Appendix C: Construction and Analysis of the Databases.

The basic data used in our analysis have been taken from the Penn World Table, Version 6.2 (PWT 6.2), and Barro and Lee (2001). Sections C.1 and C.2 discuss the construction of our databases used in, respectively, the examination of output per capita distributions and the analysis of convergence by parts. Sections C.3–C.5 delve into particular issues regarding our data sets and that of Feyrer (2003).

C.1. Output-per-Capita Database.

Our primary results relating to the distribution of output per capita employ the six different measures of output (per capita) found in PWT 6.2: CGDP, RGDPL, RGDPCH, RGDPEQA, RGDPWOK, and RGDPTT. We constructed two data sets, one with fewer countries (97) but covering a longer period (1960–2000) and one with more countries (137) but covering a shorter time frame (1970–2000). In each case, we included all countries with data on all of these output measures for each of the decadal years in those time frames. The countries included in our two data sets, as well as those in the Bianchi (1997) data set, are identified in Table C1.

C.2. Convergence-by-Parts Database.

The analysis of convergence by parts was carried out in three steps. First, we obtained the original data from Feyrer (2003) and conducted our modality tests for that database. Second, we updated Feyrer's data set by expanding the time dimension both backwards and forwards so as to cover the 1960's and the 1990's. Third, we ran all of our tests on these new databases.

Our construction of the capital-output ratio and the marginal product of capital in the two new data sets follows closely the approach of Casselli (2005). We include only those countries for which investment, capital stock, human capital, population, and output data exist for each decadal year we investigate. The Barro and Lee (2001) data set covers 139 countries, but data are missing for some countries for some years. Data exist for 99 countries for each decadal year from 1960 to 2000 and for 102 countries from 1970 to 2000.[1] Of those 99

[1] Data are available for Yugoslavia from 1960 through 1990, but the civil war in the mid 1990's led to the dissolution of the state.

countries, investment data are available dating back to at least 1960, and 92 have investment data dating back to 1970.[2] Indication of the countries in Feyrer's database as well as ours can be found in Table C2. An asterisk, as in X^*, indicates that the starting year (either 1960 or 1970) was also the first year of the investment series for that country. We allowed for the possibility that these values may cause spurious modes and ran our analysis both ignoring and accounting for this fact.

To construct the data for the capital-output ratio and the marginal product of capital—a function of the capital-output ratio—we must recover an output measure and construct a capital stock series. Our measure of output is recovered as did Feyrer (2003): $Y_t = RGDPCH_t * POP_t$ where $RGDPCH_t$ is real GDP per capita in international dollars in year t and POP_t is population in year t.

The construction of the capital stock series uses the perpetual inventory method. We first retrieve real aggregate investment as $I_t = RGDPL_t * POP_t * k_t$, where $RGDPL$ is real income per capita constructed using the Laspeyres method, POP is the total population of the country, and k_t is the investment share of total output ($k_t = I_t/Y_t$). The capital stock at time t is then calculated as

$$K_t = I_t + (1-\delta)K_{t-1},$$

where δ is the depreciation rate, set at 0.07 as in Easterly and Levine (2001). The big issue on the construction of capital stocks is how one goes about calculating the initial capital stock, K_0. We follow Caselli (2005) and construct initial capital stocks as

$$K_0 = \frac{I_0}{g+\delta},$$

where I_0 is the value of our constructed investment series in the first year it is available and g is the average of the yearly geometric growth rates of the investment series between the first available year and 1970 (for those countries in the 1960-2000 data set) or 1980 (for those additional countries in the 1970-2000 data set). Caselli (2005) has shown that differences in the method used to estimate the capital stock do not appear to make major differences in empirical results. This is especially true as the time between the initial capital stock and

[2] Complete education data but not complete investment data are available for the following countries: Afghanistan, Bahrain, Bangladesh, Guyana, Iraq, Kuwait, Liberia, Myanmar, Sudan, and West Germany.

current capital stock increases. We are, however, concerned about aspects of the capital-output ratio in both 1960 and 1970 and are therefore cautious about the interpretation of our results from these early years. While the low capital-output ratios are a matter of concern, they do not represent enough of a presence in the tail to dictate multimodality results.

On the other hand, the estimates of the marginal product of capital, using the standard Cobb-Douglas production function with capital's share set equal to 1/3, is highly sensitive to these low values of the capital-output ratio, causing modes in the right tail of the distribution (which may or may not be spurious).

Human capital stocks are constructed following both Hall and Jones (1999) and Feyrer (2003), using a piecewise linear representation. We extend the Feyrer analysis to consider both stocks of over 25 and over 15 years of age, which also gives us two measures of TFP: one for the human capital stock created with the over-25 data and another from the over-15 data.[3] For any given decade, this resulted in a total of 7 distributions for which we needed to test for modality.

C.3. Spurious Modes.

Interest in the Dip test is principally attributable to the fact that it is less susceptible to the occurrence of spurious modes in the tail of the distribution than is the Silverman test. On the other hand, if a true mode exists that is far away from the overall mass of the distribution, the Silverman test is more appropriate from a power standpoint than the Dip test. This is precisely the situation that occurs when considering output per capita measures for the countries of the world. The higher mode created by the relatively rich countries is very far removed from the rest of the mass of the distribution. This means that the Silverman test results should be taken as more appropriate than the Dip test, unless one is willing to claim that those observations represent outliers that are not representative of the underlying distribution.

There are several ways (all arbitrary) to deal with tail-positioned modes when using the Silverman test. The easiest is to decrease the value of these points or simply cut them

[3] We have no data on the average level of schooling for the population aged 15 and over for Malta. We calculate, for each decade, the average difference between the age 15 and age 25 population for the remaining 91 countries in the sample to create an estimate of Malta's human capital stock.

from the data set entirely.[4] Other methods involve mode testing on some preset range that is strictly within the range of the data, counting only those modes of a certain height,[5] counting points within ℓ standard deviations of the modes (which requires knowledge of their exact location), or data transformations. Data transformations are appealing in the sense that, while arbitrary, they can mitigate the effects of outliers and at the same time not distort the shape of the distribution. On the other hand, if one uses the logarithmic transformation, this is not entirely true. The logarithmic transformation is not "relative distance" preserving. Thus, for an untransformed distribution that has two modes that are close together, the logarithmic transformation will make them even closer. This makes it even more difficult for the Silverman test to confirm multimodality (see, *e.g.*, the results of Bianchi (1997, Table 1)).

C.4. Scaling and the Distribution of MPK.

Tables C3 and C4 give alternative p-values for the distribution of the marginal product of capital obtained by employing varying degrees of scaling for the determination of modes. Asterisks indicate that the number of modes is not monotonic with respect to the bandwidth. We see that the supposed multimodality of the MPK density in 1960 is very sensitive to the amount of scale that a mode must possess. This suggests that the small modes in the tail of the distribution are spurious and not actual clusters of countries that may constitute a club.

C.5. Density Comparisons.

As one way of comparing our two data sets to that of Feyrer (2003) and Johnson (2005), we plot the respective densities of salient variables. We should not, of course, expect the densities to track one another closely, in part because the Feyrer-Johnson data set was constructed using PWT 5.6 and ours were constructed using PWT 6.2 (and hence the measures of output are valued in different dollars). Moreover, our construction of the initial capital stocks differ slightly from that of Feyrer. The key feature that we are looking for is radical differences in the shape of densities rather than mere scale differences.

[4] This is a common treatment of the oil-producing countries in parametric growth analyses.

[5] This method, however, undermines the monotonicity between the number of modes and the bandwidth that makes the Silverman test so appealing.

In the comparison graphs that follow, FE is our mnemonic for our two data sets that are compared with the original Feyrer data set; thus, FE-77 refers to our sample of 77 countries over the period 1960-2000, with data taken from Barro and Lee (2001) and PWT 6.2, and FE-92 refers to our sample of 92 countries over the period 1970-2000, with data again being taken from Barro and Lee (2001) and PWT 6.2.

The plots of RGDPCH in figure C1 show that the three densities are similar in shape. While the FE–77 and Feyrer densities differ noticeability, especially around the troughs, the FE–92 density and the Feyrer track one another very closely, especially in 1990. These comparisons indicate that the difference between the Feyrer density estimate and the density estimate for our smaller data set is attributable to the existence of 15 fewer countries in the FE-77 sample, not to the utilization of a different primary database (PWT6.2 instead of PWT5.6).

Figure C2 shows that there are some significant differences in the capital-output ratio among the three data sets. In 1970, there appear to be shoulders in both Feyrer's and our larger data set. By 1980 the data sets are very similar, but again, in 1990, both of our data sets imply bimodality whereas Feyrer's is clearly unimodal. This is a puzzling result that deserves more attention.

The similarities and dissimilarities for the marginal product of capital densities, shown in Figure C3 are more striking. For 1970, we see that the differences in the data sets appears to be attributable to a few observations located in the right tail of the density. Our smaller sample is quite similar to that of Feyrer except for the tail. By 1980, these differences have disappeared in all three data sets. The panel for 1990, however, suggests that there are again several tail observations that are causing differences across our data sets and Feyrer's. We are not sure whether this is attributable to data construction or some other factor. Interestingly, there appear to be more tail observations in 1989 (1990) in the Feyrer data set than in ours.

Given that we construct our H-25 exactly as Feyrer does, apart from the fact that we use Barro and Lee (2001) rather than Barro and Lee (1993), it comes as no surprise to find that the densities are nearly identical, as shown in Figure C4. In contradistinction to our results, Feyrer finds that there is no polarization of human capital, even though it is visually bimodal in 1990 (1989). The reason for these contrasting findings is that there is relatively little movement within the distribution, even though Feyrer finds that the ergodic distribution suggests that compression towards the upper end of the distribution should take place. Also, the second mode is less potent in the Feyrer data set than in the two we construct, and this may have made it hard for the Markov methods to pull out the apparent polarization that was beginning to take place in the 1980's.

Lastly, we offer a few comments on discrepancies in the densities of total factor productivity, shown in Figure C5. While all three distributions are unimodal in 1970, the density for our smaller data set appears to have a slight shoulder to the right of 1.2. In 1980, this shoulder morphs into a bimodal distribution,[6] and the Feyrer density estimate develops a shoulder. By 1990 (1989) it appears that no major difference across the data sets exists. Bimodality is visually present in all three, consistent with the test results for the corresponding data sets.

The differences in the K/Y, MPK, and TFP densities in 1970 and 1980 appear to be attributable to the construction of the capital variable. The intial capital stock is much more important in 1970 and 1980 than it is in 1990 (1989). Any differences generated by the creation of the initial capital stock should have dissipated by the late 1980's (with time lapses from the intial to the current capital stocks stretching to almost 20 years for some countries). This is surely the case for TFP and MPK, though perhaps less so for K/Y.

[6] This pattern could be attributable to the omission of 15 countries in FE–77, in that many of them pushed up the trough, as is evident in the FE–92 density estimate.

Table C1: Countries in Output Measures Datasets

Countries	Bianchi	1960-2000	1970-2000
Afghanistan			X
Algeria	X	X	X
Angola	X		
Argentina	X	X	X
Australia	X	X	X
Austria	X	X	X
Bahamas			X
Bahrain			X
Bangladesh	X		
Barbados	X	X	X
Belgium	X	X	X
Belize			X
Benin	X		X
Bhutan			X
Bolivia	X	X	X
Botswana	X		X
Brazil	X	X	X
Brunei			X
Burkina Faso	X		X
Burundi	X		X
Cambodia			X
Cameroon	X	X	X
Canada	X	X	X
Cape Verde Island	X		X
Central African Republic	X		X
Chad	X		
Chile	X	X	X
China	X		
Colombia	X	X	X
Comoros			X
Congo	X		
Congo (formerly Zaire)	X		X
Costa Rica	X	X	X
Cuba			X
Cyprus	X		X

Table C1: Countries in Output Measure Datasets: Continued

Countries	Bianchi	1960-2000	1970-2000
Czechoslovakia	X		
Denmark	X	X	X
Dominican Republic	X	X	X
Ecuador	X	X	X
Egypt			X
El Salvador	X	X	X
Equatorial Guinea			X
Ethiopia			X
Fiji	X		X
Finland	X	X	X
France	X	X	X
Gabon	X		
Gambia	X		
Ghana	X	X	X
Greece	X	X	X
Guatemala	X	X	X
Guinea	X		
Guinea-Bissau	X		
Guyana	X		
Haiti	X		X
Honduras	X	X	X
Hong Kong	X	X	X
Hungary			X
Iceland	X	X	X
India	X	X	X
Indonesia	X	X	X
Iran	X	X	X
Iraq			X
Ireland	X	X	X
Israel	X	X	X
Italy	X	X	X
Ivory Coast	X		X
Jamaica	X	X	X
Japan	X	X	X
Jordan	X	X	X

Table C1: Countries in Output Measure Datasets: Continued

Countries	Bianchi	1960-2000	1970-2000
Kenya	X	X	X
Korea	X	X	X
Korea (North)			X
Kuwait			X
Laos			X
Lesotho	X	X	X
Liberia			X
Macao			X
Luxembourg	X		
Madagascar	X		
Malawi	X	X	X
Malaysia	X	X	X
Maldives			X
Mali	X	X	X
Malta	X		X
Mauritania	X		
Mauritius	X	X	X
Mexico	X	X	X
Mongolia			X
Morocco	X		
Mozambique	X	X	X
Myanmar	X		
Namibia	X		
Nepal		X	X
Netherlands	X	X	X
Netherlands (Antilles)			X
New Zealand	X	X	X
Nicaragua		X	X
Niger	X	X	X
Nigeria	X		
Norway	X	X	X
Oman			X
Pakistan	X	X	X
Panama	X	X	X
Papua New Guinea	X		X

Table C1: Countries in Output Measure Datasets: Continued

Countries	Bianchi	1960-2000	1970-2000
Paraguay	X	X	X
Peru	X	X	X
Philippines	X	X	X
Poland	X		X
Portugal	X	X	X
Puerto Rico	X		
Qatar			X
Romania		X	X
Rwanda	X		X
Saudi Arabia			X
Senegal	X	X	X
Seychelles	X		
Sierra Leone	X		X
Singapore	X	X	X
Solomon Islands			X
Somalia	X		
South Africa	X	X	X
Spain	X	X	X
Sri Lanka	X	X	X
Swaziland	X		X
Sweden	X	X	X
Switzerland	X	X	X
Syria	X	X	X
Taiwan	X	X	X
Tanzania		X	X
Thailand	X	X	X
Togo	X	X	X
Trinidad & Tobago	X	X	X
Tunisia	X		X
Turkey	X	X	X
Uganda	X	X	X
United Arab Emirates			X
United Kingdom	X	X	X
United States	X	X	X
U.S.S.R.	X		

Table C1: Countries in Output Measure Datasets: Continued

Countries	Bianchi	1960-2000	1970-2000
Uganda	X		
Uruguay	X	X	X
Venezuela	X	X	X
West Germany	X		
Yemen	X		
Yugoslavia	X		
Zambia	X	X	X
Zimbabwe	X	X	X

Table C2: Countries in Development Accounting Datasets

Countries	Feyrer	1960-2000	1970-2000
Algeria	X	X*	X
Argentina	X	X	X
Australia	X	X	X
Austria	X	X	X
Bangladesh	X		
Barbados	X	X*	X
Belgium	X	X	X
Benin	X		X
Bolivia	X	X	X
Botswana	X		X*
Brazil	X	X	X
Cameroon	X	X*	X
Canada	X	X	X
Central African Republic	X		X*
Chile	X	X	X
Colombia	X	X	X
Congo (formerly Zaire)	X		X*
Costa Rica	X	X	X
Cyprus	X		X*
Denmark	X	X	X
Dominican Republic	X	X	X
Ecuador	X	X	X
El Salvador	X	X	X
Fiji	X		X*
Finland	X	X	X
France	X	X	X
Ghana	X	X	X
Greece	X	X	X
Guatemala	X	X	X
Guyana	X		
Haiti	X		X*
Honduras	X	X	X
Hong Kong	X	X*	X
Hungary			X*
Iceland	X	X	X

Table C2: Countries in Development Accounting Datasets: Continued

Countries	Feyrer	1960-2000	1970-2000
India	X	X	X
Indonesia	X	X*	X
Iran	X	X	X
Ireland	X	X	X
Israel	X	X	X
Italy	X	X	X
Jamaica	X	X	X
Japan	X	X	X
Jordan	X	X	X
Kenya	X	X	X
Korea	X	X	X
Lesotho	X	X*	X
Malawi	X	X	X
Malaysia	X	X	X
Mali	X	X*	X
Malta	X		X*
Mauritius	X	X	X
Mexico	X	X	X
Mozambique	X	X*	X
Nepal		X*	X
Netherlands	X	X	X
New Zealand	X	X	X
Nicaragua	X	X	X
Niger	X	X*	X
Norway	X	X	X
Pakistan	X	X	X
Panama	X	X	X
Papua New Guinea	X		X*
Paraguay	X	X	X
Peru	X	X	X
Philippines	X	X	X
Poland			X*
Portugal	X	X	X
Romania		X*	X
Rwanda	X		X

Table C2: Countries in Development Accounting Datasets: Continued

Countries	Feyrer	1960-2000	1970-2000
Senegal	X	X*	X
Sierra Leone	X		X*
Singapore	X	X*	X
South Africa	X	X	X
Spain	X	X	X
Sri Lanka	X	X	X
Swaziland	X		X*
Sweden	X	X	X
Switzerland	X	X	X
Syria	X	X*	X
Taiwan		X	X
Tanzania		X*	X
Thailand	X	X	X
Togo	X	X*	X
Trinidad & Tobago	X	X	X
Tunisia	X		X
Turkey	X	X	X
Uganda	X	X	X
United Kingdom	X	X	X
United States	X	X	X
Uruguay	X	X	X
Venezuela	X	X	X
West Germany	X		
Yugoslavia	X		
Zambia	X	X	X
Zimbabwe	X	X	X

Table C3: Modality Test Results For Marginal Product of Capital (1960-2000 dataset)

	Uncalibrated Silverman p-value	Calibrated Silverman p-value
Scale of 1.2		
MPK-60	0.321	0.239
MPK-70	0.366	0.296
MPK-80	*****	*****
MPK-90	0.000	0.000
MPK-00	0.657	0.550
Scale of 1.5		
MPK-60	0.301	0.232
MPK-70	0.366	0.296
MPK-80	*****	*****
MPK-90	0.000	0.000
MPK-00	0.657	0.550
Scale of 2.1		
MPK-60	0.164	0.108
MPK-70	*****	*****
MPK-80	*****	*****
MPK-90	*****	*****
MPK-00	*****	*****
Scale of 2.3		
MPK-60	*****	*****
MPK-70	*****	*****
MPK-80	0.412	0.298
MPK-90	0.375	0.311
MPK-00	*****	*****
Only Evaluating over (0,1)		
MPK-60	0.287	0.133
MPK-70	0.172	0.081
MPK-80	0.452	0.302
MPK-90	0.000	0.000
MPK-00	0.103	0.059
Drop Countries with Poor Initial Investment		
MPK-60	0.206	0.095
Drop Countries w/ Poor Initial Investment and Scale by 2.1		
MPK-60	0.466	0.375

Table C4: Modality Test Results For Marginal Product of Capital (1970-2000 dataset)

	Uncalibrated Silverman p-value	Calibrated Silverman p-value
	Scale of 1.2	
MPK-70	*****	*****
MPK-80	0.037	0.006
MPK-90	*****	*****
MPK-00	0.776	0.673
	Scale of 1.5	
MPK-70	*****	*****
MPK-80	0.037	0.006
MPK-90	0.016	0.003
MPK-00	0.759	0.661
	Scale of 2.1	
MPK-70	0.653	0.552
MPK-80	0.025	0.004
MPK-90	*****	*****
MPK-00	0.653	0.540
	Scale of 2.3	
MPK-70	0.628	0.520
MPK-80	0.024	0.002
MPK-90	*****	*****
MPK-00	0.623	0.516
	Only Evaluating over (0,1)	
MPK-70	0.081	0.032
MPK-80	0.586	0.404
MPK-90	0.001	0.000
MPK-00	0.810	0.678

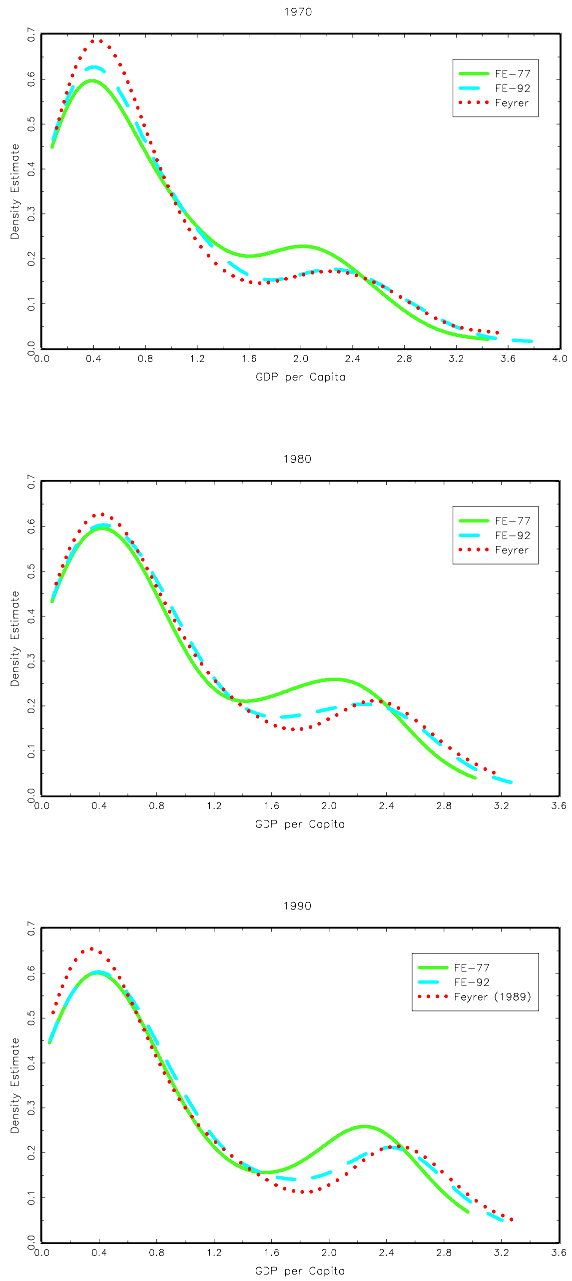

Figure C1: Dataset Comparisons–GDP

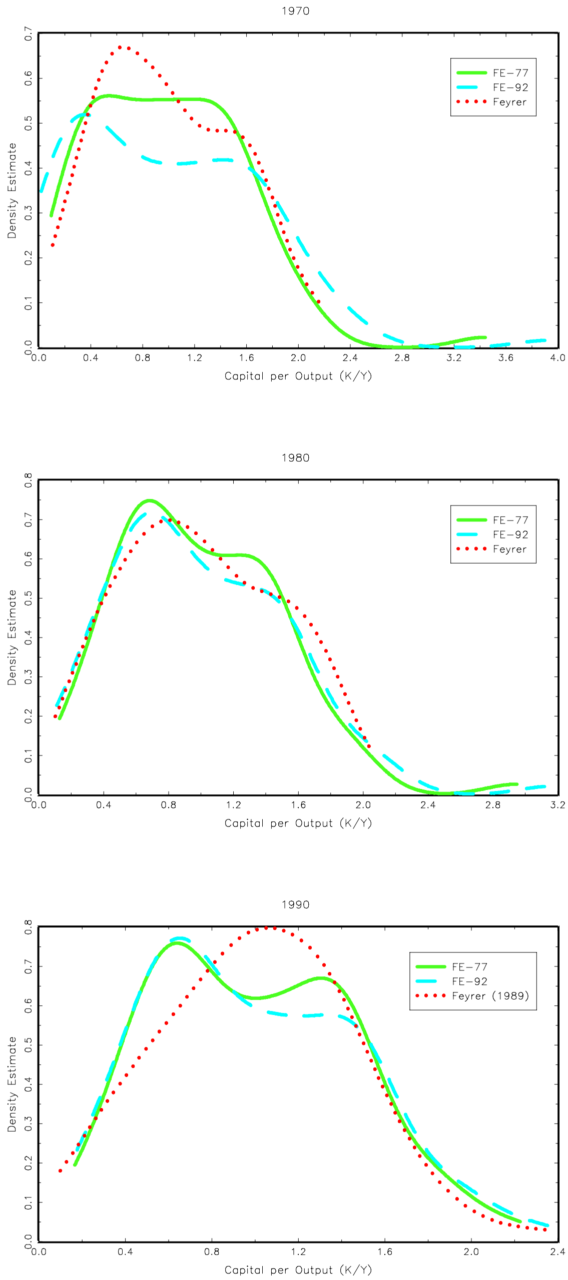

Figure C2: Dataset Comparisons–Capital Output Ratio (K/Y)

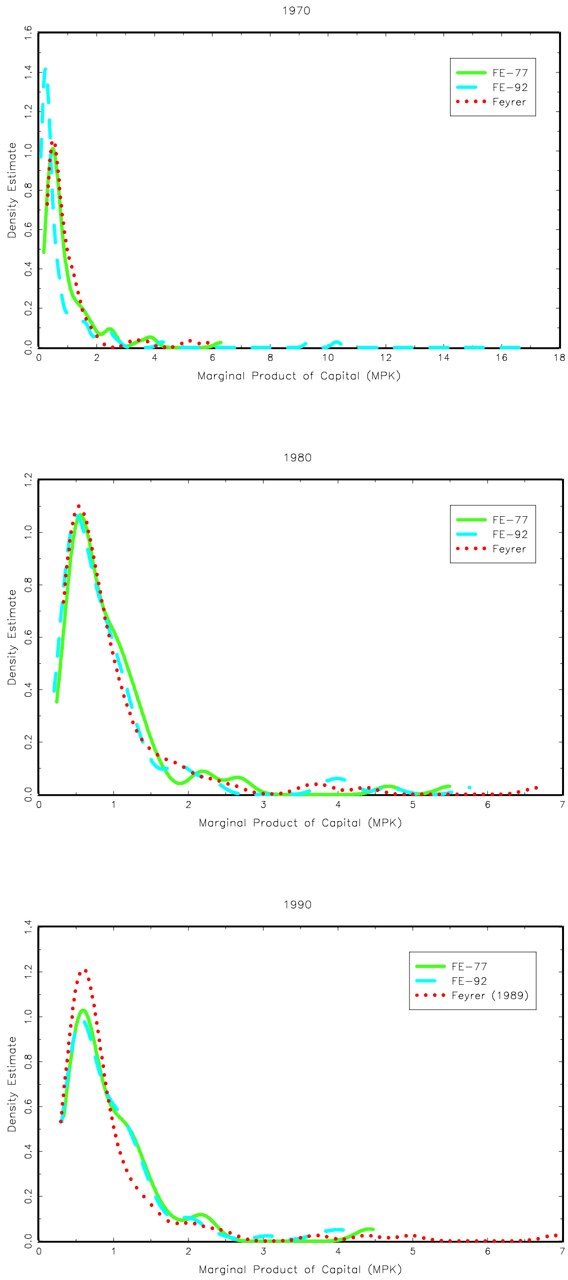

Figure C3: Dataset Comparisons–Marginal Product of Capital (MPK)

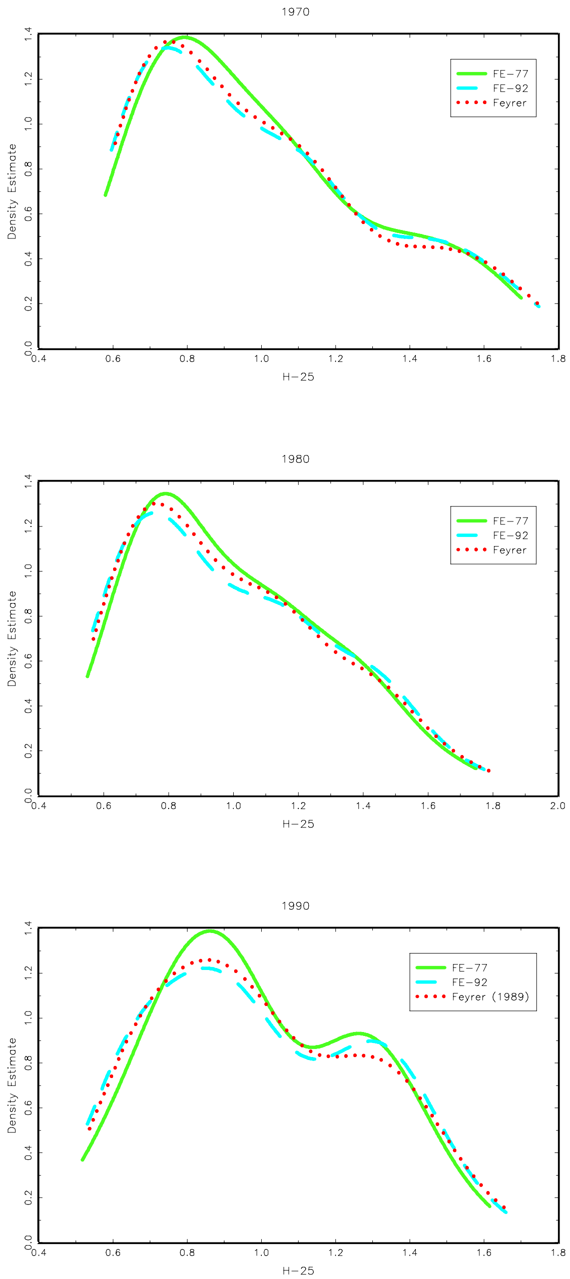

Figure C4: Dataset Comparisons–H-25

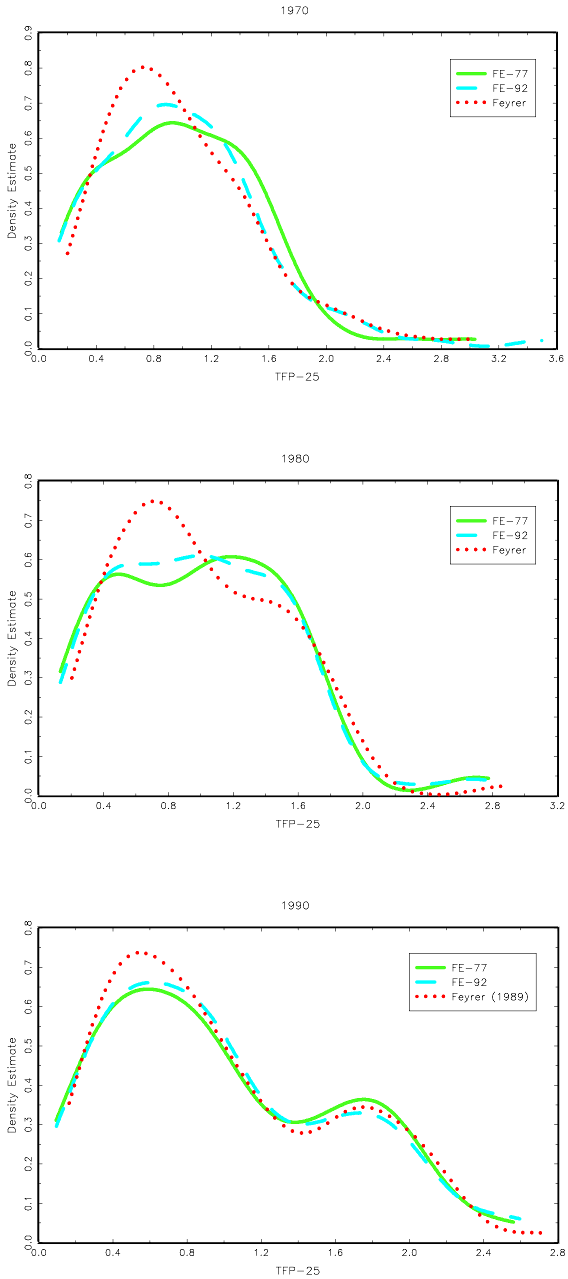

Figure C5: Dataset Comparisons–TFP-25