Experience with constructing composite asset price indices

Stephan V Arthur[1]

The Bank for International Settlements has variously published, over the past decade, papers where use is made of its aggregate asset price indices for over a dozen industrial countries. This paper explains the methodology used and recent changes in that methodology as well the extended country coverage.

Introduction

Following preliminary work done by the BIS in 1992, Borio et al published a paper exploring aggregate asset price fluctuations across different countries in 1994.[2] One of the objectives of the paper was to develop an aggregate asset price index for several of the major industrialised countries,[3] thereby summarising the information contained in the separate movements of the three asset prices - equities and residential and commercial real estate - exhibiting major fluctuations. The intention was that such an index would facilitate comparison of broad asset price movements over time and across countries, give some empirical content to notions of general asset price "inflation" and "deflation" and highlight patterns of behaviour that would otherwise remain undetected. The paper also provided a first analysis of the possible determinants of movements in the index as well as preliminary evidence on the usefulness of such an index as an input in the design of monetary policy. Their work has since become seminal and has spawned much research in other institutions. More recently, in work done within the Bank, the index of aggregate asset prices has been included in a set of indicators that attempt to predict financial crises. This note explains the original methodology used by Borio et al to construct aggregate asset prices and documents how the methodology has been adapted over time.

The aggregate asset price index

The aggregate asset price index (AAPI) was defined as being a weighted average of national price indices for equities and residential and commercial real estate, since these make up the majority of private sector wealth.[4] Although a simple (unweighted) average would have been a possibility,[5] a weighted average, where the weights represent estimates of the (normalised) shares of those assets in total private sector wealth, was seen to be more relevant.

---

[1] Statistical Analyst, Departmental Research Assistance, Monetary and Economic Department (e-mail: stephan.arthur@bis.org). Any views expressed are mine and not necessarily those of the BIS.

[2] C E V Borio, N Kennedy and S D Prowse (1994): "Exploring aggregate asset price fluctuations across countries: measurement, determinants and monetary policy implications", *BIS Economic Papers*, no 40, April.

[3] Australia, Belgium, Canada, Denmark, Finland, France, Germany, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States.

[4] For those countries where balance-sheet data are available, this amounts to over 80% of the total. Although private sector holdings of government and other bonds are not insignificant, their prices vary little, and would tend only to dampen an aggregate in which they were included. In addition, as their *price* (but not, of course, their *return*) plays no role in monetary policy, bond prices were excluded from an AAPI.

[5] Indeed, as will be shown later, within a limited range, the weighting pattern used affects the aggregate index little.

The frequency of the three national price indices used varies considerably. Equity indices are available electronically on a daily basis[6] and, in several countries, several series can be, for one purpose or another, be considered "representative". Residential property prices are generally disseminated on a quarterly basis, although a few countries publish monthly data; several industrial countries, however, are still only able to provide lower-frequency data,[7] while data from emerging market economies, in particular, is often rudimentary and, almost by definition, annual. Commercial property prices are typically annual, but there are some isolated instances of quarterly availability; most data are collected and provided as "spin-offs" for business purposes and will vary greatly in coverage.[8] Annual national[9] balance-sheet information was used to establish the weighting pattern, so that Borio et al originally restricted their data to the same frequency. Recently, work has been done to construct, for those countries where data availability allows, a quarterly AAPI.[10]

Nominal and inflation-adjusted

An AAPI in nominal terms is only of limited use, and especially so when the inclusion of high-inflation countries or periods is considered. Consequently, the AAPI was deflated by consumer prices, and it is this inflation-adjusted AAPI which was used by Borio et al in their various papers, especially in the areas discussing monetary policy implications.

The equations

The nominal AAPI is a simple weighted average of the form:

$$\Sigma\, w(a_t)\, p(a_t) \qquad (1)$$

for $a = 1, 2, 3$, and $\Sigma w(a_t) = 1$, where p is the price index of asset a at time t and w the corresponding weight. The weights were allowed to vary over time to capture significant changes in the composition of the portfolio, but intervals of five years were taken to reduce noise. The inflation-adjusted AAPI is a simple variant of this equation, taking the form:

$$\Sigma\, w(a_t)\, p(a_t)/i(a_t) \qquad (2)$$

for $a = 1, 2, 3$, and $\Sigma w(a_t) = 1$, where i is the price deflator as measured by nationwide consumer (or retail) prices.

The individual components

Equity prices. Data availability for equities provided the least problem: more so was the "correct" choice of index. As, however, the long-term trends varied little between indices purporting to be "general" or "total" within a country, recognised indices were taken in favour of, possibly, lesser known ones.[11] The additional criterion of creating an index back to (at least) 1970 also governed, in several cases, the choice of index.

---

6 And, increasingly, on a tick-by-tick basis.

7 For example, France, Germany, Italy and Japan.

8 For example, commercial data providers like Investment Property Databank or private real estate associations like Jones Lang LaSalle.

9 And, where this was not available, the UN System of National Accounts (see below).

10 Annual wealth data do not prove to be a problem, since the distribution across asset classes changes only slowly and simple interpolation techniques can be used.

11 Ie for the United States, Standard and Poor's 500 Composite rather than the Wilshire 5000.

Residential property prices. The above was equally true, but far less frequently, when a choice was possible for residential property prices. As the focus on the construction of an AAPI was, and is, to obtain an indicator for the whole economy, country-wide indices were used whenever possible and were given precedence if "splicing" (with, for example, a discontinued series) was required. This was and remains a challenge when trying to create such an index for additional countries, especially emerging markets, or when trying to "fine-tune" an existing index. In the case of residential real estate, nationwide indices were available for all countries except Germany,[12] since replaced.[13]

Commercial property prices. Country-wide commercial property price indices were, however, unavailable at the time for a number of industrial economies,[14] being based solely on data referring to the capital city. The problem was further exacerbated in that, for several countries, the data referred to a particular, and by nature volatile, subset: the (capital) value of prime property in the capital's centre. Although the situation has since improved somewhat, nationwide data now available indicate that a commercial property price index typically has 80% of the total drawn from property in that country's capital. Fortunately, the share of commercial property in total private sector wealth is only 5-20%, so that its influence on the AAPI was fairly minor. This, of course, is especially true as long as price developments in the three asset classes were more or less synchronised, and this was indeed the case for the period which Borio et al originally considered. However, almost immediately after publication of their 1994 paper, this co-movement largely disappeared (see Graphs 2 and 4) and would provide the basis for further research.

The weighting pattern

In order to calculate the weights, Borio et al used the private sector balance sheets in the national flow of funds accounts for Australia, Canada, Japan, the United Kingdom and the United States, and a combination of the data from the United Nations System of National Accounts (SNA) 1968[15] and the OECD Financial Statistics (Part 2) for Finland, (western) Germany and Sweden. They applied the same weighting pattern as Germany for Belgium, France and the Netherlands, and the Swedish weighting pattern for Denmark and Norway.

The calculation of the weights involved two steps: the first, and by far the most important (and difficult) was to identify and estimate the proportions of the three asset categories. The second was to eliminate any "double-counting" that may arise from the fact that listed companies themselves own commercial real estate, thus simultaneously changing both the price of equity and commercial property. It is difficult to obtain reliable estimates of the proportion (denoted by Borio et al as α) of total commercial property held by listed companies. Callen (1991)[16] had estimated this proportion to be 0.6 for Australia, while Borio et al found a value of 0.68 for the United States from flow of funds data. They assumed a similar value for the United Kingdom, one equal to the Australian ratio for Japan, and 0.5 for the other economies, where it was reasoned that their stock markets were rather less capitalised. Based on this proportion, a "net" commercial property weight was calculated, and the three components were normalised to unity. In the early part of the period under review, not all weights (largely those for commercial property) were available, so that only the two remaining components were normalised to unity (ie the weight for commercial property was set to zero). Co-movement of the indices, as mentioned earlier, supported this decision.

---

[12] Where an unweighted average of prices in (west) Berlin, Frankfurt, Hamburg and Munich was calculated. In fairness, detailed documentation is not always available for other countries, so that similar restrictions may also apply elsewhere. In addition, both Australia and Italy construct an index from a relatively small number of cities, but both are, at least, weighted averages.

[13] By a series calculated by the Bundesbank, based on data, provided by Bulwien AG, from 60 cities.

[14] For example, Australia, Belgium, Finland, France, the Netherlands and Norway.

[15] Which they erroneously refer to as the Standardised National Accounts.

[16] T Callen (1991): "Estimates of private sector wealth", *Research Discussion Paper* 9109, Reserve Bank of Australia, October.

The results

Results obtained at the time can only be viewed in Borio et al's paper, as the country coverage has since been extended and the methodology slightly modified (see below). Graphs 1-4 in the Appendix illustrate the results of present-day calculations but differ little for the countries and period covered in 1994: Graphs 1 and 3 plot the AAPI in nominal and inflation-adjusted terms respectively, while Graphs 2 and 4 show, in addition, the individual asset classes for each country.

Statistical work done at the BIS since 1994

Changes to the equations. Following the significant increase in equity prices, and the equivalent expansion in the private sector's equity holdings, in most countries from around the mid-1990s, it became clear that an AAPI was going to be increasingly driven and overshadowed by its equity component. Not only would the relative price of equity increase, but also its weight in private sector wealth. It was therefore agreed that a geometric weighting scheme, which, unlike an arithmetic weighting scheme, was index-level independent, would be preferable and would "dampen" indices that appeared to be historically high due to the choice of base year.[17] Consequently, the nominal and inflation-adjusted indices now take the form:

$$\Pi w(a_t)\, p(a_t) \tag{3}$$

for $a = 1, 2, 3$, and $\Sigma w(a_t) = 1$,

which is equivalent to:

$$\exp \Sigma w(a_t) \ln p(a_t) \tag{4}$$

and:

$$\Pi w(a_t)\, p(a_t)/i(a_t) \tag{5}$$

for $a = 1, 2, 3$, and $\Sigma w(a_t) = 1$,

which is equivalent to:

$$\exp \Sigma w(a_t) \ln (p(a_t)/i(a_t)) \tag{6}$$

A further change was the use of the personal consumption deflator rather than consumer (or retail) prices, which was seen to be more relevant for private sector wealth. The differences were, however, minimal.

Changes to the individual components. Efforts have been made to expand the country coverage, which essentially requires research into property prices. To date, Italy, Spain and Switzerland have been added (qv Graphs 1-4) and work on Hong Kong SAR, Ireland, New Zealand, Singapore and South Africa are nearing completion.[18] The BIS is greatly interested in expanding its country coverage, especially for emerging markets, but is dependent on, especially, reliable property price data.

Preliminary work has also been done on calculating a quarterly AAPI to feed into a set of leading indicators to predict financial crises. However, certain assumptions have had to be made when interpolating the largely annual commercial property price data. Given that another problem with such data is cross-country comparability, a further avenue to explore would be to construct an AAPI consisting of only the two components equity and residential real estate. However, it is unclear at the moment whether such an index would remain sufficiently representative.

Changes to the weighting pattern. The final area in which work has been done since Borio et al's first publication is a review of the weights. First and foremost, the weights were extended to include a

[17] Borio et al used 1980 as the base year, but this has been since changed to 1985.

[18] Although lack of data back to the 1970s will, however, result in shorter time series.

figure for the five-year period 1995-99.[19] Also, continued data "cleaning" revealed errors made in the original calculations affecting, especially, Japan. Of course, during a 10-year period, other changes to the base data[20] are inevitable, but these have had little effect; even the inclusion of former eastern Germany as from 1990 only led to a redistribution of 1 percentage point! Finally, for the additional countries, weights also had to be approximated by using those of other countries in the data set. The Table in the Appendix illustrates, for selected countries, the weights used by Borio et al and those in use at present. More work is certainly required in this area, but, since the AAPI is so dominated by the scale of price increases of its various components, applying weights intuitively makes little difference when compared with the results obtained when using the "correctly estimated" weighting pattern.[21]

Most recently,[22] the five-year weighting pattern has been replaced in favour of an annual weighting system ("moving weights") where possible. This is clearly preferable to a stepwise change in the weights, as it eliminates the resulting "shocks" at the changeover year, and which have become increasingly apparent in recent times (see also footnote 19). Future work will need to evaluate - and find! - annual asset holdings of the private sector.

Empirical work done at the BIS since 1994

Asset prices, especially in discussions on monetary policy, have been frequently mentioned and analysed in papers either presented at the Bank (at, for example, various conferences) or published by its economists. Worthy of particular mention, however, due to their direct bearing on the subject are the following:

- The Conference on Asset Prices and Monetary Policy organised by Centre for Economic Policy and Research and the BIS in January 1998. The conference volume's[23] foreword states, "The widespread liberalisation of financial markets in the 1980s has increased the interest of central banks in asset price developments in two ways. First, as the use of intermediate targets has become unreliable in many countries, central banks have sought other indicators to guide policy actions. A natural place to look has been various asset markets. Second, the greater role of asset prices in the monetary transmission mechanism, combined with their sustained volatility, has led to an increased concern that large changes in asset prices might disrupt economic activity and price stability as well as lead to financial fragility."
- The paper by Borio and Lowe,[24] in which they argue that "… financial imbalances can build up in a low inflation environment and that in some circumstances it is appropriate for policy to respond to contain these imbalances. While identifying financial imbalances ex ante can be difficult, this paper presents empirical evidence that it is not impossible. In particular, sustained rapid credit growth combined with large increases in asset prices appears to increase the probability of an episode of financial instability."

---

[19] In reality, the same weighting pattern was used for the period 1995 to date, since a weighting scheme that would include 2000 data would have captured equity holdings at its peak. As they have since dropped sharply, such weights could therefore be considered as not representative for the period as a whole.

[20] For example, the introduction of the European System of Accounts (ESA) in the euro area.

[21] Such an argument is barely convincing to a statistician, however. It is, for example, extremely unlikely that the distribution of asset classes is similar within the German and French private sector; with an increasing country coverage, the situation will only become exacerbated.

[22] And since the IMF/BIS conference. Indeed, the graphs are the result of this most recent development.

[23] BIS (1998): "Asset prices and monetary policy: four views", August.

[24] Claudio Borio and Philip Lowe (2002): "Asset prices, financial and monetary stability: exploring the nexus", *BIS Working Papers*, no 114, July.

- The paper by Filardo,[25] in which he states, "The issue of monetary policy and asset prices has been receiving much attention not only because it is an interesting topic for macroeconomists but also because central banks have faced daunting challenges from large swings in various types of asset prices. To some extent, the achievement of a low, stable inflation environment has not simultaneously brought about a more stable asset price environment. The record over the past decade, in fact, has raised the prospect of asset price booms and busts as a permanent feature of the monetary policy landscape."
- The paper by Borio and Lowe,[26] in which they argue, and demonstrate, "One important indicator that risk is building up is unusually sustained and rapid credit growth occurring alongside unusually sustained and large increases in asset prices ('financial imbalances'). Building on previous work, we show that empirical proxies for financial imbalances contain useful information about subsequent banking crises, output and inflation beyond traditional two-year policy horizons."

Concluding remarks

Work at the BIS, and elsewhere, has indicated that aggregate asset price indices could represent a welcome addition to the set of variables considered by policymakers from the perspective of both monetary and financial stability. The index developed and currently used is far from perfect, both in terms of methodology and data availability. Such indices could, of course, be further refined and better data on their individual components, particularly residential and commercial property, would help to make the indices more relevant.

[25] Andrew Filardo (2004): "Monetary policy and asset price bubbles: calibrating the monetary policy trade-offs", *BIS Working Papers*, no 155, June.

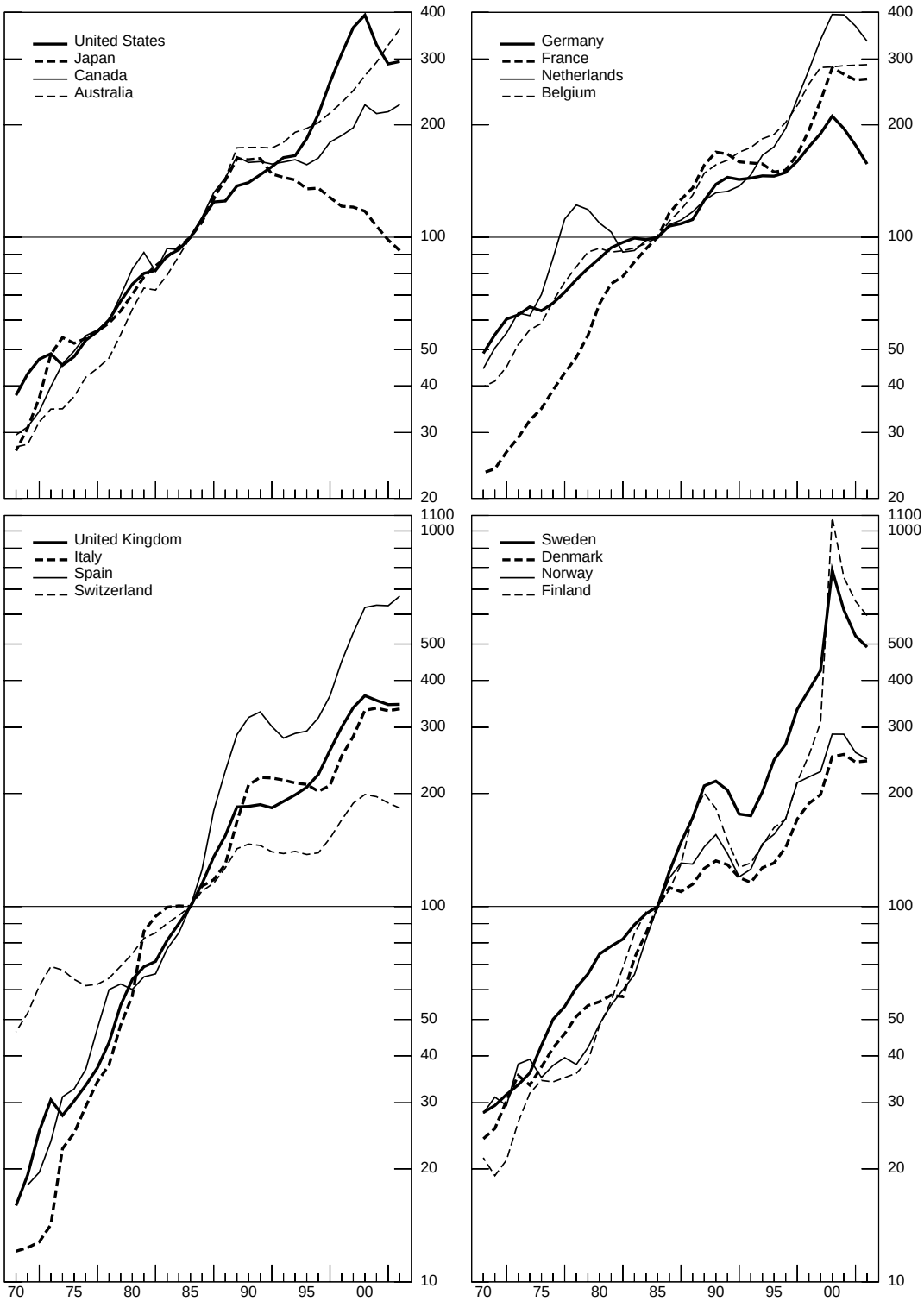
[26] Claudio Borio and Philip Lowe (2004): "Securing sustainable price stability: should credit come back from the wilderness?", *BIS Working Papers*, no 157, July.

Appendix

Graph 1

Nominal aggregate asset prices

1985 = 100; semi-logarithmic scales

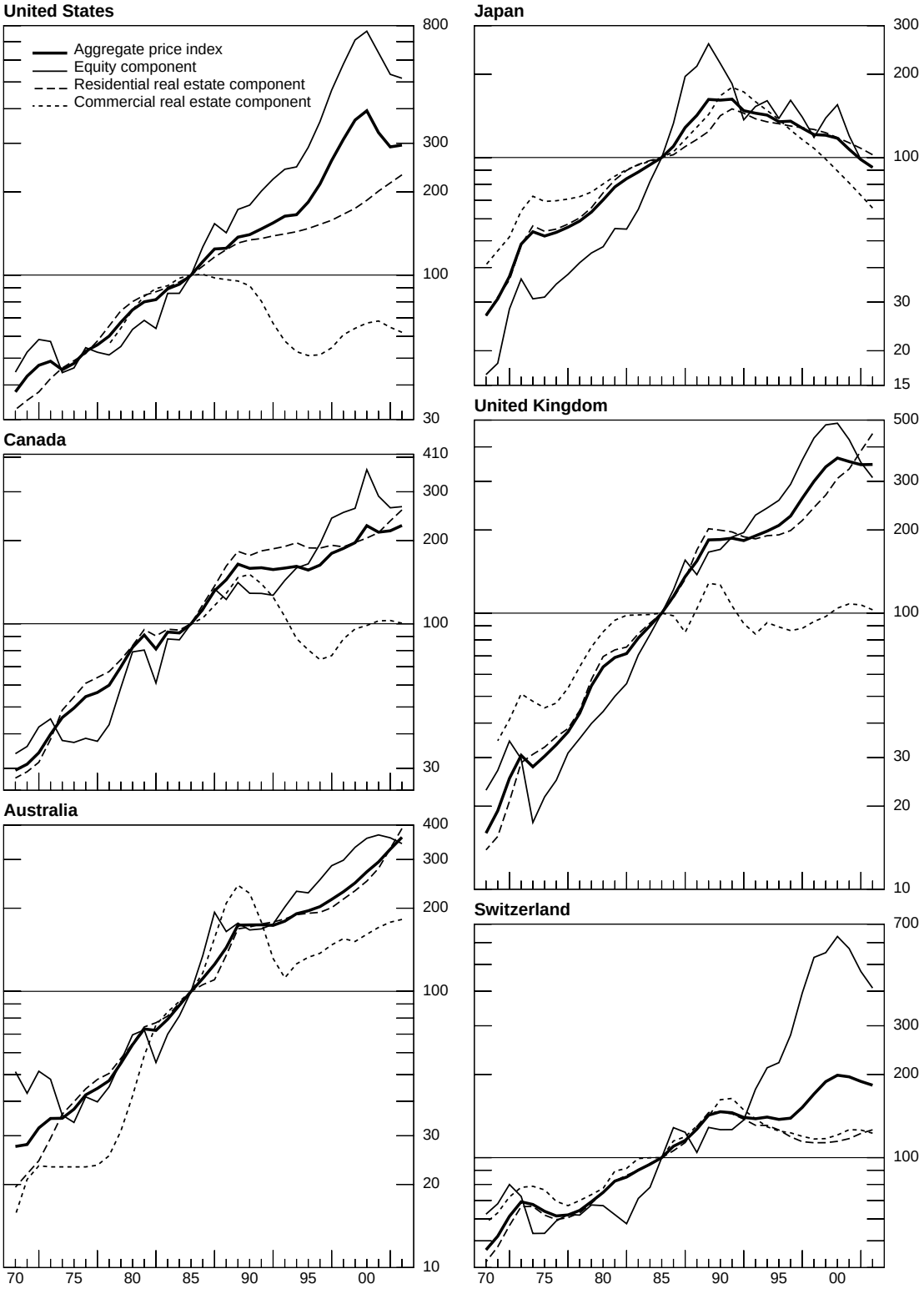


Note: For an explanation of the methodology and sources, see the notes to Graph 2.

Graph 2

Nominal asset prices: aggregate and components

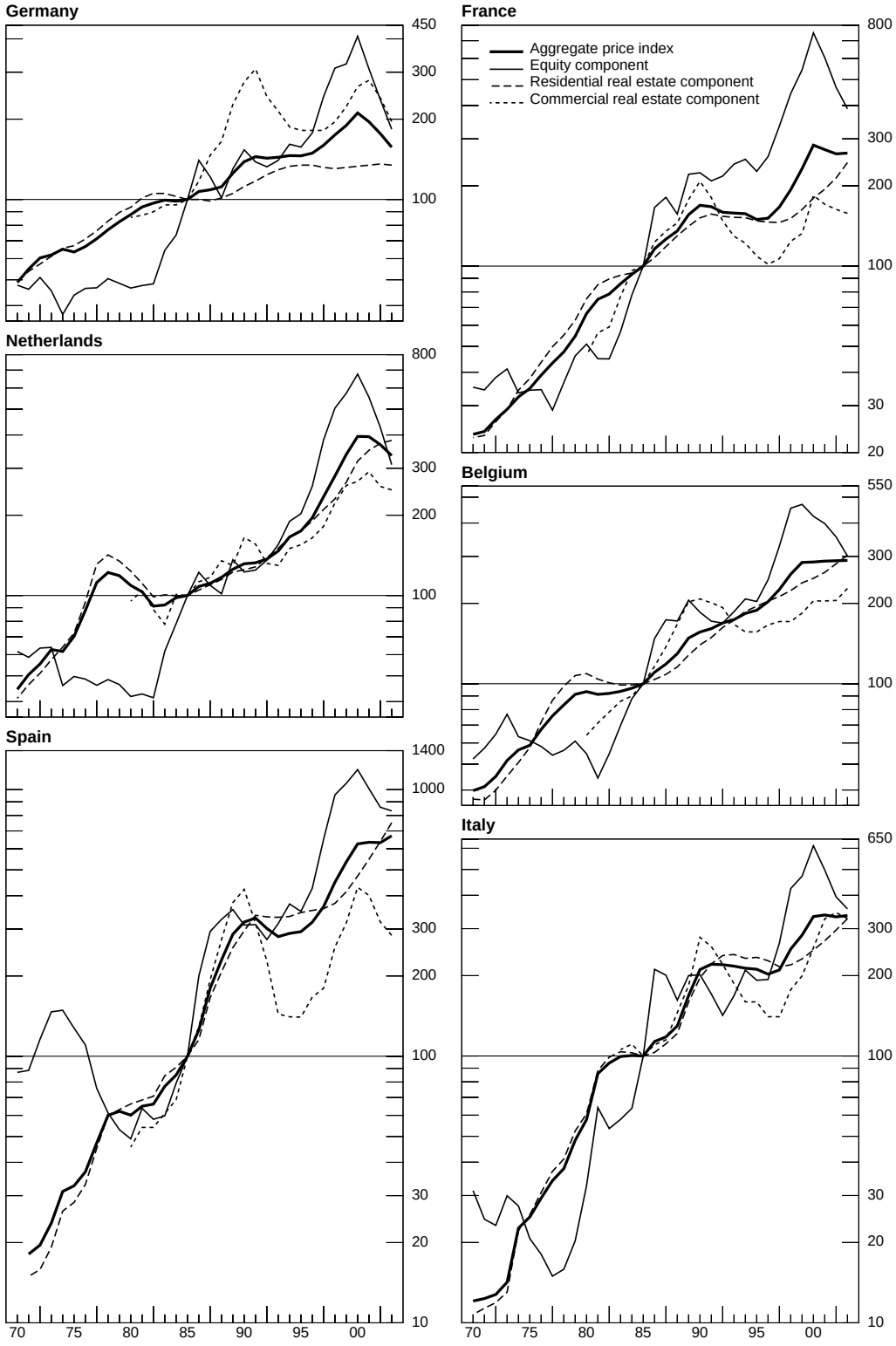
1985 = 100; semi-logarithmic scales



Graph 2 (cont)

Nominal asset prices: aggregate and components

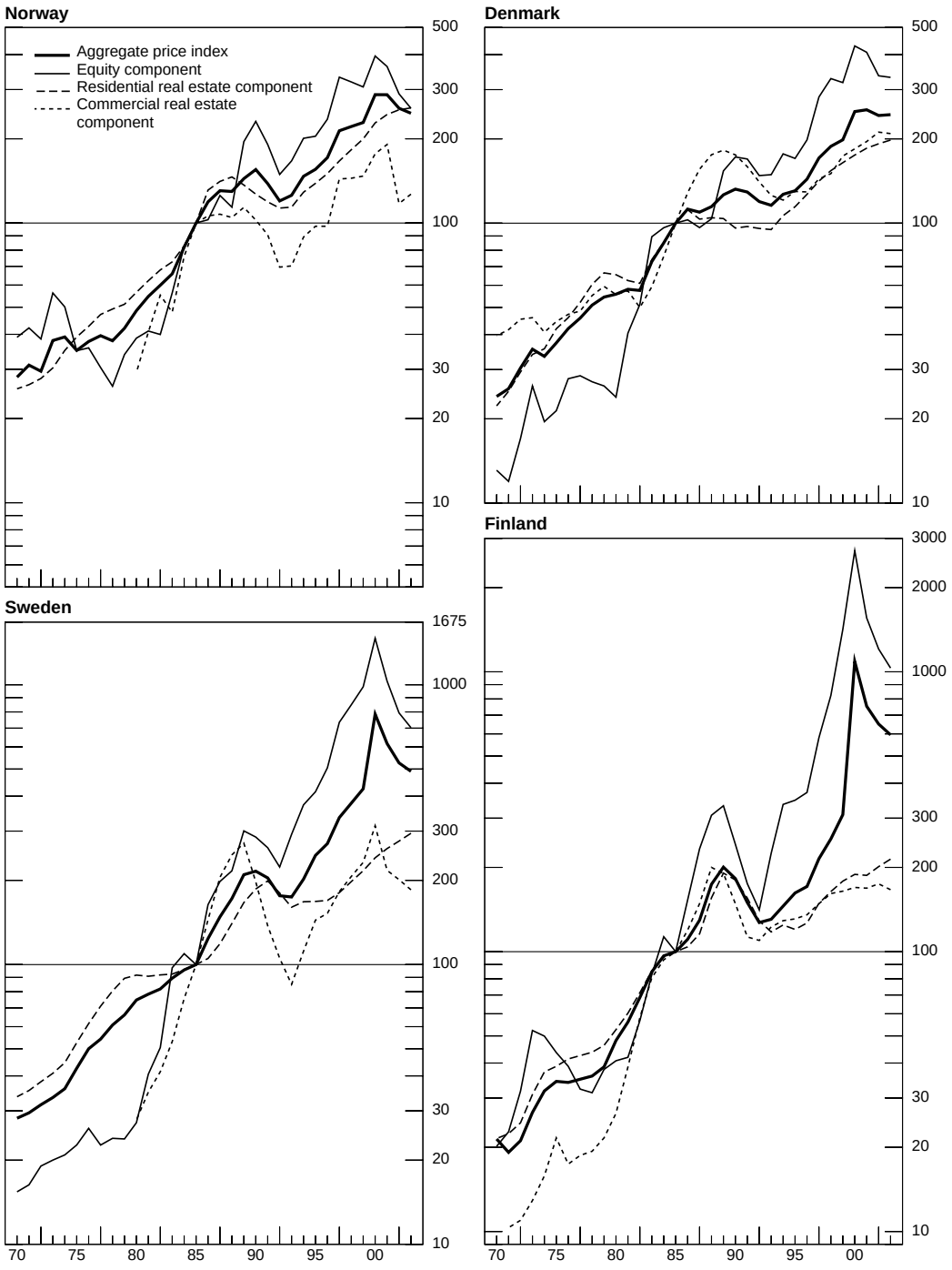
1985 = 100; semi-logarithmic scales



Graph 2 (cont)

Nominal asset prices: aggregate and components

1985 = 100; semi-logarithmic scales



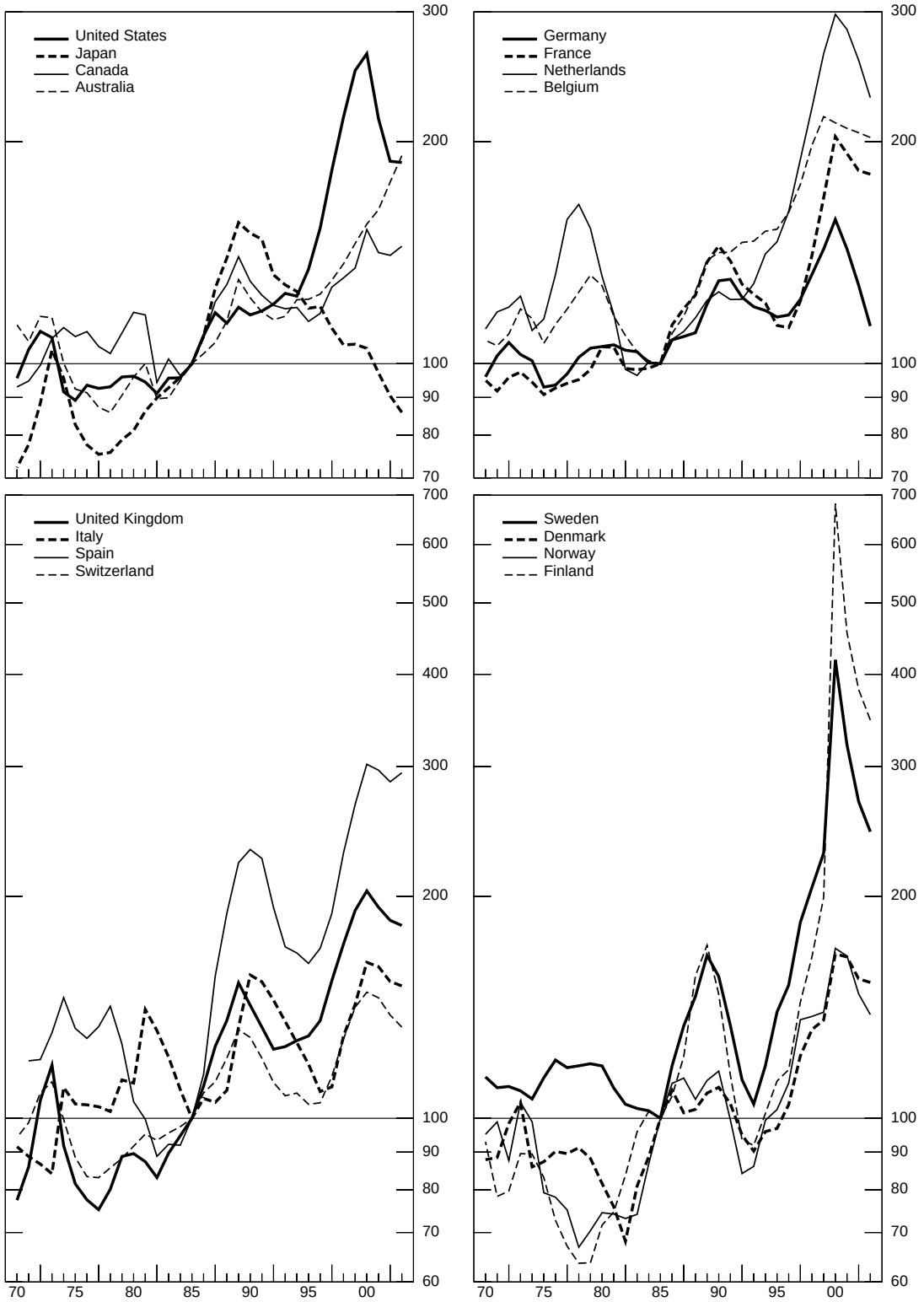
Notes: The aggregate price index is calculated as a weighted geometric mean of the three components. The weights are based, where available, on net wealth data, but in some cases are supplemented by the price change of each component. The calculation uses, where possible, moving weights; a five-year window, starting in 1970, is used where annual weights are not available. Where a component is not available, the geometric mean is calculated on the other two. For Belgium, France, Germany, the Netherlands, Norway and Sweden, the commercial real estate component is not shown in the 1970s as it is proprietary information.

Sources: Various private real estate associations; national data; BIS estimates and calculations.

Graph 3

Inflation-adjusted aggregate asset prices

1985 = 100; semi-logarithmic scales

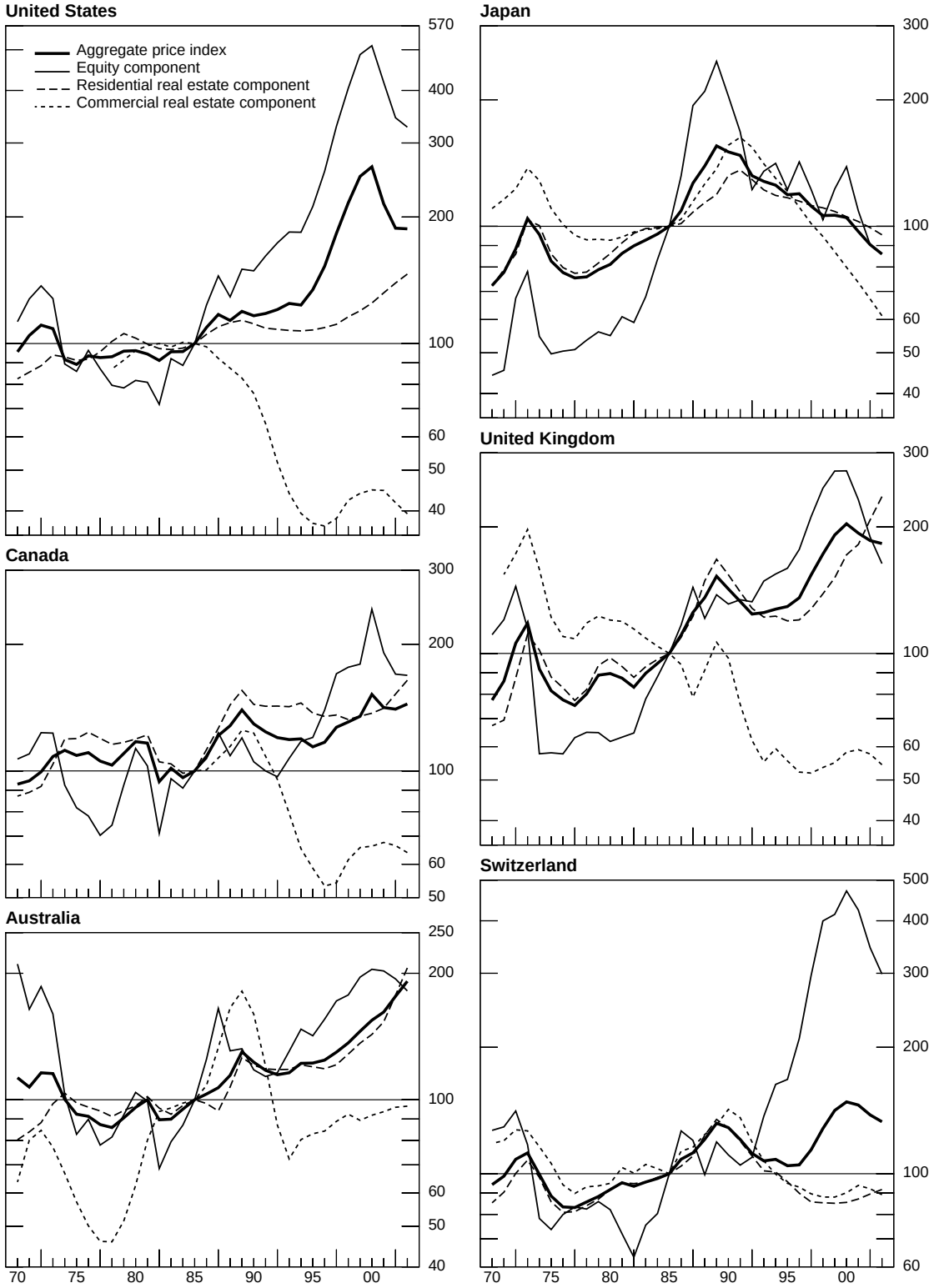


Note: For an explanation of the methodology and sources, see the notes to Graph 4.

Graph 4

Inflation-adjusted asset prices: aggregate and components

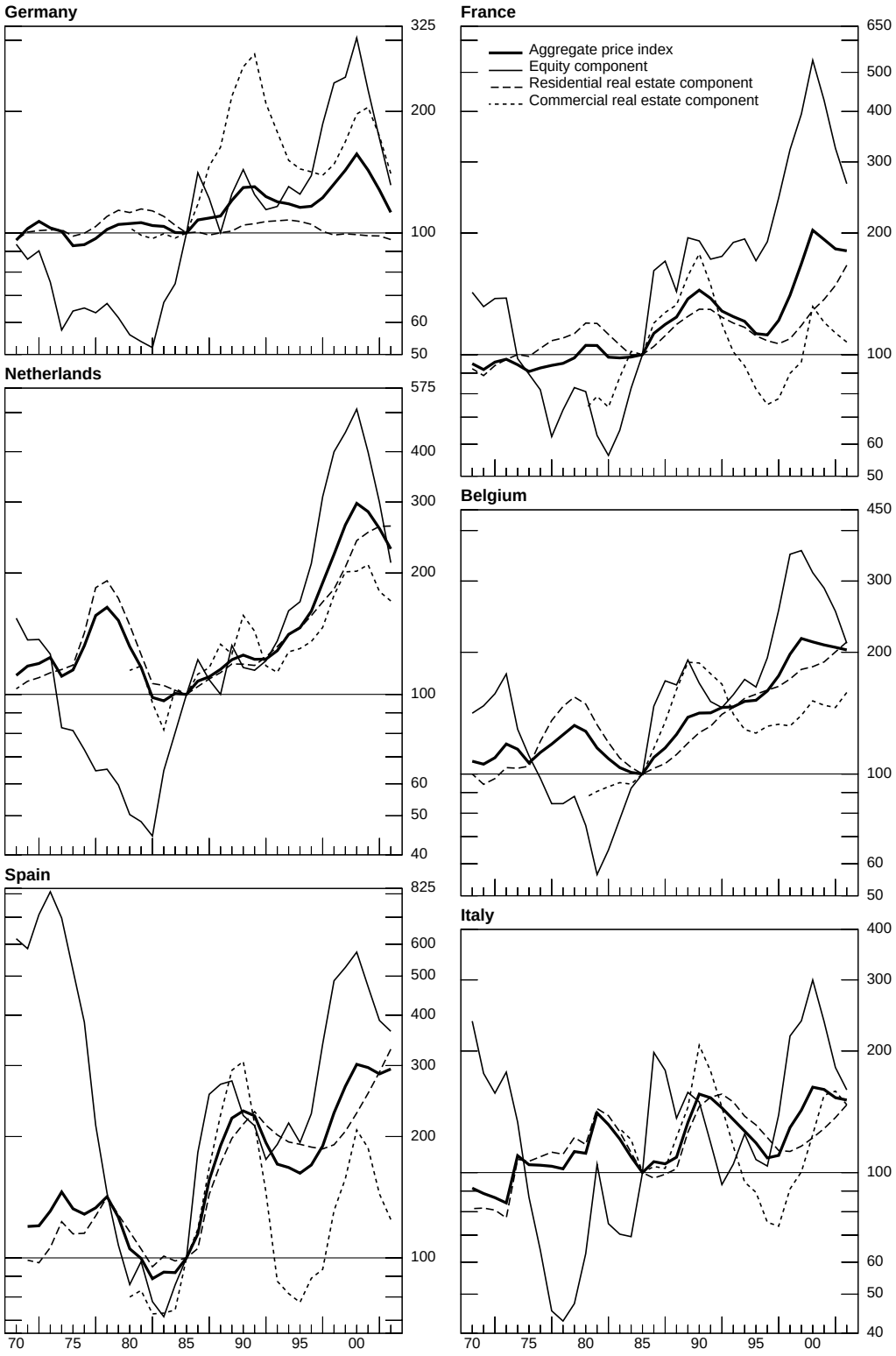
1985 = 100; semi-logarithmic scales



Graph 4 (cont)

Inflation-adjusted asset prices: aggregate and components

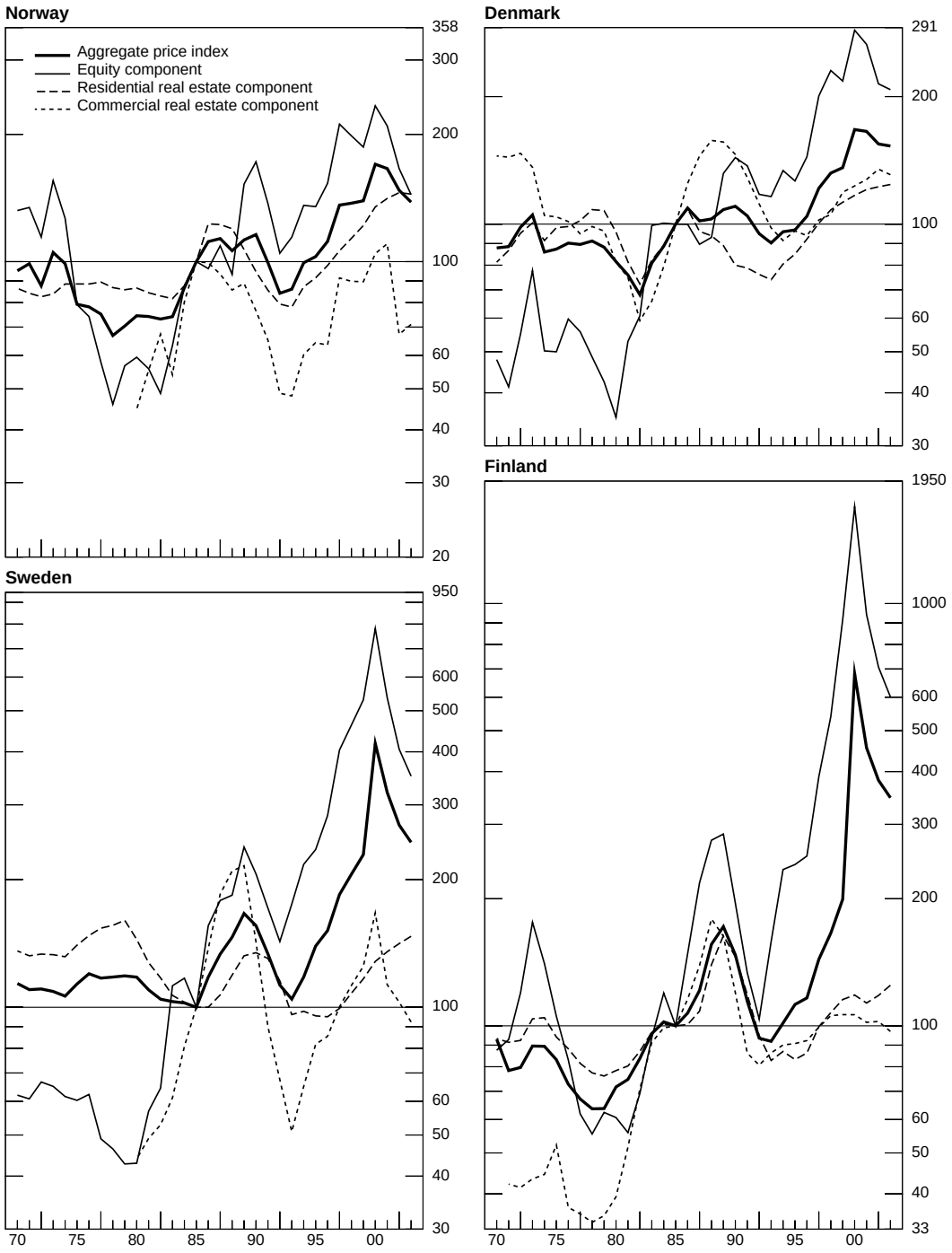
1985 = 100; semi-logarithmic scales



Graph 4 (cont)

Inflation-adjusted asset prices: aggregate and components

1985 = 100; semi-logarithmic scales



Notes: The aggregate price index is calculated as a weighted geometric mean of the three components. The weights are based, where available, on net wealth data, but in some cases are supplemented by the price change of each component. The calculation uses, where possible, moving weights; a five-year window, starting in 1970, is used where annual weights are not available. Where a component is not available, the geometric mean is calculated on the other two. For Belgium, France, Germany, the Netherlands, Norway and Sweden, the commercial real estate component is not shown in the 1970s as it is proprietary information. All indices are calculated as the nominal price indices deflated by the personal consumption deflator.

Sources: Various private real estate associations; national data; BIS estimates and calculations.

Table 1

Aggregate asset prices: a comparison of the weights

In percentages

Country	Borio et al (April 1994)				Arthur update (October 2000)			
	Period	Equity	Residential	"Net" commercial	Period	Equity	Residential	"Net" commercial
United States	1968-76	27	73	-	1972	45	45	10
	1977-82	25	68	7	1980	25	61	14
	1983-87	27	65	8	1985	26	62	13
	1988-92	31	61	8	1989	29	60	10
					1995	42	51	7
					2000	56	39	5
Japan	1960-77	5	74	21	1975	16	66	19
	1978-82	4	76	20	1980	16	66	18
	1983-87	21	62	16	1985	21	62	17
	1988-92	31	56	13	1988	31	56	14
					1995	23	59	18
					2000	18	62	19
Germany	1970-78	9	71	20	1974	8	72	20
	1979-82	8	75	17	1980	6	73	21
	1983-87	13	72	15	1985	11	70	19
	1988-92	15	69	16	1990[1]	11/12	69/68	20/19
					1995	16	66	18
					2000	32	53	15
United Kingdom	1968-76	30	70	-	1976	25	65	9
	1977-84	27	63	10	1982	27	62	11
	1985-92	34	59	7	1987[2]	34/33	58/60	8/7
					1995	46	47	7
					2000	49	46	5
Canada	1970-82	29	71	-	1976	18	56	26
	1983-87	34	66	-	1985	23	53	24
	1988-92	30	70	-	1989	24	56	20
					1995	30	53	17
					2000	37	48	15
Australia	1970-82	17	77	6	1970	37	56	7
	1983-87	19	75	6	1975	17	77	6
	1988-92	21	71	8	1980	19	76	5
					1985	19	75	6
					1990	21	71	8
					1995	25	69	6
					2000	28	67	5

[1] The first set of weights, and those prior to 1990, are for the former West Germany; the second set and those thereafter include the former East Germany. [2] The first set of weights, and those prior to 1987, are based on ESA 79; the second set and those thereafter on ESA 95.