{u_{x_2}} \right\} = 0. \tag{3.5}$$

[4]Mathematical details of the solution are available on request.

This is the well-known condition for a spatially efficient equalization transfer with attachment to place (see, for example, expression (26) in Caplan et al. (2000)). The federal agency chooses a transfer, $\rho^*$, which satisfies this condition. The transfer is efficiency enhancing in the sense that it corrects for the distorting effects of economic rents captured by state governments and redistributed on the basis of residency. Except in the fully symmetric case, the transfer that satisfies this first order necessary condition is non-zero and could be in either direction (from state 1 to 2 or vice versa) depending on the distribution of natural resource endowments, as given by $T_i$, for $i = 1, 2$, differences in relative costs, as determined by $c_i$, for $i = 1, 2$, and the value of the attachment parameter, $a$.

The model developed to this point is completely standard. No pretence is made that it contributes to the theory of fiscal federalism in any way. Rather, the contribution of this paper is to undertake a comparative static exercise using the first order necessary condition for the transfer, equation (3.5), to show how $\rho^*$ responds to an exogenously given increase in the cost parameter in either state. Consider first an increase in $c_1$, for given $c_2$.

### 3.1 Cost increase in state 1

Using the implicit function theorem on equation (3.5) gives us:

$$\frac{\partial \rho}{\partial c_1} = -\frac{F_{c_1}}{F_\rho}. \tag{3.6}$$

From equation (3.5), it is possible to obtain separate expressions for $F_{c_1}$ and $F_\rho$ as follows:[5]

$$F_{c_1} = \frac{x_1}{c_1 D}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} - 2a(1-\delta)n_1, \tag{3.7}$$

$$F_\rho = \frac{A}{D}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} + \frac{1}{n_1} + \frac{1}{n_2}, \tag{3.8}$$

where

$$H = \left(\frac{\partial \mu_1}{\partial n_1} + \frac{\partial \mu_2}{\partial n_2}\right) \tag{3.9}$$

is the sum of the marginal benefit responses to a change in labour supply for each state and $A > 0$ and $D$ are as defined at equation (3.4).

As shown in Annex 2, existence of a stable migration equilibrium requires $\mu_i < 0$ for $i = 1, 2$ and hence that the federation is over-populated. In turn, this means that $D$, defined at equation (3.4), must also be negative. From the Annex, stability is also assured if $H$, defined at equation (3.9), is negative. If these restrictions hold, from equation (3.8) we know that $F_\rho > 0$. However, even with $H < 0$ and $D < 0$, the sign of $F_{c_1}$ is, in general, ambiguous. This means that the sign of $\frac{\partial \rho}{\partial c_1}$, the comparative static derivative of interest, is also ambiguous. That said, one can unambiguously sign $F_{c_1}$, and hence $\frac{\partial \rho}{\partial c_1}$, if the population is perfectly mobile. This is shown in the following proposition:

[5] See Annex 1 for details of derivations.

**Proposition 1.** If $H < 0$ and $D < 0$, perfect population mobility is *sufficient* to ensure that the inter-state transfer from state 1 to 2 is *decreasing* in the cost structure of state 1. That is, if $a = 0$, then $F_{c_1} > 0$ and

$$\frac{\partial \rho}{\partial c_1} = -\frac{F_{c_1}}{F_\rho} < 0.$$

*Proof.* If $a = 0$, the term $2a(1 - \delta)n_1$ in equation (3.7) is equal to zero. If $H < 0$ and $D < 0$, it follows that $F_{c_1} > 0$. Since $F_\rho$ is always positive, the result follows immediately. □

Thus, perfect mobility is sufficient (though not necessary) to ensure that an increase in $c_1$ results in a decrease in $\rho$. Since $\rho$ is set up in the model as a transfer from state 1 to 2, this means that as $c_1$ increases, less income is transferred out of state 1, or alternatively, more income is transferred into the state depending on the initial sign of $\rho$. In other words, the transfer made from state 1 to 2 is decreasing in $c_1$.

However, it is reasonable to expect positive attachment ($a > 0$). In this more general case, the signs of $F_{c_1}$ and hence $\frac{\partial \rho}{\partial c_1}$ are ambiguous. Further insight for this case can be obtained from a numerical simulation. In the simulation, it is assumed that $f_i(n_i, T_i) = n_i^\alpha T_i^\beta$, with $0 < \alpha$ and $0 < \beta$ being the usual labour and capital share parameters.[6] Results from a simulation are presented in Table 3 for a case in which state 1 also has a relatively larger natural resource endowment. The first row of the Table reproduces values for the transfer, state populations and social welfare where states have the same costs, that is, $c_1 = c_2 = 1$, but state 1 has a higher endowment of the fixed factor. Social welfare maximization requires the federal agency to transfer income from the resource rich state to the state with a smaller fixed factor endowment.

Table 3: State 1 is resource rich, high cost

| $c_1$ | $\rho$ | $n_1$ | $n_2$ | W |
|---|---|---|---|---|
| 1 | 0.2720 | 6.1324 | 3.8676 | 4.0271 |
| 1.1 | 0.2050 | 5.8089 | 4.1902 | 3.9565 |
| 1.2 | 0.1431 | 5.5193 | 4.4807 | 3.8446 |
| 1.3 | 0.0867 | 5.2590 | 4.7410 | 3.7067 |
| 1.4 | 0.0360 | 5.0265 | 4.9735 | 3.5545 |
| 1.5 | -0.0094 | 4.8192 | 5.1808 | 3.3960 |

The remaining rows illustrate how the endogenous variables respond to increases in $c_1$ while holding $c_2$ fixed at one. In other words, state 1 becomes increasingly high cost relative to state 2. It is clear that the transfer made by the agency from state 1 to 2, because of the relatively high resource endowment of state 1, *decreases* as $c_1$ increases. Nevertheless, people still migrate to state 2 as costs increase in state 1. Social welfare also decreases because as costs in one state this reduces the real value of consumption.

[6] To enable replication of results, mathematical details of the numerical example and relevant Matlab code are available on request. The example assumes that $N = 10$, $T_1 = 4$, $T_2 = 2$, $\alpha = 0.5$, $\beta = 0.6$, $\delta = 0.5$, $c_2 = 1$ and $a = 0.001$. Thus, the central agency cares equally about states and state 1 has a 50 percent higher endowment of the natural resource than state 2. Note the results do not depend on constant, increasing or decreasing returns to scale.

### 3.2 Cost increase in state 2

Now consider an increase in $c_2$, for given $c_1$. The derivative of interest is:

$$\frac{\partial \rho}{\partial c_2} = -\frac{F_{c_2}}{F_\rho}, \tag{3.10}$$

where $F_\rho > 0$ is already given by equation (3.8). From equation (3.5), one derives:

$$F_{c_2} = -\frac{x_2}{c_2 D}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} + 2a\delta n_2, \tag{3.11}$$

As with state 1, even with $H < 0$ and $D < 0$, the sign of $F_{c_2}$ is ambiguous. However, once again if there is perfect mobility $F_{c_2}$ can be signed unambiguously as follows:

**Proposition 2.** If $H < 0$ and $D < 0$, perfect population mobility is *sufficient* for the transfer from state 1 to 2 to be *increasing* in the cost structure of state 2. That is, if $a = 0$, then $F_{c_2} < 0$ and

$$\frac{\partial \rho}{\partial c_2} = -\frac{F_{c_2}}{F_\rho} > 0.$$

*Proof.* If $a = 0$, the term $2a\delta n_2$ in equation (3.11) is equal to zero. If $H < 0$ and $D < 0$, it follows that $F_{c_2} < 0$. Since $F_\rho$ is always positive, the result is immediate. □

For the more general case where $a > 0$, a numerical example can once more be used to see how endogenous variable values respond to an increase in $c_2$. The example uses the same functional forms and parameter values as the simulation in Table 3. The only difference is that $c_1$ is now held fixed at one and $c_2$ is increased. Results of the simulation are presented in Table 4.

Table 4: State 2 is resource poor, high cost

| $c_2$ | $\rho$ | $n_1$ | $n_2$ | W |
|---|---|---|---|---|
| 1 | 0.2720 | 6.1324 | 3.8676 | 4.0271 |
| 1.1 | 0.3348 | 6.4370 | 3.5630 | 3.6795 |
| 1.2 | 0.3887 | 6.7115 | 3.2885 | 3.3494 |
| 1.3 | 0.4346 | 6.9599 | 3.0401 | 3.0427 |
| 1.4 | 0.4737 | 7.1866 | 2.8134 | 2.7612 |
| 1.5 | 0.5072 | 7.3966 | 2.6034 | 2.5038 |

From the first row, which is the same as row 1 in Table 3, social welfare maximization requires the federal agency to transfer income from state 1 to 2 because state 1 has the larger resource endowment. The remaining rows show how the optimal transfer, state populations and social welfare respond to increases in $c_2$. Clearly, the transfer to state 2 increases. Not only is state 1 resource rich, which in itself necessitates a transfer to state 2, it is now also relatively low cost, thus reinforcing the need for a transfer to state 2 in order to maximize national social welfare. As $c_2$ increases, people also migrate out of the high cost state 2 into state 1. Finally, as with the simulation in Table 3, social welfare is decreasing in $c_2$ for the reason already given.

### 3.3 Summary

This completes the results of the paper. They can be summarized as follows. From the propositions, if there is perfect population mobility the optimal transfer from state 1 to 2 is *always* decreasing in the cost parameter in state 1 and increasing in the cost parameter in state 2. This is an unambiguous result which holds given the general assumptions of the model. Given the way the transfer is set up, this means that with perfect mobility we can be sure the transfer received by any state is increasing in its cost parameter, for given costs elsewhere.[7] For the more general case of positive attachment, the transfer to a state is also increasing in its cost parameter, for given costs in the other states, though it was only possible to show this with a numerical example which assumes a particular production technology in each state.

The intuition for the result is as follows. When, for example, $c_1$ increases, we can see from equation (2.5) that per capita consumption in state 1, $x_1$, decreases. This is because, for a given transfer to (or from) state 1, real income in the state falls. Recall also that this income consists of wages and economic rent. From the migration constraint at equation (2.7), people will want to migrate from state 1 to 2, and the simulations show that this is what happens. However, the cost increase in state 1 decreases the real value of its economic rent, relative to the real value of rent in state 2. Part of the migration that would occur without any change in the transfer into state 2 would be in response to this change in the relative real value of rents. This, we know from the efficiency-in-migration literature, would be inefficient migration and the agency stops this by making a greater transfer into state 1 to compensate for its lower real rent value. In effect, by transferring more income into state 1 in response to its cost increase, the agency is able to stop that component of the migration into state 2 that is inefficient (i.e. in response to real rent value differentials), leaving only the efficient part associated with changes in the real value of wage income. The same logic applies to an increase in $c_2$, for given $c_1$.

## 4 Assumptions, model features and policy

The results are obtained from a model which makes some simplifying assumptions. Two are worthy of further comment.

Firstly, the model has no public goods, so the role of states is restricted to capturing and recycling economic rents arising from a fixed factor, assumed to a natural resource, to citizens on the basis of residency. An extension could be undertaken to include local public goods though this will be at the cost of added complexity. To be more specific, it would add an additional source of distortion to migration equilibria arising from fiscal externalities making the first order condition for the transfer more complex. It is unclear how changes in relative costs across states would then affect the relative real value of these externalities, and hence what influence they would exert on the direction of the transfer response to changes in relative inter-state costs. For instance, would they reinforce or tend to offset the directional changes related to economic

[7]This makes it clear why Petchey (1995) finds that the transfer should go to the high cost state. He assumes that the population is perfectly mobile, that is, $a = 0$, so propositions 1 and 2 hold in his model.

rents? What is more, if one believes state services are largely publicly provided private goods (or highly congested public goods), the fiscal externality distortions to migration equilibria arising from the introduction of local public goods would be relatively small compared to the impact of differential rents in a resource-based economy such as Australia.

Secondly, I have assumed state costs are exogenously given using a parameter. While fixing costs is fairly standard in the efficiency-in-migration literature, more generally one would expect costs to be endogenous and a function of state and federal policies, at least in part. In a world with cost equalization and endogenous costs, states might then be able to act strategically with respect to their costs and distort their policies to influence their cost equalization transfer. Cost equalisation may in this case also generate negative welfare effects which would have to be offset against the gain identified in this paper under the assumption of given costs. Whether cost equalization is efficiency enhancing in net terms when costs are endogenous is beyond the scope of this paper and remains to be explored as future research. Even so, in a world with endogenous costs, one would still expect the results here to hold: it is just that the benefit of cost equalization identified here would have to be offset against the costs of strategic behaviour that it may encourage.

Though not an assumption, a feature of the model developed in this paper is that states fully capture local economic rents and recycle them to locals on the basis of residency. This creates the need for a non-zero corrective inter-state transfer to maximize national social welfare simply because rents find their way into residents' income and distort migration decisions. The paper has argued that the Australian federation works in this way, namely, that resource rich states do capture economic rents and disburse them on the basis of residency. However, it must be recognized that if the Australian economy does not work like this and resource rich states do not capture a significant amount of economic rent, then in a model without local public goods, the optimal transfer is zero. In this case, there can, of course, be no efficiency rational for cost equalization. Hence, the case for cost equalization hangs critically upon the ability of states to capture and disburse significant economic rent on the basis of residency.

The general policy implication is that by transferring income from low to high cost states, cost equalization undertaken as part of HFE in Australia has the potential to increase national social welfare. Provided that the CGC has correctly identified high and low cost states, this means that the signs of expenditure needs arising from cost differences shown in Table 2 are right if our aim is to maximize social welfare as defined by $W$ in the agency's optimization problem. Naturally, this does not necessarily validate the magnitude of expenditure needs arising from cost differences shown in Table 2, only their sign.

# 5 Conclusion

After developing a standard efficiency-in-migration model of a federation with imperfect population mobility and two states that capture and recycle natural resource rents on the basis of residency, this paper has derived an expression for the optimal inter-state equalization transfer needed to maximize national social welfare. The main contribution has been to obtain general expressions that tell us how the optimal transfer responds to a change in the cost structure in either state. It has been shown that if the population is perfectly mobile, the transfer is unambiguously increasing in a state's relative cost structure. More generally, if population mobility is imperfect, numerical examples have been used to show that the transfer to a state is still increasing in its relative cost structure. Given these results, which, as explained, depend upon the model's assumptions and the ability of states to capture and recycle economic rents, it is concluded that cost equalization may enhance national social welfare.

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## Annex 1: Derivations

Consider state 1. Using (3.5) in the main text, and assuming that $u_{x_i} = 1$ for $i = 1, 2$, the implicit function theorem implies

$$\frac{\partial \rho}{\partial c_1} = -\frac{F_{c_1}}{F_\rho}$$

where

$$F_{c_1} = \frac{\partial \mu_1}{\partial c_1} - \frac{\partial \mu_2}{\partial c_1} - 2a\left\{(1-\delta)\left(n_1 + c_1\frac{\partial n_1}{\partial c_1}\right) - \delta c_2 \frac{\partial n_2}{\partial c_1}\right\},$$

$$F_\rho = \frac{\partial \mu_1}{\partial \rho} - \frac{\partial \mu_2}{\partial \rho} - 2a\left\{(1-\delta)c_1\frac{\partial n_1}{\partial \rho} - \delta c_2 \frac{\partial n_2}{\partial \rho}\right\}.$$

From the definition of $\mu_1$:

$$\frac{\partial \mu_1}{\partial c_1} = \frac{\partial \mu_1}{\partial n_1}\frac{\partial n_1}{\partial c_1}$$

where

$$\frac{\partial \mu_1}{\partial n_1} = \left\{\frac{\partial w_1}{\partial n_1} - \frac{\mu_1}{n_1}\right\}.$$

The equal utility condition yields:

$$\frac{\partial n_1}{\partial c_1} = \frac{x_1}{c_1 D}.$$

Similarly

$$\frac{\partial \mu_2}{\partial c_1} = -\frac{\partial \mu_2}{\partial n_2}\frac{\partial n_1}{\partial c_1}$$

where

$$\frac{\partial \mu_2}{\partial n_2} = \left\{\frac{\partial w_2}{\partial n_2} - \frac{\mu_2}{n_2}\right\}.$$

Combining these results it is possible to define $F_{c_1}$ as:

$$F_{c_1} = \frac{\partial n_1}{\partial c_1}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} - 2a(1-\delta)n_1$$

where

$$H = \left\{\frac{\partial \mu_1}{\partial n_1} + \frac{\partial \mu_2}{\partial n_2}\right\}$$

Totally differentiating the migration constraint yields the migration response to an increase in the cost parameter, $c_1$, as:

$$\frac{\partial n_1}{\partial c_1} = \frac{x_1}{c_1 D}.$$

where $D$ is defined in the main text. Using this, $F_{c_1}$ becomes:

$$F_{c_1} = \frac{x_1}{c_1 D}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} - 2a(1-\delta)n_1.$$

Next, from the definition of $\mu_1$ obtain:

$$\frac{\partial \mu_1}{\partial \rho} = \left\{\frac{\partial \mu_1}{\partial n_1}\frac{\partial n_1}{\partial \rho} + \frac{1}{n_1}\right\}.$$

Similarly, from $\mu_2$ obtain:

$$\frac{\partial \mu_2}{\partial \rho} = -\left\{\frac{\partial \mu_2}{\partial n_2}\frac{\partial n_1}{\partial \rho} + \frac{1}{n_2}\right\}.$$

It is now possible to express $F_\rho$ as

$$F_\rho = \frac{\partial n_1}{\partial \rho}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} + \frac{1}{n_1} + \frac{1}{n_2}.$$

Using the expression for $\frac{\partial n_1}{\partial \rho}$ at (3.4) in the main text, $F_\rho$ becomes:

$$F_\rho = \frac{A}{D}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} + \frac{1}{n_1} + \frac{1}{n_2}.$$

Now consider state 2. From equation (3.5) in the main text, and assuming that $u_{x_i} = 1$ for $i = 1, 2$, the implicit function theorem implies

$$\frac{\partial \rho}{\partial c_2} = -\frac{F_{c_2}}{F_\rho}$$

where, using a procedure analogous to that for state 1,

$$F_{c_2} = -\frac{x_2}{c_2 D}\left\{H - 2a\left((1-\delta)c_1 + \delta c_2\right)\right\} + 2a\delta n_2,$$

and $F_\rho$ is as defined above.

## Annex 2: Stability of a migration equilibrium

From the main text, once the federal agency has chosen a $\rho^*$ to satisfy equation (3.5), then from equation (2.8), the supply of labour to state 1 is also determined. Mobile labour makes its location choice for a given equilibrium equalization transfer to satisfy the migration constraint. This manifests itself as a solution, $n_1(\rho^* : c_i, \rho)$, to equation (2.8) which yields the labor supply to state 1. This also implies an equilibrium labour supply to state 2. Together, these labour supplies constitute a migration equilibrium.

Under what conditions will a unique, stable, solution exist? The answer begins by observing that indirect utility for a resident of state i is,

$$V_i(n_i) = \underset{\rho^*}{Max}\, u_i \qquad i = 1, 2.$$

From the envelope theorem,

$$\frac{\partial V_i(n_i)}{\partial n_i} = \frac{\partial u_i}{\partial n_i} = \frac{\partial x_i}{\partial n_i} = \frac{\mu_i}{c_i n_i}.$$

where $x_i$ is per capita consumption as defined at equation (2.5) text and $\mu_i$ is the social marginal benefit of a migrant as defined at equation (3.3). From Wildasin (1986), $x_i$ is strictly concave in $n_i$ which implies that:[8]

$$\frac{\partial^2 x_i}{\partial n_i^2} = \frac{1}{c_i n_i}\left\{\frac{\partial \mu_i}{\partial n_i} - c_i \frac{\partial x_i}{\partial n_i}\right\} < 0 \qquad i = 1, 2$$

For this to hold it is necessary that:

$$\frac{\partial \mu_i}{\partial n_i} < c_i \frac{\partial x_i}{\partial n_i} = \frac{\mu_i}{c_i n_i} \qquad i = 1, 2$$

From Boadway and Flatters (1982), migration equilibria are stable in over-populated federations where $\mu_i < 0$ for $i = 1, 2$. This, in turn, implies from the equation above that

$$\frac{\partial \mu_i}{\partial n_i} < 0 \qquad i = 1, 2 \tag{.1}$$

in a stable migration equilibrium. What is more, if $\mu_i < 0$ for $i = 1, 2$, it is also the case that

$$D < 0; \qquad H < 0 \tag{.2}$$

where $D$ and $H$ are defined at equations (3.4) and (3.9) in the text.

[8] See pages 22 to 28 and in particular diagram 3 on page 26 in Wildasin (1986).

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**ISSN 1834-9536**

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