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Abstract

We propose a social welfare function to evaluate a profile of income streams and compare the welfare gain of the actual profile relative to the income profile where the individual receives his first period income in each period. We derive necessary and sufficient conditions for the welfare gain to be positive, and show how this welfare gain can be decomposed in a pure effect of economic growth, a mobility effect and a cost due to aversion to time fluctuations given individuals' ranks in the income distribution. The mobility effect, generated by reranking in the income distribution has two components: a cost due to the time fluctuations in incomes and a benefit, due to the equalization in time averaged incomes. We illustrate the analysis using CNEF data for Australia, Korea, Germany and Switzerland. Our results indicate that the largest component of the welfare gain is the equalization of time averaged income, induced by reranking. After subtracting the cost of mobility due to the increase in time fluctuations of individual income streams, the net effect of mobility remains positive. In countries with high growth (Australia and Korea), the growth effect is larger than the mobility effect, but in countries with low growth (Germany and Switzerland), the opposite holds true.

Keywords: intertemporal growth; mobility; income streams; time horizon.

JEL Classification: D31, D63, I32.

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1 Introduction

We propose a social welfare function to evaluate a profile of income streams, and focus on the welfare gain that is obtained relative to a profile in which individuals keep their first period income level. As suggested by Shorrocks (1978), our social welfare function depends on individuals' time invariant equivalent incomes, which take into account aversion with respect to fluctuations in incomes. These time invariant equivalent incomes are then aggregated using a rank dependent social welfare function, as proposed by Yaari (1988). As such, income mobility has two effects in our framework: a negative effect, because it increases the variability of individuals' income streams, and a positive effect, because it equalizes time averaged incomes. The social welfare function is decomposable in these two effects, and two additional effects: a pure effect of economic growth and a cost due to aversion to time fluctuations in incomes given individuals' ranks.

A related approach was proposed by Chakravarty, Dutta and Weymark (1985). They are also concerned with the welfare evaluation of income streams and a welfare comparison of the actual time path of income to a hypothetical time path. This time path starts from the first period income distribution and is generated by assuming that in every time period each individual receives an income share equal to his income share in the first period. Hence, they assume complete relative immobility. The welfare function in their illustration is only sensitive to the total income received by each individual over the time periods considered.[1] We deviate from their framework in two respects. First, we generate another hypothetical time path of incomes by replacing their assumption of relative immobility by an assumption of absolute immobility. Second, our social welfare function does not depend on individuals' time averaged incomes, but on their time invariant equivalent incomes. Hence we take into account aversion with respect to fluctuations in incomes.

Our proposal is also different from three recent contributions to the literature. Aaberge and Mogstad (2010) proposed a two-step procedure that is identical to ours. However, the immobile situation is defined as the situation in which individuals' ranks do not change over time. Individuals are ranked on the basis of the first period income distribution, and they get assigned the income level in the actual income distribution associated with this rank in each of the following periods. Moreover, they define mobility as the decrease in inequality in the distribution of time invariant equivalent income due to changes over time in individuals' ranks

[1]Mobility is measured by the ratio of equally distributed equivalent incomes of the actual and immobile time averaged income distributions.

and income shares in the short term distributions of income.[2] This is different from our approach where mobility is measured by the contribution of rerankings to the welfare gain compared to the absolutely immobile first period distribution. Decancq and Zoli (2014) characterize a social welfare function for the two-period framework in which the weight given to individuals' income in each period depends on their income rank in both periods. Our social welfare function has a very different structure, as the weights given to individuals' time invariant equivalent income depends on their rank in the distribution of time invariant equivalent incomes only, and not on their ranks in the periods considered. Bossert and Dutta (2018) characterize a measure for the change in welfare in a two-period framework, equal to the difference between generalized Gini welfare of the second and the first period, with weights depending on the rank in the corresponding period. There are formal similarities with what we do, but we compare the welfare of the actual distribution of time invariant incomes to a benchmark distribution, the distribution of time invariant incomes under the assumption of absolute immobility.

Our paper is also related to the literature on economic mobility. Part of that literature investigates the role of income mobility in a profile of individual income streams over time within a two period welfare framework - see Atkinson (1981), King (1983), Gottschalk and Spolaore (2002) and Decancq and Zoli (2014). The same is true for most of the literature that quantifies income mobility, see the survey of Jäntti and Jenkins (2015). The exceptions are Shorrocks (1978) and Fields (2010). They measure mobility by the extent to which it decreases inequality in time averaged income. More in particular, Shorrock (1978) measures mobility as one minus the ratio of inequality in time averaged income to a weighted average of income inequalities in each of the time periods considered. Fields (2010) takes one minus the ratio of inequality in time averaged income divided by inequality in the first period. We find that the positive effect of mobility on the equalization of time averaged income is important.[3] However, it is also recognized that mobility has a negative effect as it leads to fluctuations in individuals' incomes over time, see Shorrocks (1978) and Gottschalk and Spolaore (2002). We develop a framework that evaluates income streams over more than two periods and allows us to trade-off these two effects of mobility in a coherent way. In our framework, this net effect of mobility can be compared to the size of the growth effect in the decomposition, such that we can determine which of the two has the largest contribution to the welfare gain.

[2] In Aaberge and Mogstad (2015) they consider the special case when time invariant equivalent income is replaced by the present value of the income stream.

[3] See also Bresson et al. (2018) for a multiperiod approach to evaluate the impact of growth on poverty.

The structure of the paper is as follows. Section 2 presents the framework, derives dominance results to establish whether the actual growth dynamics is welfare improving compared to the immobile benchmark, and shows how the welfare gain can be decomposed in four components. Section 3 describes the CNEF data for Australia, Germany, Korea and Switzerland that we use in the application. The results are given in Section 4. We find that the dominance results are useful, and that country rankings display some sensitivity to the aversion to intertemporal fluctuations in income streams and the degree of inequality aversion towards time invariant equivalent incomes. With plausible values of the parameters the positive effect of rank mobility on the equalization of time averaged incomes outweights the negative effect on the time fluctuations of incomes. For countries with high growth (Australia and Korea), the growth effect is larger than the mobility effect, while for countries with low growth (Germany and Switzerland) the opposite holds true. We show that the ranking of countries obtained with our framework differs from the country ranking in the standard framework that focuses on yearly transitions. The ranking obtained with an iso-elastic social welfare function instead of a rank dependent social welfare function is similar (but the welfare gain is not decomposable). Finally, our country ranking is different from the rankings with the mobility measures proposed by Shorrocks (1978) and Fields (2010). Section 5 concludes.

2 Framework

In this section we first define the notation necessary to formalize our social welfare function. Next we introduce the benchmark, the welfare gain and show how the latter can be decomposed in four components.

2.1 Notation

Let $N = \{1, \ldots, n\}$ be the set of individuals. For each individual we observe his income over T periods of time; $y_{it} \in \mathbb{R}_+$ is individual i's income at time t with $t \in \{1, \ldots, T\}$. Without loss of generality, individuals are ranked in the population on the basis of their income in the first period: individual i is the one with the $i-$ the lowest level of first period income. The $it-$ th element of the matrix Y is y_{it}, such that $y_{i\bullet} := (y_{i1}, \ldots, y_{it}, ..., y_{iT})$, the vector of individual i's incomes across the T periods, can be found in the $i-$ th row of Y and $y_{\bullet t}$, the $n-$ dimensional cross-sectional vector of incomes at time t in the $t-$ the column of matrix Y. The set of all $n \times T$ matrices whose entries are non-negative real numbers and with individuals ranked on the basis of their first period income is denoted by $\Omega^{n,T}$.

The proposed framework relies on a two step procedure. The first step builds a measure of individual welfare that incorporates aversion to intertemporal fluctuations in individuals' incomes. Individual welfares will be measured by their "time invariant equivalent income". The second step aggregates these individual welfare measures, by weighting individuals' time invariant equivalent incomes by their rank order in the distribution of time invariant equivalent income. We describe both steps in turn.

The first step uses a standard measure of individual welfare that is sensitive to the intertemporal fluctuations in income streams. Aversion to intertemporal fluctuations means that, if for all $s \neq t, u : \hat{y}_{is} = y_{is}$ and with $\eta > 0$, $\hat{y}_{it} = y_{it} - \eta \geq \hat{y}_{iu} = y_{iu} + \eta$, then individual i' s welfare will be larger with $\hat{y}_{i\bullet}$ than with $y_{i\bullet}$. Assuming that the utility derived from the income stream $y_{i\bullet}$ can be written as $\sum_{t=1}^{T} u(y_{it})$ and with an iso-elastic specification $u(y_{it}) = \frac{(y_{it})^{1-\epsilon}}{1-\epsilon}$, $\epsilon \neq 1$ and the limiting case $u(y_{it}) = log(y_{it})$ for $\epsilon = 1$, the time invariant equivalent income y^{TI} of individual i receiving income stream $y_{i\bullet}$ becomes

$$y^{TI}(y_{i\bullet}, \epsilon) = \left[\frac{1}{T}\sum_{t=1}^{T}(y_{it})^{1-\epsilon}\right]^{1/(1-\epsilon)}, \epsilon \neq 1 \quad (1)$$

$$y^{TI}(y_{i\bullet}, 1) = exp\left[\frac{1}{T}\sum_{t=1}^{T} log(y_{it})\right]. \quad (2)$$

This function is increasing in each y_{it}. Aversion to intertemporal fluctuations requires that $\epsilon > 0$. Larger values of ϵ correspond to a greater aversion to intertemporal income fluctuations; ϵ is an intertemporal income fluctuation aversion parameter.

The second step, the aggregation of individuals' welfares, uses the rank-ordered approach pioneered by Yaari (1988). We rank individuals on the basis of their time invariant incomes, and they receive a weight in the social welfare function that depends on this rank. Let the function $r : N \times \mathbb{R}_+ \times \Omega^{n,T} \rightarrow N$ be such that $r(i, \epsilon, Y)$ gives the rank in the initial income distribution of the individual that, given ϵ and Y, has rank i in the distribution of time invariant income. Social welfare now becomes

$$W(Y) = \frac{1}{n}\sum_{i=1}^{n} v(i, n) y^{TI}(y_{r(i,\epsilon,Y)\bullet}, \epsilon), \quad (3)$$

where $v : N \rightarrow \mathbb{R}_+$ such that $v(i, n)$ is the weight given to the time invariant equivalent income of the individual with rank i in the distribution of time invariant

incomes. We impose two properties on these weights. First, they are positive, such that social welfare is increasing in individual welfare. Second, a larger weight is attached to the welfare of those with a lower time invariant income. Written down formally, we have

Property 1: For all $i \in N$, $v(i,n) \geq 0$.

Property 2 : For all $i \in N \setminus \{n\}$, $v(i,n) \geq v(i+1,n)$.

These properties are standard. The former is equivalent to the Pareto principle, the latter to inequality aversion with respect to the distribution of individuals' welfares, measured by their time invariant equivalent income.

2.2 Benchmark

We determine whether a particular profile of income dynamics is welfare improving or not by comparing the observed profile Y to a benchmark profile $\hat{Y}$. We choose as the benchmark a situation in which individuals keep their first period level of income throughout time. This implies that we adopt an absolute approach to growth measurement.[4]

Definition 1: For a given matrix Y, the benchmark distribution, $\hat{Y}$ is such that $\hat{y}_{it} = y_{i1}$ for all $i = 1, ..., n$ and $t = 1, ..., T$.

Our measure of intertemporal growth is the difference in welfare obtained from the actual income profile Y and the benchmark $\hat{Y}$:

$$G(Y) = W(Y) - W(\hat{Y}). \tag{4}$$

In the benchmark distribution, for every individual i his time invariant income equals his first period income, and his income rank in the distribution of time invariant income i equals his income rank in the first period income distribution. Consequently,

$$W(\hat{Y}) = \frac{1}{n} \sum_{i=1}^{n} v(i,n) y_{i1}. \tag{5}$$

Using (3) and (5) in (4), the measure of intertemporal growth becomes

$$G_W(Y) = \frac{1}{n} \sum_{i=1}^{n} v(i,n) \left[y^{TI}(y_{r(i,\epsilon,Y)\bullet}, \epsilon) - y_{i1} \right], \tag{6}$$

[4]As described in the introduction, Chakravarty et al. (1985) consider a relative approach.

where $y^{TI}(y_{r(i,\epsilon,Y)\bullet},\epsilon)$ is simply the $i-$ th lowest level of time invariant equivalent income. Two results follow from this.

Result 1: Given $\epsilon \geq 0$, $G_W(Y) \geq 0$ for all W satisfying Property 1 if and only if

$$y^{TI}(y_{r(i,\epsilon,Y)\bullet},\epsilon) - y_{i1} \geq 0 \; \forall \; i = 1, ..., n, \tag{7}$$

were $(y^{TI}(y_{r(i,\epsilon,Y)\bullet},\epsilon) - y_{i1})$ is the Anonymous Absolute Intertemporal Growth Incidence Curve (AAIGIC). A growth dynamic is welfare improving for all welfare weights satisfying Property 1 if and only if its AAIGIC is positive for every $i = 1, ..., n$.

Result 2: Given $\epsilon \geq 0$, $G_W(Y) \geq 0$ for all W satisfying Properties 1 and 2 if and only if

$$\sum_{i=1}^{j}(y^{TI}(y_{r(i,\epsilon,Y)\bullet},\epsilon) - y_{i1}) \geq 0 \; \forall \; j = 1, ..., n, \tag{8}$$

where $\sum_{i=1}^{j}(y^{TI}(y_{r(i,\epsilon,Y)\bullet},\epsilon) - y_{i1})$ is the Cumulative Anonymous Absolute Intertemporal Growth Incidence Curve (CAAIGIC). Hence a growth dynamic is welfare improving for all welfare weights satisfying Properties 1 and 2 if and only if its CAAIGIC is positive for every $j = 1, ..., n$.

In case Results 1 and 2 are not able to establish whether a particular growth dynamic is welfare improving or not, we will specify the welfare weights as

$$v(i,n) = (\frac{n-i}{n})^{\delta} - (\frac{n-i-1}{n})^{\delta}. \tag{9}$$

This amounts to reranking them (in increasing order) and using the standard weights for the single-series Gini proposed by Donaldson and Weymark (1980), with $\delta \geq 1$. The larger is δ, then larger the weight given to individuals with lower time invariant equivalent incomes; δ is a rank based inequality aversion parameter with respect to the distribution of time invariant equivalent incomes.

The total welfare effect of a growth dynamic can be decomposed in four effects. Let the function $s : N \times \mathbb{R}_+ \times \Omega^{n,T} \rightarrow N$ be such that $s(i,\epsilon,Y)$ gives the rank in the distribution of time invariant income (which depends on ϵ and Y) of the individual that has rank i in the initial distribution of income. The difference in welfares, $G_W(Y)$, can then be written as

$$\frac{1}{n}\sum_{i=1}^{n} v(s(i,\epsilon,Y),n)y^{TI}(y_{i\bullet},\epsilon) - \frac{1}{n}\sum_{i=1}^{n} v(i,n)y_{i1}. \tag{10}$$

Let, for all $t = 1, ..., T$, $\tilde{y}_{\bullet t}$ contain the elements of $y_{\bullet t}$, ordered from low to high. Now, subtracting and adding $\frac{1}{n}\sum_{i=1}^{n} v(i,n) y^{TI}(y_{i\bullet}, \epsilon)$, $\frac{1}{n}\sum_{i=1}^{n} v(i,n)\frac{1}{T}\sum_{t=1}^{T} y_{it}$ and $\frac{1}{n}\sum_{i=1}^{n} v(i,n)\frac{1}{T}\sum_{t=1}^{T} \tilde{y}_{it}$, we get

$$\begin{aligned}
&\tfrac{1}{n}\textstyle\sum_{i=1}^{n} y^{TI}(y_{i\bullet}, \epsilon)\left[v(s(i,\epsilon,Y),n) - v(i,n)\right] \\
&+\tfrac{1}{n}\textstyle\sum_{i=1}^{n} v(i,n)\left[y^{TI}(y_{i\bullet}, \epsilon) - \tfrac{1}{T}\sum_{t=1}^{T} y_{it}\right] \\
&+\tfrac{1}{n}\textstyle\sum_{i=1}^{n} v(i,n)\left[\tfrac{1}{T}\sum_{t=1}^{T} y_{it} - \tfrac{1}{T}\sum_{t=1}^{T} \tilde{y}_{it}\right] \\
&\quad+\tfrac{1}{n}\textstyle\sum_{i=1}^{n} v(i,n)\left[\tfrac{1}{T}\sum_{t=1}^{T} \tilde{y}_{it} - y_{i1}\right]. \qquad (11)
\end{aligned}$$

This decomposition has a nice interpretation. The first term, which we denote C1, measures the cost in terms of time invariant income that is due to individuals' reranking. The second, C2, measures, given individuals' rank, the cost due to aversion to time fluctuations of income. The magnitude of these two effects depends on both ϵ and δ. In case $\epsilon = 0$, the second term is zero. The third term, C3, equals the welfare gain due to the equalization in time averaged incomes that is due to reranking. The fourth term, C4, gives, for given rank, the pure effect of economic growth. The latter two terms depend on δ, not on ϵ. If $\delta = 1$, the third term equals zero. Observe that reranking (mobility) has two effects, it increases the variation in time invariant income, and it decreases inequality in time averaged incomes, captured by C1 and C3, respectively.

3 Description of the data

Our empirical analysis is based on the panel component of the waves of the Cross National Equivalent File (CNEF). The CNEF was designed at Cornell University to provide harmonized data for a set of country-specific surveys representative of the respective resident population, including the British Household Panel Study (BHPS), the Household Income and Labour Dynamics in Australia (HILDA), the Korea Labor and Income Panel Study (KLIPS), the Russian Longitudinal Monitoring Survey of HSE (RLMS-HSE), the Swiss Household Panel (SHP), the German Socio-Economic Panel (SOEP), and the US panel Study of Income Dynamics (PSID). In the present paper, we consider Australia, Germany, Korea, and Switzerland, countries for which annual data are available. We exclude the US from the main analysis because observations are biennial and Russia because the number of household members is missing for 2008 which impedes the adjustment of incomes for household size. Using biennial data to overcome these problems, we include an extension of our analysis to these countries in Appendix A. The UK could not be included as we only have data up until 2006.

The years considered are: 2001-2009 for Australia, Germany, and Switzerland, and 2000-2008 for Korea. The unit of observation is the individual. The measure of living standards is equivalized disposable household income, which includes income after transfers and the deduction of income tax and social security contributions. Incomes are expressed in constant 2005 prices, using country and year-specific price indexes and are adjusted for differences in household size, dividing incomes by the square root of household size. They are then expressed in 2005 Purchasing Power Parity. Individuals with zero sampling weights are excluded since our measures are calculated using sample weights designed to make the samples nationally representative. We also exclude individuals with non-positive income. In line with the literature, for each wave, we drop the bottom and top 1% in the income distribution from the sample to eliminate the effect of possible outliers. Table 1 provides some descriptive statistics about the data.

Table 1: Descriptive Statistics

	Time Period	Sample	Mean Income		Annual Growth	
	(yearly data)	Size	Initial	Final	Absolute	Relative
Australia	2001 to 2009	9632	23734	30150	802	3.30 %
Germany	2001 to 2009	12445	22915	23497	73	0.31 %
Korea	2000 to 2008	4658	15853	23922	1009	6.36 %
Switzerland	2001 to 2009	1908	31650	32984	167	0.52 %

Notes: Absolute growth gives the average yearly increase in mean income. Relative growth gives the average yearly percentage increase in mean income.

We can see that the countries in our sample differ dramatically in terms of mean incomes and income growth. Both absolute and relative growth was highest in Korea, followed by Australia, Switzerland and Germany.

4 Results

In the first Subsection we check whether the dominance results for given value of the intertemporal income fluctuation aversion parameter can be used to establish whether the growth process experienced by the countries was welfare improving. Next we show how the welfare rankings of the countries change as the intertemporal income fluctuation aversion and the inequality aversion with respect to the distribution of time invariant equivalent income changes. The second Subsection shows the decomposition results and how the welfare gains change when the number of transitions changes. The final subsection compares our results to alternative approaches.

4.1 Welfare gain and decomposition in the base case

We first test whether, given different values for ϵ, the actual profile of income dynamics is welfare improving compared to the benchmark of absolute immobility.

Table 2: Positive welfare gains $G_W(Y)$ and results 1 and 2

	values for ϵ									
	0	0,25	0,5	0,75	1	1,25	1,5	2	3	5
Aus	2	2	2	2	2	2	2	2		
Ger	2	2	2	2	2	2				
Kor	2	2	2	2	2	2	2	2	2	
Swi	2	2	2							

Notes: ϵ is the aversion to intertemporal fluctuations in individual income streams. Entry 1 (2) means that Result 1 (2) can be applied such that the actual income stream is better than the benchmark.

Table 2 shows that Result 1 is not helpful to establish whether the countries' growth dynamic improved welfare. Result 2 is clearly more powerful, and allows us to establish dominance for all countries and a large range of values of ϵ, especially for Australia and Korea. Together, Tables 1 and 2 indicate that dominance is easier to obtain for countries where growth is high, such as Korea and Australia. However, observe that while Switzerland had a higher growth than Germany, we can establish dominance for a more limited range of ϵ for Switzerland than for Germany.

Next, we ask the question which countries established the largest welfare gain compared to the immobile benchmark, using the welfare weights defined in (9). The rankings of the different countries will depend on the values of ϵ and δ. The literature, based on surveys about risk and inequality aversion, indirect behavioral evidence and revealed social values (Evans, 2005) and life satisfaction (Layard et al., 2008) finds that ϵ is somewhere between 1 and 1,5. Hence we take $\epsilon = 0; 1; 1,25; 1,5$ and 3. For δ we take $\delta = 1$ (no concern for redistribution of time invariant equivalent income), 2 (the standard Gini weights, which are linearly decreasing in individuals' rank), 4 and 8 (which is close to being Rawlsian). As base case we take $\epsilon = 1,25$ and $\delta = 2$.

In the base case (in bold in Table 3), the largest welfare gain compared to the immobile benchmark is found for Korea, followed by Australia, then Switzerland

Table 3: Welfare gain rankings for different parameter values

	values for δ			
	1	2	4	8
$\epsilon = 0$	Kor	Kor	Kor	Kor
	Aus	Aus	Aus	Swi
	Ger	Swi	Swi	Aus
	Swi	Ger	Ger	Ger
$\epsilon = 1$	Kor	Kor	Kor	Swi
	Aus	Aus	Aus	Kor
	Ger	Swi	Swi	Aus
	Swi	Ger	Ger	Ger
$\epsilon = 1,25$	Kor	**Kor**	Kor	Swi
	Aus	**Aus**	Aus	Aus
	Ger	**Swi**	Swi	Kor
	Swi	**Ger**	Ger	Ger
$\epsilon = 1,5$	Kor	Kor	Kor	Swi
	Aus	Aus	Aus	Aus
	Ger	Swi	Swi	Kor
	Swi	Ger	Ger	Ger
$\epsilon = 3$	Kor	Kor	Aus	Swi
	Aus	Aus	Kor	Aus
	Ger	Ger	Swi	Kor
	Swi	Swi	Ger	Ger

Notes: ϵ is the aversion to intertemporal fluctuations in individual income streams, δ determines inequality aversion with respect to the distribution of time invariant incomes. Benchmark case in bold.

and, finally, Germany. This is the same ranking as the one obtained on the basis of absolute and relative growth in mean income (see Table 1). The most remarkable feature is that the position of Switzerland crucially depends on the inequality aversion with respect to the distribution of time invariant equivalent incomes: for $\delta = 1$, irrespective of the value for ϵ, Switzerland is ranked last, for $\delta = 8$ it ranks first (except when $\epsilon = 0$, in which case it ranks second). The ranking of Korea declines somewhat if aversion with respect to intertemporal incomes increases and δ exceeds 2.

The decompositions of the welfare gains for the base case, based on Equation (11), are reported in Table 4.

Table 4: Decomposition results

	C1	C2	C3	C4	TOT	MOB
Aus	-1191	-1094	2463	1592	1769	1272
	[-1267, -1108]	[-1129, -1061]	[2335, 2589]	[1400, 1770]	[1665, 1907]	[1136, 1421]
Ger	-750	-494	1371	242	370	621
	[-811, -697]	[-517, -474]	[1295, 1453]	[138, 352]	[282, 464]	[540, 708]
Kor	-1431	-1835	2970	2946	2649	1539
	[-1546, -1328]	[-1909, -1769]	[2759, 3166]	[2662, 3235]	[2509, 2682]	[1312, 1750]
Swi	-1237	-947	2713	364	892	1476
	[-1404, -1060]	[-1012, -882]	[2417, 3016]	[-73, 772]	[435, 984]	[1193, 1800]

Notes: Results are for the base case ($\epsilon = 1,25$ and $\delta = 2$). The welfare change due to income fluctuations as a result of reranking and given rank are given by C1 and C2, respectively; C3 is the welfare gain due to the equalization of time averaged incomes as a result of reranking; C4 is the pure growth effect. The total welfare effect of reranking, MOB = C1+C3. Bootstrapped confidence intervals in square brackets are based on 500 replications.

All entries in the Table, except C4 for Switzerland, are significantly different from 0. As expected, C1 and C2 are negative, while C3 and C4 are positive. For all countries, the largest term in the decomposition is C3, the welfare gain due to the reranking effect on the equalization of time averaged incomes. Except for Korea, this term is substantially larger than the growth component C4; for Korea both are about the same size and their confidence intervals overlap. The negative effects due to time fluctuations, C1 and C2, are about the same size in Australia, but in Korea the cost due to reranking, C1, is significantly smaller than the cost given rank. The opposite holds true for Germany and Switzerland. Observe also that in all countries the net effect of reranking, MOB, is positive and good for at least 58 % of the total welfare gain. For countries with high growth (Australia and Korea), the growth effect is larger than the mobility effect, but the difference is only significant for Korea. For countries with low growth (Germany and Switzerland), the opposite holds true: the mobility effect is significantly larger than the growth efect.

4.2 Welfare gains and decomposition with variable number of transitions

For each of the countries, we have incomes in 9 time periods, which means that we have 8 yearly transitions. To gain insight in the importance of the number of transitions, we compute welfare gains in Table 5 and their decomposition in Figure

1 when the 9 year period is treated as one, two, four or eight transitions.

Table 5: Welfare gains 2001-2009 and the number of transitions

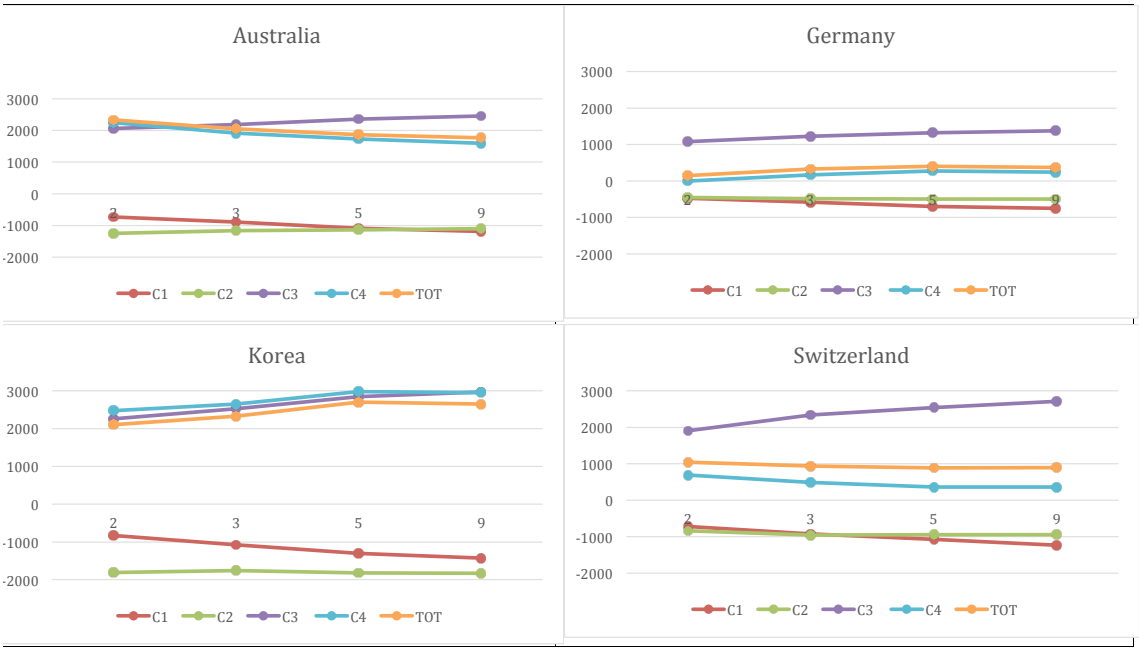
Country	Transitions			
	1	2	4	8
Aus	2333	2051	1868	1769
	[2258, 2411]	[1965, 2133]	[1766, 1962]	[1665, 1907]
Ger	147	327	399	370
	[88, 205]	[262, 396]	[326, 476]	[282, 464]
Kor	2100	2334	2702	2649
	[2010, 2194]	[2241, 2434]	[2595, 2806]	[2509, 2682]
Swi	1047	941	887	892
	[862, 1258]	[718, 1165]	[646, 1143]	[435, 984]

Notes: Results are for the base case ($\epsilon = 1,25$ and $\delta = 2$). Columns 2 to 5 give the number of transitions into which the period 2001-2009 was divided to compute the welfare gain. The Column labeled 1 considers the transition from 2001 to 2009 as one transition. Column 2 as two transitions: 2001-05-2009, Column 4 as four transition (2001-03-05-07-2009), Column 8 as eight transitions. Bootstrapped confidence intervals in square brackets are based on 500 replications.

It is striking that the welfare gain for countries behaves differently as the number of transitions is increased: for Australia the welfare gain falls uniformly as the number of transitions is increased, for Switzerland it first falls and then increases slightly, while for Korea and Germany it first increases and then falls. These changes in welfare gains as the number of transitions increases are significant, except for Switzerland. The number of transitions is relevant for the country rankings: with one transition, Australia has the largest welfare gain, with more than one transition, Korea has the largest welfare gain. Observe also that the absolute value of the change in welfare decreases as the number of transitions increases.

Looking at the components of the welfare gains in Figure 1, component C1, the cost in terms of time invariant income due to reranking decreases as the number of transitions increases, while C2, the cost due to aversion to time fluctuations given rank is almost independent of the number of transitions. The welfare gain due to the equalization of time averaged incomes, C3, increases as more transitions are considered. As C1 decreases and C3 increases, the effect of mobility on social welfare increases when the number of transitions increases. The evolution of the growth component is country specific: decreasing for Australia and Switzerland, constant for Germany and increasing for Korea.

Figure 1: Decomposition and number of transitions.



Finally, we verify that the conclusions following from our framework differ from those obtained in the standard framework, where only yearly transitions are considered. Table 6 compares the average welfare gain over 8 pairwize transitions to the average welfare gain in our framework. Figure 2 shows the yearly transitions.

Clearly, the average welfare gain over 8 pairwize transitions overestimates the absolute value of the different components of the welfare gain, except for the growth component, which is underestimated for Germany and Korea. More importantly, the ranking of countries in terms of total welfare gain is different: taking the average over pairwize transitions Australia has the largest welfare gain, while in our framework Korea comes out first.

Looking at the decomposition of yearly transitions, we see again that the largest component of the welfare gain is C3, and that C1 and C2 have about the same size, except in Korea, where C1 is smaller than C2. The size of the components differs dramatically between different countries, but seems to be fairly constant through time, although in Switzerland the equalizing effect of mobility seems to decline somewhat. As a result of the relative stability of the first three components, the fluctuations in overall pairwize welfare gain are largely driven by the growth component, C4.

Table 6: Comparison yearly transitions

	Average over 8 Pairwize transitions					
	C1	C2	C3	C4	TOT	MOB
Aus	-352	-382	749	284	299	397
	[-362, -340]	[-401, -362]	[730, 770]	[258, 312]	[279, 322]	[373, 428]
Ger	-187	-165	381	1	88	194
	[-194, -178]	[-171, -162]	[369, 393]	[-20, 17]	[15, 104]	[177, 214]
Kor	-437	-619	961	312	217	523
	[-453, -420]	[-621, -583]	[927, 993]	[266, 358]	[189, 244]	[483, 566]
Swi	-411	-384	884	99	188	473
	[-435, -379]	[-409, -367]	[837, 932]	[29, 176]	[135, 251]	[411, 546]
	Average of welfare gain over 8 periods					
	C1	C2	C3	C4	TOT	MOB
Aus	-149	-137	308	199	221	159
	[-157, -140]	[-140, -133]	[294, 322]	[179, 218]	[210, 235]	[141, 178]
Ger	-94	-62	171	30	46	78
	[-100, -88]	[-64, -60]	[164, 181]	[19, 43]	[36, 56]	[68, 89]
Kor	-179	-229	371	368	331	192
	[-192, -168]	[-238, -222]	[349, 393]	[340, 400]	[316, 346]	[164, 219]
Swi	-155	-118	339	45	111	184
	[-171, -135]	[-125, -111]	[309, 371]	[-1, 90]	[77, 145]	[149, 225]

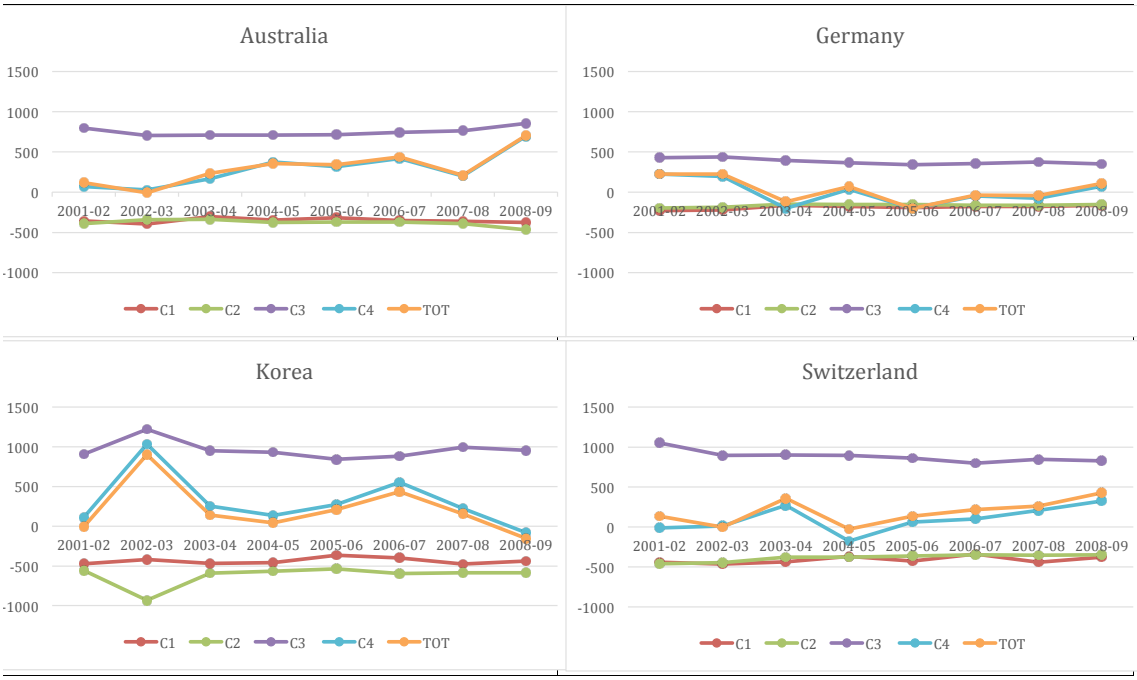
Notes: see Table 4.

4.3 Comparison with alternative approaches

In this section, we compare our results with the results obtained with alternative approaches. First, instead of computing the welfare gain using the rank dependent social welfare function (3), with weights (9), we use an iso-elastic social wefare function, as popularized by Atkinson (1970).[5] Second, as our results indicate that the largest component of the welfare gain is C3, the welfare gain due to the equalization of time averaged incomes, we compare our rankings to the rankings of the Shorrocks (1978) and Fields (2010) mobility indices that measure income mobility by the extent to which it equalizes time averaged incomes.

[5]This approach, to first compute time invariant equivalent incomes, and then the equally distributed equivalent of the distribution of time invariant equivalent incomes, was proposed in a two period framework by Creedy and Wilhelm (2002) and is equivalent to one of the recent proposals by Berger and Emmerling (2017).

Figure 2: Decomposition with yearly transitions.



The Atkinson (1970) social welfare function is given by

$$\tilde{S}(Y) = \frac{1}{n}\sum_{i=1}^{n} \frac{\left[y^{TI}(y_{i\cdot}, \epsilon)\right]^{1-\rho}}{1-\rho},$$

where ρ is a measure for inequality aversion with respect to the distribution of time invariant equivalent incomes. We measure the level of social welfare by the equally distributed equivalent income:

$$S(Y) = \left[\frac{1}{n}\sum_{i=1}^{n}\left[y^{TI}(y_{i\cdot}, \epsilon)\right]^{1-\rho}\right]^{\frac{1}{1-\rho}},$$

such that the welfare gain becomes

$$G_S(Y) = \left[\frac{1}{n}\sum_{i=1}^{n}\left[y^{TI}(y_{i\cdot}, \epsilon)\right]^{1-\rho}\right]^{\frac{1}{1-\rho}} - \left[\frac{1}{n}\sum_{i=1}^{n}\left[y_{i1}\right]^{1-\rho}\right]^{\frac{1}{1-\rho}}.$$

We then consider two well-known mobility indices that quantify the extent to which mobility equalizes time-averaged incomes: the indices proposed by Shorrocks

(1978) and Fields (2010).

Let $I(\bullet) : \mathbb{R}^n_+ \to \mathbb{R}_+$ be an inequality measure, $m_i = \frac{1}{T}\sum_{t=1}^{T} y_{it}$ time-averaged income of individual i, $\mu_t = \frac{1}{n}\sum_{i=1}^{n} y_{it}$ average income at time t, and $\mu = \frac{1}{n}\frac{1}{T}\sum_{i=1}^{n}\sum_{t=1}^{T} y_{it}$ the average of time averaged income. The Shorrocks index is defined as

$$M_S(Y) = 1 - \frac{I(m_1 \ldots, m_n)}{\frac{1}{T}\sum_{t=1}^{T}\frac{\mu_t}{\mu} I(y_{\bullet t})},$$

and equals 1 minus the inequality in time averaged income divided by the weighted average of inequality in every period. The Fields index is defined as

$$M_F(Y) = 1 - \frac{I(m_1 \ldots, m_n)}{I(y_{\bullet 1})},$$

and equals 1 minus the ratio of inequality in time averaged income divided by inequality in the first period. Clearly, if per period inequality and averaged incomes are constant, $M_S(Y)$ is equal to $M_F(Y)$. To compute the value of these indices, we only need to determine the inequality measure. Like in the main analysis, we take the single-series Gini, with $\delta = 2$.

One might observe that $G_W(Y)$ and C3 represent absolute welfare gains, while the mobility indices $M_S(Y)$ and $M_F(Y)$ measure the reduction of inequality relative to either a weighted average of inequalities or inequality in the initial income distribution. Hence, to ease comparisons, we also consider relative versions of welfare gains in this section by dividing $G_W(Y)$ and C3 by $W(\tilde{Y})$, the welfare level in the benchmark of complete immobility, defined in (5). Similarly, we also consider the relative version of our Atkinson-based welfare gain measure, dividing $G_S(Y)$ by $S(Y)$. The results are given in Table 7.

Table 7: Comparison to alternative approaches (base case)

$G_W(Y)$	$\frac{G_W(Y)}{W(\tilde{Y})}$	$G_S(Y)$	$\frac{G_S(Y)}{S(Y)}$	$\frac{C3}{W(\tilde{Y})}$	C3	$M_S(Y)$	$M_F(Y)$
		Kor				Kor	Swi
		Aus				Swi	Kor
		Swi				Aus	Aus
		Ger				Ger	Ger

Notes: The results are for the base case: $\delta = 2$ for the computation of $G_W(Y), C3, M_S(Y)$ and $M_F(Y)$, while $\rho = 1,5$ for $G_S(Y)$.

It is striking that the first five columns produce the same ranking: Korea ranks first, followed by Australia, Switzerland and Germany, while the rankings produced by C3, the Shorrocks and Field indices are different: for C3 and the

Shorrocks index, Switzerland and Australia change places, and for the Fields index, Switzerland climbs even higher in the ranking and becomes the most mobile country. This suggests that measuring the extent to which mobility equalizes time averaged income is a different exercise from measuring the extent to which mobility increases welfare and the extent to which the equalization of time averaged income contributes to the welfare gain.[6]

5 Conclusion

Most of the theoretical literature that discusses the evaluation of the distribution of income streams and income mobility uses a two-period framework. We propose a social welfare function that evaluates individuals' welfares by their time invariant equivalent income, defined over any number of periods, and aggregates their welfares on the basis of their rank in the distribution of time invariant equivalent income.

To evaluate a society's progress, we compare its level of social welfare to the value of the social welfare function in case individuals' incomes would have been stuck at their initial level. We derive conditions under which the welfare gain is positive, given the aversion to intertemporal fluctuations in individuals' incomes.

Moreover, the welfare gain is decomposable in four components. Two components can be directly related to rank mobility: a negative effect on the time fluctuations of individuals' income, and a positive effect on the distribution of time averaged incomes. The other components are a negative component due to the time fluctuations in their income (given their rank) and a pure growth effect.

We use the CNEF data from the early 2000's for Australia, Germany, Korea and Switzerland to illustrate our approach. We find that the dominance results to establish a positive welfare gain are useful, especially for low aversion to intertemporal fluctuations in income and for social welfare functions expressing inequality aversion with respect to the distribution of time invariant equivalent incomes.

The countries' ranking in terms of welfare gain for our base case mimics the ranking on the basis of absolute (and relative) income growth: the welfare gain is largest for Korea; followed by Australia, Switzerland and Germany. This ranking, however, is sensitive to the values of the parameters chosen. Especially Switzerland's ranking is sensitive to the extent of inequality aversion in the social welfare function. For higher inequality aversion, Switzerland increases in the ranking.

[6]The impact of the number of transitions on the country rankings is limited. The ranking obtained for $G_W(Y)$ only differs from the one given in Table 7 when the entire period is considered as one transition. The ranking for $G_S(Y)$, $\frac{G_W(Y)}{W(\tilde{Y})}$, $G_S(Y)$, $\frac{C3}{W(\tilde{Y})}$ and $M_S(Y)$ is independent of the number of transitions. When the number of transitions is smaller than 8, Australia and Korea change place for $M_F(Y)$. Details can be found in Appendices B and C.

The largest component in the welfare function is, for all countries, the effect of reranking on the equalization of time averaged incomes. Mobility also increases income fluctuations, and this has a negative effect on social welfare. For reasonable parameter values, the net contribution of reranking to social welfare is positive. For countries with high growth (Australia and Korea), the growth effect is larger than the mobility effect, but for countries with low growth (Germany and Switzerland), the opposite holds true. We have also shown that the effect of mobility on social welfare increases as more transitions are considered. We conclude that the contribution of mobility to social welfare should not be neglected. Finally, we have shown that our framework leads to different country rankings than the standard pairwize (usually yearly) transition framework and the Shorrocks (1978) and Fields (2010) mobility indices.

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A Biennial data

A.1 Description of the data

Apart from the yearly data for the four countries in the main text, the CNEF data also report biennial data for the US. In this Appendix we use biennial data to extend our analysis to all the countries for which income data are available. We consider Australia, Germany, Korea, Russia, Switzerland, and US. We use the 2001, 2003, 2005, 2007, 2009 waves for Australia, Germany, Switzerland, US, and Russia and the 2000, 2002, 2004, 2006 waves for Korea and check whether the conclusions in the main text hold true when these biennial data are used. The UK could not be included as we only have data up until 2006.

The unit of observation is the individual. The measure of living standards is equivalized disposable household income, which includes income after transfers and the deduction of income tax and social security contributions. Incomes are expressed in constant 2005 prices, using country and year-specific price indexes and are adjusted for differences in household size, dividing incomes by the square root of household size. They are then expressed in 2005 Purchasing Power Parity. Individuals with zero sampling weights are excluded since our measures are calculated using sample weights designed to make the samples nationally representative. We also exclude individuals with non-positive income. In line with the literature, for each wave, we drop the bottom and top 1% in the income distribution from the sample to eliminate the effect of possible outliers. Table A.1 provides some descriptive statistics about the data.

Table A.1: Descriptive Statistics

	Time Period (biennial data)	Sample Size	Mean Income Initial	Mean Income Final	Annual Growth Absolute	Annual Growth Relative
Australia	2001 to 2009	10823	23663	30090	803	3.4 %
Germany	2001 to 2009	13257	23016	23554	67	0.29 %
Korea	2000 to 2008	5464	15967	23898	991	6.2 %
Switzerland	2001 to 2139	1908	31848	33184	167	0.52 %
US	2001 to 2009	8361	32391	34783	299	0.9 %
Russia	2001 to 2009	2959	4000	7929	491	12.27 %

Notes: Absolute growth gives the average yearly increase in mean income. Relative growth gives the average yearly percentage increase in mean income.

We can see that the countries in our sample differ dramatically in terms of mean incomes and income growth. Absolute growth is highest in Korea, followed

by Australia, Russia, and US, whereas relative growth was highest in Russia, followed by Korea, and Australia. Russia has the highest growth rate, but ranks only third in terms of growth in mean incomes.

A.2 Results

We first test whether, given different values for ϵ, the actual profile of income dynamics is welfare improving compared to the benchmark of absolute immobility.

Table A.2: Welfare gains biennial data

	values for ϵ									
	0	0,25	0,5	0,75	1	1,25	1,5	2	3	5
Aus	2	2	2	2	2	2	2	2		
Ger	2	2	2	2	2	2				
Kor	1	1	1	1	2	2	2	2	2	2
Swi	2	2	2							
US	2	2	2							
Rus	2	2	2	2	2	2	2	2	2	

Notes: ϵ is the aversion to intertemporal fluctuations in individual income streams. Entry 1 (2) means that Result 1 (2) can be applied such that the actual income stream is better than the benchmark.

Table A.2 shows that Result 1 is only helpful to establish for Korea that the countries' growth dynamic improved welfare. Result 2 is clearly more powerful, and allows us to establish dominance for all countries and a larger range of values of ϵ, especially for Korea and Russia. Together, Tables A.1 and A.2 indicate that dominance is easier to obtain for countries where growth is high, such as Russia and Korea. However, observe that while Switzerland had a higher growth than Germany, we can establish dominance for a more limited range of ϵ for Switzerland than Germany. The same is true for US, this country has higher growth than Germany, but we can establish dominance only for values of ϵ between 0 and $0,5$, whereas we can establish dominance for Germany for values of ϵ between 0 and $1,25$.

Next, we ask the question which countries established the largest welfare gain compared to the immobile benchmark, using the welfare weights defined in (9). The rankings of the different countries will depend on the values of ϵ and δ. We consider the same values for the parameters as in the main text: $\epsilon = 0; 1; 1,25; 1,5$ and 3 and $\delta = 1, 2, 4$ and 8, and as base case we take $\epsilon = 1,25$ and $\delta = 2$.

Table A.3: Welfare gain rankings

	values for δ			
	1	2	4	8
$\epsilon = 0$	Kor	Kor	Kor	Kor
	Aus	Aus	Aus	Aus
	Rus	Rus	Swi	Swi
	US	Swi	Rus	US
	Ger	US	US	Rus
	Swi	Ger	Ger	Ger
$\epsilon = 1$	Kor	Kor	Kor	Aus
	Aus	Aus	Aus	Swi
	Rus	Rus	Swi	Kor
	Ger	Swi	Rus	Rus
	Swi	Ger	Ger	Ger
	US	US	US	US
$\epsilon = 1,25$	Kor	**Kor**	Kor	Aus
	Aus	**Aus**	Aus	Swi
	Rus	**Rus**	Swi	Kor
	Ger	**Swi**	Rus	Rus
	Swi	**Ger**	Ger	Ger
	US	**US**	US	US
$\epsilon = 1,5$	Kor	Kor	Kor	Swi
	Aus	Aus	Aus	Aus
	Ger	Swi	Swi	Kor
	Swi	Ger	Ger	Ger
	US	US	US	US
	Rus	Rus	Rus	Rus
$\epsilon = 3$	Kor	Kor	Aus	Swi
	Rus	Rus	Swi	Aus
	Aus	Aus	Kor	Rus
	Ger	Swi	Rus	Kor
	Swi	Ger	Ger	Ger
	US	US	US	US

Notes: ϵ is the aversion to intertemporal fluctuations in individual income streams, δ determines inequality aversion with respect to the distribution of time invariant incomes. Benchmark case in bold.

In the base case (in bold in Table A.3), the largest welfare gain compared to the immobile benchmark is found for Korea, followed by Australia, then Russia, Switzerland, Germany, and finally US. This is similar to the ranking obtained on the basis of absolute growth in mean income (see Table 1), with the only difference that US falls from the fourth position in the absolute growth ranking in mean income to the last position in the ranking of welfare gains of growth. The most remarkable feature remains that the position of Switzerland crucially depends on the inequality aversion with respect to the distribution of time invariant equivalent incomes. In particular, the rank of this country improves as δ increases. For for $\delta = 1$, Switzerland ranks among the lowest ranked countries, for $\delta = 8$ it ranks among the highest ranked. This is particularly the case for $\epsilon = 3$, where Switzerland ranks second to last for $\delta = 1$ and first for $\delta = 8$. The ranking of Korea declines somewhat if aversion with respect to intertemporal incomes increases and δ exceeds 2.

The decompositions of the welfare gains for the base case, based on Equation (11), are reported in Table A.4.

Table A.4: Decomposition results

	C1	C2	C3	C4	TOT	MOB
Aus	-1097	-1211	2434	1745	1871	1337
	[-1160, -1036]	[-1249, -1179]	[2325, 2536]	[1606, 1897]	[1792, 1960]	[1192, 1465]
Ger	-726	-523	1361	212	324	635
	[-766, -682]	[-544, -501]	[1293, 1432]	[120, 302]	[245, 398]	[547, 727]
Kor	-1314	-1833	2866	2858	2576	1552
	[-1396, -1224]	[-1888, -1779]	[2712, 3048]	[2638, 3066]	[2474, 2679]	[1360, 1764]
Swi	-1074	-942	2544	354	882	1470
	[-1190, -941]	[-1003, -885]	[2321, 2770]	[43, 686]	[667, 1112]	[1190, 1754]
US	-1617	-1672	2903	139	-247	1286
	[-1718, -1514]	[-1743, -1603]	[2684, 3122]	[-137, 407]	[-406, -102]	[1039, 1566]
Rus	-367	-836	1030	1394	1220	663
	[-396, -339]	[-866, -808]	[962, 1103]	[1303, 1479]	[1182, 1256]	[588, 742]

Notes: Results are for the base case ($\epsilon = 1,25$ and $\delta = 2$). The welfare change due to income fluctuations as a result of reranking and given rank are given by C1 and C2, respectively; C3 is the welfare gain due to the equalization of time averaged incomes as a result of reranking; C4 is the pure growth effect. The total welfare effect of reranking, MOB = C1+C3.

As expected, C1 and C2 are negative, while C3 and C4 are positive. For Russia term C4 is significantly larger than C3, for Korea the difference between C3 and C3 is not statistically significant, but for the other countries C3 is significantly larger than C4. The negative effects due to time fluctuations, C1 and C2, are not significantly different for the Switzerland and the US, for Germany C1 is significantly larger than C2, while for the other countries the cost due to reranking, C1,

is smaller than the cost given rank, C2. Observe also that in all countries the net effect of reranking, MOB, is positive and good for at least 54 % of the total welfare gain. For countries with high growth (Australia, Korea, and Russia), the growth effect is larger than the mobility effect, for countries with low growth (Germany, Switzerland, and US), the opposite holds true. Last, it is worth noticing that the actual distributional dynamics generates a statistically significant welfare gain in all countries with the exception of US. The US is the only country experiencing a statistically significant welfare loss over the 2001-2009 period; it is the only country that would have been better off if all individuals would have been stuck at their 2001 income level.

For each of the countries, we have incomes in 9 time periods, which means that we have four two-year transitions. To gain insight in the importance of the number of transitions, we compute welfare gains in Table A.5 and their decomposition in Figure A.1 when the 9 year period is treated as one, two, and four transitions.

Table A.5: Welfare gain 2001-2009 and the number of transitions

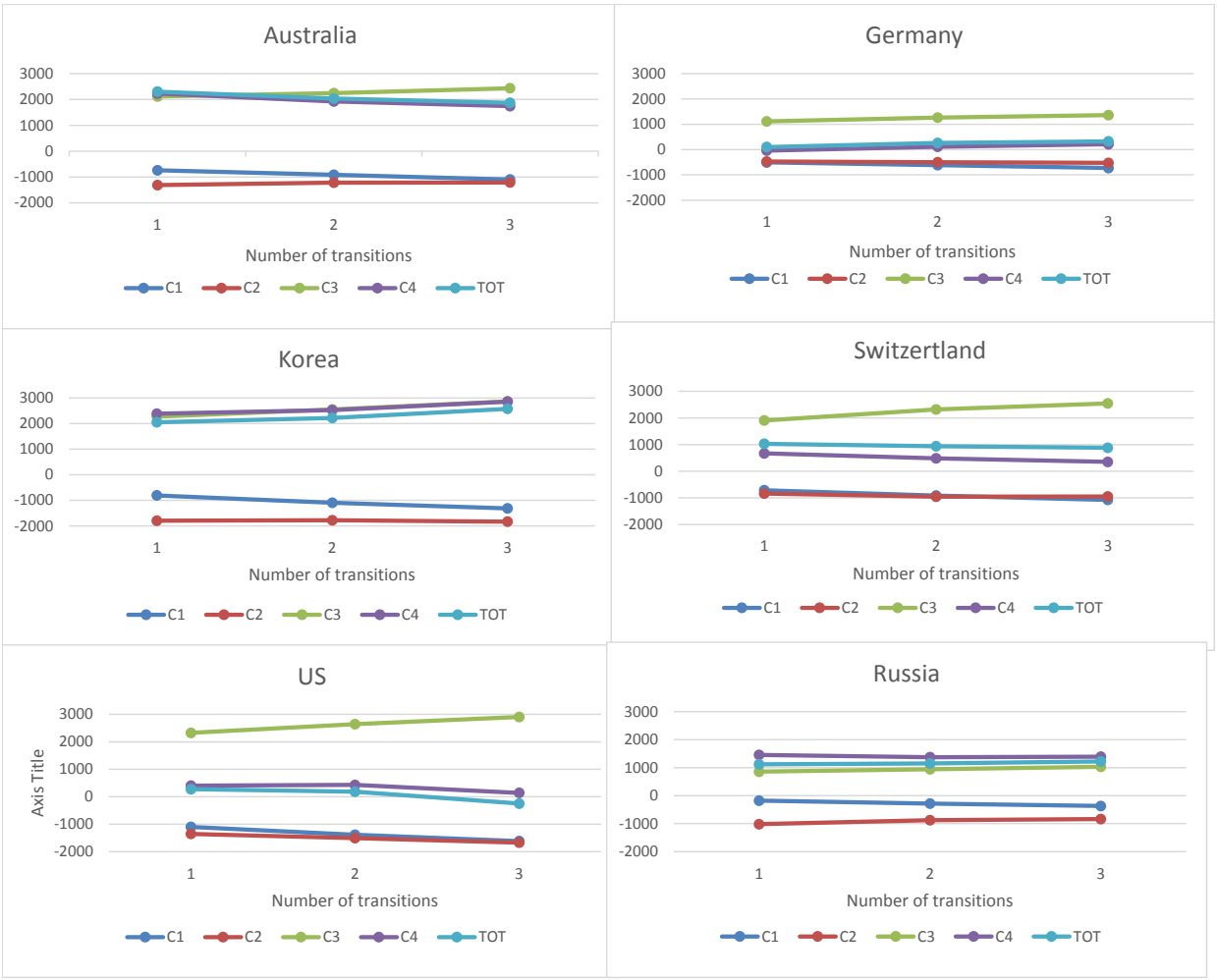
Country	Transitions		
	1	2	4
Aus	2120	2042	1871
	[2070, 2377]	[1965, 2121]	[1782, 1960]
Ger	99	260	324
	[43, 164]	[195, 325]	[245, 398]
Kor	2052	2219	2576
	[1971, 2137]	[2130, 2316]	[2474, 2679]
Swi	1028	937	882
	[846, 1227]	[697, 1152]	[667, 1112]
US	277	184	-247
	[144, 402]	[50, 326]	[-406, -102]
Rus	818	1154	1220
	[760, 1042]	[1122, 1187]	[1182, 1256]

Notes: Results are for the base case ($\epsilon = 1,25$ and $\delta = 2$). Columns 2 to 5 give the number of transitions into which the period 2001-2009 was divided to compute the welfare gain. The Column labeled 1 considers the transition from 2001 to 2009 as one transition. Column 2 as two transitions: 2001-05-2009, Column 4 as four transition (2001-03-05-07-2009).

It is striking that the welfare gain for countries behaves differently as the num-

ber of transitions is increased: for Australia, Switzerland, and US the welfare gain falls uniformly as the number of transitions is increased- for US it even becomes negative- while for Korea, Germany, and Russia it increases uniformly. The number of transitions is relevant for the country rankings: with one transition, Australia has the largest welfare gain and Germany the lowest, with more than one transition, Korea has the largest welfare gain and US the lowest.

Figure A.1: Decomposition and number of transitions.



Component C1, the cost in terms of time invariant income due to reranking decreases as the number of transitions increases, while C2, the cost due to aversion

to time fluctuations given rank is almost independent of the number of transitions. The welfare gain due to the equalization of time averaged incomes, C3, increases as more transitions are considered. As C1 decreases and C3 increases, the effect of mobility on social welfare increases when the number of transitions increases. The evolution of the growth component is country specific: decreasing for Australia, Switzerland, US, and Russia and increasing for Germany and Korea.

Finally, we verify that the conclusions following from our framework differ from those obtained in the standard framework, where only yearly transitions are considered. Table A.6 compares the average welfare gain over four pairwize transitions to the average welfare gain in our framework. Figure A.2 shows the biennial transitions.

Clearly, the average welfare gain over 4 pairwize transitions overestimates the absolute value of the different components of the welfare gain. More importantly, the ranking of countries in terms of total welfare gain is different: taking the average over pairwize transitions Australia has the largest welfare gain, while in our framework Korea comes out first.

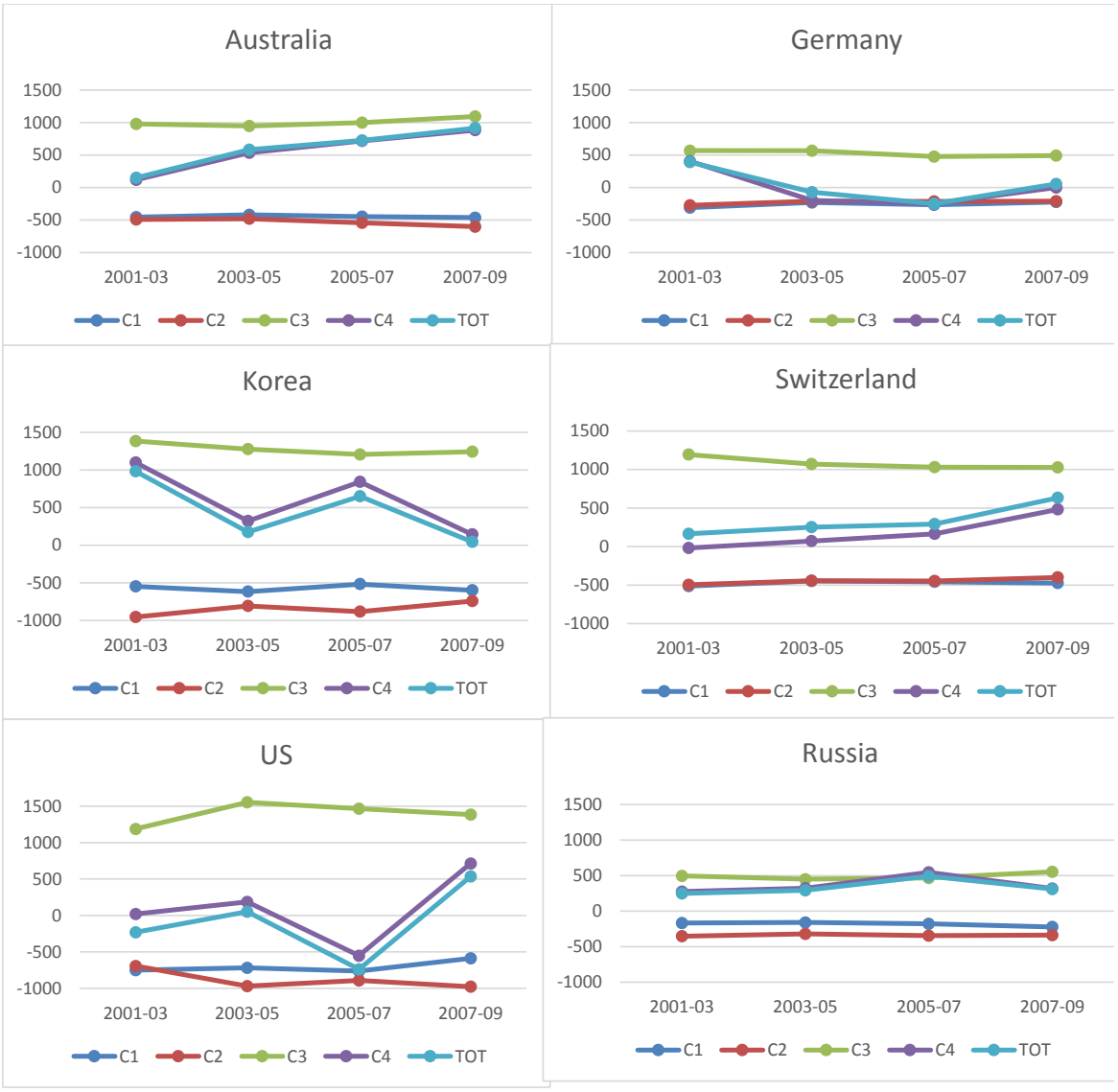
Looking at the decomposition of pairwize transitions, we see again that the largest component of the welfare gain is C3 in all countries. The confidence intervals of C1 and C2 overlap for Australia. Germany is the only country for which C1 is significantly larger than C2; for Switzerland the two are not significantly different, and for the other countries C1 is significant larger than C2. The size of the components differs dramatically between different countries, but the first three seem to be fairly constant through time, although in Switzerland the equalizing effect of mobility appears to decline somewhat. As a result of the relative stability of the first three components, the fluctuations in overall pairwize welfare gain are largely driven by the growth component, C4.

Table A.6: Comparison biennial transitions

	Average over 4 pairwize biennial transitions					
	C1	C2	C3	C4	TOT	MOB
Aus	-446	-529	1004	563	592	558
	[-464, -430]	[-543, -515]	[975, 1036]	[519, 611]	[564, 623]	[517, 598]
Ger	-257	-227	525	-10	32	269
	[-269, -243]	[-233, -220]	[505, 545]	[-41, 18]	[10, 54]	[241, 298]
Kor	-571	-846	1278	602	463	707
	[-605, -547]	[-876, -819]	[1217, 1327]	[537, 689]	[418, 500]	[620, 770]
Swi	-473	-447	1080	175	335	607
	[-504, -430]	[-476, -416]	[1005, 1150]	[79, 263]	[270, 406]	[513, 702]
US	-704	-883	1399	93	-95	695
	[-735, -671]	[-913, -852]	[1326, 1460]	[6, 179]	[-147, -42]	[601, 778]
Rus	-182	-339	492	365	336	309
	[-192, -172]	[-352, -325]	[468, 514]	[335, 397]	[321, 352]	[281, 337]
	Average biennial welfare gain over 8 years					
	C1	C2	C3	C4	TOT	MOB
Aus	-274	-303	609	436	468	334
	[-290, -260]	[-312, -295]	[581, 634]	[402, 474]	[446, 490]	[298, 366]
Ger	-187	-131	340	53	81	159
	[-191, -170]	[-136, -125]	[323, 358]	[30, 76]	[61, 100]	[137, 182]
Kor	-329	-458	717	715	644	388
	[-349, -306]	[-472, -445]	[678, 762]	[659, 766]	[619, 670]	[340, 441]
Swi	-269	-236	636	89	221	368
	[-297, -235]	[-251, -221]	[580, 692]	[11, 172]	[167, 278]	[297, 437]
US	-404	-418	726	35	-62	322
	[-430, -379]	[-436, -401]	[671, 781]	[-34, 102]	[-102, -26]	[260, 391]
Rus	-92	-209	258	349	305	166
	[-99, -85]	[-217, -202]	[240, 276]	[326, 370]	[296, 314]	[147, 185]

Notes: see Table A.4.

Figure A.2: Decomposition with pairwise transitions



B Atkinson social welfare function

In this Appendix, we look into the results obtained for the Atkinson social welfare function and the welfare gain due to mobility it implies. Table B.1 reports the countries' welfare gain rankings for the same values of ϵ as in Table 3 and for different values of ρ. As base case for the latter we take $\rho = 1,5$, which is close to estimates from the survey literature (see, e.e. Evans, 2005), and often yields a ranking of income distributions similar to the Gini coefficient. Comparing the base cases of the two tables, we see that this is also the case here: Korea has the largest welfare gain, followed by Australia, then Switzerland and, finally, Germany.

When parameters change, we see that the rankings change in a similar way as for the rank-ordered approach. Given ϵ, increasing ρ improves the position of Switzerland. Korea always ranks first, except when $\rho = 6$. These results are entirely in line with the ones discussed for the rank-ordered approach.

The Atkinson welfare gain is not decomposable in terms similar to ones in the decomposition (11) obtained for the rank-ordered social welfare function. We can, however, similar to the exercise in Table 5, investigate how the welfare gains change when the number of transitions increases. This is done in Table B.2. Just like in Table 5, we see that the welfare gain for Australia and Switzerland falls uniformly as the number of transitions is increased, while for Germany it first increases and then falls. The only differences are that, when the number of transitions increases from 4 to 8, the welfare gain of Korea does not fall, and the welfare gain of Switzerland continues to fall, but neither of these two evolutions is statistically significant. Contrary to Table 5, the welfare ranking is independent of the number of transitions, but as the evolutions for the countries is different, it is clear that this is not a general property of this approach. Actually, the rankings are the same as in Table 5, except when $\delta = 1$ when Australia ranks above Korea.

Table B.1: Welfare gain rankings

	values for ρ					
	0,25	0,5	1	1,5	3	6
$\epsilon = 0$	Kor	Kor	Kor	Kor	Kor	Aus
	Aus	Aus	Aus	Aus	Aus	Kor
	Ger	Ger	Swi	Swi	Swi	Swi
	Swi	Swi	Ger	Ger	Ger	Ger
$\epsilon = 1$	Kor	Kor	Kor	Kor	Kor	Aus
	Aus	Aus	Aus	Aus	Aus	Kor
	Ger	Ger	Swi	Swi	Swi	Swi
	Swi	Swi	Ger	Ger	Ger	Ger
$\epsilon = 1,25$	Kor	Kor	Kor	**Kor**	Kor	Swi
	Aus	Aus	Aus	**Aus**	Aus	Aus
	Ger	Ger	Ger	**Swi**	Swi	Kor
	Swi	Swi	Swi	**Ger**	Ger	Ger
$\epsilon = 1,5$	Kor	Kor	Kor	Kor	Kor	Swi
	Aus	Aus	Aus	Aus	Aus	Aus
	Ger	Ger	Ger	Swi	Swi	Kor
	Swi	Swi	Swi	Ger	Ger	Ger
$\epsilon = 3$	Kor	Kor	Kor	Kor	Kor	Swi
	Aus	Aus	Aus	Aus	Aus	Aus
	Ger	Ger	Ger	Swi	Swi	Kor
	Swi	Swi	Swi	Ger	Ger	Ger

Notes: ϵ is the aversion to intertemporal fluctuations in individual income streams, ρ determines inequality aversion with respect to the distribution of time invariant incomes. Benchmark case in bold.

Table B.2: Welfare gain 2001-2009 and the number of transitions

Country	Transitions			
	1	2	4	8
Aus	2533	2280	2128	2025
	[2435, 2631]	[2175, 2388]	[1994, 2245]	[1890, 2146]
Ger	171	382	495	465
	[93, 248]	[300, 462]	[396, 579]	[371, 563]
Kor	2570	2868	3160	3288
	[2448, 2704]	[2721, 3030]	[3153, 3486]	[3137, 3477]
Swi	1068	925	812	811
	[800, 1323]	[621, 1249]	[493, 1149]	[461, 1182]

Notes: Results are for the base case ($\epsilon = 1,25$ and $\rho = 1,5$). Columns 2 to 5 give the number of transitions into which the period 2001-2009 was divided to compute the welfare gain. The Column labelled 1 considers the transition from 2001 to 2009 as one transition. Column 2 as two transitions: 2001-05-2009, Column 4 as four transition (2001-03-05-07-2009), Column 8 as eight transitions.

C Mobility as equalizing time averaged income: alternative measures

Panel (a) in Table C.1 shows that for the Shorrocks index $M_S(Y)$, the same ranking of countries is obtained, irrespective of the number of transitions considered: Korea is the most mobile country, followed by Switzerland, Australia and Germany. Panel (b) shows, for the base case with 8 transitions, that the Fields mobility index $M_F(Y)$ produces a different ranking. Switzerland is always the most mobile country, and the difference with the other countries is always statistically significant. If the number of transitions is eight, Switzerland is followed by Korea, Australia and Germany. With fewer transitions, Korea and Australia change places in the ranking, and for two or one transitions, the difference between them is statistically significant.

We can compare these results with the findings for our welfare gain $G_W(Y)$. Table 5 shows the country rankings when the number of transitions increases. For the base case, with 8 transitions, Korea is ranked first, followed by Australia, Switzerland and Germany. If the entire period is considered as one transition, Korea and Australia change places in the ranking.

As term C3 in our decomposition measures the welfare gain due to the equalizing effect of rank mobility on time averaged incomes, it is useful to compare the rankings of the mobility indices also with the rankings produced by C3. Figure 1 shows three features. First, C3 increases as the number of transitions increases. Table C.1 shows that the Shorrocks and Fields mobility indices follow the same pattern. Moreover, the increase in the indices is statistically significant, except for Germany in panel (b). Second, C3 is largest for Korea, followed by Switzerland, Australia and Germany.[7] Third, Germany has the smallest value for C3. It turns out that the difference with the other countries is always statistically significant. This also occurs in Table C.1. Germany is the country where the equalizing effect of mobility on the distribution of time averaged income is smallest.

The comparison with C3 (or the overall welfare gain) might be a bit strange, as the mobility indices $M_S(Y)$ and $M_S(Y)$ are comparing inequality to a weighted average of inequality in every period, or to inequality in the first year, while $G_W(Y)$ and C3 are absolute welfare gains. The following Table therefore normalizes $G_W(Y)$ and C3 by dividing them by $W(\tilde{Y})$, the welfare level in the benchmark. After normalization, both $G_W(Y)$ and C3 rank the countries in the same way as $G_W(Y)$.

[7]Except when the entire period is considered as one transition. In that case component C3 is larger for Australia than for Switzerland.

Table C.1: Alternative mobility indices and the number of transitions

Panel (a) Shorrocks' (1978) mobility index

Country	Transitions			
	1	2	4	8
Aus	0.129	0.141	0.145	0.148
	[0.124, 0.133]	[0.137, 0.146]	[0.141, 0.149]	[0.144, 0.153]
Ger	0.094	0.101	0.105	0.106
	[0.090, 0.098]	[0.097, 0.104]	[0.101, 0.108]	[0.103, 0.110]
Kor	0.136	0.158	0.179	0.192
	[0.130, 0,143]	[0.152, 0.166]	[0.175, 0.189]	[0.185, 0.198]
Swi	0.131	0.156	0.164	0.168
	[0.121, 0.142]	[0.146, 0.166]	[0.155, 0.175]	[0.159, 0.180]

Panel (b) Fields' (2010) mobility index

Country	Transitions			
	1	2	4	8
Aus	0.130	0.145	0.144	0.146
	[0.122, 0.139]	[0.137, 0.153]	[0.135, 0.155]	[0.138, 0.156]
Ger	0.060	0.067	0.068	0.071
	[0.051, 0.067]	[0.058, 0.075]	[0.058, 0.077]	[0.062, 0.080]
Kor	0.091	0.107	0.139	0.152
	[0.075, 0.107]	[0.091, 0.123]	[0.125, 0.157]	[0.136, 0.168]
Swi	0.161	0.187	0.200	0.206
	[0.146, 0.178]	[0.169, 0.205]	[0.180, 0.218]	[0.187, 0.226]

Notes: Columns 2 to 5 give the number of transitions into which the period 2001-2009 was divided to compute the welfare gain. The Column labelled 1 considers the transition from 2001 to 2009 as one transition. Column 2 as two transitions: 2001-05-2009, Column 4 as four transition (2001-03-05-07-2009), Column 8 as eight transitions. Bootstrapped confidence intervals in square brackets are based on 500 replications.

Table C.2: Normalized welfare gains and the number of transitions (base case)

Panel (a) Total normalized welfare gain

Country	Transitions			
	1	2	4	8
Aus	0.136	0.120	0.109	0.103
Ger	0.008	0.018	0.023	0.021
Kor	0.193	0.214	0.239	0.243
Swi	0.044	0.039	0.037	0.037

Panel (b) Normalized C3 component

Country	Transitions			
	1	2	4	8
Aus	0.120	0.128	0.138	0.144
Ger	0.061	0.069	0.075	0.077
Kor	0.207	0.232	0.264	0.273
Swi	0.079	0.097	0.106	0.113

Notes: Columns 2 to 5 give the number of transitions into which the period 2001-2009 was divided to compute the welfare gain. The Column labeled 1 considers the transition from 2001 to 2009 as one transition. Column 2 as two transitions: 2001-05-2009, Column 4 as four transition (2001-03-05-07-2009), Column 8 as eight transitions. Bootstrapped confidence intervals in square brackets are based on 500 replications.