Convergence across the Swedish counties, 1911–1993

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Abstract

This paper finds strong and robust evidence of convergence in per capita income across the twenty-four Swedish counties, 1911–1993. In contrast to most previous studies on regional convergence this study adjusts incomes to account for regional differences in the cost of living. The main conclusion is that using adjusted incomes as opposed to non-adjusted incomes does not qualitatively change the results on convergence for the Swedish counties. However, a quantitative difference is that estimated speeds of convergence are higher and the standard deviation of the log of per capita income is lower when adjusted incomes are used, which is consistent with cross-country evidence. © 1997 Elsevier Science B.V.

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1. Introduction

One of the most debated issues in the economic growth literature during the last ten years is whether per capita incomes in different countries are converging. In their seminal papers both Romer (1986) and Lucas (1988) cite the lack of observed cross-country convergence as evidence against the neoclassical model and in favor of their theories of endogenous growth. Since then numerous cross-country studies (e.g. Barro, 1991; Mankiw et al., 1992) find a negative
relationship between initial per capita income and subsequent growth in per capita income after having controlled for other variables that affect per capita income growth. In other words, these studies find conditional \( \beta \)-convergence, which is the prediction of the neoclassical model. Moreover, Barro and Sala-i-Martin (1991, 1992, 1995) find absolute \( \beta \)-convergence across regions in the U.S. and in a number of other countries, i.e. they find that poorer regions tend to grow faster than richer ones in per capita terms without including conditioning variables. Barro and Sala-i-Martin argue that the differences with respect to variables that determine economies' steady states, i.e. with respect to preferences, technology and institutions, are likely to be smaller for regions within countries than across countries, which should then explain their findings of absolute \( \beta \)-convergence across regions.

However, \( \beta \)-convergence is not only consistent with the neoclassical growth model but also with some endogenous growth models. There are one-sector models that generate both endogenous steady-state growth and exhibit convergence due to diminishing returns to capital. Furthermore, two-sector models, such as the Lucas–Uzawa model, could fit the regression statistics on convergence given that the initial per capita income of an economy is correlated with the degree of imbalance among the sectors (Barro and Sala-i-Martin, 1995, ch. 5). Moreover, a class of growth models that is often put forward as an explanation for convergence is models of technological diffusion. On the other hand, \( \beta \)-convergence is not consistent with one-sector AK-models (see Sala-i-Martin, 1994).

A related but different concept of convergence is \( \sigma \)-convergence. It deals with how the distribution of income across economies evolves over time whereas \( \beta \)-convergence deals with the mobility of income within the same distribution. \( \beta \)-convergence is a necessary but not a sufficient condition for \( \sigma \)-convergence (for a discussion of the concepts of convergence see Sala-i-Martin, 1995).

The main purpose of this paper is to test for absolute \( \beta \)-convergence and to study \( \sigma \)-convergence in per capita income across the twenty-four Swedish counties during the period 1911–1993. This paper will also discuss the effects of interregional migration on convergence. As opposed to most studies on regional convergence, this paper adjusts incomes for differences in price levels across regions. On the other hand, like most of the empirical literature on convergence, this paper does not attempt to discriminate between different growth models that predict \( \beta \)-convergence.

The remainder of the paper is organized in the following way: Section 2 describes the data set and the method of cost of living adjustment. Section 3 presents the empirical results. Section 4 concludes.

2. Data description and the cost of living adjustment

The analysis in this paper is based on data on per capita income for the twenty-four Swedish counties, 1911–1993 (Fig. 1). Annual observations for the
years 1911–1912, 1916 and 1919–1993 are used. The income concept is gross per capita income net of taxable government transfers. However, prior to 1919 the income concept is taxable income net of taxable government transfers. The analysis starts in 1911 because before 1911 certain major sources of agricultural income were not taxable.

As is the case for many other countries, there exist no regional price indices for Sweden. To get a more accurate representation of each county’s per capita income the incomes are, however, adjusted for regional differences in cost of living. Previous regional convergence studies (e.g. Barro and Sala-i-Martin, 1991, 1992, 1995)
1995) tend not to adjust for these differences. The cost of living adjustment utilized in this paper is mainly based on the cost of housing, since the regional price differences on goods that are of more tradable nature (e.g. foodstuffs and fuels), although positively correlated with the cost of housing and per capita income, are small. Even in the beginning of the sample period when transportation costs might have been relatively more important for the regional price determination than they are in more recent years, these price differences are small.

There exist regional data on retail prices for foodstuffs and fuels as well as on rents from the very start of the sample period. Expenses on these items constitute 67% (51% for foodstuffs and fuels and 16% for housing) of the total expenses in the first standard consumer budget, i.e. the budget that is used in the first official national cost of living index of 1914. This budget has the intention of reflecting the consumption pattern of a ‘normal family’ of the working class or lower middle class living in a town or built-up area. The weight of foodstuffs, fuels and housing in the national cost of living index and in the consumer price index (CPI), that is introduced in 1954, falls over time due to a diminishing foodstuffs budget. However, the weight of these items is almost 50% percent or more throughout the whole sample period.

We can see from a simple analysis of our data that the price differences for foodstuffs and fuels over regions are in fact small. Table 1 shows the average retail price level and the cost of a standard budget of foodstuffs and fuels in six or seven geographical regions during the period 1911–1989. The price level is calculated as an unweighted average across the goods that represent the whole foodstuffs and fuels budget. The weights of the foodstuffs and fuels budget are assumed to be the same across regions but are different for the different years presented in Table 1. Table 1 shows that using the unweighted average price level or the cost of a standard budget gives about the same picture; the cost of living differences for foodstuffs and fuels are small as well as decreasing over time. These results are not dependent upon the selected years. The regional comparison of Table 1 may perhaps appear unsatisfactory, since it is based on geographical areas larger than the county-level, which is the unit of analysis in this paper. However, a comparison based on retail prices in the county capitals shows the same basic pattern.

A suitable measure of the cost of housing remains to be developed which has a number of practical problems. This study uses rents and the average sales price of 

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2 This section is based on the Royal Social Board (1914, 1933, 1961), Myrdal (1933) and Statistics Sweden. Consumer prices and index computations, various issues.

3 For example, in 1911 Stockholm was the most expensive capital with index numbers of 108.5 for the average price level and 108.3 for the cost of the budget. The least expensive capital (county no. 6) had the index numbers 94.7 and 91.8. The standard deviations were 3.7 and 4.2, respectively. Source: Own calculations based on the Royal Social Board (1914), Table 2. In a few cases the capital is not the county’s largest city. In those cases price data of the largest city is used.
Table 1
Retail prices and the cost of a standard budget of foodstuffs and fuels across regions (average across regions = 100)*

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockholm</td>
<td>107.6</td>
<td>107.7</td>
<td>105.6</td>
<td>104.9</td>
<td>102.9</td>
<td>101.9</td>
<td>101.5</td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>96.5</td>
<td>97.2</td>
<td>99.4</td>
<td>98.0</td>
<td>100.9</td>
<td>100.5</td>
<td>100.2</td>
<td></td>
</tr>
<tr>
<td>Southeast</td>
<td>96.3</td>
<td>95.6</td>
<td>96.3</td>
<td>96.1</td>
<td>97.9</td>
<td>97.5</td>
<td>99.9</td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>99.3</td>
<td>97.4</td>
<td>98.2</td>
<td>96.1</td>
<td>95.4</td>
<td>96.7</td>
<td>100.5</td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>98.9</td>
<td>98.8</td>
<td>97.3</td>
<td>96.9</td>
<td>99.3</td>
<td>99.1</td>
<td>99.1</td>
<td></td>
</tr>
<tr>
<td>Lower North</td>
<td>—</td>
<td>—</td>
<td>99.7</td>
<td>99.6</td>
<td>99.1</td>
<td>100.0</td>
<td>99.5</td>
<td></td>
</tr>
<tr>
<td>Upper North</td>
<td>101.5</td>
<td>103.3</td>
<td>103.6</td>
<td>106.0</td>
<td>104.6</td>
<td>104.3</td>
<td>99.3</td>
<td></td>
</tr>
<tr>
<td>Standard Dev.</td>
<td>4.2</td>
<td>4.6</td>
<td>3.4</td>
<td>4.1</td>
<td>3.1</td>
<td>2.6</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

* The table is based on retail prices for 48 goods in 27 towns (including all counties) for 1911. The number of localities from which price data was collected is higher for 1931 and 1959. Also rural areas are included in 1959. The number of goods also varies somewhat between the years, but all major items of the foodstuffs and fuels budget are always represented. The data for 1989 is, however, only based on consumer prices for foodstuffs. The regions consist of the following counties (see Fig. 1 for county numbers): East: 2, 3, 17 and 18; Southeast: 5, 6, 7 and 8; South: 9, 10, 11 and 12; West: 13, 14 and 15; Lower North: 16 and 19 and Upper North: 20, 21, 22, 23 and 24. In 1911 Lower North is part of Upper North. Sources: Own calculations based on the Royal Social Board (1914, table 1), Royal Social Board (1961, table B8) and Skedinger (1991).

family houses as proxies for the counties’ cost of housing. For the first half of the sample period, two different rents (excluding heating costs) are used; (1) the average rent per room in the county capitals and (2) a weighted average for one room and kitchen (without central heating) based on the average rent in the capitals and the average rent in the rural areas. The weights are given by the proportion of the population living in towns and in rural areas, respectively. In the subsequent text these two rents are called urban rent and county rent. The data is taken from the Housing Census (Royal Social Board, Housing census, various issues) and the related Census of Rent (Royal Social Board, Census of rent, various issues) 4. Data on rents in the rural areas is only available in the Housing Census.

4 One room and kitchen is the most common form of housing in both towns and rural areas. Moreover, the data on rent per room in the capitals is adjusted for regional differences in the availability of central heating. It can be noted that the dispersion of the rent per room defined in this way is basically identical to the dispersion of the rent for one room and kitchen (without central heating) across the capitals. In those few cases where the capital is not the county's largest city, the rent of the largest city is used. Data on average rents in the cities is available for the years 1912–1913, 1924–1925, 1928–1929, 1933–1934, 1939–1940, and 1945–1946. For years that data is not available the rents of the most adjacent period are used to adjust incomes.
Census of 1912–1914 and of 1939–1940. This data is based on non-agricultural households. Agricultural households that rent housing typically also rent a piece of land for cultivation. Since it is hard to separate the cost of land from the cost of housing, agricultural households are not included in the statistics (Royal Social Board, Housing Census 1912–1914, ch. III:B4).

A priori, the county rent would appear to be the best proxy for the cost of housing across counties since it is broader in coverage. Especially, considering that about 68% of the population in 1912–1913 lived in so-called rural areas and that the proportion living in rural areas varied greatly across counties makes the county rent preferable. However, one main problem with the statistics on rents in the rural areas, at least for the years 1912–1913, is that it is partly based on employer-owned housing: about one fifth of the households covered by the inquiry in 1912–1913 lived in such housing. In the towns this practice had been largely abandoned. The rents observed for employer-owned housing tend to be lower than rents paid for regular housing of similar standard. These tenants should nevertheless have born the whole cost of their housing through lower money wages. Because of the presence of employer-owned housing in the statistics (at least for 1912–1913), the difference between rents in towns and in rural areas is likely to be exaggerated. As a result, the dispersion of the county rent should tend to overestimate the true dispersion of the cost of housing across counties. On the other hand, not taking into account the lower cost of housing in the countryside by using the urban rent should tend to underestimate the true dispersion. It turns out, however, that the results on convergence are fairly insensitive to whether the proxy for the cost of housing is based on rents in the rural areas or not.

In 1942 a rent control was introduced, a version of which is still in place in the market for leased apartments. Since rent controls over time tend to generate extensive illegal trading, the official statistics on rents, during the era of rent control, are less useful in providing a good proxy for the cost of housing across regions. Therefore, for the period after 1946, the average sales price of permanent one- and two-family houses in the counties is used as a proxy for the cost of housing. This market is not subject to any price controls. The first observation available is an average for the period 1952–1956. Annual data is available from 1957. The data on sales prices corresponds rather closely to the data on rents; for example, the correlation between the average sales price in 1952–1956 and the

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5 About 48% of the total population was engaged in agricultural activities. For the counties this share ranged from 18% for Stockholm to 76% for the most agricultural county.

6 The average rent in the rural areas is about 50% of the rent in the corresponding capital for most counties in 1912–1913. For one room and kitchen the correlation between the rent in the capital and the rent in the rural areas is 0.7. The corresponding figures for 1939–1940 are 60% and 0.7.

urban rent in 1945–1946 is 0.74 and the coefficients of variation of these two variables are about the same, 15.6%, which also is the lowest value of the whole sample period.

Table 2 shows the cost of housing across larger geographical regions. Columns 1 and 3 present data on the county rent, whereas columns 2 and 4 present data on the average rent in the capitals. Table 2 shows that the cost of housing differs substantially across regions throughout the whole sample period. The magnitudes are such that the cost of housing play a much larger role for the regional differences in cost of living than the price differences on foodstuffs and fuels do, even though expenditures on foodstuffs and fuels, during most of the sample period, carry a larger weight than housing expenditures in the national cost of living and consumer price indices. The last row of Table 2 presents the standard deviation of the relative cost of housing across the twenty-four counties (that is, the coefficient of variation of the cost of housing across the counties). The standard deviation falls from 38.1 in 1912–1913 to 25.8 in 1993 if the data in column 1 is used, whereas the dispersion stays fairly constant if the data in column 2 is used.

To adjust incomes the weight of housing in the national cost of living index and in the CPI is used. The weight of housing is fairly constant over time, on average.

Table 2
The cost of housing across regions, (average across regions = 100)

<table>
<thead>
<tr>
<th>Region</th>
<th>1912–1913</th>
<th>1939–1940</th>
<th>1960</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>county rent</td>
<td>urban rent</td>
<td>county rent</td>
<td>urban rent</td>
</tr>
<tr>
<td>Stockholm</td>
<td>198.5</td>
<td>164.2</td>
<td>170.3</td>
<td>147.7</td>
</tr>
<tr>
<td>Gothenburg</td>
<td>127.2</td>
<td>113.7</td>
<td>121.8</td>
<td>108.9</td>
</tr>
<tr>
<td>Malmöhus</td>
<td>99.7</td>
<td>95.7</td>
<td>101.6</td>
<td>95.2</td>
</tr>
<tr>
<td>East</td>
<td>92.5</td>
<td>98.9</td>
<td>96.4</td>
<td>99.3</td>
</tr>
<tr>
<td>Southeast</td>
<td>60.3</td>
<td>67.4</td>
<td>72.2</td>
<td>78.6</td>
</tr>
<tr>
<td>Southwest</td>
<td>57.9</td>
<td>66.7</td>
<td>71.4</td>
<td>78.7</td>
</tr>
<tr>
<td>Lower North</td>
<td>75.8</td>
<td>86.4</td>
<td>79.6</td>
<td>89.3</td>
</tr>
<tr>
<td>Upper North</td>
<td>88.1</td>
<td>107.1</td>
<td>86.7</td>
<td>102.3</td>
</tr>
<tr>
<td>Standard Dev.</td>
<td>38.1</td>
<td>21.9</td>
<td>26.6</td>
<td>19.0</td>
</tr>
</tbody>
</table>

The cost of housing in the regions is calculated as an unweighted average across the counties included in the regions. The rents refer to one room and kitchen (without central heating and excluding heating cost). The county rent is based on the average rent in the county capitals and the average rent in the rural areas, weighted with the proportion of the population living in towns and in rural areas, respectively. The urban rent refers to the average rent in the capitals. The standard deviations are based on values for the twenty-four counties. The regional grouping differs somewhat from the one in Table 1. Stockholm, Gothenburg and Malmöhus are the counties of the larger metropolitan areas. The other regions consist of the following counties; East: 2, 3, 4, 17 and 18; Southeast: 5, 6, 7, 8 and 9; Southwest: 10, 12, 14 and 15; Lower North: 16, 19 and 20 and Upper North: 21, 22, 23 and 24.
about 17% (it ranges from 14% in 1943 to 21% in 1990). Also across the counties the share of income spent on housing is fairly constant. For example, the standard deviation across the capitals of the average share of a family's gross income spent on housing is only 1.3% around a mean of 15% in 1912–1913 (Royal Social Board, Housing Census 1912–1914, table 11).

For our purposes, a constant share of 20% over time and across counties is assumed when adjusting incomes. 20% is a few percentage points higher than the actual values during the first part of the sample period which is a way to take into account the regional price differences on foodstuffs and fuels since they are positively correlated with the cost of housing. For example, the correlation across counties between the average price level (cost of budget) of foodstuffs and fuels in 1911 and the urban rent in 1912–1913 is 0.63 (0.74). For those goods and services that have not been subject to study, due to lack of data, it is assumed that their prices do not differ across counties.

3. Empirical results

3.1. β-convergence

Per capita incomes differ substantially across counties in the beginning of the sample period. In 1911 the real per capita income adjusted for regional differences in cost of living, based on the urban rent, is around 8600 kronor in the richest county, Stockholm, whereas it is only about 1600 kronor in the poorest county, all measured in 1980 prices. As a comparison, if incomes are not adjusted for regional differences in cost of living, then the real per capita income in Stockholm is about 10,100 for the same year.

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8 The average is based on the cost of living budgets for the years 1913–1914, 1931 and 1943, and on the CPI weights for every ten years, i.e. for 1960, 1970, 1980 and 1990 (sources: Royal Social Board, 1933, 1961; Statistics Sweden, Consumer prices and index computations, various issues). Furthermore, the housing censuses of 1912–1914, 1933, 1939–1940 and 1945 provide data on the average share of a family's gross income spent on housing; these figures are very similar to the weights in the cost of living index. For the post-war period it is less transparent what weights to use for the adjustment. The prices used in the CPI include VAT but exclude subsidies. Consumption of housing has, however, been heavily subsidized in various ways in Sweden since the mid-40's. As a result, the weights in the CPI might not be a bad proxy for the how much of gross income is spent on housing, since some of the taxes finance the housing subsidies.

9 The factor of adjustment is given by $z_{it} = \left(\frac{p_i}{\bar{p}_t}\right) - 1 \cdot 0.2 + 1$, where $p_i$ is county $i$'s cost of housing at time $t$, $\bar{p}_t$ is the average cost of housing across counties at time $t$. For example, for a county $i$, whose cost of housing at time $t$ is twice as high as the average, $z_{it}$ is 1.2. The adjustment is done by dividing county $i$'s real per capita income, deflated by the CPI, at time $t$ by $z_{it}$.

10 The correlation between the average price level (cost of budget) of foodstuffs and fuels in 1930 and the urban rent in 1928–1929 is 0.65 (0.68). Source: Own calculations based on the Royal Social Board (1933), Table 2. For the larger regional groupings as in Table 1, the correlation for 1959 is somewhat lower, 0.52 (0.42). Moreover, the correlation across counties between the cost of the foodstuffs budget and the cost of housing is 0.50 in 1989.
To test for absolute $\beta$-convergence we estimate the basic regression equation

$$\begin{align*}
\frac{1}{T} \cdot \log\left( \frac{y_{it}}{y_{i,t-T}} \right) &= a - \left[ \frac{1 - e^{-\beta \cdot T}}{T} \right] \cdot \log y_{i,t-T} + u_{it},
\end{align*}$$

following Barro and Sala-i-Martin (1991, 1992, 1995). $y_{it}$ and $y_{i,t-T}$ are county $i$'s per capita income at time $t$ and at time $t - T$, respectively. $a$ is the intercept and $\beta$ is the rate of convergence parameter. A positive value of $\beta$ implies convergence and a higher value of $\beta$ corresponds to a faster convergence rate. $u_{it}$ is the disturbance term. Table 3 shows the nonlinear least-squares estimates of $\beta$. The standard errors of the estimates of $\beta$ are given in parentheses and the standard errors of the regressions are given in brackets. Column 1 shows the estimates of $\beta$ when incomes are adjusted for regional differences in cost of living (based on the urban rent during the first half of the sample period). For the period 1911–1993 the estimate of $\beta$ is 0.0417 (s.e. = 0.0080). The good fit, a $R^2$ value of 0.99, can also be seen in Fig. 2, which plots the average annual per capita income growth rates between 1911 and 1993 against the log of per capita incomes in 1911. The results on convergence for the period 1911–1993 do not change much if the county rent is used to adjust income in 1911. In this case the estimate of $\beta$ is only marginally lower, 0.0404 (0.0077). The $R^2$ value of this regression is also 0.99.\footnote{This result is not shown in Table 3. Data on rents in the rural areas is also available for 1939–1940. If the urban rent is used to adjust income in 1940, the estimate of $\beta$ for the period 1940–1993 is 0.0647 (0.0190). If, on the other hand, the county rent is used for the adjustment, the estimate of $\beta$ is about the same, 0.0632 (0.0189). In contrast, if non-adjusted incomes are used, the estimate of $\beta$ is considerably lower, 0.0305 (0.0027), for the same period.}
Table 3
Cross-county income growth regressions\(^a\)

<table>
<thead>
<tr>
<th>Period</th>
<th>Basic equation</th>
<th>Equation with agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) adjusted income</td>
<td>(2) non-adj. income</td>
</tr>
<tr>
<td></td>
<td>(\hat{\beta})</td>
<td>(R^2[\sigma])</td>
</tr>
<tr>
<td>(1) 1911–1993</td>
<td>0.0417 (0.0080)</td>
<td>0.99 [0.0004]</td>
</tr>
<tr>
<td>(2) 1919–1993</td>
<td>0.0441 (0.0078)</td>
<td>0.99 [0.0005]</td>
</tr>
<tr>
<td>(3) 1911–1921</td>
<td>0.0206 (0.0041)</td>
<td>0.51 [0.0062]</td>
</tr>
<tr>
<td>(4) 1921–1930</td>
<td>0.0038 (0.0036)</td>
<td>0.05 [0.0051]</td>
</tr>
<tr>
<td>(5) 1930–1940</td>
<td>0.0252 (0.0058)</td>
<td>0.43 [0.0065]</td>
</tr>
<tr>
<td>(6) 1940–1950</td>
<td>0.0599 (0.0081)</td>
<td>0.82 [0.0052]</td>
</tr>
<tr>
<td>(7) 1950–1960</td>
<td>0.0262 (0.0071)</td>
<td>0.42 [0.0041]</td>
</tr>
<tr>
<td>(8) 1960–1970</td>
<td>0.0451 (0.0048)</td>
<td>0.85 [0.0017]</td>
</tr>
<tr>
<td>(9) 1970–1980</td>
<td>0.0818 (0.0099)</td>
<td>0.85 [0.0016]</td>
</tr>
<tr>
<td>(10) 1980–1993</td>
<td>0.0292 (0.0139)</td>
<td>0.05 [0.0018]</td>
</tr>
<tr>
<td>(11) Joint, eight</td>
<td>0.0259 (0.0012)</td>
<td>—</td>
</tr>
<tr>
<td>(12) Likelihood-ratio statistic (p-value)</td>
<td>49.3 (0.000)</td>
<td>46.4 (0.000)</td>
</tr>
</tbody>
</table>

\(^a\) For the whole sample period (rows 1 and 2) the estimation method is nonlinear least squares. For the subperiods the estimation method is nonlinear SUR. The standard errors of the estimates are given in parentheses and the standard errors of the regressions are given in brackets. The likelihood-ratio statistic in row 12 refers to a test of equality of the convergence coefficient over the eight subperiods. Under the null, this statistic is asymptotically distributed as chi-squared with seven degrees of freedom.
As is well known, a temporary measurement error in income due to, for example, poor nominal income estimates tends to bias the estimate of β upwards (De Long, 1988). One check on the importance of measurement errors due to poor nominal income estimates can be performed by examining convergence starting at some later point in time for which data is more reliable. The first and the second rows of Table 3 show that the estimates of β for the two sample periods, 1911–1993 and 1919–1993, are fairly similar.

The sample is also divided into eight subperiods which can be seen as a test of robustness. The estimation method for these subperiods is nonlinear seemingly unrelated regression (SUR). Using SUR is a way to account, for example, for long-lasting sectoral shocks, since it allows for correlation of disturbances over time, i.e. across equations. Rows 3–10 in the first column of Table 3 show that the estimates of β are positive and significant for all but one subperiod, 1921–1930, which was a period of declining relative prices of agricultural commodities (see Myrdal, 1933) that should have hurt the relative poor agricultural counties the most. If β is restricted to be the same across subperiods while allowing for individual constants, the joint estimate is 0.0259 (0.0012). The hypothesis of equal βs is, however, rejected; the likelihood-ratio statistic is 49.3 with a p-value of 0.000. (Under the null hypothesis, the likelihood-ratio statistic follows a χ² distribution with seven degrees of freedom.)

Column 2 of Table 3 shows the estimates of β when incomes are not adjusted for differences in cost of living. The estimates of β for the whole sample period are positive and significant, and for the subperiods only one of the estimates (period 1980–1993), that are positive and significant when using adjusted incomes, turns insignificant. Since the results are qualitatively similar for adjusted and non-adjusted incomes, our conclusion is that a temporary measurement error in income, due to lack of cost of living adjustment, is unlikely to be the real source of convergence for the Swedish counties.

However, a quantitative difference is that the estimates of β are lower when non-adjusted incomes are used. In the absence of price convergence or divergence, that is, if the relative cost of housing across counties stays constant over time, only the levels of per capita incomes (but not the growth rates) differ between the two data sets. (The formulae of adjustment is given in 9.) In this case the estimated speed of convergence tends to be lower for non-adjusted incomes because the richest counties tend to have the highest cost of living. (The fitted line to the

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12 The correlation between the log of per capita income (non-adjusted) and the cost of housing is around 0.7 or more at the starting and endpoints of the subperiods; that is, for 1911, 1921, ... and 1993. For example, the correlation between the log of per capita income (non-adjusted) in 1911 and the urban rent in 1912–1913 is 0.74. In 1993 the correlation between the cost of housing and income is 0.83.
observations for non-adjusted incomes is drawn in Fig. 2.) If, on the other hand, there is price convergence (or divergence); that is, when the relative cost of housing in poor counties increases (falls) over time, then the growth rates also differ between the two data sets. Price convergence (divergence) dampens (reinforces) the tendency of \( \beta \) to be lower when non-adjusted incomes are used. In other words, price convergence tends to reduce the discrepancy of the estimates of \( \beta \) between the two data sets whereas the opposite tends to be true for price divergence. However, the cost of housing of poor relative to rich counties did not change much between the years 1911 and 1993.

The result that the estimates of \( \beta \) for the Swedish counties are higher when adjusted incomes are used is consistent with cross-country evidence. Barro and Sala-i-Martin (1995, ch. 12) test for conditional convergence across a large sample of countries for the period 1965–1985 using the Summers–Heston data on GDP as well as the World Bank data on GDP. The World Bank data is based on domestic GDP figures and market exchange rates to compare the values of GDP across countries, whereas the Summers–Heston data attempts to adjust for cross-country differences in the cost of living by using observed prices of goods and services. The estimated speed of convergence is about 3% per year for the Summers–Heston data, whereas it is only about 1.5% for the World Bank data. In all other respects, i.e. with respect to countries included, other regressors, etc., the estimations are identical. It is also found that the standard deviation of the log of the countries’ per capita GDP is lower for the Summers–Heston data than for the World Bank data. Barro and Sala-i-Martin’s explanation of their findings is that poor countries tend to have relatively low prices for nontraded goods which more accurately is reflected by the Summers–Heston data. Both these results parallel those for the Swedish counties: the estimated speeds of convergence are higher and the standard deviations of the log of per capita income are lower when differences in cost of living (more properly) are accounted for.

The third and fourth columns of Table 3 present estimates of \( \beta \) when the proportion of the population (or the labor force) engaged in agriculture at time \( t - T \) is included as a regressor. This variable has been added to hold constant aggregate shocks that affect the counties differently and that are correlated with initial per capita income, such as shifts in the relative prices of agricultural

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13 If the urban rent is used as a proxy for the cost of housing in 1912–1913, then the correlation between the log of per capita income (adjusted) in 1911 and the growth rate of the counties’ relative cost of housing between 1912–1913 and 1993 is 0.20 (t-value = 1.0). Hence, there is some price divergence. If, on the other hand, the county rent is used as a proxy for the cost of housing in 1912–1913, then the correlation is -0.32 (-1.6); that is, we observe price convergence. Furthermore, using the urban rent, price convergence takes place during the following subperiods of Table 3: 1911–1921, 1930–1940, 1940–1950 and 1970–1980.

14 The data is from Statistics Sweden, Population census, various issues and from Statistics Sweden, Tax assessments and income statistics, various issues.
products (see Barro and Sala-i-Martin, 1991, 1992, 1995)\textsuperscript{15}. One difference from the results in the first and second columns is that the estimates of $\beta$ are significant and positive for the 1920’s, which was a period of falling relative prices of agricultural products that adversely affected the relatively poor agricultural counties. Another difference is that the hypothesis of equal $\beta$s across the eight subperiods can no longer be rejected for the two data sets; the likelihood-ratio statistics are 8.5 and 10.5, respectively (the $p$-values are 0.288 and 0.160). The joint estimate of $\beta$ is 0.0393 (0.0036) for adjusted incomes and 0.0302 (0.0025) for non-adjusted incomes. In these restricted panel estimations of $\beta$ the coefficients of the agricultural variable as well as the intercepts are allowed to vary over the subperiods. A third difference from the results in the first and second columns is that the estimates of $\beta$ are insignificant for the subperiods adjacent to the 1920’s. The presence of multicollinearity should explain this. By and large, the results of the regressions with the agricultural share variable are similar to those found by Barro and Sala-i-Martin (1992) for the U.S. states.

3.2. $\sigma$-convergence

Figs. 3 and 4 provide evidence of $\sigma$-convergence. Fig. 3 plots the log of the counties’ per capita incomes adjusted for differences in cost of living (using the urban rent for the period 1911–1946) from 1911 to 1993. Fig. 4 shows the cross-sectional standard deviation of the log of per capita income. The standard deviation for non-adjusted income, for income adjusted using the urban rent and for income adjusted using the county rent are shown in Fig. 4. For the county rent we have only observations for the years 1912–1913 and 1939–1940. The values of other years are based on interpolation.

Taking into account the regional differences in cost of living compresses the distribution of income. However, for both non-adjusted and adjusted income the dispersion decreases over time. For adjusted income (using the urban (county) rent for the period 1911–1946) the standard deviation falls from 0.345 (0.321) in 1911 to 0.036 in 1993. For non-adjusted income the standard deviation falls from 0.380 in 1911 to 0.062 in 1993. The decline in these measures of dispersion is not monotonic over time. They increase between 1920 and 1932, which should reflect the adverse shock to agriculture during this period. Moreover, these measures of dispersion increase somewhat during the 1980’s and early 1990’s, even though the rise is reversed in 1992 and 1993. Also several countries in the sample of Barro and Sala-i-Martin (1995, ch. 11) experience increased dispersion during the 1980’s.

\textsuperscript{15} The correlation between the log of per capita income (adjusted) in 1911 and the share of population engaged in agriculture in 1910 is $-0.94$. This correlation falls over time. In 1990 it is $-0.51$. 
3.3. Migration and convergence

Migration is one mechanism that can contribute to convergence. In a neoclassical model that allows for labor mobility (Barro and Sala-i-Martin, 1995, ch. 9), migration of labor with low human capital from poor to rich economies tends to increase the capital-labor ratios and wages in the economies of departure and to decrease the capital-labor ratios and wages in the economies of destination. In this section the effect of migration on the speed of convergence is studied by including the average annual net migration rate into county \( i \) between time \( t - T \) and \( t \) into the panel regressions of the type presented in row 11 of Table 3\(^\text{16}\). A positive value of the net migration rate means that the county is a net receiver of migrants. In column 1 of Table 4 the estimation method is nonlinear SUR. The coefficient of the migration rate is constrained to be the same for each subperiod. Moreover, since these panel estimations correspond to those presented in row 11 of Table 3,\(^\text{16}\) The migration figures include migration to and from abroad (source: Statistics Sweden, Vital statistics, various issues).
Table 4
Migration and convergence*  
<table>
<thead>
<tr>
<th>Basic equation</th>
<th>Adjusted income</th>
<th>Non-adjusted income</th>
<th>Equation with agriculture</th>
<th>Adjusted income</th>
<th>Non-adjusted income</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) SUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \hat{\beta} )</td>
<td>migration</td>
<td>( \hat{\beta} )</td>
<td>migration</td>
<td>( \hat{\beta} )</td>
<td>migration</td>
</tr>
<tr>
<td>1. Adjusted income</td>
<td>0.0269 (0.0015)</td>
<td>0.0753 (0.0457)</td>
<td>0.0267 (0.0035)</td>
<td>-</td>
<td>0.0243 (0.0019)</td>
</tr>
<tr>
<td>2. Non-adjusted income</td>
<td>0.0263 (0.0011)</td>
<td>0.2648 (0.0365)</td>
<td>0.0223 (0.0028)</td>
<td>-</td>
<td>0.0228 (0.0013)</td>
</tr>
<tr>
<td>(2) Two-stage SUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \hat{\beta} )</td>
<td>migration</td>
<td>( \hat{\beta} )</td>
<td>migration</td>
<td>( \hat{\beta} )</td>
<td>migration</td>
</tr>
<tr>
<td>3. Adjusted income</td>
<td>0.0411 (0.0042)</td>
<td>0.1274 (0.0543)</td>
<td>0.0432 (0.0051)</td>
<td>-</td>
<td>0.0414 (0.0040)</td>
</tr>
<tr>
<td>4. Non-adjusted income</td>
<td>0.0365 (0.0029)</td>
<td>0.3885 (0.0445)</td>
<td>0.0319 (0.0040)</td>
<td>-</td>
<td>0.0334 (0.0027)</td>
</tr>
<tr>
<td>(3) Two-stage SUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \hat{\beta} )</td>
<td>migration</td>
<td>( \hat{\beta} )</td>
<td>migration</td>
<td>( \hat{\beta} )</td>
<td>migration</td>
</tr>
<tr>
<td></td>
<td>0.1274 (0.0543)</td>
<td>0.0432 (0.0051)</td>
<td>-</td>
<td>0.1317 (0.1017)</td>
<td></td>
</tr>
</tbody>
</table>

* The regressions correspond to the joint estimations in row 11 of Table 3. The migration coefficients refer to the average annual net migration rate between time \( t - T \) and \( t \). The coefficients of the migration rate are allowed to vary across subperiods in column 2, whereas they are restricted to be the same in columns 1 and 3. The coefficients of the initial share of population in agriculture are always allowed to vary. The estimation method is nonlinear SUR in column 1 and two-stage nonlinear SUR in columns 2 and 3. The instrument is, aside from the log of the initial per capita income (and the agricultural share variable in rows 2 and 4), the migration rate of the previous subperiod.
The constants as well as the coefficients of the agricultural variable in the regressions with agriculture are allowed to vary over the subperiods.

The contemporaneous average annual net migration rate is not a predetermined variable. To address the potential problem of simultaneity, the income growth regressions are also estimated by two-stage nonlinear SUR. These estimates are presented in the second and third columns. In column 2 the coefficients of the migration rate are allowed to vary over the subperiods, whereas they are constrained to be the same in column 3. Aside from the predetermined variable, the log of the initial per capita income (and initial agricultural share in the regressions with agriculture), the migration rate during the previous subperiod is used as an instrument for the contemporaneous average annual net migration rate. For the first subperiod, 1911–1921, the average annual migration rate during the period 1901–1910 is used as an instrument. Due to the slow speed of convergence, income differentials and the direction of the migration flows are persistent over time (Persson, 1995), which makes the contemporaneous and the lagged migration rate correlated. On the other hand, if the error terms are correlated across the equations, then lagged migration rate is correlated with the error term. However, the correlation of the residuals between adjacent subperiods is never substantial, which means that it is not unreasonable to use lagged migration rate as an
The lack of a substantial correlation between the residuals of adjacent subperiods also means that the efficiency gains of using SUR instead of estimating each equation individually is likely to be minor.

In comparison with the corresponding estimates of β in row 11 of Table 3 the estimates of β stay fairly constant when migration is added as a regressor. Hence, we find no empirical evidence that migration has contributed to the observed convergence in any major way. This result is consistent with findings for other regional data sets (Barro and Sala-i-Martin, 1995, ch. 11).

4. Concluding remarks

This paper finds strong and robust evidence of convergence in per capita income across the twenty-four Swedish counties 1911–1993. This evidence is not in favor of growth models that do not predict convergence. It is found that using cost of living adjusted incomes as opposed to non-adjusted incomes introduces only quantitative changes on convergence. The estimates of β are higher and the standard deviation of the log of per capita income is lower when adjusted incomes are used, which is consistent with cross-country evidence.

When adjusted incomes are used, both the estimate of β for the long-run single regression and the joint estimate of β for the panel regression with agriculture (for which the restriction of β being constant over the subperiods cannot be rejected) are around 4% per year. The estimates of β for other regional data sets are around 2–3% per year (Barro and Sala-i-Martin, 1995, ch. 11). Since these regional studies typically do not adjust for differences in cost of living, one possible explanation of this difference is the cost of living adjustment. Moreover, these estimates of β for the Swedish counties are also higher than conditional cross-country estimates of 2–3% per year. Even though one should be careful in comparing absolute and conditional estimates of β, this result is consistent with the expectation that capital and technology are more mobile within countries than across countries, which tends to increase the speed of convergence.

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\footnote{We focus on the restricted panel regressions in row 11 of Table 3. For each of the restricted panel regressions in columns 1, 3 and 4 only one correlation (of the seven) of the residuals between adjacent subperiods is significant at the 5 percent level. The t-values of the significant correlations are 2.2, 2.1 and −2.2. For the restricted panel regression in column 2 two correlations of the residuals between adjacent subperiods are significant. The t-values are −2.4 and −2.6.}
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Royal Social Board, Housing census and census of rent, various issues. Stockholm.