A Tale of Two Dominions: Comparing the Macroeconomic Records of Australia and Canada Since 1870

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By DAVID GREASLEY and LES OXLEY

A ustralia and Canada have distinctively different macroeconomic histories. Australia's GDP per caput was well above those of Britain and the United States in 1870, and more than twice the Canadian level. By the 1980s the figure for Canada almost matched the United States, and was substantially above that of Australia and Britain. Why Canada and Australia, both regions of recent European settlement with British colonial origins, should have widely different macroeconomic records raises a number of puzzles, which we explore by utilizing new developments in growth theory and time series analysis. Our primary purpose is to investigate the extent to which Australia's links with Britain, and Canada's with the United States, shaped the comparative economic development of the two dominions. Convergence of incomes between economies arises naturally within Solow's growth model as leaders suffer diminishing returns to investment.[2] However, the historical records of Australia and Canada, in comparison with those of Britain and the United States, point to a greater complexity in patterns of economic development than predicted by simple growth models, and diversity appears even greater outside the English-speaking world.[3]

Abramovitz argues that income convergence depends on social capability, and his perspective may shed light on the performance of the two dominions.[4] The possibility that income convergence may be conditional on social capability receives formal treatment in Barro's growth model, which augments the standard Solow approach to incorporate, for example, differences in education.[5] Here convergence may be long drawn out, as in the case of income levels between individual US states. The issue of social capability centres on the cultural and institutional milieu underpinning an economy's technological capability. Within the augmented

[2] Solow, 'Contribution'. Brezis, Krugman, and Tsiddon, 'Leapfrogging', considers the implications for economic leadership of alternative growth models.

[3] DeLong, 'Productivity growth', and Foreman-Peck, 'Model', consider other economies.

[4] Abramovitz, 'Catching up', pp. 387-90.

[5] Barro and Sala i Martin, 'Convergence'.

Solow-Abramovitz perspective emphasizing social and technological capabilities, discussion normally focuses on the forces promoting, precluding, or constraining the catch-up in productivity by lagging economies. Williamson takes a different approach, and, by highlighting the price effects of factor and commodity flows in stimulating income convergence, offers insights which also have relevance for the economic records of the two dominions.[6] Australia and Canada have been recipients of substantial labour and capital inflows, and export staples loomed large in their early economic development.

The diverse performance of the two British dominions occurred despite some clear similarities in their economies. Both countries have small populations compared with large land resources. Canada has the larger population, but this was as much the case in 1913 as it is today. Then Australia's population was around 4.8 milliion, or 63 per cent of Canada's; by 1989 it reached 16.8 million, 64 per cent of the Canadian figure. Further, while export staples figured prominently in their early development, the shift towards industrial and service employment in the twentieth century was equally strong in Australia and Canada. Their export staples—wool in the case of Australia and wheat for Canada—were important in the pre-1914 period. Yet by 1987 only 6 per cent of the Australian and 5 per cent of the Canadian workforce were employed in agriculture. Industry and services accounted respectively for 26 per cent and 68 per cent of Australian, and 25 per cent and 70 per cent of Canadian employment in 1987.[7]

Some signs of diversity in the economic development of the two dominions can be observed in the orientation and the expansion of their external trade. Export-GDP ratios differed little in 1913. Australia's, at 18.3 per cent, was modestly above the 15.1 per cent Canadian level, and around 50 per cent of Australia's and Canada's exports went to Britain in that year.[8] However, there were substantial markets for Canadian exports in the United States. In 1913 around one-third of Canadian exports went there, and subsequently the dominance of the United States in Canada's trading links grew. Canada's exports to the United States were over four times those to Britain in 1950 and over 12 times by 1975. In contrast, Australia's exports to Britain were four times greater than those to the United States in 1950. It was not until 1969 that the United States overtook Britain as a destination for Australia's exports. Canada's closer links with the faster growing US market were accompanied by a rising export-GDP ratio which reached 23.9 per cent by 1987, whereas Australia's ratio fell to 13.5 per cent.

Perhaps more important, given their role in technology transfer, were imports of goods and capital into the two dominions respectively from the United States and Britain.[9] Canada's merchandise imports from the

[6] Williamson, 'Evolution', p. 162.
[7] Carter, 'Service sector', p. 199.
[8] Mitchell, *International historical statistics*, pp. 536-617, 884-931.
[9] Aitken, *American economic impact*, p. 9, emphasizes the importance of capital flows in his wide-ranging assessment of the US economic impact on Canada.

United States were three times those from Britain by 1913, and the relativities were five and 20 times in 1950 and 1975. In contrast Australia's imports from Britain were five times greater than those from the United States in 1950, and remained greater until 1967. British investment predominated in Australia and Canada before 1914, but was primarily portfolio, and in effect financed Canada's and Australia's imports of merchandise from the United States and Britain. US investment in Canada exceeded Britain's by the 1920s, and was eight times as great by 1970. Much of the US investment in Canada was undertaken directly by producers, and Wilkins estimates that half was in manufacturing by 1929.[10] In the case of motor vehicles, the US 'big three' had Canadian plants by 1929, by which time Canada was a larger producer of vehicles than Britain. By contrast, US manufacturing investment in Australia was under 10 per cent of the level in Canada in 1929. As late as 1984, Britain's share of the overseas owned corporate equity in Australia was around twice that of the United States.[11]

Overall investment also exhibited distinctive features in Canada and Australia, principally because of disparities in human capital formation. Physical investment shows less divergence—the ratio to GDP has been around 24 per cent in both economies since 1945.[12] Investment peaks were not coincidental in earlier years. Australian investment was the stronger in the 1880s, when its investment ratio averaged 22 per cent of GDP, whereas during the wheat boom of 1900-13 Canada's investment ratio averaged 25 per cent of GDP. Over the longer term the physical investment ratios of the two dominions are similar. More distinctive are the respective levels of investment in human capital. MacKinnon argues that Australian education followed the British model, to the neglect of secondary and tertiary education.[13] In 1920-1, 14 per cent and 28 per cent respectively of 16-year-olds were students in Australia and in Canada. The comparable figures for 1970-1 are 55 per cent and 86 per cent. Low levels of secondary education in Australia are reflected in the figures for higher education. In 1975 around 6.7 per cent of the 20-4 years age group were students in Australia, compared with 9.3 per cent in Britain, 18.3 per cent in Canada, and 24.4 per cent in the United States.[14]

A corollary to low levels of formal education arose in the importance of workplace training and apprenticeship in Australia and Britain. The craft skills encouraged by the Australian and British system of industrial organization were less relevant for machine intensive North American systems of production.[15] The dominance of British labour, with distinctive craft skills and workplace traditions, in immigration to Australia may

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[10] Wilkins, Maturing, p. 55.
[11] Dyster and Meredith, Australia, p. 286.
[12] The investment data are from Urquhart, 'New estimates', pp. 33-4, Marr and Patterson, Canada, pp. 223-30, and Maddock and McLean, eds., Australian economy, p. 26. McLean, 'Savings', highlights the similar domestic savings ratio of the two economies.
[13] MacKinnon, 'Years of schooling', p. 63.
[14] Maddock and McLean, Australian economy, p. 24.
[15] Broadberry and Wagner, Human capital, p. 39.

have reinforced the transmission of British systems of production to Australia. Rather differently, Canada often experienced net outmigration, principally to the United States, before the wheat boom of the 1890s. Subsequently, in the period 1904 to 1921, Canada received in excess of 1 million immigrants from the United States.[16] In part these were Canadian returnees, but two-way flows occurred within the North American labour market. Migrants reinforced the effects of capital and enterprise flows from the United States to Canada during the early decades of the twentieth century.

Unionization of the workforce proceeded rapidly in Australia from the 1890s, to cover 58 per cent in 1953-4, compared with 47 per cent in Britain, 30 per cent in the United States, and 23 per cent in Canada.[17] The Australian industrial relations system did not precisely imitate Britain's—for example, compulsory arbitration figured prominently in Australia. However, the closed shop and the ubiquity of small craft unions emerged as key elements in both the Australian and British industrial relations systems.[18] In contrast, Canadian unions in the period since 1870 are distinguished by their US affiliations, with head offices often located in the United States. In earlier years Canadian unions were affiliated to British craft unions—for example, the Amalgamated Society of Engineers had Canadian branches—but these links were not sustained. Increasing flows of labour within North America after 1870, and the emergence of mass production utilizing unskilled labour, encouraged the affiliation of Canadian unions to US institutions.[19] The Knights of Labor had their first Canadian meeting in 1881. Unionization of the workforce was less strong in Canada than in Australia, and tended to follow the US rather than the British model.

The issue of the size and role of government also arises in the historiography of comparative Australian decline. Size of government does appear greater in Australia and Britain, but more attention focuses on the objectives of policy, which appear distinct in Australia and Britain compared with Canada and the United States.[20] Restrictive practices abound in Australia to the extent that Pincus argued that governments there tend to promote sectional rather than general interests.[21] Australia's most influential economic historian, Butlin, observed that that country's economy has all the restrictive practices known to man.[22] However, the examples cited, ranging from marketing schemes and occupational licences to trade union rights, also have resonance in British history.[23] The theme of powerful interests influencing policy to reduce competition

[16] Green and Sparks, 'Macro reinterpretation', p. 97.
[17] Withers, 'Labour', pp. 274-5; Marr and Patterson, Canada, pp. 207-10.
[18] Withers, 'Labour', p. 255.
[19] Marr and Patterson, Canada, pp. 207-10.
[20] Pincus, 'Government', p. 315.
[21] Hunter, 'Restrictive practises', p. 25, notes that the Australian Industries Preservation Act, passed in 1906, was modelled on the US Sherman Act, but fell into desuetude following the failure of important prosecutions.
[22] Butlin, Barnard, and Pincus, Government and capitalism.
[23] Broadberry and Crafts, 'Britain's productivity gap', pp. 545-53.

arises strongly in the British historiography, for example in relation to British governments' sponsoring of cartels in the coal and steel industries during the 1930s, and in their support for price maintenance. In contrast, the attempts by Roosevelt in the 1930s to promote market sharing and price fixing in US industry were effectively challenged by the judiciary.[24] Industrial concentration has been greater in Canada than in the United States, and anti-trust policy weaker, although Canada's small open economy and the proximity of its southern neighbour may offset the effects of these anti-competitive tendencies.

Surveying the historiography and the records of Australian and Canadian macroeconomic development highlights elements of similarity and diversity. The availability of land, labour, and capital, and their sectoral allocation show few differences in the two dominions, and these appear insufficient to account for their distinct macroeconomic records. The differences that do emerge centre on the direction of their commercial links, and on the institutional and cultural milieu underpinning their product and factor markets. More specifically at issue is whether the transmission of British traditions shaped Australia's social capability for income growth, while the force and influence of US traditions promoted a different development path for Canada. Certain of the Australia-Britain and Canada-United States links appear straightforward, and concern the flows of capital, labour, and enterprise which helped to shape the terms of trade and the organization of production in the two dominions. However, the depths of shared experience between Australia and Britain, and between Canada and the United States, go beyond their trading relations, and influenced the sentiments and policies surrounding education, training, workplace organization, trade unions, and the restrictive practices of sectional interests.

Modern time series methods are used here to assess the effects on Australia's and Canada's economic development of their links with Britain and the United States. Specifically, we consider the tendency for the incomes of Australia or Canada to converge with those of Britain or the United States. Most investigations of the convergence hypothesis utilize cross-sectional data for large groups of countries, and seek to make generalizations rather than country-specific observations. Baumol, for example, reports inverse correlation between initial income levels and growth rates among industrial economies.[25] Our perspective differs, and, by focusing on a narrower group of countries and utilizing annual time series, allows a more detailed assessment of particular historical records and the profile of convergence. The next section outlines a time series-based approach to convergence, which deploys and extends the methods of Bernard and Durlauf.[26]

[24] Fearon, *War, prosperity, and depression*, p. 198.
[25] Baumol, 'Productivity growth', p. 1076.
[26] Bernard and Durlauf, 'Interpreting tests'.

I

Following Abramovitz and Baumol, most tests of convergence consider cross-sectional correlations between initial levels of income per caput and growth rates among groups of countries. A weakness of cross-sectional tests is that they are limited when it comes to investigating the process of convergence or the tendency towards catching up. Cross-sectional tests do not provide evidence on the existence of long-run income convergence.[27] Bernard and Durlauf propose alternative time series tests of convergence, deploying a unit root testing procedure for investigating both long-run convergence and catching up.[28] Essentially, long-run convergence concerns the attainment of income equality, and catching up the tendency for income gaps to narrow. Accordingly, Bernard and Durlauf formally offer two definitions of convergence, where τ_t denotes all information available at time t.

Definition 1. Convergence as catching up. Countries i and j converge between dates t and T if the (log) per caput output, Y, disparity at t is expected to decrease in value. If $Y_{i,t} > Y_{j,t}$,

$$E\ (Y_{i,\,t+T} - Y_{j,\,t+T} \mid \tau_t) < Y_{i,t} - Y_{j,t}$$

Definition 2. Convergence as equality of long-term forecasts at a fixed time. Countries i and j converge if the long-term forecasts of (log) per caput output, Y, are equal at a fixed time t,

$$\lim_{k \to \infty} E\ (Y_{i,\,t+k} - Y_{j,\,t+k} \mid \tau_t) = 0$$

The two definitions have clear implications for the time series properties of comparative GDP per caput, and therefore lead to simple time series-based tests for convergence. Both definitions are violated if the levels of the comparative series are non-stationary, since comparative income shifts will persist to preclude convergence. Thus, the non-stationarity of comparative income series excludes both long-run income equality and the expectation that income gaps will diminish. Unit root tests are widely used to assess the stationarity of time series, and Bernard and Durlauf's extension of the strategy to comparative series forms the basis for convergence tests based on time series analysis. The tests adopt non-convergence as the null hypothesis.[29] Failure to reject a unit root in the comparative GDP per caput series implies that non-stationarity and hence non-convergence cannot be rejected.

If the unit root tests reject non-convergence, the remaining issue concerns the distinction between long-run convergence and the tendency towards catching up. Stationary comparative GDP per caput series indi-

[27] Bernard and Jones, 'Productivity'.

[28] Bernard and Durlauf, 'Interpreting tests', pp. 98-100.

[29] Adopting a null of non-convergence has empirical and statistical appeal. The view that macroeconomic time series are typically non-stationary now commands wide support. Durlauf, 'Output persistence', fails to reject non-stationarity and non-convergence for any comparative income series. Any results rejecting non-convergence are thus non-trivial. Further, Mills, *Time series techniques*, p. 201, stresses the statistical dangers of utilizing erroneous stationary (and, by implication, convergence) maintained hypotheses.

cate that income movements tend to transmit between economies, but do not necessarily point to the completion of the convergence process. Clearly, the existence of a significant time trend in a stationary comparative series would violate definition 2 to preclude long-run convergence, but would not violate definition 1 and the existence of catching up. Thus, tests of convergence based on time series analysis involve two stages. First, the stationarity of comparative income series is investigated, and failure to reject a unit root implies that non-convergence cannot be rejected. Secondly, where non-stationarity can be rejected, testing for the presence of significant trend allows catching up to be distinguished from long-run convergence.

The data utilized in the convergence tests are illustrated as Figure 1. A number of salient features emerge from the patterns of comparative Australian, British, Canadian, and US GDP per caput.[30] The Australian figure exceeded the British and US levels by at least 25 per cent before the 1890s, and then shows sharp relative decline. Since the 1890s British and Australian incomes equate closely, although Australia's position improved temporarily during the First World War and in the early 1920s. In contrast, the downward trend in Australia's GDP per caput relative to the United States continued to the Second World War, then exhibited modest improvement to reach around 75 per cent of the US level by the 1970s. Canadian incomes were less than 50 per cent of Australian levels before the 1890s, and then show generally faster growth in the twentieth century, although the catching-up process was interrupted in the years immediately after the First World War and in the 1930s. By the 1980s Canadian GDP per caput stood 25 per cent above Australian levels. Canada's catching up and surging past Britain's income levels shows a similar pattern, although in this case the interruption in the process arose principally in the 1930s. Canada's GDP per caput approached 80 per cent of the US level by 1917, and after relative deterioration through the interwar years, its income gap with the United States fell to under 10 per cent by the 1980s.

The initial step in assessing whether these data support either the catching-up or long-run variants of the convergence hypothesis involves testing for a unit root in the comparative GDP per caput series for each pair of countries. In all cases the null of a unit root cannot be rejected.[31] Ostensibly, these results are damaging to the convergence hypothesis, since non-stationarity and non-convergence cannot be rejected for any of

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[30] The data for Australia and Canada are from Butlin, *Australian domestic product*, pp. 33-4, and Urquhart, 'New estimates', pp. 30-1, extended to 1992 with official statistics: see Maddison, *Dynamic forces*, pp. 201-3, and Bureau of Census, *Statistical abstracts*. The British and US data are from Maddison, *Dynamic forces*, pp. 220-1, extended with official statistics. The Maddison series for Britain incorporates Feinstein's compromise GDP index, and that for the United States utilizes Balke and Gordon's revisions (in 'Estimation') to the NBER-Department of Commerce data. Robustness of results for the United States and Britain has been checked with alternative data from Romer, 'Prewar business cycle', pp. 22-3, and Greasley, 'Stationarity', pp. 208-9, and no material differences have been found. The data are adjusted for purchasing power parity utilizing Heston and Summers, 'New set', pp. 14-21, estimates for 1985.

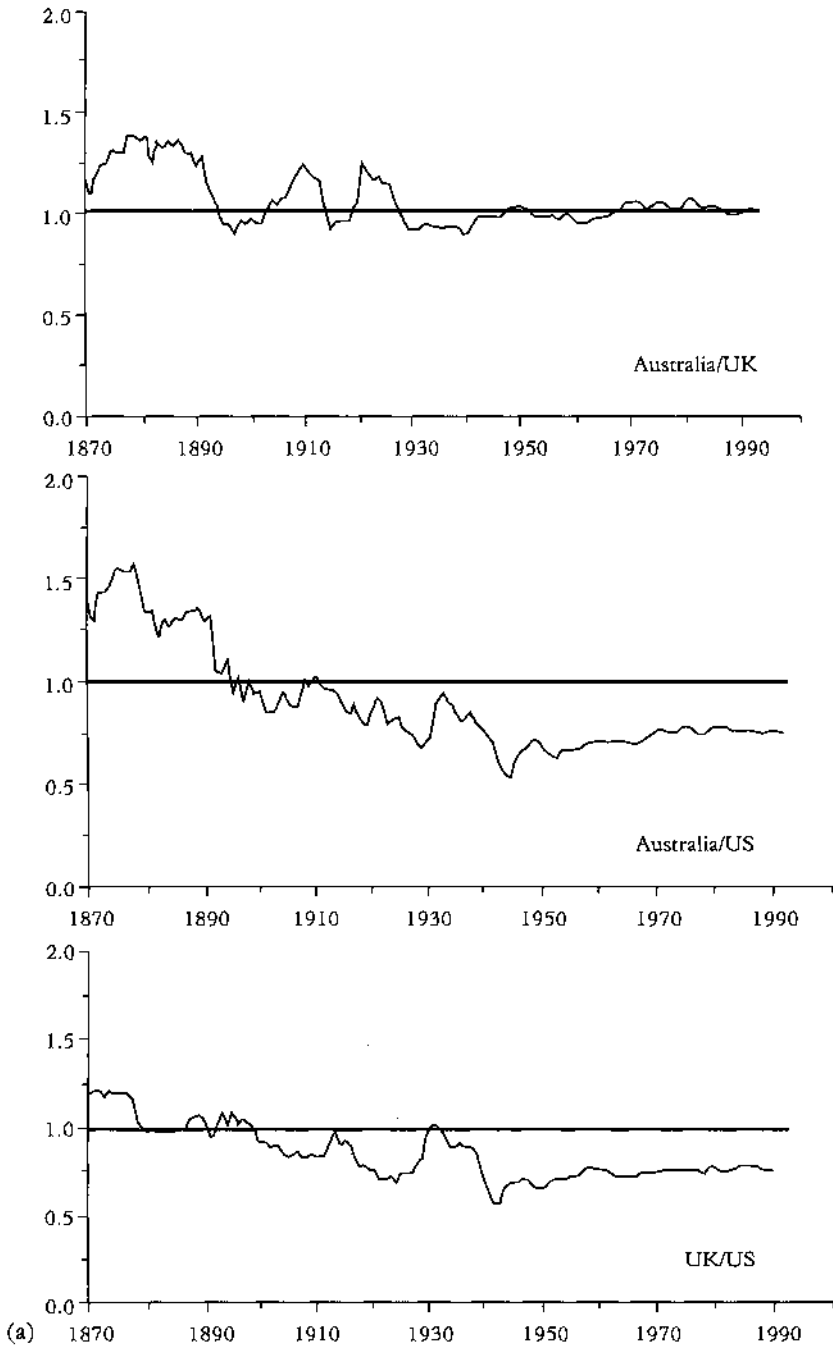[31] The results may be found in the appendix.

Figure 1. *Relative GDP per caput, 1870-1992* (in US$ of 1985, adjusted
for purchasing power parity) *(continues overleaf)*
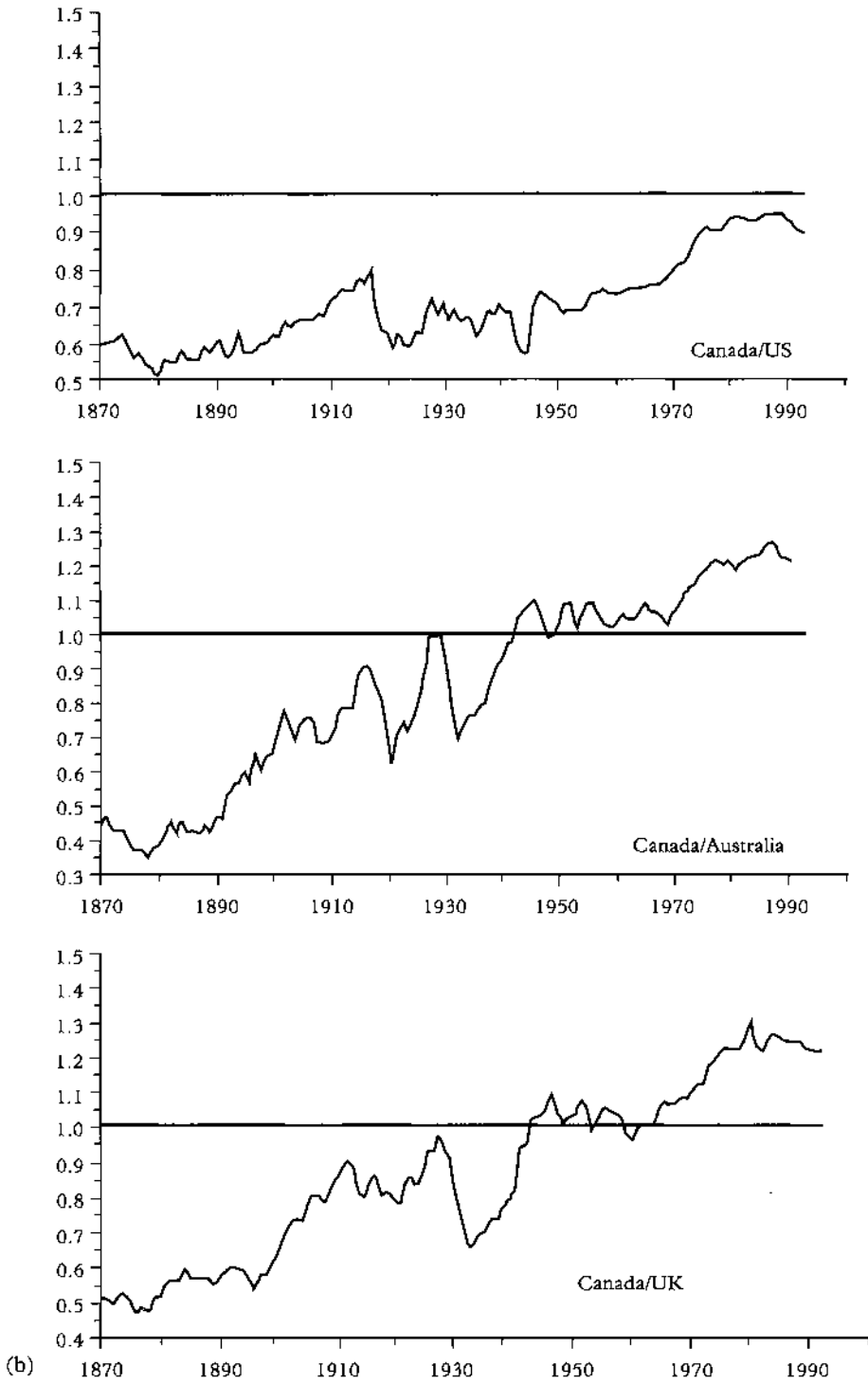*Sources:* see text

(b)

Figure 1. continued

the pairwise comparisons. However, Rappaport and Reichlin, and Perron show that unit root tests are fragile when the time series contain structural breaks such as those associated, for example, with the world wars or the Wall Street crash.[32] The issue of structural breaks has particular resonance for Australian and Canadian economic development since possible discontinuities are highlighted in the respective historiographies. Here we extend Bernard and Durlauf's methods by allowing for possible structural breaks in the GDP per caput time series. This allows for more robust tests of the convergence hypothesis, and helps to articulate the forces shaping or constraining the profile of any income convergence between the four economies. We focus first on the experience of the individual economies, particularly Australia and Canada, and subsequently investigate the relations between the two dominions and Britain and the United States.

<div style="text-align:center">II</div>

The issue of structural discontinuity looms large in both Australian and Canadian macroeconomic history. In the Canadian historiography the impact of the wheat boom of the 1890s attracts considerable discussion, and the effects of gold discoveries on the nineteenth-century Australian economy are widely debated.[33] The new time series methods have been utilized to explore the economic development of the two dominions. Inwood and Stengos argue that Canadian GDP growth is segmented by breaks in the years 1896, 1914, and 1939, coinciding with the wheat boom, and the onset of the world wars.[34] Others lay more stress on the impact of the world depression after 1929 on both Canadian and Australian growth.[35] Elsewhere, we argue that the gold discoveries around 1851 and the depression of the early 1890s break the trend in Australian GDP growth.[36] Less attention has been given to the chief concern here, the modelling of GDP per caput in Australia and Canada. We approach the issue first by surveying the historiography to identify possible breakpoints, and then utilize statistical methods to assess their significance.

The role of export staples dominates discussions of pre-1914 Canadian economic history.[37] The prairie wheat boom around the turn of the century provides the most dramatic example of growth in Canadian staple exports. Historians have long debated whether the wheat boom shifted the Canadian economy to higher trend growth, or whether the expansion was a strong, but transitory, cyclical upturn. Dale, McManus, and Watkins argue that the wheat boom was vital for promoting extensive growth,

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[32] Rappaport and Reichlin, 'Segmented trends', and Perron, 'Great crash'. Greasley and Oxley, 'Technological epochs', and Greasley and Oxley, 'Unit roots', provide historical illustrations.
[33] Urquhart, 'New estimates', pp. 37-42, and Maddock and McLean, 'Supply-side shocks'.
[34] Inwood and Stengos, 'Discontinuities', p. 279.
[35] Raj, 'International evidence', p. 288, and Sereletis, 'Random walk', pp. 400-2.
[36] Greasley and Oxley, 'Segmenting the contours', pp. 48-9.
[37] Bertram, 'Economic growth', and Watkins, 'Staple theory'.

as export growth encouraged inward migration and investment.[38] Their position receives statistical support from Inwood and Stengos, who discern an upward shift in trend GDP growth around 1896. The consequences of wheat exports for GDP per caput appear less certain, though Chambers and Gordon emphasize their modest importance for intensive growth.[39] In comparison with Australia's experience, Canada's GDP per caput rose strongly after 1890, with relative income improving from 45 to 78 per cent of Australia's between 1890 and 1914. These figures give some credence to the tradition of treating the two decades before the First World War as a Canadian golden age. However, the statistical analysis carried out by Inwood and Stengos does not consider GDP per caput, and the impact of the wheat boom on intensive per caput growth remains an open issue.

A depressed Australian economy in the 1890s may partly explain the improvement in Canada's comparative fortunes during the two decades prior to 1914. The issue of whether the 1890s mark an Australian climacteric receives considerable attention. Maddock highlights the slight rise in Australia's GDP per caput in the half century after 1890, and Jackson believes that the 1890 dividing line may segment the profile of Australian economic development.[40] Discussion of Australia's depression centres on the 1891 balance of payments crisis, and the difficulties faced in servicing growing overseas liabilities.[41] Some interpretations emphasize the role of external forces, particularly the cessation of British lending following the Baring crisis of 1890.[42] However, Butlin highlights more distinctively Australian origins, arguing that much of the railway, land, and pastoral investment of the 1880s earned low returns, making the servicing of overseas debt difficult.[43] This issue of whether intrinsically Australian or international forces dominate has relevance here, given our concern to assess the connection between Australian and British incomes. The disparate fortunes of Canada and Australia in the 1890s do point to distinctively national elements in economic development, and cast some doubt on the general validity of the convergence hypothesis.

The effects of the First World War on Canada and Australia also appear different, although the historiography fails to reach consensus on the implications for trend growth in the two dominions. Wartime disruption of world trade was particularly detrimental to Australia, with GDP per caput not regaining 1913 levels until 1924. Inwood and Stengos also suggest that the onset of war in 1914 marked a slowdown in Canadian trend GDP growth, though trends in per caput income may differ. Urquhart highlights the continuing rise in Canadian exports to 1917, while his GDP per caput estimates show 1917 levels 8 per cent above

[38] Dale, McManus, and Watkins, 'Primary products', pp. 876-7.
[39] Chambers and Gordon, 'Primary products', p. 881.
[40] Maddock, 'Long boom', p. 79; and Jackson, *Australian economic development*, pp. 23-7.
[41] Oxley and Greasley, 'Time series', p. 268.
[42] Boehm, *Prosperity and depression*, pp. 165-8.
[43] Butlin, *Investment*, pp. 407-23.

those in 1913.[44] Subsequently, Canadian GDP per caput fell in each of the next four years to stand 27 per cent below 1917 levels in 1921. Over the same 1917-21 period Canada's export/GDP ratio fell from 37 per cent to 22 per cent, and terms of trade deteriorated by 18 per cent, highlighting the possible importance of price shifts for comparative incomes. Canada's 1917 income levels were not regained until 1927, raising the possibility of a discontinuity in GDP per caput after the First World War.

Both the dominions experienced deteriorating performance during the troubled interwar years, although the timing of their respective downturns was not coincidental. Australia's interwar GDP per caput was at its highest in 1925, and the economy was already on a downward path when the crash of the US economy after 1929 heralded a collapse in world trade. Pope argues that the downturn after 1925 was associated with a collapse of domestic investment, where construction was particularly hard hit.[45] To some extent the origins of the contraction appear distinctively Australian, since the building cycle there partly reflected demographic swings. However, Britain's return to the gold standard in 1925 was accompanied by constraints on capital flows to Australia, and these may have contributed to the early downturn of the Australian economy.[46] The causes of the sharper Australian decline after 1929 also attract debate between those emphasizing the primacy of either domestic or international forces. Schedvin's emphasis on the role of domestic events has been criticized recently by Siriwardana, who contends that the Australian trade cycle was disrupted by a collapse of inward investment and deteriorating terms of trade when the world economy slumped.[47] As for Britain, the trough of the depression was reached in 1931, although the pace of recovery was slower in Australia.

The interwar collapse of the Canadian economy occurs later than in Australia, but Safarian's classic account argues that the world slump was particularly detrimental to Canada.[48] Traditional accounts emphasize the transmission of the contraction from the United States, although more recently Betts, Bordo, and Redish take a different view, suggesting that the profile and the causes of the depression were common to the North American continent.[49] Certainly the depth and prolongation of the contraction look similar in the two North American economies, with the implication that recovery in Canada lagged that in Australia and Britain by two years. However, the timing of the onset of depression casts some doubt on the coincidental experience of the two North American economies, since both Serletis, and Zelhorst and de Haan postulate an earlier decline in Canadian GDP per caput from 1928.[50]

[44] Urquhart, 'New estimates', pp. 33-4.
[45] Pope, 'Population', pp. 34-6.
[46] Tsokhas, 'Australian role', pp. 141-3.
[47] Schedvin, Australia and the great depression, and Siriwardana, 'Causes', pp. 71-6.
[48] Safarian, Canadian economy.
[49] Betts, Bordo, and Redish, 'Small open economy'.
[50] Sereletis, 'Random walk', p. 288 and Zelhorst and de Haan, 'Testing for a break', p. 359.

The historiography suggests that both Australia and Canada experienced strong growth from the onset of the Second World War. For Australia, Maddock emphasizes that the long boom to the 1970s dates from the onset of war, while the war presaged three decades of historically fast growth in Canadian GDP per caput.[51] Australia appears to have been the harder hit by the disruption to the world economy caused by the oil price shocks of the 1970s. Its position was exacerbated by a loss of competitiveness, both then and during the early 1980s mining boom.[52] Canada was less seriously affected, and GDP per caput rose strongly during the 1970s in comparison to the other three countries.

III

Surveying the historiography highlights a number of possible discontinuities in economic development in Australia and Canada after 1870. Any breaks in the patterns of growth in GDP per caput for individual economies will have important implications for the existence of international income convergence, since discontinuities may promote, deter, or preclude convergence. Some of the potential breaks coincide with events of international significance, notably the world wars, the world depression after 1929, and the oil price shocks of the 1970s. To the extent that countries are similarly influenced, transnational events do not shift comparative incomes, but they may have differing national impacts which shape patterns of income convergence or divergence. Other possible discontinuities, for example the Australian downturns of 1891 and 1925, and that in Canada after 1917, appear to be more country specific and are more likely to affect comparative incomes. This section assesses the statistical significance of all potential breakpoints in Australian and Canadian GDP per caput. The wider significance of these results lies in their implications for the existence and patterns of income convergence between Australia, Britain, Canada, and the United States.

The search procedure of Zivot and Andrews offers a simple approach to assessing the statistical significance and form of all the potential discontinuities in Australian and Canadian GDP per caput, including those identified *a priori* by surveying the historiography.[53] They deploy an equation of the form:

$$Y_t = \alpha Y_{t-1} + \beta 1 + \beta 2 \text{Time} + \beta 3 \text{Dslope} + \beta 4 \text{Dintercept} + \text{error}$$

where Y and Y_{t-1} denote (log) GDP per caput in the current and previous year, Time is a time trend, Dslope and Dintercept are dummy variables which shift the slope and intercept of the time trend, and α and the βs are the parameters to be estimated. If $\alpha = 1$, GDP per caput depends on GDP per caput in the previous year and on the random error component, with the implication that shifts in GDP per caput have

[51] Maddock, 'Long boom', pp. 79-80, and Marr and Paterson, *Canada*, p. 6.
[52] Pagan, 'End', pp. 112-5.
[53] Zivot and Andrews, 'Further evidence'.

permanent effects on future levels of GDP per caput.[54] Alternatively, if $\alpha < 1$, GDP per caput may be represented as a deterministic function of time, where fluctuations in GDP per caput are transitory around the time trend. Including the dummy variables allows the slope or the intercept of the deterministic time trend to change, permitting the representation of varying trend growth and of periodic shifts in the level of GDP per caput. In cases where $\alpha < 1$ without breaks in the slope or intercept of the time trend, time series are defined as trend stationary, whereas if $\alpha < 1$ only if breaks are incorporated, time series are denoted segmented trend stationary.
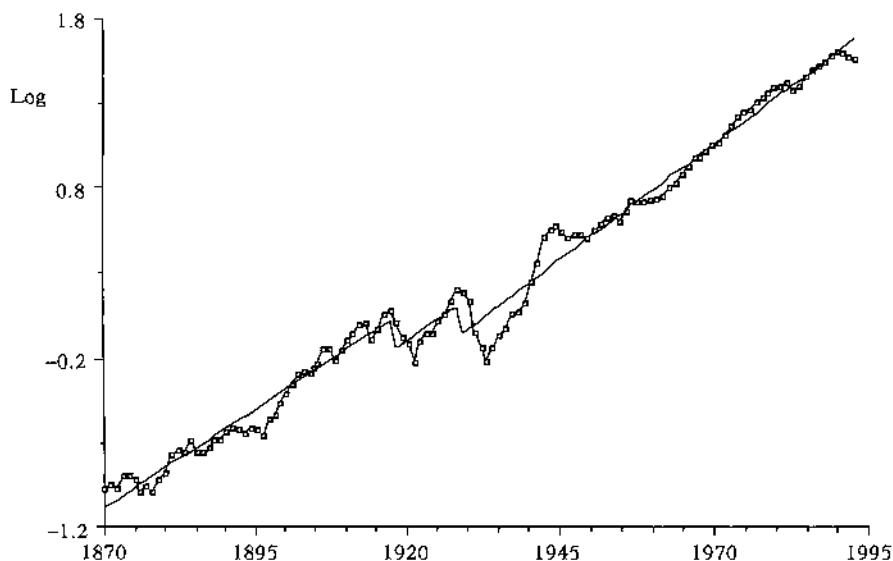

Figure 2. *Actual and fitted values for Canada's GDP per caput, 1870-1992* (1913 = 100)
Sources: see text

The results here suggest that both Australian and Canadian GDP per caput follow segmented trend stationary processes, although the timing of the break points is not coincidental.[55] The recursive searching of the Zivot and Andrews procedure identifies the year for which the dummy variable gives the maximum absolute t value for assessing the significance of α, and provides critical values for testing whether $\alpha = 1$. For Canada, an intercept dummy in 1917 and a slope and trend dummy in 1928 give the highest absolute t values, and, in each case, the t values are sufficient to favour the segmented trend stationary representation. Further, the joint incorporation of breaks in both 1917 and 1928 reinforces the strength of the trend stationary representation. Figure 2 illustrates the

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[54] Put more technically, $\alpha = 1$ means a unit root cannot be rejected, implying that levels of GDP per caput are non-stationary.
[55] Details are in the appendix.

two-break profile of Canadian GDP per caput realized by applying the methods of Zivot and Andrews.

Following a similar procedure with the Australian GDP per caput data yields the large absolute t value for the intercept dummy in 1891, and for a joint intercept and trend dummy in 1925. A single trend dummy in 1931 also favours the trend stationary representation of GDP per caput. For combinations of breaks, those including the 1891 and 1925 breaks give higher absolute t statistics than combinations which include the 1931 break. The significance of the 1931 discontinuity in the single break results reflects the omission of the earlier 1925 discontinuity. The preferred segmented trend stationary representation of Australia's GDP per caput appears in figure 3.
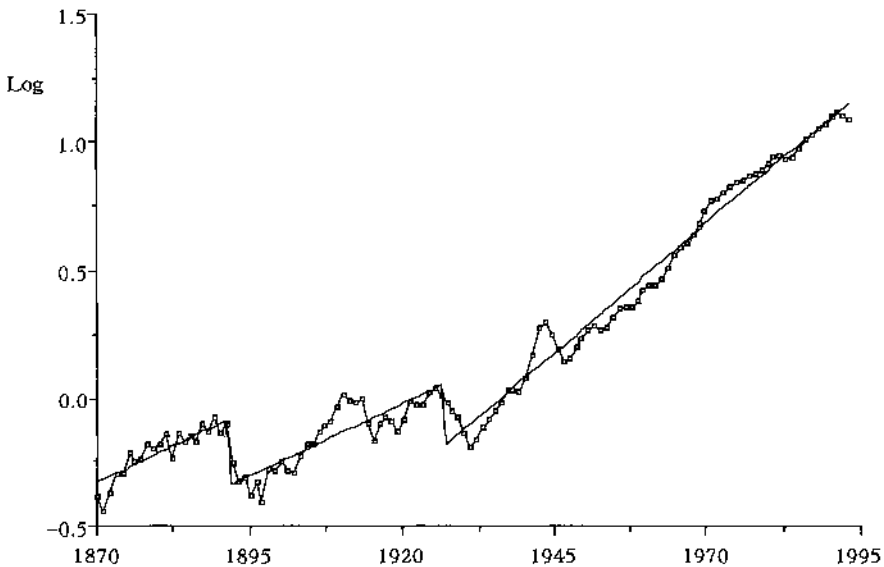

Figure 3. *Actual and fitted values for Australia's GDP per caput, 1870-1992* (1913 = 100)
Sources: see text

The results delineate the distinctive elements in Australian and Canadian macroeconomic history, and offer evidence on key issues raised by their respective historiographies. They suggest that the Canadian wheat boom after 1896 did not shift upward the trend for growth in GDP per caput—rather, the associated upturn appears cyclical and transient. It would seem that the primary force of the wheat boom was on extensive GDP growth via the stimulus given to immigration. Nor does the finding of Inwood and Stenglos of a slowdown in GDP growth coinciding with the onset of the First World War carry over to GDP per caput. Most novel are the results which show a collapse after 1917 in Canadian GDP per caput since this idea receives scant attention in the historiography of that country, even though its GDP per caput levels were not regained until 1927. However, the result does highlight the importance of staple

exports in Canadian economic development since the 1917 crash coincided with the collapse of Canada's terms of trade and its export-GDP ratio. The subsequent peak in Canadian GDP per caput occurred in 1928, and suggests a Canadian downturn one year in advance of that in the United States. The finding of an early Canadian peak conforms to those of Raj and Sereletis, but does not preclude that later events in the United States kept the Canadian economy on a downward path until 1933.[56] Neither the Second World War nor the 1970s oil price shocks, on the results here, subsequently deflected the trend growth of the Canadian economy.

On the Australian side, the results reveal idiosyncratic shifts in trend GDP per caput in 1891 and 1925. Neither the two world wars, the world depression after 1929, nor the 1970s oil price shocks segmented the Australian macroeconomic record. The characteristics of the 1890s depression attract widespread debate in Australian historiography, in relation both to whether domestic or international causes dominate, and to whether the decade marks the onset of a 50-year low-growth phase in Australian economic development. The statistical results here cast doubt on the existence of a slowdown in trend GDP per caput dating from the 1890s. Rather, the results show a collapse in the level of GDP per caput after 1891, with the previous growth trend resuming from a lower income level. The collapse of 1891 coincided with a sharp deterioration in Australia's terms of trade, with prices falling by around 20 per cent in comparison with Britain's. The precise timing of the collapse may be associated with external events. The Baring crisis of 1890 deterred British overseas investment, although over the longer term international factor and commodity flows were eroding the benefits of Australia's natural resource advantages.[57]

Within the discussions of Australia's macroeconomic performance during the troubled interwar period, the possibility that the downturn of 1925 may have been a major turning point attracts surprisingly little attention. GDP per caput fell in each of the six years following the peak of 1925, although the pace of decline accelerated after 1929. Pope emphasizes the role of the construction cycle, the peak of which occurred in 1925, in shaping the overall profile of interwar growth. However, most interpretations of Australia's interwar depression date the onset later, and focus on the symmetry between Australian and British experience.[58] Green and Sparks raise the possibility of an earlier Australian downturn, dating from 1928, but they consider that the interwar depressions in Australia and Canada mirror respectively the experiences of Britain and the United States.[59] The new statistical results here offer a different view, and identify a major discontinuity in Australian GDP per caput in 1925. They suggest that demographic swings shaped a distinctive Australian

[56] Raj, 'International evidence', p. 288, and Sereletis, 'Random walk', pp. 400-2.
[57] Boehm, *Prosperity and depression*, considers Australia's circumstances, while Williamson, 'Globalization', discusses the wider issues.
[58] Gregory, 'Overview', p. 1.
[59] Green and Sparks, 'Macro interpretation', p. 104.

interwar growth profile, although the barriers to capital inflows following Britain's return to the gold standard may play a role in explaining the timing of the downturn.

Further, the finding of a collapse in GDP per caput after 1925 sheds light on the causes of slow Australian growth during the half century after 1890. Trend growth does not appear to decelerate after 1890—rather, the cause of slow growth between 1890 and 1940 arose from the severity of the collapses after 1891 and 1925. Indeed, trend growth in GDP per caput accelerated, albeit from a low level, after 1925. However, the size of the output losses stemming from the crashes of 1891 and 1925 meant that levels of Australia's GDP per caput remained below those that would have been attained, if the 1870 to 1891 growth trend had been sustained, until the 1960s. On the basis of the statistical findings here the search for the causes of the Australian economy's comparative decline after 1890 should centre on the collapses after 1891 and 1925, rather than on the alleged slowdown in trend growth from the 1890s.

IV

The statistical results highlight the distinctive individual characteristics of Australian and Canadian macroeconomic history. The growth of GDP per caput in both dominions appears segmented by occasional breaks, but these are not coincidental. Canada's economic growth was interrupted by crashes after 1917 and 1928. In contrast, the major collapses in the Australian economy occur after 1891 and 1925. Both economies experienced higher trend growth for GDP per caput subsequent to their downturns of the interwar years. Overlaying the shorter-term idiosyncratic segmented growth trends in the two economies was generally faster Canadian growth, which led to the catching up and surpassing of Australian incomes. This section considers the extent to which the shorter-term segments and the longer-term profile of comparative Australian and Canadian economic development can be explained by their respective connections to the British and US economies.

Without allowing for the effects of structural breaks, the time series tests in section I fail to reject the null of non-convergence. These results, ostensibly, reject long-run income convergence and catching up between the four economies, with the implication that distinct national forces shape Australian and Canadian economic development. Yet the macroeconomic records of Australia and Canada do suggest that their trends in GDP per caput are interrupted by occasional breaks, and these ought to be taken into account when investigating convergence. A break in an individual economy's GDP per caput may not disrupt its comparative position if common international forces, for example the effects of world wars or the international depression after 1929, have similar cross-country effects. Of more interest here are structural breaks which are country specific, since these may deter or promote international income convergence.

Searches using the methods of Zivot and Andrews, analogous to those undertaken for the individual economies, are used to establish the timing

of any breakpoints in the comparative series of GDP per caput. In all cases non-stationarity and non-convergence can be rejected once the effects of structural breaks are incorporated into the unit root tests. These results identify 1891 as the significant break year in the comparative British-Australian series, 1928 for Britain and Canada, 1917 for the United States and Canada, 1944 for the United States and Australia, and 1950 for the United States and Britain.[60]

The findings for Australia and Britain stand apart since they point to long-run income convergence between the two economies. The 1891 discontinuity takes the form of a collapse in the level of relative Australian GDP per caput, rather than a shift in the comparative income trend. Nor are there significant trends in the British-Australian GDP per caput gap before or after 1891. Levels of GDP per caput were on average 25 per cent higher in Australia before 1891, and fluctuations around the mean gap were transient. Subsequent to the 1891 discontinuity, incomes per caput equate in Australia and Britain. As figure 1 illustrates, there have been fluctuations in comparative British and Australian GDP per caput since 1891. Australian growth was faster in the decade to 1914 and in the early 1920s, and Britain's during the First World War and in the later 1920s. However, the statistical results suggest that these were transitory fluctuations, which did not affect the long-term income equality between the two economies. Thus, while a significant break appears in Australia's own growth record after 1925, Britain also experienced collapse and recovery after the First World War, with the effect that neither episode permanently shifted the longer-term comparative position.[61]

The comparative results illustrate a different relationship between the Canadian and US economies, and indicate catching up, rather than the attainment of long-run income convergence, since they show a significant trend in comparative GDP per caput. The major discontinuity occurred in 1917, and took the form of a collapse in comparative Canadian incomes. The underlying rate of Canadian catching up did not change in the period 1870-1992; rather, the catching-up process resumed after 1917 from a comparatively lower level of Canadian incomes. The effects of the collapse in Canadian incomes after 1917 appear dramatic and long-lasting. Canada's GDP per caput reached 80 per cent of the US level by 1917, but the relativity fell to below 60 per cent by the early 1920s. It was not until the 1970s that Canadian incomes once again exceeded 80 per cent of the US level. While 1917 marks a distinctive break in Canada's macroeconomic record, one which perhaps deserves greater prominence in the historiography, the discontinuity after 1928 in Canada's own growth record does not affect its longer-term comparative position with the United States. Although the US peak occurs later, in 1929, the overall profiles of the ensuing depressions appear similar in the two economies. The results here do not identify a significant shift in

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[60] Further explanation and full details of the results are in the appendix.
[61] Greasley and Oxley, 'Discontinuities', highlights the detrimental effect of the First World War on Britain.

their relative incomes during the depression, a finding which supports those recent interpretations which point to a common North American experience.

The results also indicate the catching up of Australian and British incomes towards US levels, albeit at a slower pace than for Canada. Discontinuities in the income gaps for Britain and Australia with the United States take the form of a trend break around the years of the Second World War. The trends indicate widening income gaps with the United States until 1944 and 1950 respectively for Australia and Britain, and narrowing gaps thereafter. The eventual narrowing of the income gaps stemmed from faster growth in Australia and Britain. However, the modest excess of growth in GDP per caput in Australia and Britain over the US rate since the Second World War suggests that the catching-up process towards the US income levels will be protracted, especially in comparison with the performance of Canada.

<div align="center">V</div>

Typically, on the basis of results derived from cross-sectional studies, Australia, Britain, Canada, and the United States have been considered to be members of the same convergence club. The time series results here offer a different perspective, highlighting the intimacy of Australia's economic links with Britain, and suggesting that faster income growth in Canada arose from its closer connections to the US economy. The British and Australian economies moved closely together throughout the period 1870-1992, with no significant trend apparent in their comparative incomes. Australian GDP per caput was the higher prior to 1891, but equated closely with Britain's thereafter, following a downward shift in the level of Australian incomes. In the earlier years Australia's higher incomes reflected its natural resource advantages, but exploitation of these required capital inflows. The resulting debt proved difficult to service once mass migration and substantial commodity exports eroded the benefits to Australia of its natural resource advantages by contributing to a deterioration in its terms of trade. The Australian collapse of 1891 corrected a balance of payments disequilibrium by reducing Australia's prices, and incomes, relative to Britain's by around 25 per cent.[62]

In contrast, Canadian incomes surged past Australia's and Britain's during the twentieth century. The simple explanation lies in the faster catching up by Canada on the global leader, the United States. The time series results do suggest that Britain's and Australia's incomes are also catching up to the US level, but the pace and form of the process appear to differ from Canada's experience. Faster Canadian catching up points to that country's greater social capability for achieving US income levels. The tendency for Canada's education system to follow the US model, coupled with the flow of migrants, capital, and enterprise from the United States, set Canada apart from Australia. In contrast, British workplace

traditions, with their emphasis on craft skills, apprenticeships, and the closed shop, were prominent in Australia, and were reinforced by the migration of British capital and labour, and by the orientation towards Britain of Australia's trading and cultural linkages. The prominence of restrictive practices in Australian product and factor markets echoed the British experience. While the depth and character of the relationship between Australia and Britain do not preclude catching up towards the US income level, they reduce the pace well below that realized by Canada.

The results have implications for the wider debates surrounding the convergence hypothesis and the related growth modelling strategies.[63] At a simple level, neither the predictions of the Solow model, which points to rapid convergence as leaders suffer diminishing returns, nor the endogenous Rebelo model, which raises the possibility of sustained leadership with investment in education offsetting diminishing returns, accords with the historical experience of Australia, Britain, Canada, and the United States.[64] Variety of experience, even among these four English-speaking economies which are often considered to be members of the same convergence club, suggests that income convergence depends on a complex range of conditions. To an extent, the findings support Barro's approach, which augments the Solow model to allow for different conditions in (for example) education, but even his perspective fails to do full justice to the historical record. The depth and complexity of Australia's cultural, social, institutional, and economic links with Britain, and Canada's with the United States, extend beyond what might, for example, be indicated by schooling provision or investment ratios. By implication, the historical perspective casts some doubt on Barro's cross-sectional findings for the pace of convergence, since these estimates may not be robust if the relevant conditions are not fully specified.[65]

Alternatively, a time series approach leads to firm conclusions on the existence of income convergence, and allows for more realistic representation of the historical record. Time series tests distinguish long-run convergence, non-convergence, and catching up. The results here are generally favourable towards the convergence hypothesis, since none of the findings indicates non-convergence. Most distinctively, they show that Australia and Britain attain long-run income convergence. In contrast, Canada, Britain, and Australia all experience the tendency during the twentieth century of catching up towards US GDP per caput. However, Canada's closer ties with the United States led to a faster pace of catching up than that achieved by Australia and Britain.

A faster rate of catching up for Canada to the US compared with that of Australia to Britain supports Abramovitz's stress on the importance of social capability for income convergence. However, the results here also highlight that patterns of catching up show occasional interruptions which

[63] Greasley and Oxley, 'Endogenous growth', discusses the implications for alternative growth models of the time series properties of production data.
[64] Rebelo, 'Long run policy', and Solow, 'Contribution'.
[65] Islam, 'Growth empirics', pp. 1162-3.

appear too dramatic to be associated with shifts in social capability. Most striking are the collapse of the Australian economy after 1891, and the Canadian economy after 1917. These discontinuities give credence to Williamson's view that factor and commodity flows, by shifting relative prices, contribute to the process of income convergence. Thus, the price and income effects of deteriorating terms of trade, rather than an abrupt shift in social capability, led to a severe collapse of Canada's income relative to the United States after 1917. There are, however, nuances in the role international factor and commodity flows play in shaping income convergence between the four countries, which diverge from Williamson's global perspective. Australian and British incomes, for example, show no sign of converging prior to 1891, despite substantial Australian inmigration and commodity exports, suggesting that distinctively national forces were operating against the backcloth of global convergence tendencies. In this case Australia's balance of payments crisis eventually leads to abrupt deterioration of its comparative incomes in the 1890s.

Over the longer term the results suggest that Canada's relationship with the United States, and Australia's with Britain, dominate the comparative macroeconomic records of the two dominions. Most strikingly, Australian and British incomes equated closely throughout the twentieth century. More general convergence forces are not entirely absent since Australia and Britain, as well as Canada, experienced catching up towards US income levels. However, the catching-up process appears protracted for Britain and Australia, whereas Canada's incomes surged past these two early leaders, to approach the US level. Within the English-speaking world, distinctive North American traditions set Canada and the United States apart, whereas the commonality of Australia's and Britain's experience led to income equality between those two countries.

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APPENDIX: results from the unit root tests

Our approach to identifying income convergence rests on the time series properties of individual country and comparative (log) GDP per caput series. Unit root tests of the Dickey-Fuller type are the standard approach towards establishing the statistical properties of time series. Discontinuities in trends in GDP per caput are potentially vital elements in the process of income convergence, since the breaks may hasten, retard, or preclude convergence. However, the existence of the structural breaks in time series undermines the reliability of standard unit root tests.

The Zivot and Andrews procedure provides a robust unit root test in the presence of discontinuities by incorporating dummy variables to allow shifts in the parameters of the time trend. Without allowing for breaks in trend, the ADF statistics in table A1 do not reject a unit root in comparative Australian, British, Canadian, and US (log) GDP per caput. The lowest augmentations of the Dickey-Fuller statistics which give results free from serial correlation are used throughout.

Nor can a unit root be rejected for Australia's and Canada's own (log) GDP per caput for the period 1870 to 1992 when breaks are not included. The respective ADF(2) statistics are -1.577 and -3.278. The Zivot and Andrews results for Canada in table A2 indicate the years which give the maximum absolute ADF statistics for each form of

Table A1.   *Testing for a unit root in comparative (log) GDP per caput, 1870-1992*

	ADF	LM(SC)	Q6
Britain and Australia[a]	−3.052	0.270	4.471
US and Australia	−2.301	0.047	1.823
US and Canada	−3.156	0.574	2.441
Canada and Britain	−3.026	0.663	1.724
Canada and Australia	−2.894	0.273	4.751
Britain and US	−3.241	0.998	5.860

Note: ADF denotes ADF(2) except that marked *a* which relates to ADF(4). LM(SC) relates to a Lagrange Multiplier test for first-order serial correlation of errors in the ADF test equation, and Q6 is a Ljung-Box test based upon 6 lags. None of the ADF statistics are significant at the 5% level according to MacKinnon, 'Critical values'.

Table A2.   *Unit root tests using the Zivot and Andrews approach, Canadian (log) GDP per caput, 1870-1992*

	ADF(2)		LM(SC)	Q6
Intercept	−5.241[a]		0.022	0.476
	1917			
Trend	−4.066		0.331	0.478
	1933			
Intercept and trend	−5.326[a]	−5.224[a]	0.251	1.025
	1928	1917		

Note: a denotes significant at the 5% level according to Zivot and Andrews, 'Further evidence'. The column headings are as defined in the note to tab. A1.

dummy variable. The unit root hypothesis is rejected with breaks either in 1917 or in 1928. Jointly incorporating a 1917 intercept shift and a 1928 intercept and trend break gives an ADF(2) statistic of −6.178. The critical values of Zivot and Andrews are not appropriate for multiple break models, but Inwood and Stengos report values which are critical at the 5 per cent level for a similar two-break model at −4.86.[66]

In the case of Australia the single breaks giving the highest absolute ADF statistics are for the intercept in 1891, intercept and trend in 1925, and trend in 1931. The results for multiple breaks are shown in table A3. Since incorporating the 1931 dummy variable

Table A3.   *Unit root tests with multiple breaks, Australian (log) GDP per caput, 1870-1992*

	1891 intercept 1925 intercept and trend	1891 intercept 1925 intercept and trend 1931 trend	1891 intercept 1931 trend
ADF(2)	−5.555	−5.193	−4.465
LM(SC)	1.723	1.105	3.499
Q6	1.290	1.448	1.594

Note: the row headings are as defined in the note to tab. A1.

[66] Inwood and Stengos, 'Discontinuities', p. 284.

Table A4.   *Unit root tests for comparative (log) GDP per caput, 1870-1992, using the Zivot and Andrews approach*

	Intercept	*Trend*	*Intercept and trend*
Britain and Australia[a]	−5.071[b]	−4.012	−5.080[b]
	1891	1935	1891
US and Australia	−4.085	−4.483[b]	−4.585
	1891	1943-4	1941
US and Canada	−5.364[b]	−3.699	−5.431[b]
	1917	1951	1917
Canada and Australia	−5.506[b c]	−5.365[b d]	−5.431[b c]
	1891	1902 and 1905	1896
Canada and Britain[a]	−4.481	−4.211	−5.130[b]
	1896	1909	1928
Britain and US[a]	−4.282	−4.707[b]	−5.235[b]
	1966	1950	1941

Notes: Results based upon ADF(2) except those denoted *a* which relate to ADF(4);
b denotes significant at the 5% level according to Zivot and Andrews, 'Further evidence';
c denotes that any year between 1886 and 1897 leads to rejection of a unit root;
d denotes that any year between 1891 and 1919 leads to rejection of a unit root;
e denotes that any year between 1891 and 1921 leads to rejection of a unit root.

reduces the absolute value of the ADF statistic, a two-break model with discontinuities in 1891 and 1925 is preferred.

For the comparative (log) GDP per caput series, the results in table A4 report the years for which the dummy variables give the highest absolute ADF statistics. The results with breaks allow a unit root to be rejected for all the pairwise comparisons, and therefore favour the convergence hypothesis. However, other than for Australia and Britain, the results show significant trends in comparative GDP per caput, to indicate the existence of catching up rather than the attainment of long-run income convergence. The findings for Britain and Australia stand apart in favouring long-run convergence. For the period 1892 to 1992 breaks are not needed to reject a unit root in comparative British and Australian GDP per caput, and the absence of a significant intercept in the results for this period points to income equality between the two economies.

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