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Portugal: Selected Issues

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PORTUGAL

Selected Issues

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Contents Page

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Portugal: Basic Data 1/

Total area: 34,312 square miles
Population: 10.0 million
GDP per capita (1998): US$10,863

	1993	1994	1995	1996	1997	1998	1999
	(Changes in percent, except as otherwise indicated)						
Domestic economy							
Real GDP	-1.4	2.4	2.9	3.6	3.8	3.9	3.0
Real domestic demand	-1.6	3.1	2.4	3.5	5.2	6.5	4.1
Private consumption	1.0	2.3	1.7	2.8	3.3	5.6	4.5
Investment	-10.1	6.5	4.4	6.6	12.3	10.5	4.2
Foreign sector contribution	0.3	-0.9	0.3	-0.2	-1.8	-3.0	-1.5
Employment	-2.0	-0.1	-0.6	0.6	1.9	2.3	0.8
Unemployment rate	5.5	6.8	7.2	7.3	6.7	5.0	4.6
Compensation per worker (manufacturing)	7.7	4.8	6.0	4.9	4.6	4.1	3.8
Unit labor costs (manufacturing)	7.7	2.8	-1.9	0.9	0.7	2.4	2.4
Consumer prices (national index)	6.5	5.2	4.1	3.1	2.2	2.8	2.5
Consumer prices (harmonized index)	...	...	...	2.9	1.9	2.2	2.3
GDP deflator	7.0	6.1	5.0	2.5	3.1	4.5	3.0
External accounts							
Export volume	-2.2	13.2	12.9	12.7	10.0	7.4	6.0
Import volume	-5.8	11.3	9.7	8.4	13.2	15.2	6.8
Export unit value	6.0	6.5	4.2	-3.8	0.4	0.2	1.0
Import unit value	9.2	4.3	1.7	-0.3	0.3	-1.2	1.3
Trade balance (US$ billions, f.o.b.)	-8.0	-8.3	-8.9	-9.4	-10.0	-12.2	-13.0
Current transfers (net, US$ billions) 2/	6.7	5.4	7.1	4.4	3.7	4.0	4.3
Current account (US$ billions) 3/	0.1	-2.2	-0.2	-2.3	-2.8	-4.6	-5.6
In percent of GDP 3/	0.1	-2.5	-0.2	-2.1	-2.8	-4.3	-5.1
Current account excluding capital transfers (in percent of GDP)	...	...	...	-4.2	-5.4	-6.7	-7.5
Financial account (in percent of GDP)	-3.3	0.7	3.5	3.6	6.2	5.6	...
Of which: inward foreign direct investment	1.8	1.4	0.7	1.3	2.5	1.6	...
inward portfolio investment	5.3	4.4	2.0	3.9	8.3	5.8	...
Nominal effective exchange rate 4/	-5.7	-3.4	1.7	0.2	-2.1	-1.1	-1.5
Real effective exchange rate (CPI based) 4/	-2.9	-1.2	2.9	0.9	-1.8	0.2	-0.7
Net official reserves (end of period; in US$ billions)	21.8	21.3	21.7	21.3	18.2	18.7	...
General government finances (in percent of GDP)							
Revenues	41.1	39.5	40.6	43.2	43.4	43.4	44.5
Expenditures	47.2	45.5	46.4	46.5	46.0	45.5	46.1
Of which: capital expenditures	5.9	4.9	5.2	6.2	6.3	6.4	6.6
Overall balance	-6.1	-6.0	-5.7	-3.3	-2.5	-2.1	-1.6
Public debt (Maastricht definition)	63.1	63.8	65.9	65.0	61.4	57.0	55.4
Of which: external debt	7.4	9.4	11.6	11.8	14.1	14.9	...
Privatization receipts	0.6	1.3	2.3	2.8	4.8	4.0	1.7
Financial variables (end of period)							
Harmonized M3 5/	...	...	8.2	6.1	6.4	6.8	6.9
Liquidity of residents (L-)	6.2	9.4	8.0	8.8	6.3	7.8	...
Domestic credit 5/	8.8	13.7	11.7	12.6	11.6	17.1	18.5
Credit to the general government 5/	2.3	22.0	-5.3	-3.1	-28.1	-40.0	-65.1
Credit to the private sector 5/ 6/	11.4	11.1	17.7	17.1	20.8	25.1	28.1
Interest rates (percent) 7/							
Overnight rate	11.2	8.9	8.6	6.7	5.1	3.3	2.4
Deposit rate, 91–180 days	10.2	9.3	8.1	5.5	4.6	3.3	2.7
Lending rate, 91–180 days	15.7	14.7	12.7	11.0	8.4	6.0	5.0
Government benchmark bond	9.0	11.6	10.0	7.0	5.7	4.1	5.4
Nonperforming loans (in percent of total) 8/	6.9	6.5	5.9	5.1	4.0	2.8	...
Risk-based capital asset ratio 9/	...	11.6	8.5	8.4	9.1	9.1	...
Long-term foreign currency debt rating (S&P) 10/	AA-	AA-	AA-	AA-	AA-	AA	AA
Long-term foreign currency debt rating (Moody's) 10/	A1	A1	A1	A1	Aa3	Aa2	Aa2

Sources: Bank of Portugal; Ministry of Finance; National Statistics Office (INE); and Fund staff estimates and projections.

1/ Unless otherwise noted, 1999 data are staff estimates or projections.

2/ Statistical break in 1996. Figures exclude transfers to finance capital expenditure for 1996–1999. These transfers equaled US$2.2 billion in 1996.

3/ Statistical break in 1996. Figures include transfers to finance capital expenditure, which equaled US$2.2 billion in 1996.

4/ Data for 1999 correspond to year-on-year rates of change through July.

5/ Data for 1999 correspond to year-on-year rates of change through August.

6/ Includes nonfinancial public enterprises and nonmonetary financial institutions.

7/ Data for 1999 refers to September.

8/ Includes credit unions, and encompasses activity of off-shore branches and branches abroad.

9/ Capital over risk-weighted liabilities according to BIS methodology; lowest value among the six largest banking groups (which account for 90 percent of the banking system).

10/ 1999 ratings refer to those available as of July.

INTRODUCTION

1. Since the mid-1990s, the Portuguese economy has combined one of the highest growth rates in the euro area with a successful disinflation process. This reflected, to an important extent, sound macroeconomic policies in the run-up to the third stage of European Economic and Monetary Union (EMU), as well as flexible labor markets that helped accelerate the convergence process.

2. Achieving durable convergence in living standards remains the key policy challenge facing the Portuguese economy. Since joining the European Union (EU) in 1986, per capita income growth has exceeded that in EU partner countries by about 1 percent per annum. In the past, Portugal's growth was fueled primarily by the accumulation of capital, rather than increases in total factor productivity. This brings to the fore the issue of the sustainability of the catch-up process, at a time when per capita income is still only about two-thirds of the EU average. The impending reduction in EU transfers (as a share of GDP) expected toward the end of the Agenda 2000 horizon (in 2006) draws further attention to the need to strengthen factor productivity growth.

3. In this context, the background chapters presented here focus on two key issues: **education** and **public investment**. Both areas are generally considered as critical for Portugal's prospects for sustaining or accelerating the drive toward real income convergence. Moreover, both areas absorb a substantial share of public resources and thus have important implications for fiscal balances, which are, under EMU, constrained by the Stability and Growth Pact.

4. Chapter I (by Benedict Clements) assesses the performance of the Portuguese **education system** and delineates a possible agenda for reform. The accumulation of human capital is widely recognized in the growth literature as a driving force in economic development. This issue is of particular concern to Portugal, where the small share of the population having completed secondary school (about 20 percent) constitutes a major stumbling block to higher labor productivity. The chapter finds that considerable progress has been achieved in recent years. Nevertheless, rates of educational attainment for the current school-age cohort still lag behind much of the OECD, suggesting the need for additional steps to complement recent reforms.

5. Low attainment rates reflect several factors, among them high failure rates, which exceeded 30 percent for grades 10–12 for the latest year for which data are available (1995/96). As a result, both school dropout and repetition rates are high. Scores on internationally comparable examinations in math and science also indicate significant lags in educational performance.

6. Portugal's low educational performance has coincided with the highest level of primary and secondary education expenditure relative to GDP in the OECD, suggesting a large degree of inefficiency. Portugal's relatively high spending in the public system is linked to both a low number of students per teacher and generous salaries (relative to per capita

income), and high repetition rates that boost school enrollments. Public expenditures on capital and nonwage current outlays in public schools are well below OECD norms, however, indicating some possible misallocation in the composition of spending. Comparisons with the private sector are also suggestive of the room for improving efficiency in the public sector: while student/teacher ratios in Portugal's private schools are 50 percent higher, failure rates are lower. The empirical results from the application of a nonparametric technique for production frontier estimation (Free Disposable Hull analysis) also support the view of a relatively high degree of inefficiency in the Portuguese education system.

7. The government's efforts to improve educational attainment have focused on strengthening participation in preschool education and increasing the range of vocational and technically oriented courses offered to students. While these measures will have a salutary effect over the long run, deeper and more ambitious reforms may be necessary to more rapidly close the gap with the rest of the OECD. Among the reforms that could be considered are: (i) adoption of a goal-oriented management and incentive system, with school and teacher performance assessments based on progress in meeting quantitative targets for reducing failure rates, repetition rates, and improving scores on national examinations; in this context, additional modifications to the curriculum may be required to support stronger academic achievement; (ii) establishing minimum school sizes and student/teacher ratios; and (iii) an easing of employment and work rules governing public school teachers, which would allow for a reallocation of experienced staff to areas of greatest need. There is also scope for raising user fees in publicly funded higher education.

8. Chapter II (by Jenny Ligthart) attempts to shed light on the role of **public investment** in Portugal. Public capital expenditures are among the highest in the EU; including capital transfers, these outlays have averaged some 5¾ percent of GDP in the 1990s, and were over 6 percent of GDP in 1998. In view of this sizable commitment of public resources, the question arises of how productive public investment has been, that is, how much it has contributed to Portugal's economic growth.

9. The chapter finds that public capital has been about as productive in Portugal as in other industrialized countries, with a 1 percent increase in the public capital stock increasing output, on average, by close to 0.3 percent. These estimates imply a high rate of return to public investment (about 40 percent), a result that is consistent with the findings for other industrial counties. With respect to the effects of separate components of the public capital stock, the estimates indicate that, in particular, public investment in infrastructure and in machinery and transport equipment stimulates growth. The evidence on whether public investment crowds out private sector capital formation is mixed: while there is some evidence to this effect in the short run, over the longer term no crowding out was found. There is little evidence to suggest that public investment responds to the business cycle; rather, public investment appears to be determined exogenously.

10. To assess the robustness of the results and allow for comparability with studies for other countries, the chapter employs a number of econometric techniques, using annual data over 1965–95. Results from a production function approach, estimated in levels by ordinary

least squares, are broadly consistent with the findings for other countries in the literature. The long-term relationship between public investment and output is also ascertained using Johansen's (1988) cointegration approach, as well as impulse response functions from the unrestricted vector autoregressive approach. The results consistently point to a positive relationship between public investment and output. However, the size of the effect differs, depending on the technique utilized, and additional work is warranted to gauge the precise effect of public investment on economic activity.

11. The positive nexus between public capital formation and growth revealed by these diverse approaches lends support to a fiscal strategy that safeguards adequate levels of public investment, even after EU-related funding diminishes. Within the constraints of the Stability and Growth Pact and the need to ensure a competitive tax burden, the maintenance of high levels of public investment would necessitate sufficient restraint over the growth of the government's current expenditure.

12. Portugal's **publication of data** is characterized by a high degree of frequency and openness, with extensive use of the Internet. The Bank of Portugal, Ministry of Finance, and National Statistics Office have several websites with long- and short-term economic indicators, and they also provide assessments of economic developments. Additional information is available from international organizations. A list of the principal national and international sites is provided in chapter III.

I. The Portuguese Education System: Performance and Reform Agenda[1]

A. Introduction

13. It is widely accepted that the accumulation of human capital plays a vital role in the process of economic development (e.g., Rebelo, 1991). Given the positive externalities associated with many kinds of education spending, and credit market failures that can lead to underinvestment in human capital by households, there is a clear rationale for public sector involvement in the education sector. What is less clear, however, is the precise role of the public sector, be it through direct provision of educational services, or the financing of private sector provision. A key issue in this regard is the appropriate level of public expenditure, and whether this public expenditure is efficient, that is, is producing educational outputs at the lowest possible cost.

14. These issues are of particular concern to Portugal as it continues its drive to bridge the gap in living standards with the rest of the EU. With a large share of its population having failed to complete secondary education, there is a dearth of workers qualified for intermediate, technical-level positions, which constitutes a major stumbling block to higher labor productivity and economic growth.[2] And despite recent improvements, rates of educational attainment for the present school-age population still lag behind much of the EU and OECD, implying little relief from these labor bottlenecks in the near term. At the same time, public education spending, at nearly 5¾ percent of GDP, is well above the OECD average. Given the need to contain the growth of public expenditure under the Stability Program, an improvement in the efficiency of educational spending could help the government improve the output of the education system without raising spending.[3]

15. This chapter attempts to shed light on these issues by examining the performance of the Portuguese education system and various options that could be explored for improving its efficiency and performance. The chapter is organized as follows. First, an overview of the education system and educational attainment levels over the longer term is presented. Second, public expenditures on education are described. Third, educational performance for the most recent periods is assessed. Fourth, the interface between education and labor market outcomes is addressed. Fifth, the efficiency of spending in Portugal relative to other countries is assessed with the help of a nonparametric production frontier technique called Free Disposable Hull (FDH) analysis. Sixth, recent reform efforts and proposals of the

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[1] Prepared by Benedict Clements.

[2] See OECD (1995a) for evidence from firm survey data regarding the adverse impact of shortages of educated labor on labor productivity.

[3] Continued improvements in job training are also critical for increasing labor productivity. An examination of this topic is outside the scope of the present chapter.

government are discussed. Finally, a discussion of possible directions for future reform and additional areas for further research concludes the chapter.

B. The Portuguese Education System: An Overview

Organization of the system

16. The public system covers the lion's share of the student population in Portugal (Tables 1 and 2), although the private sector maintains an important presence in tertiary education. Primary or "basic" schooling is comprised of three cycles, with the first cycle covering years one through four; the second, years five and six; and the third, seven through nine. Secondary school covers the years 10 through 12. The minimum years of required schooling was raised from six years to nine years in 1986, which resulted in a significant rise in the number of students at the third cycle of primary education. Primary education follows a common curriculum in all schools determined by the central government. At the secondary level, curricula differ, depending on whether general or technical studies are pursued. All students, however, must pass the same final examination to complete the twelfth grade.

17. The central government finances the vast majority of pubic spending on education, and is responsible for paying teachers' salaries at the primary and secondary level. The central government also pays for other current expenditures and capital outlays for the second and third cycles of primary education and secondary education. Municipal governments are responsible for transportation outlays for grades one through six, and for capital expenditures for grades one through four. With the exception of spending at the tertiary level, education expenditures in the autonomous regions of Azores and Madeira are financed through their coparticipation in national tax revenues and general transfers from the central government. The public sector finances the provision of education in a number of private sector institutions at the preschool through secondary level, and in 1998 these outlays reached about Esc 60 billion (0.3 percent of GDP).

18. The management of the public schools at the primary and secondary level is centralized in some ways but decentralized in others. Some of the more centralized aspects are the common curricula followed by all schools, and the central government's role in hiring all teachers and paying all salaries, which follow a uniform pay schedule based on seniority. One of the more decentralized elements of school management is the fact that individual school directors are not appointed by the central or local government, but are elected by teachers.[4] Another aspect of management that is decentralized is the method of student evaluation, which varies from school to school (Alaiz and others, 1997).

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[4] The Ministry of Education provides guidelines on the qualifications and experience necessary to qualify as a candidate. It should be noted also that since 1998, a representative of the students' parents also has a vote in selecting the school director.

19. The public universities are autonomous units that receive funding from the central government, and their expenditures are included in the Ministry of Education budget. These transfers are determined by formulas based on the number of students. Some university expenditures are financed by tuition fees. These fees are very modest, as they presently are equal to just one monthly minimum wage (about US$327) per annum. These fees were expected to generate about Esc 12 billion (0.1 percent of GDP) for academic year 1998/99, or less than 5 percent of the Ministry of Education's outlays for higher education.[5]

School enrollments and attainment indicators: a long-run view

20. Universal coverage at the primary level was achieved in the early 1970s, with gross enrollment rates exceeding 100 percent of the school-age population.[6] Nevertheless, total enrollment in primary education has declined in absolute terms since the mid-1980s, owing to the reduction in the school-age population. At the secondary level, the number of students has climbed steadily, as a result of the extension of the mandatory age of school attendance to 14 in 1987 and success in reducing school dropout rates. The student population at the tertiary level has risen dramatically in the 1990s, more than doubling between 1989/90 and 1997/98.

21. Despite the surge in secondary school attendance, gross enrollment rates continued to be well below the rest of the OECD in the 1970s and 1980s. Throughout those decades gross enrollment rates remained below 60 percent. The high dropout rate reflected difficulties in advancing in school, including at the primary level. These difficulties are also reflected in the figures on repetition rates at the primary level, which hovered near 25 percent in the early 1970s, before declining to below 15 percent by 1990.[7] These repetition rates far exceeded those in other OECD countries; a sample of 10 OECD countries in the UNESCO database indicate an average rate of under 3 percent in 1990.[8] Low gross enrollment rates and high dropout rates are mirrored in the low rate of educational attainment of the population, especially for older generations. Table 3 indicates that in 1996 only 20 percent of the population aged 25–64 had completed upper secondary education (12 years of schooling),

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[5] Calculation based on Ministry of Education transfers in the 1999 budget to universities, polytechnical institutions, and scholarships, and for living expenses at universities (*Acção Social*).

[6] Gross enrollment rates can exceed 100 percent when students from older age groups retake courses with a younger cohort.

[7] Figures derived from the UNESCO educational database.

[8] Belgium, Denmark, Western Germany, former Czechoslovakia, France, Hungary, Italy, Norway, Poland, and Sweden.

compared with 64 percent for other OECD countries.[9] The share of the population that had completed tertiary education was 7 percent, compared with 13 percent for the OECD. As late as 1970 the illiteracy rate exceeded a third of the population, and in that year only 1½ percent of the population had received a tertiary degree.[10]

22. Education attainment levels of more recent generations are closer to those of the rest of the OECD, but significant disparities continue to exist. Of the population aged 25–34, only 32 percent had completed secondary education in 1996, compared with 75 percent for the rest of the OECD. Female educational attainment in recent years has outstripped that of males in Portugal, with 36 percent of women aged 25–34 having completed secondary school in 1996. Data from the national employment survey (*Inquérito ao Emprego*) for 1997 indicate a further strengthening of attainment levels for younger cohorts, with 46 percent of the population aged 20–24 having completed at least secondary education.

C. Education Expenditure

23. Portugal's expenditure on education, as a share of GDP, is high relative to the OECD average (Table 4).[11] At 5.7 percent of GDP, spending for the public sector alone is also higher than in most OECD countries.[12] Outlays are especially high for primary and secondary education. Portugal's high expenditures at the primary level do not appear to be linked to an unfavorable demographic profile, as the share of the population between 5 and 14 years old (12 percent in 1996) was actually one percentage point lower than that in comparator OECD countries. Nevertheless, the percentage of the population attending primary education is more

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[9] Throughout this chapter, references to the OECD average indicates the unweighted average for OECD countries (excluding Mexico and Turkey) for which data are available.

[10] See the historical tables assembled in Barreto and others (1996).

[11] Figures on primary and secondary education spending for 1996 are based on data provided by the Ministry of Education, and include outlays of the regional and local governments of 0.5 percent of GDP. Figures for public spending are based on budgetary allocations, rather than actual budgetary execution. Spending for the private sector is estimated based on enrollment shares (approximately 10 percent in primary and secondary school and 36 percent at the tertiary level), netting out the financial support these institutions receive from the public sector. GDP figures are taken from the Bank of Portugal. More recent expenditure figures for Ministry of Education outlays alone indicate an increase in this spending from 5.3 percent of GDP in 1996 to 5.5 percent of GDP in 1998.

[12] The Ministry of Finance also provides an estimate of public education expenditure, on a national accounts basis, which includes some spending on training activities. Net of transfers (primarily pensions to retired teachers) estimated by the author on the basis of 1995 data, these figures indicate projected spending of approximately 7 percent of GDP in 1999.

than 20 percent above the European average, due to high repetition rates.[13] At the secondary level, Portugal has a relatively large school-age population, as roughly 8 percent of the population is aged 15–19, compared with 7 percent for other OECD countries. Tertiary spending is slightly above the OECD average.[14]

24. Measured in terms of expenditure per student in purchasing-parity adjusted dollars, Portugal's spending is modest at the primary and secondary levels (Table 5). Spending at the tertiary level is also lower than the OECD average, although it exceeds that of some of its richer neighbors (Italy and Spain).

25. Another angle for assessing educational outlays is expenditure per student as a fraction of GDP per capita (Table 6). From this vantage point Portuguese outlays per student are above the OECD average, except for secondary education. While the margin is not exceptionally large (15 percent) at the primary level, it is nonetheless surprising in light of the low level of expenditure for nonwage inputs.[15] As in other OECD countries, tertiary spending per student in Portugal is more than twice as high as per student outlays at the primary level.

26. What are the reasons behind Portugal's above-average outlays per student at the primary level? One reason appears to be the low student/teacher ratio (Table 7). Portugal's student/teacher ratio is well below the mean of its OECD counterparts at both the primary and secondary levels. This is in part attributable to the low student/teacher ratios in rural areas and the fact that the primary school network—which was designed before World War II—has not yet been reconfigured, resulting in an extraordinarily high number of schools with just a smattering of students. In 1997/98, there were over 5,300 schools with less than 30 students, and over 600 schools with fewer than five students. There are over 8,000 primary school covering the first four grades, with an average student body of just 50. These numbers can be put in perspective by noting that the *total* number of public educational institutions (excluding the tertiary level) in Portugal is only 10,700, and that the average secondary school has more than a thousand students.

27. The central government's preponderant role in financing education expenditures has contributed to the resistance of local governments to the closure of these small schools. Given that all costs are borne by the central government in maintaining these schools and paying wages, high costs per student have not been born by local governments or their

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[13] UNESCO data indicate an average gross enrollment rate at the primary level of about 105 in Europe in 1995; the comparable figure for Portugal for 1995/96 was 128.

[14] The expenditure figure for Portugal includes a staff estimate for spending in the private universities.

[15] This issue is discussed further below. See Table 9 for comparative data on educational expenditure by economic category.

citizens, and hence the incentive to consolidate these schools has been muted. Increased private sector costs associated with school consolidation (travel time to and from school), as well as the loss of prestige for the community when a school closes, also explain the dearth of local support for school consolidation. In spite of these obstacles, however, the government's reform efforts include the planned consolidation of these small schools, with a view to improving the quality of education for the affected students (see Section G).

28. Relatively high teacher salaries also contribute to Portugal's high spending per student. At the primary level, beginning salaries, as a multiple of per-capita income, are about 20 percent above the average for other OECD countries (Table 8). This discrepancy increases dramatically for more experienced teachers: for those with 15 years of experience, Portuguese primary school teachers earn a third more. A similar situation prevails at the secondary level, with differentials for experienced teachers at the lower secondary and upper-secondary level (general programs) of 27 and 17 percent, respectively. Higher salaries in Portugal do not coincide with longer teaching hours relative to other countries. At the primary level, teaching hours are about the same, but for lower secondary, general secondary, and vocational secondary schools, the number of hours taught are between 8 and 13 percent lower than the rest of the OECD. Teaching hours in public schools declined between 1990 and 1996, falling by some 10–12 percent at the secondary level, compared with a 1–2 percent decline in other OECD countries.[16] [17]

29. Measured in terms of purchasing-parity adjusted dollars, teacher salaries in Portugal are below the OECD average. Nevertheless, it should be noted that salaries for experienced teachers exceed those in a number of countries with higher per-capita income (Italy, Spain, Norway, and Sweden). Furthermore, salary per teaching hour for experienced teachers is at the OECD average at the primary level and just 5–10 percent below at the secondary level. Pensions for teachers (in terms of replacement rates) are also relatively generous in Portugal (European Commission, 1996).

30. To some extent Portugal's high salaries relative to per capita income are not surprising, as cross-country comparisons reveal that this measure of teacher compensation tends to fall as income levels rise (OECD, 1996b). However, Portuguese compensation levels are still some 22 percent above the level predicted from a simple ordinary least squares

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[16] See OECD (1998), Table E3.1

[17] The number of teaching hours is an imperfect measure of teacher effort, given that nonteaching duties may vary across countries. Some notion of the extent of nonteaching duties can be culled from information on the length of the school year. According to the European Commission (1996), the length of the school year is 175 days, compared with an average of 188 in 13 other EU countries (figures based on 1992/93 data).

regression of compensation levels as a function of GDP per capita.[18] Furthermore, Portugal's high salaries in relation to per-capita income are associated with low student/teacher ratios; comparing across countries, more generous compensation is usually accompanied by a higher teaching burden. For example, in a sample of countries excluding Portugal, salaries for experienced teachers at the primary level in relation to GDP per capita are positively correlated with student/teacher ratios ($r = .75$), and also at the lower secondary level (correlation coefficient of r equal to .76). They are also positively correlated at the upper secondary level ($r = .61$), although this result is heavily influenced by Korea's high student/teacher ratio; excluding Korea, the relationship becomes insignificant ($r = .17$).

31. Portugal's high spending per student relative to GDP per person appears to be linked to the high level of outlays for staff compensation, rather than large expenditures for capital and other current inputs. Current outlays absorb, on average, a higher share of the budget than in other OECD countries (Table 9).[19] [20] Measured in terms of purchasing-parity adjusted dollars, outlays for nonwage spending are small, and are lower than in every country but Greece. The low level of these expenditures over the years may have contributed to deficiencies in physical infrastructure. Maintenance spending, for example, declined in real terms from 1986 through the first half of the 1990s, and in 1995 these outlays equaled just 8 percent of nonwage current spending (Pinto, Barros, and Lopes, 1998). The modest state of the physical infrastructure and facilities in the mid-1990s is also illustrated by the dearth of computers available to students; in 1995, there were 137 students per computer at the eighth grade level, for example, compared with an average of 34 in other OECD countries.[21] Studies on the state of school infrastructure and other problem areas in Portugal relative to other OECD countries, conducted in the early 1990s, are also suggestive of infrastructure

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[18] See OECD (1996b), Figure 4.3. This figure refers to predicted salary for 1994 data, when the average salary of primary school teachers with 15 years of experience was 2.0 times per capita income. Given the decline in this ratio between 1994 and 1996, this discrepancy may have subsequently narrowed.

[19] These figures should be interpreted with caution, as at least in one country (Korea) it appears that some nonwage current spending is classified under capital spending.

[20] Data from other years show roughly a similar pattern with respect to the share of capital expenditures in total spending.

[21] See OECD (1998), Table E6.1. Based on the number of schools without any computers, however, Portugal was near the mean of 13 percent. Furthermore, it should be noted that in recent years the availability of computers has risen dramatically, and by 1998 the ratio of students to computers rose to 35 (ratio calculated excluding the first cycle of primary education).

deficiencies.[22] [23] Furthermore, a survey of teachers in 1995/96 at the primary level indicated that only 23 percent of teachers in grades one through four thought there was a sufficient level of teaching materials (*material didáctico*), while only about half felt the level of these inputs was sufficient for grades five through nine (Alaiz and others, 1997). Furthermore, less than half of teachers surveyed indicated sufficient physical space at their schools. More recent data on the composition of expenditures indicate no increase in the share of nonwage spending in current outlays for primary and secondary schools between 1996 and 1998.[24] In sum, there is evidence to suggest that the wage bill may have squeezed other inputs (such as maintenance) that may potentially have high productivity.

D. Recent Improvements in Educational Performance: Convergence to OECD Averages?

Enrollment, attainment, and graduation rates

Primary and secondary education

32. Educational attainment rates for past generations provide a misleadingly dour view of educational performance for the current cohort of Portuguese students, given the large gains in enrollment and graduation rates realized in recent years. Figures on gross enrollment rates (Table 10) indicate a groundswell in the percentage of the population attending school, with rates rising at the third cycle of basic education and secondary education from 74 percent at the beginning of the decade to almost 112 percent by 1995/96. Due to high failure rates and dropout rates throughout the secondary school years (Tables 11 and 12), however, the percentage of the population that graduates from secondary school on time (at 18 years of

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[22] As part of the International Assessment of Educational Progress, schools were asked whether or not they had one or more of the following problems: overcrowded classrooms; inadequate facilities and maintenance; shortages of textbooks and other educational materials; student absenteeism; lack of discipline; and vandalism of school property. Fifty-six percent of Portuguese schools reported one or more problems, compared with 23 percent of schools in 11 OECD countries (based on the unweighted average across these countries). These figures are only suggestive of infrastructure problems, as they include problem areas not pertaining to infrastructure per se. See http://www.nces.ed.gov/internat/index.html.

[23] For an examination of the difficult conditions at a secondary school in one of the poorer suburbs of Lisbon (Ameixoeira), see Santos Silva (1999). Among the difficulties he cites are the deterioration in the prefabricated housing structure, which was designed in the 1980s and originally intended for just temporary use, and the lack of space for sports or recreational activity. According to one school official, the school is inadequately heated in the winter months, providing a poor environment for learning.

[24] Figures based on the Ministry of Education budget for public schools only.

age) is considerably lower. Failure rates are especially acute in the twelfth grade, with only 56 percent of students passing the grade in 1995/96. The high failure rate has led to a high repetition rate (Table 13), with a large share of the student body well beyond normal school age.[25]

33. The extent to which Portugal lags behind the rest of the OECD in completing secondary education at a normal age is suggested by the data on net enrollment rates (gross enrollments corrected for overaged students) by age (see OECD (1998), Table C1.3, for data on countries besides Portugal). According to data from the Portuguese Ministry of Education, only 31 percent of 17 year-olds in continental Portugal were enrolled in twelfth grade or tertiary studies for the beginning of the academic year 1995/96, compared with an average of 85 percent at grade level in other OECD countries. The 31 percent figure overstates to some degree the eventual percentage that successfully completes high school, given the high failure rate in that grade. In fact, only 15 percent of all 18 year olds graduated from secondary school in that year.

34. Figures on net enrollment rates in Portugal require a fairly nuanced interpretation, as low net enrollment does not necessarily translate into failure to eventually complete secondary education. Through the repetition of courses and extension of education beyond the normal school age, approximately 56 percent of students eventually complete secondary education.[26] This figure is nevertheless well below the 87 percent of the population in other OECD countries that finishes high school by a normal graduation age (Table 14).

35. Portugal's high repetition rates continue to signal inefficiencies in the educational system, given the high public and private costs of repeating the same course of education.[27]

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[25] For purposes of comparison, UNESCO data indicate that the repetition rate at the secondary level for a group of 12 other OECD countries, based on the latest available data over the 1987–95 period, was 5 percent, compared with a weighted average in grades 10 through 12 of 19 percent in Portugal in 1995/96.

[26] This figure is an approximation for the number of students currently finishing secondary school, and may overstate current performance; recall that labor force survey data from 1997 indicate that 46 percent of the population aged 20–24 had finished secondary school. It is based on the total number of students graduating in 1995/1996 divided by the number of 18 year olds in the population. As such, it includes overage students in the nominator. A similar measure used by the Portuguese Ministry of Education is the rate of schooling, which is used for projections of future educational attainment by grade level. This ratio is defined as the number of graduates in grade n divided by the number of students entering the school system n years earlier.

[27] The repetition rate should be evaluated with due caution as an indicator of educational inefficiency; reductions in the repetition rate achieved through a lowering of educational standards would not imply any improvement in efficiency.

From the standpoint of the public finances, the costs of the high repetition rate can be assessed by quantifying the savings that would occur if the gross enrollment rates in primary and secondary education fell, for example, by 10 percentage points. Under this scenario, outlays would fall by 0.5 percentage point of GDP.[28]

36. Partly as a consequence of Portugal's high repetition rate, a significant share of the student population consists of overaged students (including adults) in special repeater courses (*ensino recorrente* and *ensino nocturno*) in attempts to complete either primary or secondary education. In 1995/96, these students accounted for some 4 percent of the total student population at these levels in Portugal.[29] These intensive courses follow the traditional curriculum in Portugal, which is designed to prepare students for university studies. The success rate in these courses has been very low, however. For *ensino recorrente*—which covers the bulk of these students—the percentage of students in continental Portugal successfully completing the coursework necessary for completion of fourth grade was only 9 percent, and for completion of sixth grade, 28 percent (Ministry of Education, 1998a). A recent study of success rates for *ensino recorrente* for completion of ninth grade and secondary education also pointed to success rates below 10 percent (Contreras, 1999). The experience of schools using alternative curricula however, has been more favorable (see Contreras, 1999).

37. Educational performance shows some variation across regions in Portugal (Tables 15–17). Net enrollment rates at the secondary level vary with per-capita income levels, and are about ten percentage points above the continental average in the Lisboa and Vale do Tejo region, while they are below average in the north and central regions. The passing rates of enrolled students are very similar, with the exception of Algarve. The percentage of above-age students (a reflection of repetition rates in earlier years) varies somewhat more dramatically, but generally reinforces the view that the performance of Portugal's poorer regions are not the cause of its relative standing vis-à-vis other OECD countries.

38. Differences in expenditure levels—as proxied by student/teacher ratios—do not appear to be correlated with differences in conclusion rates by region (Table 18). Interestingly, student/teacher ratios are the highest in continental Portugal in its wealthiest

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[28] This assessment overstates the savings that could be achieved in the short run, given the high share of fixed costs in total education spending (including for salaries of tenured teachers).

[29] Figure based on total student population from Ministry of Education in continental Portugal of 1,712,275 students and 70,896 students at the primary and secondary levels in *ensino recorrente* and *ensino nocturno* (1998a). The figure does not include the over 62,000 students attempting to finish secondary school *via ensino*, of which 96 percent are over the normal school age.

region (Lisboa and Vale do Tejo) for the first cycle of primary education.[30] This may reflect the absence of the extremely small schools that account for the bulk of these institutions in the less populous regions of Portugal. At the secondary level, student/teacher ratios show little regional variation, and in all regions there are fewer students per teacher than the prevailing average for other OECD countries.

39. Striking differences in performance are observed between public and private schools in Portugal. Table 19 indicates that conclusion rates are systematically higher in private schools across all grades. At grades 4, 6, and 9, private schools' success rates average over 94 percent, some 8 percentage points higher than in public schools. At the secondary level, performance differences are narrower for general courses and negligible for vocational studies, but very wide (over 20 percent) for college preparation students studying *via ensino*.

40. These higher conclusion rates enjoyed by private schools are associated with lower expenditures, as proxied by student/teacher ratios. For the first cycle of primary education (grades one through four), student/teacher ratios in public schools averaged about 12.8 in 1995/96, compared with 18.3 in private schools. For other levels of primary education and secondary education combined, student/teacher ratios in that year for public and private schools averaged 11.2 and 14.7, respectively.[31] These figures suggest that the private schools may be more efficient than their public sector counterparts.

41. In sum, Portugal continues to lag behind the rest of the OECD in educational attainment at the primary and secondary level. Nevertheless, impressive strides have been made in recent years to improve performance, especially at the primary level, where dropout rates and repetition have fallen sharply in response to the government's reform efforts (see Section G below). One especially telling sign is the rapid rise in the percentage of students finishing the obligatory nine years of schooling, which rose from 63 percent in 1991/92 to 89 percent in 1994/95 in continental Portugal. Progress has been more uneven at the secondary level, however; while repetition rates fell between 1990 and 1995, they rebounded in 1996, and dropout rates at grade 10 show no systematic trend toward improvement. The increased success of students at lower levels is reflected in the Ministry of Education's projections regarding school completion (Table 20); by 2000/01, it is expected that 100 percent of all students will finish ninth grade, and 66 percent twelfth grade. Looking

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[30] Student/teacher ratios are above the average of continental Portugal in the Azores, but below average in Madeira.

[31] Fund staff calculations based on data from Ministry of Education (1998d) for 1995/96. It should be noted that the dominant role of the public sector in serving rural areas—where student/teacher ratios tend to be lower—has the effect of lowering the country-wide student/teacher ratio relative to the private sector. Nevertheless, it should be noted that 1995/96 data for primary education (1st cycle) reveal that student/teacher ratios were still lower in public than private schools across all regions in continental Portugal.

further ahead, by 2005 it is projected that 54 percent of the population aged 20–34 in continental Portugal will have completed secondary education (Ministry of Education, 1998b).

Tertiary education

42. In contrast to the rather slow movement toward the OECD norm on secondary educational attainment, in recent years the share of the near school-age population attending and completing tertiary education appears to have converged to OECD averages. The number of university students nearly doubled between 1990/91 and 1997/98, despite a decline in the population aged 18–22 (Table 21). Total enrollment as a share of the population aged 18–22 rose from 23 percent at the turn of the decade to about 43 percent in 1997/98, and the share of 22 year olds with a tertiary degree soared from under 12 percent in 1990/91 to 25 percent in 1996/97.[32] Almost half of all tertiary students are older than 22, and hence net enrollment rates for 18–22 year olds lag behind OECD averages by a substantial margin; however, when measured in terms of a wider age group (17–34 year olds), net enrollment in Portugal is just one year behind the average for other OECD countries. In light of the recent strong gains in enrollment, it appears safe to infer that this gap has now been closed, and that participation rates in higher education are now comparable to the rest of the OECD.

43. Despite the rapid ascent of enrollment rates, higher education is still plagued by a number of problems, including high repetition rates. For example, of the 51 percent of students that advanced onward from the conclusion of secondary education into tertiary studies in 1996, repetition rates in the first year ranged from 19 to 24 percent (Ministry of Education, 1999). Dropout rates are also large; for 1993, the OECD estimates a figure of 50 percent, compared with the average in other OECD countries of 31 percent (OECD, 1998, Table C4.1). Another problem identified by the Ministry of Education is the gap between chosen fields of study and job openings; in particular, there appears to be an excessive number of students with humanities degrees (Ministry of Education, 1999). OECD data for 1996 (OECD, 1998, Table C4.4) also support the view that the percentage of students specializing in the humanities is out of step with the rest of the OECD: in that year 48 percent of Portuguese students specialized in the humanities or general studies, 11 percentage points higher than the average for other OECD countries. Correspondingly, the share of Portuguese students in the natural sciences was some five percentage points below average.[33]

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[32] Figures on net enrollment (which exclude students over the ages of 22) are lower (see OECD (1998)).

[33] See also "Da Escola para o Trabalho," *Expresso*, April 2, 1999, regarding the need to strengthen the ties between the workplace and universities.

Performance on international examinations

44. One drawback to the use of educational attainment rates as a measure of performance is that they say little about what students learn, given differences in curricula and standards across countries. Thus, it is useful to supplement these measures of performance with other yardsticks that assess basic abilities in mathematics, science, and reading.

45. Table 22 provides data on the performance of Portugal relative to other selected countries on international examinations conducted during the 1990s for eight-grade students. Portuguese scores on reading are slightly above the average of other countries. Math and science scores, however, are substantially below par. The math score was some 14 percent below the average for other OECD countries, and the lowest among the group of OECD countries covered in the 1995 examinations. Performance on science was marginally better, but still some 10 percent below average. Similar lags in mathematics performance are evidenced in the results of the fourth-grade examinations, where scores were some 15 percent below the mean.

46. To only a small extent does the discrepancy in performance reflect the impact of Japan and Korea in boosting up the overall average; removing these countries from the sample reduces the average math score by only 1 percent (from 527 to 520). It is also interesting to note that test scores do not appear to be a simple function of per-capita income. One factor that does appear to be correlated with test scores is the repetition rate: countries with a high share of above-age students score *lower* on eight-grade math examinations (OECD, 1997). Thus, it appears that countries that force students to repeat grades do not enjoy improved academic performance. This result has potentially important implications for Portugal, given its high repetition rate relative to the rest of the OECD.

E. Education and Labor Market Outcomes in Portugal

47. The importance of improving educational performance in Portugal is underscored by the high rates of return for completing secondary and tertiary education. The high rate of return for completing secondary education can be observed by examining the penalty for not doing so, as measured by the earnings of those without their secondary school diplomas relative to those finishing high school. Table 23 reveals that the earnings of nongraduates are only 64 percent of those enjoyed by their counterparts finishing school, the lowest share amongst the OECD. More formal studies of rates of return to one additional year of education, controlling for worker experience and age, also indicate high returns relative to many OECD countries (OECD, 1995a). The high disparity in earnings reflects Portugal's relatively flexible labor markets and the small share of the population completing high school, as indicated earlier in Table 3. In a similar vein, the premium on university education is also the highest in the OECD; in light of these high rates of return to schooling, some have called into question the low degree of cost recovery in public education at the tertiary level (Machado and Mata, 1998).

48. Recent studies indicate an increase in the returns to education since the 1980s (Machado and Mata, 1998), despite the fact that levels of education have risen dramatically. This is consistent with the observed increase in the inequality of earnings (OECD, 1995a,1996a). Figures on income differentials by education level for more recent generations (those aged 30–44) also support this view, as they indicate an even wider earnings gap (41 percent) for those not finishing secondary school than for the adult population as a whole. In sum, it appears that the increase in demand for skilled labor has outstripped the increase in supply, which may be a harbinger of increased levels of inequality. In this context, it is not surprising that recent studies indicate that aggregate income inequality in Portugal is the highest in the EU.[34]

F. The Efficiency of Education Expenditure in Portugal: Insights from FDH Analysis

An overview of FDH analysis

49. One method for assessing the efficiency of an educational system is to assess how well it converts spending inputs into educational "outputs." In this section of the chapter, such an analysis is conducted with the help of a nonparametric technique for production frontier estimation called Free Disposable Hull (FDH) analysis. The analysis involves a comparison of spending levels across different countries of the OECD and different measures of output or educational performance.[35]

50. FDH analysis, like other production frontier techniques, provides a framework for ranking the efficiency of producers through comparison of their performance with a production frontier reflecting "best practices."[36] The first step in FDH analysis is to establish a production frontier that shows, for each level of input use, the highest level of output that can be observed among the producers in the sample. Once this production frontier is

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[34] A recent study by Eurostat (1998) of 13 member countries, based on 1994 data, revealed a Gini coefficent of 0.37 for Portugal, compared with .31 for the 12 other EU countries included in the study.

[35] Recent examples of studies applying this technique to measure the efficiency of government spending are Vanden Eeckaut, Tulkens, and Jamar (1993), who assess the efficiency of Belgian municipalities; Fakan and Crombrugghe (1997), who rank the efficiency of OECD and transition economies' government spending in terms of its ability to provide a diverse set of outputs (inter alia, a low infant mortality rate, life expectancy, the number of telephone lines); and Gupta, Honjo, and Verhoeven (1997), who examine the efficiency of government spending on health and education in developing countries.

[36] The FDH technique was first introduced in Deprins, Simar, and Tulkens (1984). The present exposition of the FDH technique draws heavily from Gupta, Honjo, and Verhoeven (1997).

established, a ranking of inefficient producers (those that produce less output than possible with a given level of input use) can be determined. The advantage of FDH analysis relative to other production frontier techniques is its parsimonious approach to the construction of the production frontier. The only assumption is that inputs and outputs can be freely disposed of; this implies that for the same production technology, a continuous production frontier can be established that maps any given input level with the highest possible level of output.

51. FDH analysis is particularly attractive for the task at hand, where the "producer" in question is the government, and the output is educational services. In particular, the fact that FDH makes no assumptions about the shape of the production frontier is appealing, as past research on educational production functions provides no conclusive evidence on the appropriate shape of the frontier.[37] Under a parametric approach, in contrast, a functional form must be assumed, and parameters chosen that best fit the data. In light of the uncertain relationship between educational inputs and outputs, a parametric estimate based on a small number of observations (such as the sample of countries examined in this chapter) could be well off the mark. FDH is also preferable to other nonparametric approaches in the present context, such as Data Envelopment Analysis (DEA), which assumes a convex production frontier.[38] The parsimonious approach of FDH is not without drawbacks; as a nonparametric approach, the production frontier is more heavily influenced by (and indeed determined by) outliers, and thus is more vulnerable to measurement error than a parametric technique. Furthermore, the absence of any restrictions on the shape of the production frontier (such as convexity) means that a smaller number of observations can be identified as inefficient than with DEA, reducing the ability of FDH to sort out efficient and inefficient producers.

52. The approach of FDH in measuring efficiency can be better understood with the help of Figure 1, which is reproduced from Gupta, Honjo, and Verhoeven (1997). Let us assume the simple case of one input (X) and one output (Y). Suppose there are four firms (A, B, C, and D). The first step of FDH analysis is to construct the production frontier on the basis of the most efficient producers. In the context of Figure 1, those firms are A, C, and D. A firm is efficient (that is, on the production frontier) if there are no other firms associated with the same (or greater) level of output at the same (or lower) level of input use. For example, firm C is efficient, even though firm D produces a higher level of output. Firm A is also efficient; although C and D produce more output than A, they use more input. Firm B, however, is clearly inefficient, as firm A is able to produce more output with an even smaller level of input. By assuming the free disposal of inputs and outputs, a continuous production frontier can be formed by connecting a line through the points representing the most efficient producers. FDH provides a framework for calculating both input efficiency and output

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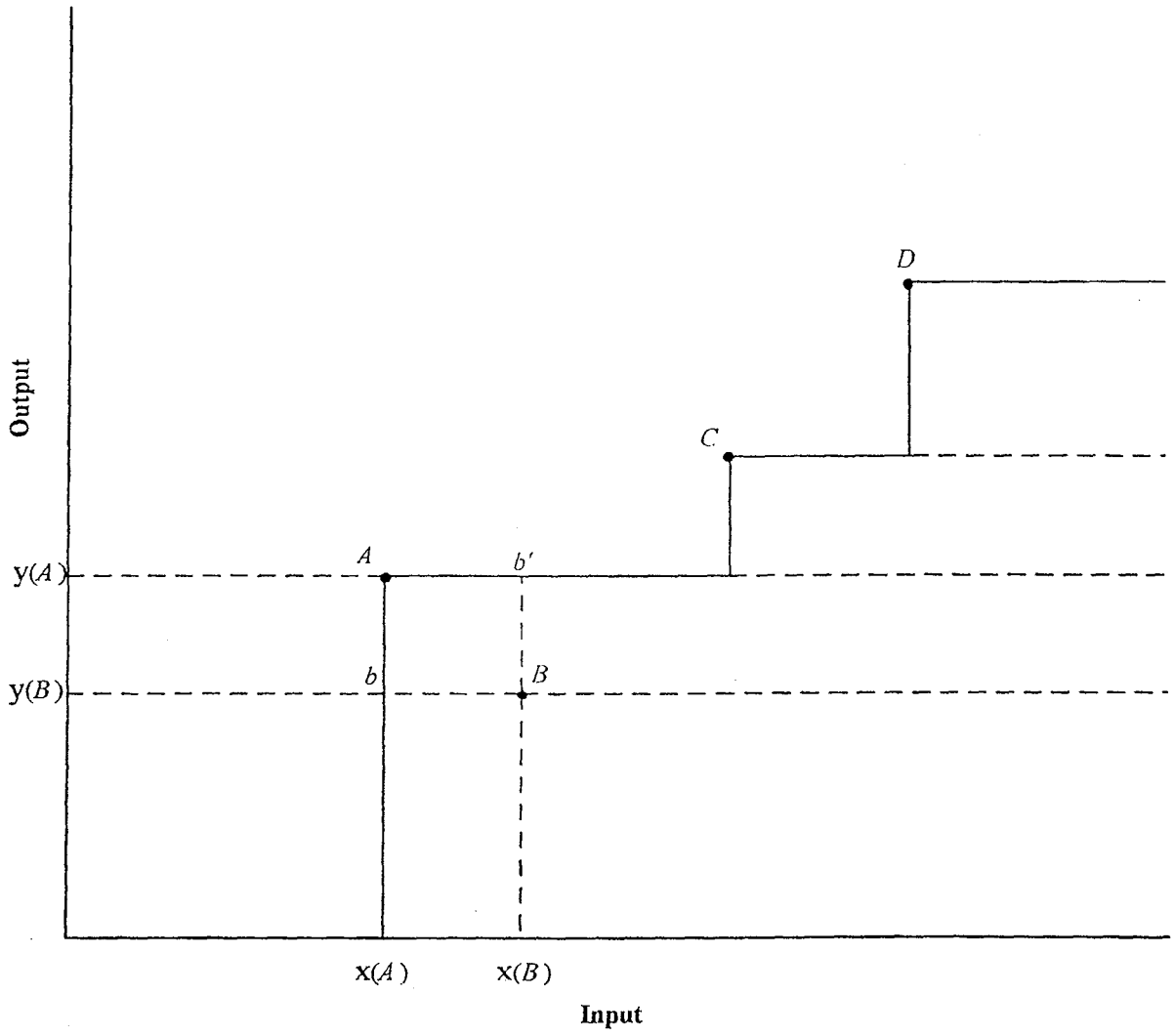
[37] See Harbison and Hanushek (1992) for a review of educational production function studies.

[38] See Gupta, Honjo, and Verhoeven (1997) and Tulkens and Vanden Eeckaut (1995) for further elaboration on the differences between FDH and DEA.

Figure 1. Free Disposable Hull (FDH) Production Possibility Frontier



Source: Reproduced from Gupta, Sanjeev, Keiko Honjo, and Marijn Verhoeven, 1997, "The Efficiency of Government Expenditure: Experiences from Africa," Working Paper 97/153 (Washington: International Monetary Fund).

efficiency scores that vary from a minimum of 0 for producers on the horizontal axis beyond X(A) to a maximum of 1 for firms on the production frontier. The input efficiency score indicates how much less input could be used by the inefficient firm to produce the same or a greater level of output. In Figure 1, firm B's input efficiency score is given by X(A)/X(B). The output efficiency score reveals the other side of the coin, assessing how much more output could be produced with the same (or an even lower) level of input use. Firm B's output efficiency score is given by Y(B)/Y(A). FDH analysis can also be applied in the case of multiple inputs and outputs to compute input and output efficiency scores, although their computation is slightly more involved. [39]

53. This example also underscores the weakness of FDH analysis, which ranks all three observations (A, C, and D) as equally efficient (with scores of 1.0). If a functional form had been assumed, then efficiency could have been addressed by comparing the observed mapping of inputs and outputs with that predicted from the production function. In FDH analysis, however, these observations are all ranked equally. In the case of multiple inputs and outputs the information content of FDH is even more limited, as producers can only be identified as inefficient if they produce less of all of the outputs and use the same or more of at least one of the inputs.

Educational inputs and outputs for FDH analysis

54. The choice of educational inputs and outputs merits discussion. With respect to inputs, one alternative is to measure spending in purchasing-parity adjusted (PPP) dollars. A drawback of this measure is that it will be highly correlated with country income levels. That is, in richer countries, education spending tends to be higher, as teacher salaries tend to move upward with rising income levels. Higher salaries do not necessarily correspond to a higher quality of inputs from one country to another, as teachers across many OECD countries have similar levels of education and training. An alternative input measure that overcomes these difficulties is spending per student as a share of per-capita GDP, or the share of educational expenditure to GDP adjusted for cross-country differences in the school-age population. It should be noted that the FDH analysis could potentially yield very different results, depending on the choice of inputs; in this context, it is worthwhile to note that Portuguese spending per student is quite modest in PPP terms, although it is relatively high when viewed from the standpoint of GDP per capita. To assess the sensitivity of the results to these assumptions, the results are computed using both input measures.

55. Regarding output measures, an important consideration is the desirability of selecting variables that measure the performance of the present system, rather than the accumulated performance of the system over years past. This is an important consideration for the case of Portugal, where educational attainment rates for recent generations are far above those in

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[39] See Gupta, Honjo, and Verhoeven (1997) for an exposition of FDH analysis using multiple inputs and outputs.

earlier years. In this light, a good measure of the performance of the education system is the percentage of the population that completes secondary education at a normal graduation age, as indicated in Table 14, or educational attainment rates for a cohort slightly older than the normal age for school completion (Table 3). The latter figure is especially fitting in the case of Portugal, as it allows for the possibility that low net enrollment rates at the secondary level are attributable to relatively high standards for graduation. We also use test scores on international examinations at the eight grade as an output indicator. An especially attractive feature of this measure is that it can be seen as a barometer that assesses the quality of education across countries, rather than a simple quantity measure such as school completion rates.[40]

Empirical results

56. We start by presenting the simple case of one input and one output in Table 24. The input is measured as total primary and secondary expenditure per student in purchasing-parity adjusted dollars (Table 9). The output measure is the percentage of the population finishing secondary school at the normal graduation age (see Table 14).[41] This measure of output provides a good yardstick for an analysis of efficiency, since countries that take additional time and expenditure to finish secondary school (e.g., due to high repetition rates) are penalized in the resulting efficiency scores. This measure is also to be preferred to enrollment rate figures, since these do not indicate whether students actually complete their intended course of study.

57. The results indicate that Portugal is about in the middle of the pack when efficiency is gauged from the input side. Among the 20 countries assessed in Table 24, Portugal is ranked ninth with respect to input efficiency. Nevertheless, its score of .54 denotes that at least the same level of output could be achieved with 54 percent of the present level of input (spending per student), demonstrating ample scope for improving efficiency. Among the

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[40] Educational attainment rates are nevertheless an important measure of educational output and the production of human capital. The completion of secondary education is strongly correlated with reading and numerical literacy, a more direct measure of worker skills (OECD, 1997). Furthermore, more educated workers tend to receive greater amounts of job-related adult education (OECD, 1995b, 1997), implying that initial levels of educational attainment are strongly correlated with levels of human capital throughout the life cycle.

[41] Note that in the case of Portugal, as in Table 14, we include those students that finish secondary school above the normal age. In this sense, the results overstate the efficiency of the Portuguese education system relative to other OECD countries.

most efficient countries are Japan, Korea, Hungary, and Norway, where all four countries are efficient (a score equal to 1.0) and located on the production possibilities frontier.[42]

58. One notable pattern indicated in Table 24 is that high income countries (e.g., the United States and Sweden) tend to have low efficiency scores. This reflects the observations made in the section above, where it was noted that the higher teacher salaries found in higher-income countries make it difficult to avoid relatively elevated spending per student. For this reason it is also worthwhile to assess output efficiency, which provides less of a penalty for advanced countries that must pay high salaries to their educational staff. In general, the output efficiency scores reveal much less inefficiency (i.e., higher scores) than the input efficiency measures, and present some interesting differences in country rankings. Most notable among these is Portugal, which falls to the bottom of the ranking in terms of efficiency. The output efficiency score of .62 indicates that the secondary school completion rate is only 62 percent of what it could be if spending was efficient. This implies that if the production of educational services was efficient in Portugal, present levels of spending would allow a graduation rate of close to 91 percent, as opposed to 56 percent. This suggests that the gap in educational attainment in Portugal may not be due to inadequate levels of spending, but to how efficiently that spending is translated into educational output.

59. Given the focus here on differences in secondary school completion, a closer examination of the linkage between secondary school spending per se and graduation rates is warranted. Table 25 provides an evaluation of the case of one output (graduation rates, as before) and one input, where the input is defined as secondary school spending per student as a share of GDP per capita. The advantage of this measure is that it quantifies spending per student relative to prevailing income levels in the country, and hence incorporates the fact that higher income countries tend to pay more generous teacher salaries. The results are similar to those in Table 24, with a correlation coefficient of .7 between common observations for input efficiency, and over .9 for the output efficiency scores. Both Japan and Korea are among the most efficient countries; within Europe, expenditure is also relatively efficient in Greece and the Netherlands, reflecting low levels of spending per student. The high efficiency score of Belgium (Flemish Community), on the other hand, mirrors the universal completion of secondary school by normal graduation age. Portugal's ranking among the least efficient reflects both its high spending per student and its low graduation

[42] Following Gupta, Honjo, and Verhoeven (1997), countries with a score of 1.0 are ranked according to the number of countries they "dominate." The number of countries dominated refers to the number of countries which produce less output with the same or a greater level of input. The rationale for this procedure is that the efficiency score of a country dominating a large number of other countries is likely to be more robust to small variations in the sample than one dominating a smaller number of countries.

rate; as noted earlier, this high spending is due to both high salaries in relation to GDP per capita and low student/teacher ratios.[43]

60. A drawback of these assessments of efficiency based on spending per student is that they fail to provide any penalty for countries with high repetition rates and the concomitantly large share of the population in school beyond the normal age of graduation. To address this shortcoming, efficiency was also measured in terms of the nexus between graduation rates at a normal age and primary and secondary expenditure to GDP, adjusted for population structure.[44] The results in Table 26 reveal that Portugal falls to last in the assessment of efficiency under this yardstick, reflecting the fiscal burden of high repetition rates.

61. Portugal fares only slightly better when educational efficiency is assessed in terms of the production of both secondary and tertiary graduates. Table 27 presents the results for the one input, two output case, where the input is total education spending to GDP, adjusted for the share of the population under age 29, and the two separate outputs are (i) graduation rates at the normal age for secondary education and (ii) graduation rates at the normal age for tertiary education. Portugal's input efficiency score of 0.62 suggests that the same number of secondary and tertiary graduates could be produced using 38 percent less spending.[45]

62. Portugal's ranking is also low (but not the lowest of the OECD countries) when educational output is measured in terms of performance on international examinations (Table 28). In Case (A) in Table 28, input efficiency scores are provided for the one-input, two-output case, where the two outputs refer to math and science scores for eight-grade students (see Table 22). Portugal is ranked thirteenth out of the 18 countries assessed, with Korea, Japan, Ireland, and the Czech Republic among the most efficient. Surprisingly, the rankings are very similar to those presented in Table 26, where efficiency was assessed in terms of the linkage between spending and completion of secondary school; the correlation coefficient between the input efficiency measures is .88. This suggests that there is no

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[43] Fairly similar results (not reported here) were obtained when educational output was measured in terms of the percentage of the population aged 25–34 having completed secondary education, and input measured as primary and secondary expenditure to GDP (adjusted for student enrollment to population rates).

[44] The adjustment for population structure is meant to incorporate the fact that countries with relatively younger populations (e.g., Ireland) can be expected to spend a higher share of GDP on education than countries where a larger share of the population is not of school age (e.g., Germany). Using data from the OECD (1998), this adjustment is made on the basis of the share of the population under 19 years of age.

[45] It should be noted that Canada is not included in the ranking in Table 27 because it is "independently efficient," that is, it does not dominate any other observation, but is not dominated by any other observation. This reflects a high level of input matched by a high level of output.

apparent tradeoff between achieving high rates of school completion and providing quality education (as proxied by high scores in international examinations) in a cost-effective manner.

63. In Case B, where the output is reading scores, Portugal's efficiency is higher (.710) than when efficiency is assessed in terms of math and science achievement (.648). This is due to Portugal's above-average scores for reading, compared to its subpar scores on international math and science examinations. Among the most efficient countries in this regard are Finland, Iceland, and Ireland.

64. What country characteristics or factors are generally associated with high efficiency in the provision of education? Some insights into this question can be gained from Table 29, where correlation coefficients between various input measures and input efficiency scores are presented. The results should be interpreted with caution, given the small number of observations available for some variables and the fact that correlations at best are only suggestive of causality, as other factors are not controlled for; furthermore, there may be some nonlinearities in the relations between the relevant variables. Keeping these caveats in mind, it appears that countries with high student/teacher ratios at the primary level are relatively efficient, regardless of whether educational output is measured in terms of graduation rates or scores on math and science examinations. This relationship is more tenuous at the secondary level, as the correlation coefficient for one of the measures is low (r =.09). Teacher salaries show a positive but low correlation with efficiency scores, but this relationship evaporates when Korea is excluded from the sample. Higher nonteacher spending is not associated with efficiency, given the negative and sizeable correlation between nonstaff current outlays in purchasing-parity adjusted dollars and efficiency. There also is no hard rule of thumb regarding the composition of spending, as there is no consistent relationship between the share of spending absorbed by personnel costs and efficiency.

65. One notable result from Table 29 is the deleterious effect of repetition rates on efficiency, not only in terms of the ability of countries to translate educational spending into graduates at a normal age (an almost tautological result), but also to produce high scores in math and science achievement tests. The latter results confirm the aforementioned findings of the OECD (1997), which indicated that high repetition rates tend to weaken, rather than strengthen student performance.

G. Education Reform in Portugal

66. A number of initiatives have been taken in the 1990s to address the problems of high repetition and dropout rates and increase educational achievement. One of the cornerstones of the government's strategy to enhance student achievement has been the expansion of the preschool system. Preschool education is widely believed to have a salutary effect on student achievement, and it has been suggested that Portugal's relatively low participation in preschool education could be contributing to high dropout rates (OECD, 1995a). Aided by a

substantial investment program supported by the European Community, participation in preschool education rose from 34 percent in 1988 to 64 percent in 1997/98.[46]

67. The government has also introduced special programs to reduce school dropout rates, including the Program for Education Success (PIPSE) during 1988–92 and the Program of Education for All (PEPT) during 1991–98. In addition, school attendance of lower-income groups has been promoted through the Guaranteed Minimum Income Program introduced in 1997, which requires school attendance for school-age children of recipient families. More recently, a concerted effort has been made to target poorer regions with high dropout rates through the Territories of Priority Educational Intervention (TEIP) program covering schools at the basic level (grades one through nine). The TEIP attempts to coordinate public services targeted to the poor by grouping together schools in poorer regions with a common set of problems and better coordinating existing social services. Forty-seven TEIPs were in place in 1998/99, covering 330 schools.

68. The government has also stepped up its program of school consolidation at the first cycle of primary education. The Ministry of Education plans to consolidate 1,300 schools over the next few years, with 120 being consolidated in academic year 1998/99. The grouping of schools is expected to enhance both the quality of education and reduce expenditures over the longer term. The quality of education will be improved by placing students in class settings of more appropriate sizes and in improved facilities; cost savings will come by a reduction in outlays for substitute teachers and maintenance costs for older, underutilized buildings. Reduced spending on substitute teachers will occur in line with the decline in the number of schools with only one teacher, which must use substitutes more often than their larger counterparts. As a first step for improving the efficiency of primary and secondary spending more generally, the government has also improved the dissemination of information on expenditures by school to school directors.

69. The government's efforts to boost performance at the secondary level have centered on expanding the educational options for students at this level, with a view to increasing the share of students in vocational studies. Among the most important of the government's efforts was the creation of separate professional schools at the secondary level (*Escolas Professionais*) in 1989, with the intent of attracting students to vocational training. Between 1989 and 1993 the number of such schools rose from 50 to 168, but has remained roughly constant since that year. Approximately seven percent of all secondary school students were enrolled in these professional schools in 1997/98. In order to provide better guidance to students in their choice of studies, counseling services were also expanded. Coverage is still modest, however, as only about 10 percent of all students had access to these services by

[46] Figures for 1996 from the OECD (1998) indicate that schooling rates for 2–4 year olds (at 33 percent) were below the average for other OECD countries (42 percent).

school year 1998/99. Further improvements in student guidance are expected through the AZIMUTE program launched in 1998, which seeks, among other objectives, to create an Internet database on public educational opportunities for secondary students.

70. A wider gamut of technology and vocational courses has also been offered through the regular secondary school system. This has coincided with a rise in the share of secondary students enrolled in these courses from 13 percent of all students in 1991/92 to 29 percent in 1997/98.[47] Apprenticeship programs through the Institute for Employment and Professional Training (IEFP) were also expanded sharply in the 1990s. In 1998, some 16,000 students participated in apprenticeship programs. Apprenticeships increased rapidly in 1998 (by 27 percent), exceeding the Employment Action Plan target of 20 percent. The total number of apprenticeship opportunities remains modest, however, in relation to the total student population at lower and upper secondary school (less than 5 percent), and the shortfall in training opportunities is estimated at about 40 percent. Vocational training was also strengthened in 1996 with the creation of special one-year programs for students completing the ninth grade; by 1998/99, enrollment had reached approximately 1,200 students. Adult education was also expanded in 1998 with the initiation of the ENDURANCE program, which seeks to promote life-long learning.

71. Despite the gains of recent years, the share of students in vocational studies remains significantly below the OECD average, as well as the percentage of the population graduating with a secondary degree in a vocational field. More rapid progress on these fronts has been hampered by the low success rates of students enrolled in these classes, which are actually lower than those in the more academically oriented studies at the secondary level. Thus, the available evidence indicates that a reallocation of students from general studies into vocational studies, while potentially helpful, would not be a panacea for boosting aggregate completion rates.

72. To enhance the success rate of repeater courses (*ensino recorrente*), the government has also introduced alternative curricula in some schools that are designed to better meet the needs of older students returning to the classroom. These alternative curricula are still not available at the secondary level, however.

73. A more general reform of the curriculum is slated for completion in 1999. The new curriculum will provide more flexibility for schools to tailor their course offerings to the needs and preferences of their students by concentrating on a core set of subjects, leaving more time than at present up to the discretion of individual school administrators. In addition, secondary students specializing in technical studies (including those at professional schools) will begin taking different twelfth grade exit examinations than those in general studies, beginning in academic year 2000/01. This will allow a greater share of classroom time to be

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[47] This figure includes students in professional schools; see Ministry of Education (1998a), page 23.

devoted to technical material, and hence improve the effectiveness of these programs. In addition, the Ministry of Education has proposed a reform of the secondary school curriculum—to be put in place for school year 2001/02—that would allow more flexibility and reduce the required amount of mathematics for those students concentrating on the humanities.[48]

74. School attendance rates of vulnerable groups at the secondary level are also expected to rise on account of a new merit scholarship program for low-income families. Introduced in school year 1998/99, these scholarships provide cash of 100,000 escudos per annum (US$555) in three payments. Between 3,600 to 5,000 students are projected to receive this benefit this school year.

75. A critical component of the government's strategy at both the primary and secondary level is improved monitoring and evaluation of educational performance. Research efforts of the Ministry of Education have been stepped up through the creation of a research department within the ministry in 1997. In 1998, the Permanent Observatory for Secondary Education was created, with a view to disseminating information on best practices in secondary education; looking forward, the government has proposed the creation of a similar program for primary education to commence in the academic year 1999/2000, with a view to conducting further research on the factors behind high dropout rates at the primary level. The government will also finish by end-1999 the design of nationwide standardized tests at the fourth, sixth, and ninth grades, which will provide better data on academic performance across schools and regions.

76. The government is also promoting an increase in school autonomy as a means to improve academic outcomes. The reorganization of school administration proposed in 1998 envisages that schools will receive greater autonomy in resource management (including personnel) in return for agreeing to meet specific targets or quantitative goals formalized through "contracts" between the school and the Ministry of Education. By end-1999, it is envisaged that the government will agree upon the quantitative targets that could provide the basis for such contracts, which could be put in place by academic year 2000/01. It is unclear how many schools will move to the more autonomous form of management, however, given that participation will be voluntary.

77. In sum, the government's reforms planned in the near term are likely to have a salutary effect on school achievement, and hence offer the possibility of improved efficiency. The effects on expenditures are likely to be limited, however, given the absence of any planned reduction in the number of regular teaching staff.

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[48] See Melo (1999).

H. Possible Directions for Further Reform and Research

78. Given the sizable disparity in performance that still exists between Portugal and the rest of the OECD, and some concern about the pace of expected improvement, the examination of possible reforms to further strengthen the performance of the educational system merits attention. Many of these reforms could be incorporated into the authorities' framework for educational reform delineated above. Among those that could be considered are the following:

- *Set explicit and appropriately defined targets for performance by school.* Educational performance could be improved by setting explicit targets on key quantitative measures of achievement or performance, such as success rates (percentage of students successfully completing the grade), repetition rates, and scores on national examinations. The establishment of quantitative targets could be woven into the school contracts envisaged under the government's planned increase in school autonomy. The new achievement examinations being implemented at various grade levels also provide an important opportunity for tracking and assessing performance by school. In this context, additional modifications to the curriculum could be required to strengthen academic performance and facilitate meeting these targets.

- *Design an appropriate management and incentive system to facilitate achievement of educational goals.* Imbuing the public education system with a more goal-oriented focus would require a substantial change in the incentive and evaluation system for educational personnel. At present, school directors are chosen largely on the basis of the preferences of their fellow teachers. Increasing the accountability of school directors would appear to be a necessary first step in providing the basis for improving school performance. In a similar vein, the system of teacher compensation could warrant review, as salary increments are based on length of service, rather than any measure of merit. In tandem with the tenure system, the present system provides little incentive or reward for improved performance.[49] Drawing on the Dutch experience, public school performance could also be enhanced by wide publicity and dissemination of evaluations of school performance (for example, average scores on the forthcoming national tests at various grades).[50] This information would allow the public to evaluate the comparative performance of their schools and allow greater public pressure to bear on those schools with sub-par academic outcomes.

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[49] On the importance of incentives in achieving improved educational performance, see Hanushek and others (1994).

[50] Parents are also free to choose among different schools for their children in the Netherlands. In this context, the wide dissemination of information on school performance is seen as a critical element in ensuring that competition leads to improved educational efficiency (see Ritzen, 1999).

- *Improve the flexibility of personnel management.* The quality of education could be enhanced by providing greater flexibility in managing educational personnel. At present, teachers compete for school openings at a national level, with preference given to those with the most experience. This results in a systematic movement of teachers from less desirable areas to developed urban centers, and a high degree of turnover of both teachers and school directors relative to other OECD countries—to the detriment of the quality of education (Clímaco, 1997). The quality of education could be improved if greater discretion was given to the Ministry of Education to allocate teachers by region or school, especially in light of the desire to concentrate resources in areas where dropout rates are high and educational attainment levels are low. The present system of teacher tenure could also be reviewed, in particular the practice of granting tenure to teachers in a particular school. This implies that schools that lose student population over time may have excessively high teacher/student ratios and high costs per student, while other schools are relatively understaffed. Improved flexibility of staffing could limit the need for new hires and allow some reduction in public outlays, without any adverse effect on educational output. Consideration could be given to hiring more teachers on a contractual basis, without the obligation of providing tenure.

  Increased flexibility of resource management is also important in light of uncertainties over the projected demand for secondary education. The Ministry of Education does not foresee a decrease in the student population, owing to rising enrollment rates. If enrollment rates do not climb as expected, however, it is likely that the projected decline in the population of 15–19 year olds (almost a 30 percent drop from end-1995 to 2005) could lead to a much smaller student body and a reduced demand for teachers. Levels of teacher compensation, which exceed those in other OECD countries relative to GDP per capita, could also be reviewed, especially in light of generous pension benefits and the modest level of working hours.

- *Establish minimum student/teacher ratios across schools and minimum school sizes.* The Ministry of Education's plan to consolidate primary schools at the first cycle provides a useful first step for a more economical allocation of educational resources, and the planned consolidation should move forward as soon as possible, with a view to merging all small schools where cost savings can be achieved. At the same time, there is a need to examine student/teacher ratios at all levels of education, and consideration should be given to establishing minimum student/teacher ratios and minimum school sizes.

- *Examine the composition of expenditures.* Given the low level of nonwage current outlays, and the low level of spending for maintenance indicated in 1995 data, there is an urgent need to assess the adequacy of present allocations for nonwage inputs. As such, the possibilities of reallocating spending to achieve improved performance should be contemplated. Further, as noted by Pinto, Barros, and Lopes (1998), an improved database is needed to provide information on spending per student and a

more detailed composition of expenditure per student to form the basis for improved management of educational expenditures.

- *Reassess the level of cost recovery in public universities.* Given the high subsidy element involved in public education, as well as the high rates of return to university education, a more targeted approach to this subsidy may be warranted. This could be achieved, for example, by an increase in tuition fees, matched by an expansion of scholarships to poor students.

In many respects the conclusions of this study are tentative and further analysis will be needed. Further research could usefully focus on the following topics:

- *The causes of Portugal's high repetition and failure rate.* In particular, it would be useful to assess whether promotion standards are unduly high relative to other countries; whether assessment and testing methods are responsible for high failure rates; and whether assessment based on national examinations would provide a more uniform and accurate assessment of students. An item of special concern is the high failure rate at the twelfth grade, which may indicate that graduation standards are not consistent with the learning goals established at earlier grades.

- *The comparative performance of public and private schools.* As suggested by Pinto, Barros, and Lopes (1998), additional research is warranted on the relative efficiency and performance of private schools in Portugal. The preliminary evidence gathered in this chapter suggests that private schools may be more efficient than their public sector counterparts, as they achieve higher success rates with higher student/teacher ratios. Additional work is needed to address whether these differences simply reflect the more favorable socio-economic status of students in private schools, rather than greater efficiency per se.

Table 1. Portugal: Student Enrollment at Preschool and Primary Levels, 1985/86–1995/96

	Preschool	Primary 1st cycle 1/	Primary 2nd cycle	Primary 3rd cycle	Primary total
1985/86	...	817,544	388,994	375,162	1,581,700
1986/87 2/	...	784,264	395,064	372,391	1,551,719
1987/88 2/	140,246	738,734	394,536	395,690	1,528,960
1988/89 2/	154,357	717,924	372,450	429,422	1,519,796
1989/90 2/	160,129	668,033	378,531	444,626	1,491,190
1990/91 2/	170,052	626,340	356,420	458,138	1,440,898
1991/92 2/	176,822	613,578	354,631	496,246	1,464,455
1992/93	179,135	572,762	339,244	488,948	1,400,954
1993/94	183,298	544,445	343,437	500,353	1,388,235
1994/95	185,088	539,717	321,492	506,474	1,367,683
1995/96	...	513,671	315,209	471,816	1,300,696
Memorandum items:			(In percent)		
Public share (1995/96) 3/	...	91.4	91.8	91.1	...
Private share (1995/96) 3/	...	8.6	8.2	8.9	...

Source: Ministry of Education (1998a, 1998d).

1/ Figures refer to continental Portugal only (and thus exclude the autonomous regions of Azores and Madeira).
2/ Preschool figures exclude Azores.
3/ Figures for 1st cycle based on figures that include Azores and Madeira.

Table 2. Portugal: Student Enrollment at Secondary and Tertiary Levels, 1970/71–1997/98

(In thousands)

	Secondary general studies	Secondary technical	Secondary total	Tertiary
1970/71	...	...	...	59,683
1975/76	...	...	...	86,665
1980/81	...	...	...	95,001
1985/86 1/	204,463	17,488	221,951	107,789
1986/87	219,031	23,690	242,721	...
1987/88	248,370	27,826	276,196	...
1988/89	244,218	31,741	275,959	134,162
1989/90	272,509	36,242	308,751	155,032
1990/91	300,048	46,214	346,262	186,800
1991/92	339,780	61,483	401,263	218,300
1992/93	347,522	68,339	415,861	246,100
1993/94	338,772	99,509	438,281	270,000
1994/95	339,074	118,120	457,194	290,400
1995/96 2/	336,577	119,829	456,406	313,500
1996/97 2/	316,519	110,865	427,384	334,100
1997/98 2/	295,208	118,718	413,926	344,900
Memorandum items:		(In percent)		
Public share (1995/96)	...	...	87.2	63.8
Private share (1995/96)	...	...	12.8	36.2

Sources: Ministry of Education (1998a); unpublished Ministry of Education data; and Barreto et al. (1996).

Note: Data for years before 1985/86 were drawn from Bareto et al. (1996), while data from 1985/86 through 1994/95 were taken from Ministry of Education (1998a).

Figures from 1995/96 onward were drawn from the Ministry of Education (1998c, 1998d).

Unpublished data provided by the authorities were used for tertiary education estimates for 1990/91 to the present.

1/ Figure for tertiary refers to school year 1984/85.

2/ Figures refer to continental Portugal alone (and thus exclude the autonomous regions of Azores and Madeira) for secondary education.

Table 3. Percentage of the Population that has Attained a Specific Level of Education
(By age group, 1996)

	At least upper secondary education					At least university-level education				
	Age 25–64	Age 25–34	Age 35–44	Age 45–54	Age 55–64	Age 25–64	Age 25–34	Age 35–44	Age 45–54	Age 55–64
Portugal	20	32	24	15	9	7	11	9	6	4
Other OECD Countries	64	75	68	59	45	13	15	15	13	8
Australia	57	62	60	54	46	15	16	18	14	8
Austria	71	82	75	67	53	6	7	7	5	4
Belgium	53	70	58	47	31	11	14	11	10	6
Canada	76	85	81	73	56	17	20	18	17	11
Czech Republic	84	92	87	84	71	10	11	12	10	8
Denmark	66	74	70	65	50	15	16	17	16	11
Finland	67	83	76	60	40	12	13	13	12	7
France	60	74	64	56	38	10	12	10	10	5
Germany	81	86	85	81	71	13	13	16	14	9
Greece	44	66	52	36	22	12	16	14	11	6
Hungary	63	80	75	62	28	13	14	15	15	9
Ireland	50	66	54	38	30	11	14	11	9	6
Italy	38	52	46	31	17	8	8	11	8	5
Korea	61	88	63	41	25	19	30	18	11	7
Netherlands	63	72	66	57	47	23	25	25	21	16
New Zealand	60	65	64	56	49	11	14	13	10	6
Norway	82	91	87	78	62	16	19	17	14	8
Poland 1/	74	88	82	68	47	10	10	10	12	8
Spain	30	50	34	20	11	13	19	15	10	6
Sweden	74	87	80	70	53	13	11	15	16	10
Switzerland	80	87	82	78	71	10	11	10	9	6
United Kingdom	76	87	81	71	60	13	15	15	12	8
United States	86	87	88	86	77	26	26	26	28	20

Source: Modified version of Table A1.2a from OECD (1998).

1/ 1995 data.

Table 4. Educational Expenditure from Public and Private Sources for Educational Institutions
as a percentage of GDP by level of education (1995)

	Primary and secondary education			Tertiary education			All levels of education combined (including preprimary and undistributed)	All levels of education combined (public sector only) 1/
	All	Primary	Secondary	All	Non-university	University-level		
Portugal 2/	4.5	2.1	2.4	1.5	...	...	6.4	5.7
Other OECD countries or regions (mean)	3.8	1.4	2.3	1.3	0.2	1.1	5.7	5.0
Australia	3.7	1.6	2.1	1.8	0.3	1.5	5.6	4.5
Austria	3.9	1.2	2.7	1.0	0.1	0.9	5.5	5.3
Belgium (Flemish Community)	...		...	...	...	...	...	5.0
Canada	4.3	...	...	2.5	0.9	1.5	7.0	5.8
Czech Republic	3.9	0.9	2.9	1.0	0.1	1.0	5.7	4.8
Denmark	4.3	1.7	2.6	1.3	...	...	7.1	6.5
Finland	4.2	1.8	2.4	1.7	0.3	1.3	6.6	6.6
France	4.4	1.2	3.2	1.1	...	...	6.3	5.8
Germany	3.8	...	...	1.1	0.0	1.0	5.8	4.5
Greece 3/	2.8	1.3	1.5	0.8	0.2	0.7	3.7	3.7
Hungary	3.6	1.1	2.5	1.0	n.a.	1.0	5.5	4.9
Iceland	3.6	...	...	0.7	0.0	0.6	5.2	4.5
Ireland	3.4	1.3	2.1	1.3	...	..	5.3	4.7
Italy	3.2	1.1	2.1	0.8	0.0	0.8	4.7	4.5
Japan	3.1	1.3	1.7	1.0	0.1	0.9	4.7	3.6
Korea	3.8	1.7	2.2	1.9	0.4	1.5	6.2	3.6
Luxembourg	...	...	...	...	...	...	...	4.3
Netherlands	3.2	1.2	2.0	1.3	n.a.	1.3	4.9	4.6
New Zealand	...	...	...	...	...	...	...	5.3
Norway	...	...	...	...	...	...	...	6.8
Poland	...	...	...	...	...	...	...	5.2
Spain	4.0	1.3	2.7	1.1	n.a.	1.1	5.7	4.8
Sweden	4.5	2.0	2.5	1.7	...	...	6.7	6.6
Switzerland	...	...	...	...	...	...	...	5.5
United Kingdom	...	...	...	1.0	...	...	...	4.6
United States	3.9	1.8	2.0	2.4	0.4	2.0	6.7	5.0

Sources: Modified version of Tables B1.1a and B1.1d from OECD (1998); for Portugal, Fund staff estimates based on data provided by the authorities.

1/ Excludes public subsidies to households and students. These averaged 0.13 of GDP for countries reporting these data.

2/ Author's estimate based on 1996 data. Total spending includes outlays of local governments and independent regions of 0.5 percent of GDP. Figures include private sector spending, which are based on Fund staff estimates using public sector costs per student and private enrollment shares.

3/ Public sector only.

Table 5. Expenditure per Student (U.S. Dollars Converted Using PPPs) on Public and Private Institutions by Level of Education (Based on full-time equivalents, 1995)

	Early childhood	Primary	Secondary	Tertiary			All levels of education combined
				All	Non-university	University-level	
Portugal 1/ 2/	...	2,699	3,069	6,073	...	...	...
Other OECD countries or regions (mean)	3,337	3,673	4,740	8,357	6,875	9,013	4,861
Australia	...	3,121	4,899	10,590	7,699	11,572	...
Austria 3/	4,907	5,572	7,118	7,943	12,834	7,687	6,763
Belgium (Flemish Community) 4/	2,391	3,270	5,770	6,043	...	...	4,694
Canada	5,378	...	...	11,471	10,434	12,217	6,717
Czech Republic	2,052	1,999	2,820	6,795	2,502	7,656	2,885
Denmark	4,964	5,713	6,247	8,157	...	...	5,968
Finland	5,901	4,253	4,946	7,315	6,933	7,412	5,323
France	3,242	3,379	6,182	6,569	...	...	5,001
Germany 3/	5,277	3,361	6,254	8,897	6,817	9,001	5,972
Greece 4/	...	...	1,950	2,716	1,750	3,169	1,991
Hungary 3/	1,365	1,532	1,591	4,792	n.a.	4,792	1,782
Ireland	2,108	2,144	3,395	7,249	...	...	3,272
Italy 3/	3,316	4,673	5,348	5,013	6,705	4,932	5,157
Japan	2,476	4,065	4,465	8,768	6,409	9,337	4,991
Korea	1,450	2,135	2,332	5,203	3,980	5,733	2,829
Netherlands	3,021	3,191	4,351	9,026	n.a.	9,026	4,397
New Zealand	2,262	2,638	4,120	8,737	10,018	8,380	4,099
Norway 3/	...	...	...	9,647	...	...	6,360
Spain	2,516	2,628	3,455	4,944	3,973	4,966	3,374
Sweden	3,287	5,189	5,643	13,168	...	...	5,993
Switzerland 3/	2,436	5,893	7,601	15,685	8,226	18,365	7,241
United Kingdom 4/	5,049	3,328	4,246	7,225	...	...	4,222
United States	...	5,371	6,812	16,262	7,973	19,965	7,905

Sources: Modified version of Table B4.1 from OECD (1998); for Portugal, Fund staff estimates based on data provided by the authorities. Tertiary spending figures for Portugal are from OECD (1998).

1/ Public institutions, continental Portugal, based on 1996 data. Tertiary data refer to 1995.
2/ Staff estimates, except for tertiary spending.
3/ Public institutions.
4/ Public and government-dependent private institutions.

Table 6. Expenditure Per Student as a Share of GDP per Capita, 1995

	Early childhood	Primary	Secondary	Tertiary			All levels of education combined
				All	Non-university	University-level	
Portugal 1/2/	...	23	26	49	...	...	...
Other OECD countries or regions (mean)	18	20	27	46	36	50	26
Australia	...	16	25	54	39	59	...
Austria 3/	24	27	35	39	62	37	33
Belgium (Flemish Community) 4/	11	16	27	29	...	...	22
Canada	26	...	52	55	50	58	32
Czech Republic	20	19	27	66	24	74	28
Denmark	23	27	29	38	...	...	28
Finland	33	24	28	41	39	41	30
France	16	17	31	33	...	...	25
Germany 3/	21	16	...	43	33	44	29
Greece 4/	...	17	16	22	14	26	16
Hungary 3/	20	22	23	70	n.a.	70	26
Iceland	...	...	...	...	...	...	...
Ireland	12	12	20	42	...	...	19
Italy 3/	17	24	27	26	34	25	26
Japan	11	19	20	40	29	43	23
Korea	12	17	19	42	32	46	23
Netherlands	15	16	22	45	n.a.	45	22
New Zealand	13	16	24	52	59	49	24
Norway 3/	...	...	...	42	...	...	28
Spain	18	18	24	35	28	35	24
Sweden	18	28	30	70	...	...	32
Switzerland 3/	10	24	30	63	33	74	29
United Kingdom 4/	28	19	24	40	...	...	24
United States	...	20	26	61	30	75	30

Sources: Modified version of Table B4.3 from OECD (1998); for primary and secondary education in Portugal, Fund staff estimates based on data provided by the authorities. Tertiary spending figures for Portugal are from OECD (1998).

1/ Public institutions, continental Portugal, based on 1996 data. Tertiary data refer to 1995.

2/ Fund staff estimates, except for tertiary spending.

3/ Public institutions.

4/ Public and government-dependent private institutions.

Table 7. Ratio of Students to Teaching Staff by Level of Education, 1996

(Calculations based on full-time equivalents)

	Early childhood education	Primary education	Lower secondary education	Upper secondary education	All secondary education	Non-university tertiary	University-level	All tertiary education
Portugal 1/ 2/	...	12.6	11.2	9.5	...	...	18.5	...
Other OECD Countries or regions (mean)	17.3	17.9	14.6	13.7	14.5	13.1	17.1	16.2
Australia	...	18.1	...	...	...	...	15.4	...
Austria	18.9	12.7	9.2	8.5	8.9	...	14.5	...
Canada	21.5	17.0	20.0	19.5	19.7	12.8	16.4	14.6
Czech Republic	11.9	20.4	13.0	11.7	12.3	9.0	11.7	11.2
Denmark	13.1	11.2	10.1	12.1	11.0	...	...	...
Finland	11.9	16.8	12.4	...	...	...	...	...
France	24.6	19.5	...	...	13.3	...	17.2	17.1
Germany	23.7	20.9	16.0	13.1	15.0	12.3	12.5	12.5
Greece	14.9	15.0	11.4	11.3	11.3	23.0	23.9	23.6
Hungary	11.7	12.2	9.5	11.3	10.4	n.a.	9.9	9.9
Iceland 2/	4.5	17.6	...	...	...	...	...	...
Ireland	24.1	22.6	...	...	15.8	12.2	21.6	16.7
Italy	13.9	11.2	10.8	9.8	10.2	7.6	29.0	25.7
Japan	17.8	19.7	16.2	15.6	15.9	10.8	13.5	12.4
Korea	24.9	31.2	25.5	23.1	24.3	...	...	...
Netherlands	20.0	20.0	...	...	18.6	n.a.	18.7	18.7
New Zealand	6.0	22.0	18.1	14.1	16.1	11.6	16.1	14.9
Spain	19.4	18.0	17.8	14.2	15.1	12.3	17.6	17.4
Sweden	20.2	12.7	12.2	15.2	13.7	...	...	...
Switzerland 2/	18.3	15.9	13.0	10.2	12.3	...	21.2	...
United Kingdom	19.1	21.3	16.0	15.3	15.6	...	...	16.7
United States	21.9	16.9	17.5	14.7	16.1	19.4	14.1	15.4

Sources: Modified version of Table 7.1 from OECD (1998); for primary and secondary education in Portugal, data provided by the Ministry of Education.

1/ Preliminary data for 1997/98 for public schools in continental Portugal only. Primary school estimates based on an unweighted average of the first and second cycles of primary education. University data refer to 1996.

2/ Public institutions only.

Table 8. Annual Statutory Teachers' Salaries in Public Institutions at the Primary Level of Education, in Equivalent U.S. Dollars Converted Using PPPs (1996)

	Starting salary /minimum training	Salary after 15 years' experience /minimum training	Salary at top of scale /minimum training	Ratio of starting salary to per capita GDP	Ratio of salary after 15 years' experience to per capita GDP	Ratio of salary after 15 years' experience to starting salary	Salary after 15 years' experience per teaching hour	Salary after 15 years' experience per student enrolled
Portugal	16,283	24,501	42,303	1.2	1.9	1.5	31	...
Other OECD countries and regions	19,432	26,563	32,134	1.0	1.4	1.4	31	1,511
Australia (New South Wales)	19,166	34,897		0.9	1.7	1.8	...	1,931
Austria	19,508	25,005	39,323	0.9	1.2	1.3	37	1,970
Belgium	19,924	27,055	32,194	0.9	1.2	1.4	31	...
Czech Republic	6,391	8,279	9,910	0.6	0.8	1.3	13	405
Denmark	23,269	28,388	29,086	1.0	1.3	1.2	38	...
Finland	17,664	23,384	24,057	0.9	1.2	1.3	...	...
France	19,474	26,298	36,409	0.9	1.3	1.4	29	1,346
Germany	28,384	35,885	38,703	1.3	1.7	1.3	46	1,720
Greece	13,941	17,156	20,699	1.1	1.3	1.2	22	1,147
Hungary	3,533	4,789	6,184	0.5	0.7	1.4	9	394
Ireland	22,681	35,061	41,495	1.2	1.8	1.5	38	1,550
Italy	17,725	21,392	25,941	0.9	1.1	1.2	29	1,913
Korea	23,675	42,311	67,353	1.7	3.1	1.8	...	1,357
Netherlands	23,321	28,424	34,947	1.1	1.4	1.2	29	...
New Zealand	15,267	22,821	22,821	0.9	1.3	1.5	28	1,039
Norway	17,328	21,127	21,416	0.7	0.9	1.2	30	...
Spain	24,544	28,783	36,850	1.6	1.9	1.2	32	1,599
Sweden	16,246	20,815	...	0.8	1.1	1.3	33	1,635
Switzerland	32,508	43,467	50,048	1.3	1.7	1.3	50	2,733
United Kingdom	19,434	29,948	29,948	1.0	1.6	1.5	38	...
United States	24,090	32,533	40,398	0.9	1.2	1.4	34	1,924

Source: Modified version of Table E1.1a from OECD (1998).

Table 9. Educational Expenditure on Primary and Secondary Education by Resource Category for Public and Private Institutions (1995)

	Percentage of total expenditure		Percentage of current expenditure		Average compensation per student (In equivalent U.S. dollars)				
	Current	Capital	Compensation of all Staff	Other Current Expenditure	All Staff	Other Current Expenditure	Current	Capital	Total
Portugal 1/	92	8	94	6	2,501	163	2,663	228	2,891
Other OECD countries and regions	91	9	81	20	3,160	858	3,916	322	4,239
Australia	92	8	79	21	2,849	741	3,589	333	3,922
Austria	91	9	76	24	...	...	...	...	...
Belgium (Flemish Community) 2/	...	...	86	14	3,988	673	4,661	10	4,671
Canada	96	4	81	19	4,277	1,012	5,289	196	5,485
Czech Republic 3/	87	13	60	40	1,330	877	2,207	327	2,534
Denmark	95	5	80	20	4,566	1,168	5,733	295	6,028
Finland 2/	93	7	72	28	3,085	1,228	4,313	310	4,623
France	91	9	79	21	3,617	975	4,592	449	5,041
Germany 3/	92	8	76	24	3,262	1,057	4,319	371	4,690
Greece 3/	86	14	97	3	1,658	57	1,715	280	1,995
Hungary 3/	93	7	75	25	1,096	374	1,470	102	1,572
Iceland	88	12	71	29	...	...	...	...	
Ireland 3/	96	4	89	11	2,391	288	2,679	123	2,802
Italy 3/	96	4	89	11	4,380	532	4,912	187	5,099
Japan	85	15	87	13	3,182	479	3,661	621	4,282
Korea 3/	80	20	100	...	1,810	...	1,810	439	2,248
Luxembourg	92	8	97	3	...	...	...	...	...
Netherlands	96	4	78	22	2,869	792	3,661	153	3,814
Norway 3/	88	12	82	18	4,220	900	5,120	690	5,810
Spain	95	5	84	16	2,502	486	2,988	160	3,148
Sweden	...	...	56	44	3,035	2,394	5,430	...	7,824
Switzerland 3/	89	11	86	14	5,174	858	6,032	771	6,803
United Kingdom 2/	95	5	70	30	2,522	1,092	3,614	196	3,809
United States 3/	91	9	80	20	4,554	1,168	5,722	559	6,281

Sources: Modified version of Table B5.1a from OECD (1998); for Portugal, Fund staff calculations based on data provided by the authorities.

1/ Based on 1996 expenditure data deflated to 1995 prices and converted to dollars using ppp exchange rates for 1995. Figures on the composition of spending derived on the basis of expenditures of the Ministry of Education for public institutions. Total spending per student calculated for continental Portugal only. Spending figures include local government outlays of 0.1 percent of GDP, but exclude outlays for unallocated spending of the Ministry of Education, which totaled 0.1 percent of GDP for all levels of education.

2/ Public and government-dependent private institutions.

3/ Public institutions.

Table 10. Portugal: Gross Enrollment Rates, 1989/90–1995/96

Year	Grades 1–6	Grades 7–12	Tertiary
1989/90	126.5	74.2	19.5
1990/91	124.4	80.6	22.8
1991/92	128.1	91.6	27.0
1992/93	126.2	95.0	29.9
1993/94	128.0	102.3	32.9
1994/95	129.5	109.2	35.4
1995/96	127.9	111.7	37.9

Source: Ministry of Education.

Table 11. Percentage of Students Successfully Completing the School Year in Continental Portugal, 1994/95 and 1995/96 1/

	1994/95	1995/96
Basic education	87.2	86.5
Grade 1	100.0	100.0
Grade 2	84.8	84.1
Grade 3	91.7	92.1
Grade 4	85.0	86.0
Grade 5	87.7	85.3
Grade 6	88.4	88.5
Grade 7	80.6	79.0
Grade 8	83.4	82.0
Grade 9	86.4	85.0
Secondary education	71.3	63.6
General studies	70.2	64.9
Year 10	71.0	63.7
Year 11	90.6	82.3
Year 12	60.4	56.0
Vocational studies	75.7	59.2
Year 10	74.2	51.4
Year 11	89.4	75.6
Year 12	56.2	56.7

Source: Data provided by the Ministry of Education.

1/ Defined as the percentage of students entering the school year that successfully pass or conclude that grade.

Table 12. Dropout Rates by Grade in Continental Portugal 1/

	1981 2/	1990 2/	1995
Basic education			
Grade 1	0	0	...
Grade 2	1	2	...
Grade 3	0	0	...
Grade 4	8	4	0
Grade 5	11	7	2
Grade 6	24	16	3
Grade 7	14	9	6
Grade 8	11	8	5
Grade 9	9	7	9
Secondary education			
Year 10	3	8	17
Year 11	14	...	...
Year 12	17	...	...

Sources: OECD (1995a), for 1981 and 1990; and Ministry of Education for 1995.

1/ The dropout rate is measured as the percentage of students who are enrolled in a given school year that are not enrolled in the following year.

2/ Covers public schools only.

Table 13. Repetition Rates by Grade in Continental Portugal 1/

	1981 2/	1990 2/	1994/95	1995/96
Basic education	...	...	8	10
Grade 1	0	0	0	0
Grade 2	41	31	14	14
Grade 3	0	0	6	8
Grade 4	27	19	11	16
Grade 5	20	13	5	8
Grade 6	17	10	7	8
Grade 7	25	18	7	12
Grade 8	24	18	9	10
Grade 9	24	15	7	10
Secondary education	...	...	15	19
General studies 3/				
Year 10	11	23	10	14
Year 11	31	26	2	9
Year 12 4/	15	33	24	28
Vocational studies				
Year 10	...	...	16	19
Year 11	...	...	3	14
Year 12	...	...	3	3

Sources: OECD (1995a) for 1981 and 1990; and Ministry of Education for other years.

1/ The repetition rate is measured as the percentage of students who are enrolled in the same grade over two consecutive school years.

2/ Covers public schools only.

3/ Includes all secondary students for 1981 and 1990.

4/ Refers to rate for all 12th grade students, including those in vocational courses.

Table 14. Ratio of Upper Secondary Graduates to Population at Typical Age of Graduation (times 100), First Educational Programs, 1996

	Total			General			Vocational and apprenticeship		
	M + W	Men	Women	M + W	Men	Women	M + W	Men	Women
Portugal 1/	56	48	65	45	38	53	11	10	12
Other OECD countries	86	83	88	40	37	46	48	49	44
Austria	86	88	84	15	13	18	71	76	66
Belgium (Flemish Community) 2/	100	100	100	34	30	39	82	74	90
Canada	73	70	77	...	...	...	...	...	...
Czech Republic	83	81	85	11	9	14	71	72	70
Denmark	81	76	87	46	38	55	35	38	32
Finland 2/	98	93	100	48	40	57	50	53	47
France	85	85	86	34	29	40	51	56	46
Germany	86	86	86	25	22	29	61	64	58
Greece	80	75	86	54	46	63	26	29	23
Hungary	86	...	...	25	18	33	59	...	...
Ireland	79	75	83	77	72	82	2	2	2
Italy	79	76	82	19	16	22	59	59	59
Japan 2/	99	96	100	73	69	76	26	27	26
Korea	91	91	91	54	57	50	37	33	41
Netherlands	81	...	...	33	...	...	48	...	...
New Zealand	93	86	99	63	59	67	30	27	33
Norway 2/	100	100	100	49	43	56	68	90	45
Poland	94	...	...	25	...	...	69	...	...
Spain	73	65	81	44	...	...	27	25	29
Sweden	81	80	82	27	21	34	54	59	48
Switzerland	81	86	76	20	18	23	61	68	53
United States	72	69	76	...	...	...	...	...	...

Sources: OECD (1998), Table C2.3 for all countries except Portugal. Portuguese data are from the Ministry of Education.

1/ Refers to the number of persons graduating in 1996 divided by the number of 18 year olds in continental Portugal. Thus, it includes overage students, whereas the figures for other countries do not.

2/ Total does not equal sum of general and vocational studies, due to problems of double counting. In these cases, the total has been set to a maximum of 100.

Table 15. Net Enrollment Rates in Continental Portugal, 1994/95

	Basic education			Secondary education
	Grades 1–4	Grades 5–6	Grades 7–9	(average)
Continent	109.7	84.9	78.5	51.2
North	108.7	82.2	74.4	42.5
Central	110.2	82.3	76.3	49.7
Lisbon and Tejo Valley	109.9	89.5	84.7	61.5
Alentejo	106.9	83.5	76.9	53.7
Algarve	121.8	91.2	84.7	59.1

Source: Ministry of Education (1998b).

Table 16. Conclusion Rates in Continental Portugal, 1995/96

	4th Grade	6th Grade	9th Grade	12th Grade		
				General studies	Vocational studies	Via ensino
Continent	86.0	88.5	85.0	64.5	56.7	48.8
North	84.7	89.5	86.1	65.3	58.7	52.4
Central	86.9	89.5	84.4	61.8	50.9	46.3
Lisbon and Tejo Valley	87.1	86.9	84.2	65.6	57.4	47.6
Alentejo	87.5	86.8	85.6	64.8	65.7	53.2
Algarve	84.7	87.7	83.8	58.7	49.9	44.2

Source: Ministry of Education (1998d).

Table 17. Portugal: Students Above the Normal Age in Grades 7–9, by Region, 1994/95

(Percentage of students by number of years behind grade)

	0 Year	1 Year	2 Years	3 or More
North	57.3	24.0	12.2	6.4
Central	50.8	24.8	14.5	9.9
Lisbon and Tejo Valley	57.0	22.0	13.0	8.0
Alentejo	53.1	22.9	14.4	9.6
Algarve	49.6	22.6	15.1	12.7

Source: Ministry of Education (1998a).

Table 18. Portugal: Student/Teacher Ratios by Region, 1997/98 1/

	Basic education			Secondary school	Per-capita GDP
	Grades 1–4	Grades 5–6	Grades 7–9	Grades 10–12	in US$, 1996
Portugal	14.5	...	...	...	10,865
Continental Portugal	14.5	8.8	11.2	9.5	...
North	13.9	9.8	11.8	9.6	9,573
Central	13.2	8.1	9.9	9.1	9,161
Lisbon and Tejo Valley	16.5	8.3	11.4	9.4	13,823
Alentejo	13.5	8.3	11.3	9.9	8,918
Algarve	16.4	8.7	11.7	9.9	10,846
Azores	16.9	...	...	...	7,733
Madeira	13.6	...	...	...	8,066

Sources: Ministry of Education; and National Statistics Office (INE).

1/ Preliminary estimates.

Table 19. Conclusion Rates in Continental Portugal for Private and Public Schools, 1995/96

	4th Grade	6th Grade	9th Grade	12th Grade		
				General studies	Vocational studies	Via ensino
Total	86.0	88.5	85.0	64.5	56.7	48.8
Men	83.7	85.5	83.3	61.3	51.4	45.8
Women	88.6	91.8	86.8	66.6	61.2	51.7
Public	85.2	88.0	84.1	64.0	56.6	46.6
Men	82.9	85.0	82.1	61.0	51.5	43.4
Women	87.9	91.4	86.0	66.0	60.9	49.8
Private	95.4	93.1	93.8	69.5	57.4	66.9
Men	93.3	90.5	91.7	64.6	49.5	65.1
Women	97.7	95.9	96.0	73.2	65.2	68.8

Source: Translation of Table 2.1, Ministry of Education (1998d).

Table 20. Actual and Projected Educational Attainment Rates, Continental Portugal, 1990/91–2000/01 1/

Year	6th Grade	9th Grade	11th Grade	12th Grade	Tertiary
1990/91	82	58	47	...	...
1995/96	98	85	64	56	35
2000/01	100	100	72	66	40

Source: Ministry of Education (1998c).

1/ Figures refer to the number of actual or projected graduates divided by the number of students beginning school *n* years earlier. For example, the 66 percent figure for 2000/01 implies that the number of new high school graduates in that year will be 66 percent of the student population that started school 12 years earlier.

Table 21. Portugal: Net Enrollment Rate and Share of the Population Completing Tertiary Education, 1990/91–1997/98

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
Number of students (thousands)	186.8	218.3	246.1	270.0	290.4	313.5	334.1	344.9
Number of new graduates (thousands)	18.7	21.4	27.5	32.7	36.4	39.2	42.6	...
Total Portuguese population ages 18–22 (thousands)	816.2	819.2	826.5	841.3	848.5	842.3	827.8	807.2
Total Portuguese population age 22 (thousands)	161.4	161.8	159.4	163.2	167.7	166.5	170.5	173.7
Enrollment as share of population 19–22	22.9	26.7	29.8	32.1	34.2	37.2	40.4	42.7
Net enrollment rate, ages 17–34	...	...	...	...	...	10.5	...	...
Tertiary graduates as share of population age 22	11.6	13.3	17.2	20.0	21.7	23.5	25.0	...
Memorandum item:								
Net enrollment rate, ages 17–34, other OECD countries	...	...	...	...	...	11.5	...	...

Source: Ministry of Education, except for net enrollment rate, which is drawn from OECD (1998), Table C3.3.

Table 22. Performance on International Examinations

	8th Grade Mathematics 1/ (1995)	8th Grade Science 1/ (1995)	8th Grade Reading 2/ (1991)	4th Grade Mathematics 1/ (1995)	PPP per capita (US$) (1995)
Portugal	454	480	500	340	11,968
Other OECD countries or regions (mean)	527	531	498	402	17,956
Australia 3/	530	545	...	408	19,943
Austria 3/	539	558	...	421	20,211
Belgium (Flemish Community)	565	550	...	...	...
Belgium (French Community)	526	471	446	...	...
Canada 4/	527	531	494	395	21,733
Czech Republic	564	574	...	428	9,145
Denmark 3/	502	478	...	...	20,659
Finland	...	...	545	...	17,776
France	538	498	...	...	20,896
Germany 3/5/	509	531	500	...	19,394
Greece 3/	484	497	482	356	8,950
Hungary 3/	537	554	...	410	6,341
Iceland	487	494	514	338	18,729
Ireland	527	538	484	412	16,061
Italy	...	...	488	...	19,808
Japan	605	571	...	457	21,461
Korea	607	565	...	471	11,829
Netherlands 3/	541	560	486	438	19,621
New Zealand	508	525	528	362	16,974
Norway	503	527	489	365	21,596
Spain	487	517	456	...	14,496
Sweden	519	535	529	...	19,313
Switzerland	545	522	515	...	23,612
UK (England)	506	552	...	376	...
UK (Scotland) 3/	499	517	...	383	...
United States	500	534	514	407	26,479

Sources: OECD (1998); TIMSS International Study Center; and OECD (1997).

1/ Third International Mathematics and Science Study (TIMSS).

2/ International Association for the Evaluation of Educational Achievement (IEA) Reading Literacy Study for 13–14 year olds.

3/ Countries that did not satisfy one or more guidelines for sample participation rates, age/grade specifications, specifications, or classroom sampling procedures under the TIMSS.

4/ Reading score refers to British Columbia only.

5/ Reading score represents an average of the former Democratic Republic of Germany and the former Federal Republic of Germany. The scores of the two regions varied by three points.

Table 23. Relative Earnings of 25–64 Year-olds with Income from Employment (Upper secondary education=100) by level of educational attainment and gender (1996)

	Year	Below upper secondary education			University-level education		
		M+W	Men	Women	M+W	Men	Women
Portugal	1996	64	62	64	184	182	175
Other OECD countries	...	80	81	78	162	161	156
Australia	1995	89	105	87	142	161	139
Canada	1996	87	87	76	161	152	172
Czech Republic	1996	67	72	75	161	155	149
Denmark	1996	84	86	87	134	138	132
Finland	1995	93	91	93	185	187	173
France	1996	82	85	79	178	185	167
Germany	1996	76	82	82	158	152	151
Hungary	1996	72	79	68	169	189	150
Ireland	1994	85	77	62	183	171	187
Italy	1995	76	73	76	156	173	129
Netherlands	1995	86	87	77	137	135	143
New Zealand	1996	82	78	85	176	171	148
Norway	1996	85	87	81	142	143	146
Spain	1995	78	62	76	153	145	147
Sweden	1996	90	88	89	153	158	144
Switzerland	1996	71	80	75	161	146	161
United Kingdom	1996	74	79	69	181	161	190
United States	1996	67	64	64	183	183	175

Source: OECD (1998), Table F7.1.

Table 24. Efficiency Scores: Expenditure per Student in Purchasing-Power Adjusted Dollars and Secondary Graduates to Population at Typical Graduation Age

(Input: Spending per student in purchasing-power adjusted U.S. dollars at primary and secondary level; output indicator: ratio of secondary graduates to population at typical graduation age)

	Input efficiency		Output efficiency	
	Score	Rank	Score	Rank
Portugal	0.544	9	0.620	20
Austria	0.401	12	0.945	6
Canada	0.287	16	0.740	18
Czech Republic	0.621	7	0.910	8
Denmark	0.261	17	0.813	14
Finland	0.926	5	0.992	5
France	0.312	14	0.864	12
Germany	0.335	13	0.870	10
Greece	0.788	6	0.928	7
Hungary	1.000	1	1.000	1
Ireland	0.561	8	0.868	11
Italy	0.308	15	0.798	17
Japan	1.000	3	1.000	3
Korea	1.000	2	1.000	2
Netherlands	0.412	11	0.892	9
Norway	1.000	4	1.000	4
Spain	0.500	10	0.802	16
Sweden	0.201	20	0.813	13
Switzerland	0.231	19	0.809	15
United States	0.250	18	0.725	19

Source: Fund staff calculations.

Table 25. Efficiency Scores: Education Spending Per Student as Share of GDP Per Capita (Secondary Level) and Secondary Graduates to Population at Typical Graduation Age

(Input: Spending per student at the secondary level as a share of GDP per capita; output indicator: ratio of secondary graduates to population at typical graduation age)

	Input efficiency		Output efficiency	
	Score	Rank	Score	Rank
Portugal	0.613	15	0.571	20
Austria	0.540	19	0.860	9
Belgium (Flemish)	1.000	3	1.000	3
Canada	0.310	20	0.731	19
Czech Republic	0.681	10	0.838	11
Denmark	0.640	12	0.813	13
Finland	0.738	9	0.980	5
France	0.600	17	0.854	10
Greece	1.000	4	1.000	4
Hungary	0.801	8	0.874	7
Ireland	0.812	7	0.868	8
Italy	0.583	18	0.788	16
Japan	1.000	1	1.000	1
Korea	1.000	2	1.000	2
Netherlands	0.851	5	0.822	12
New Zealand	0.839	6	0.937	6
Spain	0.664	11	0.739	17
Sweden	0.619	14	0.813	14
Switzerland	0.612	16	0.809	15
United States	0.628	13	0.734	18

Source: Fund staff calculations.

Table 26. Efficiency Scores: Education Spending to GDP and Educational Attainment Levels

(Input: Educational expenditure to GDP at the primary and secondary, level, adjusted for population structure; output indicator: ratio of secondary graduates to population at typical graduation age)

	Input efficiency		Output efficiency	
	Score	Rank	Score	Rank
Portugal	0.579	17	0.575	17
Austria	0.721	10	0.877	9
Canada	0.598	16	0.803	14
Czech Republic	0.878	7	0.910	6
Denmark	0.638	14	0.830	12
Finland	1.000	2	1.000	2
France	0.732	8	0.871	10
Germany	0.703	11	0.877	8
Greece	1.000	3	1.000	3
Hungary	0.896	6	0.949	5
Ireland	1.000	3	1.000	3
Italy	0.651	13	0.866	11
Korea	1.000	1	1.000	1
Netherlands	0.903	5	0.892	7
Spain	0.622	15	0.802	15
Sweden	0.654	12	0.829	13
United States	0.723	9	0.764	16

Source: Fund staff calculations.

Table 27. Efficiency Scores: Education Spending to GDP and Ratio of Secondary and Tertiary Graduates to Population at Typical Graduation Age

(Input: Educational expenditure to GDP, adjusted for population structure; output indicators: ratio of graduates to population at typical graduation age, secondary school, and ratio of graduates to population at typical graduation age, tertiary)

	Input efficiency			Output efficiency		
	Score	Rank	Independently efficient 1/	Score	Rank	Independently efficient 1/
Portugal	0.623	17		0.571	17	
Austria	0.830	9		0.870	9	
Canada	1.000		+	1.000		+
Czech Republic	0.976	6		0.838	11	
Denmark	0.633	16		0.823	12	
Finland	0.758	11		0.992	6	
France	0.826	10		0.864	10	
Germany	0.749	12		0.870	8	
Greece	1.000	4		1.000	5	
Hungary	0.958	8		0.874	7	
Ireland	1.000	3		1.000	3	
Italy	0.676	15		0.798	15	
Japan	1.000	1		1.000	1	
Korea	1.000	2		1.000	2	
Netherlands	0.964	7		0.822	14	
Spain	0.681	14		0.739	16	
Sweden	0.654	13		0.822	13	
United States	1.000	4		1.000	4	

Source: Fund staff calculations.

1/ Refers to observations that do not dominate any others, and are not dominated by any other observation.

Table 28. Efficiency Scores: Education Spending to GDP At Primary and Secondary Level and Achievement in Eighth-Grade International Achievement Examinations

(Input: Educational expenditure to GDP at the primary and secondary level, adjusted for student enrollment as a share of the population; output indicators: (A) scores on Eighth-grade math and science exams; and (B) reading examinations)

	(A) Math and Science Input efficiency		(B) Reading Input efficiency	
	Score	Rank	Score	Rank
Portugal	0.648	13	0.710	9
Australia	0.892	8		
Austria	0.564	17		
Canada	0.632	14	0.697	10
Czech Republic	1.000	4		
Denmark	0.573	16		
Finland			1.000	2
France	0.708	12		
Germany	0.598	15	0.660	12
Greece	0.983	5	0.983	4
Hungary	0.780	9		
Iceland	0.902	7	1.000	1
Ireland	1.000	3	1.000	3
Italy			0.673	11
Japan	1.000	2		
Korea	1.000	1		
Netherlands	0.933	6	0.918	5
Spain	0.737	10	0.737	8
Sweden	0.556	18	0.893	6
United States	0.711	11	0.778	7

Source: Fund staff calculations.

Table 29. Correlations Between Educational Inputs and Efficiency Measures

	Input efficiency: Secondary graduation Rates 1/	Input efficiency: Math and Science 2/
Student/teacher ratio, primary	0.49	0.54
Student/teacher ratio, second. 3/	0.09	0.31
Total spending per student, ppp dollars	-0.59	-0.69
Nonstaff current outlays, ppp dollars	-0.27	-0.58
Share of personnel costs in total spending	0.03	0.24
Teacher salary to GDP per capita 4/	0.18	0.25
Memorandum items:		
Correlations with other country characteristics		
GDP per capita	-0.46	-0.40
Private share of education provision 5/	-0.24	0.24
Repeater rate, secondary	-0.61	-0.32

Source: Fund staff calculations.

1/ Based on input efficiency score in Table 26.
2/ Based on input efficiency score in Table 28.
3/ Lower secondary school (grades 7–9).
4/ Refers to teachers with 15 years of experience.
5/ Based on direct private sector payments to institutions. Includes tertiary level.

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II. Public Capital and Output Growth in Portugal: An Empirical Analysis[51]

A. Introduction

79. Since Portugal joined the European Union (EU) in 1986, it has received on average 3.3 percent of GDP in transfers per annum from the EU. These transfers—primarily designed to promote infrastructure investment, human capital accumulation, and private investment—boosted the expansion of public investment (including capital transfers) from 4.8 percent of GDP in 1986 to 6.3 percent of GDP in 1998. As a result, gross public capital formation in Portugal (as a share of GDP) is currently the second highest in the EU area (see Figure 2). On average, the real value of the public capital stock grew by 5.1 percent during 1986–95, which is considerably above that of the United States (2.1 percent) but below that of Spain (see Table 30). However, the highest average change in the real value of the Portuguese capital stock was recorded during the 1974–85 period, just after the shift in the political regime,[52] indicating that even before joining the EU a substantial share of resources was devoted to public capital accumulation.

80. Various authors have tried to determine the productivity effects of public capital by estimating a Cobb-Douglas production function that includes public capital as an input.[53] Aschauer (1989, 1990) was one of the first to investigate this issue for the United States in an attempt to explain the productivity slowdown in the 1970s. He found that a 1 percent increase in the public capital stock increased private capital productivity by 0.39 percent, suggesting that public capital is an important determinant of production. Since then, many authors have employed this approach, but some have also pointed to its lack of attention to feedback effects because it assumes that the causality runs from public capital to output. Recently, a number of authors (e.g., Otto and Voss, 1996; Batina, 1998; and Sturm, Jacobs, and Groote, 1999) have employed a vector autoregressive (VAR) model with a view to capturing the dynamic interactions between output, public capital, and private capital. The VAR approach models every endogenous variable as a function of its own lagged value and the lagged values of the other endogenous variables and can therefore assess whether there is any feedback from private sector variables to the public capital stock.[54]

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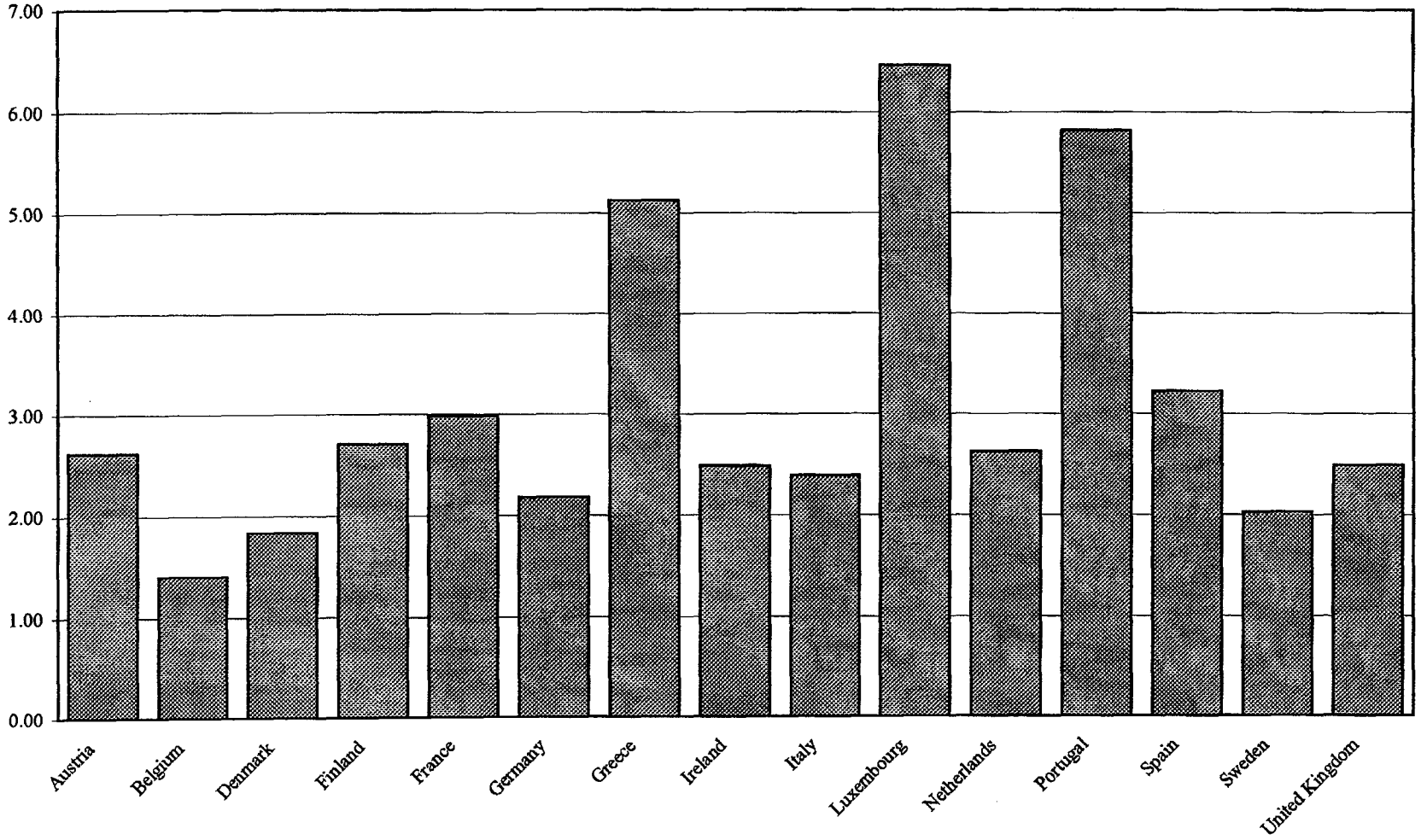
[51]Prepared by Jenny Ligthart.

[52]In April 1974, a revolution replaced "The New State" with a democratic regime.

[53]See Table 31 for an overview of the studies to date.

[54]Other approaches include the estimation of cost functions, cross-sectional studies using country level data, and calibrated structural models. For example, see Gaspar and Pereira (1995) for an application of a computable general equilibrium model to assess the growth effects of EU-financed capital expenditures in Portugal.

Figure 2. Average Gross Public Capital Formation as share of GDP
for Various Countries, 1994-98 1/



Source: *World Economic Outlook* database.

1/ Includes capital transfers for Portugal.

81. The objective of this chapter is to study the effects of public capital on output growth in Portugal using annual data over the period 1965–95. To this end, two approaches are taken. First, a production function incorporating public capital, private capital, and employment is estimated using both the conventional technique of ordinary least squares (to ensure comparability with other studies) and Johansen's (1988) cointegration procedure.[55] The results indicate that public capital is a significant long-term determinant of real output growth. In the second approach, a VAR model is estimated to assess the causal dynamics between public capital and output. A positive, Granger (1969)-causal relationship is found, which runs from public capital to Portuguese production, providing support for the view that public capital has contributed to Portugal's economic growth.

82. The remainder of the chapter is structured as follows. In Section II results are presented for the single equation approach. Section III addresses short-run dynamics by specifying a vector autoregressive model. Section IV summarizes the main findings.

B. The Production Function Approach

Conceptual framework

83. Assume a Cobb-Douglas production function that incorporates the public capital stock, G, as an input:[56]

$$Y = AK^{\alpha}G^{\beta}L^{\gamma}, \quad \alpha,\beta,\gamma>0, \tag{1}$$

where A denotes an index of economy-wide productivity, K is private capital, L denotes employment, and Y is output. In this setup, an increase in public capital raises output directly (i.e., $Y_G=\beta(Y/G)>0$, where a subscript denotes a partial derivative), but also indirectly through its positive effect on the marginal productivity of labor and capital (i.e., $Y_{KG}>0$ and $Y_{LG}>0$).

84. By taking natural logs on both sides of the equation, and denoting lowercase variables as the natural log of the respective uppercase variable, the following equation results:

$$y = a + \alpha k + \beta g + \gamma l, \quad \alpha>0, \beta>0, \gamma>0. \tag{2}$$

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[55]A number of authors have employed Johansen's procedure to estimate production functions (e.g., Batina, 1998; Flores de Frutos, Gracia-Diez, and Pérez-Amaral, 1998; Ghali, 1998; and Mamatzakis, 1999). See below for a further discussion of cointegration issues.

[56]Arrow and Kurz (1970) were one of the first to study theoretically the growth implications of incorporating public capital in a neoclassical production function.

The coefficients α, β, and γ are the output elasticities of the factor inputs. Inclusion of public capital in the production function raises the issue of returns to scale. Imposing the restriction of constant returns to scale across all inputs (i.e., $\alpha+\beta+\gamma=1$), which is a common assumption in the literature, yields an expression featuring decreasing returns with respect to private inputs:

$$y-k = a + \beta(g-k) + \gamma(l-k), \quad \alpha+\gamma<1. \tag{3}$$

An alternative model assumes constant returns to scale in both private inputs, allowing for increasing returns to scale across all inputs:

$$y-k = a + \beta g + \gamma(l-k), \quad \alpha+\gamma=1. \tag{4}$$

This specification has been employed at times in the endogenous growth literature (see, for example, Barro, 1990).

85. In the econometric specification, all equations to be estimated include a capital utilization rate, *cu*, to capture the effects of the business cycle on factor use. Because the capital utilization rate enters the equation in an additive fashion, it does not affect the optimal capital-labor ratio.[57] Many studies also include a constant and a time trend to capture Hicks-neutral technological progress. The current study will represent the technology variable, *a*, by a constant. This specification reflects the underlying hypothesis that economic growth in Portugal has been mainly driven by factor accumulation and not by increases in factor productivity—a hypothesis supported by a preliminary staff assessment (see Box 1 of SM/99/232, 9/15/99). In addition, a dummy variable for the period 1975–85 will be introduced to capture the period in between the new regime after the 1974 revolution and EU accession in 1986.

Evidence for OECD countries

86. Most time series studies employ a Cobb-Douglas production function to estimate the output effects of public capital. On average, these studies estimate a production elasticity of public capital (β) of 0.25 for various OECD countries when the production function is estimated in levels. Estimates of β vary considerably across countries but lie in the interval 0.20–0.30 at a 95 percent level of confidence (Table 32). If the model is estimated in first differences, estimates of β are on average higher and confidence intervals are wider. Panel

[57]Some studies (e.g., Tatom, 1991) also include the relative price of energy in the equation to capture supply shocks but it is not immediately clear why any price variable should be included in a production function.

studies—based on regional data for a single country—find in general much lower estimated coefficients, which could be ascribed to "leakages" reflecting the fact that, at the regional level, not all beneficial spillover effects of public investment can be internalized (see Munnell, 1992).

The data

87. The empirical analysis employs annual data for Portugal over the period 1965–95. Data on GDP, the number of employed persons, the private capital stock, and the public capital stock are obtained from the Historical Series for the Portuguese economy.[58] All series are expressed in constant prices. Estimates of the private and public capital stock are constructed by employing the permanent inventory method (OECD, 1993). This approach computes the value of the capital stock by summing over past investments, appropriately adjusted for the rate of depreciation. It is assumed that asset lifespans are the following: residential buildings, 70 years; investments in machinery and equipment, 16 years; and public works (roads, railways, etc.), 35 years. The perpetual inventory method has been widely applied in the literature but is not free of criticism. Some authors (e.g., Sturm and de Haan, 1995) have shown that assumptions concerning the lifespans of capital goods matter for the size of the production elasticity estimate for public capital.

88. Table 33 shows the composition of the estimated Portuguese capital stock. The ratio of public to private capital was 18 percent for Portugal in 1995 (27 percent if only structures and equipment are included), compared with, for example, a ratio of 31 percent for the United States (58 percent if only equipment and structures are counted) with a PPP-based per capita income more than twice that of Portugal. Nearly 60 percent of public capital consists of core infrastructure such as roads, railways, airports, and the like. Investment in equipment and transport material amounts to only 9 percent of the public capital stock.

Empirical results for Portugal

Ordinary least squares estimates

89. For purposes of comparison with the literature, equations (2)–(3) are first estimated in levels using ordinary least squares.[59] Because no time series data on capital utilization over a sufficiently long time span are available, the estimated output gap is used as a proxy. Potential output is obtained by employing a Hodrick-Prescott (1997) filter to the actual real output series. An alternative measure, the unemployment rate, u, is used as an indicator of demand

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[58]The time series were kindly provided by the Bank of Portugal.

[59]Issues of cointegration and the econometric validity of the ordinary least squares results will be discussed below.

pressure in factor markets.[60] The estimation results for equation (2) are presented in Table 34.[61] Fitting an unrestricted production function yields a production elasticity of public capital significantly different from zero (using standard inference criteria), amounting to 0.19, just at the lower bound of the confidence interval derived from the results of previous studies for other countries (Table 32). This implies that a 1 percent increase in the public capital stock raises GDP by 0.19 percent. The private capital elasticity amounts to 0.37, whereas the labor elasticity is on the order of 0.67. These values are closely in line with traditional assumptions on capital and labor shares in industrialized countries but higher than the Portuguese labor share of value added. Summing over the three input coefficients yields a value of 1.2, a little above unity. To test whether production can be characterized by constant returns to scale, a Wald test on the coefficients was conducted, which indicated that the restriction of constant returns to scale cannot be rejected. Accordingly, the focus below will be on the specification that assumes constant returns to scale.

90. Imposing the restriction of constant returns to scale—in line with Aschauer's (1989) specification, which serves as a useful benchmark (see equation (3))—yields slightly higher values for the output elasticity of public capital, β, ranging from 0.22–0.27 (Table 35). The estimated private capital elasticity amounts to 0.33–0.48, which seems to be a plausible range of values both in terms of capital income shares and in terms of the results obtained for other countries. Given that the public capital stock amounted to 51 percent of GDP in 1995, an estimate of the production elasticity of public capital in the range of 0.22–0.27 implies a marginal productivity of public capital of 43 to 52 percent a year. This is roughly four to five times the implicit nominal interest rate on public debt in that year. Gramlich (1994) finds even larger rates of returns (on the order of 100 percent a year or more) for the United States. These returns on public capital are very large and should be interpreted with caution.[62]

91. Estimating an equation that includes the unemployment rate (rather than capital utilization) as an indicator of demand pressure in factor markets yields a slightly larger β coefficient (specification II in Table 35). Specification III includes an interaction dummy variable for the period 1975–85 to capture possible productivity effects on public capital during the period when the role of the state was greatly expanded. The negative interaction coefficient is large and suggests that public investment actually contributed to reducing output

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[60]The unemployment rate is obtained from das Neves (1994) and the IMF's World Economic Outlook database.

[61]The results are obtained using PcGive Version 9 (Doornik and Hendry, 1997) and Eviews Version 3.1.

[62]Munnell (1992) concludes that the estimated returns on public capital for the United States are too large to be credible but stresses that these results should not be discarded altogether, since evidence from cost-benefit studies of individual projects and cross-sectional studies indicates that investment in public infrastructure may have a large payoff.

in these years.[63] In addition, the negative value of the "intercept" dummy (as observed in all the specifications) indicates that during this time period of accelerated public investment, total factor productivity growth was also lower.[64] Because of the presence of autocorrelation in the error terms, the equations are also estimated using the Cochrane-Orcutt (C-O) procedure, which changes the coefficient on public capital marginally.

92. Table 36 presents results for various components of public capital: core construction projects, *gc*, public buildings, *gb*, and transport equipment and machinery, *ge*. The equation including all three components shows that none of the coefficients on public capital are significant and two of them (core infrastructure and buildings) have the wrong sign. In addition, the coefficient on employment becomes implausibly large. That the coefficient on each component is insignificant while, as shown above and in Table 36, the coefficient on aggregate public capital is significant, suggests that there maybe important interrelationships between the different components of public capital. Statistically, the insignificant coefficients on public capital also reflect multicollinearity between the various components. Nevertheless, to obtain some idea about differences in productivity of various types of public capital, the equations are also estimated for each component separately. The coefficient on core infrastructure is now significant and close to the estimate found for the aggregate capital stock. The growth effect of transport material and equipment is also statistically significant, but substantially smaller than core infrastructure (i.e., β=0.10 compared with β=0.18 in the benchmark case). Government buildings and equipment do not appear to play a significant role in explaining capital productivity, which is confirmed by the statistically insignificant coefficient. These results should be interpreted with care, given the poor results that were obtained when all three components of public capital were included together.

Integration and cointegration issues

93. So far, the issue of stationarity of the variables has not been addressed. If variables are nonstationary, the usual test statistics have nonstandard distributions, implying that the use of standard inference tests may give rise to seriously misleading inferences. A related problem is the possibility of finding spurious relationships between variables. Only when variables are cointegrated—expressing the presence of a long-run equilibrium relationship between a group of nonstationary economic time series—can the equations be estimated in levels. The first step is to determine the order of integration of the variables. To this end, tests for unit roots are performed on the levels, first differences, and second differences of the variables. The results of the augmented Dickey-Fuller (1981) tests are presented in Table 37. The evidence suggests that the variables *g, k, l,* and *y* are all integrated of order one (i.e., they are $I(1)$ variables) and thus nonstationary in levels, but stationary in first differences. The public capital stock appears to be $I(2)$ but its coefficient is very far from unity (i.e., -0.35), indicating that it could be an

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[63]The sum of the two coefficients for public capital is negative.

[64]The dummy may also capture somewhat the negative output effect of higher oil prices after the oil shocks of 1973 and 1979.

$I(1)$ variable. Most of the variables expressed in terms of the private capital stock are stationary in levels, except the labor-capital ratio, which seems to be integrated of order two.

94. The second step is to examine whether the series of the variables used in the estimation of the production function are cointegrated. To this end the Engle-Granger (1987) procedure can be employed, which consists of a unit root test on the residuals of the estimated equation.[65] The Engle-Granger statistics (see the bottom row in Tables 34 and 35) indicate that the null hypothesis of no cointegration cannot be rejected at the 95 percent level of confidence.[66] From the literature it is well known that the Engle-Granger procedure has low power in finite samples[67] and may therefore be unable to detect cointegration when it is present in the data (see Kremers, Ericsson, and Dolado, 1992).

95. As an alternative to the single equation Engle-Granger test, the Johansen (1988) procedure—based on estimating a VAR—can be employed to test for cointegration. The maximum likelihood test statistics (i.e., the maximum eigenvalue statistic, λ_{max}, and the trace statistic, λ_{trace}, both adjusted for the degrees of freedom) for the system of equations are reported in Table 39. In contrast to the Engle-Granger results, both test statistics strongly reject the null hypothesis of no cointegration in favor of at least one cointegrating vector.[68] There is little evidence of more than one cointegrating relationship.

96. In sum, the evidence on cointegration is mixed. The Engle-Granger results point to a lack of cointegration, which would invalidate the earlier ordinary least squares results. However, the Johansen test (generally recognized to be superior to Engle-Granger tests) indicates cointegration. In light of these results, the ordinary least squares estimates should be interpreted with caution, and carefully compared with those obtained by other techniques.[69]

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[65]Owing to its simplicity, the Engle-Granger method has been widely applied in the literature. Sturm and de Haan (1995) employ it to argue that Aschauer's model should be estimated in first differences because their test results could not identify cointegration.

[66]The standard critical values cannot be used for present purposes because they were applicable to the actual values of the variable being tested, whereas here, only estimated values of the relevant process are available. MacKinnon (1991) has derived relevant critical values for finite samples from Monte Carlo simulations, which are used in the present case.

[67]In addition, the Engle-Granger procedure imposes an invalid common factor restriction on the dynamics by performing the test on a single equation.

[68]The capital utilization rate, 1975–85 dummy, and interaction term are not included.

[69]In the absence of cointegration, but with nonstationary variables, the literature recommends taking first differences of the variables to obtain stationary time series. Table 38 includes the estimation results in first differences and shows that the coefficient on public capital appears

(continued...)

Estimates based on Johansen's approach

97. One advantage of the Johansen cointegration approach is that it is based on a multiple equation VAR.[70] As such, it captures the feedback that might be present between the variables at hand. For example, if public capital crowds out private capital this would be captured, unlike in the ordinary least squares estimates. The text table (see below) reports the standardized cointegrating vector (i.e., the β' eigenvector), showing that all coefficients have their anticipated signs; it features a public capital elasticity of 0.39, whereas the private capital elasticity amounts to 0.44 if no restrictions are imposed. However, the employment elasticity is very imprecisely estimated and only 0.10, which seems to be implausibly small. The sum of the coefficients is close to unity (i.e., 0.93) and the homogeneity restriction cannot be rejected (i.e., $\chi^2(1)=0.01$ [$p=0.98$]), confirming the results of the previous ordinary least squares estimation. The coefficient on public capital in the equation restricted to constant returns to scale (see the second row of the text table) generally does not differ much from the one in the unrestricted equation. The coefficient on employment is higher and significant now, but still low in view of the labor share. When compared with the ordinary least squares results in Table 34 (see the second row, with the results presented without the dummy variable, intercept, and capital utilization rate), the coefficient on public capital does differ substantially. It is interesting to note that the coefficient on public capital in the restricted maximum likelihood equation is only slightly smaller than the coefficient of 0.39 that was obtained by Aschauer (1989, 1990) for the United States.

Standardized Eigenvectors Under Johansen's Approach 1/ 2/

	y	*g*	*k*	*l*
β'	1.000	-0.387	-0.443	-0.104
unrestricted	(n.a.)	(-7.43)	(-15.81)	(0.39)
β'	1.000	-0.370	-0.441	-0.188
restricted 3/	(n.a.)	(-12.74)	(-44.10)	(-12.33)

1/ t-statistics are in parentheses.
2/ Note that the coefficients of *g*, *k*, and *l* need to be multiplied by minus one to derive the respective elasticities.
3/ A constant returns to scale restriction is imposed.

[69](...continued)
to be similar to that from the ordinary least squares equation, as long as no interaction dummy for the 1975–85 period is included. A notable drawback of first differencing is that it discards information on the long-term relationship between the variables.

[70]The system of equations is estimated by the maximum likelihood technique.

C. The Unrestricted Vector Autoregression Approach

98. This section employs an unrestricted vector autoregression model to analyze the dynamic interaction between public capital, private capital, employment, and output. Granger causality analysis, impulse response functions, and variance decompositions are employed to quantify the dynamic relationships.

Method

99. The VAR approach sidesteps the need to specify a structural model by modeling every endogenous variable as a function of its own lagged values and the lagged values of the other variables in the system. In the literature, VARs have been criticized for being atheoretical because no a priori theoretical relationship between the variables is assumed. However, the VAR can be used to provide empirical evidence on the dynamic responses of macroeconomic variables to impulses in the public capital stock in order to discriminate between alternative theoretical models of public capital.

100. In its most general form, a VAR with p lags can at time t be written as follows:

$$\vec{z}_t = \Psi_1 \vec{z}_{t-1} + \Psi_2 \vec{z}_{t-2} + \ldots + \Psi_p \vec{z}_{t-p} + \Omega \vec{x}_t + \epsilon_t, \tag{5}$$

where $\vec{z}_t$ is a k vector of endogenous variables, $\vec{x}_t$ is a j vector of exogenous variables, $\Psi_1,\ldots,\Psi_p$ and Ω are matrices of coefficients, and ϵ_t is an error term. In the present case, the VAR is estimated in levels and consists of four endogenous variables, $\vec{z}_t = \left[g_t \;\; k_t \;\; l_t \;\; y_t\right]'$ and a constant term.[71] The system features two lags that were chosen using a likelihood ratio test (see Table 40). Although the four variables are nonstationary and the Johansen (1988)-based results suggested one cointegrating relationship, the VAR is estimated in an unrestricted (levels) format (see Sims, Stock, and Watson, 1990, for a discussion of this issue) by ordinary least squares. As previously noted, estimating the VAR in levels is allowed, as long as the relevant variables are cointegrated.[72]

Granger-causality tests

101. Granger-causality tests can be used to study the short- and medium-run linkages between public capital and other macroeconomic variables. It can address a number of issues that have been raised in the literature. Some authors (e.g., Aschauer, 1990; and Munnell, 1992) have argued that the direction of causation may run from high levels of output to larger public investment rather than the other way around. Two hypotheses have been put forward

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[71]The VAR includes a constant, but the 1975–85 dummy and the capital utilization rate are not included.

[72]This strategy involves no costs in terms of the consistency of the estimators but some costs are incurred in terms of reduced efficiency of estimation.

to explain this reverse causation. First, public expenditure may be a luxury good that rises more than proportionally with national income. Second, public capital may move pro-cyclically; during recessions less tax revenue is collected, implying that governments may need to cut public investment to meet their fiscal targets. Other authors have focused on the linkage between public and private investment. Aschauer (1985) found that public investment crowds out private investment in the United States. On the other hand, a large number of theoretical studies assume that public investment initiates private investment through its positive effect on the marginal productivity of private capital.

102. The results of bivariate Granger-causality tests indicate that the public capital stock Granger-causes output, but output does not Granger-cause public capital (Table 41).[73] This is consistent with the hypothesis that variations in public capital play a part in economic fluctuations. There is bidirectional causality between output and private capital. However, a larger *F*-value (and thus significance) is attached to output positively Granger-causing private capital. Note that public capital does not Granger-cause private capital, indicating that direct "crowding out" is not present, but this does not preclude private capital being indirectly reduced through other variables (see below). The Granger causality between employment and output is found to run from output to employment, implying that employment responds with a lag to fluctuations in output.

Impulse response analysis

103. To study the dynamic properties of the VAR, impulse-response functions are employed. These functions trace out the effect of a one standard deviation shock to the orthogonalized residuals of equation *i* (where *i*=y, *k*, *l*, and *g*) on current and future values of the endogenous variables in the system. Because of the dynamic structure—in which each equation consists of its own lagged values and the lagged values of all the other endogenous variables—an innovation in one variable is transmitted to all other variables. The ordering of the variables is *g*, *k*, *l*, and *y*, reflecting the underlying presumption that output is the most endogenous variable in the system. Public capital is assumed to be least sensitive to contemporaneous innovations in the other variables, reflecting the fact that public capital is predominantly the outcome of exogenous government decisions. Various other orderings of the variables were employed and yielded qualitatively similar results. Figures 3a and 3b present the impulse-response functions for the four variables, where the first column of figures displays the results of innovations in the public capital stock. The solid lines in the figures trace the response of a variable over a 10-year time period and the dashed lines represent the

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[73]The results are derived by running a bivariate regression of the relevant pair of variables in the group of variables. Each equation contains lagged values of the left-hand-side variable plus lagged values of the other variable under consideration. In essence, this is equivalent to running a two-variable VAR. The Granger analysis tests whether the lags of the latter are significantly different from zero.

Figure 3a. Portugal: Impulse Response Functions

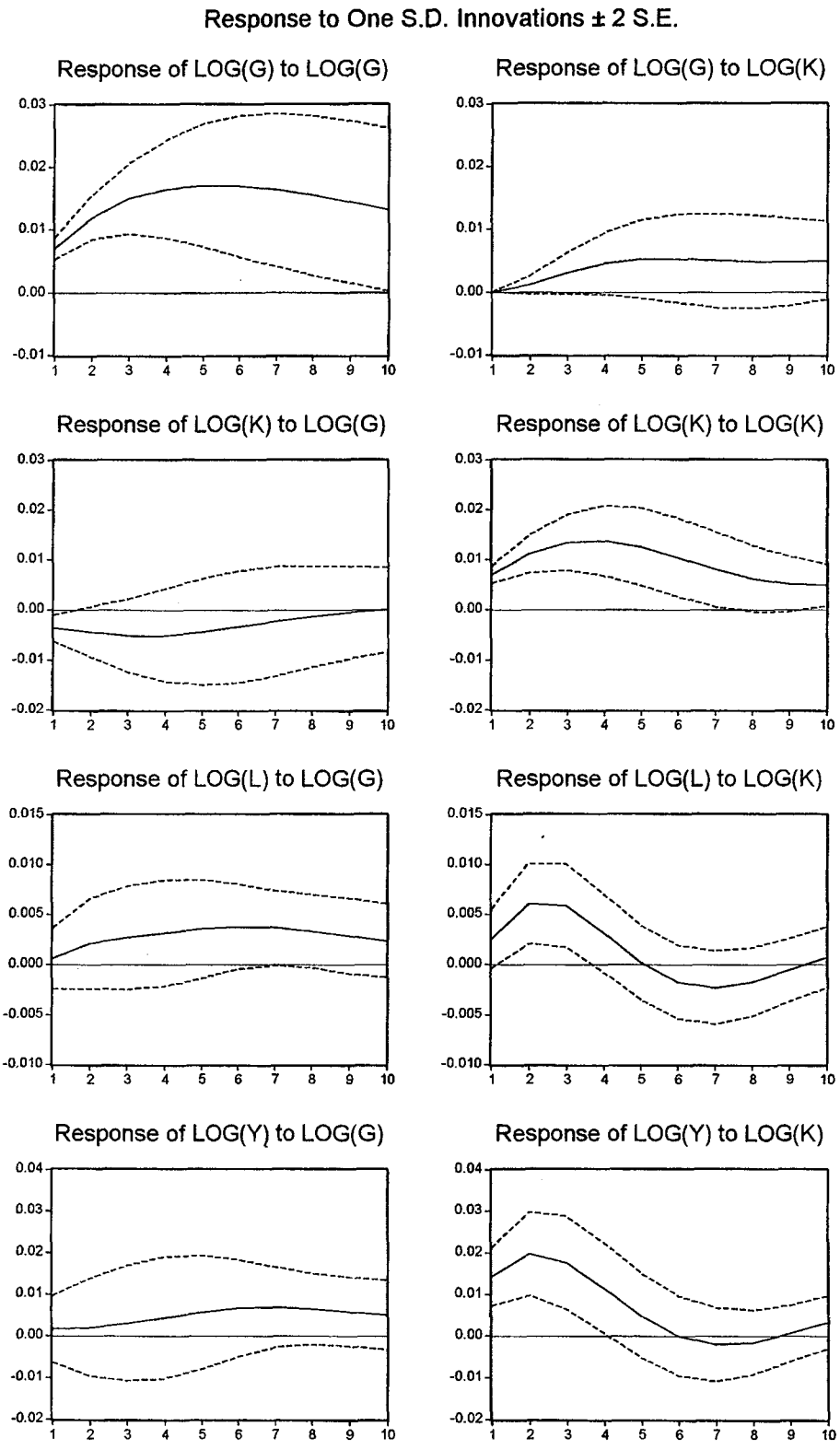
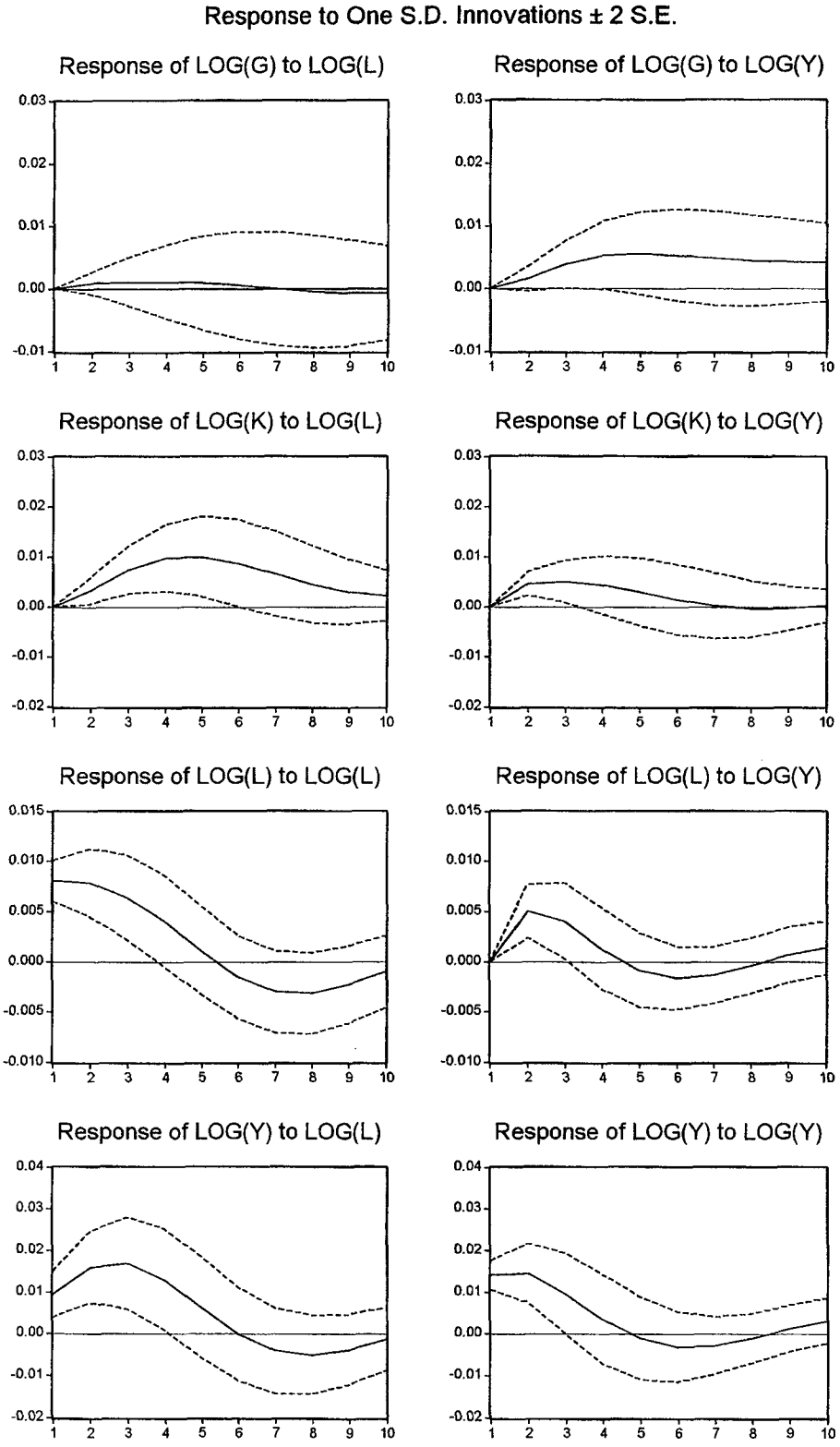


Figure 3b. Portugal: Impulse Response Functions



95 percent confidence intervals.[74] All variables are in logarithms, implying that the vertical axis represents percentage changes in a variable (i.e., a 0.01 movement corresponds to a 1 percent change). Note that the confidence intervals are relatively large, indicating that a considerable amount of uncertainty is present so that the results should be interpreted with care.[75]

104. GDP responds the strongest to innovations in the private sector variables, that is, the private capital stock, employment, and output itself. As can be seen from the lower left-hand panel, the public capital stock has a positive effect on GDP growth, and it adds more to growth in the medium run than during the first year. This could be interpreted as evidence that it takes some time for public capital to become fully productive. However, in light of the large error band, especially during the years immediately following a shock to public investment, this should be interpreted cautiously. Initially, public capital does not respond much to innovations in output, private capital and employment. Over time, private capital and output do contribute to public capital accumulation, as may be expected, given that private and public capital are usually complementary inputs. The medium-term effects of innovations in output on public capital are small, but not significantly smaller than the effect of public capital on output. This might give some support to the reverse causation hypothesis: during an expansionary phase of the business cycle, with larger tax revenues and a less tight fiscal situation, the government becomes more willing to finance public investment projects.

105. On impact, innovations in public capital depress private capital formation, and it takes approximately 10 years before the negative effect on private capital has died out. In the long run, the effect on private capital is zero. This suggests that in the short run some crowding out is present, but this was not confirmed in the Granger-causality analysis, implying that crowding out occurs through other variables. Employment and private capital are complementary factors of production in the short run, which is consistent with, for example, a Cobb-Douglas production structure. Both private factors of production contribute positively to GDP growth in the short and medium run.

Variance decompositions

106. Variance decomposition is another method used to analyze the dynamics of the system of variables. It provides information on the quantitative importance of random shocks to the variables in the system. In Table 42 the rows give the variance of the *k*-steps ahead forecast error explained by contemporaneous shocks in one of the three other variables, whereby the four rows for each variable add up to 100 percent.[76] It is evident that in the short and medium run, a significant share of the variation in output is due to innovations in private capital (43 percent in year 5) and employment (34 percent in year 5). Innovations in public capital

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[74]These were computed using the option of analytic asymptotic standard errors in Eviews 3.1.

[75]Eichenbaum (1992) argues that this uncertainty is typical of unrestricted VAR models.

[76]The same variable order as in the case of the impulse-response analysis is employed.

contribute only about 10 percent to the variance in output in the medium term. If the low productivity of public capital during the period 1975–85 is filtered out by including the intercept dummy, public capital contributes 22 percent to the variance in output in year 5. Public capital appears to be largely exogenous in the short and medium run; its forecast error is mainly due to its own innovations, indicating that it does not respond much to private economic activity. This is in line with the assumption that contemporaneous shocks to public investment and thus the capital stock stem mainly from government decisions that are independent of other variables considered here.

D. Summary and Concluding Remarks

107. This chapter has analyzed the short- and long-run output effects of public capital using data for the Portuguese economy over the period 1965–95. Public capital is shown to be a significant long-run determinant of output growth. This supports the earlier work of Gaspar and Pereira (1995), showing that EU-supported public investment has a positive effect on economic activity. The size of the estimated production elasticity suggests that a 1 percent increase in the public capital stock increases output by some 0.20–0.35 percent. If a conservative view is taken and the lower bound is adhered to, this would imply a marginal productivity of public capital over 40 percent in 1995—4 times the implicit nominal rate of interest on public debt in that year. These high numbers are roughly in line with results found by studies for the United States and various other countries. Disaggregating public capital shows that investment related to, among other things, roads, railways, and airports is more productive than public investment in other major categories.

108. Public capital is found to Granger-cause output, supporting the hypothesis that public investment contributes positively to output fluctuations. Variance decompositions suggest, however, that public capital does not explain a quantitatively important amount of the variation in output, although the result reflects in part the low productivity of public capital during the 1975–85 period. On the issue of crowding out of private by public investment, the results were mixed. The impulse-response analysis shows that public capital may crowd out private capital. But Granger-causality tests could not validate this, implying that crowding out occurs through other variables. In the short and medium run, public capital does not respond much to changes in private sector variables. Hard evidence in support of the reverse causation argument—which alleges that public investment responds positively to upswings in the business cycle—could not be found.

109. In light of limitations of the econometric methods employed in this study (and studies for other countries), it is important to be cautious in deriving policy conclusions from the empirical findings presented here. Keeping this caveat in mind, the results consistently indicate, in line with other studies, a substantial growth payoff from public investment. Additional research to gauge the precise size of the positive effect of public capital on Portuguese growth is warranted.

Table 30. Growth Rates of Private and Public Capital Stocks in Portugal, Spain, and the United States for Selected Time Periods

(Average annual growth rate of the capital stock)

	1966–95	1966–73	1974–85	1986–95 1/
Private sector				
Portugal	7.0	12.0	5.3	4.4
Spain	5.8	10.2	3.2	4.6
United States	3.0	4.0	3.0	2.2
Public sector				
Portugal	5.5	5.3	5.6	5.1
Spain	5.3	8.1	4.1	7.2
United States	2.0	2.8	1.8	2.1

Source: Data for Portugal are from accumulated investment flow data provided by the Bank of Portugal. Data for Spain are taken from Flores de Frutos and others (1998). United States data are from the U.S. Department of Commerce, Bureau of Economic Analysis (1998).

1/ Data for Spain are only up to 1992.

Table 31. Overview of Empirical Studies: The Production Function Approach

Author	Country	β	Specification	Data
Ratner (1983)	U.S.	0.06	CD, LL	TS, 1949–73
Aschauer (1989)	U.S.	0.39	CD, LL	TS, 1949–85
Ram and Ramsey (1989)	U.S.	0.24	CD, LL	TS, 1948–85
Munnell (1990)	U.S.	0.31	CD, LL	TS, 1949–87
		0.37 1/	CD, LL	
Aaron (1990)	U.S.	0.41	CD, LL	TS, 1952–85
		0.27	CD, DL	
Tatom (1991)	U.S.	0.13	CD, LL	TS, 1948–89
		0.04 2/	CD, DL	
Ford and Poret (1991) 3/	U.S.	0.30	CD, LL	TS, 1949–87
		0.25	CD, DL	
	Germany	0.53	CD, DL	TS, 1961–87
	Canada	0.63	CD, DL	TS, 1963–88
	Belgium	0.52	CD, DL	TS, 1967–88
	Finland	0.54	CD, DL	TS, 1967–88
	Australia	0.34	CD, DL	TS, 1967–87
Hulten and Schwab (1991)	U.S.	0.21	CD, LL	TS, 1949–85
		0.03 2/	CD, DL	
Berndt and Hansen (1991)	Sweden	n.a. 4/	CD, LL	TS, 1960–88
Finn (1993)	U.S.	0.16	CD, LL	TS, 1950–89
Bajo-Rubio and Sosvilla-Rivero (1993)	Spain	0.19 5/	CD, LL	TS, 1964–88
Eisner (1994)	U.S.	0.27	CD, LL	TS, 1961–91
Ferreira (1994)	U.S.	0.08 6/	CD, LL	TS, Q, 1975–86
Sturm and de Haan (1995)	Netherlands	0.41	CD, LL	TS, 1949–85
		0.26	CD, LL	

Table 31. Overview of Empirical Studies: The Production Function Approach (Concluded)

Author	Country	β	Specification	Data
Dalamagas (1995)	Greece	0.53 7/ 6/	TL	TS, 1950–92
Ai and Cassou (1995)	U.S.	0.15	CD, DL	TS, 1947–89
Otto and Voss (1996)	Australia	0.17	CD, LL	TS, Q, 1959III–92II
Wylie (1996)	Canada	0.11–0.52	CD, LL	TS, 1946–91
Crowder and Himarios (1997)	U.S.	0.17–0.38	CD, LL	TS, 1947–89
Flores de Frutos et al. (1998)	Spain	0.21 5/	CD, LL	TS, 1964–92
Ramirez (1998)	Mexico	0.12 6/	CD, DL	TS, 1950–90
Mamatzakis (1999)	Greece	0.25	CD, LL	TS, 1959–93
Costa et al. (1987)	U.S.	0.19–0.26	TL	CS, 48 states, 1972
Merriman (1990)	U.S.	0.20	TL	CS, 48 states, 1972
	Japan	0.43–0.58	TL	P, 9 regions, 1954–63
Munnell and Cook (1990)	U.S.	0.15	CD, LL	P, 48 states, 1970–86
Aschauer (1990)	U.S.	0.11	CD, LL	P, 50 states, 1965–83
Eisner (1991)	U.S.	0.17 2/	CD, LL	P, 48 states, 1970–86
Garcia-Milà and McGuire (1992)	U.S.	0.04–0.05	CD+TL, LL	P, 48 states, 1969–83
Munnell (1993)	U.S.	0.14–0.17	CD, LL	P, 48 states, 1970–86
Evans and Karras (1994)	U.S.	n.a. 2/	CD, TL, LL, DL	P, 48 states, 1970–86
Holtz-Eakin (1992)	U.S.	n.a. 2/	CD, LL	P, 48 states, 1969–86
Pinnoi (1994)	U.S.	0.08	TL	P, 48 states, 1970–86
Baltagi and Pinnoi (1995)	U.S.	n.a. 2/	CD, LL	P, 48 states, 1970–86
Mas et al. (1996)	Spain	0.08	CD, LL	P, 17 regions, 980–89
Garcia-Milà et al. (1996)	U.S.	n.a. 2/	CD, DL	P, 48 states, 1970–83

Key: CD=Cobb-Douglas, LL=estimated in log levels, DL=estimated in first differences of logs, TL=translog in levels, TS=time series, CS=cross-section, P=panel data, and Q=quarterly data.

1/ No constraints on the production function imposed.
2/ Coefficient is insignificant at the 5 percent level.
3/ Study of 11 OECD countries. Only the coefficients of the listed countries were significant.
4/ Finds implausible values of the coefficients.
5/ Cointegrating relationship identified.
6/ Public investment rather than the public capital stock.
7/ Only when fiscal deficit is included in the equation, otherwise the coefficient is insignificant.

Table 32. Summary Descriptive Statistics for Studies Estimating the Production Elasticity of Public Capital

	Time Series: National Data				Cross-Section/Panel		All Studies
	U.S.		OECD 1/ 2/		U.S.	OECD 1/	
	Levels	First difference	Levels	First difference	Levels	First difference	Levels
Average	0.25	0.22	0.25	0.39	0.14	0.17	0.22
Number of observations	11	3	17	9	7	9	26
Standard deviation	0.11	0.06	0.10	0.17	0.06	0.13	1.2
95 percent confidence interval	[0.19, 0.31]	[0.15, 0.30]	[0.20, 0.30]	[0.28, 0.50]	[0.09, 0.19]	[0.08, 0.26]	[0.18, 0.27]

Source: Based on the overview of studies presented in Table 31.

1/ Studies for selected OECD countries.

2/ The average production elasticity derived from studies employing first differences drops to 0.23 if the study of Ford and Poret (1991) is excluded.

Table 33. Portugal: Composition of the Total Capital Stock, 1975 and 1995

	Percent of Total 1975	Percent of Total 1995
Total capital stock	100.0	100.0
Total private capital stock	87.2	85.1
Equipment and transport material	25.4	29.6
Construction	61.8	55.5
Residential	33.1	30.7
Nonresidential	28.7	24.8
Total public capital stock	12.8	14.9
Equipment and transport material	0.6	1.4
Construction	12.3	13.5
Buildings	3.0	4.9
Other (including core infrastructure)	9.2	8.6
Public-private capital stock ratio	0.15	0.18

Source: Historical Series of the Bank of Portugal.

Table 34. Portugal: Unrestricted Estimates of the Production Function in Levels, 1965–95

$$\ln(Y) = 1.43 + 0.374\ln(K) + 0.667\ln(L) + 0.186\ln(G) + 0.682\ln(CU) - 0.02^{*}D_{7585}$$
$$(1.07) \quad (16.06)^{**} \quad (5.10)^{**} \quad (3.15)^{**} \quad (6.97)^{**} \quad (-3.96)^{**}$$

R^2 ajd. = 0.998, D-W = 0.74, E-G = -2.49 1/

	F-statistic	Probability
Wald test on the restriction: $\alpha + \beta + \gamma = 1$ 2/	1.52	0.229

$$\ln(Y) = 0.337\ln(K) + 0.193\ln(G) + 0.901\ln(L)$$
$$(3.70)^{**} \quad (7.93)^{**} \quad (32.11)^{**}$$

R^2 ajd. = 0.992, D-W = 0.62, E-G = -2.38

Source: Fund staff calculations.

1/ Engle-Granger (E-G) procedure which tests whether the $I(1)$ variables in the equation are cointegrated. The Davidson and MacKinnon (1993) asymptotic critical values for cointegration are -4.10 (-4.64) for the 5 percent (and 1 percent) level, respectively.

2/ Tests whether production can be characterized by a constant returns to scale specification.

Table 35. Portugal: Estimates of the Production Function in Levels, 1965–95 1/

	I		II		III	
	OLS	C-O	OLS	C-O	OLS	C-O
Constant	3.061	3.075	2.482	2.337	3.043	3.211
	(79.26)	(8.46)	(17.14)	(7.69)	(113.94)	(11.33)
ln(L/K)	0.405	0.395	0.321	0.314	0.390	0.391
	(59.31)	(11.48)	(15.46)	(8.72)	(71.50)	(16.58)
ln(G/K)	0.215	0.273	0.256	0.205	0.282	0.371
	(7.73)	(4.26)	(5.35)	(1.94)	(12.45)	(5.65)
ln(CU)	0.775	0.807			0.820	0.883
	(12.21)	(13.43)			(18.51)	(15.45)
ln(U)			-0.07	-0.07		
			(-5.16)	(-3.88)		
D_{7585}	-0.03	-0.01			-0.688	-0.546
	(-5.48)	(-1.94)			(-5.78)	(-3.26)
D_{7585} ln(G/K)					-0.355	-0.288
					(-5.50)	(-3.18)
ρ 2/		0.876		0.656		0.787
		(7.48)		(4.40)		(5.071)
R^2 adj.	0.997	0.998	0.986	0.992	0.998	0.999
D-W	0.63	1.34	0.68	1.42	1.14	1.88
E-G 3/	-2.14		-2.95		-3.30	
	(0)		(4)		(0)	

Source: Fund staff calculations.

1/ t-statistics in parentheses.
2/ Coefficient of the C-O estimation procedure.
3/ Engle-Granger (E-G) test for cointegration. The number in parentheses refers to the number of lags—determined by Akaike's Information Criterion included in the unit root test on the estimated residuals.

Table 36. Portugal: Disaggregated Estimates of the Production Function 1/

	All Three Components	Core Infrastructure	Buildings	Transport Material and Equipment
Constant	0.440	0.344	-1.070	2.535
	(0.11)	(1.25)	(-0.39)	(1.60)
ln(K)	0.506	0.403	0.367	0.374
	(6.15)	(18.85)	(3.54)	(15.01)
ln(GC)	-0.018	0.185		
	(-0.06)	(4.71)		
ln(GB)	-0.147		0.078	
	(-1.61)		(0.80)	
ln(GE)	0.139			0.104
	(0.75)			(4.63)
ln(L)	0.930	0.751	1.195	0.720
	(3.760)	(3.53)	(3.61)	(3.28)
ln(CU)	0.468	0.651	0.462	0.608
	(2.92)	(6.55)	(2.77)	(6.41)
D_{7585}	-0.03	-0.032	-0.029	-0.029
	(-3.62)	(6.55)	(-2.66)	(-3.70)
R^2 adj.	0.999	0.998	0.996	0.998
D-W	1.04	0.78	0.87	0.72
E-G 2/	-2.95	-2.65	-4.00**	-2.46

Source: Fund staff calculations.

1/ t-statistics in parentheses.
2/ Asterisks denote significance at the 1 percent level.

Table 37. Portugal: Augmented Dickey-Fuller Tests for Nonstationarity 1/

variable	ADF	lags 2/	variable	ADF	Lags	variable	ADF	lags
ln(Y/K)	-4.68**	7	Δln(Y/K)			Δ^2 ln(Y/K)		
ln(L/K)	-2.59	1	Δln(L/K)	-1.70	0	Δ^2 ln(L/K)	-7.28**	0
ln(G/K)	-3.97**	5	Δln(G/K)			Δ^2 ln(G/K)		
ln(GC/K)	-4.73**	6	Δln(GC/K)			Δ^2 ln(GC/K)		
ln(GB/K)	-0.25	7	Δln(GB/K)	-2.79	5	Δ^2 ln(GB/K)	-7.03**	0
ln(GE/K)	-0.69	1	Δln(GE/K)	-2.15	1	Δ^2 ln(GE/K)	-4.05**	0
ln(Y)	-1.96	1	Δln(Y)	-4.00**	2	Δ^2 ln(Y)		
ln(K)	-2.60	2	Δln(K)	-3.79**	7	Δ^2 ln(K)		
ln(L)	-0.74	1	Δln(L)	-3.72**	0	Δ^2 ln(L)		
ln(G)	-0.47	2	Δln(G)	-2.66	1	Δ^2 ln(G)	-4.39**	0
ln(GC)	0.25	1	Δln(GC)	-2.09	0	Δ^2 ln(GC)	-5.18**	0
ln(GB)	-2.61	1	Δln(GB)	-1.93	4	Δ^2 ln(GB)	-7.44**	0
ln(GE)	-0.65	3	Δln(GE)	-3.84**	2	Δ^2 ln(GE)		
ln(CU)	-1.37	1	Δln(CU)	-3.76**	0	Δ^2 ln(CU)		
ln(u)	-5.51**	2	Δln(u)			Δ^2 ln(u)		

Source: Fund staff calculations.

1/ The tests are conducted with a constant, ϕ, included in the following equation:

$\Delta y_t = \phi + \rho y_{t-1} + \sum_{s=1}^{n} \Omega_s \Delta y_{t-s} + \varepsilon_t$, where y_t is the relevant time series, ε_t is an i.i.d. sequence of random variables.

2/ The number of autoregressive lags is chosen so as to minimize Akaike's (1969) Information Criterium. The null hypothesis is that the variable under investigation has a unit root (i.e., $\rho = 1$) against the alternative that it does not. A value of the augmented Dickey-Fuller (ADF) statistic exceeding the critical value for the specific lag length leads to a rejection of the null hypothesis.

* Significant at the 5 percent level.

** Significant at the 1 percent level.

Table 38. Portugal: Estimates of the Production Function in First Differences, 1965–95 1/

	Total Stock		Core Infrastructure		Buildings		Equipment and Transport Material	
constant	0.010	0.000	0.007	0.006	0.013	0.014	0.011	0.004
	(1.03)	(0.13)	(1.68)	(1.34)	(3.43)	(3.41)	(1.70)	(0.72)
Δln(L/K)	0.481	0.347	0.489	0.449	0.673	0.687	0.639	0.537
	(4.51)	(3.14)	(4.81)	(4.22)	(13.54)	(12.85)	(7.74)	(6.40)
Δln(G/K)	0.199	0.371						
	(2.03)	(3.30)						
Δln(GC/K)			0.175	0.216				
			(2.05)	(2.35)				
Δln(GB/K)					0.022	0.035		
					(0.36)	(0.56)		
Δln(GE/K)							0.034	0.188
							(0.54)	(2.33)
Interaction		-0.415		-0.184		-0.081		-0.185
dummy		(-2.54)		(-1.16)		(-0.75)		(-2.67)
Δln(CU)	0.825	0.893	0.829	0.854	0.770	0.773	0.762	0.770
	(14.35)	(15.18)	(14.26)	(13.83)	(14.11)	(14.01)	(13.82)	(15.45)
R^2 adj.	0.947	0.954	0.944	0.945	0.936	0.935	0.943	0.948
D-W	1.51	1.50	1.50	1.46	2.11	2.25	2.00	2.04
E-G 2/	-4.22		-4.19		-4.63		-5.43	
	(0)		(0)		(1)		(0)	

Source: Fund staff calculations.

1/ t-statistics in parentheses below the coefficients.
2/Engle-Granger (E-G) test for cointegration. The number in parenthesis is the number of lags included in the unit root test on the estimated residuals.

Table 39. Portugal: Johansen's Cointegration Analysis of Portuguese Production 1/

	Null hypothesis for test statistics			
Statistic 2/	r = 0	r ≤ 1	r ≤ 2	r ≤ 3
Eigenvalue	0.727	0.477	0.362	0.124
λ_{max}	37.6**	18.2	13.0	3.9*
λ^{a}_{max}	27.3*	13.6	9.4	2.8
95 percent critical value	27.1	21.0	14.1	3.8
λ_{trace}	73.3**	35.7**	16.9*	3.9*
λ^{a}_{trace}	53.1*	25.8	12.2	2.8
95% critical value	47.2	29.7	15.4	3.8
	Standardized β' eigenvectors			
Variable	y	g	k	l
	1	-0.387	-0.442	-0.104
	9.161	1	-3.907	-23.623
	-3.359	0.529	1	4.952
	-2.244	-0.138	1.545	1
	Standardized α^{*} coefficients			
y	0.214	0.018	0.229	0.033
g	0.256	0.002	-0.026	0.010
k	0.137	0.006	0.072	-0.019
l	-0.002	0.042	0.038	0.013

Source: Fund staff calculations.

1/ The estimated equation is as follows: $\Delta x_t = \alpha^{*}\beta' x_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \varepsilon_t$, where x_t is a vector of variables, α^* is an adjustment coefficient, β' is a long-run elasticity and ε_t is an error term. The VAR includes two lags on each variable and is estimated over the period 1967–95.

2/ The statistics λ_{max} and λ_{trace} are the maximum eigenvalue and trace eigenvalue statistics (λ^{a}_{max} and λ^{a}_{trace} adjust for the degrees of freedom) for testing cointegration in the Johansen procedure. The null hypothesis is defined in terms of the cointegration rank, *r*. The critical values are taken from Osterwald and Lenum (1992): (**) denotes significance at the 1 percent level whereas (*) indicates significance at the 5 percent level.

3/ The statistics for testing weak exogeneity are evaluated under the assumption that r=1.

Table 40. Portugal: Likelihood Ratio Tests to Determine the Lag Length 1/

Lag	Loglikelihood	F-test 2/
1	477.10	308.89**
2	515.57	4.43**
3	537.42	1.43
4	562.22	1.03
5	603.60	0.77

Source: Fund staff calculations.

1/ F-form of the likelihood ratio test. At a 1 percent level, the restrictions involved in moving to a lag length of 2 cannot be rejected.

2/ The asteriks indicate signficance at the 1 percent level.

Table 41. Portugal: Granger Causality Tests

	G		K		L		Y	
Direction of causality:	sum 1/	F-stat. 2/	sum	F-stat.	sum	F-stat.	sum	F-stat.
G →	0.972		-0.039	1.13	0.066	3.95*	0.139	3.30*
K →	-0.024	1.20	0.926		-0.036	1.66	0.277	3.74*
L →	-0.238	1.21	0.233	1.97	0.438		0.856	0.74
Y →	0.121	1.54	0.057	8.45**	0.079	7.47**	0.202	
R^2	0.99		0.99		0.97		0.99	

Source: Fund staff calculations.

1/ The sum of the coefficients in the VAR with common lag length is included as a rough indicator of the sign of the relationship between two variables.

2/ The reported F-statistic are the Wald statistic for the null hypothesis that lagged values of variable x cannot improve the explanation of the variation in variable y. Significant x coefficients—which means that y is Granger caused by x—are indicated by asteriks: (*) denotes significance at the 5 percent level and (**) indicates significance at the 10 percent level.

Table 42. Portugal: Variance Decompositions 1/

Equation	Innovation	1	3	5	7	10	15
g	g	100.0	93.6	88.0	86.7	85.7	81.3
	k	0.0	2.2	5.0	6.1	7.0	10.6
	l	0.0	0.4	0.3	0.2	0.2	0.3
	y	0.0	3.8	6.7	7.0	7.1	7.8
k	g	22.2	11.8	9.5	8.7	8.2	7.5
	k	77.8	66.8	60.8	59.6	60.4	61.8
	l	0.0	112.5	23.1	26.4	26..5	25.7
	y	0.0	7.7	6.5	5.3	4.9	5.0
l	g	0.5	3.9	9.6	15.2	19.0	19.9
	k	9.1	26.2	25.2	24.1	22.4	23.4
	l	90.4	56.0	52.7	48.7	47.3	44.6
	y	0.0	13.9	12.5	12.0	11.3	12.0
y	g	0.5	0.7	2.6	5.9	9.2	10.3
	k	41.0	44.0	42.7	40.7	38.7	39.7
	l	18.1	30.7	33.8	32.7	32.3	30.5
	y	40.4	24.6	20.9	20.6	19.8	19.5

Source: Fund staff calculations.

1/ The columns contain the percentage of forecast variance of a variable in time period t (=1,..,15) explained by a shock to one of the four variables (g, k, l, or y). The following variable ordering is used: g, k, l, y.

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III. Sources of Data and General Information on the World-Wide Web

A considerable amount of statistical and general information on Portugal's economy is available on the world-wide web. Listed below are key national and international sites. Many of the Portuguese sites provide access not only to macroeconomic data, but to assessments of economic developments; and several sites are documented in English as well as Portuguese.

1. National Sources

Bank of Portugal
http://www.bportugal.pt

Ministry of Finance
General: http://www.min-financas.pt
Budget Department: http://www.dgo.pt
Economic Research and Forecasting Department: http://www.dgep.pt

National Statistics Office
http://www.ine.pt

Public Debt Institute
http://www.igcp.pt

Lisbon Stock Exchange
http://www.bvl.pt

2. International Sources

European Central Bank
http://www.ecb.int

European Union
http://www.europa.eu.int

Eurostat
http://www.europa.eu.int/en/comm/eurostat/serven

International Monetary Fund
http://www.imf.org
http://dsbb.imf.org/country/prtcats.htm

Organisation for Economic Co-operation and Development
http://www.oecd.org