

Università degli Studi di Padova  
Dipartimento di Scienze Statistiche  
Corso di Laurea Magistrale in  
Scienze Statistiche



**A longitudinal analysis of the  
determinants of public debt**

Relatore Prof. Adriano Paggiaro  
Dipartimento di Scienze Statistiche

Correlatore Prof. Stanisław Kubielaś  
Faculty of Economic Sciences  
University of Warsaw

Laureando: Luca Romare  
Matricola N. 625634-sst

Anno Accademico 2012/2013



# Table of content:

---

1. Introduction	1
2. Public debt: definition	3
3. Public debt management:	5
a. Bank for international settlements	5
b. Guidelines for public debt management	6
4. Government bonds:	9
a. Definition of government bonds	9
b. Current kinds of bonds in Italy	9
5. History of public debt in Italy	11
6. Theoretical framework:	23
a. The Ricardian equivalence proposition	23
b. Keynesian theory	25
c. Other models	26
d. Reference article used	28
7. Panel data:	29
a. Structure of panel data	29
b. Estimation methods	31
8. The creation of the dataset	37
9. Preliminary analysis:	41
a. Sources of variability	42
b. Dependent variable: the public debt / GDP ratio	43
c. Independent variables	45
d. Summary of the preliminary analysis	74
10. Econometric model:	77
a. Pooled OLS method	77
b. Fixed effects method	78
c. Random effects method	80
d. Comments on the results	82
e. Interpretation of the final model	84
11. Conclusions	85
Bibliography	87
Appendix	89



# **1. Introduction**

Nowadays the public debt problem is one of the most discussed topics in Italy. Every day the media discuss crisis, spread, public debt, and so on.

Our thesis is divided into two main parts.

In the first part, after defining what public debt is, the relevant institutions and the guidelines that countries should follow in order to correctly manage public debt are set out.

In the first part of this paper, we want also to make clear when this public debt has emerged and why this is a big problem in Italy. For this reason there is an account of the history of the Italian public debt starting from when Italy became a unified country, right up to today. This helps us understand how Italy has managed its public debt during various economic periods.

In the second part an econometric analysis is developed, with the objective of creating an econometric model aimed at explaining the public debt / GDP ratio over time for the main developed countries.

Econometric modelling derives from the economic theory which suggests a list of variables pertinent to the problem to be faced. In our case, the main studies carried out on public debt or on the public debt/GDP ratio are revised. These studies lead us to choose a list of the variables that seem to have an impact on public debt.

As it is our intention to create a model showing the development of the Italian public debt, a list of countries having similar economic characteristics to Italy is therefore chosen. In order to select the appropriate countries, we make use of how the World Bank separated nations into the high income or the low income category. Italy is one of the high income countries and so the data regarding a total of 19 countries is used.

Besides the specification of the variables and the list of countries concerned, other hypotheses are necessary, such as the specification of the model and a possible transformation of the chosen variables. The relationship is obviously stochastic due to the presence of an error term in the function, containing any omitted effects making the relationship presumed by the theory inexact. Moreover, the use of panel data allows us to obtain more efficient estimation by taking into account the correlation between unobserved and observed individual effects.

Once the list of pertinent variables and the specification of the econometric model to be created is identified, a check is made to see whether other works similar to our idea have already been published.

One article has made a similar analysis to ours and our first idea is to create an identical dataset. However, further to careful sensitivity analysis, a shorter period of time than the one used by the author of that article is thus chosen to be analysed.

We attempt to make a balanced dataset with real data. In order to obtain that, we check a lot of websites which contain economic data such as the World Bank, Eurostat, oecd, the International Monetary Fund and so on. We observe that the oecd database contains almost all the values we need. Thus, we decide to make a dataset using the data from the oecd website as the main source, integrating it with values from other websites. To be precise, we integrate the missing values with the dataset from the World Bank and Eurostat

because their values are mutually consistent in certain cases. For the population variables we use the values from the World Bank website.

Before creating the model, we make a careful sensitivity analysis, so as to understand how the results change with the inclusion of one country as opposed to another one, or with a different range time.

A preliminary analysis is also added to the article by Sinha et al. (2011), in order to realize whether using panel data makes sense. In this analysis we specify how each variable is measured, its relationship to the public debt / GDP ratio and the hypotheses we expect from the variables.

The next step is to estimate the models by using Pooled OLS Fixed effects and random effects models.

Another aim of our analysis is to check whether there are important differences between the various estimation methods used, and also focus on the differences in the results obtained from simple regressions and multiple regressions.

At the end of this thesis a summary of the main results is made and how these results change according to the type of estimation method, range time and countries considered.

## **2. Public debt: definition**

Public debt, also known as Government debt or national debt, is the debt of a state against other subjects (foreign states, people, banks, companies) who signed a credit to the state. When the public expenditure of one state is greater than its revenue, it must cover the deficit by the issuing of financial obligations. Public debt is created when the necessary resources for the socio-economic development of a state are greater than the opportunities that exist at that time.

The value in money of the public debt is often considered according to the duration period by when repayment is due: short term is used for repayments due within one year and long term for those that are due in more than ten years.

The debt owed to foreign lenders is called external debt, while the debt owed to lenders within the country is called internal debt. External borrowing allows to increase the country's resources while domestic borrowing just transfers resources within the country. External borrowing is usually associated with vulnerabilities that may lead to debt crises because central banks cannot print the hard currency necessary to repay external debt. And this is the motivation of why most of the analysis of public debt has traditionally focused on external debt.





## **3. Public debt management**

### **3.a Bank for international settlements**

Public debt are often set by the Bank for International Settlements which is an intergovernmental organization of central banks. It is “a bank for central banks”. It is based in Basel (Switzerland) and has 58 members from the central banks. Nowadays, central banks in 30 countries report their aggregate national consolidated data to the BIS, which uses them as basis for calculating and publishing global data. The main goals of BIS are two: regulating capital adequacy and making reserve requirements transparent.

In the website of the BIS, it is possible to find the banking services for the central banks of each country.

“The BIS offers a wide range of financial services specifically designed to assist central banks and other official monetary institutions in the management of their foreign exchange reserves. Some 140 customers, including various international financial institutions, currently make use of these services and on average, over the last few years, some 4% of global foreign exchange reserves have been invested by central banks with the BIS. BIS financial services are provided out of two linked trading rooms: one at its Basel head office and one at its office in Hong Kong SAR.”

“The BIS continually adapts its product range in order to more effectively respond to the evolving needs of the central banks. Beside standard services such as sight/notice accounts and fixed-term deposits, the BIS has developed a range of more sophisticated financial products which central banks can actively trade with the BIS to increase the return on their foreign assets. The BIS also transacts foreign exchange and gold on behalf of its customers.

In addition, the BIS offers a range of asset management services in sovereign securities or high-grade assets. These may be either a specific portfolio mandate negotiated between the BIS and a central bank, or an open-end fund structure - the BIS Investment Pool (BISIP) - allowing customers to invest in a common pool of assets. The two Asian Bond Funds (ABF1 and ABF2) are administered by the BIS under the BISIP umbrella: ABF1 is managed by the BIS and ABF2 by a group of external fund managers.”

“The BIS also extends short-term credits to central banks, usually on a collateralised basis. From time to time, the BIS also coordinates emergency short-term lending to countries in financial crisis. In these circumstances, the BIS advances funds on behalf of, and with the backing and guarantee of, a group of supporting central banks.”

“The BIS's Statutes does not allow the BIS to open current accounts in the name of, or make advances to, governments. The BIS does not accept deposits from, or generally provides financial services to, private individuals or corporate entities.”

### **3.b Guidelines for public debt management**

The public debt/GDP ratio is the most important indicator of the health of an economy. It is calculated as a country's total debt amount as a percentage of its Gross Domestic Product (GDP). With a low ratio the economy probably produces a large number of goods and services which allow the government to pay back debts.

From the manual proposed by International Monetary Fund (2003) it is possible to extract the following information.

Public debt management is the process for managing the government's debt and pursue any other public debt management objectives. The main goal for the governments should be to ensure that the rate level and growth level in their public debt are sustainable over the time. A good strategy has also to reduce the country's vulnerability to domestic and international financial shocks.

Every government has to make policy choices about debt management objectives, focusing on risk tolerance, how to manage their liabilities, and so on. All the governments aim for low debt-GDP ratio. Obviously a government with high public debt has bond interest rates higher than other with public debt smaller.

The actual possibility for the governments to accumulate a huge debt usually causes a set of wrong politics. Since the benefit of a high public expenditure has effect in short term, the government prefers to have high public expenditure in order to be viewed positively by the population. By doing so, the next government has to repay the previous debt with strong action ( i.e. increase of tax burden ), and it is viewed as a negative government by the population.

Another problem for a country with high public debt is the international view. The foreign investors consider the public debt as a measurement of stability of a country economy. For this reason, a country with high public debt cannot respond well to an eventual financial crisis as a country with a smaller debt.

When the public debt is too big, the indebted country can lose its autonomy. If the creditor is a foreign state and the indebt government cannot cover its debt, the creditor will have strong consequences in the economy of indebted country. An example is the government of Nauru. Nauru was heavily in debt to Australia and its government could not cover its debt. The consequence of that situation was the bankruptcy of Nauru and Australia imposed its currency. Similar cases happened in Iceland. In this country the exchange of currency did not happen, but after the bailout by Russia and by the International Monetary Fund, Iceland could not have the same financial autonomy.

Because of the importance of public debt management in the countries, International Monetary and Financial Committee requested the staff from the International Monetary Fund and World Bank to create a set of guidelines for public debt management. The purpose of this work is to assist countries in order to cope with economic and financial shocks. Government debt managers from 30 countries, in July 2000, provided an initial draft that was discussed by the IMF and World Bank. At the end, more than 300 representatives from 122 countries participated to outreach the guidelines. The final version was approved in March 2001. The guidelines focused on principles applicable to a board range of countries and with various institutional structures of national debt management.

As mentioned before the main objective of public debt management is to ensure that the government's financing needs and its obligation payments, are met at the lowest possible cost over the medium and long runs and have a low degree of risk. To achieve these goals it is necessary that debt managers, fiscal policy advisers and central bankers share their objectives. They should have the interdependencies between their different policy instruments. Debt management, fiscal and monetary authorities should also share information about the government's current and future liquidity needs.

The guidelines state the need of clear roles and clear objectives of the financial agency responsible for debt management. It highlights that the goals should be clearly defined and publicly disclosed. It also states that measures of cost and risk that are adopted by a country should be explained. According to the guidelines, the people must be informed on the past, current and projected budgetary activity by publishing information of its debt and of the stocks (currency, maturity and interest rate structure). The risk of government losses from inadequate operations must be supported by a management information system with proper safeguards. An important point states that the staff involved in debt management should be subject to code of conduct and to conflict of interest guidelines regarding the management of their personal financial affairs.

By following the guidelines, a framework should be draft to enable the identification and management of the trade-offs between expected costs and risks in the government debt portfolio. In order to address the, it should conduct tests of the debt portfolio on the basis of the economic and financial shocks which the government is potentially exposed. Debt managers have to consider the impact on liquidity if they issue new borrowings. To ensure an efficient market for government securities, the government should achieve a broad investor base for its obligations. It is necessary that debt management operations in the primary market are transparent and predictable. Finally, the governments and central banks should try to make resilient secondary markets in order for it to be efficient in different market conditions.



## **4. Government bonds**

### **4.a Definition of government bonds**

Government bonds are bonds issued by a government to cover the deficit accumulated on the finance period. Those bonds are traditionally regarded as risk-free bonds, because every country can print more money to be able to redeem the bond at maturity. In most of the countries, it is forbidden to print money just to pay the bonds at the maturity. However, also in these countries the bonds are regarded as risk-free because the central banks may buy government bonds in order to ensure the debt monetizing. Despite this, some risks exist such as currency risk for foreign investors and inflation risk. Currency risk arises when investors have bonds in a currency which is declining against most of the other currencies. Inflation risk, instead arises when the inflation rate is higher than expected at maturity time. A real example is what happened in the Weimar Germany of the 1920s when the government's inability to pay the national debt derived from the costs of the World War I, causing a hyperinflation. This fact causes a less purchasing power than expected and for this reason most governments issue inflation indexed bonds, that protect investors against this type of risk.

The bond interest rates are different from country to country because they reflect the economic situation of each country. A country with a very bad financial situation has to issue the bond with a higher interest rate than a country with more stable economy in order to attract investors. A clear example is the difference between the Italian bond interest rates and German bonds interest rates. This difference is called spread Btp Bund.

### **4.b Current kinds of bond in Italy**

The Italian government uses five main types of bonds, which can be found on the Banca d'Italia website: BOT, CTZ, CCT/CCT EU, BTP, BTP€I . (information at [www.dt.tesoro.it](http://www.dt.tesoro.it))

- ❖ BTP€I, Buoni (BTP indexed to Italian inflation). It is a government bond which allows to have a protection against an increase in the Italian level of price. Both the coupons and the principal are revalued with the inflation rate. As inflation rate Italian government uses the rate measured by Istat. Every six month the government repaid the holder of these BTP for an amount equal to the loss of purchasing of power. By this action the investors have a minimum yield guaranteed constant. If the price index have some adjustment after the first publication, the calculations of amount to repaid the investor will be still the first index published.
- ❖ BOT ( Treasury Bills). They are short term securities, the longest maturity of these bills is one year. The remuneration, determined entirely by the discount at issue, is consider anticipated for fiscal purpose. This fact because the tax for retail investors is applied at time subscription. The auctions, since April 2009, are expressed in yield term and not in price. The different maturities are three, six or twelve months. The remuneration will be at the maturity time, and in one time. The BOTs are zero coupon, so they are easy to manage, because the expenditure for this kind of bills are lesser than the nomination redemption value. These BOTs could be purchase for a minimum value of 1000€ or for multiple of this amount. The auctions to buy these bounds are competitive auction where the investor offers are in yield term.

- ❖ CTZ (Zero Coupon Treasury bonds). It is bond with maturity of 24 months at the issue time, but then this maturity can be changed. The remuneration are equal to the difference between nominal value and the price paid. They are zero coupon and so they are so easy to ménage for the same reason of BOTs. The CTZ could be buy for a minimum nominal value of 1000€ or multiple of this amount. The issue take place through a marginal auction with discretional determination of the allocation price and of the quantity issued. There is a mechanism to exclude the speculative request. The responsible for the sales of these bills are the Banca d'Italia.
- ❖ CCT (Treasury Certificates). It is bond with floating rate, with 7 years of maturity. The interest are paid with deferred coupons indexed to 6-month BOTs yield. The auction has the same characteristics of the CTZ auctions. These auction are once per month. The CCTs allows, if investors want to have the remuneration before the maturity date, to have a principal as well as the initial amount. These bonds could be purchase for a minimum nominal value of 1000€ or multiple of this amount. From March 1991 the CCTs have 7 year maturity.
- ❖ CCTeu (Treasury Certificates linked to 6-month Euribor). It is bond with floating rate, usually with 5 years maturity. The interest rate are indexed 6-month Euribor. On the remuneration impact also the different between the nominal value at the repayment date and the price to buy it at the issue date. The auctions have the same characteristics of CCT and CTZ. They are issue in auctions once every three month. Being bills index with a floating rate, they allows to have a remuneration in line with market yields. The coupons are paid every 6 month.
- ❖ BTP ( Treasury Bond). It is a medium/long term bond, with a fix coupon paid every six month. They can be with three, five, ten, fifteen or thirty years maturity. The auction mechanism has the same characteristic of CTZ and CCT. These auction are twice per month. This kind of bills allows to have a regularity liquidity during the years. The minimum nominal value to buy a BTP is 1000€.
- ❖ BTP€is (Treasury Bonds Linked to Euro-zone Inflation). It is a bond which allows to investors a protection against the price increase. Both the principal and the coupons are paid once every six month in line with the Euro area inflation rate. The inflation rate are took by the Harmonised Index of Monthly prices (HICP). These index are took by Eurostat, and if this index will be changed, the remuneration will be still calculated with the first index published. If during the life of these bills there will be a price decies, the minimum amount repaid will be never smaller than the nominal value. It is also possible to have the remuneration before the maturity date. The amount in this case will be equal to the value of principal amount multiplied by the index coefficient. Usually they have five, ten, fifteen or thirty years maturity. The auctions are the same characteristic of CCTs and there are once every month. These bond guarantee a constant interest in nominal terms.

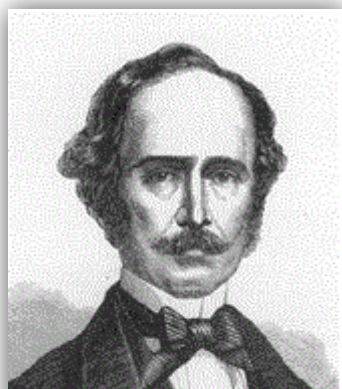
## 5. History of public debt in Italy

Public debt in Italy is not a recent phenomenon, but has existed since the beginning of Italian history. Several articles were consulted to enable me to summarize the history of the Italian public debt up to 1980. One of these articles was written by Toniolo (2011), another one by members of the IMF staff (2003) , a third one by members of the Treasury (1988) and lastly one by Francesca (2008). Here below the main phases are reported.

After the unification of the Italian peninsula on 17/3/1861, the Gran Libro del Debito Pubblico italiano (large book of Italian public debt) was instituted and on 4/08/1861, with the law for the Italian public debt unification, all debts from pre-unitary states were written inside this book. The amount was about 2400 million lire :

- ❖ Sardinian states: 1300 million
- ❖ Lombardy: 150 million
- ❖ Parma: 12 million
- ❖ Modena: 18 million
- ❖ Romagna: 19 million
- ❖ Marche: 5 million
- ❖ Umbria: 7 million
- ❖ Tuscany: 140 million
- ❖ Naples: 520 million
- ❖ Sicily: 210 million

In the first ten years the public debt increased from 45% to 95% of the **GDP**<sup>1</sup>. The main reasons for this were structural budget deficits, extraordinary defence spending on the Third War of Independence (1866) and the engagement of the annexed debts of all regions.



Pietro Bastogi (1808-1889)

The first **loan**<sup>2</sup> of 500 million Lire was placed in the market by the Minister of Finance, Pietro Bastogi, in July 1861 to cover the deficit achieved in 1861 and to cover the expected debt for 1862.

In 1862, Quintino Sella replaced Bastogi in the position of Minister of Finance, but the result of his policy was catastrophic in the short-term.

In the following years, Sella was replaced by Marco Minghetti, who had to take another loan of 700 million Lire. He also increased the movement of Treasury Bonds, which amounted to 227,5 million Lire.

In 1864, Sella was reinstated as Minister of Finance and he tried to find

---

<sup>1</sup> **GDP (gross domestic product):** the monetary value of all the goods and services produced by an economy over a specific period. It is measured in three ways on the basis of: 1) expenditure; 2) income; 3) the value added by industry.

<sup>2</sup> **Loan:** money lent under the condition that it will be repaid, either in instalments or all at once, at agreed dates. Usually the borrower pays the lender an agreed rate of interest.

alternative solutions which would be less onerous than a normal loan. He made an agreement with an Anonymous Society responsible for selling state properties that it would act as the State's representative in the selling procedure in order to obtain money in less time. That convention was approved on 20/11/1864, with this action the decrease of public debt quotations stopped.

Tax on income from movable wealth was also introduced in 1864 and the property tax was revised.

1865 was the year of a new loan of 425 million Lire, the sale of railways for 185 million Lire and the balanced budget net of interest. It was just temporarily balanced, as in fact the following year an international financial crisis caused a decrease in the value of Italian rates abroad, from 66 Lire in March to 49 Lire in April.

It was also the time when tax on grain and on income from public debt stock was introduced. On 10<sup>th</sup> March 1867 a determinant decree for the history of the Italian economy was issued. This ordinance forced the National Bank to give a loan to the Treasury of 250 million Lire with an interest rate of 1.5%. The **forced circulation of all banknotes**<sup>3</sup> was imposed.

Before this action the only alternative for the placement of loans had been the sale of state property, but now printing money as a solution to cover the deficit had become possible.

On 28<sup>th</sup> July 1866 a loan which became a great success was placed in Italy. The cause of that success was the strong patriotic spirit which Italian people had felt since June when the war against Austria had broken out.

In 1867 the Rattazzi law was adopted (15/08/1867) and bonds of 500 million Lire were issued. Those **obligations**<sup>4</sup> were not a great success. In the same period of time, the government had been searching for a way to collect money on the sale of tobacco. In 1868, Cambay-Digny created a society which had to monitor such sales. That company gave the Treasury 180 million Lire in gold and a specific annual rent and, in exchange, the state gave it the monopoly on tobacco for 15 years.

During 1869 neither new loans nor laws were introduced.

In 1870, Sella, who had returned to the position of Minister of Finance, needed to find a remedy for the residual deficit. He required 200 million Lire, so he signed an agreement with the National Bank according to which he received 122 million Lire. The total loan taken from the National Bank amounted to 500 million Lire. Sella deleted all unsold bonds, issued new obligations repayable only with the purchase of church property and also asked for a new normal loan of 80 million Lire.

---

<sup>3</sup> **Forced currency:** FIAT money. Money is not supported by a specific reserve, but is decreed to be legal tender in payment of all debts and forced into circulation.

<sup>4</sup> **Obligation:** the duty of a borrower to repay a loan and that of the lender to ensure that the repayment is made; it can be a bond or another promise to pay a sum of money.



Because of military expenditure and not wanting to skimp on public works, cuts on public spending had never been applied. Adding to that, the assumption of the last adjoining regions (Veneto in 1868 and the Papal State in 1871), the payment to Austria for war indemnity and the **buyback**<sup>5</sup> of railways from Alta Italia, the debt continued to increase.

The implicit deflator of the GDP in the first ten years of Italian history increased by about 10% but grew to 23% in the years 1872 and 1873. The capital market was monopolized by government bonds, there was no place for private titles.

In 1871 there was a new operation for 150 million Lire. The credit transactions with the National Bank had become so large. As result of this, the National bank was only the **guarantor**<sup>6</sup> of bonds. In this way, the State had a new income issuance: it paid interest regularly, which was returned in cash, only shelling out 0.60% for it.

In April 1872 there was a new contract with that Bank. The contract had three main points. The first one was the concession of a new loan of 300 million Lire with the interest rate reduced to 0.5%. The second main point was the conversion of the **callable bonds**<sup>7</sup> of 1866 into a consolidated 5%. This conversion was assigned to the National Bank; this process led to a saving of 217 million Lire for the Treasury. The third point was the subsistence of the amount of ecclesiastical bonds deleted, which returned to the bank by means of the operation of a loan to the Treasury, for which the bank was guarantor.



Quintino Sella (1827-1884)

In the next 40 years, through two institutional interventions, the public debt saw a positive period due to the positive trend of the economy and there was an interest rate reduction on bonds.

The first action was the creation of Cassa Depositi e Prestiti (Postal Savings Banks) by Sella in 1875. This institution allowed for the provision of more adequate funding for local government indebtedness and for the activation of an important channel of institutional placement of treasury bonds, as an alternative to emission by banks.

The second operation was the foundation of the Treasury by Agostino Depretis in 26 December 1877.

---

<sup>5</sup> **Buyback:** the repurchase of outstanding shares by a company in order to reduce the number of shares on the market.

<sup>6</sup> **Guarantor:** A surety. One who guarantees payment. A person, firm, or corporation, as the bank, may agree to guarantee a note for another party and become liable by endorsement to pay the obligations in case of failure or default by the original market (principal debtor).

<sup>7</sup> **Callable bonds:** bonds that may be called for redemption before compulsory maturity as a result of the option exercised by the debtor (issuer), recited in the bond indenture and frequently on the face of the bond certificate. Bonds are often issued subject to call, i.e., redemption in whole or in part on any interest date, upon proper notice. Callable bonds are also known as optional bonds or redeemable bonds.

However, only on 18 March 1889 was there a clear separation between the Ministry of Finance and the Treasury. The first Treasury Minister was Giovanni Giolitti (9 March 1889).

After those events the forced currency was abolished under Agostino Magliani, who was Treasury and Finance Minister. He wanted to reduce the number of national bank notes in circulation from 940 to 340 million, paying for 600 of these in gold or silver coming from foreign countries. With this operation exports decreased, foreign payments increased and the price of gold started to go down. This result was not only due to this action but also to the deteriorating national and international economies from 1888 to 1893.

The advertising expenditure of the railways for 30 years also contributed to increasing the public debt. To transfer railway property into private hands seemed to be a good idea in the short term, but not in the long term. Even with the big loan that the State gave to the private societies, the people's needs could not be satisfied. For this reason, the government reacquired the property of the Roman railways and those of Alta Italia. At the end of the above negotiations, there was an annual burden of 39.5 million Lire.

In that period, the annual net product of the nation was about 34 million Lire.

On 29 June 1879, with the left-wing in power, the construction of 6,070 kilometers of railway lines began. This operation cost about 1,260 million between 1880 and 1900. On 27 April 1885 the railways that were not already of state property were purchased. With the law of 27 April 1885 all the Italian railways were administered by three private societies.

In 1888, on observing the initial cost estimate for the railways, the government discovered that the real amount was 2,431 million Lire.

There were no other significant actions till 1905, when the parliament discussed the renewal of the contract with the three societies. In that year, the re-appropriation of all railways by the State was voted and 910 million Lire was spent to update the existing railroad and 1 billion Lire to pay the three companies. Another 530 million Lire was estimated as necessary expenditure for the development of State interventions.

The public debt increment was also due to the following public works:

- ❖ 50 million Lire in 1881 granted for public works in Rome.
- ❖ 170 million Lire in 1883 for a public guarantee granted for a bond of the City of Rome and for necessary work on the River Tiber.
- ❖ The assumption of interest payments of the City of Naples, which was a debt that the city could not pay, for an amount of 92 million Lire.

From 1889 to 1892, there was the worst period of the first fifty years of the Italian economy, as for the first time after Sella's fiscal adjustment, expenses exceeded public revenues. That crisis was caused by the breakdown of commercial relationships with France, the deflation of speculative building, a banking crisis and an agrarian crisis.

With that situation, the government had to find a different way to finance and reorganize the public debt.

In April 1892 treasury bonds were issued; their maturity was 5 years for interest rates of 4.5%. In this dark period the bank system was reordered and in 1893 the Banca d'Italia (Bank of Italy) was founded. In this

year, there was also the introduction of the **affidavit**<sup>8</sup> to block the escape of gold from Italy due to the growing foreign requests for the payment of interest rates on public debt bonds.

In 1894-95, an action was made to put the public debt in order, but with little effect. Only at the beginning of the 1900s, the public debt was reordered. Before a balanced budget was made and afterwards there was a budget surplus.

In 1902 a new consolidated bond with a net 3.50% interest rate was issued for the conversion of redeemable railway bonds and long term Treasury bonds. As that solution produced good results, the following year another similar conversion was made.

Further to the great results of these operations, and the easy sell Certificati di Credito Ferroviari (Railway Credit Certificates) issued in 1905 at 3.65%, the government launched the law of the Grande Conversione dei Consolidati (big conversion of consolidates) on 29 June 1906 at 5% gross and 4% net. With this law 8 billion of nominal capital was covered, 60% of the total Italian debt.

After this law was passed, as of 1 July 1906 the government was authorized to pay off the consolidated bonds at 5% gross and 4% net, offering holders either the repayment at par, or the exchange with new titles. The new titles had annual interest rates of 3.75% till December 1911 and then 3.5% but free from all taxes and not subject to conversion until 1920. Those conversions took place between 2 and 7 July 1906 with the presence of two Banking Consortiums, one from Italy, directed by Banca d' Italia, and Rothschild from Paris. With this transaction, the Treasury spent just over 9.5 million Lire, saving annually around 20.2 million till 1911.

From 1915 to 1924, the state deficits were substantial. The expenditures of the war were paid for with national loans. About 20 billion Lire was released, of which only 12.4 was paid in cash. The remainder was covered by Treasury bonds or other financial titles. 99% of the war debt was owed to Britain (about 611 million Pounds) and to the United States (around \$1648 million).

The BOT (Buono Ordinario del Tesoro, Treasury bond) on the market increased from 401 million in 1915 to 4.1 billion in 1917 and it went up to 24.1 billion in 1922. This debt caused an inflationary process, causing the long-term government bonds to become less attractive. In the post-war years, the Italian State had to eliminate the deficits and had to try to lengthen the maturity of debt. To resolve the first problem, at the end of 1915 the government created a tax on war profits and, in 1919 a property tax. However, these taxes gave the state only 20 billion in 25 years.

The first minister to treat the lengthening of the debt maturity problem was Volpi. He began a negotiation with the United States to settle the public debt, but especially to stimulate interest in foreign investment in Italy. At the end of the negotiation Italy had to pay an amount of \$2,042 million, payable annually from 1931 to 1986/87. The negotiation with England ended on 27/01/1926, when an agreement was made to reduce the debt owed to England from £611 million to £276.7 million. The Italian government was able to obtain an amount of 3.4 billion Lire from Germany for the war reparations.

---

<sup>8</sup> **Affidavit:** a written statement subscribed and sworn to before a notary public, commissioner, consul, or other officer empowered to administer oaths. The affidavit must contain the affiant's name and address, and the signature of the attesting officer.

The main problem in these years were the requests from the United States and England for stabilization of the Lira and to return to the **gold standard**<sup>9</sup> system. After these urgent requests Volpi fixed the lira at “quota 90” (90 lire for one pound sterling).

On 5/08/1927, the Cassa di Ammortamento (Bank Amortization) was founded. This bank had to pay off the internal public debt with the surplus on budget expenditure. Until 30/06/1939 this Bank cancelled bonds for an amount of 1,850 million Lire. This bank was closed in 1945.

The causes of this unusual financial structure were the Great Depression of 1929, the crisis due to Lira stabilization and Mussolini’s war ventures.

With this situation the Treasury created new loans from the Cash Deposits and Loans. In 1931, 1932 and 1934, some emissions of titles were made with a maturity of nine years. With the conversion of 3 February 1934, the government offered redeemable titles at 3.5%. That interest rate was inappropriate so that everybody wanted to sell, even speculators. This operation caused a huge cost for the State.

With the beginning of the War of Ethiopia, Italy needed new money. To obtain this money, various exceptional taxes and a forced loan were made. The forced loan obliged owners of real property (except for government agencies, the church and charities) to sign a loan for 25 years at 5% of the value of the property. For the loan service the landlords also had to pay an extraordinary housing tax of 3.5% for 25 years. This amount would cover the interest payments and loan repayment after 25 years. The next loans were with a five or nine year maturity and realized a revenue of about 146 million Lire till June 1945.

In June 1939 the public debt was 86% of the GDP and at the end of 1945/46 it was around 33%, decreasing to 21% in 1946/47 and increasing in the next few years to about 30%. The interest expenditure also decreased.

In 1946 another loan with an interest rate of 3.5% gave 231 million Lire to the State. This loan had an interest rate below the market rate, but it was free of all taxes. On April 1947 there was the voluntary conversion of those titles into titles of 5%, this operation giving 125 billion Lire to the State. For the next three years there were no other loans since the only long term investment was for the electrification of the railways.

In 1950, in order to convert part of the floating debt into medium term debt, treasury bills were offered with an interest rate of 5%, maturing in 9 years. This operation converted 107 billion Lire of old multiannual treasury bonds and 194 billion Lire of BOT. The total number of BOT in the market decreased by 88 billion Lire. The majority of the remaining BOT was possessed by banks. With this operation Italy had a great level of stability in its BOT. Between 1945 and 1950, the biggest expansion rates were on the **floating debt**<sup>10</sup>, which increased from 63.8% to 75.4% of the public debt.

---

<sup>9</sup> **Gold standard:** among monetary standards, that system in which the standard unit of money is defined in terms of gold.

<sup>10</sup> **Floating debt:** The aggregate of current indebtedness. The term is used for the short term indebtedness of a business corporation or of a government, state, or municipally.

The cash deficit after the liberation of Italy amounted to 258 billion Lire. 81 billion Lire of that deficit was covered by the sale of BOT.

In 1945, public debt was 53% of the GDP, then it decreased to 23% in the next two years and it was at 30% at the end of 1950. The diminution of the public debt-GDP ratio in those five years was also a result of inflation. In the financial statement from 1947/48 to 1949/50, there was 1,133 billion Lire of expenditure for public works.

From 1951 to 1963, the GDP had an average annual increase of 5.8%, industrial production increased by 160% with 1.8 million new job opportunities. The fixed investment in the industrial sector increased by 19% in 1961. Despite the good economic period in 1951/52 the cash flows of the treasury recorded a deficit of 335 billion Lire and 234 billion in 1952/53, those were respectively 2.9% and 1.8% of the GDP.

The public debt continued to increase in absolute value, but it remained around 5% of the GDP because of the extraordinary economic growth. From 1953 the ordinary income growth rate was higher than the expenditure rate. The same happened in the next seven years and, in the financial years 1959/60 and 1960/61, there was a surplus.

In November 1962, a new reform about bond issue was introduced, this said BOT had to separate into two parts. One part for the obligatory reserve, assigned to the base price. The second part called "free" sold with the Dutch auction method. With this reform of BOT placing, more power to control the creation of money was given to the Central Bank.

The real purpose of Cassa Depositi e Prestiti was to provide funds to local authorities. Only a small part of those funds actually reached the local authorities, as the main part of the money collected from this entity went to the Ministry of the Treasury.

The best and most flourishing period for the Italian economy was in the years 1960-70. This prosperous economic period was also due to the Marshall plan, according to which the U.S.A. gave loans to Italy. The biggest boom took place in Northern Italy, where high exportation levels of goods and services were recorded. In that decade only the Japanese economy was better than the Italian economy.

This growth was possible thanks to some factors common to all European countries, but also due to certain specific elements of our country. For example, Italy had a large labour force, adequate basic schooling and few, yet excellent, engineers. These were the ideal conditions for a Fordist model economy.

Up to the mid-1960s, public enterprises under excellent managers helped to accelerate aggregate investment. The IRI (Institute for Industrial Research, 1933-2002) produced intermediate goods at competitive prices in sectors where private industry was weak..

In that period, when the North was approaching a full level of employment, it was clearly necessary for public intervention to adapt institutions, financial markets, research and development in order to suit the characteristics of a highly developed economy. However, very little was done in this sense.

In 1966, the Bank of Italy guaranteed, by means of operations in the secondary market, returns of around 6.5% on obligations from special credit institutions, and 5.5% on bonds. Those operations were used to increase the liquidity of the money in order to increase the **fixed income**<sup>11</sup> securities.

In 1969, it was no longer possible to use the rates set in 1965. That fact caused the end of the policy of price stabilization, there followed a reduction of demand for securities, a decrease in long and medium term loans and in investment.

In the next decade, there was a stop in economic growth due to the increment in labour costs. This increment reduced marginal profit and self-financing of companies. In consequence, enterprises resorted to bank loans. In fact, in that period loans increased by 20% compared to those of the previous decade.

At the beginning of the 70s, in Europe, the impetus from factors of post-war growth, for example reconstruction, and the progressive opening up of markets, petered out. That deceleration was maybe also due to the first oil shock.

In 1973, a portfolio limit for all banks was made to increase the demand for long and medium term securities, and also a maximal value on the expansion of bank lending was introduced. These two forms of control had a positive effect on the monetary policy so that investments and the national income increased more than forecast.

From 1971 to 1973, the debt-GDP ratio increased by 11 points. Since sales of BOT between 1969 and 1972 were few, in 1973 the maturity of the BOT was shortened from 12 months to 6 or 3 months.

Current revenues of the government were between 30% and 32% of the GDP from 1963 to 1975. In the early 70s, there was the first huge growth of the public debt. The current public expenditure exceeded the current revenue.

In 1973, there was a recovery of income and also of investments. That year's energy crisis caused an aggravation on foreign accounts and inflationary pressure in the short term, which was difficult to control. The government made a stabilization programme to limit the deficit of payment and to lower prices.

In 1974, a new tax on imported goods was added. Furthermore, a new programme was made (this made indirect taxes and tariffs rise), which reduced the deficit of Treasury below the level established with the Monetary Fund, but did not stop the inflation.

In 1975, the deficit was higher than the Monetary Fund level. In 1976, the last **forced loan**<sup>12</sup> was issued to survive the currency crisis.

In 1977, a stand-by loan was granted by the Monetary Fund. This loan had a negative aspect in the long term but allowed for the oil crisis to be overcome with acceptable outcomes.

---

<sup>11</sup> **Fixed income:** income which does not fluctuate in accordance with the general price level. A period of low prices is beneficial and a period of high prices disadvantageous to those having a fixed income.

<sup>12</sup> **Forced loan:** obligatory loan for an amount proportional to the "investor" possibilities. In the modern finance it is not used often cause their obligatoriness, which that decreasing confidence towards the public authority.

1979 was a permissive year for the monetary policy, which at first allowed for economic recovery. That was then stopped by inflation due to the doubling of oil prices. The investment process increased anyway thanks to the urgencies of rebuilding.

From 1976 to 1980, the indirect revenue from public administration increased to a higher percentage than the increment of current expenditure. The deficit from the second half of the 70s was due to the imbalance between expenditure and revenue in the first half. In the years following 1975 the public debt increased its incidence on the GDP from 7% to 11.7%.

In the 80s, the balance sheet of the public administrator net of interest was positive. It was clear that the interest expenditure was significant on the public debt amount. This interest rate did not allow a decrement of debt amount.

With the second oil crisis in 1979, there was a high unemployment level and high inflation. In order to solve those problems the Italian government instituted an alliance aimed at reducing civil disorder and creating the basis for new growth.

In 1980, there was the separation between the Treasury and the Central Bank.

From those years till nowadays, the interest rate is impacting on the public economic balance. In the years 1982-1983, the deficit between the public expenditure and the GDP was of 6 points.

In fourteen years, from 1974 to 1987, the public debt became 17 times larger, amounting to 840 billion Lire (excluded debt against the Banca d'Italia). The public debt prediction for the future was not good and, for this reason, on June 1986 the Minister of the Treasury made a plan to stabilize the debt/GDP ratio in 1990. The goal of this draft was to reduce expenditure and to increase revenue. The plan was not about the tax burden but about expenditure.

The new economic growth began as of 1983 and the results were a high increase in welfare and general benefits for Italy.

Up to now a lot of new methods have been made regarding public debt management. One of the crucial points in the management of public debt is to avoid various payments of interest rates in the same period.

Another important point on the management of public debt is the maturity period of loans. In 1981, the average maturity of all loans was 9 months. In 1982, in order to extend loan maturity, loans with variable rate (CCT) were introduced.

At the end of 1983 the average maturity was one and a half years, which then became three years and four months in 1987, and went to three and a half in 1988. At the end of 1987 the BTE in ECU with annual maturity appeared on the market. In July 1983, indexation bonds were issued. Those bonds were unsuccessful because they were issued without adequate information and the interest rate was too low. The government also used postal savings as borrowed money.

Also the Certificati a Sconto were made. These CTS (certificates at a discount) had a partly fixed and partly variable interest rate. Those stocks did not have great success. After the failure of CTS, the government instituted a Lead-Manager and a co-manager group.

The public debt assumed a strange structure compared to other countries: Italian public debt contains 80% of the short maturity stock. One essential condition to have a good financial market is to have fixed rate long maturity stocks.

Between 1973 and 1992 the per capita GDP grew with an average rate of 2.5 per cent per year. In 1992 the per capita GDP in Italy was equal to that in Germany and in the United Kingdom.

The importance of policy decisions thus grew. Inflation was higher in Italy than in the countries it competed with. However, again nothing was done in terms of reforms, which were indispensable.

The quality of the school system deteriorated, the time for the justice in civil and administrative courts lengthened. There were also the weakening of public and private enterprises. The labour market became more rigid.

Italy remained locked into a production concentrated in sectors with low or medium technology, although there was a continuous request in many sectors for the quality "made in Italy".

It is important to know that before the 80s the Italian economy was a free economy characterized by strong State control. Another important fact was the optimal mentality of State enterprise, which worked efficiently for the country's growth.

From the mid-80s the public sector began to change. Many state employees stole public money in order to have a higher standard of living. Moreover, the management of State companies became similar to a policy of political favours and this fact caused high corruption. From those years onwards the collapse of the economy started, which then culminated with the 1990 crisis.

After this crisis all Italian people, for the first time, understood the extent of the problem of public debt in their economy. The government tried to reduce the State's impact on the economy. At the end of the 80s Alfa Romeo, which was State property, was privatised.

In order to enter the European Monetary Union (EMU), the Italian government had to decrease inflation, reduce the public deficit and the interest rate. The government applied some measures, which allowed Italy to enter the European Monetary Union.

In the year from 1998 to 1999 the economy saw another boom. This time, differently from the first boom, the main protagonists of the new growth were the small and medium sized firms in the north of Italy. The importance of big firms began to decrease.

The latter boom was also due to the social partnership pact brokered by the government with the Italian people. That partnership stated flexible working hours, lower wages, part-time contracts and so on. These actions were also applied in the public sector. From 1992 to 1998 more than 500,000 public workers passed to the private sector. In fact the main State firms of that time were privatised, such as Agip, Italgas, Credito Italiano, Telecom Italia, Alitalia, Tirrenia and many others. With this new growth investments in technological development and job security were also made.

The occupation increased more in small and medium-sized firms because they had an easier flexibility but were less capacity for research and development. It was probably thanks to this characteristic that Italy could maintain its share of the world export market.



In 1994 the public expenditure reached the 44% of GDP, which was 27% in 1960. Approximately 70% of that increase was due to pensions and healthcare. That increase was amplified by the growth in interest payments. At the beginning of 90' the primary budget balance (budget balance net of interest) was achieved.

On 1991 per capita GDP was equal to 76% of the US value. From that it started 20 years of economic setback. Other countries in the Europe, although less precipitously, feel back.

From 1992 to 2000 the Italian per capita GDP grew with an average of 1.7% every year.

As of 1992, the Italian Treasury changed the structure of its liabilities. The public debt management policy in Italy followed the Maastricht Treaty. In 1992, the law regarding the organization and structure of reforms in the field of public debt management were approved.

During 1996 there was a diminution of the primary balance from 4.4 to 4.0%, due to an acceleration of private spending levels. Prodi's government made further efforts to reduce the deficit by including a fiscal manoeuvre in 1997 which produced positive results. In the same period the interest rate on public debt dropped.

Between 1995 and 2000 the Italian economic problem was clear observing only the productivity. In fact the increase on that was half that of the euro area countries. This negative trend was partially due to the increase in employment, resulting from reforms of labour market law, at the same time of a deceleration in the growth of GDP. In fact, on 1995 the unemployment rate had the maximum value in the history of Italian economy.

In the next seven years, per capita GDP grow rate had an average increase of 0.5% per year and productivity growth rate had a diminution. In 2005 the latter rate was negative.

Between 2005 and 2007 Italy was hit by a crisis of the real sector. As result of these years of economic contraction the per capita GDP in 2010 was equal the one in 1999.

In Italy in the year 2000 there was little economic growth, indeed it was the smallest of all the countries which had created the European Monetary Union. Despite the slowest growth, the economy index remained acceptable. The problem was the high unemployment rate in some parts of southern Italy and the continued increase in crime. In order to solve these latter problems, the government facilitated the emergence of new firms in the south. It proposed benefits for people wanting to start up new firms or hire new workers. As result of this action, from 1997 to 2000, approximately 100,000 people found jobs in southern Italy. Another important cause of the slow growth in Italy was the phenomenon of illegal work. The government also promoted actions to favour legal work.

Nowadays, in 2011-2012, the Italian economy is in recession because of the global crisis and the serious problem of public debt. The main economic index shows that there is not enough private consumption in Italy and there is a reduction in investments.

Other negative aspects of the Italian economy are both expectations of inflation and the increase in the consumer price index. The main cause of the latter problem is the continued growth of oil prices.

Also, the unemployment rate is growing nowadays.

The last reforms by the government of Mr. Mario Monti regarded pensions, the liberalization of markets and products, the promotion of competition, less bureaucracy and lower tax evasion and lower public expenditure.

## **6.Theoretical framework**

Most of the previous studies about public debt refer to the relationship between public debt and economic growth. In particular there are two schools of thought: the first one is the Ricardian theory which denies the presence of long term effects between these two variables; the second one is the conventional theory which asserts the existence of a relationship between debt and growth due to the accumulation of capital.

### **6.a The Ricardian equivalence proposition**

The Ricardian equivalence states that the government can raise money either by means of taxes or by issuing bonds. Moreover, it states that with these two methods, the effect on aggregate demand would be the same. In fact, the consumer knows that when there is an increase in debt, there will be an increase in future taxes and so they save money today in order to be able to pay those future taxes. This means the aggregate demand remains the same with an increase in tax burden or selling bonds.

The Ricardian equivalence assumes the following hypotheses:

1. The capital market is perfect (it is possible to borrow and lend at the same single rate);
2. A guarantee, with intergenerational ties, that the present generation doesn't benefit from tax reduction at the expense of their descendants .
3. Taxes should not influence agents' choices.

The intertemporal government constraint is expressed by the following equation:

$$(6.1) \quad G_t + r D_{t-1} = T_t + (D_t - D_{t-1})$$

where the volume of real government expenditure during period  $t$  is called  $G_t$ , which is assumed to be exogenous. The real tax revenue obtained by the government in each period is called  $T_t$  and the real stock of public debt at time  $t$  is  $D_t$ . The real rate of return on public and private debts,  $r$ , is assumed to be constant.

The Ricardian equivalence is based on two main ideas: the intertemporal government constraint and the assumption of perpetual income. The latter means that families plan their spending and savings considering at the same time both current and future flow values. For the assumption of perpetual income an exchange on taxes by the government in a different time period does not influence the aggregated demand.

The conclusion of this work by Ricardo views the public debt merely as a transfer of taxation in time. Obviously this equivalence doesn't state that fiscal policies are inefficient on public debt. For example, if the government decreases the tax burden and, at the same time implements acts to reduce public expenditure, household income will increase and there will be an increase in consumption.

This theorem is the basis of some theories for optimal public finance.

Since this theorem is based on strong assumptions, it has some limits:

- ❖ The assumption of a perfect capital market is, in most circumstances, untrue. For example, it is possible that some consumers think they have more utility with current consumption than that of the future.
- ❖ The assumption about intergenerational ties is more realistic than the perfect capital market assumption. Since the future generations are the children of current generations, it is strange to think that a parent can benefit to the detriment of the child.
- ❖ The Ricardian equivalence does not consider a final moment when the debt must be repaid, since it is viewed as a possibility to defer the tax burden. If the government decides to reduce the tax burden with some debt issuance, it is sure that in the next year the government will not be able to cover the debt with a high tax burden but it will have to issue new bonds. Hence the debt will rise every year. The sustainability of the previous mechanism depends on the economy growth rate. When this rate is higher than bond interest rate, a new debt may be issued to cover the prior debt. If the growth economy rate is lower than bond interest rate, it is not possible to cover the old debt with new issue bonds. In this situation either the tax burden will be increased or bankruptcy will be declared.
- ❖ As in all economic models, consumer rationality is assumed. It is presumed that consumers want optimal utility in the long term. In real life this is not true and also not everybody knows the future effect of a reduction in the tax burden.

## 6.b Keynesian theory

This theory states an impact on savings, capital accumulation and national income by public debt. In an open economy the public debt also impacts on the currency exchange rate. Keynes states that a reduction in the tax burden or an increase in public expenditure, followed by an increase in debt, is an act to apply in a recession period in order to stimulate the economy. This is because prices and salaries presumably remain constant in the short term.

On the other hand, in the long term, prices and the cost of productive factors are no longer constant.

The budget constraint of the private sector is described by the following equation:

$$(6.2) \quad Y = C + S + T$$

where Y is the national income amount, C the consumption amount, S the saving amount and T the tax amount.

The national income is given by the equation below

$$(6.3) \quad Y = C + I + G + NX$$

where I is the domestic investment amount, G the public expenditure amount and NX the net exports amount of goods and services. From those previous equations it is possible to write as follows

$$(6.4) \quad C + S + T = C + I + G + NX$$

$$(6.5) \quad S + (T - G) = I + NX$$

Keynes also states that, with an approximation, the net exports amount of goods and services can be viewed as net foreign investments (NFI), thus

$$(6.6) \quad S + (T - G) = I + NFI$$

Observing the last equation it is possible to state that the creation of deficit, due to a reduction in the tax burden, can be covered by an increment in private savings, with a reduction in domestic investment or foreign investment.

The reduction in net foreign investments leads to the contraction of citizens' income, besides a reduction in net exports. The trade balance deficit and the public deficit are very closely linked. When one of them increases, the other one also increases. A country having a high public debt will surely also have a high interest rate. The central bank may reduce both of these by means of a suitable monetary policy. Such a policy works in the short term, whereas real rates remain virtually unaltered in the long term. Thus nominal rates will be raised as a result of inflation.

In accordance with the last equation, it is possible to understand that a reduction in public saving may be covered by an increment in private saving. In real life this situation is unlikely to happen, and this fact causes a reduction in both foreign and domestic investment. In the long term this reduction will, in turn, cause a reduction in capital stock, which will then lead to a reduction in labour productivity. The first important result of this cycle is a reduction in real wages and aggregate output. The second one is an increase in the interest rate on bonds.

## 6.c Other studies

Other models have been developed up to the present and the main results are listed below:

- ❖ **Harrod-Domar's model:** this was developed in 1946 to explain the growth rate of an economy in terms of savings and capital productivity levels. Harrod assumed that change of capital stock is equal to national savings.

$$(6.7) \quad I = \Delta K = S$$

Where  $S = s * Y$  with  $s$  being a marginal propensity to save and  $Y$  the national productivity,  $\Delta K = k * \Delta Y$  since  $k = \Delta K / \Delta Y$  with  $\Delta Y$  being the change in national productivity.

Harrod's paper states that knowing  $K$  (capital stock) and  $S$  (total saving), it will be possible to know the growth rate guaranteed in one country by the following equation:

$$(6.8) \quad g = s / k$$

- ❖ **Solow's model:** this was developed from the above-mentioned model for the first time in 1956 by Robert Solow. He was inspired by the Cobb-Douglas function :

$$(6.9) \quad Y = AK^\alpha(EL)^\beta$$

where  $Y$  represents the aggregate output (total production),  $K$  capital stock (corporate capital or risk capital is the capital that shareholders contribute to the company),  $L$  the workforce,  $A$  scale parameter and  $E$  work productivity. The parameters  $\alpha$  and  $\beta$  are positive and their sum is equal to 1:  $\alpha + \beta = 1$ .

In a closed economy this study asserts that an increase in public expenditure or in debt have a negative impact on growth. In particular, if the ratio between deficit and output is higher than the following critical level

$$(6.10) \quad b^* = \frac{(1-g)s}{1-s}$$

where  $g$  is the fraction of the national revenue used for public expenditure  $G = gY$ , the growth rate is negative. The growth rate of the debt will be

$$(6.11) \quad \hat{D} = \frac{bAK}{D}$$

with  $D$  the debt amount. This growth rate will be constant if

$$(6.12) \quad \frac{D}{K} = \frac{b}{(1+b-g)*s-b}$$

Where  $b$  is the fraction of the deficit which is created to finance public expenditure.

- ❖ **Olg model (overlapping generations model):** The first economist who introduced this kind of model was Irving Fisher (1930) in *The Theory of Interest*.

An overlapping generations model is an economic model which considers the agents' length of life finite, but long enough to also play a role in the subsequent generation. The life of the people in this project was viewed as two separate periods: the young period and the old period.  $N_t^t$  denoted the number of people born in every period.  $N^{t-1}_t$  denoted the number of old people alive in period  $t$ . In the first analysis period there are surely people who are already old. Those people were called "initial old" and denoted with  $N_0$ . An assumption was also made that people do not die young in life in order to have 
$$N_t^t = N_{t+1}^t.$$

Since the future generation has to pay the debt of the old generation, those models were used for the public financing of government debt. The main consideration recognized by this article regarded the level of sustainability: this factor depends on public debt, demographics, current and future spending .

Using this model Barro (1974) in his paper "Are government bonds net wealth?" focused on whether an increase in government debt constitutes an increase in perceived household wealth. The basic conclusion of this paper was that there isn't a persuasive theoretical case for treating government debt as a net component of perceived household wealth.

An important result by OGM models was the fact that if the economic and population growth rates don't match, there will be problems of deficit for the economy.

Diamond, in a review of these models, also shows that citizens save more than what is socially optimal when the competitive equilibrium of economy has dynamic inefficiency.

Other studies have been carried out on public debt but most of them are reviews of those mentioned above.

From the previous studies we can understand that the variables which are closely linked to public debt are: capital stock, savings, GDP, the workforce, GDP growth rate, foreign direct investment, taxes and interest rates. It also seems that demographic variables can have an impact on public debt.

## 6.d Reference article

Many articles have discussed the public debt problem, but the work by Sinha et al.(2011) has a similar structure to mine, although some variables are different.

Their aim of is to understand which factors influence public debt in middle and high income group countries using Panel regression. The following methods were utilized: the total effects model, the fixed effect model, the random effect model and an autoregressive multiple regression model. The authors estimated two models: one for the middle income countries and one for the high income countries. The dependent variable was public debt to GDP ratio, while they studied the following independent variables: the countries' current account balance, their central government's expenditure, their prevailing long term interest rate, their real GDP growth rate, their annual inflation of consumer prices, their foreign direct investment, and the number of people per sq. km per country.

The authors report a table such as the following one to summarize the results of their analysis.

Variable	Middle Income Group Countries				High Income Group Countries			
	Total effect	Fixed Cross section	Random Cross section	Auto regressive model	Total effect	Fixed Cross section	Random Cross section	Auto regressive model
Current account balance	I	S	S	S	I	S	S	I
Expenditure	S	I	I	I	I	S	S	I
FDI	S	I	I	I	I	I	I	I
Inflation	S	S	S	I	I	I	I	I
Interest rate	S	S	S	I	NA	NA	NA	I
Population density	I	I	I	I	I	I	I	I
Population over 65	I	I	I	I	I	I	I	I
GDP growth	S	S	S	S	S	S	S	S

**Table 6.1** Results from the article by Sinha, Pankaj (2011)

Where:

- ❖ I: insignificant factor
- ❖ S: significant factor
- ❖ NA: not applicable

It will be interesting to build a table as the above in order to compare our results with these results.

The major sources of data in the MPRA paper were World Bank dataset, OECD statsbook, IMF forecasts and CIA world fact book. Since Italy is among the high income group countries, we only intend to repeat the analysis carried out for this group. We will check whether it is really possible to create a dataset in the way the authors of this article did, that is by mixing data from various sources.

At the end of the theoretical framework we decided to analyse the following variables: inflation, Balance of payments, population over 65 years old, density of population, population growth, public expenditure, FDI inflow and outflow and GDP growth rate.



## 7. Panel data

For the purposes of understanding elaborated panel data in Stata I used the following publications: Bontempi and Golinelli (2004), Vuri(2004),Wooldridge (1999), Russel et al. (1993) and Barro (1979).

### 7.a Structure of panel data

Panel data are collected for the same group of subjects over different times. In our context the subjects are the different countries and the time is the different years. To get a clear idea, a general structure of panel data is represented in Table 7.1.

TIME	COUNTRIES	VARIABLES				
		variable 1	variable 2	variable 3	-----	variable n
year 1	country 1					
year 2	country 1					
⋮	⋮					
year T	country 1					
year 1	country 2					
year 2	country 2					
⋮	⋮					
year T	country 2					
⋮	⋮					
⋮	⋮					
year 1	country N					
⋮	⋮					
year T	country N					

**Table 7.1** *The final structure of the database.*

As an example, Sinha et al.(2011), use 10 temporal observations and 19 countries (statistical units) for the public debt / GDP ratio variable and for 9 independent variables.

The availability of information of this type allows us to specify models that are more flexible than the normal cross series ones.

However, automatic pooling of all the observations implies hypotheses of behaviour homogeneity of the 19 different countries, with the consequent restrictions that might not be very credible. Homogeneity cannot therefore be sustained in advance, because different countries in different historical periods could have different attitudes to public debt.

The data dependent variable  $y_{it}$  that we wish to explain is potentially influenced by many more factors than the observed  $x_{it}$  as those presented in chapter 6. The model originates as a simplification of reality. We will undoubtedly have omitted some explanatory factors of various kinds, as below:

1. Those which vary per individual country but remain constant in time (such as the physical characteristics of the country)
2. Those which vary only in time (such as the economic cycle)
3. Those which vary both in time and per individual country

The econometric approach to panel data supposes the possibility of highlighting two error types:

- $c_i$  relative to omission typology 1;  $c_i$  is called unobserved individual effect
- $u_{it}$  relative to omission typologies 2 and 3;  $u_{it}$  is called idiosyncratic error (disturbance)

The total effect of the omitted explanatory factors is therefore represented by the sum of the latter:

$$(7.1) \quad v_{it} = c_i + u_{it}$$

with the hypothesis that the covariance between  $c_i$  and  $u_{it}$  is equal to 0.

The specification of the model will be the following:

$$(7.2) \quad y_{it} = \beta x_{it} + c_i + u_{it}$$

The panel model allows for better utilization of the individual variability of the data to take into account omitted effects.

## 7.b Estimation methods

Before describing the various estimator methods, we need to define the following notations:

- INDIVIDUAL AVERAGE:

$$(7.3) \quad \bar{x}_i = \frac{\sum_t x_{it}}{T}$$

$$(7.4) \quad \bar{y}_i = \frac{\sum_t y_{it}}{T}$$

- TOTAL AVERAGE:

$$(7.5) \quad \bar{x} = \frac{\sum_i \sum_t x_{it}}{N*T} = \frac{\sum_i \bar{x}_i}{N}$$

$$(7.6) \quad \bar{y} = \frac{\sum_i \sum_t y_{it}}{N*T} = \frac{\sum_i \bar{y}_i}{N}$$

- WITHIN TRANSFORMATIONS:

$$(7.7) \quad w_{xx} = \sum_i \sum_t (x_{it} - \bar{x}_i)^2$$

$$(7.8) \quad w_{yy} = \sum_i \sum_t (y_{it} - \bar{y}_i)^2$$

$$(7.9) \quad w_{xy} = \sum_i \sum_t [(x_{it} - \bar{x}_i) * (y_{it} - \bar{y}_i)]$$

- BETWEEN TRANSFORMATIONS:

$$(7.10) \quad B_{xx} = T \sum_i (\bar{x}_i - \bar{x})^2$$

$$(7.11) \quad B_{yy} = T \sum_i (\bar{y}_i - \bar{y})^2$$

$$(7.12) \quad B_{xy} = T \sum_i (\bar{x}_i - \bar{x})(\bar{y}_i - \bar{y})$$

- DEVIATIONS FROM THE AVERAGE:

$$(7.13) \quad T_{xx} = \sum_i \sum_t (x_{it} - \bar{x})^2 = w_{xx} + B_{xx}$$

$$(7.14) \quad T_{yy} = \sum_i \sum_t (y_{it} - \bar{y})^2 = w_{yy} + B_{yy}$$

$$(7.15) \quad T_{xy} = \sum_i \sum_t [(x_{it} - \bar{x}_i) * (y_{it} - \bar{y})] = w_{xy} + B_{xy}$$

## ❖ Pooled ols

$$(7.16) \quad y_{it} = \beta x_{it} + v_{it}$$

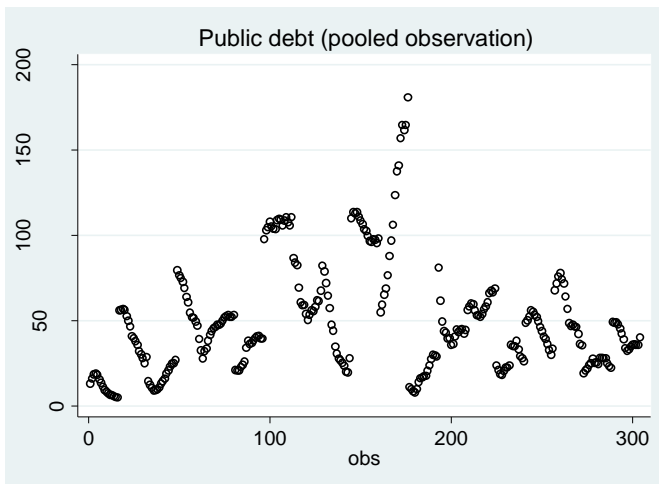
where  $v_{it} = c_{it} + u_{it}$  are composite errors.

Hypothesis of specification :

- $y_{it} = \beta x_{it} + v_{it}$  the true link between y and x
- $E(x'_{it} v_{it}) = 0$  which implies that  $E(x'_{it} c_i) = 0$ . This condition is necessary for consistency.

The estimation method used will be OLS (pooled), with the following results:

- (7.17)  $\hat{\beta}_{OLS} = \frac{T_{XY}}{T_{XX}}$
- (7.18)  $\hat{a}_{ols} = \bar{y} - \hat{\beta}_{ols} * \bar{x}$



**Graph 7.1** How the OLS (pooled) estimator sees the observations.

In the presence of individual effects correlated with the explanatory variables, the OLS estimations are biased and not consistent. The pooled OLS estimator does not consider the fact that T temporal observations for N different individuals are not necessarily the same thing as NT different individuals. The pooled OLS estimator virtually ignores the panel structure of the data that distinguishes two types of data variability: within and between. The graph shows how the estimator sees the observations; it is like a large cross-section of unconnected cases.

## ❖ Fixed effects model

$$(7.19) \quad y_{it} = \beta x_{it} + c_i + u_{it}$$

Assuming fixed effects means to assume that the differences between the individuals are characterised by the differences in the constant term .

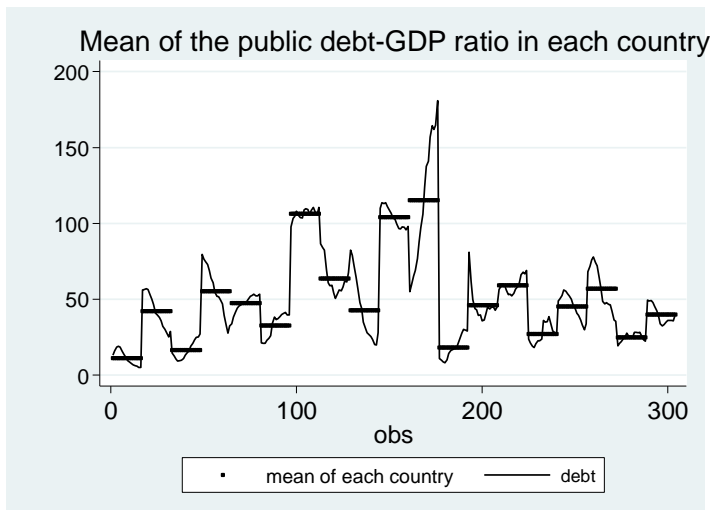
Specification hypothesis:

- We allow individual effects  $c_i$  to be correlated with  $x_{it}$
- (7.19) is the true link between y and x
- For the consistency of fixed effects estimator we only need strict ergogeneity assumption  $E(u_{it}|x_i, c_i) = 0$  for  $t= 1, \dots, T$

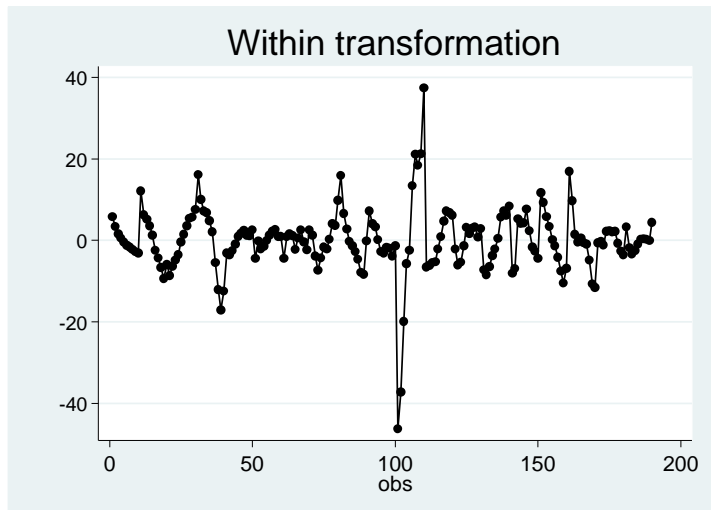
The estimation method used is called OLS with dummy variables (least squares with dummy variables, LSDV)

- (7.20) 
$$\hat{\beta}_{lsdv} = \frac{w_{xy}}{w_{xx}}$$
- (7.21) 
$$\hat{a}_{lsdv,i} = \bar{y}_i - \hat{\beta}_{lsdv} * \bar{x}_i$$
- (7.22) 
$$\hat{a}_{lsdv} = \frac{\sum_i \hat{a}_{lsdv,i}}{N}$$

If the real DGP is (7.16) but it is estimated by the LSDV method, the estimator is still correct and consistent, but inefficient. The FE model gives no importance to the variability between individuals because the individual components  $\bar{y}_i$  and  $\bar{x}_i$  are subtracted from the observations  $y_{it}$  and  $x_{it}$  , it considers the deviations. The LSDV estimator only uses the internal variability within each individual.(see graphs below)



**Graph 7.2** Mean of the debt / GDP ratio in each country



**Graph 7.3** How the FE estimator sees the observations.

The relevant information for the within transformation of the debt/GDP ratio is that of the distances between the mean of each country and the debt/GDP curve. If  $x_{it}$  has no temporal variability, its within transformation always assumes a value of zero and the corresponding coefficient cannot be estimated.

## ❖ Random effects model

(7.23)  $y_{it} = \beta x_{it} + v_{it}$  where  $v_{it} = c_i + u_{it}$  are composite errors.

Specification hypothesis for the consistency of random effects model:

- (7.23) is the real link between  $y$  and  $x$ ;
- Strict exogeneity:  $E(u_{it}|x_i, c_i) = 0$  for  $t=1, \dots, T$ .
- Independence in mean between  $c_i$  and  $x_i$ ,  $E(c_i|x_i) = 0$  where  $x_i = x_{i1}, x_{i2}, \dots, x_{iT}$

Idiosyncratic error terms  $u_{it}$  are homoscedastic and uncorrelated :

- $E(u_{it}^2) = \sigma_u^2$
- $E(u_{it}u_{is}) = 0$
- Not correlated with individual effects  $E(u_{it}, c_i) = 0$

The error term composed of  $v_{it}$  will therefore have:

- $E[v_{it}] = 0$
- $E[v_{it}^2] = \sigma_c^2 + \sigma_u^2$  where  $\sigma_c^2$  is the variance of  $c_i$
- $Cov(v_{it}, v_{is}) = \sigma_c^2$  ( $t \neq s$ ). The errors of country  $i$  at different times are correlated;
- $Cov(v_{it}, v_{jt}) = 0$  ( $i \neq j$ ). The errors of country  $i$  and country  $j$  are never correlated.

The estimation method for this model is GLS:

- (7.24)  $\hat{a}_{GLS} = \bar{y} - \beta_{GLS} * \bar{x}$
- (7.25)  $\hat{\beta}_{GLS} = \frac{(w_{xy} + \theta * B_{xy})}{w_{xx} + \theta * B_{xx}}$
- (7.26)  $\theta = \frac{\sigma_u^2}{\sigma_u^2 + T * \sigma_c^2}$

The GLS estimator of the model with random effects uses information both on variability within and on variability between. The parameter  $\theta$  is the weight the GLS estimator attributes to the variability between the individuals; in fact, from (7.25) it can be noted that:

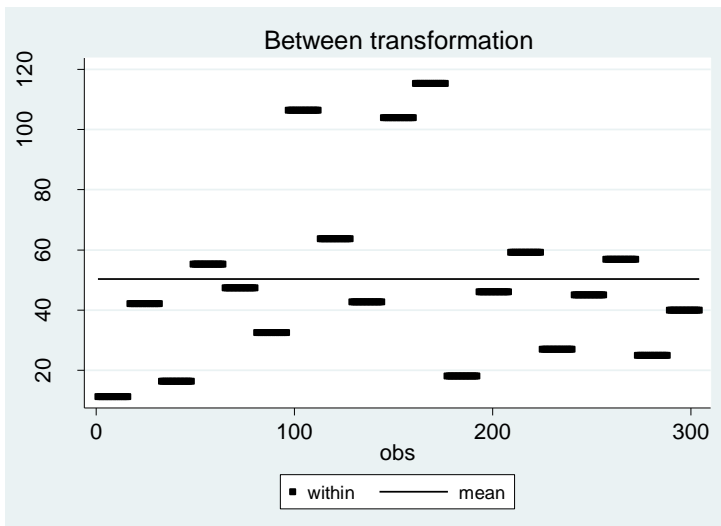
$$\theta = 0 \rightarrow \hat{\beta}_{GLS} \equiv \hat{\beta}_{LSDV} \text{ because there is a variability of the individual effects } \sigma_c^2 \text{ much higher than } \sigma_u^2$$

$$\theta = 1 \rightarrow \hat{\beta}_{GLS} \equiv \hat{\beta}_{OLS}$$

Depending on the values of  $\theta$ ,  $\hat{\beta}_{GLS}$  moves closer to the estimate with fixed effects or to the pooled one (without individual effects).

The  $\hat{\beta}_{LSDV}$  estimator on generated data from the model of type (7.18) is correct and consistent, but inefficient.

The pooled OLS and LSDV are “all-or-nothing” ways of using the information between individuals: OLS looks at all the sources of variability without distinction (“all”), whereas LSDV gives no importance (“nothing”) to the between variability.



**graph 7.4** The relevant information is the differences between the averages of each country and the mean of all the countries together

The GLS estimator thus represents the intermediate case between two extreme approaches in considering the individual effects:

all the same → total poolability (OLS) or all different → totally non poolable (LSDV). The transformation BE does not consider the single observation but concentrates on the mean values for each country.

We can say that the RE is obtained as the weighted average of the between and within estimators, where the importance depends on the relative variance of the two estimators.

## ❖ Fixed effects or random effects?

The fixed effects model is easier to use than the random effects one, moreover the LSDV estimator is robust to the omission of time-invariant explanatory variables. In cases where the random effect is valid, the LSDV estimator is still consistent, it has just less efficiency. Usually the fixed effect model is the first step for panel data analysis. Because the assumption  $E(c_i|x_i) = 0$  is not needed the fixed effect analysis is more robust than random effect analysis.

The random effects approach takes into account the variability between and within the countries, while the fixed effects just the within one. For the latter, if the specification (7.23) is true the random effects method is more efficient than the fixed effects method. The random effect considers the individual effects as a stochastic variable such as the error term. This method allows us to also take into account variables which are constant over time.

The choice between random effect and fixed effect depends on the following characteristics:

- If the individual effects are caused by a high number of random circumstances and are unobservable, it is better to use the random effect.
- If the database has a high number of countries and a short period of time observation, it is better to use the random effects method.
- When the sample is closed the fixed effects method is the first solution, whereas if the sample is open (N individual extract from a population) it is better to use the random effects model. In our case the random effects methods is more appropriate.

The statistical answer to this question is found by the Hausman test. This test has the following hypothesis:

$$H_0: \text{Cov}(x_{it}, c_i) = 0$$

$$H_1: \text{Cov}(x_{it}, c_i) \neq 0$$

Under  $H_0$  the RE model is the best, whereas under  $H_1$  the statistical properties of the GLS estimator of the RE model are not valid. The LSDV estimator of the FE model is consistent both under  $H_0$  and under  $H_1$ , whereas it is not efficient under  $H_0$ .

Under  $H_0$  the estimates will therefore be statistically similar and so the choice will be the GLS of the RE model. Vice versa under  $H_1$ .

The Hausman test statistic is:

$$(7.27) \quad w = (\widehat{\beta}_{FE} - \widehat{\beta}_{RE})' [\text{var}(\widehat{\beta}_{FE} - \widehat{\beta}_{RE})]^{-1} (\widehat{\beta}_{FE} - \widehat{\beta}_{RE})$$

which has a  $\chi_k^2$  distribution under  $H_0$ . The problem is  $\text{var}(\widehat{\beta}_{FE} - \widehat{\beta}_{RE})$ .

Hausman states that the covariance between an efficient estimator and its difference with an inefficient one is zero (7.28):

$$(7.28) \quad \text{cov} [\widehat{\beta}_{RE}, (\widehat{\beta}_{FE} - \widehat{\beta}_{RE})] = \text{cov}(\widehat{\beta}_{RE}, \widehat{\beta}_{FE}) - \text{var}(\widehat{\beta}_{RE}) = 0$$

From the latter result we can state:

$$(7.29) \quad \text{var} (\widehat{\beta}_{FE} - \widehat{\beta}_{RE}) = \text{var}(\widehat{\beta}_{FE}) + \text{var}(\widehat{\beta}_{RE}) - 2\text{cov}(\widehat{\beta}_{FE}, \widehat{\beta}_{RE}) = \text{var} (\widehat{\beta}_{FE}) - \text{var}(\widehat{\beta}_{RE})$$



## 8. The creation of the dataset

As described in Chapter 1 our goal is to create an econometric model aimed at explaining the public debt / GDP ratio over time. For this reason a list of countries having similar economic characteristics to Italy was chosen. In order to select the appropriate countries, we made use of how the oecd separated nations into the high income or the low income categories. Italy is one of the high income countries and so we used the data regarding a total of the following 19 countries:

- Australia
- France
- Germany
- Italy
- Japan
- United states
- Canada
- Republic of Korea
- Denmark
- Czech Republic
- Greece
- Hungary
- Ireland
- Portugal
- Poland
- Spain
- Slovak Republic
- Sweden
- Switzerland

All the variables we want to include in the dataset, derived from the economic theory, are listed below :

- Government debt as a percentage of the GDP
- Balance of payments: current account balance
- Foreign Direct Investments (inward and outward)
- Inflation
- Population density
- Population over 65
- GDP growth
- Public Expenditure
- Population growth

We use a balanced dataset similar to the one used by Sinha et al. (2011). We are not interested in having exactly the same dataset, we rather need a dataset which contains the most important variables. For example, we are not interested in having in our dataset the variable *long term interest rate* because it does not seem to affect the public debt. Regarding the expenditure variables, we are interested only in the value

of government expenditure. In the reference article the values of specific expenditure are also considered as *Military expenditure* and *education expenditure*.

At first we tried to create a balanced dataset from the World Bank website (<http://data.worldbank.org/topic>). We wanted to analyse the data from 1993 to 2010. However, due to the lack of some data, we realized it was impossible to do so.

Specifically:

For Australia, the values of debt from 1993 to 1998 are not available. For Japan, we cannot know the value of debt from 1993 to 2004. For the United States, instead, the values of debt are unavailable from 1993 to 2000. For the Republic of Korea it is not possible to obtain the data on debt from 1998 to 2000. The value of Polish debt is available only from 2001 to 2004. As for the Slovak Republic we can only obtain the value of debt from 2003 to 2010. We do not have the data regarding Switzerland's debt for the years 2009 and 2010. The debt value is also unavailable in 1993 and 1994 for France, Germany, Italy, Denmark, Greece, Hungary and Spain. The debt amount is available only for the years 2001 to 2004 in Poland. We have the values for the Portuguese debt from 1994 to 2010. For the variable *balance* we have only two missing values: for the year 1998 in Greece and for the year 2001 in the Slovak Republic. For the latter two states we do not have the values of Foreign Direct Investment from 1993 to 1998 (outflow) and in 1998 (inflow) for Greece, and in the year 2001 in the Slovak Republic (inflow and outflow). It is not possible to have the value of the Irish GDP growth from the year 1993 to 2000 either. For Ireland we do not have the value of inflation for the years 1993 to 2000 either. All the unavailable data is summarized in Table 8.1.

	<b>Debt</b>	<b>balance</b>	<b>FDI in</b>	<b>FDI out</b>	<b>GDP growth</b>	<b>Inflation</b>
<b>Australia</b>	1993-1998					
<b>France</b>	1993,1994					
<b>Germany</b>	1993,1994					
<b>Italy</b>	1993,1994					
<b>Japan</b>	1993-2004					
<b>United States</b>	1993-2000					
<b>Canada</b>						
<b>Korea, Rep.</b>	1998-2010					
<b>Denmark</b>	1993,1994					
<b>Czech Republic</b>						
<b>Greece</b>	1993,1994	1998	1998	1993-1998		
<b>Hungary</b>	1993,1994					
<b>Ireland</b>	1993-1997				1993-2000	1993-2000
<b>Portugal</b>	1993-1996					
<b>Poland</b>	1993-2000; 2005-2010					
<b>Spain</b>	1993,1994					
<b>Slovak Republic</b>	1993-2002	2001	2001	2001		
<b>Sweden</b>	1993,1994					
<b>Switzerland</b>	2009;2010					

**Table 8.1** In this table only the years for which we do not have the value of data are reported.

We therefore have a problem, our dataset is not balanced. In order to obtain a balanced dataset we need to integrate the dataset built with data from the World Bank website with data from the other websites.

This operation is not straightforward, because it is necessary for the variables from the two websites to be mutually consistent. In order to observe whether we can integrate our dataset with the data from other websites, we are going to make the difference between the common variables. If these differences range from tiny to none, it means that the variables are mutually consistent.

Observing that difference, we found that almost all variables are mutually consistent. We have an issue for the FDI (outflow) data in Hungary, in fact the difference value is more than 40% in years 2007 and 2008. However the main problem is for the variable debt. In fact the difference between the values in the various websites are more than 20% for many countries. Thus, we cannot integrate the data from World Bank with data from other websites.

Several techniques can be used in order to obtain a balanced dataset, the two most usually are:

- Partial deletion: it consists in the elimination of missing values, in order to obtain a reduced dataset, but balanced. (this is the methods we used in the comparison above). This is the easiest method to manage the missing value, but using this technique we are going to lost information and this fact is always bad.
- Imputation: This technique substitutes plausible values for the missing value. More information about this technique. It is possible to have more information reading *Rubi, and Little(2002)*. We are not interested to this method because it is not commonly used for macroeconomic data.

Obviously it is better to use real data and, for this reason, we tried to make a balanced dataset with real data from the period 1993 to 2008. In order to obtain that, we checked a lot of websites which have economic data such as World Bank, Eurostat, oecd, International Monetary Fund and so on. We observed that the oecd database(<http://stats.oecd.org/>) contains almost all the values we need. Thus, we decided to make a dataset using as the main source the data from the oecd website, integrating it with values from other websites. To be precise, we integrated the missing values with the dataset from the World Bank and Eurostat because their values are mutually consistent in certain cases that interest us.

For the variables regarding the population we used the values from the World Bank website.

In the end we were unable to find the data on foreign direct investment in Greece for the years 1993 to 1998. So, our dataset had 6 missing values, which were not available on any Internet websites. In order to understand whether Greece should be included or not, or whether to delete 6 years for each country, we carried out sensitivity analysis (see appendix). After these analyses we chose to create the dataset containing the values for all the 19 countries from 1999 to 2008.



## 9. Preliminary analysis

Our dataset therefore contains the data for the following variables:

- Government debt
- Balance of payments: Current account balance
- GDP growth
- Foreign Direct Investment (inflow and outflow)
- Inflation
- Public expenditure
- Population aged 65 and above
- Population density, number of people per sq. km of land area
- Population growth

For the following countries :

- Australia
- France
- Germany
- Italy
- Japan
- United states
- Canada
- Republic of Korea
- Denmark
- Czech Republic
- Greece
- Hungary
- Ireland
- Portugal
- Poland
- Spain
- Slovak Republic
- Sweden
- Switzerland

For the period of time from 1999 to 2008 we have gathered 190 observations for each variable considered. We therefore intend to shape our econometric model using this data.

Our model will be like the following:

$$(9.1) \quad y_{it} = \beta x_{it} + c_i + u_{it}$$

If the behavior of each country is similar, pooling is more advisable. This is as data pertinent to the other countries may be used to make up for the little knowledge available for one particular country.

It is essential to avoid presuming that all countries will show similar characteristics.

This chapter is going to describe the variables in our dataset in a precise way. In particular we will report the definitions of each variable and how it is calculated, as well as its relation with the dependent variable.

Moreover, we will carry out three single simple regressions on the dependent variable (OLS pool, fixed effects and random effects method) for each variable. This is in order to note whether there are differences in terms of estimates between these single regressions and the regressions containing all the variables together.

## 9.a Sources of variability

Before doing the above, we want to know the characteristics of the concerned variables in terms of their means and their variability between and within the States.

Variable		Mean	Std.dev	Min	Max	Observations	
<b>Debt</b>	overall	49.38702	33.73324	4.922	180.783	N	190
	between		33.59361	7.967	143.3626	n	19
	within		7.946095	3.06742	86.80743	T	10
<b>Pop. gr.</b>	overall	0.546461	0.574291	-0.53631	2.38548	N	190
	between		0.544407	-0.22496	1.766302	n	19
	within		0.218046	-0.3089	1.289821	T	10
<b>Pop. d.</b>	overall	136.2184	117.5986	2.463585	504.4728	N	190
	between		120.4645	2.61419	492.2646	n	19
	within		2.962915	116.1203	148.4266	T	10
<b>Pop. 65</b>	overall	14.93793	2.93012	7.002876	21.46098	N	190
	between		2.930766	8.689578	19.15839	n	19
	within		0.636579	12.51406	17.34756	T	10
<b>Expend.</b>	overall	18.98063	3.735148	10.36898	27.25471	N	190
	between		3.755158	11.32281	26.33374	n	19
	within		0.722227	16.8888	21.91275	T	10
<b>Fdi in.</b>	overall	3.715739	4.694854	-14.9221	26.438	N	190
	between		2.280929	0.20103	7.2893	n	19
	within		4.133613	-18.445	22.91517	T	10
<b>Fdi out.</b>	overall	3.312812	3.669024	-4.87319	19.391	N	190
	between		2.923631	0.254578	10.6255	n	19
	within		2.306761	-6.05827	13.65827	T	10
<b>Cur. acc.</b>	overall	-1.55666	5.605859	-14.6876	14.43558	N	190
	between		5.387309	-9.60403	10.32891	n	19
	within		1.945408	-10.1731	2.922195	T	10
<b>GDP gr.</b>	overall	3.049816	2.218376	-2.1	11.1	N	190
	between		1.395501	1.089519	5.56	n	19
	within		1.751144	-4.61018	8.589816	T	10
<b>Inflation</b>	overall	2.877011	2.060009	-0.89987	12.03578	N	190
	between		1.616552	-0.15426	6.708207	n	19
	within		1.324702	-0.7852	8.924667	T	10

Table 9.1 Xtsum output

From Table 9.1 it can be noted how the variability between countries is higher than the variability within for most of the variables. In particular this is the case for the public debt / GDP ratio, population density, population over 65, public expenditure and balance of payment (current account).

Only the FDI inflow variable has a higher variability within than between.

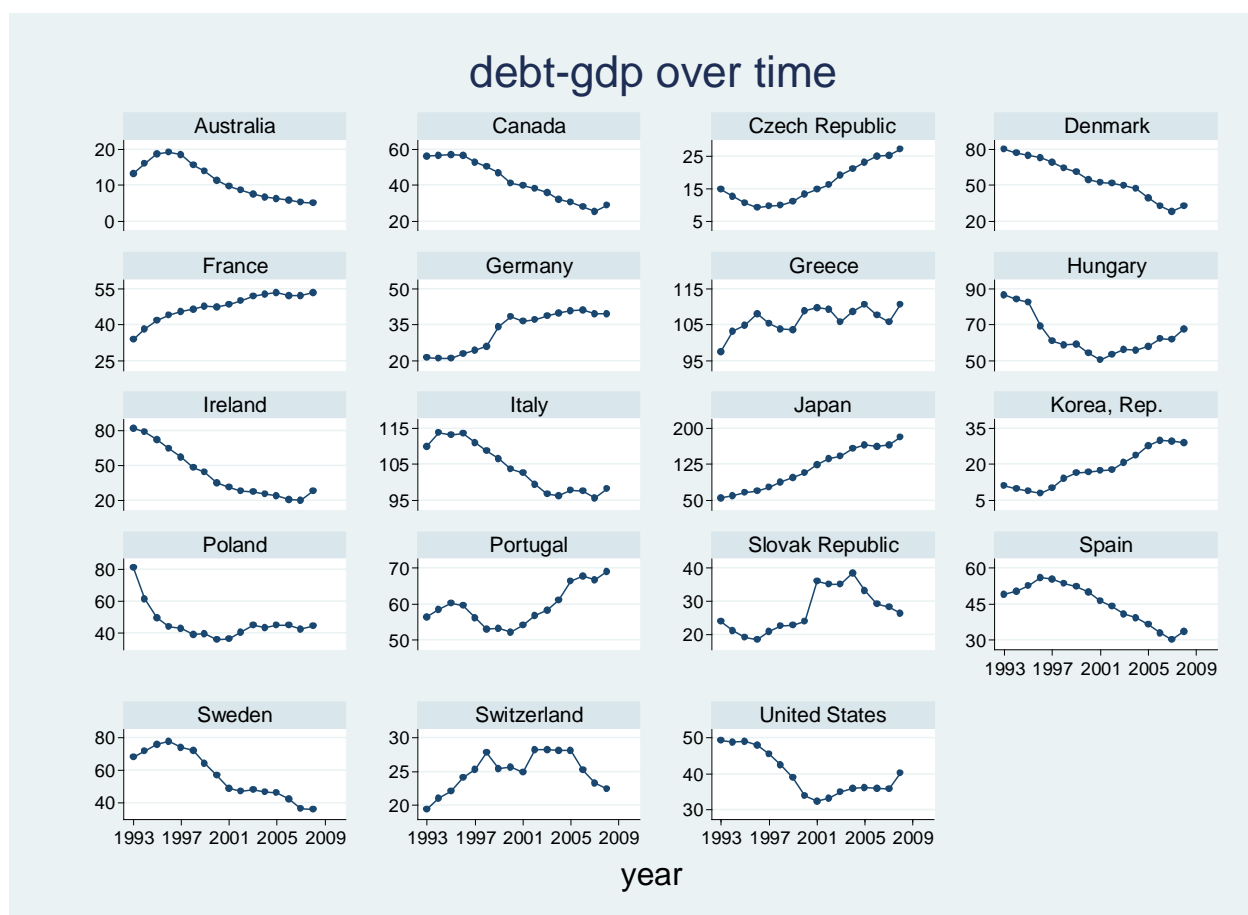
## 9.b Dependent variable: the public debt / GDP ratio

The dependent variable is the debt-to-GDP ratio, expressed as a percentage. The debt-GDP ratio is the most important indicator of the health of an economy .

The data is from the oecd dataset. The oecd website gives the following definition of the debt-to-GDP ratio: "It is calculated as the total debt amount in a country as a percentage of its Gross Domestic Product (GDP). With a low ratio the economy probably produces a large number of goods and services which allow the government to pay back debts. The coverage of the data is limited to central government debt issuance and therefore excludes state and local government debt and social security funds."

Graph 9.1 gives a general idea of how the public debt / GDP ratio changes within countries over a longer period of time compared to the data used for regressions.

The same time period will also apply to the other independent variables (except in the case of FDI outflow).



**Graph 9.1** The public debt / GDP ratio over time by country

The graph shows the time series of the public debt / GDP ratio from 1993 to 2008 for each country.

It can be noted that there is a clear-cut change in trend for most countries around 1996-97. This feature may be due to the introduction of the Maastricht Treaty. It was in Maastricht that some economic parameters were established, which future member states would have to respect in order to join the European Union.

The aim of the above-mentioned treaty, also known as European Union treaty, was to lead the different economies of the various countries towards a common economy. It is the treaty with which the first members of European Union fixed both politics and economic rules to enter in that Union.

In order to enter in the European community a country have to be in line with five main points:

1. Public debt/GDP has to be smaller than 60% (it was made an exception for Italy and Belgium, in fact when they entered were higher than this threshold).
2. Public deficit/GDP has to be smaller than 3%
3. The inflation must not exceed by 1.5% that of the three state members which have the best results for price stability in the year prior to the examination of the state member's situation.
4. Long term interest rate smaller than 2% with respect to the three best country in economic term.
5. To join, for two consecutive years, in the exchange-rate mechanism (ERM) under the European Monetary System and without devaluation of its currency in this time period.

Afterwards, we will analyse these last two variables and we will see their behaviour over time on the graphs, so as to note how this treaty affected the trend.

On observing graph 9.1 we can state that Japan clearly has the highest public debt / GDP ratio of all the countries examined. Greece is in second place and Italy third. Japan also had the highest growth in the time period analysed, rising from approximately 50% in 1993 to 180% in 2008.

Other countries, such as Czech Republic, France, Korea, Portugal Switzerland and Germany showed a rising trend in the public debt / GDP ratio, but they were all around a maximum of 20 percentage points.

After adopting the Maastricht treaty, Italy seemed to show a decreasing trend in its public debt / GDP ratio, although the level is still high today. Other countries, such as Australia Canada Denmark Ireland Spain Poland and Sweden have shown a decreasing trend in their public debt / GDP ratio during the time period analysed.

Greece seems to be an interesting case as, in the last few years, it has had a seesaw trend

Spain seems to have suffered from the 2008 crisis more than other countries. Indeed, up to 2007, as can be seen in the previous graph, the level of the public debt / GDP ratio showed a decreasing trend up to the point that it reached a level equal to about 30% in 2007. In 2012 it reached 84.1%.



## 9.c Independent variables

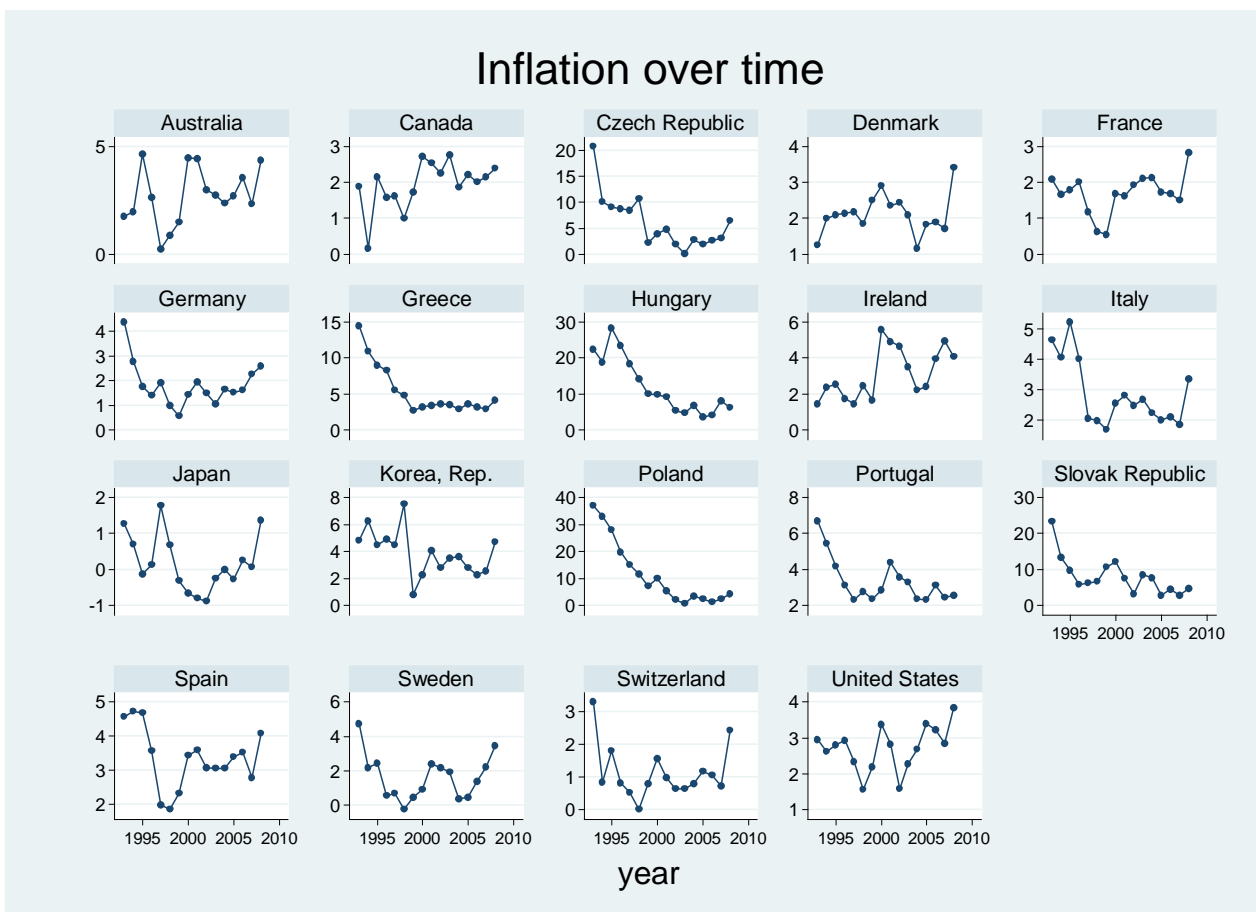
### ❖ Inflation

The data regarding inflation rates comes from the oecd dataset. The oecd website gives the following definition:

“Inflation is a rise in the general level of prices of goods and services that households acquire for the purpose of consumption in an economy over a period of time. The main measure of inflation is the annual inflation rate which is the movement of the **Consumer Price Index (CPI)** from one month/period to the same month/period of the previous year expressed as percentage over time.”

In our dataset inflation is measured as the percentage difference from the previous year.

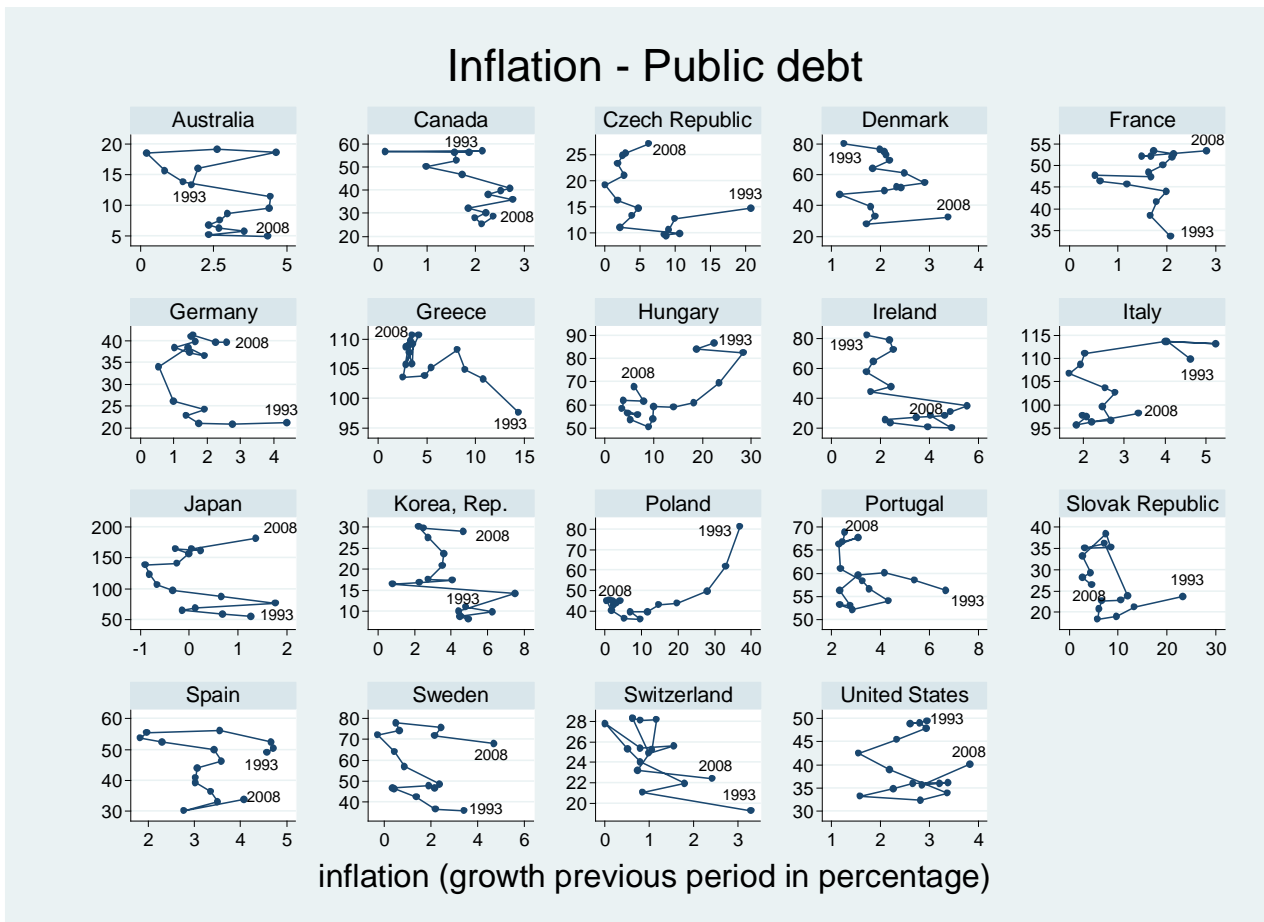
Graph 9.2 shows inflation over time from 1993 to 2008. As previously stated, inflation must not exceed by 1.5% that of the three state members which have the best results for price stability in the year prior to the examination of the state member’s situation. Observing the graphs we can understand that the countries which had a lower inflation level (around 0.5%) in 1999 are Germany and France.



**Graph 9.2** Inflation rate over time.

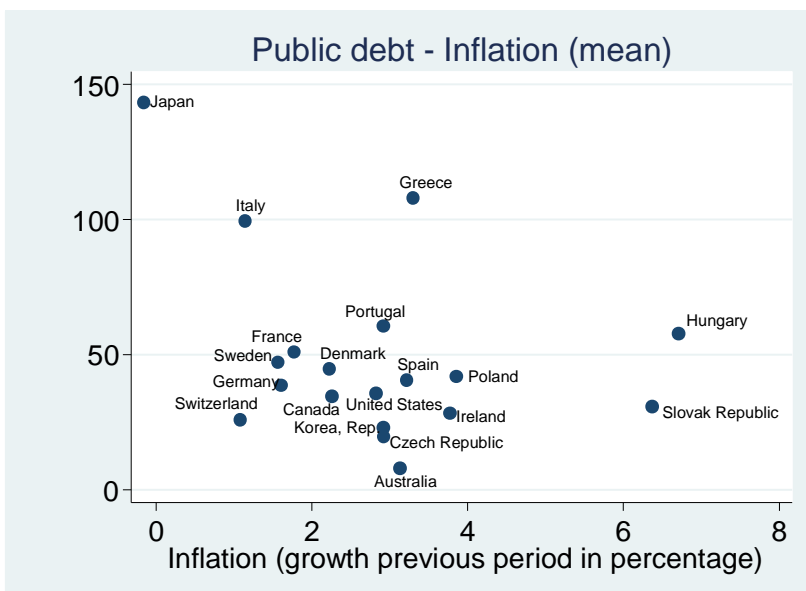
It can be seen how some countries which adopted the single currency in 1999, such as Ireland, Italy, Portugal and Spain, did their best to reach a low level of inflation. It also shows Greece, which adopted the single currency in 2001.

Graph 9.3 shows the relationship between the public debt / GDP ratio and the inflation rate over time



**Graph 9.3** Public debt over inflation, by year (within countries).

The relationship between the public debt / GDP ratio and inflation does not seem to be similar for all the countries, but rather different. It therefore seems inappropriate to use one regression model only, which is applicable to all the different countries. To get an idea of where all the individual countries in graph 9.3 would be placed in one graph only, the average of the debt and the average of the inflation was calculated for each country.



**Graph 9.4** Public debt over inflation, means over time (between countries).

This graph thus helps us to understand whether it is right to apply a linear regression and presume the slope of the regression line. In this case we can imagine a negative regression line between the means, while the same is not true for the within variability. Afterwards we will run three regressions in order to compare our expectations with the results actually obtained from the three different estimation methods.

The outputs of the single regressions using the three estimation methods (see panel data chapter) are reported below:

```

reg debt inflation
Source |          SS          df          MS          Number of obs =      190
-----+-----
Model | 11126.0061          1 11126.0061      F( 1, 188) = 10.26
Residual | 203943.086        188 1084.80365      Prob > F      = 0.0016
-----+-----
Total | 215069.092        189 1137.93171      R-squared     = 0.0517
                                           Adj R-squared = 0.0467
                                           Root MSE     = 32.936

debt |          Coef.      Std. Err.      t      P>|t|      [95% Conf. Interval]
-----+-----
inflation | -3.724514      1.162989      -3.20   0.002     -6.018699     -1.43033
_cons | 60.10249      4.111539      14.62   0.000     51.99181      68.21317

```

**Table 9.2** Output of the regression public debt / GDP – inflation

```

xtreg debt inflation, re
Random-effects GLS regression          Number of obs      =      190
Group variable: country                Number of groups    =       19

R-sq:  within = 0.0017                  Obs per group: min =       10
       between = 0.0884                  avg                =      10.0
       overall = 0.0517                  max                =       10

Random effects u_i ~ Gaussian          Wald chi2(1)       =       0.42
corr(u_i, X) = 0 (assumed)              Prob > chi2        =      0.5164

debt |          Coef.      Std. Err.      z      P>|z|      [95% Conf. Interval]
-----+-----
inflation | -.2973628      .4582108     -0.65   0.516     -1.19544      .6007139
_cons | 50.24254      7.695651      6.53   0.000     35.15934      65.32574

sigma_u | 32.897881
sigma_e | 8.3714659
rho | .939184      (fraction of variance due to u_i)

```

**Table 9.3** Output of the regression public debt / GDP – inflation, RE

```

xtreg debt inflation, fe
Fixed-effects (within) regression      Number of obs      =      190
Group variable: country                Number of groups    =       19

R-sq:  within = 0.0017                  Obs per group: min =       10
       between = 0.0884                  avg                =      10.0
       overall = 0.0517                  max                =       10

corr(u_i, Xb) = 0.2195                  F(1,170)          =       0.28
                                           Prob > F           =      0.5967

debt |          Coef.      Std. Err.      t      P>|t|      [95% Conf. Interval]
-----+-----
inflation | -.2436964      .4596767     -0.53   0.597     -1.151106      .6637131
_cons | 50.08814      1.455281     34.42   0.000     47.21539      52.96089

sigma_u | 33.478594
sigma_e | 8.3714659
rho | .94115242      (fraction of variance due to u_i)

F test that all u_i=0:      F(18, 170) = 152.23      Prob > F = 0.0000

```

**Table 9.4** Output of the regression public debt / GDP – inflation, FE

Observing the estimation values of the coefficients - as expected – since the variability of the individual effects  $\sigma_c^2$  is much higher than  $\sigma_u^2$ , it can be noted that  $\hat{\beta}_{RE} \approx \hat{\beta}_{FE}$  (see Chapter 7.b). The pooled OLS estimation is however different, due to the correlation of the inflation variable with the fixed effects that were not considered in the regression .

From the single regressions it seems that the inflation variable is not statistically significant in explaining our dependent variable using both random and fixed effects methods, but seems to be significant using the OLS pooling method, confirming the evidence from Graph 9.4.

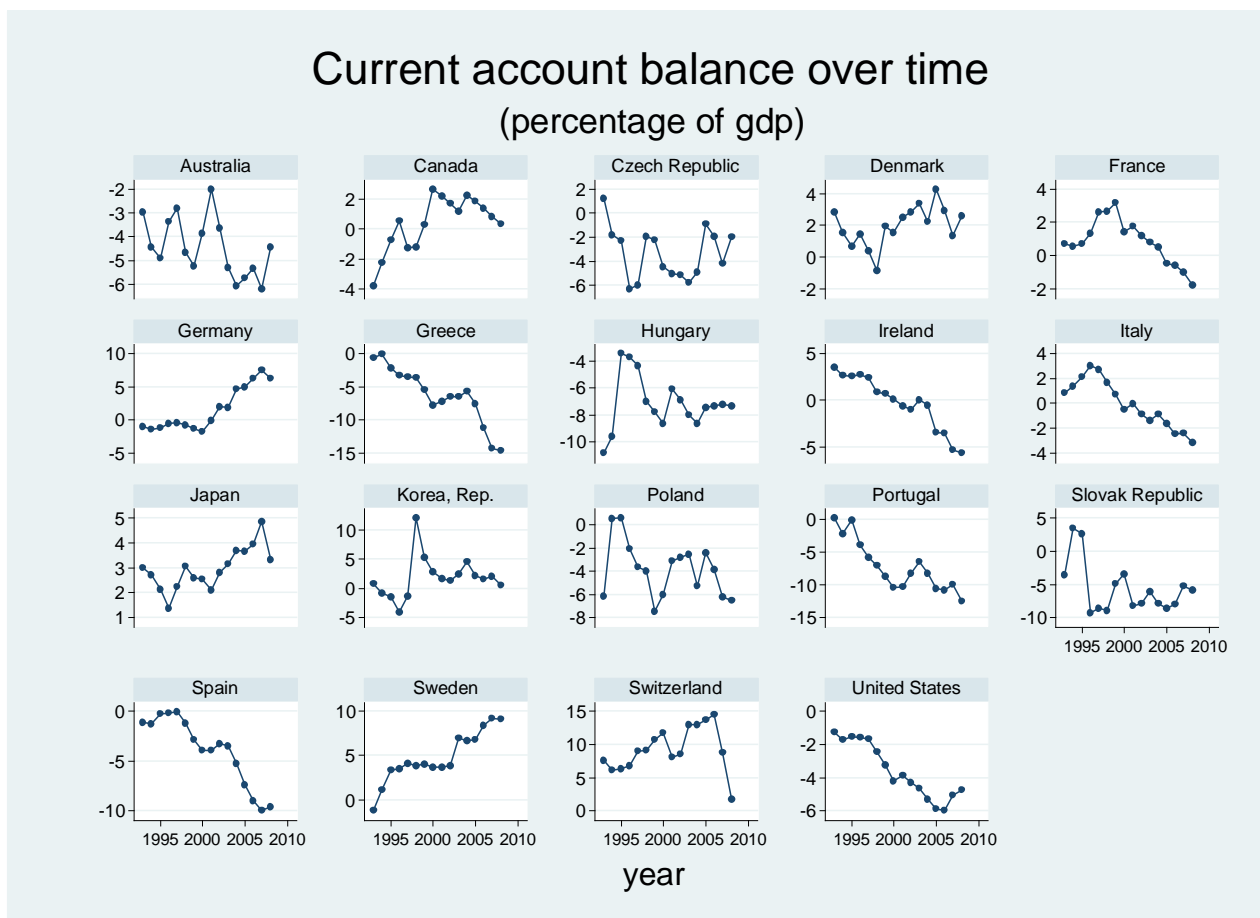
Because there are different thoughts on how inflation influences public debt, it will be interesting to discover how inflation, in our range time, affects the public debt/GDP ratio in the regression where all the variables are jointly estimated. In fact, on the one hand, some economists think that inflation can decrease the public debt/GDP ratio because higher prices lead to a higher GDP. On the other hand, some economists say that inflation is not a good solution because if there is an increase in inflation, there will also be an increase in the interest on the public debt.

## ❖ Balance of payments: current account

The oecd website gives the following definition of this variable:

“The current account includes all the transactions (other than those in financial items) that involve economic values and occur between resident and non-residents entities. The balance of payments is a statistical statement that provides a systematic summary of economic transactions of an economy with the rest of the world, for a specific time period. The transactions are for the most part between residents and non-residents of the economy. The transactions included comprise: goods, services, and income; those involving financial claims on and liabilities to the rest of the world; and transfers. A transaction is defined as an economic flow that reflects the creation, transformation, exchange, transfer, or extinction of economic value and involves changes in ownership, of goods or assets, the provision of services, labour or capital.”

This variable is thus measured as a percentage of the GDP.

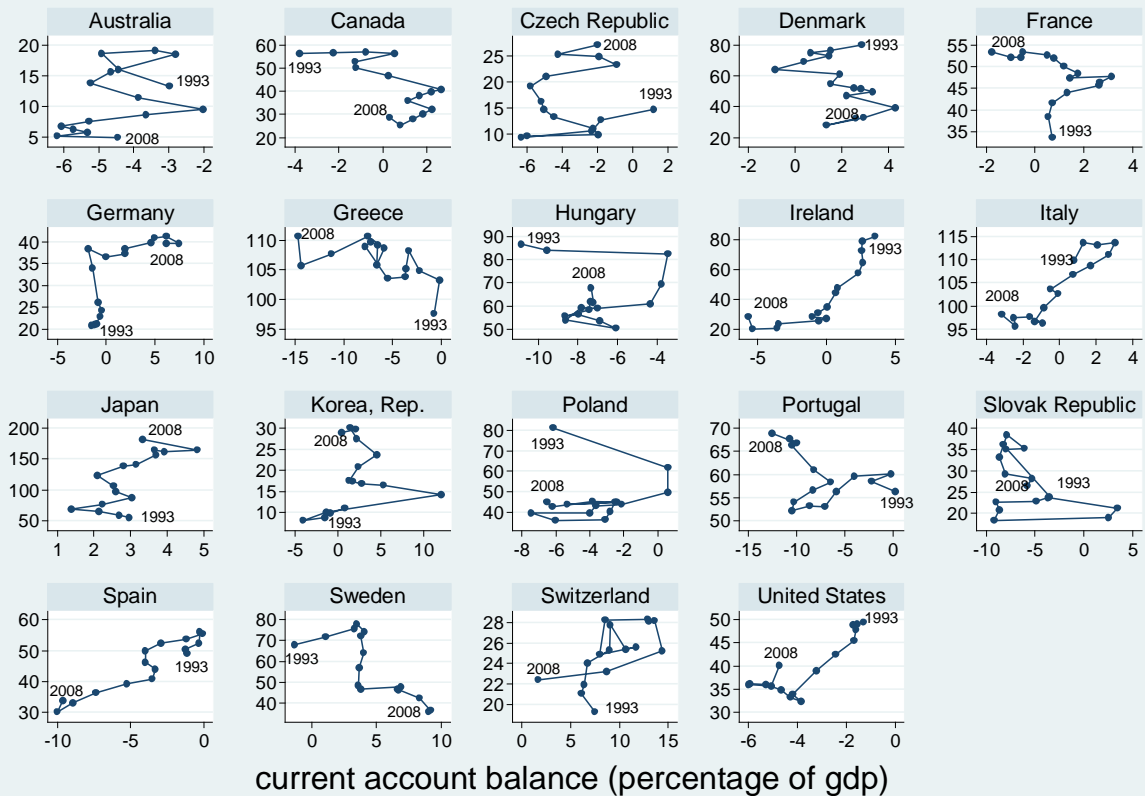


**Graph 9.5** Balance of payments over time

It can be seen that all the countries which chose to adopt the single currency, in the period between 1998-99, tried to reach a deficit no higher than 3%.

Graph 9.6 shows the relationship between the public debt / GDP ratio and the balance of payments.

## Current account balance - Public debt

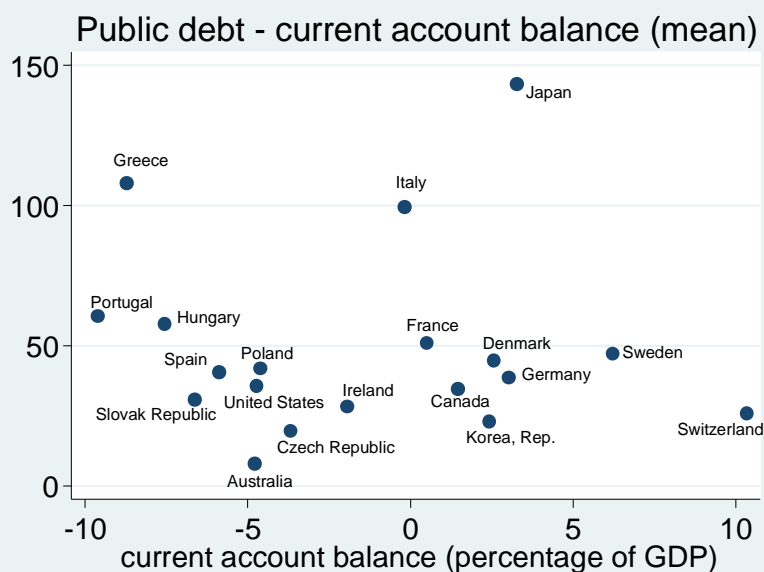


**Graph 9.6** Public debt over current account balance, by year (within countries).

Since the current account balance (as % of GDP) is the sum of the net exports of goods, services, net income, and net current transfers; it is expected that a negative balance account will increase the public debt/GDP ratio. Observing graph 9.6 we cannot state this, since a common relationship between all

countries is not clearly defined.

Looking also at graph 9.7, it seems that there is not a clearly relationship between Balance of payments and the public debt / GDP ratio. We are going to see with the following regressions, the different coefficient estimation obtained with the three usual model.



**Graph 9.7** Public debt over current account balance, means over time (between countries).

The single regressions are:

**reg debt curacc**

Source	SS	df	MS			
Model	495.555804	1	495.555804	Number of obs =	190	
Residual	214573.537	188	1141.3486	F( 1, 188) =	0.43	
Total	215069.092	189	1137.93171	Prob > F =	0.5107	
				R-squared =	0.0023	
				Adj R-squared =	-0.0030	
				Root MSE =	33.784	

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
curacc	-.2888505	.4383652	-0.66	0.511	-1.153597	.5758961
_cons	48.93738	2.544159	19.24	0.000	43.91861	53.95615

**Table 9.5** Output of the regression public debt / GDP – balance of payments

**xtreg debt curacc, re**

Random-effects GLS regression	Number of obs =	190
Group variable: country	Number of groups =	19
R-sq: within = 0.0090	Obs per group: min =	10
between = 0.0037	avg =	10.0
overall = 0.0023	max =	10
Random effects u <sub>i</sub> ~ Gaussian	Wald chi2(1) =	1.36
corr(u <sub>i</sub> , X) = 0 (assumed)	Prob > chi2 =	0.2441

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
curacc	.3550312	.3048034	1.16	0.244	-.2423725	.9524349
_cons	49.93968	7.913889	6.31	0.000	34.42875	65.45062
sigma_u	34.401888					
sigma_e	8.3407971					
rho	.94448074	(fraction of variance due to u <sub>i</sub> )				

**Table 9.6** Output of the regression public debt / GDP – balance of payments, RE

**xtreg debt curacc, fe**

Fixed-effects (within) regression	Number of obs =	190
Group variable: country	Number of groups =	19
R-sq: within = 0.0090	Obs per group: min =	10
between = 0.0037	avg =	10.0
overall = 0.0023	max =	10
	F(1,170) =	1.54
corr(u <sub>i</sub> , X <sub>b</sub> ) = -0.1148	Prob > F =	0.2170

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
curacc	.3864594	.3118644	1.24	0.217	-.2291662	1.002085
_cons	49.9886	.7757761	64.44	0.000	48.45721	51.52
sigma_u	33.784897					
sigma_e	8.3407971					
rho	.94255196	(fraction of variance due to u <sub>i</sub> )				

F test that all u<sub>i</sub>=0: F(18, 170) = 161.91 Prob > F = 0.0000

**Table 9.7** Output of the regression public debt / GDP – balance of payments, FE

Considering the previous estimates, this variable seems not to have a significant impact on the public debt /GDP ratio.

Observing the estimation values of the coefficients, it can be understood that  $\hat{\beta}_{RE} \approx \hat{\beta}_{FE}$ . The pooled OLS estimation is however different, surely due to the correlation of the fixed effects that were not considered in the regression and the balance of payments variable. Since the POLS model ignores the serial correlation in the composite error due to the presence of  $c_i$  (see panel data chapter), the estimation obtained with this method are biased. This explains the differences between the estimation obtained with the POLS as opposed to the other two (RE and FE).

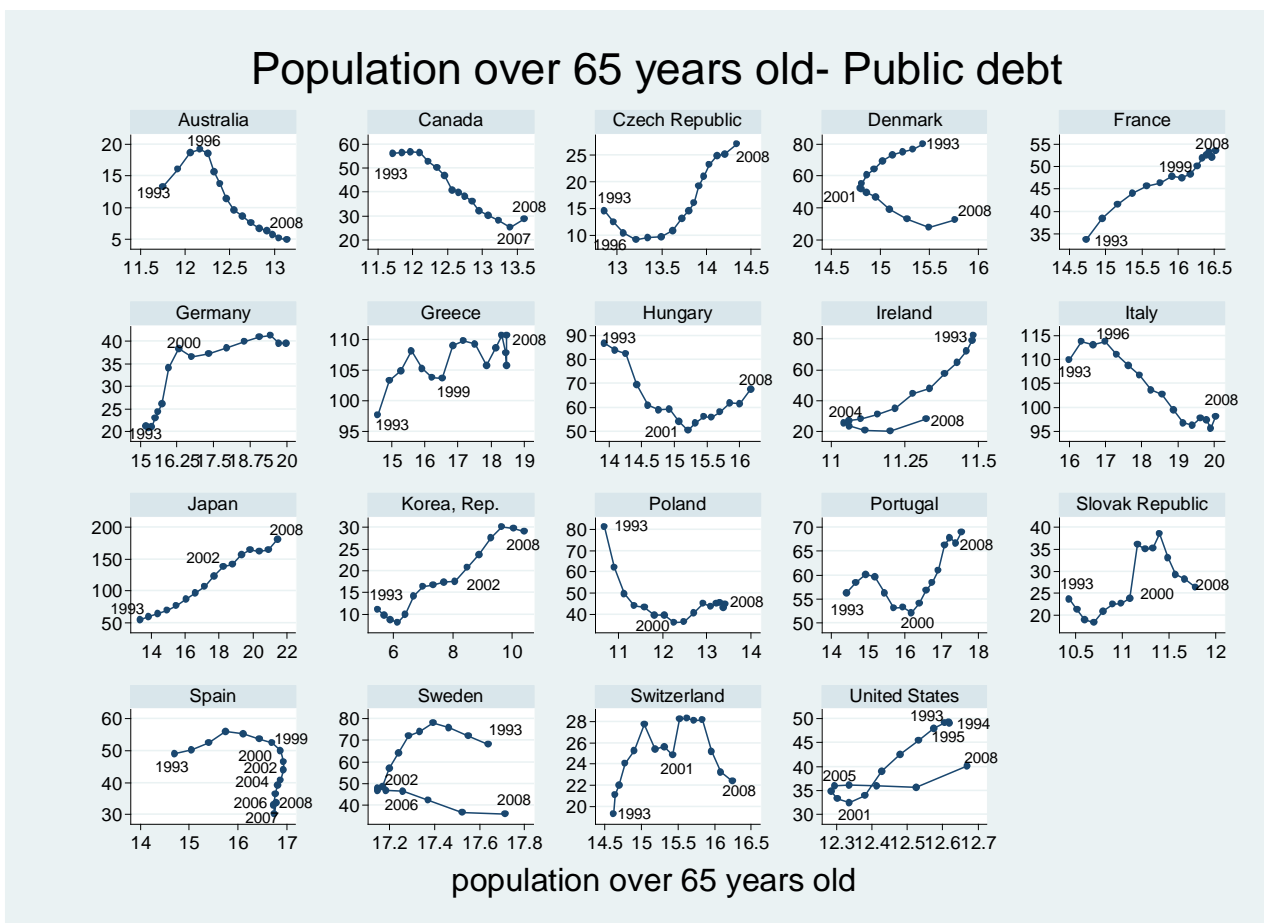


## ❖ Population over 65 years old

The data pertinent to this population group has been taken from the World Bank website, which gives the following definition of this variable:

“Population aged 65 and above as a percentage of the total population. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship - except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of the country of origin.”

Graph 9.8 shows the relationship between the population over 65 years old and the public debt / GDP ratio over time.



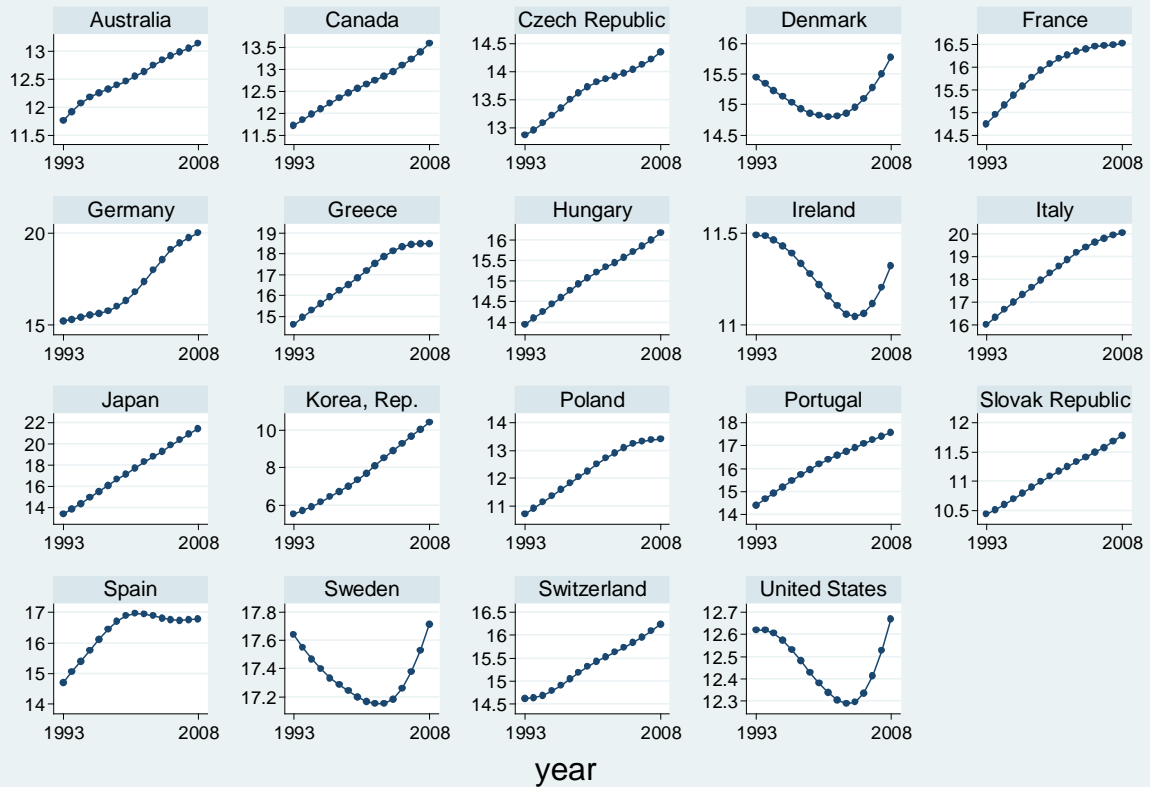
**Graph 9.8** Public debt over population over 65 years old, by year (within countries).

The above graph is very similar to the one in which we have the debt in y and the time in x (see graph 9.1)

This may be explained by a linear increase in the part of the population aged 65 and above over time.

To discover this, the following graph has been created. It can be seen that as the years have passed, in many countries there has been a linear increase in the percentage over 65s in the population.

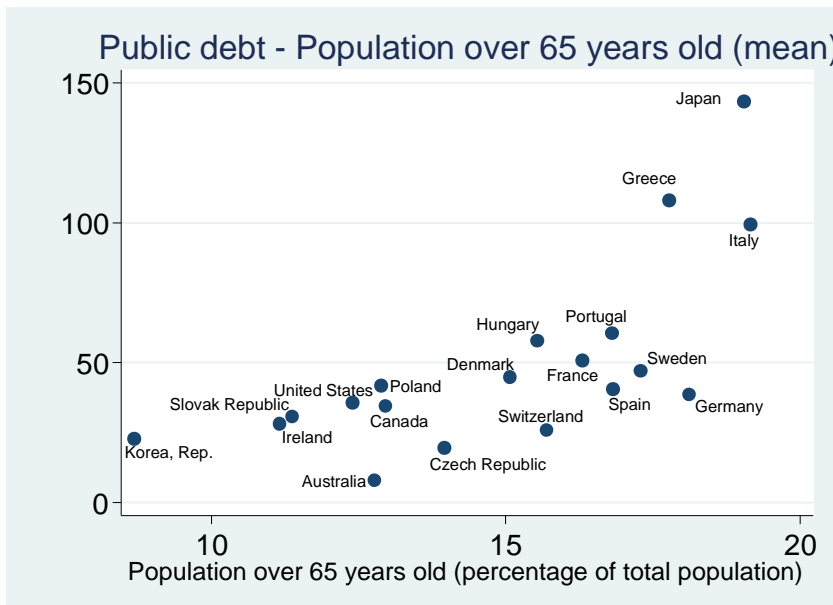
## Population over 65 years old



**Graph 9.9** Population over 65 years old over time

Observing the results from Sinha et al. (2011), the population variables seem not to influence the public debt/GDP ratio. This fact may seem strange. One country with a large number of people over 65 (retirement age) has a higher public expenditure and thus a bigger public debt than another country where fewer people get a pension. In fact the following graph (9.10) shows a clear positive relationship between

public debt and the over 65 age range. We are going to run the usual three regressions in order to understand how the different estimation methods treat this relationship.



**Graph 9.10** Public debt over population over 65 years old, means over time (between countries).

The following shows whether the over 65 year old population variable has a significant relation in statistical terms on the public debt / GDP ratio.

**reg debt pop65**

Source	SS	df	MS	Number of obs = 190		
Model	100103.597	1	100103.597	F( 1, 188)	=	163.70
Residual	114965.495	188	611.518592	Prob > F	=	0.0000
				R-squared	=	0.4654
				Adj R-squared	=	0.4626
Total	215069.092	189	1137.93171	Root MSE	=	24.729

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	7.854319	.6138872	12.79	0.000	6.643327	9.065312
_cons	-67.94028	9.344046	-7.27	0.000	-86.37293	-49.50763

**Table 9.8** Output of the regression public debt / GDP – population over 65 years old

**xtreg debt pop65, re**

Random-effects GLS regression	Number of obs	=	190
Group variable: country	Number of groups	=	19
R-sq: within = 0.2340	Obs per group: min	=	10
between = 0.4803	avg	=	10.0
overall = 0.4654	max	=	10
Random effects u_i ~ Gaussian	Wald chi2(1)	=	66.96
corr(u_i, X) = 0 (assumed)	Prob > chi2	=	0.0000

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
pop65	6.322063	.7725674	8.18	0.000	4.807859	7.836267
_cons	-45.05154	12.87733	-3.50	0.000	-70.29063	-19.81244

sigma_u	24.81052
sigma_e	7.3327825
rho	.91966657 (fraction of variance due to u_i)

**Table 9.9** Output of the regression public debt / GDP – population over 65 years old, RE

**xtreg debt pop65, fe**

Fixed-effects (within) regression	Number of obs	=	190
Group variable: country	Number of groups	=	19
R-sq: within = 0.2340	Obs per group: min	=	10
between = 0.4803	avg	=	10.0
overall = 0.4654	max	=	10
corr(u_i, Xb) = 0.2194	F(1,170)	=	51.94
	Prob > F	=	0.0000

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	6.038491	.8378873	7.21	0.000	4.384487	7.692494
_cons	-40.81556	12.52761	-3.26	0.001	-65.54526	-16.08585

sigma_u	24.852341
sigma_e	7.3327825
rho	.91991508 (fraction of variance due to u_i)

F test that all u_i=0:	F(18, 170) =	109.34	Prob > F =	0.0000
------------------------	--------------	--------	------------	--------

**Table 9.10** Output of the regression public debt / GDP – population over 65 years old, FE

The three different estimation methods used seem to lead to estimations which are very similar the one to the othe. In all the three single regressions the over 65 variable seems to positively influence the public debt / GDP.

The variability of the individual effects  $\sigma_c^2$  is much higher than  $\sigma_u^2$ ,this explains why  $\hat{\beta}_{RE} \approx \hat{\beta}_{FE}$  (see section 7.b).

The OLS estimation of the coefficient concerned seems to be in line with the values estimated with FE and RE , thus it seems less biased than in previous covariates.

It is important to note how the  $R^2$  value for this variable is much higher than the  $R^2$  values seen up to now.

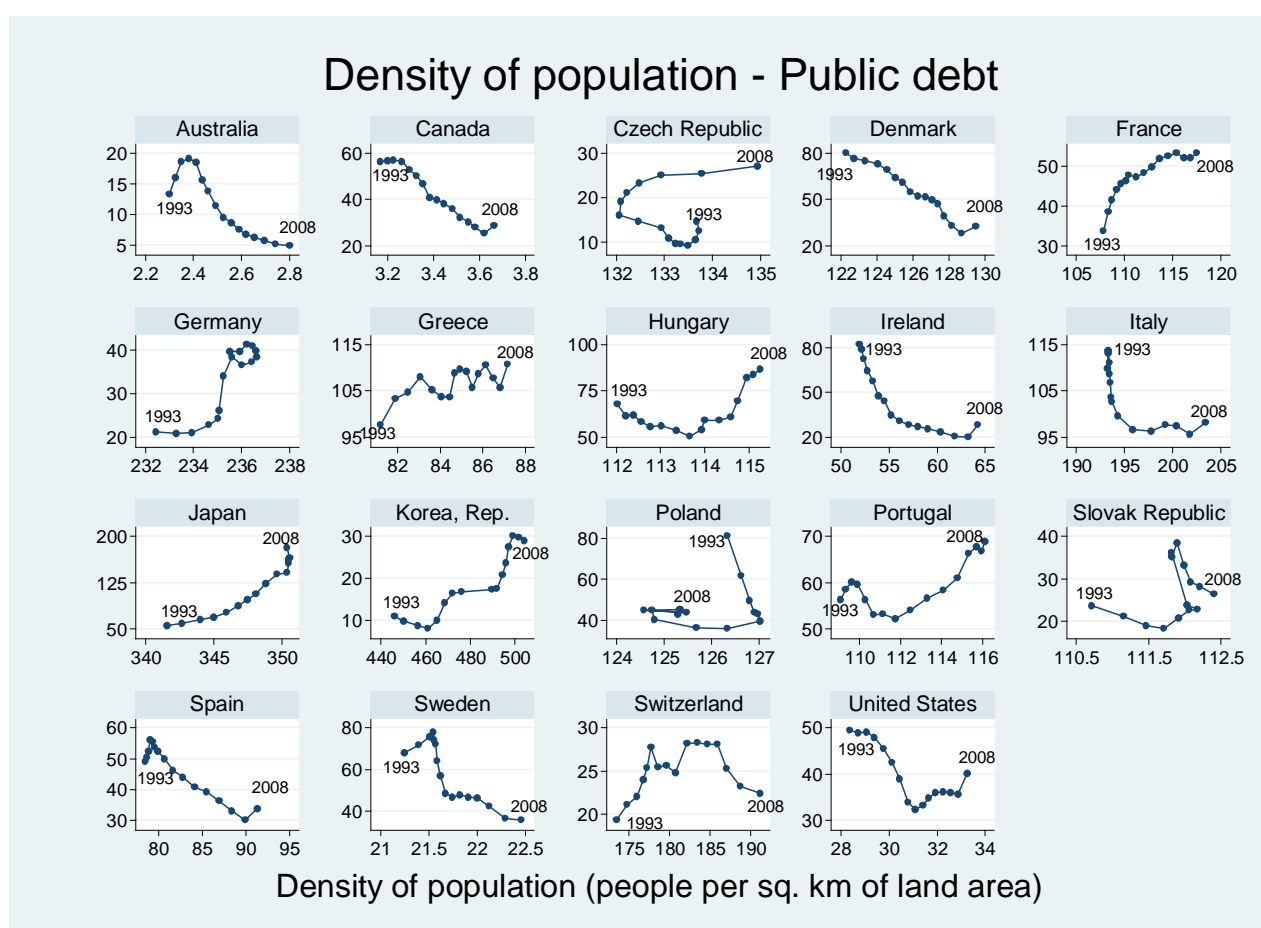
## ❖ Density of population

These data, as all those relative to the population, have been taken from the World Bank dataset, which gives the following definition:

“Population density is mid-year population divided by land area in square kilometres. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship - except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.”

Measurements will consider number of people per sq.km of land area.

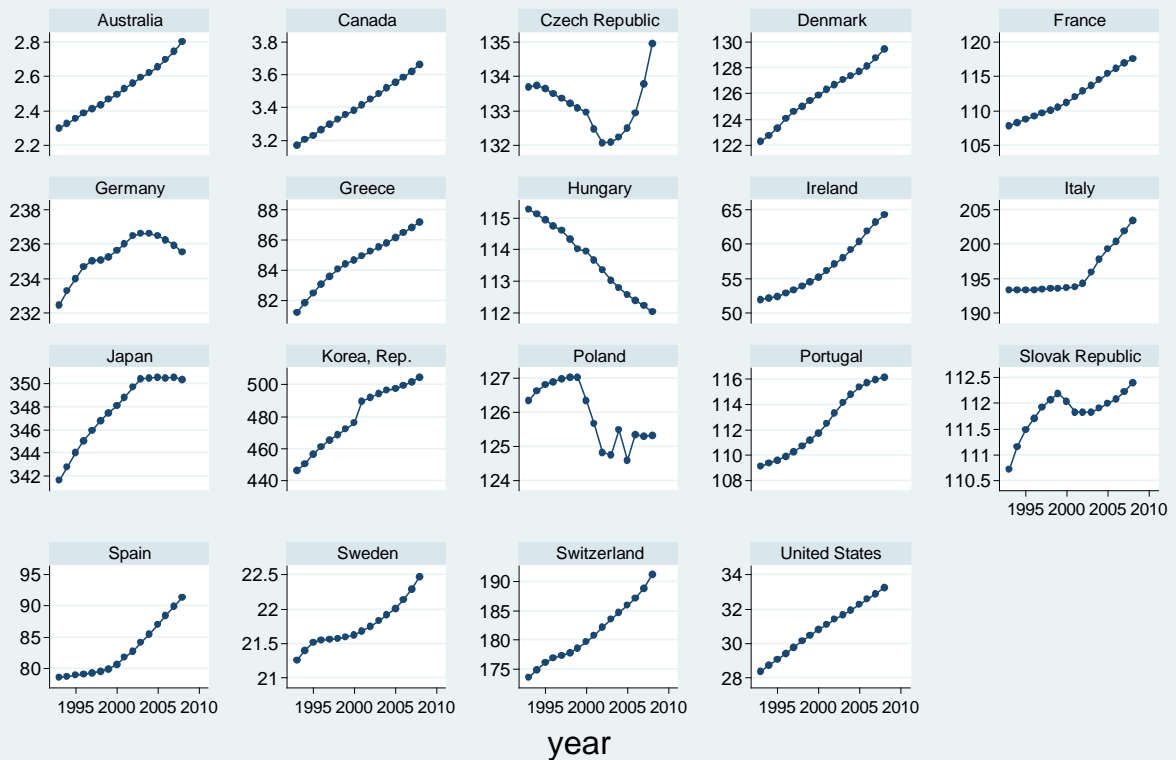
The graph below shows the relationship between the density of population and the public debt / GDP ratio over time.



**Graph 9.11** Public debt over density of population, by year (within countries).

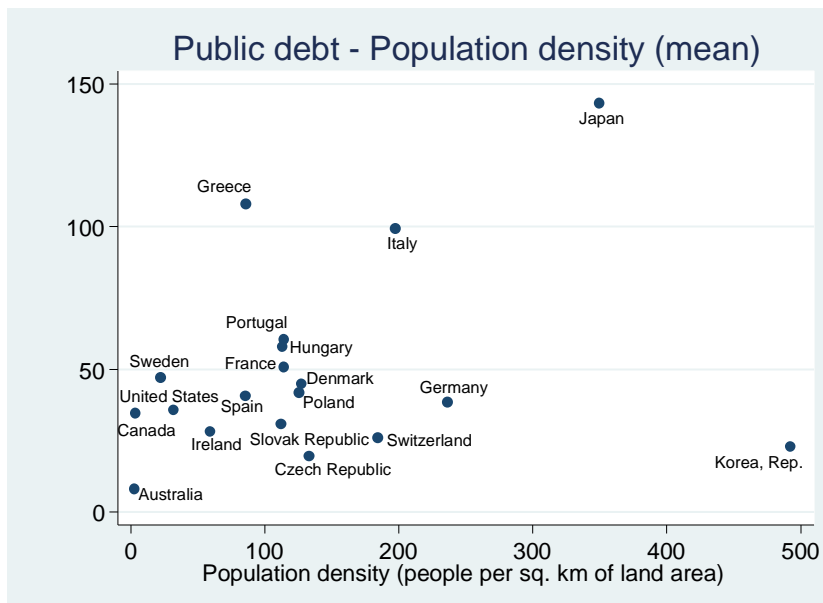
This graph seems to reflect the trend of debt over time in the majority of the countries considered. In fact, on observing the graph we can see that, in most cases, the density of population also increases or decreases in a linear way over time.

## Population density over time (people per sq. km of land area)



**Graph 9.12** Population density over time.

Now we will see whether the density of population variable has a significant impact in statistical terms on the public debt / GDP ratio. Graph 9.13 clearly shows a positive relationship between the debt and population density variable. On the next page we are going to run the usual three regressions in order to understand how the different estimation methods treat this relationship.



**Graph 9.13** Public debt over population density, means over time (between countries).

**reg debt popden**

Source	SS	df	MS	Number of obs = 190		
Model	15318.4205	1	15318.4205	F( 1, 188)	=	14.42
Residual	199750.672	188	1062.50357	Prob > F	=	0.0002
				R-squared	=	0.0712
				Adj R-squared	=	0.0663
Total	215069.092	189	1137.93171	Root MSE	=	32.596

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
popden	.076555	.0201619	3.80	0.000	.0367824	.1163277
_cons	38.95882	3.624221	10.75	0.000	31.80945	46.10818

**Table 9.11** Output of the regression public debt / GDP – population density

**xtreg debt popden, re**

Random-effects GLS regression	Number of obs	=	190
Group variable: country	Number of groups	=	19
R-sq: within = 0.0015	Obs per group: min	=	10
between = 0.0753	avg	=	10.0
overall = 0.0712	max	=	10
Random effects u_i ~ Gaussian	Wald chi2(1)	=	1.63
corr(u_i, X) = 0 (assumed)	Prob > chi2	=	0.2020

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
popden	.0788981	.0618449	1.28	0.202	-.0423157	.200112
_cons	38.63964	11.34983	3.40	0.001	16.39438	60.88491

sigma_u	33.13447
sigma_e	8.3722658
rho	.93998668 (fraction of variance due to u_i)

**Table 9.12** Output of the regression public debt / GDP – population density, RE

**xtreg debt popden, fe**

Fixed-effects (within) regression	Number of obs	=	190
Group variable: country	Number of groups	=	19
R-sq: within = 0.0015	Obs per group: min	=	10
between = 0.0753	avg	=	10.0
overall = 0.0712	max	=	10
corr(u_i, Xb) = -0.0962	F(1,170)	=	0.25
	Prob > F	=	0.6188

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
popden	.1024641	.2055384	0.50	0.619	-.3032722	.5082003
_cons	35.42953	28.0047	1.27	0.208	-19.85221	90.71127

sigma_u	32.454165
sigma_e	8.3722658
rho	.93760294 (fraction of variance due to u_i)

F test that all u_i=0:	F(18, 170) =	148.87	Prob > F =	0.0000
------------------------	--------------	--------	------------	--------

**Table 9.13** Output of the regression public debt / GDP – population density, FE

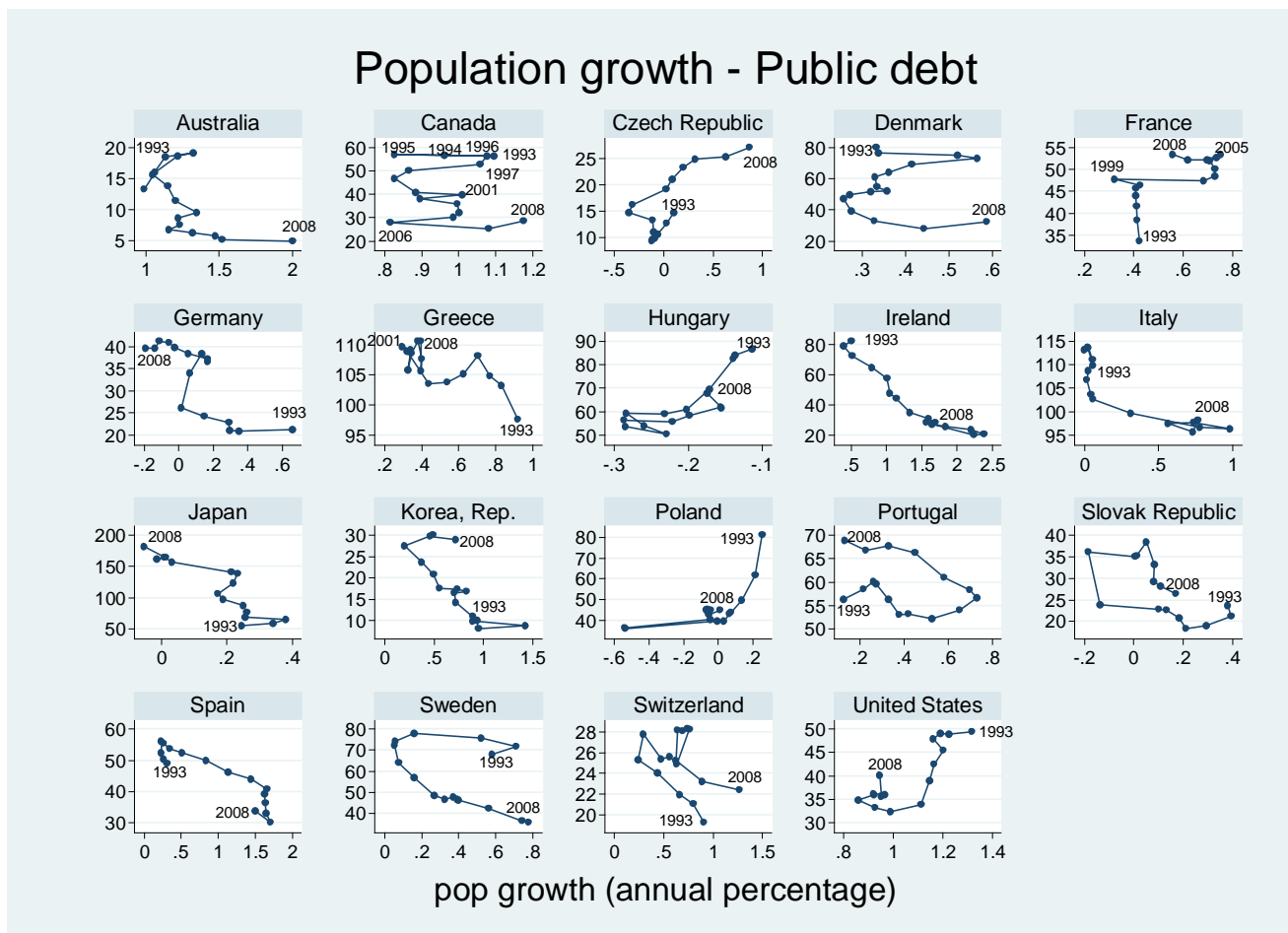
Observing the three estimates obtained using the usual three estimation methods, it can be stated that a growth in population density leads to a growth of the public debt / GDP ratio. However, looking at the pvalue we can realize that the estimation obtained using POLS is significant, but those obtained with FE and RE are not significant for the public debt. As the POLS estimation is biased, it is plausible to state that the population density is not statistically significant in explaining the public debt / GDP ratio. This is due to the different behaviors observed in Graph 9.11

## ❖ Population growth

The data relative to this variable have been taken from the World Bank website, which gives the following definition:

“Population growth rate (PGR) is the increase in a country’s population during a period of time, usually one year, expressed as a percentage of the population at the start of that period. It reflects the number of births and deaths during the period and the number of people migrating to and from a country.”

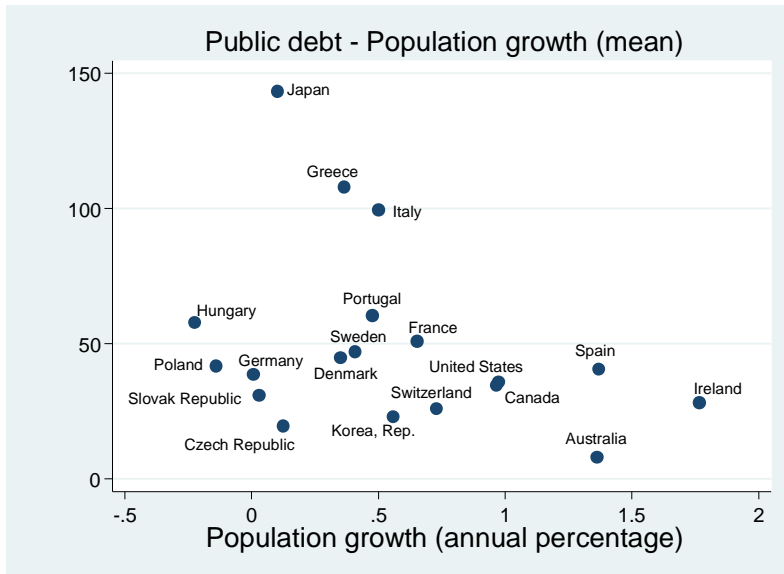
As usual, we can see a graph in which the relationship between this explanatory variable and the dependent variable over time is shown.



**Graph 9.14** Public debt over population growth rate, by year (within countries).

Here (graph 9.14) it seems complicated to see on a graph how the relationship between the two variables is similar for each country. In some countries, such as Portugal, Sweden, Switzerland and Canada, we cannot state that an increase (or a decrease) in the growth rate of the population leads to a diminution (or an augmentation) in the public debt / GDP ratio. Indeed, looking at Graph 9.15 it is plausible to state a negative relationship between population growth and public debt.





Graph 9.15 Public debt over population growth, means over time (between countries).

We will now see whether the population growth variable is statistically significant in explaining the public debt / GDP ratio.

**reg debt popgrowth**

Source	SS	df	MS			
Model	23782.0743	1	23782.0743	Number of obs =	190	
Residual	191287.018	188	1017.48414	F( 1, 188) =	23.37	
Total	215069.092	189	1137.93171	Prob > F =	0.0000	
				R-squared =	0.1106	
				Adj R-squared =	0.1058	
				Root MSE =	31.898	

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
popgrowth	-19.5327	4.040184	-4.83	0.000	-27.50262	-11.56278
_cons	60.06088	3.19837	18.78	0.000	53.75157	66.37018

Table 9.14 Output of the regression public debt / GDP – population growth

**xtreg debt popgrowth, re**

Random-effects GLS regression	Number of obs =	190	
Group variable: country	Number of groups =	19	
R-sq: within = 0.1043	Obs per group: min =	10	
between = 0.1141	avg =	10.0	
overall = 0.1106	max =	10	
Random effects u_i ~ Gaussian	Wald chi2(1) =	21.65	
corr(u_i, X) = 0 (assumed)	Prob > chi2 =	0.0000	

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
popgrowth	-12.07736	2.595665	-4.65	0.000	-17.16477	-6.989951
_cons	55.98683	7.58624	7.38	0.000	41.11807	70.85558

sigma_u	32.439636					
sigma_e	7.9294922					
rho	.94361867	(fraction of variance due to u_i)				

Table 9.15 Output of the regression public debt / GDP – population growth, RE

**xtreg debt popgrowth,fe**

```

Fixed-effects (within) regression
Group variable: country
R-sq:  within = 0.1043
      between = 0.1141
      overall = 0.1106
Number of obs   =      190
Number of groups =      19
Obs per group: min =      10
                  avg =     10.0
                  max =      10
F(1,170)       =     19.79
Prob > F       =     0.0000
corr(u_i, Xb) = 0.1428

```

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
popgrowth	-11.76835	2.645254	-4.45	0.000	-16.99012	-6.546575
_cons	55.81796	1.55579	35.88	0.000	52.74681	58.88912
sigma_u	32.003105					
sigma_e	7.9294922					
rho	.94215964	(fraction of variance due to u_i)				
F test that all u_i=0:		F(18, 170) =	159.57	Prob > F = 0.0000		

**Table 9.16** Output of the regression public debt / GDP – population growth, FE

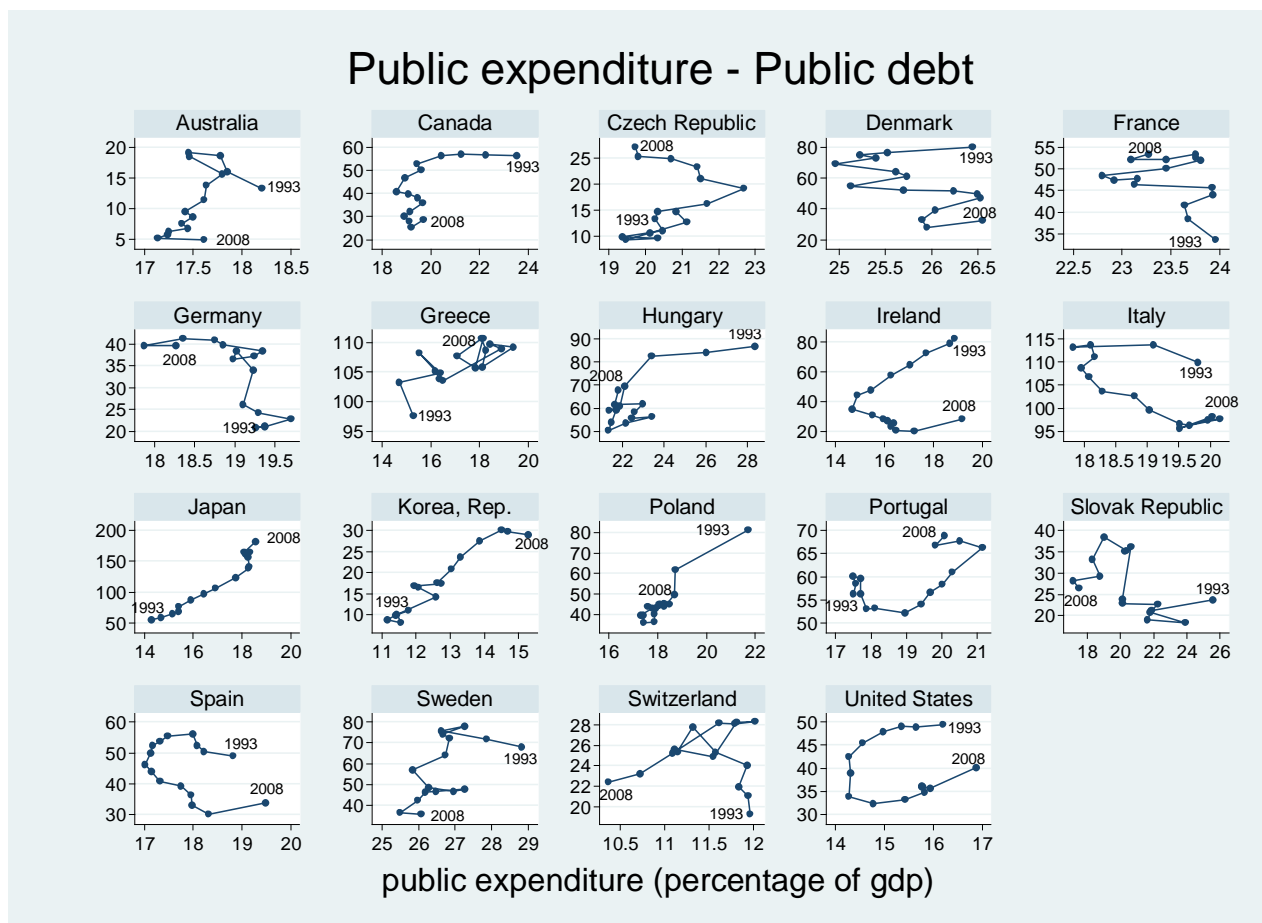
Population growth also seems to have a significant impact in statistical terms on the public debt / GDP ratio. However, since the POLS give us biased estimation, it is better to consider estimations obtained with FE and RE model. Those estimates are similar to each other because variability of the individual effects  $\sigma_c^2$  is much higher than  $\sigma_u^2$  (see panel data chapter). Thus a negative relation seems to be confirmed by all estimates.

## ❖ Public expenditure

The data relative to this variable have been taken from the oecd website, which gives the following definition:

“Public expenditure refers to spending of public authorities at all levels. Expenditure that is not directly related to education (e.g., culture, sports, youth activities, etc.) is, in principle, not included. Expenditure on education by other ministries or equivalent institutions, for example Health and Agriculture, is included.”

As usual, we will see the graph showing the relationship between the public expenditure variable and the public debt / GDP ratio over time.

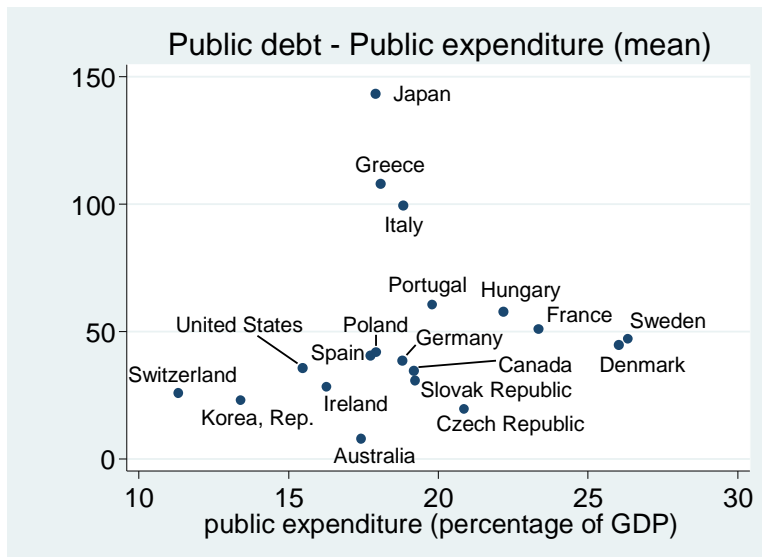


**Graph 9.16** Public debt over public expenditure, by year (within countries)..

From the graph 9.16 we are unable to state a valid general rule, as was expected from previous studies.

As far as countries such as Japan, the Republic of Korea, Poland, Portugal, Hungary, Ireland, Greece and Canada are concerned, it seems we can expect (or perceive by intuition) that an increase in public expenditure will lead to an increase in the public debt / GDP ratio.

However, for other important countries as Italy, France or Germany, we cannot make the same affirmation. This can be explained by the Keynesian theory which sustains that an increase in public expenditure is to be considered as an action that will be carried out to motivate the economy in periods of recession, and therefore lower the public debt / GDP ratio in the long term. Indeed, observing graph 9.17 a relationship between these two variables is not clear, whereas for the other variables analysed so far it is clear.



From the adjacent graph a positive relationship between public debt / GDP ratio and public expenditure seems to be present. In the following it will be shown how the different estimation methods treat this relationship.

Graph 9.17 Public debt over public expenditure, means over time (between countries).

**reg debt expend**

Source	SS	df	MS			
Model	4096.95712	1	4096.95712	Number of obs =	190	
Residual	210972.135	188	1122.19221	F( 1, 188) =	3.65	
Total	215069.092	189	1137.93171	Prob > F =	0.0576	
				R-squared =	0.0190	
				Adj R-squared =	0.0138	
				Root MSE =	33.499	

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
expend	1.246499	.6523713	1.91	0.058	-.0404095	2.533408
_cons	25.72769	12.61866	2.04	0.043	.8353358	50.62004

Table 9.17 Output of the regression public debt / GDP – public expenditure

**xtreg debt expend, re**

Random-effects GLS regression	Number of obs =	190	
Group variable: country	Number of groups =	19	
R-sq: within = 0.0279	Obs per group: min =	10	
between = 0.0187	avg =	10.0	
overall = 0.0190	max =	10	
Random effects u_i ~ Gaussian	Wald chi2(1) =	5.15	
corr(u_i, X) = 0 (assumed)	Prob > chi2 =	0.0232	

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
expend	1.757144	.7739646	2.27	0.023	.2402011	3.274087
_cons	16.03533	16.64977	0.96	0.335	-16.59761	48.66827

sigma_u	34.142909					
sigma_e	8.26076					
rho	.94469907	(fraction of variance due to u_i)				

Table 9.18 Output of the regression public debt / GDP – population growth, RE

```

xtreg debt expend,fe
Fixed-effects (within) regression           Number of obs   =       190
Group variable: country                    Number of groups =        19
R-sq:  within = 0.0279                     Obs per group:  min =        10
        between = 0.0187                    avg =          10.0
        overall = 0.0190                    max =           10
                                           F(1,170)       =        4.88
corr(u_i, Xb) = -0.0678                    Prob > F        =       0.0286
-----+-----
      debt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
      expend |   1.837095   .8319848    2.21   0.029   .1947434   3.479447
      _cons  |  14.5178    15.80296    0.92   0.360  -16.67751  45.71311
-----+-----
      sigma_u |  33.357577
      sigma_e |   8.26076
      rho     |  .94221677   (fraction of variance due to u_i)
-----+-----
F test that all u_i=0:   F(18, 170) =  162.31           Prob > F = 0.0000

```

**Table 9.19** Output of the regression public debt / GDP – population growth, FE

From the output of the single regressions we can thus state that the variables seem to explain a small part of the public debt / GDP ratio. It is possible to state, from the three estimation methods, that there is a positive relationship between the public debt / GDP ratio and public expenditure, but it is clearer by using the within variability.

## ❖ Foreign direct investment

These values have also been taken from the dataset of the oecd website, which gives the following definition:

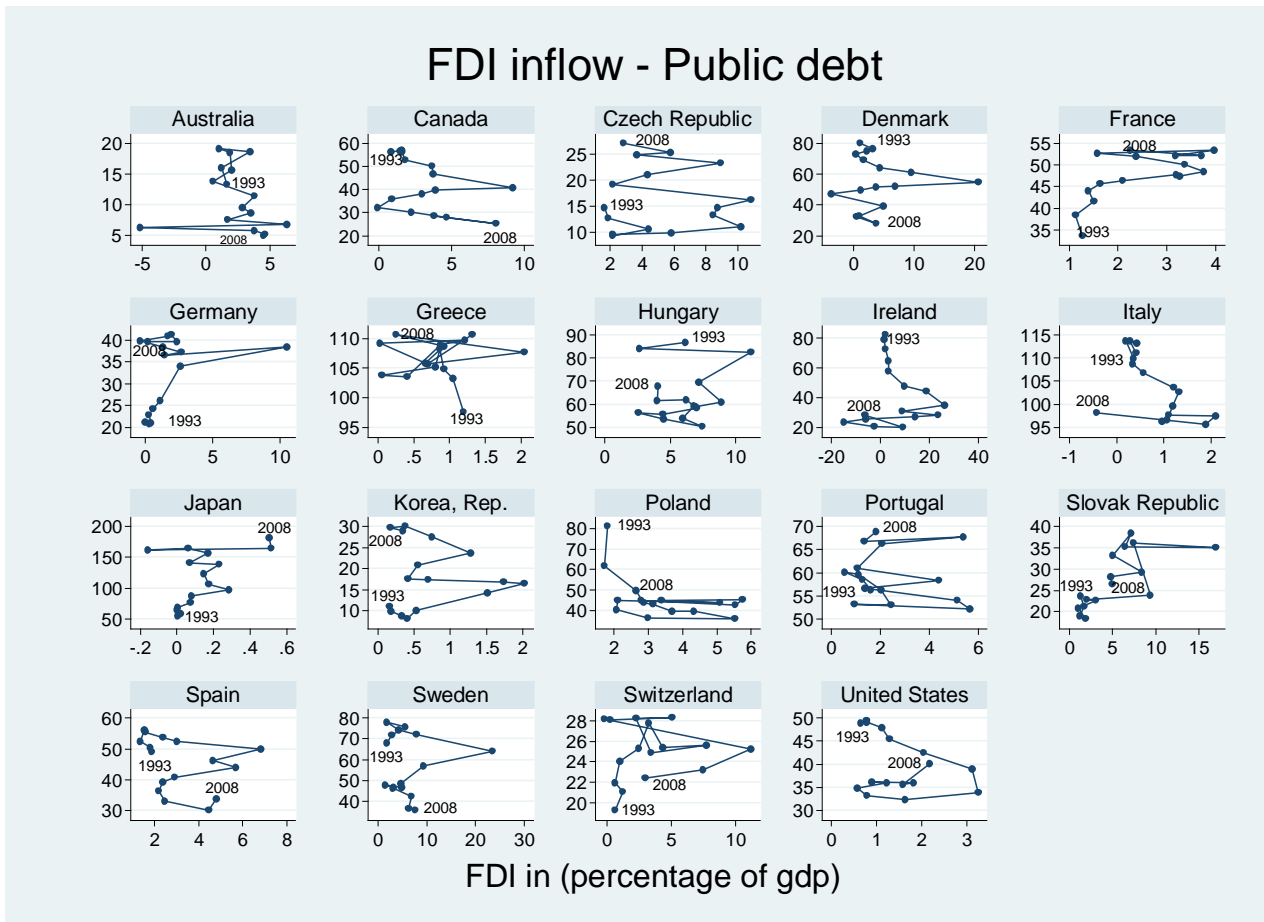
“Foreign direct investment (FDI) is a key element in international economic integration. FDI creates direct, stable and long-lasting links between economies. It encourages the transfer of technology and know-how between countries, and allows the host economy to promote its products more widely in international markets. FDI is also an additional source of funding for investment and, under the right policy environment, it can be an important vehicle for enterprise development.”

In our dataset we divided the FDI between FDI inward and FDI outward:

“Inward stocks refer to all direct investments held by non-residents in the reporting economy; outward stocks are the investments of the reporting economy held abroad. Corresponding flows relate to investment during a period of time. Negative flows generally indicate disinvestments or the impact of substantial reimbursements of inter-company loans. The FDI index gauges the restrictiveness of a country's FDI rules through four types of restrictions: foreign equity limitations; screening or approval mechanisms; restriction on key foreign employment; operational restrictions.”

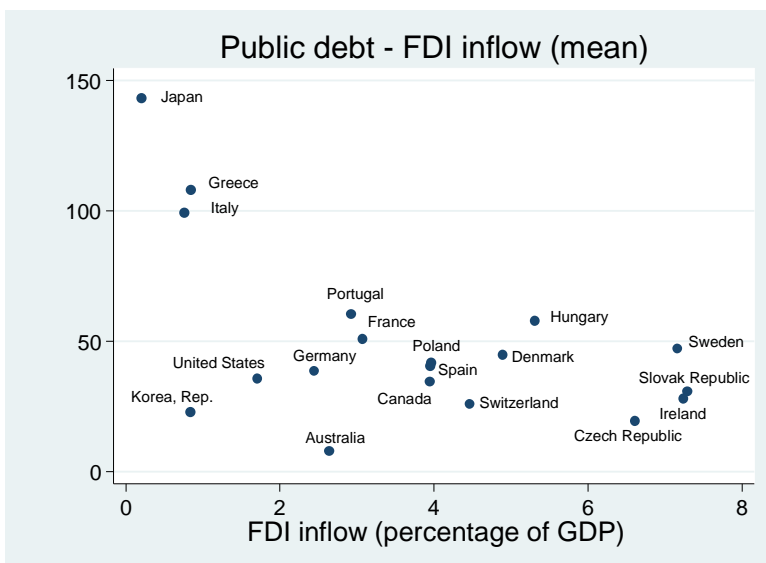
❖ Foreign direct investment (inflow)

As usual, we will see the graph showing the relationship between FDI (inflow) and the public debt / GDP ratio.



Graph 9.18 Public debt over FDI inflow, by year (within countries).

From the previous studies we expect the Foreign Direct Investment variable, net inflows (% of GDP), to affect public debt negatively. This means that we conjecture that an increase in the net inflows decreases the public debt/GDP ratio. However, from the above graph (9.18), we are not able to identify a similar relationship between these two variables for all the countries.



Graph 9.19 Public debt over FDI inflow, means over time (between countries).

Thus, we cannot understand whether there is a relationship that allows us to declare that public debt increases or decreases when FDI inflow increases. From graph 9.19 the relationship between these two variables seems to be negative. On the next page we will now see the simple regressions of FDI inflow on the public debt / DGP ratio.

```

reg debt fdiinoecd
-----+-----
Source |           SS          df           MS              Number of obs =      190
-----+-----+-----+-----
Model |    9481.50746         1    9481.50746             F( 1, 188) =      8.67
Residual |   205587.585       188   1093.55098             Prob > F      =    0.0036
-----+-----+-----+-----
Total |   215069.092       189   1137.93171             R-squared     =    0.0441
                                           Adj R-squared =    0.0390
                                           Root MSE     =   33.069
-----+-----
debt |           Coef.      Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----+-----+-----
fdiinoecd |   -1.50864      .5123498    -2.94  0.004    -2.519334   -.4979471
_cons |    54.99273     3.06265    17.96  0.000     48.95116    61.03431
-----+-----

```

**Table 9.20** Output of the regression public debt / GDP – FDI inflows

```

xtreg debt fdiinoecd, re
Random-effects GLS regression              Number of obs   =      190
Group variable: country                   Number of groups =      19
R-sq:  within = 0.0265                    Obs per group:  min =     10
      between = 0.2798                      avg             =    10.0
      overall  = 0.0441                      max             =     10

Random effects u_i ~ Gaussian              Wald chi2(1)    =      3.97
corr(u_i, X) = 0 (assumed)                 Prob > chi2     =    0.0462
-----+-----
debt |           Coef.      Std. Err.      z    P>|z|     [95% Conf. Interval]
-----+-----+-----+-----
fdiinoecd |   .2943637     .1476497     1.99  0.046     .0049756     .5837518
_cons |   48.29324     6.860891     7.04  0.000     34.84614     61.74034
-----+-----
sigma_u |  29.219096
sigma_e |  8.2665879
rho |   .92588974   (fraction of variance due to u_i)
-----+-----

```

**Table 9.21** Output of the regression public debt / GDP – FDI inflows, RE

```

xtreg debt fdiinoecd, fe
Fixed-effects (within) regression          Number of obs   =      190
Group variable: country                   Number of groups =      19
R-sq:  within = 0.0265                    Obs per group:  min =     10
      between = 0.2798                      avg             =    10.0
      overall  = 0.0441                      max             =     10

corr(u_i, Xb) = -0.2579                    F(1,170)       =      4.63
                                           Prob > F       =    0.0328
-----+-----
debt |           Coef.      Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----+-----+-----
fdiinoecd |   .3129803     .1454674     2.15  0.033     .0258253     .6001353
_cons |   48.22407     .8073575    59.73  0.000     46.63033     49.81781
-----+-----
sigma_u |  33.976626
sigma_e |  8.2665879
rho |   .94411236   (fraction of variance due to u_i)
-----+-----
F test that all u_i=0:   F(18, 170) =   157.69              Prob > F = 0.0000

```

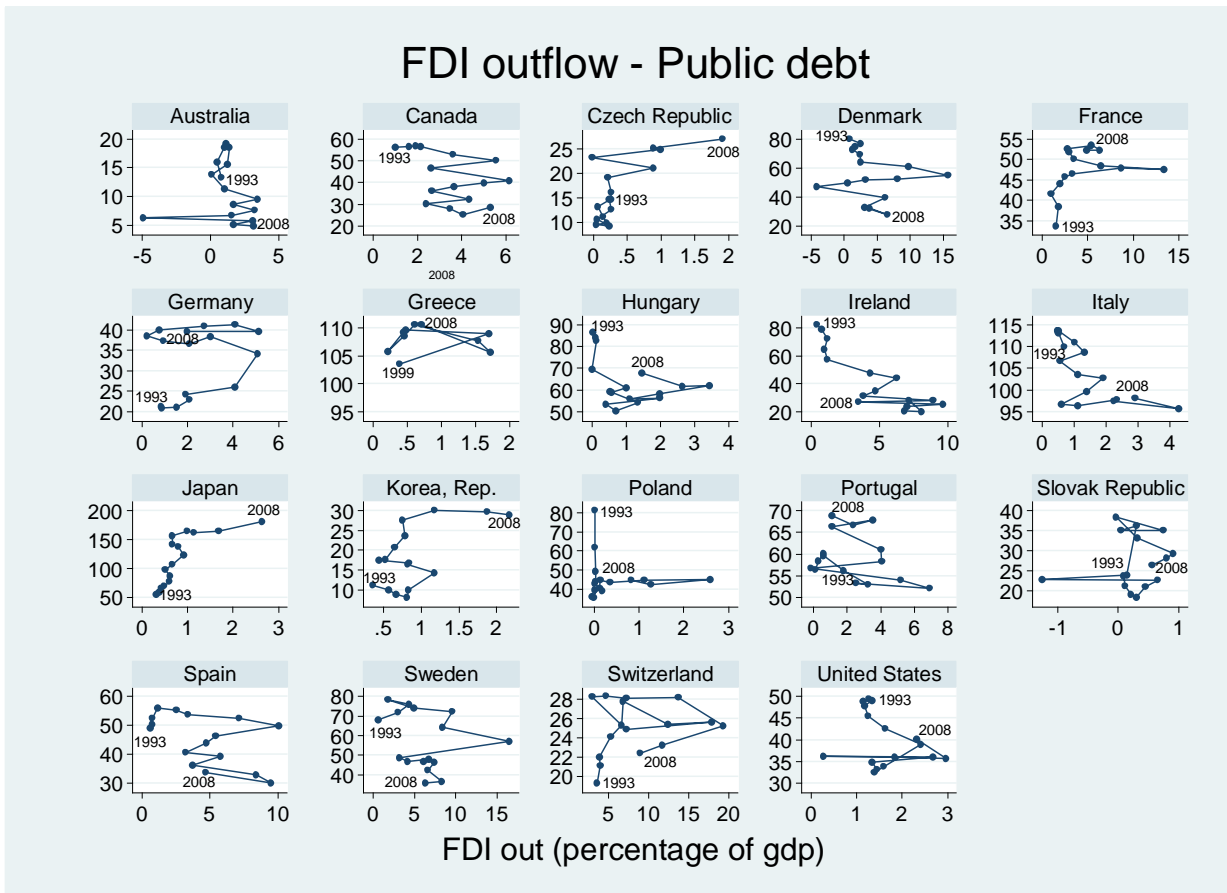
**Table 9.22** Output of the regression public debt / GDP – FDI inflows, FE

The FDI inflow variable alone also seems to explain the public debt / GDP ratio, in fact the three coefficient estimates obtained are all statistically significant. Observing the estimation values of the coefficients it can be noted that  $\hat{\beta}_{RE} \approx \hat{\beta}_{FE}$ , because of the variability of the individual effects  $\sigma_c^2$  is much higher than  $\sigma_u^2$  (see section 7.b). The pooled value of OLS estimates is different, the sign even changes, meaning that when the FE and RE model is used the FDI inflow has a positive effect on the public debt / GDP ratio. On the other hand, using the POLS this impact is negative. This fact is due to the correlation of the fixed effects that were not considered in the regression.



❖ Foreign direct investment (outflow)

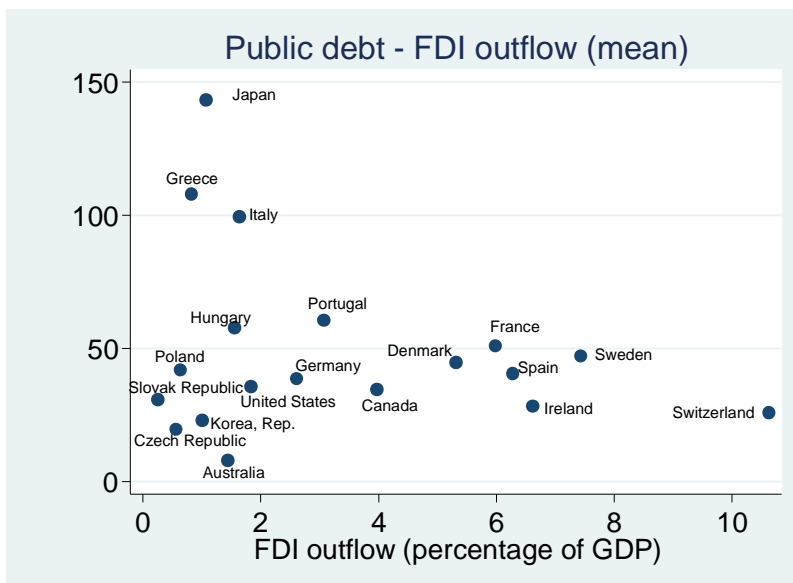
The following graph shows the relationship between public debt and FDI outflow.



Graph 9.20 Public debt over FDI outflow, by year (within countries).

Obviously, we expect that an increase in the net outflows positively affects the public debt/GDP ratio. An increase of these net outflows causes an increase in the public debt.

However, in the above graph a common relationship between the public debt / GDP ratio for all the countries analysed cannot be found, while a negative relationship emerges from graph 9.21. On the next page it will be shown how the different estimation methods treat this relationship.



Graph 9.21 Public debt over FDI outflow, means over time (between countries).

The following shows the output of the single regressions between the public debt / GDP ratio and FDI outflow.

```

reg debt fdioutoecd
Source |          SS          df          MS          Number of obs =      190
-----+-----
Model |    5901.9614         1    5901.9614    F( 1, 188) =      5.30
Residual |   209167.131       188   1112.59112    Prob > F      =  0.0224
-----+-----
Total |   215069.092       189   1137.93171    R-squared     =  0.0274
                                           Adj R-squared =  0.0223
                                           Root MSE     =  33.356

-----+-----
debt |          Coef.      Std. Err.      t      P>|t|      [95% Conf. Interval]
-----+-----
fdioutoecd |   -1.523059      .6612815     -2.30   0.022    -2.827544   -.2185738
_cons |    54.43263     3.264187     16.68   0.000    47.99349    60.87177

```

**Table 9.23** Output of the regression public debt / GDP – FDI outflows

```

xtreg debt fdioutoecd, re
Random-effects GLS regression           Number of obs      =      190
Group variable: country                 Number of groups   =       19

R-sq:  within = 0.0058                  Obs per group: min =       10
      between = 0.0548                    avg              =      10.0
      overall = 0.0274                    max              =       10

Random effects u_i ~ Gaussian           Wald chi2(1)       =       0.80
corr(u_i, X) = 0 (assumed)              Prob > chi2        =      0.3712

-----+-----
debt |          Coef.      Std. Err.      z      P>|z|      [95% Conf. Interval]
-----+-----
fdioutoecd |   .2345944      .262316     0.89   0.371    -.2795355   .7487243
_cons |    48.60985     7.76236     6.26   0.000    33.39591    63.8238

sigma_u |   33.502905
sigma_e |   8.3540687
rho |   .9414625      (fraction of variance due to u_i)

```

**Table 9.24** Output of the regression public debt / GDP – FDI outflows, RE

```

xtreg debt fdioutoecd, fe
Fixed-effects (within) regression       Number of obs      =      190
Group variable: country                 Number of groups   =       19
R-sq:  within = 0.0058                  Obs per group: min =       10
      between = 0.0548                    avg              =      10.0
      overall = 0.0274                    max              =       10

                                           F(1,170)          =       0.99
corr(u_i, Xb) = -0.1987                  Prob > F           =      0.3209

-----+-----
debt |          Coef.      Std. Err.      t      P>|t|      [95% Conf. Interval]
-----+-----
fdioutoecd |   .2622422      .2634295     1.00   0.321    -.2577721   .7822565
_cons |    48.51826     1.062502    45.66   0.000    46.42087    50.61566

sigma_u |   33.781331
sigma_e |   8.3540687
rho |   .94236807      (fraction of variance due to u_i)

F test that all u_i=0:      F(18, 170) =    157.06          Prob > F = 0.0000

```

**Table 9.25** Output of the regression public debt / GDP – FDI outflows, FE

After observing the outputs from the FE and RE methods we can state that the FDI outflow variable does not seem to explain the public debt / GDP ratio. As known the estimates obtained with POLS methods is surely biased and counter intuitive.

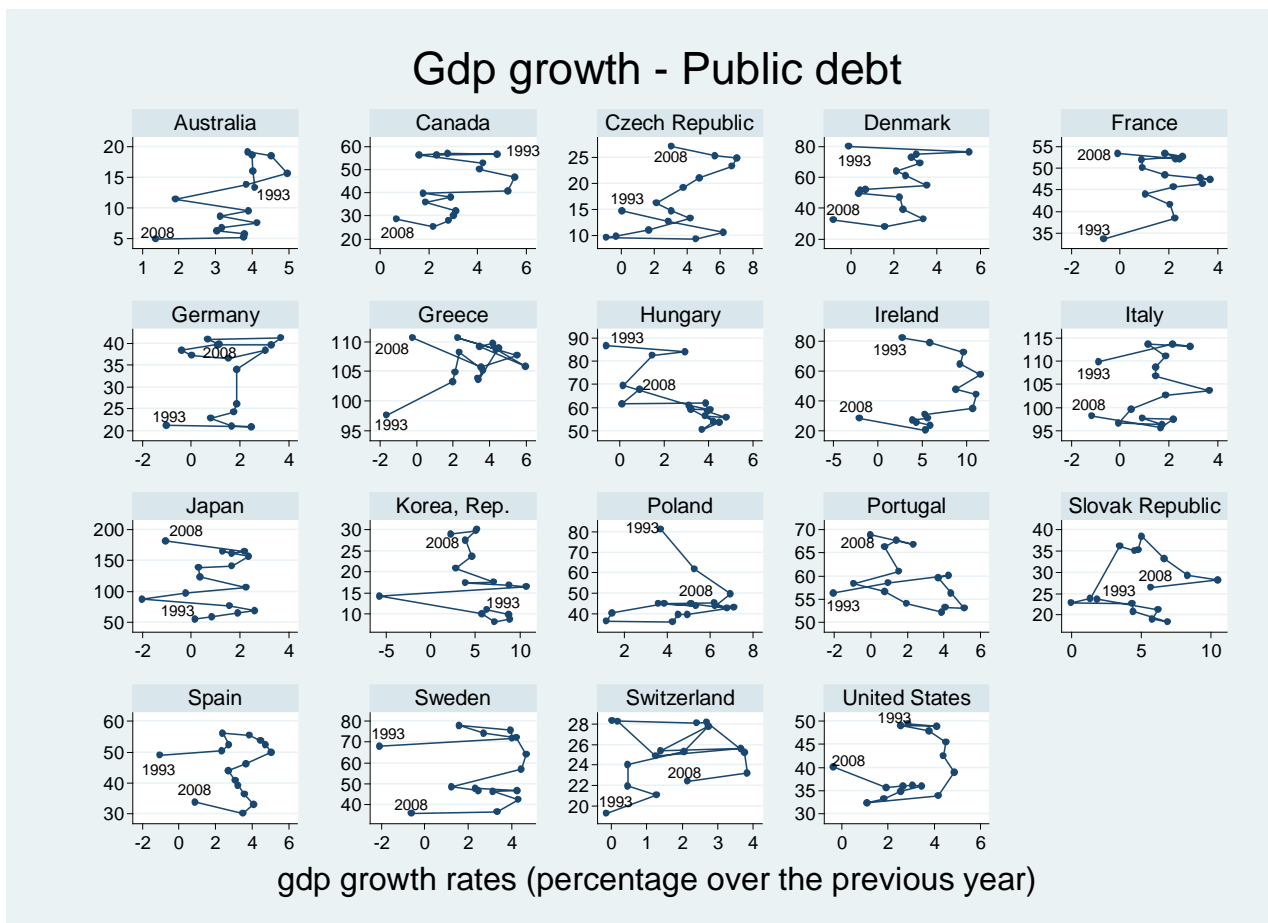
## ❖ GDP growth rate

This data is taken from the oecd website, which gives the following definition:

“Gross domestic product is an aggregate measure of production equal to the sum of the gross values added of all resident institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs). The sum of the final uses of goods and services (all uses except intermediate consumption) measured in purchasers' prices, less the value of imports of goods and services, or the sum of primary incomes distributed by resident producer units.”

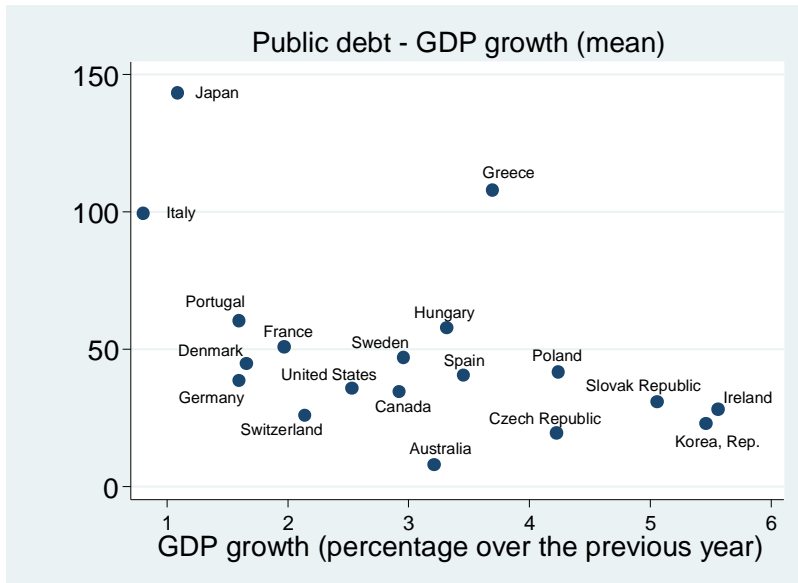
The GDP growth is calculated as the percentage difference compared to the previous year.

The following graph shows the relationship between the public debt /GDP ratio and the GDP growth rate over time.



**Graph 9.22** Public debt over GDP growth rate, by year (within countries).

It is natural to think that an increase on the variable GDP growth rate reduces the public debt/GDP ratio. However, it does not seem possible to state this after observing the graphs for each country. Indeed, it seems possible to state that by looking at graph 9.23.



Graph 9.23 Public debt over GDP growth rate, means over time (between countries).

The outputs of single regressions are shown below:

```
reg debt gdpgrow
```

Source	SS	df	MS			
Model	15593.9493	1	15593.9493	Number of obs =	190	
Residual	199475.143	188	1061.038	F( 1, 188) =	14.70	
Total	215069.092	189	1137.93171	Prob > F =	0.0002	
				R-squared =	0.0725	
				Adj R-squared =	0.0676	
				Root MSE =	32.574	

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
gdpgrow	-4.094604	1.068069	-3.83	0.000	-6.201544	-1.987664
_cons	61.87481	4.02432	15.38	0.000	53.93618	69.81343

Table 9.26 Output of the regression public debt / GDP - GDPgrowth rate.

```
xtreg debt gdpgrow, re
```

Random-effects GLS regression

Group variable: country

R-sq: within = 0.0097  
between = 0.2323  
overall = 0.0725

Number of obs = 190  
Number of groups = 19  
Obs per group: min = 10  
avg = 10.0  
max = 10

Random effects u\_i ~ Gaussian  
corr(u\_i, X) = 0 (assumed)

Wald chi2(1) = 1.25  
Prob > chi2 = 0.2635

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
gdpgrow	.390963	.3496771	1.12	0.264	-.2943916	1.076318
_cons	48.19466	7.112026	6.78	0.000	34.25534	62.13397

sigma_u	30.173095					
sigma_e	8.3378272					
rho	.92905717	(fraction of variance due to u_i)				

Table 9.27 Output of the regression public debt / GDP - GDP growth rate, RE

**xtreg debt gdpgrow,fe**

Fixed-effects (within) regression  
Group variable: country  
R-sq: within = 0.0097  
      between = 0.2323  
      overall = 0.0725  
corr(u\_i, Xb) = -0.3045

Number of obs = 190  
Number of groups = 19  
Obs per group: min = 10  
                  avg = 10.0  
                  max = 10  
F(1,170) = 1.66  
Prob > F = 0.1996

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
gdpgrow	.445931	.346338	1.29	0.200	-.2377459	1.129608
_cons	48.02701	1.217206	39.46	0.000	45.62423	50.4298
sigma_u	33.897913					
sigma_e	8.3378272					
rho	.94295088	(fraction of variance due to u_i)				

F test that all u\_i=0: F(18, 170) = 149.96 Prob > F = 0.0000

**Table 9.28** Output of the regression public debt / GDP – GDP growth rate, FE

The GDP growth rate does not seem to affect the public debt / GDP ratio negatively. When the GDP growth rate rises, it is possible to think that the public debt/ GDP ratio will decrease. The FE and RE estimations do not however seem to be statistically significant and the sign of the coefficient is not as expected. It will be interesting to see whether this variable becomes significant in the model we will estimate with multiple regressions.

## 9.d Summary of the preliminary analysis

We will now summarize what has been discovered in the above preliminary analysis.

We created the following table showing the results of the simple regressions carried out in terms of significance of the parameters.

variables	Simple regressions			
	ols	re	fe	expected
<b>Population over 65</b>	+	+	+	+
<b>population density</b>	+	(n) +	(n) +	?
<b>population growth</b>	-	-	-	-
<b>expenditure</b>	(n) +	+	+	+
<b>FDI in (oecd)</b>	-	+	+	-
<b>FDI out(oecd)</b>	-	(n) +	(n) +	+
<b>Balance of payments (oecd)</b>	(n) -	(n) +	(n) +	-
<b>GDP growth</b>	-	(n) +	(n) +	-
<b>inflation</b>	-	(n) -	(n) -	?

In this table (n) stands for a non-significant variable.

“?” stands for an unclear relationship between the independent variable and the public debt/GDP ratio.

The plus and minus signs show the slope of the regression line.

**Table 9.29** Results of all the single regressions.

As far as the relationship between the independent variables and the public debt / GDP ratio is concerned, we can make the following summary:

- ❖ **POPULATION OVER 65:** there is a linear relationship between the population over 65 and the public debt / GDP variable for most of the countries analysed. In the majority of the cases, the relationship seems to be positive (for 12 countries), whereas for another 5 countries (including Italy) it is negative. A relationship between population over 65 and the public debt / GDP ratio can be noted observing both the between and within variability (positive). (see graphs 9.8 and 9.10)
- ❖ **DENSITY OF POPULATION:** here there also seems to be a more or less linear relationship, as there is for the population over 65. (see graphs 9.11 and 9.13)
- ❖ **POPULATION GROWTH:** there seems to be a linear relationship common to most of the countries observed: an increase in the growth rate of the population leads to a decrease in the public debt / GDP ratio in 12 countries, and an increase in the other 5 countries; using between information a more clear relationship between public debt/GDP and population growth can be noted. From the between variability a negative relationship emerged. (see graphs 9.14 and 9.15)
- ❖ **PUBLIC EXPENDITURE:** there is a clear positive relationship between the public expenditure variable and the public debt / GDP ratio using the within variability. This relationship cannot to be observed using the between variability; (see graphs 9.16 and 9.17)
- ❖ **FOREIGN DIRECT INVESTMENT (INFLOW):** there seems to be no relationship between the public debt / GDP ratio and FDI inflow variables; a negative relationship can be observed using the between variability. (see graphs 9.18 and 9.19)
- ❖ **FOREIGN DIRECT INVESTMENT (OUTFLOW):** there seems to be no common relationship between FDI outflow and the public debt / GDP ratio for all the countries analysed; a negative relationship emerged observing the between information. (see graphs 9.20 and 9.21)
- ❖ **BALANCE OF PAYMENTS:** there seems to be no relationship between the public debt / GDP ratio observing both within and between information. (see graphs 9.5 and 9.6)

- ❖ GDP GROWTH RATE: it is not possible to highlight a common linear relationship between the public debt / GDP ratio and GDP growth rate in most of the countries analysed. Using the between information it is possible to see a negative relationship between the public debt / GDP ratio and the GDP growth rate . (see graphs 9.22 and 9.23)
- ❖ INFLATION : there does not seem to be a relationship between the public debt / GDP ratio and the inflation rate for the within variability, while it seems to exist for the between information(negative). (see graphs 9.2 and 9.3)

These above observations, coming from the graphs, do not always correspond with the results obtained in the simple regressions summarized in table 9.29 .





# 10. Econometric model

As carried out previously, we will try to create three different models in order to explain the public debt / GDP ratio, using the three different methods explained in the panel data chapter.

## 10.a Pooled OLS model

Using the following command in Stata, we obtained the results set out below:

```
reg debt pop65 popden popgrowth expend fdiinoecd fdioutoecd curaccoecd gdpgrow
inflation, robust
```

```
Linear regression                                Number of obs =      190
                                                F( 9, 180) =      30.26
                                                Prob > F          =      0.0000
                                                R-squared        =      0.6129
                                                Root MSE       =      21.507
```

debt	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	8.605045	.8943621	9.62	0.000	6.840262	10.36983
popden	.0790408	.0158357	4.99	0.000	.0477933	.1102883
popgrowth	-1.563786	3.088904	-0.51	0.613	-7.658907	4.531334
expend	-.2362898	.3996968	-0.59	0.555	-1.024984	.5524042
fdiinoecd	-.0501376	.4101978	-0.12	0.903	-.8595525	.7592773
fdioutoecd	-1.358355	.554251	-2.45	0.015	-2.45202	-.2646901
curaccoecd	-1.01143	.3840255	-2.63	0.009	-1.769201	-.2536588
gdpgrow	1.243748	.8505371	1.46	0.145	-.4345582	2.922054
inflation	-.8761197	.8285954	-1.06	0.292	-2.51113	.7588902
_cons	-82.74268	15.30741	-5.41	0.000	-112.9477	-52.53763

**Table 10.1** Output of the multiple regression on public debt / GDP with all variable, POLS

Eliminating the non-significant variables at a 5% level, we obtained the following estimated model

```
reg debt pop65 popden fdioutoecd curaccoecd, robust
```

```
Linear regression                                Number of obs =      190
                                                F( 4, 185) =      56.21
                                                Prob > F          =      0.0000
                                                R-squared        =      0.6044
                                                Root MSE       =      21.444
```

debt	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	8.318302	.6627401	12.55	0.000	7.010802	9.625802
popden	.0865824	.0137512	6.30	0.000	.0594532	.1137117
fdioutoecd	-1.294725	.5026329	-2.58	0.011	-2.286354	-.3030953
curaccoecd	-.9530034	.322357	-2.96	0.004	-1.588972	-.317035
_cons	-83.85967	10.03228	-8.36	0.000	-103.652	-64.06728

**Table 10.2** Output of the multiple regression on public debt / GDP with only significant variables, POLS

The following is the model obtained using the pooled OLS method:

$$(10.1) \quad \frac{\text{debt}}{\text{gdp}} \% = -83.86 + 8.318 * \text{pop65} + 0.087 * \text{popden} - 1.295 * \text{fdiout} - 0.953 * \text{curracc} + \varepsilon$$

## 10.b Fixed effects method

Estimating the model for the public debt / GDP ratio in Stata using the fixed effects method, we obtained the following output:

```

xtreg debt pop65 popden popgrowth expend fdiin fdiout curacc gdpgrow infl, fe
Fixed-effects (within) regression      Number of obs   =      190
Group variable: country                Number of groups =      19

R-sq:  within = 0.4243                  Obs per group:  min =      10
      between = 0.0027                      avg =     10.0
      overall = 0.0017                      max =      10

corr(u_i, Xb) = -0.9320                  F(9,162)       =     13.27
                                          Prob > F       =     0.0000
-----+-----
      debt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
      pop65 |   7.262538   .8991022     8.08  0.000     5.487067    9.038009
      popden |  -0.6515275  .2275663    -2.86  0.005    -1.100906   -0.2021488
      popgrowth | -9.733813   2.341221    -4.16  0.000   -14.35706   -5.110568
      expend |   2.665998   .8467599     3.15  0.002     .993888    4.338108
      fdiin  |   .1708323   .131241     1.30  0.195    -.0883315    .429996
      fdiout |   .0399842   .2196386     0.18  0.856    -.3937396    .4737079
      curacc |  -0.2297955  .2787048    -0.82  0.411    -.7801583    .3205674
      gdpgrow |   .8048876   .3624146     2.22  0.028     .0892217    1.520553
      infl   |   .3004342   .403143     0.75  0.457    -.4956587    1.096527
      _cons  | -20.07748   26.90006    -0.75  0.457   -73.19745    33.0425
-----+-----
      sigma_u |   93.77147
      sigma_e |    6.5120587
      rho     |   .99520039   (fraction of variance due to u_i)
-----+-----
F test that all u_i=0:      F(18, 162) =    100.08          Prob > F = 0.0000
-----+-----

```

**Table 10.3** Output of the multiple regression on public debt / GDP with all variables, FE

Eliminating, as usual, the non-significant variables, we obtained the following:

```

xtreg debt pop65 popden popgrowth expend gdpgrow, fe
Fixed-effects (within) regression      Number of obs   =      190
Group variable: country                Number of groups =      19

R-sq:  within = 0.4107                  Obs per group:  min =      10
        between = 0.0004                  avg =      10.0
        overall = 0.0001                  max =      10
                                           F(5,166)       =      23.14
                                           Prob > F        =      0.0000

corr(u_i, Xb) = -0.9095
-----+-----
      debt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
      pop65 |   7.006687   .8561314     8.18  0.000     5.316377     8.696996
      popden |  -0.5571161   .2089698    -2.67  0.008    -0.9696973    -0.1445349
  popgrowth | -10.34044    2.242162    -4.61  0.000    -14.76727    -5.913607
      expend |   2.486169   .813646     3.06  0.003     .8797405     4.092597
      gdpgrow |  .8186932   .3217089     2.54  0.012     .1835248     1.453862
      _cons | -23.4242    25.13398    -0.93  0.353    -73.04766     26.19926
-----+-----
      sigma_u | 81.754856
      sigma_e |  6.5087768
      rho     | .99370164   (fraction of variance due to u_i)
-----+-----
F test that all u_i=0:      F(18, 166) =   116.56      Prob > F = 0.0000
-----+-----

```

**Table 10.4** Output of the multiple regression on public debt / GDP with only significant variables, FE

The following is the model obtained using the fixed effects method:

$$(10.2) \quad \frac{\text{debt}}{\text{gdp}} \% = -23.424 + 7.007 * \text{pop65} - 0.557 * \text{popden} - 10.34 * \text{popgrowth} + 2.486 * \text{expend} + 0.819 * \text{gdpgrowth} + \varepsilon$$

## 10.c Random effects method

We obtained the following output using the random effects method:

**xtreg debt pop65 popden popgrowth expend fdiinoecd fdioutoecd curaccoecd gdpgrow inflation, re**

```
Random-effects GLS regression      Number of obs   =      190
Group variable: country           Number of groups =       19

R-sq:  within = 0.3892            Obs per group:  min =       10
        between = 0.4800                avg   =      10.0
        overall = 0.4750                max   =       10
```

```
Random effects u_i ~ Gaussian      Wald chi2(9)    =    118.90
corr(u_i, X) = 0 (assumed)        Prob > chi2     =     0.0000
```

	debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
pop65		6.145646	.7589186	8.10	0.000	4.658193	7.633099
popden		.0436237	.0510506	0.85	0.393	-.0564335	.143681
popgrowth		-10.81526	2.317565	-4.67	0.000	-15.35761	-6.272919
expend		1.486112	.7635251	1.95	0.052	-.0103698	2.982594
fdiino		.1886551	.1333312	1.41	0.157	-.0726693	.4499796
fdiout		-.039844	.2222789	-0.18	0.858	-.4755026	.3958145
curacc		-.0058527	.2582497	-0.02	0.982	-.5120129	.5003074
gdpgrow		.8320571	.3602543	2.31	0.021	.1259715	1.538143
inflation		.0372168	.4009477	0.09	0.926	-.7486263	.8230599
_cons		-73.87861	19.25633	-3.84	0.000	-111.6203	-36.13689
sigma_u		26.253336					
sigma_e		6.5120587					
rho		.94203892	(fraction of variance due to u_i)				

**Table 10.5** Output of the multiple regression on public debt / GDP with all variables, RE

Excluding the non-significant variables in the previous regression, we obtained the following:

**xtreg debt pop65 popgrowth gdpgrow, re**

```
Random-effects GLS regression      Number of obs   =      190
Group variable: country           Number of groups =       19

R-sq:  within = 0.3650            Obs per group:  min =       10
        between = 0.5009                avg   =      10.0
        overall = 0.4930                max   =       10
```

```
Random effects u_i ~ Gaussian      Wald chi2(3)    =    113.22
corr(u_i, X) = 0 (assumed)        Prob > chi2     =     0.0000
```

	debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
pop65		6.509979	.7213216	9.03	0.000	5.096215	7.923744
popgrowth		-11.87043	2.189851	-5.42	0.000	-16.16246	-7.578401
gdpgrow		.6028089	.2800535	2.15	0.031	.0539141	1.151704
_cons		-43.21035	12.47351	-3.46	0.001	-67.65798	-18.76272
sigma_u		25.729341					
sigma_e		6.7156814					
rho		.93621777	(fraction of variance due to u_i)				

**Table 10.6** Output of the multiple regression on public debt / GDP with only significant variables.RE

The following is the model obtained using the random effects method:

$$(10.3) \quad \frac{\text{debt}}{\text{gdp}} \% = -43.21 + 6.51 * \text{pop65} - 11.87 * \text{popgrowth} + 0.603 * \text{gdpgrowth} + \varepsilon$$

We then carried out the Hausman test (table10.7) to ascertain whether it was better to use the random effects or the fixed effects method.

**hausman fe re**

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
pop65	7.262538	6.145646	1.116892	.4821071
popden	-.6515275	.0436237	-.6951513	.2217662
popgrowth	-9.733813	-10.81526	1.081449	.3319743
expend	2.665998	1.486112	1.179886	.3661034
fdiinoecd	.1708323	.1886551	-.0178229	.
fdioutoecd	.0399842	-.039844	.0798282	.
curaccoecd	-.2297955	-.0058527	-.2239427	.1048021
gdpgrow	.8048876	.8320571	-.0271695	.0395116
inflation	.3004342	.0372168	.2632174	.0420146

```

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
      chi2(9) = (b-B)'[(V_b-V_B)^(-1)](b-B)
              =      13.61
      Prob>chi2 =      0.1369
      (V_b-V_B is not positive definite)

```

**Table 10.7** Output of the Hausman test

On observing the usual value for verifying the null hypothesis, we would be led to saying that the best model is the one obtained with RE. However, this test is not correct as, on observing the final column in the above table, we can see that two values are missing. This omission is due to the negative difference between the  $Var(FE)$  and  $Var(RE)$ , which can never be negative as it is a variance.

Remember that Hausman showed:  $Var(\widehat{\beta}_{FE} - \widehat{\beta}_{RE}) = Var(\widehat{\beta}_{FE}) - Var(\widehat{\beta}_{RE})$ . (see section 7.b)

We can create single t-tests in order to observe parameter by parameter whether the best model is FE or RE (using the  $(\widehat{\beta}_{FE} - \widehat{\beta}_{RE})/S.E.$  ratio). The values resulting from the latter are all higher than 2 (excepting GDP growth rate), and so we can say that the best model to use is the Fixed effects one. For further details see the chapter on panel data.

The final model is set out below (10.2):

$$\frac{debt}{gdp} \% = -23.424 + 7.007 * pop65 - 0.557 * popden - 10.34 * popgrowth + 2.486 * \\ \text{expend} + 0.819 * gdpgrowth + \varepsilon$$

## 10.d Comments on the results

Observing the previous model of the regression formed with all the variables together, it can be seen how some variables are no longer significant, whereas they were statistically significant in the single regressions in explaining the public debt / GDP ratio.

In order to examine more closely what has just been stated, and to highlight the differences between the simple and multiple results in terms of their statistical significance, the following table has been created.

Variables	Simple regression			Multiple regression		
	ols	re	fe	ols	re	fe
Population over 65	+	+	+	+	+	+
Population density	+	(n) +	(n) +	+	(n) +	–
Population growth	–	–	–	(n) –	–	–
Public expenditure	(n) +	+	+	(n) –	(n) +	+
FDI in	–	+	+	(n) –	(n) +	(n) +
FDI out	–	(n) +	(n) +	–	(n) –	(n) +
Balance of payments	(n) –	(n) +	(n) +	–	(n) –	(n) –
GDP growth	–	(n) +	(n) +	(n) +	+	+
Inflation	–	(n) –	(n) –	(n) –	(n) +	(n) +

**Table 10.8** Results of the simple and multiple regressions

The fixed effects and random effects estimations always turned out to be in line in the simple regressions. This is because, as explained in the chapter on panel data, the RE estimator can be seen as a weighted average between the within transformation and the between transformation. The weight depends on the error variability due to individual effects, and on the variability of the idiosyncratic error. In our analysis we always obtained a much higher variability due to the individual effects than due to that of the idiosyncratic error. For this reason the results of the FE and RE estimations are more or less equal.

Again focusing on simple regressions. There are variables where the coefficients estimated with the POLS models seem to have a negative impact on the public debt, while the impact seems to be positive when estimated with FE and RE. Examples of this are the GDP growth rate, balance of payments, FDI outflow and inflow variables.

The differences between the estimations obtained with the POLS method and those of the FE and RE methods are due to the biased POLS estimations. The POLS model, in fact, does not consider the correlation in the composite error because of the presence of individual effects ( $c_i$ ).

On observing the differences obtained between the results of the simple regressions with those obtained from multiple regressions it can be noted how some variables which, when considered individually have a negative effect on the public debt / GDP ratio, yet when analysed all together, have a positive influence on that same ratio, or vice versa.

The estimations obtained with the random effects method on simple regression suggest there is a positive relationship between FDI outflows and the public debt / GDP ratio. If, however, they are analysed along with the other variables concerned, the relationship between them is negative.

Looking at the balance of payments variable it can be noted how both the estimations obtained with RE and FE, if analysed separately, seem to have a positive influence on the public debt / GDP ratio. When they are considered with all the other variables, they express a negative relationship with the variable in question.

These two previous variables do not however result statistically significant in the final model (10.2). In fact, except for the population density variable, the variables in the model 10.2 show a valid relationship both when analysed individually and when analysed with the others. The population density variable however, when estimated alone with the FE method, gives a positive impact on the ratio concerned; when analysed with all the other factors, a negative relationship between the two variables is implied. It should be noted how the estimation obtained with the FE method in the simple regression is statistically non-significant.

It is also possible to discover differences between the FE and RE methods observing multiple regressions. For example population density variable seems to have a negative impact on the public debt / GDP ratio using RE, but this impact seems to be positive with FE. The opposite can be observed for the FDI outflows variable. However, these two latter variables are non-significant in the RE method.

Lastly, considering only the differences obtained from the simple and multiple regressions in terms of their significance, other interesting results emerged. For example, when the FDI inflows and public expenditure variables are run in simple regressions, they are statistically significant on the public debt / GDP ratio, but are not so when run in multiple regressions. A plausible reason is the fact that other variables in the multiple regression explain the latter two variables. It is right to think, for example, that the GDP growth variable is correlated with the public expenditure variable.

There are some variables, however, which seem to influence the public debt / GDP ratio only when associated with others. This is the case with the GDP growth rate.

## 10.e Interpretation of the final model

The final model (10.2 ) is reported below:

$$\frac{\text{debt}}{\text{gdp}}\% = -23.4242 + 7.006687 * \text{pop65} - 0.5571161 * \text{popden} - 10.34044 * \text{popgrowth} + 2.486169 \\ * \text{expend} + 0.8186932 * \text{gdpgrowth} + \varepsilon$$

- The estimation of the factor relative to GDP growth seems to be a strange result. If there is a 1% growth of the GDP compared to the previous year, the model suggests an increase of approximately 0.81 percentage points of the public debt / GDP ratio. It may be due to an increase in public spending.
- The result for the over 65s is as we expected. Thus, if there is a population increase in the over 65s age range, we could be led to think that the public debt will increase. The model precisely suggests that with a 1% increase in the over 65s group, the debt increases by about 7 percentage points. This may explain Mario Monti's recent pension reforms
- It is plausible to think that with an increase in the population growth rate, the public debt / GDP ratio will decrease. In other words, a 1% rise in the total population compared to the previous year will lead to a diminution of the public debt / GDP ratio equal to 10.34 percentage points.
- It seems that a population density increase may also contribute to a reduction of the public debt / GDP ratio, even if in a smaller measure compared to an increase in the population growth rate. From the estimated model it seems that an increase of ten people per sq.km decreases the public debt / GDP ratio by about 5.5 percentage points.
- Finally, an increase in the percentage of public expenditure on the GDP by one percentage point leads to an increase of the public debt / GDP ratio equal to about 2.5 percentage points.



# 11. Conclusions

The primary aim of this analysis was to identify the determining factors on the public debt, by estimating an econometric model which would explain the public debt / GDP ratio.

The most important result regards the demographic variables, such as population over 65 , population density and population growth. These seem to have more impact on the public debt / GDP ratio than the other macroeconomic variables analysed. The only economic variables which emerged as being significant in explaining the public debt / GDP ratio over time seemed to be the GDP growth rate and public expenditure.

In previous studies these variables (foreign direct investments, inflation and balance of payments) appeared to have an impact on the public debt / GDP ratio, but in our analysis , this seemed not to be the case.

Having ascertained that the population structure had a fundamental role in the public debt / GDP ratio in our range time, the per capita public debt / GDP ratio was considered as the dependent variable. No great differences were however obtained. Another analysis carried out aimed at improving the model: models considered trends, adding dummy variables, but obtained no significant variations.

These above-mentioned results, which do not seem to confirm the main studies on public debt, may be due to the range time analysed. Our range time starts in the years when the Euro was being introduced and ends in those immediately prior to the global crisis of 2008.

Another objective of our thesis was that of highlighting how different estimation results can be obtained by using different estimation methods. From our analysis, the strong influence that the different estimation methods have on the results clearly emerged.

Differences between the various estimation methods in simple regressions were visible. In particular there are substantial differences between the results obtained with the POLS method and the FE and RE methods. There are some variables where the single coefficients estimated with the POLS model seem to have a negative effect on the public debt / GDP ratio, whereas a positive effect is achieved when estimating with FE and RE. These differences are explained by the biased estimates obtained by using POLS.

Similar differences were noted in multiple regressions.

Lastly, we observed the differences between the results obtained from both the simple and the multiple regressions. We discovered that in the simple regressions some variables had a negative impact on the public debt / GDP ratio, but in the multiple regressions had a positive one, or vice versa.

For more details on these differences, see section "Comments on the results".

At the end of our analysis we can therefore state that the different estimation methods used greatly influence the estimation results.

Our final model obtained from the multiple regression with FE methods state that an increase on the population over 65 years old, public expenditure and GDP growth ratio seems to increase the public debt/GDP ratio. Instead, an increase on the population density and population growth seems to decrease the public debt / GDP ratio.

As state before we tried to realize other different regressions in order to obtain a better model. It could be interesting to run some regressions with an autoregressive model to understand how the results could change, as was done by Sinha et al. (2011).

Lastly, data sensitivity emerged. For more details see “Appendix”.

Adding or deleting single countries and/or years sometimes has strong effects on the main results. Thus, all the results of this thesis and similar papers have to be taken with caution.

## **Bibliography**

- [1] Chiara Rapallini and Aldo Rustichini.(2010). *Debito pubblico, crescita e riforma fiscale: idee per ripartire*.
- [2] Daniela Vuri. (2004). *STATA tutorial*. Università di Firenze.
- [3] Davidson R. and J. G. MacKinnon (1993). *Estimation and Inference in Econometrics*. New York: Oxford University Press.
- [4] Gianni Toniolo. (2011). *Italy and the World Economy, 1861-2011*. Introduction to the research on “Italy and the World Economy, 1861-2011”. Banca d’Italia.
- [5] International Monetary Fund and The World Bank. *Guidelines for public debt management: Accompanying Document and Selected Case Studies*
- [6] Irving Fisher (1930). *The theory of interest*. New York: Macmillan
- [7] Jeffrey M. Wooldridge. (1999). *Introductory Econometrics*.
- [8] Maria Elena Bontempi e Roberto Golinelli. (2004). *Econometria dei dati panel: teoria e pratica in STATA 7*.
- [9] Maura F. and Angelo P.(2008). *Il debito pubblico italiano dall’Unità a oggi. Una ricostruzione della storia*. Banca d’Italia.
- [10] Robert J. Barro. (1979). *On the determination of the public debt*. The Journal of Political Economy, Vol.87, No. 5, Part 1, pp. 940-971.
- [11] Sinha, Pankaj, Arora, Varun and Bansal, Vishakha. (2011). *Determination of Public Debt for middle income and high income group countries using Panel Data regression*. Munich Personal RePEc Archive.
- [12] Treasury (1988).*Il debito pubblico in Italia 1864-1987*



## Appendix

In order to understand how the results changed with the inclusion of one country as opposed to another one or with a different range time we made the following sensitivity analysis of data, running various regressions.

At first we ran regression with two different datasets. One dataset contains values for all the 19 countries considered, for the years 1999 to 2008. The other one contains values for 18 countries (without Greece) for the whole time range (1993-2008). If the results of these regressions are mutually identical, we will state that whether to include the values for Greece in our dataset or not is not a crucial question, as set out below.

### MODEL WITH DATASET FROM 1999 TO 2008 FOR THE 19 COUNTRIES.

We estimated our first model including all variables from 1999 to 2008, via the normal OLS model:

Source	SS	df	MS			
Model	131809.321	9	14645.4802	Number of obs =	190	
Residual	83259.7709	180	462.554283	F( 9, 180) =	31.66	
				Prob > F =	0.0000	
				R-squared =	0.6129	
				Adj R-squared =	0.5935	
				Root MSE =	21.507	
Total	215069.092	189	1137.93171			

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	8.605045	.7321963	11.75	0.000	7.160253	10.04984
popden	.0790408	.0180366	4.38	0.000	.0434504	.1146313
popgrowth	-1.563786	3.738671	-0.42	0.676	-8.941048	5.813475
expend	-.2362898	.5308581	-0.45	0.657	-1.283795	.8112158
fdiinoecd	-.0501376	.4076097	-0.12	0.902	-.8544456	.7541704
fdioutoecd	-1.358355	.5824969	-2.33	0.021	-2.507756	-.2089545
curaccbala~d	-1.01143	.3922788	-2.58	0.011	-1.785486	-.2373731
gdpgrow	1.243748	.8833057	1.41	0.161	-.4992183	2.986714
inflation	-.8761197	.9915802	-0.88	0.378	-2.832736	1.080497
_cons	-82.74268	18.03062	-4.59	0.000	-118.3213	-47.1641

**Table 11.1** Output of the multifactor regression on public debt / GDP with all high income countries with range time 1999-2008.

There are some non-significant variables: population growth, public expenditure, foreign direct investment (inflow), GDP growth and inflation.

We then checked the output with random effect:

```

Random-effects GLS regression                Number of obs    =       190
Group variable: country                    Number of groups =       19

R-sq:  within = 0.3892                    Obs per group:  min =       10
        between = 0.4800                  avg =      10.0
        overall = 0.4750                  max =       10

Random effects u_i ~ Gaussian              Wald chi2(9)     =      118.90
corr(u_i, X) = 0 (assumed)                Prob > chi2     =       0.0000

```

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Intervall]
pop65	6.145646	.7589186	8.10	0.000	4.658193 7.633099
popden	.0436237	.0510506	0.85	0.393	-.0564335 .143681
popgrowth	-10.81526	2.317565	-4.67	0.000	-15.35761 -6.272919
expend	1.486112	.7635251	1.95	0.052	-.0103698 2.982594
fdiinoecd	.1886551	.1333312	1.41	0.157	-.0726693 .4499796
fdioutoecd	-.039844	.2222789	-0.18	0.858	-.4755026 .3958145
curaccbala~d	-.0058527	.2582497	-0.02	0.982	-.5120129 .5003074
gdpgrow	.8320571	.3602543	2.31	0.021	.1259715 1.538143
inflation	.0372168	.4009477	0.09	0.926	-.7486263 .8230599
_cons	-73.87861	19.25633	-3.84	0.000	-111.6203 -36.13689
sigma_u	26.253336				
sigma_e	6.5120587				
rho	.94203892	(fraction of variance due to u_i)			

**Table 11.2** Output of the multifactor regression on public debt / GDP with all high income countries with range time 1999-2008.RE

The non-significant variables are: population density, public expenditure, FDI investment (inflow and outflow), balance of payments(current account) and inflation.

The third model was estimated using the fixed effect method:

```
Fixed-effects (within) regression      Number of obs   =      190
Group variable: country                Number of groups =       19

R-sq:  within = 0.4243                  Obs per group:  min =      10
      between = 0.0027                    avg =      10.0
      overall  = 0.0017                    max =      10

corr(u_i, Xb) = -0.9320                  F(9,162)        =      13.27
                                          Prob > F         =      0.0000
```

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	7.262538	.8991022	8.08	0.000	5.487067	9.038009
popden	-.6515275	.2275663	-2.86	0.005	-1.100906	-.2021488
popgrowth	-9.733813	2.341221	-4.16	0.000	-14.35706	-5.110568
expend	2.665998	.8467599	3.15	0.002	.993888	4.338108
fdiinoecd	.1708323	.131241	1.30	0.195	-.0883315	.429996
fdioutoecd	.0399842	.2196386	0.18	0.856	-.3937396	.4737079
curaccbala-d	-.2297955	.2787048	-0.82	0.411	-.7801583	.3205674
gdpgrow	.8048876	.3624146	2.22	0.028	.0892217	1.520553
inflation	.3004342	.403143	0.75	0.457	-.4956587	1.096527
_cons	-20.07748	26.90006	-0.75	0.457	-73.19745	33.0425
sigma_u	93.77147					
sigma_e	6.5120587					
rho	.99520039	(fraction of variance due to u_i)				

F test that all u\_i=0: F(18, 162) = 100.08 Prob > F = 0.0000

**Table 11.3** Output of the multifactor regression on public debt / GDP with all high income countries with range time 1999-2008.FE

The non-significant variables are: FDI(inflow and outflow), balance of payments and inflation.

MODEL WITH DATASET FROM 1993 TO 2008, WITHOUT GREECE.

The first model we checked was, as usual, via OLS:

```
. reg debt pop65 popden popgrowth expend fdiin fdiout curaccoecd gdpgrow inflation
```

Source	SS	df	MS	Number of obs = 288		
Model	126342.959	9	14038.1066	F( 9, 278) = 29.24		
Residual	133459.754	278	480.071056	Prob > F = 0.0000		
Total	259802.713	287	905.235934	R-squared = 0.4863		
				Adj R-squared = 0.4697		
				Root MSE = 21.911		
debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	7.854413	.639811	12.28	0.000	6.594923	9.113902
popden	.06066	.0144588	4.20	0.000	.0321972	.0891227
popgrowth	2.771964	3.374758	0.82	0.412	-3.871363	9.41529
expend	.6673709	.4194888	1.59	0.113	-.1584071	1.493149
fdiinoecd	-.1603494	.3802093	-0.42	0.674	-.9088043	.5881055
fdioutoecd	-2.291238	.544076	-4.21	0.000	-3.36227	-1.220206
curaccoecd	.4204936	.3182111	1.32	0.187	-.2059158	1.046903
gdpgrow	1.86807	.6485186	2.88	0.004	.5914393	3.144701
inflation	.7252762	.3028295	2.39	0.017	.1291461	1.321406
_cons	-89.2286	13.91897	-6.41	0.000	-116.6286	-61.82864

**Table 11.4** Output of the multifactor regression on public debt / GDP with 18 high income countries (without Greece) with range time 1993-2008.

The non-significant variables are: population growth, public expenditure, FDI (inflow) and balance of payments.

The second model estimated with this dataset is with the random effect approach:

```

Random-effects GLS regression                Number of obs    =    288
Group variable: var2                        Number of groups  =    18

R-sq:  within = 0.5359                      Obs per group:  min =    16
        between = 0.2912                      avg   =    16.0
        overall = 0.3151                      max   =    16

Random effects u_i ~ Gaussian              Wald chi2(9)     =    297.87
corr(u_i, X) = 0 (assumed)                 Prob > chi2      =    0.0000

```

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
pop65	7.086101	.6756472	10.49	0.000	5.761857	8.410346
popden	.0028865	.049103	0.06	0.953	-.0933535	.0991266
popgrowth	-16.14376	2.386523	-6.76	0.000	-20.82126	-11.46626
expend	3.280234	.6198379	5.29	0.000	2.065374	4.495094
fdiinoecd	.0387713	.183083	0.21	0.832	-.3200647	.3976073
fdioutoecd	-.8790706	.2875412	-3.06	0.002	-1.442641	-.3155003
curaccoecd	.1037255	.2661989	0.39	0.697	-.4180147	.6254658
gdpgrow	1.667625	.3308997	5.04	0.000	1.019074	2.316177
inflation	.9751063	.1870067	5.21	0.000	.6085799	1.341633
_cons	-115.5351	15.45021	-7.48	0.000	-145.817	-85.25328
sigma_u	24.798816					
sigma_e	9.5062484					
rho	.87188097	(fraction of variance due to u_i)				

**Table 11.5** Output of the multifactor regression on public debt / GDP with 18 high income countries (without Greece) with range time 1993-2008.RE

Here the non-significant variables are: population density, FDI (inflow) and balance of payments.



The last model is with the fixed effect method:

```

Fixed-effects (within) regression      Number of obs   =      288
Group variable: var2                  Number of groups =      18

R-sq:  within = 0.5759                 Obs per group:  min =      16
      between = 0.0022                   avg   =      16.0
      overall = 0.0066                   max   =      16

corr(u_i, Xb) = -0.9545                F(9,261)        =      39.37
                                          Prob > F         =      0.0000

```

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	8.855702	.7446631	11.89	0.000	7.38939	10.32201
popden	-.6708006	.1378655	-4.87	0.000	-.9422708	-.3993303
popgrowth	-16.78474	2.308272	-7.27	0.000	-21.32995	-12.23954
expend	4.272984	.6313298	6.77	0.000	3.029835	5.516132
fdiinoecd	.06088	.1747967	0.35	0.728	-.2833114	.4050713
fdioutoecd	-.6305231	.2776676	-2.27	0.024	-1.177277	-.0837693
curaccoecd	-.0045214	.2601649	-0.02	0.986	-.5168107	.5077679
gdpgrow	1.526482	.3185929	4.79	0.000	.8991421	2.153821
inflation	1.078031	.1816887	5.93	0.000	.7202686	1.435793
_cons	-67.7684	17.64309	-3.84	0.000	-102.5093	-33.02748
sigma_u	98.50813					
sigma_e	9.5062484					
rho	.99077326	(fraction of variance due to u_i)				

F test that all u\_i=0: F(17, 261) = 71.52 Prob > F = 0.0000

**Table 11.6** Output of the multifactor regression on public debt / GDP with 18 high income countries (without Greece) with range time 1993-2008. FE

The non-significant variables are: FDI(inflow) and balance of payments.

To show the output differences between the two datasets more clearly and to resume the differences between the results obtained, we made the following table:

	with Greece from 1999 to 2008			without Greece from 1993 to 2008		
	total effect	fixed effect	random effect	total effect	fixed effect	random effect
population over 65	+	+	+	+	+	+
population density	+	-	(n) +	+	-	(n) +
population growth	(n) -	-	-	(n) +	-	-
public expenditure	(n) -	+	(n) +	(n) +	+	+
FDI in	(n) -	(n) +	(n) +	(n) -	(n) +	(n) +
FDI out	-	(n) +	(n) -	-	-	-
current account	-	(n) -	(n) -	(n) +	(n) -	(n) +
GDP growth	(n) +	+	+	+	+	+
inflation	(n) -	(n) +	(n) +	+	+	+

**Table 11.7** It shows differences in significance term between two different dataset: 1)with Greece from 1999 to 2008, 2) without Greece from 1993 to 2008.

It is possible to see some differences. We are interested in knowing whether these differences are caused by the presence of Greece or not, or whether they are due to the different range time considered in the datasets.

In order to discover this fact we acted as below.

We ran some more regressions without Greece in the same time range (1999-2008) in which it was included before.

With the total effect method we have the following output:

Source	SS	df	MS	Number of obs = 180		
Model	105784.257	9	11753.8063	F( 9, 170)	=	27.40
Residual	72934.04	170	429.023765	Prob > F	=	0.0000
-----				R-squared	=	0.5919
-----				Adj R-squared	=	0.5703
Total	178718.297	179	998.426238	Root MSE	=	20.713

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	7.445852	.7520961	9.90	0.000	5.961202	8.930502
popden	.0920245	.0176012	5.23	0.000	.0572794	.1267697
popgrowth	-.0217241	3.617357	-0.01	0.995	-7.162447	7.118999
expend	.264858	.5234747	0.51	0.614	-.7684898	1.298206
fdiinoecd	.2518903	.3984782	0.63	0.528	-.5347122	1.038493
fdioutoecd	-1.191634	.5652491	-2.11	0.036	-2.307445	-.0758227
curaccoecd	-.7090495	.3936608	-1.80	0.073	-1.486142	.0680436
gdpgrow	.3103384	.8937049	0.35	0.729	-1.45385	2.074527
inflation	-1.008794	.9593352	-1.05	0.294	-2.902537	.8849502
_cons	-77.48484	17.50581	-4.43	0.000	-112.0416	-42.92807

**Table 11.8** Output of the multifactor regression on public debt / GDP with 18 high income countries (without Greece) with range time 1999-2008.

We ran the second regression with this dataset with the random effect method:

Random-effects GLS regression	Number of obs	=	180
Group variable: country	Number of groups	=	18
R-sq: within = 0.4006	Obs per group: min	=	10
between = 0.4941	avg	=	10.0
overall = 0.4877	max	=	10
Random effects u_i ~ Gaussian	Wald chi2(9)	=	116.92
corr(u_i, X) = 0 (assumed)	Prob > chi2	=	0.0000

debt	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
pop65	6.346665	.8147065	7.79	0.000	4.74987	7.943461
popden	.0509877	.0525967	0.97	0.332	-.0521	.1540753
popgrowth	-10.83357	2.352358	-4.61	0.000	-15.4441	-6.22303
expend	1.50686	.8358231	1.80	0.071	-.1313232	3.145043
fdiinoecd	.1884409	.1347934	1.40	0.162	-.0757493	.452631
fdioutoecd	-.0386686	.2249192	-0.17	0.863	-.4795023	.402165
curaccoecd	-.0676804	.2932052	-0.23	0.817	-.6423519	.5069911
gdpgrow	.9065053	.3810392	2.38	0.017	.1596822	1.653329
inflation	.0652651	.408324	0.16	0.873	-.7350353	.8655655
_cons	-81.00369	20.22327	-4.01	0.000	-120.6406	-41.3668

sigma_u	26.83834
sigma_e	6.5771066
rho	.94334613 (fraction of variance due to u_i)

**Table 11.9** Output of the multifactor regression on public debt / GDP with 18 high income countries (without Greece) with range time 1999-2008.RE

In the end, the output by regression with the fixed effect method:

```

Fixed-effects (within) regression          Number of obs   =       180
Group variable: country                  Number of groups =        18

R-sq:  within = 0.4431                    Obs per group:  min =         10
        between = 0.0208                  avg =         10.0
        overall = 0.0167                  max =         10

corr(u_i, Xb) = -0.9565                    F(9,153)        =       13.53
                                                Prob > F         =       0.0000

```

debt	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
pop65	7.957795	.9831314	8.09	0.000	6.01553	9.90006
popden	-.745611	.2370146	-3.15	0.002	-1.213855	-.2773674
popgrowth	-9.936394	2.370342	-4.19	0.000	-14.61922	-5.253569
expend	2.657005	.9260648	2.87	0.005	.8274799	4.486529
fdiinoecd	.1620829	.1327195	1.22	0.224	-.1001165	.4242824
fdioutoecd	.0428834	.222509	0.19	0.847	-.3967032	.48247
curaccoecd	-.449957	.3240979	-1.39	0.167	-1.090242	.1903277
gdpgrow	.8530571	.3867533	2.21	0.029	.088991	1.617123
inflation	.3681982	.4115043	0.89	0.372	-.4447657	1.181162
_cons	-17.78341	28.64383	-0.62	0.536	-74.37189	38.80508
sigma_u	108.17193					
sigma_e	6.5771066					
rho	.99631669	(fraction of variance due to u_i)				

F test that all u\_i=0: F(17, 153) = 90.18 Prob > F = 0.0000

**Table 11.10** Output of the multifactor regression on public debt / GDP with 18 high income countries (without Greece) with range time 1999-2008.FE

Taking the left part of the last table, we compared it with the new results:

	with greece from 1999 to 2008			without greece from 1999 to 2008		
	total effect	fixed effect	random effect	total effect	fixed effect	random effect
population growth	+	+	+	+	+	+
population density	+	-	(n) +	+	-	(n) +
population over 65	(n) -	-	-	(n) -	-	-
public expenditure	(n) -	+	(n) +	(n) +	+	(n) +
FDI in	(n) -	(n) +	(n) +	(n) +	(n) +	(n) +
FDI out	-	(n) +	(n) -	-	(n) +	(n) -
current account	-	(n) -	(n) -	(n) -	(n) -	(n) -
GDP growth	(n) +	+	+	(n) +	+	+
inflation	(n) -	(n) +	(n) +	(n) -	(n) +	(n) +

**Table 11.11** It shows differences in significance term between two different dataset: 1)with Greece from 1999 to 2008, 2) without Greece from 1999 to 2008.

It is possible to see that there are no substantial differences between the results obtained in the two sets above. This seems to imply that including Greece or not may be irrelevant, but the range time seems to be relevant.

In order to confirm this we compare the results obtained from the regressions without Greece in two different range times

	without greece from 1993 to 2008			without greece from 1999 to 2008		
	total effect	fixed effect	random effect	total effect	fixed effect	random effect
population growth	+	+	+	+	+	+
population density	+	-	(n) +	+	-	(n) +
population over 65	(n) +	-	-	(n) -	-	-
public expenditure	(n) +	+	+	(n) +	+	(n) +
FDI in	(n) -	(n) +	(n) +	(n) +	(n) +	(n) +
FDI out	-	-	-	-	(n) +	(n) -
current account	(n) +	(n) -	(n) +	(n) -	(n) -	(n) -
GDP growth	+	+	+	(n) +	+	+
inflation	+	+	+	(n) -	(n) +	(n) +

**Table 11.12** It shows differences between two different dataset: 1) without Greece from 1999 to 2008, 2) without Greece from 1999 to 2008.

Observing table 11.12 we can state that the adding or the deleting of some years has effects on the results. In order to understand whether this can also be stated for the inclusion or exclusion of some countries, we run some regressions removing countries from the dataset one by one. We discovered that the inclusion or the exclusion of countries may considerably alter the results. (see table 11.13).

	with all 19 countries from 1999 to 2008			without Hungary from 1999 to 2008		
	total effect	fixed effect	random effect	total effect	fixed effect	random effect
population growth	+	+	+	+	+	+
population density	+	-	(n) +	+	-	(n) +
population over 65	(n) -	-	-	(n) -	-	-
public expenditure	(n) -	+	(n) +	(n) -	+	+
FDI in	(n) -	(n) +	(n) +	(n) -	(n) +	(n) +
FDI out	-	(n) +	(n) -	-	(n) +	(n) -
current account	-	(n) -	(n) -	-	(n) -	(n) +
GDP growth	(n) +	+	+	(n) +	+	+
inflation	(n) -	(n) +	(n) +	(n) -	(n) +	(n) +

**Table 11.13** It shows differences in significance term between two different dataset: 1) with Hungary from 1999 to 2008, 2) without Hungary from 1999 to 2008.

From the previous analysis it emerges that both including or excluding countries and a variation in the range time considered change the results.

Finally, our choice is to analyse all the countries for the time period 1999-2008, so as to avoid having the presence of the anomalous behaviour that the countries wishing to adopt the Euro showed from 1995 to 1998.